An Interactive Supply Framework to Improve the Successful Outcome of the Acquisition of a Complex System

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Abstract

The investigation into and interest in the effect of the human factors in the successful execution of a program started in the middle part of the author's 35-year career when he worked as a program manager responsible for the supply of a ground-based weapon system. An improved understanding of the specific interface between the customer's and the supplier's agents as a specific focus area is of interest. The new insights, thus obtained, will lead to improved interactive events and possible proactive and premeditated relationship

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strategies that can be used to increase or accelerate the propensity for the success of a project. These new insights will provide the enterprise with a competitive advantage.

The specific choice of the human factors to study had to include the leadership role to support the strategy, the relationship with the customer as it defines the interaction, the effect of informed decision making on the outcome and the standardised way of performing these tasks within the organisation.

The supply processes in the enterprise is a mirror image of the acquisition processes prescribed and practised by the western world's procurement agencies in the USA, UK, NATO and others. The notion of investigating the effect of the human factors on the elements of a typical set of supply processes gave rise to the formulation of the research question as:

What is the contribution of the human enabling factors of leadership, relationship, wisdom and culture towards the success of a project or enterprise during the acquisition phase of a complex system, when interacting with a customer?

The research is made possible by the definition of the Executable Domain Factors representing, in a structured way, the supply processes and the Enabler Domain Factors representing the human factors listed above. These two domains are then combined into an Interactive Supply Framework to study the effect of one upon the other as required by the research question.

The firm BAE Systems, Land Systems South Africa presented the author with an opportunity to observe, using a case study containing multiple cases, the effect of these factors in real life. The cases available spanned three customer bases (USA, NATO and South Africa), four product life cycles and four enterprise phases.

The outcome of the case study, albeit limited in size and respondents, resulted in the identification of the relationship factor as a dominant factor, which was supported by the company executive as well as the author's experience. The author also developed a relationship framework, in which the alignment of the different parties' belief systems may affect the relationship positively or negatively. The data from three of the cases with the same product and customer, cover a span of ten years, and show a remarkable correlation between the change in the belief system factors for different teams on both sides as well as the observed relationship status.

Opsomming

Die ondersoek na en die belangstelling van die skrywer in die effek van menslike faktore in beïnvloeding van programme het begin in die middelfase van sy loopbaan van 35 jaar waar hy verantwoordelik was as die program bestuurder van 'n land gebasseerde wapenstelselsel. 'n Verbeterde begrip van die intervlakke tussen die kliënt en die verskaffer en sy agente is noukeurig ondersoek as 'n spesifieke fokusarea. Die nuwe insigte wat hierdeur ontwikkel is sal aanleiding gee tot verbeterde interaktiewe aktiwiteite en selfs moontlike pro-aktiewe en

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voorafvasgestelde verhouding strategieë wat gebruik kan word om die sukses van ‘n projek te versnel of verbeter. Laasgenoemde sal vir die organisasie ‘n kompeterende voordeel verskaf.

Die spesifieke besluit om menslike faktore te bestudeer moes die volgende insluit; die leierskapsrol om die strategie te ondersteun, die professionele verhouding met die kliënt want dit bepaal die interaksie, die effek van ingeligte besluitneming op die uitkoms en die gestandardiseerde manier om hierdie take in ‘n organisasie te vervul.

Die verskaffingsproses in ‘n organisasie is ‘n spieëlbeeld van die aanskaffingsprosesse soos hulle voorgeskryf en uitgevoer word in die westerse wereld se aanskaffingsagentskappe in die VSA, Verenigde koninkryk, NAVO en andere.

Die besluit om die effek van menslike faktore op die elemente van ‘n tipiese stel verskaffingsprosesse te ondersoek het aanleiding gegee tot die formulering van die volgende navorsingsvraag:

‘Wat is die bydrae van die menslike faktore van leierskap, verhoudings, wysheid en kultuur op die sukses van ‘n projek of organisasie tydens die aanskaffingsfase van ‘n komplekse sisteem terwyl interaksie met die kliënt plaasvind?’

Die navorsing is moontlik gemaak deur die definisie van die Uitvoerbare Domein Faktore wat op ‘n gestruktureerde basis die verskaffingsprosesse bepaal en die Bydraende Domein Faktore wat die menslike faktore wat bo gelys is verteenwoordig. Die twee domeine word dan gekombineer in ‘n Interaktiewe Verskaffings Raamwerk, om die effek van die een op die ander te bestudeer, soos vereis deur die navorsingsvraag.

Die firma BAE Systems, Land Systems South Africa het die skrywer die geleentheid gebied om, deur middel van ‘n gevalle studie wat verskeie gevalle verteenwoordig, die effek van bogenoemde faktore in die werklike lewe te ondersoek. Die beskikbare gevalle strek oor drie kliëntebasisse in die VSA, NAVO en Suid Afrika en verteenwoordig vier produklewensfases en vier organisasielewensfases.

Die uitkoms van die gevallestudie, hoewel beperk in grootte en die aantal respondente, het tot gevolg gehad dat die identifikasie van die verhoudingsfaktor as ‘n dominante faktor navore gekom het. Hierdie dominansie is verder bevestig deur die maatskappy se uitvoerende bestuur asook die skrywer se ervaring. Die skrywer het verder ook ‘n verhoudingsraamwerk ontwikkel waarin die belyning van die verskillende partye se geloofsisteme die verhouding positief of negatief kan beïnvloed. Die inligting van die drie gevalle wat dieselfde produk en kliënt verteenwoordig strek oor tien jaar en wys ‘n merkwaardige verband tussen die verandering in die geloofsisteemfaktore vir verskillende spanne aan beide kante en as die verhoudingstatus wat waargeneem is.

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I would like to start by thanking Prof. Niek du Preez for his continued guidance and support from the conception to the completion of this research. I further want to extend thanks to Assoc. Prof. Eric Lutters for the input and advice he provided on several occasions over the duration of this study.

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I would like to thank my wife, Agatha, for her support throughout this project and my two daughters, Martie and Agatha for always showing an interest in my work. Special mention must go to Willem Stiglingh who enlightened me regarding the human interaction and the relationship model he has yet to publish.

Finally, I thank our Heavenly Father for blessing me with the opportunity, health and abilities to complete this research.

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Table of Contents

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

List of Figures

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

Stellenbosch University https://scholar.sun.ac.za

List of Tables

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List of Acronyms

ABC	Activities, Belief system, Consequence
AEE	Affordability, Efficiency and Effectiveness
ASG	Acquisition System Guidance
CAD	Computer Aided Design
CBT	Cognitive Behavioural Theory
CEO	Chief Executive Officer
CIO	Chief Information Officer
CVP	Customer Value Proposition
CRM	Customer Relationship Management
DAU	Defense Acquisition University
DIKW	Data, Information, Knowledge, Wisdom
DoD	Department of Defense
DoDAF	Department of Defense Architectural Framework
DRL	Design Readiness Levels
EMD	Engineering and Manufacturing Development
FCA	Functional Configuration Audit
FMV	Swedish Defence Material Administration
FRP	Full Rate Production
GM	Gauss-Markov
IC	Intellectual Capital
ICMM	Innovation Capability Maturity Model
IED	Improvised Explosive Device
IMC	Integrated Marketing Communication
IPP	Innovation Production Process
KC	Knowledge Cube
KCM	Knowledge Chain Model
KM	Knowledge Management
LCC	Life Cycle Cost
LCM	Life Cycle Management

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LRIP	Low Rate of Initial Production
LSSA	Land Systems South Africa
MOD	Ministry of Defence
MODAF	Ministry of Defence Architectural Framework
MPV	Mine Protected Vehicle
MRAP	Mine-Resistant Ambush Protected
MRP	Material Resource Planning
NASA	National Aeronautical and Space Administration
NATO	North Atlantic Treaty Organisation
NAF	NATO Architectural Framework
NDIA	National Defence Industry Association
OEM	Original Equipment Manufacturer
OPM	Object-Process Methodology
PAEI	Producer, Administrator, Entrepreneur, Integrator
PCA	Physical Configuration Audit
PDCA	Plan, Do, Check, Act
PES	Process for Exchange of data Specification
PLC	Product Life Cycle
PMBOK	Project Management Body of Knowledge.
P&L	Profit and Loss
REBT	Rational Emotive Behavioural Theory
SOW	Statement of Work
TACOM	Tactical Acquisition Command
TLC	Technology Life Cycle
TLMP	Through Life Management Plan
TRL	Technology Readiness Level
VCM	Value Chain Marketing
WEF	World Economic Forum

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Glossary

Agility	The capacity to recognise and shape opportunities and threats, to seize opportunities, and to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets.
Culture	The driving force behind the way a group (and an individual) react will be defined in the description of its "culture."
Customer	An individual or business that purchases the goods or services produced by a business. The customer is the end goal of businesses since it is the customer who pays for supply and creates demand. Businesses will often compete through advertisements or sales to attract a larger customer base.
Customer Relationship	The crucial function of relational exchange between the firm and the buyer as the key that makes this roadmap work
Customer Value	The customer value is based on the combination of the relative selling price of the customer as well as the product differentiation and image factors defining a real benefit to the customer.
Design	Any design process comprises a basic sequence of tasks that are performed in various situations. Assuming that we have an initial concept about what should be achieved in the design process, the first step is to generate an initial layout. The next step is the simulation of the design at hand. If the simulation reveals some errors, then the design must be changed to overcome the problems. The redesigned version is again simulated to determine whether the errors have disappeared. This loop repeats until the simulation indicates a successful design
Enablers	All the human factors that can, or will influence the executable factors, directly or indirectly, to enhance the positive result of the enterprise. These factors are not mandatory but may enable the executable factors to increase the propensity for success or failure.
Engineering Life Cycle	Engineering Life Cycle of a Product or System has five major phases as follows: • Concept Creation Phase • Development and Qualification Phase • Manufacture Phase • Support during Deployment Phase • Disposal Phase

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Enterprise	A purposeful or industrious undertaking that is especially difficult, complicated, or risky showing readiness to engage in a courageous action that requires boldness and energy, and which is organised for commercial purposes as well as having initiative and resourcefulness to reach its intended goal.
Enterprise Life Cycle	Enterprise Life Cycle refers to an organisation's approach to managing activities and making decisions during continuous refreshment of business and technical practices to support its mission.
Executables	All the factors related to the direct running of a business that needs to be deployed to a minimum required level. The enterprise can influence these factors directly or indirectly.
Knowledge	Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowledge workers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms
Knowledge Cube	The knowledge cube defines the "What", "When", "How" Domains of any Knowledge Artefact's attributes can be used in the structuring of the knowledge of any item.
Knowledge Management	Knowledge management involves connecting people with people, as well as people with information. It is a management philosophy, which combines good practice in purposeful information management with a culture of organisational learning, to improve business performance.

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Knowledge Migration	The migration path of a knowledge item through the Interactive Supply Framework to end as the definition of the value created for the customer. The process consist out of the following elements: • The formulation of an idea as the most basic definition of a knowledge item • The understanding of the basic engineering or change cycle • The life cycles of technology, product development and their related context • The life cycle of the enterprise that must produce the knowledge item • The eventual customer value defined as the outcome of the process • The identification of the driving force behind the knowledge growth of the knowledge item • The knowledge migration context diagram
Leadership	Leadership is to get the different people to work together synergistically by complementing each other's differences in a culture of mutual respect and trust.
Life Cycles	The life cycle of innovations can be described using the S-Curve. In the early stage of innovation, growth is relatively slow as the new product establishes itself. At some point, customers begin to demand the product, and the revenue from the product increases more rapidly. New incremental innovations or changes to the product allow growth to continue during this time. Towards the end of its life cycle, growth slows and may even begin to decline. In the later stages, no amount of new investment in that product will yield a normal rate of return.
Marketing Strategies	Functionalist: The functionalist approach focuses on the marketing system and endeavours to improve the outcome. Managerial; An analytic approach to managerial and buyer behaviour. Collaborative: Buyers and sellers do not only compete, but they must also be able to collaborate. Relational: A relational approach to managing marketing function.

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Product	A product or service is best described as an artefact (idea, method, information, object or service) presented for sale and described by its tangible and intangible knowledge attributes.
Product Life Cycle	The Product Life Cycle describes the whole life cycle of a product, from the first idea conception to the disposal of the product.
Relationship	Defined as a healthy business relationship that contributes towards the customer value and therefore also to the success of the enterprise. A specific relationship model will be developed to investigate the effect of this factor on the positive result.
Interactive Supply Framework	The factors contributing towards success will be grouped into two categories: **The Executables:** All the factors related to the direct running of a business that needs to be deployed to a minimum required level. The enterprise can influence these factors directly or indirectly. **The Enablers:** All the human factors that can, or will influence the executable factors, directly or indirectly, to enhance the positive result of the enterprise. These factors are not mandatory but may enable the executable factors to increase the propensity for success or failure. Together the executable factors, as well as the enabler factors formulate the **Interactive Supply Framework** for the Enterprise.
Interactive Event	An Interactive Event is defined as a specific action that contributes towards the ultimate success of the project and therefore also that of the business. Examples of Interactive Events are: • A communication interaction like a meeting, a letter, e-mail, during work or social sessions with the customer. • The formal presentation of a bid, a product description, contract negotiations. • Formal design, program and contract reviews with the customer. • A strong, honest and speedy reaction towards the solution of a problem or a perceived problem. • The informal and formal presentation of an in-process and a final product. • The interaction during the delivery of a service. • The actual performance of the fielded product against the expected performance.

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Strategic Planning	The strategy has two fundamental concerns – **value creation** and **value capture**. Traditional perspectives that focus primarily on how to create sustainable sources of competitive advantage are primarily concerned with value capture.Value innovation, while concerned with both creation and capture, shifts the primary focus in strategy development back to customers rather than competitors, and to the challenge of how to create game-changing breakthroughs in the value-to-cost ratio.
Wisdom	The combination of explicit and tacit knowledge with sound decision making combines to form the wisdom concept.

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Chapter 1
Introduction to the Research Definition

The objective of this chapter is to introduce the research undertaken. The chapter commences with a brief theoretical background which leads to the research problem statement, the formulation of the research questions and the research objectives. After that the scope of the dissertation is demarcated along with the research design and methodology followed by addressing the identified problem. Finally, the chapter concludes with the outline or roadmap of the study.

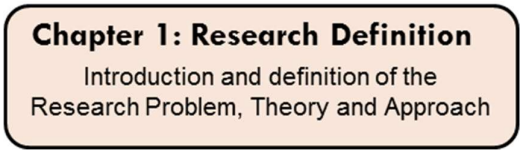

Figure 1-1: The Research Definition

1.1 Background and Rationale of the Research

The interest in and investigation into the effect of the human factors in the successful execution of a program started in the middle part of the author's 35-year career when he worked as a program manager responsible for the supply of a ground-based weapon system. Some observations during the preceding years led to the identification of factors like appropriate leadership, sound business relationships, good decision making and the way we work that were contributing towards the success of specific projects.

An opportunity presented itself to the South African company, BAE Land Systems, owned by the international BAE Systems enterprise, to study a variety of variables that relate to these factors.

The idea of defining and optimising the outcome of a series of interactive events between the supplier and the customer was conceived earlier and has been successfully employed in a few projects led by the author before this study commenced.

1.1.1 The Acquisition Processes

The acquisition of a complex military vehicle system is well documented in the western world with the USA Department of Defense's (DODD, 2007)[1] and the UK Ministry of Defence's 'How Defence Works' (MOD, 2015)[2]. The MOD's Acquisition System

[1] DOD Directive 5000.01 (2007) *The Defense Acquisition System*. USD (AT&L).
[2] Ministry of Defence (2015) *How Defence Works.* Published by the Ministry of Defence.

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Guidance (ASG), formerly the Acquisition Operating Framework (AOF) (MOD, 2012)[3], is the main source of policy and guidance on acquisition for the DoD, MOD and industry partners. The MOD website is partially secure and can only be viewed with the required access approval profile. This dissertation will only show information available in the public domain.

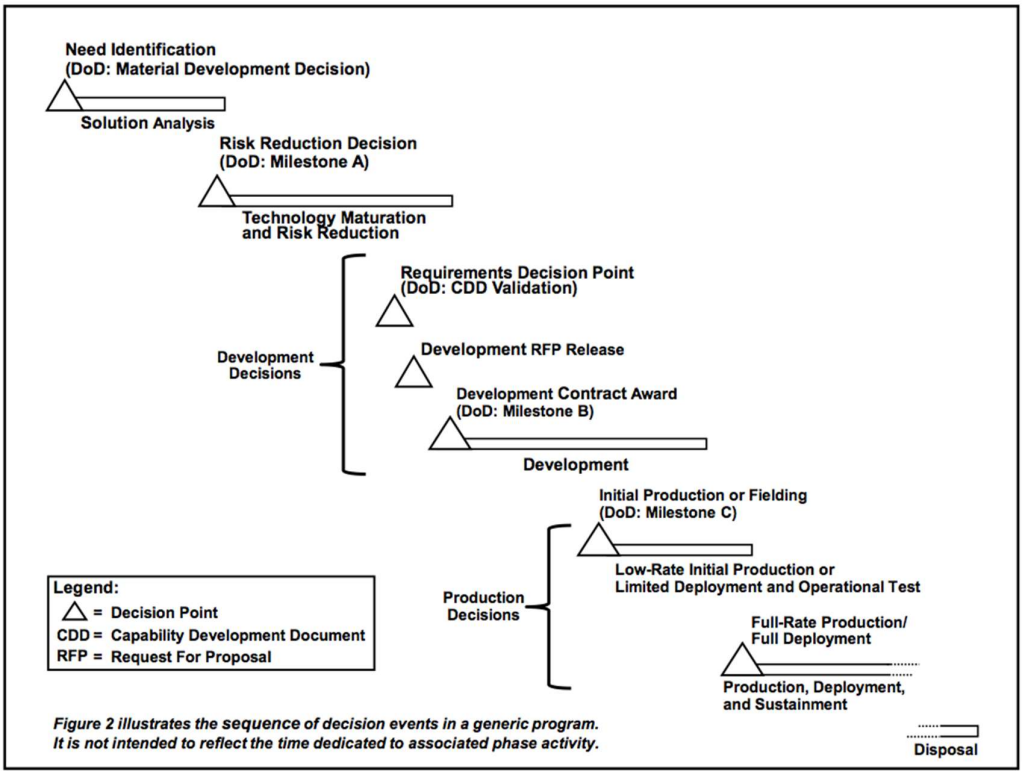

Figure 1-2: Generic Acquisition Phases and Decision Points (DODD 5000.01, 2007)

The Acquisition System Guidance (ASG) defines the conduct, governance and control of the UK defence acquisition projects. The intention of the ASG is to improve the delivery to the armed forces and to produce greater value for money for the UK taxpayer. The ASG explains in detail the process required to ensure a successful acquisition of complex military systems. The generic phases and decision points in these process in the USA (DoD), as well as the overall context of the acquisition inside the UK's MOD, are depicted in Figures 1-2 and 1-3 below.

[3] Ministry of Defence (2012) *Acquisition System Guidance* (formerly the AOF). Available at: https://www.gov.uk/guidance/acquisition-operating-framework [Accessed May 2015].

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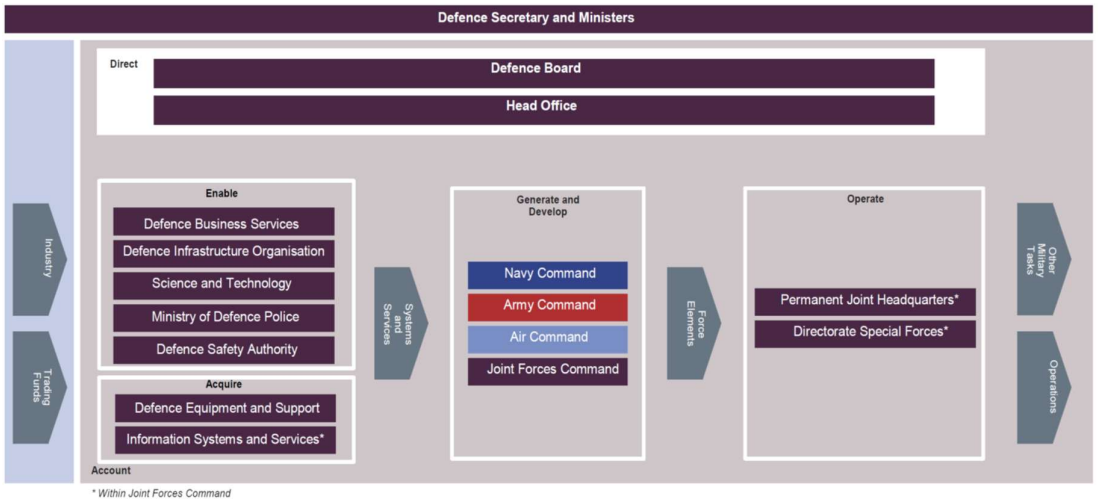

Figure 1-3: The Defence Operating Model (Ministry of Defence, 2015)

The process of acquisition is typically used during military systems' purchases and is very well defined in the US, UK and NATO series of Standards on Military Acquisition (DSP, 2017)[4], (UK Defence Standardisation, 2014)[5] and (NSO-NATO, 2014)[6].

During a career of more than thirty years in the supply of weapon systems, the author realised that just following the prescribed acquisition/supply processes was not enough to guarantee a successful outcome for a specific program. Success in this sense is defined as the value realised both for the customer in his use of the product related to his expense, as well as for the owner of the supply business, as more value in the profit, cash and growth profile contribution from the project.

It was further understood that the acquisition processes, as defined in the Department of Defense (DoDD 5000.01, 2007) of the USA as well as the Ministry of Defence (MOD, Acquisition-operating Framework, 2015) of the United Kingdom, are both based on the growth and maturity of the knowledge of the product and its associated processes in a structured product life cycle process. These steps contain the various phases of development, production and support (DoD 5000.02 Instruction, 2015)[7] and are named the acquisition process. Figure 1-4 below (Vitech Solutions, 2017)[8] defines the relationship between the '*Architecture Value'* (knowledge about artefact) and the '*Process Maturity'* (phases of the acquisition process) and shows an exponential growth in the knowledge about the artefact

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[4] Department of Defense (2017) *Defense Standardization Program, Making it Work*. Available at: http://www.dsp.dla.mil/Specs-Standards/ [Accessed June 2017].
[5] Ministry of Defence (2014) *Guidance UK Defence Standardization.* Available at: https://www.gov.uk/uk-defence-standardization [Accessed July 2014].
[6] NATO Standardisation Office (2016) *NATO Standardization Office (NSO) Public Web site*. Available at: http://nso.nato.int/nso/ [Accessed June 2017].
[7] DoD Instruction 5000.02 (2015) *Operation of the Defense Acquisition System.* Available at: http://www.acq.osd.mil/fo/docs/500002p.pdf [Accessed June 2015].
[8] Vitech Solutions (2017) *Leverage the Power of Architectures for Project and Business Success.* Available at: http://www.vitechcorp.com/solutions/DoDAF.shtml [Accessed June 2017].

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as the phases and acquisition milestones are reached.

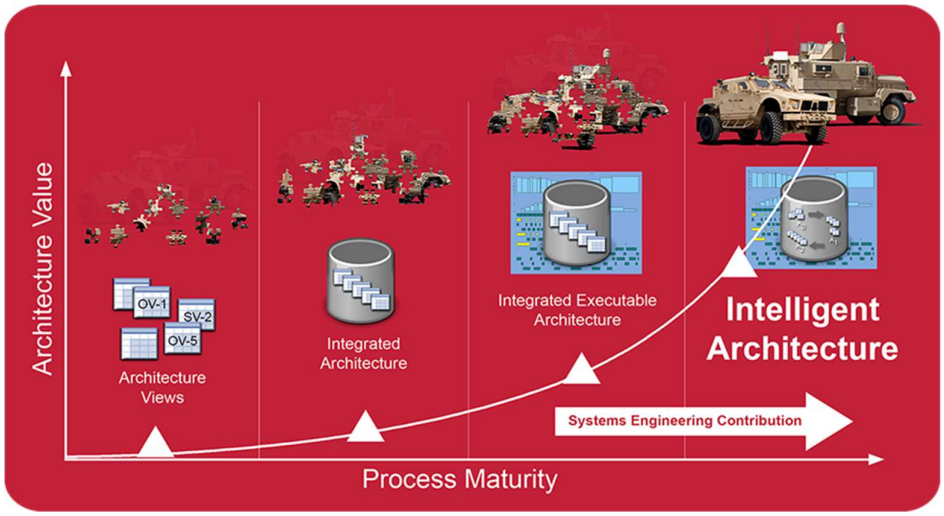

Figure 1-4: Leverage the Power of Architectures for Project and Business Success (Copyright -Vitech Solutions, 2017)

In the past few years all three main acquisition processes under review, moved towards the use of architectural frameworks to integrate the procurement process into the wider process of Defense (CIO, DoD, 2017)[9]. These architectural frameworks are aptly named as DoDAF (Dam, 2014)[10], MODAF (MOD, 2005)[11] and NAF (NATO, 2014)[12] respectively and represent, among other things, the acquisition interface between the Supplier and the User.

The DoDAF Meta-Model Version 2.02 (DM2) relates to the Zachman Framework (Kappelman & Zachman, 2013)[13] interrogatives as shown in figure 1-5 below.

- The Data Description — What
- The Function Description — How
- The Network Description — Where
- The People Description — Who
- The Time Description — When
- The Motivation Description — Why

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[9] Chief Information Officer, U.S. Department of Defense. (2017) *DM2 CDM Relationship to Universal Core and Zachman Framework Interrogatives.* Available at: http://dodcio.defense.gov/Library/DoD-Architecture-Framework/dodaf20_conceptual/ [Accessed June 2017].

[10] Dam, S.H. (2014) *DoD Architecture Framework, A Guide to Apply System Engineering to Develop Integrated Executable Architectures.* Copyright © 2014 SPEC Innovations, Manassas, VA All rights reserved. Available at: https://www.slideshare.net/elizabethdam58/dodaf-overview-using-innoslate-webinar [Accessed May 2017].

[11] Ministry of Defence. (2005) *MODAF-M10-004, MOD Architectural Framework, Acquisition Community of Interest Desk book.* Prepared by MODAF Partners, p 6.

[12] NATO. (2014) *NAF Version 4.0 Draft Documentation.* Available at: http://nafdocs.org/introduction/ - [Accessed June 2017].

[13] Kappelman, L.A. & Zachman, J.A. (2013) *The Enterprise and Its Architecture, Ontology & Challenges.* The Journal of Computer Information Systems; Summer 2013; 53, 4; ProQuest, p 87.

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This Meta Model forms the basis of the development of the three Architectural Frameworks listed above.

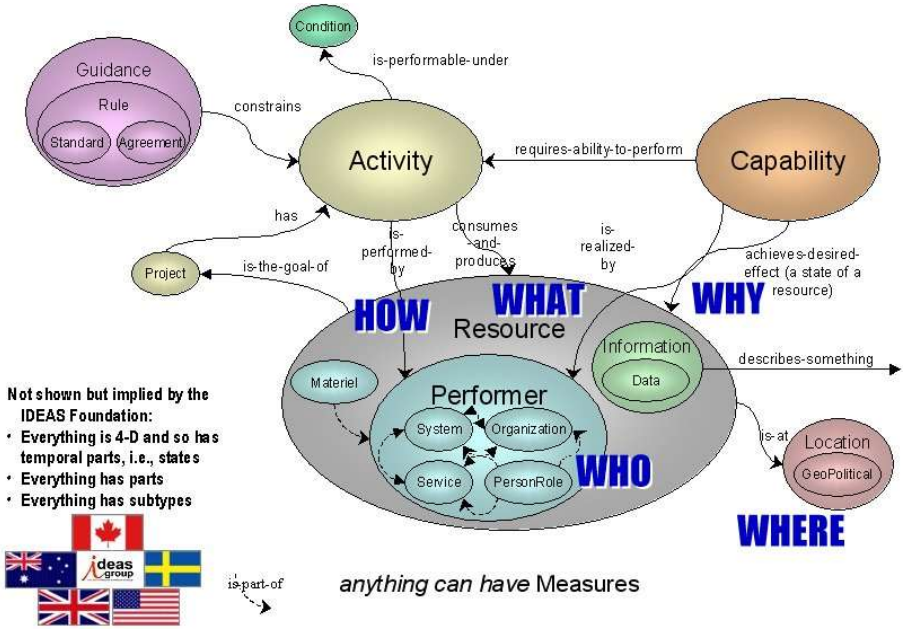

Figure 1-5: Overlay of Zachman Framework Interrogatives with DM2 (CIO, DoD, 2017)

The DoDAF Models are defined in figure 1-6 as different views of the same architectural Framework.

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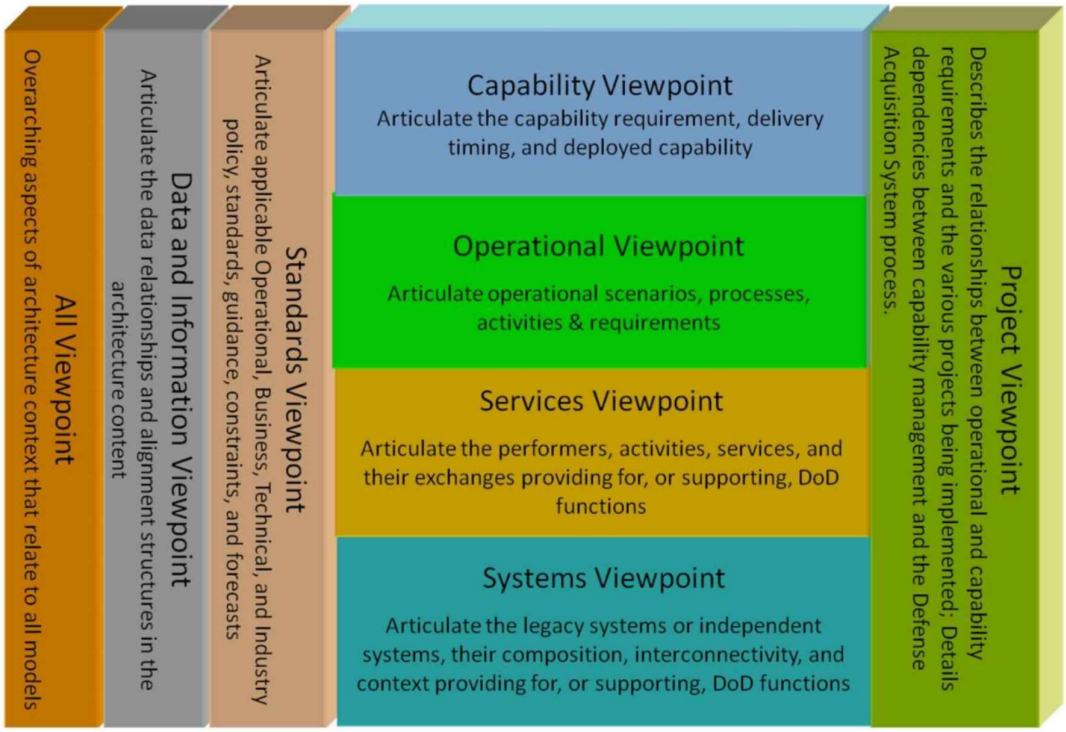

Figure 1-6: DoDAF Models (Dam, 2014)

The MODAF viewpoints are slightly different and are listed (Figure 1-7) as:

- Strategic
- Operational
- Systems
- Acquisition
- Technical
- Holistic Views

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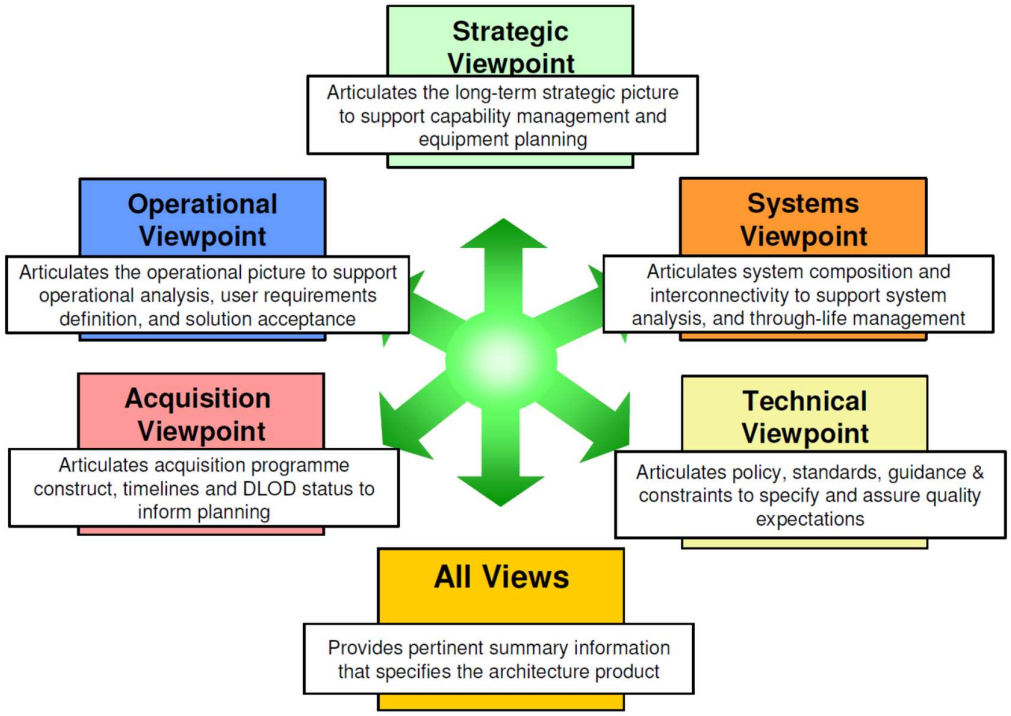

Figure 1-7: MODAF Viewpoints (MOD, 2005)

The latest development of the NAF V4.0 Meta Model (NATO, 2014) shown in figure 1-8 consist out of the following main domains:

- Whole life Enterprise
- Logical Architecture
- Service Specification
- Physical Architecture
- Deployed Architecture
- Project Domain

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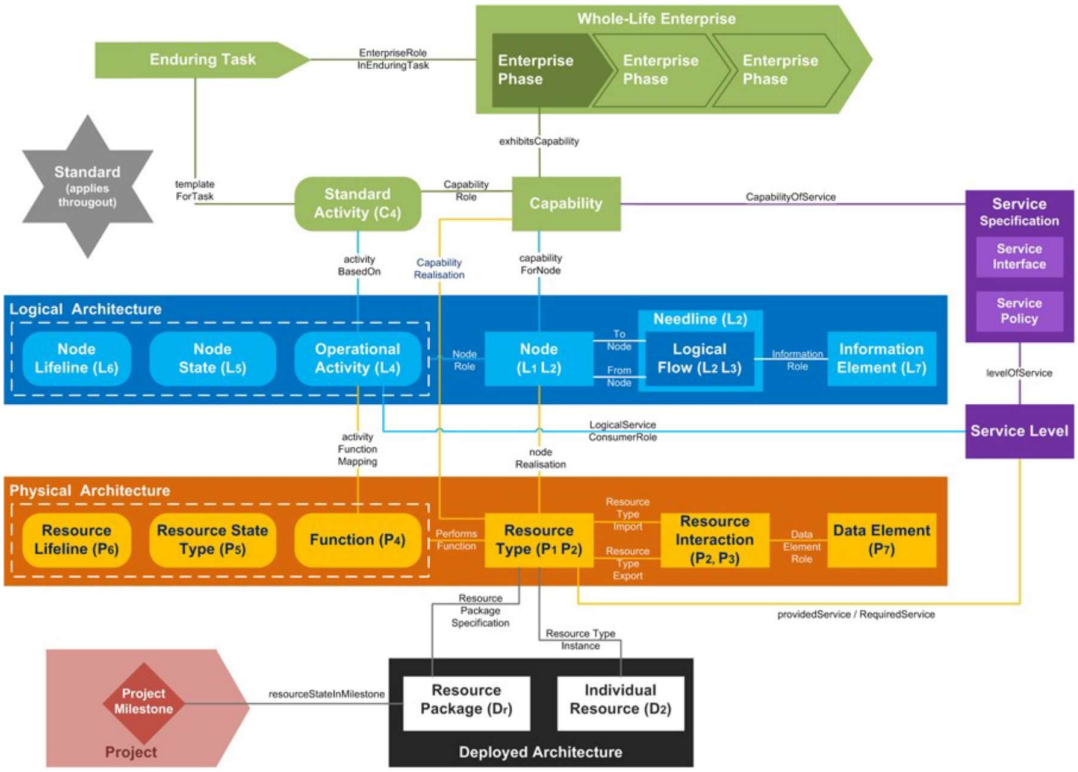

Figure 1-8: NATO Architectural Framework Version 4.0 Meta Model (NATO, 2014)

In a further development the MOD (Hasteley, 2015)[14] indicates that the MODAF will be replaced by NAF Version 4.0 which in turn will introduce a grid approach to the view structure as defined in figure 1- 9 below:

[14] Hasteley, K. (2015) *NATO Architecture Framework v4 Update.* Presentation available at: http://www.integrated-ea.com/wp-content/uploads/2015/03/6-MOD-Update-on-NAF-v4.pdf [Accessed June 2017].

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Figure 1-9: NATO Architectural Framework Version 4.0 View Structure (Hasteley, 2015)

To move forward, one can define the generic main elements of the acquisition process of a vehicle-based weapon system to consist, as a minimum, out of the following phases:

- Stating the user requirement of the system in technical terms.
- Developing or adapting the products to be presented as a solution and integrating them into the system definition.
- Developing the support elements to be used during the fielding of the system.
- Industrialising the process to produce the product efficiently and consistently.
- Deploying the system successfully in the user environment.
- Maintaining the system through a series of support activities.
- Midlife upgrades of the system which can repeat most of these phases.
- Eventual phase-out and decommissioning of the system.

1.1.2 Factors Influencing the Success of an Acquisition Program

From the references above, it can be concluded that the acquisition process and its application are still evolving. The successful supply process of a weapon system by an enterprise must, therefore, be agile and adaptable to fit into the ever-changing customer environment.

The opportunity to adapt the supply process for a specific project will be locked in, as soon as a specific phase is under contract, which represents a typical two to five-year cycle. During this time frame, a lot of changes to the acquisition process can and does happen. It seems that performing only the prescribed process steps will not necessarily result in a positive result and that one needs to investigate other catalytic factors that may also

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contribute to the success of a supply project.

Research conducted by Lawrence and Scanlan (2007)[15] provided insight into project failure in defense industries and identified the following critical elements that *'strongly impact project success or failure*:

- *Poor initial planning*
- *Lack of clear objectives and deliverables*
- *Lack of understanding of dependencies*
- *Inadequate resource allocation*
- *Poor risk analysis*
- *Poor change management*
- *Lack of buy-in from stakeholders*
- *Poor understanding of priorities'*

The Defense Acquisition University Smart Shutdown Guidebook (DAU, 2009)[16] also provides the following list of factors that '*lead to program success or failure that eventually result in termination*:

- *Changes in threat environment*
- *Technology changes*
- *Changes in budget environment*
- *Unsustainable cost growth in development, production, or deployment*
- *Failure to meet key performance parameters*
- *Policy changes that affect system deployment*
- *Selection of alternative approaches to mission requirements*
- *Shifting executive authority from one Service to another Service*
- *Other programmatic factors'*

Mir & Pinnington's (2014)[17] project management research on the dynamic relationships and interactions of successful project management factors concluded that a positive correlation exists between *'project management performance and contributing variables of project success. The project management performance variables identified were:*

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[15] [15] Lawrence, P. & Scanlan, J. (2007) *Planning in the dark: Why major engineering projects fail to achieve key goals.* Technology Analysis & Strategic Management, 19(4), pp. 509–525.
[16] Defense Acquisition University (2009) *Defense Acquisition University Smart Shutdown Guide.* Fort Belvoir, VA: DAU Visual Arts and Press.
[17] Mir, F. A. & Pinnington, A. H. (2014) *Exploring the Value of Project Management: Linking Project Management Performance and Project Success*. International Journal of Project Management, 32(2): 202–217.

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- *Project efficiency*
- *Impact on customer*
- *Impact on project team*
- *Business success*
- *Preparing for future*
- *Project success factors included*
- *Project manager leadership*
- *Project manager staff*
- *Project manager policy and strategy*
- *Project manager partnerships and resources*
- *Project manager life cycle management processes*
- *Project manager key performance indicators*

Mir & Pinnington (2014) concluded that dynamic relationships exist between the factors identified and as a result, dynamic relationships must be considered as the factors are not static; *'each factor or variable in a project dynamically influences other factors.'*

Research conducted by Allen et al. (2014)[18] on project success, concluded that the following factors *'influence project success:*

- *Project management plan*
- *Responsibility assignment matrix*
- *Budget monitoring*
- *Schedule monitoring*
- *Insufficient stakeholder engagement*
- *Broad scope and requirements*
- *Product monitoring.'*

The Defense Acquisition University (Clowney et al., 2016)[19] in a study on Department of Defense Acquisition Program Terminations: Analysis of 11 Program Management Factors, identified the most common eleven factors contributing to failure listed in Table 1-1 below.

Cowley et al. (2016) found that:

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[18] Allen, M. A., Alleyne, D., Farmer, C., McRae, A. & Turner, C. (2014) *A Framework for Project Success.* Journal of IT and Economic Development, 5(2): 1–17.

[19] Clowney, P., Dever, J. and Stuban, S. (2016) *Department of Defense Acquisition Program Terminations: Analysis of 11 Program Management Factors.* Available at: http://dau.dodlive.mil/2016/06/20/department-of-defense-acquisition-program-terminations-analysis-of-11-program-management-factors/ [Accessed June 2017].

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'DoD program managers and defense industry program managers agreed on the top three factors that influence program termination: schedule-related attributes, budget-related attributes, and scope-related attributes. DoD consultants ranked schedule-related attributes and budget-related attributes one and two respectively, but contractor-related attributes were the other top three-factor.'

Table 1-1: Leading Factors that influence Program Failure (derived from Cowley et al., 2016)

Number	Main Factor	Detailed Description	Human Factor
1	Schedule Related Attributes	Plan schedule management, defining activities and establishing milestones, sequencing activities, low-speed decision making, unrealistic duration, delays in work approval, consistent and compressed schedule pressure, inability to consider ramp-up time	Leadership, Wisdom, Culture
2	Budget Related Activities	Cost management, budget/cost estimation, budget determination, controlling cost, size of budget, estimating activity resources, managing cash flow, contractor financial difficulties	Wisdom, Leadership
3	Scope, Requirement Related Attributes	Vagueness in scope, plan management, requirements master plan, requirements collection, defining scope, well-defined work breakdown structure, client initiated requirement changes, inadequate scope/ requirements definition process, failure to curtail scope/requirements creep, lack of understanding the significance of operational environment	Wisdom, Culture, Leadership, Relationship
4	Project Management Team Related	Capability of firms, capability of DoD team, anticipation of design changes, delays in receiving instructions, positive attitudes of participants	Wisdom, Relationship, Leadership
5	Contract Related	Type of contract, inaccurate estimates in contract, form of procurement and contractual agreements, poor contract management, contract negotiation	Wisdom, Culture, Leadership
6	Planning Attributes	Not developing a thorough plan, lack of planning buy-in by all, informal plan for change requests, underestimating complexities of project, planning deficiencies, coordinating ability, rapport between participants, selection of program managers	Wisdom, Relationship

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Number	Main Factor	Detailed Description	Human Factor
7	Stakeholder Engagement	Identifying key stakeholders, stakeholder management plan, controlling stakeholder engagement, considering project from stakeholder perspective, failure to get stakeholder buy-in on the main decisions, lack of communication between stakeholders	Relationship, Wisdom, Leadership
8	Risk Mitigation	Risk management, performing qualitative risk assessment, performing quantitative risk assessment, planning risk responses, controlling risks, inability to anticipate problems	Culture, Wisdom
9	Communication Related	Communication between project management team members and communication to stakeholders	Relationship, Leadership
10	Technology Readiness Level (TRL)	TRL level, shortage of technical personnel, delays in testing	Wisdom, Leadership
11	Contractor Related	Inadequate contractor experience, lack of communication between contractor and DoD, subcontractor projects, low labour productivity, poor procurement management	Wisdom, Relationship, Culture, Leadership

Clowley et al. (2016) also identified that further cause analysis is needed to provide a clearer understanding of the factors identified.

If one lists the human-related factors prevalent in the previously determined and referenced work that contributes towards the success of an acquisition program – keeping in mind that success or failure is not defined the same by all references – then the following list emerges:

- Lack of planning, vision, vagueness in scope, risk management, cost control, efficiency, project team, business success, project management, policy, strategy, assigning responsibility. - **Leadership**
- Lack of understanding and poor change management in the threat environment, technology, budget, system deployment, key performance parameters, slow decision making. - **Wisdom**
- Lack of buy-in, change management in authority, impact on the customer, project team, partnerships, communication between project management team members and communication to stakeholders. – **Relationships**
- Lack of risk management, performing qualitative risk assessment, performing quantitative risk assessment, planning risk responses, low labour productivity, consistent and compressed schedule pressure. - **Culture**

The overall success factor research has been going on for some time. In the search for the

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catalytic effect of the success factors, the author proposes that one needs to step away from the standard process of acquisition and supply itself and view the human-based success factors contribution as it interacts and influences the rest of the process as a separate and focused research domain. This dissertation, therefore, endeavours to increase our understanding of the effect of some of these human factors that can influence the success of the supply process. As the human factors are all interrelated, and based on his practical experience, the author decided to investigate the effect on the rest of the supply process of a potential grouping of human factors: leadership, relationship, wisdom and culture. This study is about researching the effect of these catalytic human factors that may enhance the propensity of success.

The Defence System Suppliers, like BAE Systems, define their version of the Supply Process in response to the Customer's Acquisition Processes. The supply process is usually done as a generic process for the enterprise, a standardised process for a specific company within the company and a specific instance of the application on a project or part of a project.

The definition of the supply process will be reflected in Chapter 2 of this dissertation.

1.2 Research Theory and Problem Statement

Research conducted on the acquisition process success factors during the execution of the procurement process in the US (Clowley, 2016) as well as reforms to the process (National Defence Industry Association, 2014)[20] in the UK, have not sufficiently addressed the human factors and their affected and associated complex internal relationships within the process.

The underlying **theory** that **'the human does have an influence on the outcome of the supply and, by deduction, the acquisition project's outcome'** will be tested through the application of this research project.

The k**ey research question** to be addressed by this study is therefore defined as follows:

What is the contribution of the human enabling factors of leadership, relationship, wisdom and culture's contribution towards the success of a project or enterprise during the acquisition phase of a complex system, when interacting with a customer?

As this research question is compounded the following supplementary research questions are defined and will be used in the analysis and confirmation of the research results. This will add more structure to the research process in support of the final response to the research question as stated. The additional research question set to be considered are:

1. **What process is considered as the acquisition process of a complex system?**
2. **What attributes define a successful outcome of the acquisition process?**
3. **What are the processes embedded into the supply framework of a complex system?**

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[20] National Defence Industry Association. (2014) *Pathway to Transformation, NDIA Acquisition Reform Recommendations.* Available at: http://www.ndia.org/issues/acquisition-reform [Accessed June 2017].

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4. **What are the potential human interactive enabling factors that can play a role in the enhancement of the successful outcome of a complex weapon acquisition process?**
5. **How can a conceptual framework be constructed that combines all the executable and enabling elements of the process an enterprise needs to execute to supply a complex military vehicle system?**
6. **How are these specific enabling factors contributing towards success?**

During the research process the answers to all these questions will be considered, in turn, and combined to form the result the author wishes to convey in response to the overall research question posed above.

1.3 Research Objectives

It will be of immense value if one can isolate the catalytic effect of the specific human factors on the success of a project as this potentially can be used to increase the propensity of achievement for the enterprise. Success is defined as an increase in perceived and real value for money for the customer as well as growth in wealth of the company.

Hinkelmann & Witschel (2011)[21] argue that the goals of the behaviouristic research should be based on the analysis of actual situations as a phenomenon to establish the interrelationship of its parts.

The **main aim** of this investigation is to understand the catalytic contribution of the human factors of leadership, relationship, wisdom and culture in the supply of a complex weapon system into a prescribed acquisition process.

The research also aims to deliver the following **sub-goals** in support of the main objective:

a. The acquisition processes of the USA DoD, the UK MOD as well as the NATO Forces, for a complex weapon system will be investigated.
b. The attributes that define a successful outcome of the acquisition process will be investigated and defined.
c. The elements of, and processes embedded in, the execution of the supply framework as practised by the enterprise will be investigated and formulated.
d. The potential human interactive catalytic or enabling factors that can play a role in the enhancement of the successful supply of a complex weapon system will be investigated and formulated.
e. A conceptual Interactive Supply Framework will be constructed that combines all the executable and enabling factors of the process an enterprise needs to execute to supply a complex military vehicle system. This

[21] Hinkelmann, K. & Witschel, H.F. (2011) *How to choose a research methodology?* Presentation from University of Applied Science North-western Switzerland, School of Business.

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Interactive Supply Framework will enable the research to investigate the selected human factors' effect on the executable part of the supply process.

f. Specific enabling human factors' contribution towards success will be investigated in a real-life case study and will present a qualitative understanding of the contribution of each human factor.

1.4 Research Contribution

This research, when concluded, will deliver a better insight into the factors that can be used to increase the propensity of a project's success as well as the growth in the wealth of the enterprise that supplies the product.

The research will also contribute towards the knowledge base regarding the effect of some of the success factors as a continuum of previous research, as shown before. This dissertation will contribute towards our understanding of the catalytic effect of the human in the supply of a complex system. This result will present the possible application of the dominant factor(s) in a predetermined way so that propensity for success may increase for future projects.

All enterprises would like to benefit from an increase in wealth that accompanies the execution of a successful supply project. Similarly, all customers and end users would like to receive good value for money products to satisfy their needs within their technical requirements, budget and timeline constraints.

1.5 Research Design

The first research decision is to define the research philosophy that this investigation is based on and what this dissertation will reflect. Saunders & Tosey (2013)[22] stated about the research onion model that:

> *'It is the researcher's understandings and associated decisions in relation to these outer layers that provide the context and boundaries of which data collection techniques and analysis procedures will be selected.'*

1.5.1 Research Philosophy

The research is concerned about real life human interaction within a limited small group of selected individuals over a ten-year period. The knowledge thus obtained will not be explicit and will have to be interpreted through the application of the researcher's direct experience in the management of supply programs, the associated engineering efforts and strategies.

The research focusses on the efforts, decisions, interactions and belief systems of the respondents and is a product of the individual's social environment.

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[22] Saunders, M & Tosey, S. (2009) *The Layers of Research Design*. Postgraduate Research Programmes at the Surrey Business School, University of Surrey.

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As the number of potential respondents is finite, the best effort of the researcher went into maximising the effective respondents to obtain the data of a relatively small sample. The qualitative data, when analysed, will be subjected to interpretation and further interrogation by the researcher based on his experience.

The research philosophy is classified as *'interpretivist'* (Saunders & Tosey, 2013);

> *'Interpretivists contend that only through the subjective interpretation of an intervention, in reality, can that really be fully understood. The study of phenomena in their natural environment is key to the interpretivist philosophy, together with the acknowledgement that scientists cannot avoid affecting those phenomena they study. They admit that there may be many interpretations of reality, but maintain that these interpretations are in themselves a part of the scientific knowledge they are pursuing.'*

Hinkelmann & Witschel (2011) state that the interpretivist believes that it is required '*to understand the differences between humans in their roles as social actors to:*

- *understand the world from the social actors,* and that
- *different interpretations are possible and thus are subjective qualitative, non-quantitative questions'*

1.5.2 Research Approach

The research approach will be defined through the application of the proposed research structures of Hinkelmann & Witschel (2011) and Saunders & Tosey (2013) as follows:

- The deductive approach focuses on understanding the essential characteristics of small samples of qualitative data:
  - Develop a theory (out of previous findings, literature, experience, some first observation).
  - Derive a framework in support of the theory.
  - Make observations about the framework.
  - Obtain a confirmation or rejection of the theory through the interpretation of the observations about the framework.
- Data collection strategy using a case study methodology to study:
  - An empirical investigation of a contemporary phenomenon within its real-life context.
  - Gaining a rich understanding of the framework of the research and the processes being enacted.
  - Triangulation: using simple multiple sources of data to ensure reliability, e.g. triangulating qualitative data from questionnaires and using qualitative data from semi-structured interviews and experience.
  - The case study will include multiple cases (products and customers)

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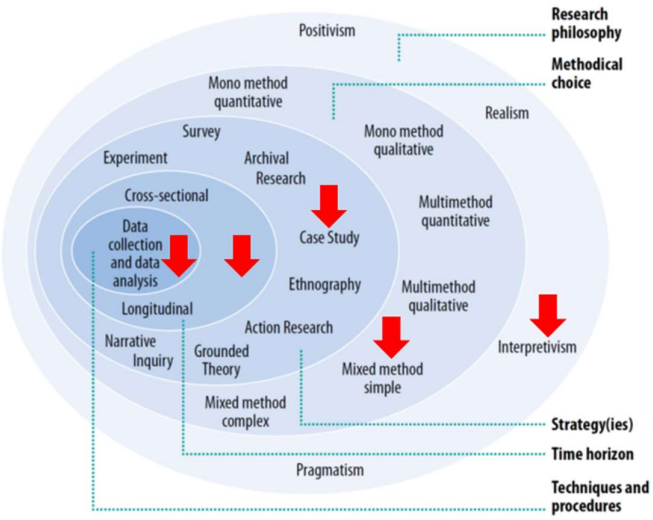
embedded in a specific company as they evolved over different phases of the product and enterprise life cycles.

- As the effect of the life cycles of both the product, the enterprise as well as the acquisition processes are under consideration, this research will have a 'longitudinal' approach to the timeline of the observed data. A different way to define the timeline approach is to identify different instances of data sets of the same product at various phases of both the product and the enterprise life cycles.
- The actual data collection will be done through the application of a questionnaire:
  - Structured from a predefined set of questions.
  - Collects qualitative data from a predetermined population of potential respondents.
  - With statistical evaluation to detection of patterns, trends, etc.

The red arrows indicate the application of the research onion's different layers for this research project in figure 1-10 below:



Source: ©Mark Saunders, Philip Lewis and Adrian Thornhill (2011)

Figure 1-10: Research Onion (Sanders et al., 2012)

Another view of possible research techniques is described in figure 1-11 as a specific area in the continuum between quantitative and qualitative as well as positivist and interpretivist approaches as indicated by De Villiers (2005)[23].

[23] De Villiers, M.R. (2005) *Interpretive Research Models for Informatics: Action Research, Grounded Theory, and the Family of Design- and Development Research,* p14. Available at: http://journals.co.za/docserver/fulltext/alt/12/2/389.pdf?expires=1498369613&id=id&accname=guest&checksum=14866F6EAE155DD8E1820A34BA438A84 [Accessed June 2017].

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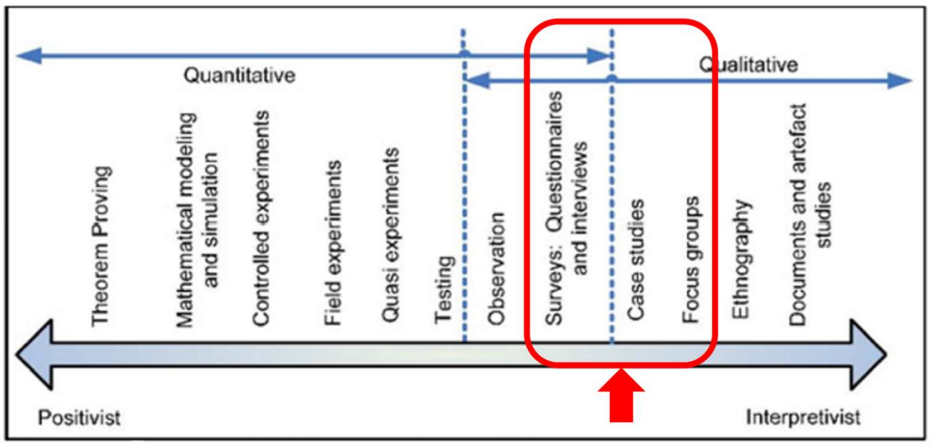

Figure 1-11: Research Techniques adapted from De Villiers (2005)

The following table combines the research questions, the research objectives as well as the research methods that will be employed in the execution of this research project.

Table 1-2: Research Questions, Objectives and Methods

No	Research Questions	Research Objectives	Research methods
1	What process is considered as the acquisition process of a complex system?	The acquisition processes of the USA DoD, the UK MOD as well as the NATO Forces of a complex weapon system will be investigated.	Literature research
2	What attributes define a successful outcome of the acquisition process?	The attributes that define a successful outcome of the acquisition process will be investigated and defined.	Literature research
3	What are the processes embedded into the supplied framework of a complex system to the acquisition process required by the customer?	The elements of, and processes embedded in, the execution of the supplied framework as practised by an enterprise will be investigated and formulated.	Literature research Formulating a Framework
4	What are the potential human interactive enabling factors that can play a role in the enhancement of the successful outcome of a complex weapon acquisition process?	The potential human interactive catalytic or enabling factors that can play a part in the improvement of the successful supply of a complex weapon system will be investigated and formulated.	Literature research Formulating a Framework

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No	**Research Questions**	**Research Objectives**	Research methods
5	How can a conceptual framework be constructed that combines all the executable and enabling elements of the process an enterprise needs to execute to supply a complex military vehicle system?	A conceptual interactive supply framework will be constructed that combines all the executable and enabling factors of the process an enterprise needs to execute to supply a complex military vehicle system. This Interactive Supply Framework will enable the research to investigate the selected human factors' effect on the executable part of the supply process.	Literature research Formulating an Interactive Supply Framework
6	How are these specific enabling factors contributing towards success?	The specific enabling human factors' contribution towards success will be investigated in a real-life case study will present a qualitative understanding of the contribution of each human factor.	Formulating a Questionnaire Obtaining Data from Respondents Analysing and Interpreting the Data Conduct Interview with Executive of Company Document Researcher's Experience Triangulation of Results between Questionnaire, Interview with Executive and Researcher's Experience Interpretation and Summary of Results on Interactive Supply Framework
Overall	What is the contribution of the human enabling factors of leadership, relationship, wisdom and culture towards the success of a project or enterprise during the acquisition phase of a complex system, when interacting with a customer?	The main aim of this research is to understand the catalytic contribution of the human factors of leadership, relationship, wisdom and culture in the supply of a complex weapon system into a prescribed acquisition process.	Summary of all previous work Summary and interpretation of the results Confirmation of the validity of the Framework Identifying future research based on the Interactive Supply Framework

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1.6 The Research Processes

The research process logic builds on a deductive approach as defined by Hinkelmann & Witschel (2011) and the resultant research logic is specified in figure 1-12 below:

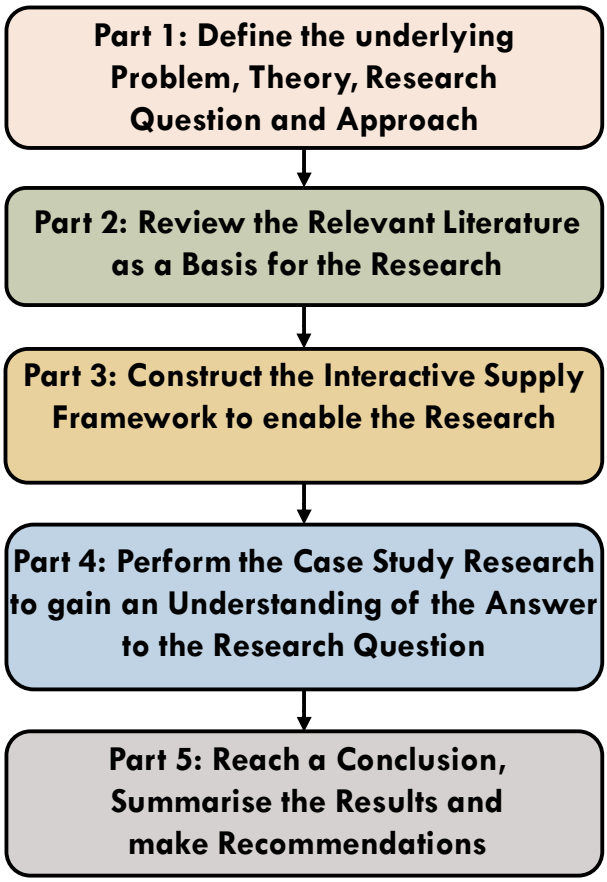

Figure 1-12: The Summary of the Deductive Approach to the Research Process

This dissertation will reflect the results of these research steps in five distinct chapters as defined in the more detailed research roadmap followed. This roadmap depicted in figure 1-13 below:

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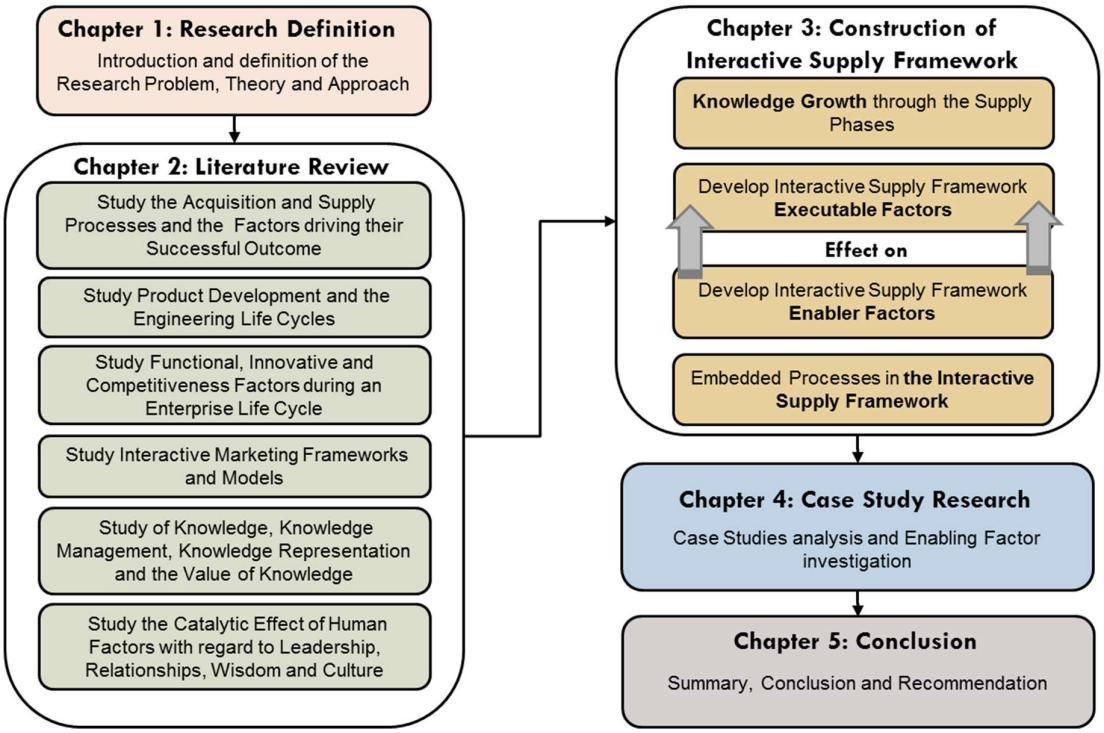

Figure 1-13: The Research Roadmap

It comprises out of five chapters as follows:

Chapter 1: Introduction to the Research Definition:

- Presentation and definition of the research problem
- Defining the research question investigated
- Defining the research approach followed
- The dissertation outline

Chapter 2: Literature Reviews performed on the potential Elements of the Interactive Supply Framework:

- Study the acquisition and supply processes and the factors driving their successful outcome
- Study product development and the engineering life cycles
- Study functional, innovative and competitiveness factors during an enterprise life cycle
- Study interactive marketing frameworks and models
- Study knowledge management, knowledge representation and the value of knowledge

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- Study the catalytic effect of human factors on leadership, relationships, wisdom and culture

Chapter 3: Construction of the Interactive Supply Framework:

- **Knowledge Growth** through the supply phases
- Develop interactive supply framework **Executable Factors**
- Develop interactive supply framework **Enabler Factors**
- The embedded processes in the **Interactive Supply Framework**

Chapter 4: Case Studies Analysis and Enabling Factor Investigation

- The introduction and definition of the case studies
- The enabling factor investigation using questionnaires
- The leadership factor's contribution to success
- The relationship factor's contribution to success
- The wisdom factor's contribution to success
- The culture factor's contribution to success
- The effect of enterprise life cycle on the successful outcome
- The effect of a specific customer/product
- Validating the **Interactive Supply Framework** Results

Chapter 5: Summary, Conclusions and Recommendations

- The research summary
- The research conclusion and contribution
- The research limitations and recommendations for future research

This roadmap will form the basis of the outline of this dissertation as defined in paragraph 1-9 below.

1.7 Delimitations and Limitations

The scope of this research is limited by the finite list of respondents available, the specific products supplied to the South African Procurement Agency (Armscor), the DOD (USA) as well as a NATO-based country (FMV in Sweden) under their ever-evolving acquisition processes as defined earlier.

The product case studies were chosen to reflect the development, industrialisation, production and support phases to be able to investigate the effect of the product life cycle

To explore the effect of the enterprise life cycle, the case studies were selected in the growth, stability and turn-around phases of the company.

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The study was further limited to the South African business entity of the BAE Systems group and only products from this entity of activity was selected. The results also only reflect the actual supply process as practised in the company.

The underlying assumption of this research was that the required processes are indeed carried out as defined by the various models and that the human interaction acts as a catalyst in the process for increased success (or failure) during the average five to twenty years of the acquisition of armoured vehicles and systems.

Finally, the unwritten assumption, which is that the human will have a discernible effect on the outcome of a project, is simply assumed.

1.8 Ethical Implications of the Research

Formal written approval was obtained from the BAE Systems, Land Systems South Africa company to allow the researcher to conduct the case study as defined in this dissertation.

The case study does not cover the last four years of business activity, and the results, therefore, should no longer be able to influence the current business environment of BAE Systems, Land Systems South Africa.

The results of the case study were also presented to the executive management of the company, and a summary report was obtained from this interview as to their specific view.

All the respondents - 120 out of a possible 143 - volunteered their contribution directly to the author. Only their titles and respondent numbers are linked to the results as contained in the Annexure to this dissertation.

1.9 Dissertation Outline

The research as described in this chapter is qualitative and deterministic in nature, involves the human as the catalytic factor in the successful supply of a complex weapon system and has the potential to become a way to increase the propensity for the company to be more successful in the future.

The author, as a previous and current program, engineering and strategy executive, has a vested interest in understanding the complexities and contribution potential of the human role that allows the project success and the company to become more competitive and to grow from strength to strength.

There are quite a few lessons learnt in all three major acquisition domains in the western world (The USA, UK and NATO) which resulted in the continuous adaptation of the acquisition processes fuelled by many research projects. These ‘lessons learnt’ studies, however, investigate the problem as viewed by the customer and the procurement process and not the supplier and his similar supply process. These studies also focus on the process architectural framework development and not so much on the human contribution inside the process.

This study’s approach is to view the problem from a supply perspective with the exclusive

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focus to determine the enabling or catalytic effect that the human can have on the process outcome.

The following chapters will be dedicated to the literature study of all the related aspects to increase our understanding of the field of study (Chapter 2), the formation of a specific Interactive Supply Framework and its supportive Framework on Relationships, and Knowledge Migration (Chapter 3), the investigation of a series of cases in a case study with interpreted results (Chapter 4) and finally the summary, conclusions and future research identified (Chapter 5).

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Chapter 2
Literature Review

This chapter is dedicated to reviewing the literature that relates to the acquisition process used in the Western world. The success factors pertinent to the acquisition and supply of a weapon system warrants an investigation.

The product development life cycle is of interest as it supplies the knowledge maturity levels that form part of the 'value add' currency in the acquisition frameworks. The supply process of the systems requires a functional approach, innovation and competitiveness during the enterprise life cycle. To reach the customer, one must also consider the interactive marketing frameworks and models available in the literature. Knowledge, its management, as well as the value it represents for a customer, will be reviewed next.

Finally, to understand the effect the human can bring to bear on the success of the supply of a weapon system, human factors warrant further investigation. The specific focus will be on leadership, relationship, wisdom and culture as the chosen candidates for review. All the above research areas are defined in figure 2-1 below.

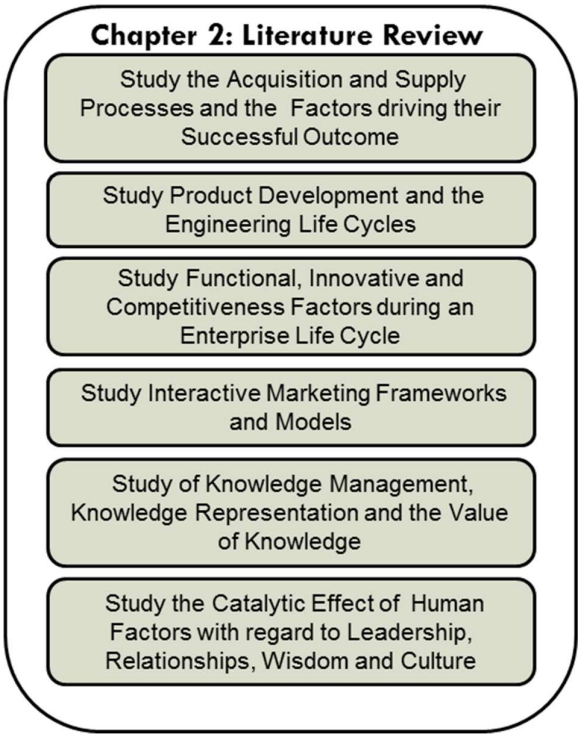

Figure 2-1: Literature Review Content

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2.1 The Weapon System Acquisition Processes

The three most important acquisition agencies of weapon systems in the Western World is the USA, UK and NATO.

The Ministry of Defence Architecture Framework of the UK (MOD, 2012)[24] is an internationally recognised enterprise architecture framework developed by the Ministry of Defence (MOD) to support defence planning and change management activities. It does this by enabling the capture and presentation of information in a rigorous, coherent and comprehensive way that aids the understanding of complex issues.

The MODAF based Acquisition Process View is also defined by (MOD, 2005) and is depicted in figure 2-2 below.

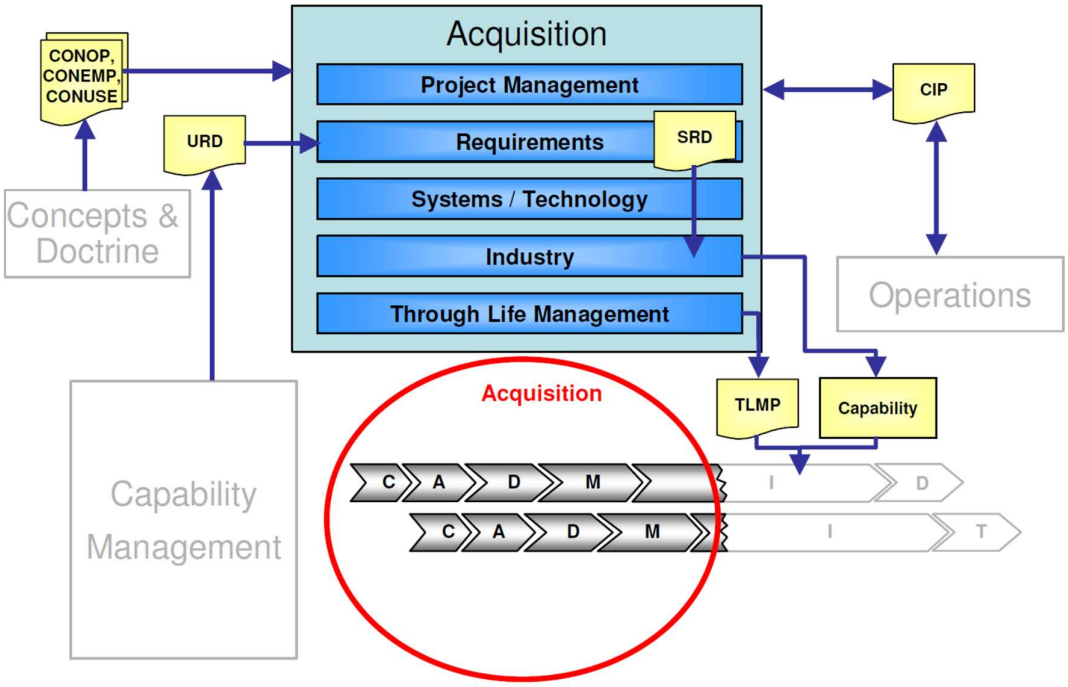

Figure 2-2: UK's MODAF Acquisition Process (MOD, 2005)

The use of an Architectural Framework like MODAF for the planning and management of the acquisition process integrates and coordinates all the acquisition activities into the total defence process.

The USA's Department of Defense (DoD) utilises an Architectural Framework as an integrated information system to manage and coordinate the defence business. The framework is known as the DoDAF V2.02 as defined in chapter 1. Of interest for the supplier of weapon systems, is the information sharing process integrated into DoDAF V20.2. This process is shown in figure 2-3 below.

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[24] Ministry of Defence (2012) *MOD Architecture Framework (MODAF) Guidance,* Military Equipment, Logistics and Technology. Available at: https://www.gov.uk/guidance/mod-architecture-framework [Accessed June 2017].

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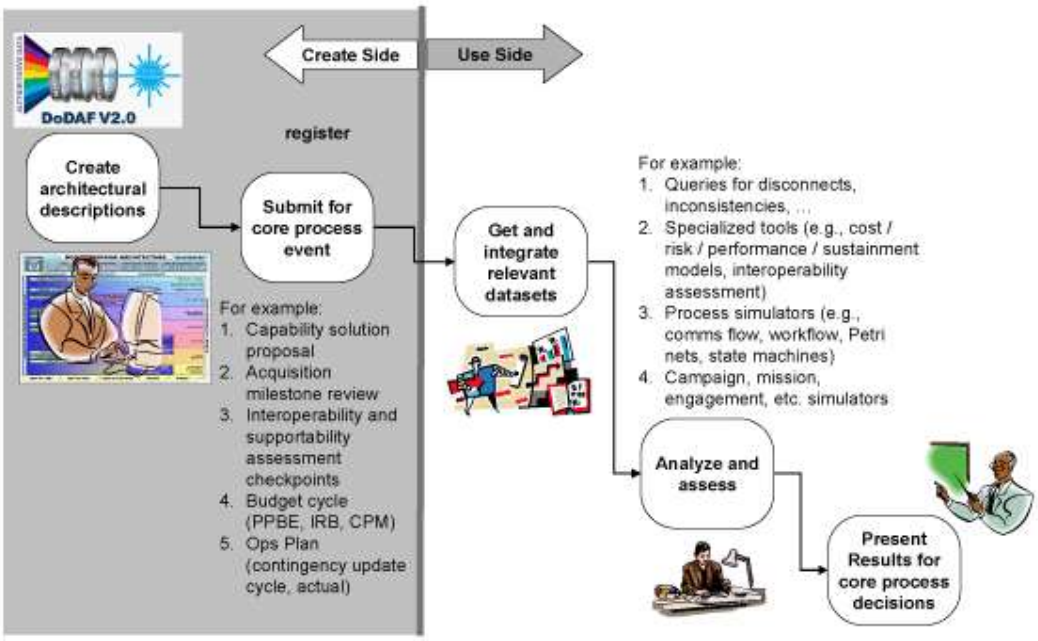

Figure 2-3: EA Information Sharing for Assessment Processes (CIO, 2017)

The Chief Information Officer (CIO, 2017)[25] of the Department of Defense (DoD) defines the Process for Exchange of Data Specification (PES) from the stakeholders into the DoDAF V2.0. The PES provides an efficient and standard means to ensure that data sharing can occur in a toolset-agnostic, methodology-agnostic environment.

When a customer wishes to acquire a technologically complex and structurally compound system (Lu & Suh, 2009)[26], the acquisition cannot be performed as a single event, as the level of the technical fit to the user requirement is simply not known at the time of the purchase decision milestone. This process gave rise to the system engineering process (Blanchard & Fabrycky, 1981)[27] later used by BAE Systems (2011)[28] and many others, where the evolution of the system's knowledge is systematically enhanced, and the technical risk of ownership is systematically reduced, using the continued application of the basic engineering design process (Roozenburg & Eekels, 1995)[29].

The generic phases and decision points of the DoD's acquisition process are shown in figure

[25] Chief Information Officer, U.S. Department of Defense. (2017) *DM2 DoDAF V2.02 Physical Exchange Specification (PES).* Available at: http://dodcio.defense.gov/Library/DoD-Architecture Framework/dodaf20_pes/ [Accessed June 2017].

[26] Lu, S.C. & Suh, N.P. (2009) *Complexity in design of technical systems*, Annals of CIRP 58/2:157–160.

[27] Blanchard, B.S. & Fabrycky, W.J. (1981). *Systems Engineering and Analysis*, Prentice Hall, New Jersey.

[28] BAE Systems. (2011) *Life cycle Management, The Handbook to the Engineering Life cycle*, HB05/01, this is an unpublished work created in 2005 to 2011.

[29] Roozenburg, N. and Eekels, J. (1995) *Product Design: Fundamentals and Methods*, Chichester: Wiley, pp. 84-93.

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2-4 below (Muzzelo & Arndt, 2014)[30]:

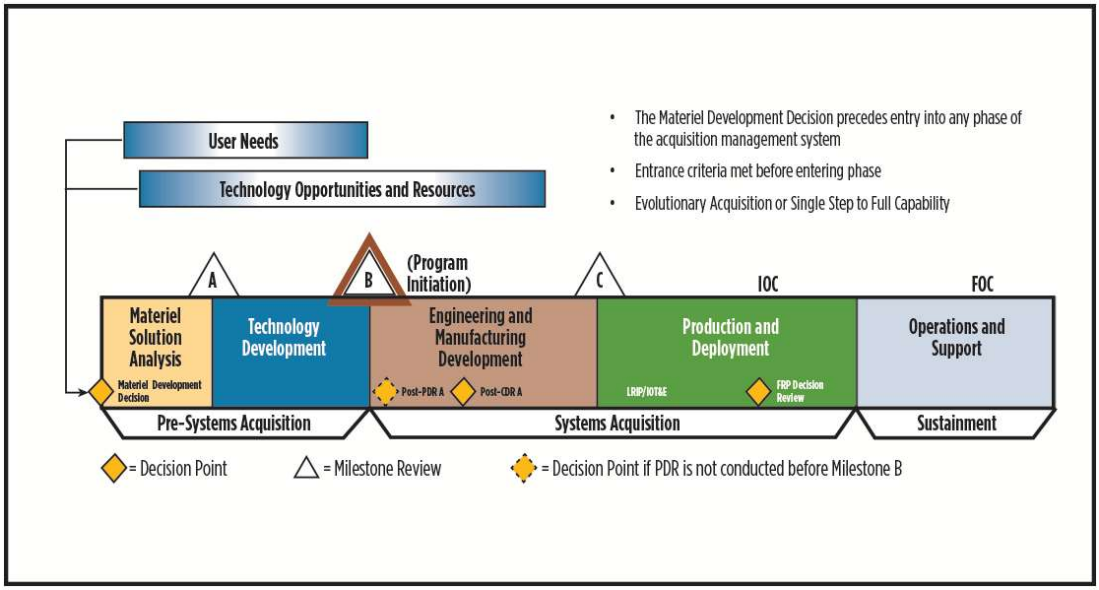

Figure 2-4: Phases and Decision Points of the DOD's Acquisition Process (Muzzelo & Arndt, 2014)

Verification and validation are always done by comparing the current state of the system knowledge against the knowledge at the start of a specific design process. Through this action, a series of technical baselines are established. These baselines, when strung together in a process, define the product life cycle of the system. (Noyen, 2004)[31]. This growth, or migration, of knowledge, was previously defined (Pretorius & Du Preez, 2013)[32] as a Knowledge Migration Framework where the knowledge growth of the artefact (product) through the various lifecycles were investigated.

This logic is also applicable when the system is decomposed into products, subsystems, components and even some materials. The number of design cycles used, however, is dependent on the ease of obtaining a solution, on the level of technical risk and on the time and resources available to get to a solution.

2.1.1 Defining Successful Outcome of a Weapon System Acquisition Process

Delano (1999)[33] from the Air Command and Staff College defined critical success factors for DoD program managers as:

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[30] Muzzelo, L. & Arndt, C.M. (2014) *Data Rights for Science and Technology Projects. Defense.* ARJ, April 2014, Vol. 21 No. 2: 625–650. A Publication of the Defense Acquisition University. Available at: http://dau.dodlive.mil/files/2014/11/ARJ69_Muzzelo.pdf [Accessed June 2017].

[31] Noyen, M. (2004) *Design Reviews and their Impacts on the Enterprise Life Cycle.* Thesis for the degree of Diploma-Engineer of Mechanical Engineering at the University of Dortmund/Germany in cooperation with the Department of Industrial Engineering of the University of Stellenbosch/South Africa, pp. 13-20.

[32] Pretorius, G.D.P. & du Preez, N.D. (2013) *The Migration of a Knowledge Item through the Life Cycles of Technology, Product Development and the Enterprise*, SAIIE25 Proceedings, 9th – 11th of July 2013, Stellenbosch, South Africa © 2013 SAIIE.

[33] Delano, K.J. (1999) *Critical Success Factors for DoD Program Managers*. Air Command and Staff College Air University, AU/ACSC/039/1999-04.

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Acquisition Factors

- well defined requirements
- acquisition strategy
- works well when fielded
- stability of supply

Resource Factors

- program manager skills
- quality people
- program management responsibility and authority
- the total team concepts

Rendon (2010)[34] from the Graduate School of Business and Public Policy at the Naval Post-Graduate School in Monterey, California, investigated the key performance areas of contract and project managers at seven government acquisition agencies and found these results:

- **Workforce related critical success factors – 37% contribution**
    - Workforce – 46%
    - Training – 39%
    - Organisational – 6%
    - Experience – 5%
    - Promotion – 3%
    - Mentoring – 1%
- **Process related critical success factors – 16% contribution**
    - Standardisation – 39%
    - Procurement Planning – 28%
    - Contract Administration – 16%
    - Source Selection – 15%
    - Solicitation – 10%
    - Contract Close-out – 4%
    - Solicitation Planning – 3%
    - Project Management – 2%

[34] Rendon, R.G. (2010) *Critical Success Factors in Government Contract Management.* Available at: www.ippa.org/IPPC4/Proceedings/19Others/Paper19-2.pdf [Accessed June 2017].

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  - Risk Management – 2%
- **Relationship related critical success factors – 15% contribution**
  - Relationships – 31%
  - Communication – 31%
  - Teaming – 22%
  - Customers – 16%
- **Resources critical success factors – 9% contribution**
- **Leadership related critical success factors – 9% contribution**
  - Strong Empowered Leadership and Management Support
  - Quick Decision Making
  - Clear Lines of Authority
  - People Orientated Management
- **Other critical success factors – 6% contribution**
- **Policy related critical success factors – 4% contribution**
- **Requirements related critical success factors – 3% contribution**

Boehm (2014)[35] identified the following system engineering and acquisition success factors:

- Agile System Engineering, Acquisition and Best Buying Practice 3.0
  - Best Buying Practice
- Critical Success Factors vary by Life Cycle
  - In-house Agile Life Cycle
  - Out-source Agile Development
  - Out-source Agile Life Cycle
- Other Critical Success Factors
  - Avoid a Herding Mentality
  - Process, Product, People, Project and Risk Factors
  - Agility and Safety
  - Avoiding a one-size-fits-all Process Models

[35] Boehm, B. (2014) *Agility in Defense System Engineering and Acquisition – Some Critical Success Factors.* Presentation to NDIA System Engineering Conference, 30 October 2014.

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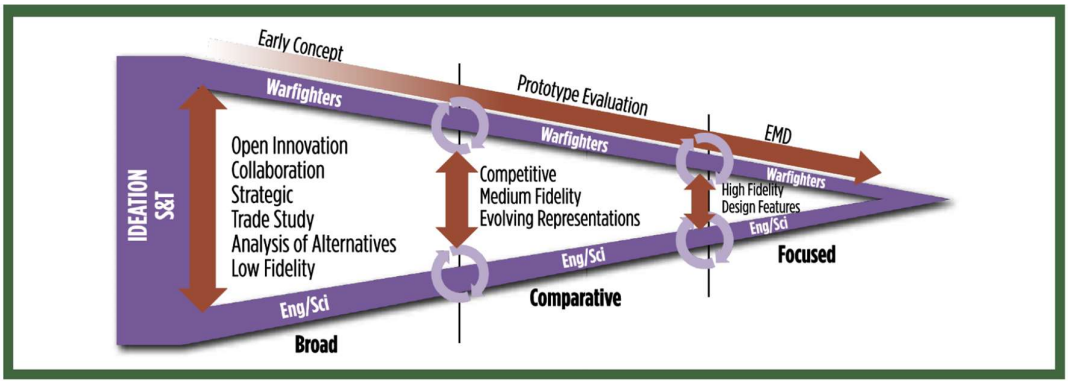
Spainhower (2014)[36] identified the knowledge base for the Best Buying Practice (BBP):

- Achieve affordable programs
- Control costs throughout lifecycle
- Incentivize productivity
- Eliminate bureaucracy
- Promote competition
- Improve tradecraft in services
- Improve professionalism

Romanczuk et al. (2017)[37] postulated the interactions and knowledge fidelity changes over the system life cycle from broad to focused. In the end state, the 'warfighter' and the engineer/scientist eventually converge.



Note. EMD = Engineering and Manufacturing Development; Eng/Sci = Engineers/ Scientists; S&T = Science and Technology.

Figure 2-5: Knowledge Fidelity Changes over the System Life Cycle (Romanczuk et al., 2017)

MITRE and AEROSPACE (2013)[38] in their publication about Affordability, Efficiency and Effectiveness (AEE) Best Practices, listed the following practice that is fundamental to engineering for affordability, efficiency and effectiveness and achieving successful acquisition. They reflect some best practices and are derived from lessons learned:

- Understand the operational mission

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[36] Spainhower, K (2014) *Knowledge Sharing and DAU… Learning at the Point of Need.* Briefing for DAU South Lunch & Learn. Available at: https://dap.dau.mil/cop/daullblog/DAU%20Lunch%20and%20Learn/DAU%20South%20Lunch%20And%20Learn%20%20FY15%201st%20Quarter/5%20Nov_After_Knowledge%20Sharing%20and%20DAU_finapdf [Accessed June 2017].

[37] Romanczuk, R., Willey, C. & Bischoff, J.E. (2017) *Critical Success Factors for Crowdsourcing with Virtual Environments to unlock Innovation.* Defense ARJ, April 2017, Vol. 24 No. 2: 334–367. Available at: https://doi.org/10.22594/dau.16-758.24.02 [Accessed June 2017].

[38] MITRE and AEROSPACE (2013) *Affordability, Efficiency and Effectiveness (AEE) Best Practices*. Version 1.0. Copyright: The Mitre Corporation and the Aerospace Corporation approved for public release no #13-0941, pp. 55-58.

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- Understand the operational gaps
- Conduct market research
- Assess the value proposition
- Use early systems engineering
- Evaluate and compare the life cycle cost, effectiveness and risk of alternatives
- Assess user stakeholder expectations against realism of budgets, time and technology maturity
- Establish, document and maintain a comprehensive technical baseline
- Communicate the technical baseline
- Assess the completeness and realism of the program's cost and schedule estimate
- Manage cost and technical baselines throughout the program
- Treat cost and schedule as part of the design – capabilities trade space
- Document all system interfaces, interoperability requirements, dependencies on other systems, programs and resources, and assess their associated risk
- Manage affordability as a key parameter in the contractor's system development effort
- Inform key design and programmatic decisions with assessment and understanding of affordability and associated risk
- Keep users well informed and involved

Nothing goes according to plan, and some of the typical problems experienced when acquiring/supplying such a weapon system are:

- The breakdown of translating the user requirement into technical terms (DoDI 5000.02, 2015) and ending up procuring for the wrong requirement or the inappropriate product. The best way to overcome this problem is through applying due process combined with technical and user experience within a sound communication and relationship environment.
- The premature fielding (Bogus et al., 2005)[39] of the product which causes unacceptable technical complications during the production and use phases. To address this problem, one defines sub-processes focussing on the known risk areas during the development phase, to obtain surety about the state of the product knowledge early in the process. The awareness of the maturity level of the product will enable an informed decision on initial fielding to be possible. The decision, however, is not a single one and should be

[39] Bogus, S., Molenaal, K., Diekmann, J. (2005) *Concurrent engineering approach to reducing design delivery time*. Journal of Construction Engineering and Management, (November), pp. 1179–1185.

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made in consultation with the user or customer. The above calls for maintaining good industrial relationships.

- The level of acceptable quality of the product delivered is determined by the specific user or customer and is entrenched in the user or customer's belief system (DiGiuseppe et al., 2014)[40] which will drive his view on how he feels about the real customer value. There are two ways to counter this, namely:
    a. Produce the best quality regardless of the cost, which is not practical, or
    b. Understand the customer's view on quality through effective communication fostered within a healthy relationship environment and deliver what is important to him.
- When deploying a system within the user environment, one needs to understand the way the user operates and what is important to him to make fair decisions (IEEE – 15288.1, 2015)[41]. A healthy relationship is paramount.

Barton & Whittington (2011)[42] postulate about the UK's MOD acquisition process, that, instead of following the capability and trade spaces logic defined in figure 2-6, trading is mostly focused at the end of the process in an effort to optimise a specific project with poor trading done at the national and cross capability trade spaces.

In the same presentation (Barton & Whittington, 2011) the UK's Secretary of Defence is quoted stating:

> *"…. We must rebalance our relationship with industry so that we can achieve maximum value for money…."*

[40] DiGiuseppe, R.A., Doyle, C.A., Dryden, W. & Backx, W. (2014) *A Practitioner's Guide to Rational Emotive Behavior.* 3rd Edition, Oxford University Press, pp. 21-23.
[41] IEEE – 15288.1 (2015) *Standard for Application of Systems Engineering on Defense Programs.* Available at: http://everyspec.com/ [Accessed June 2017].
[42] Barton, B. & Whittington, D. (2011) *Meeting Capability Goals through Effective Modelling and Experimentation of C4ISTAR Options.* Paper 007, ICCRTS 16, June 2011.

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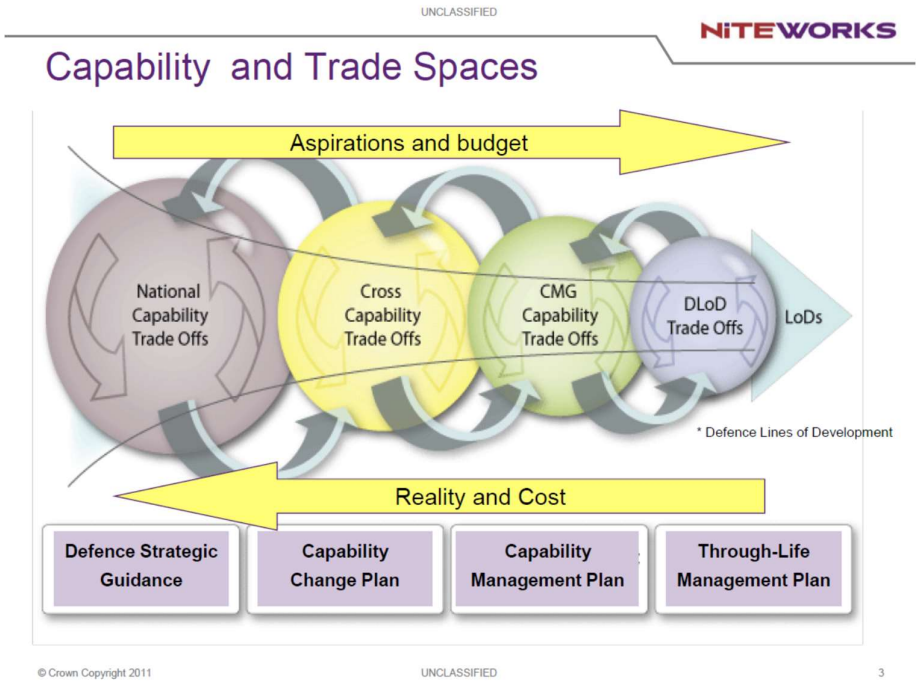

Figure 2-6: The UK's MOD Acquisition Process Trade Space Logic (Barton & Whittington, 2011)

NATO's Lessons Learned Conference (2016)[43] on *'The Future of Lessons Learned: Innovation and Improvement'* resulted in the following key takeaways:

Key Focus Areas for improvement are:

- Command & Control
- Logistics & Sustainability
- Training & Exercises
- Partnerships
- Capabilities & Human Capital

For the improvement of the NATO / Centre of Excellence (COE) mutual and beneficial relationship, the following four improvement areas were identified:

- Contribution to Lessons Learned
- Education & Training
- Concept Development & Experimentation
- Doctrine Development

[43] NATO's Lessons Learned Conference (2016) *The Future of Lessons Learned: Innovation and Improvement.* Available at: https://nllp.jallc.nato.int/news/Pages/2016NATOLESSONSLEARNEDCONFERENCE.aspx [Accessed June 2017].

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2.1.2 Frameworks or Models supporting the Enterprise to Supply Weapon Systems

McNaughton (2017)[44] defines the enterprise as an organisation with *'a capability that demonstrates the ability to create, acquire and use processes to deliver products and services to customers. Organisational capabilities are realised through the interaction of people, process and technology.'* Figure 2-7 below defines the Enterprise as a System of Systems.

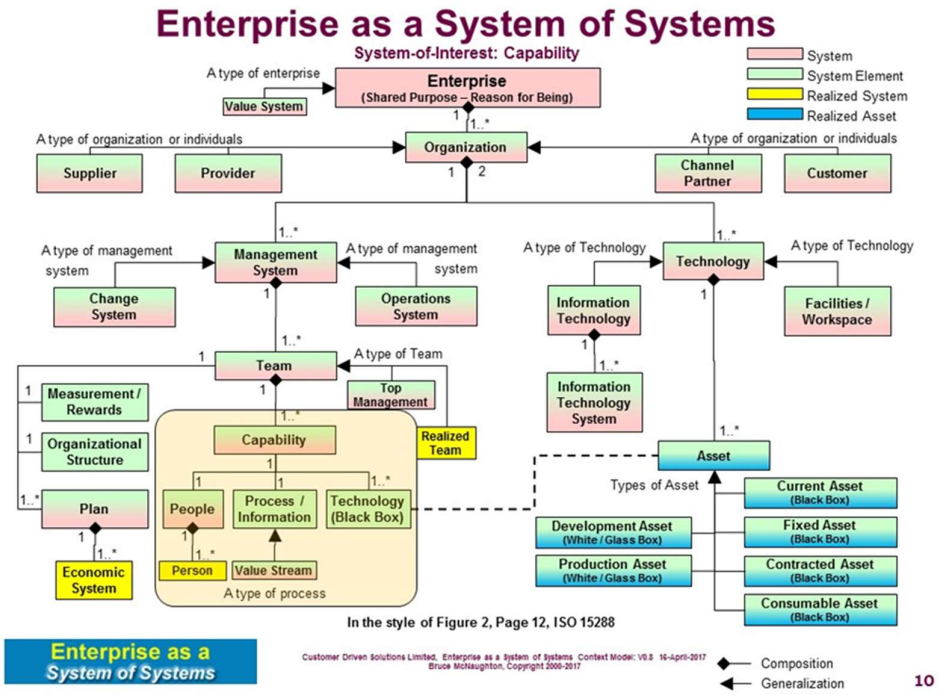

Figure 2-7: The Enterprise as a System of Systems (McNaughton, 2017)

The generic main phases of the acquisition process of a vehicle-based weapon system were defined in Chapter 1 as:

- Stating the user requirement of the system in technical terms
- Developing or adapting the products to be presented as a solution and integrating them into the system definition
- Developing the support elements to be used during the fielding of the system
- Industrialising the process to produce the product efficiently and consistently

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[44] McNaughton, B. (2017) *Enterprise as a System of Systems Context Model: V0.8.* Customer Driven Solutions Limited, Copyright 2000-2017. Available at: http://eaasos.info/Content/EntSoS/Ent_SystemsContext.pdf [Accessed June 2017].

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- Deploying the system successfully in the user environment
- Maintaining the system through a series of support activities
- Midlife upgrades of the system which can repeat most of these phases
- Eventual phase-out and decommissioning of the system.

The touch points between the acquisition process life cycle as well as the supply process life cycle are represented by the technical milestone reviews or gates put in place between the two parties and processes.

2.1.2.1 The Generic Supply Life Cycle

BAE Systems (2011), in their Engineering Life Cycle Handbook, defines the Generic Engineering Life Cycle of a Product or System as having five major phases, as follows:

- Concept Creation Phase
- Development and Qualification Phase
- Manufacture Phase
- Support during Deployment Phase
- Disposal Phase.

Thirteen distinctly different design review gates have been identified to manage the success of the knowledge migration throughout the life cycle. These are depicted numerically in figure 2-8 below:

Figure 2-8: The Engineering Life Cycle of a Product or System (BAE Systems, 2011)

The Gate Definitions are:

Gate 0: Feasibility review at the start of a project.

Gate 1A: The Key User Requirements should be known and understood as defining the basis for the demonstrator's objectives.

Gate 1B: To review candidate Product/solution trade-off analyses against maturing requirements. To review closure of Knowledge gaps, including any future manufacturing issues.

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Gate 2A: The following goals must be reached:

- To review acceptability of preferred solution together with agreed development strategy
- To agree on completeness of technical risks and plans for their mitigation.

Gates 2B: To review the effects of any changes to requirements that have emerged from negotiations before contract award.

Gate 2C: To confirm the acceptable level of technology maturity for Product and to agree on the baseline for Product's requirements.

Gate 3A: The following goals must be reached:

- To confirm viability of Product architecture – physical and logical and to agree Allocated Baselines for Product components
- To agree on Qualification and Acceptance Test approaches
- To confirm maturity of sub-systems designs and harmonisation with dependent components.
- To confirm maturity of test/support equipment designs.

Gate 3B: The following goals must be reached:

- To confirm maturity and compliance of component design and their readiness for pre-production implementation
- To confirm maturity of any particular production tooling.

Gate 4: To confirm maturity and compliance of integrated Subsystem/Component and readiness for qualification.

Gate 5: The following goals must be reached:

- To confirm conformity of Product and degree of customer acceptance
- To verify maturity of the manufacturing system
- To agree on acceptance of Product.
- To establish series production configuration of Product
- To verify maturity of accompanying support solution.

Gate 6: The following goals must be reached:

- To agree operational acceptability of Product with Customer

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- To verify the effectiveness of manufacturing process during Low Rate of Initial Production (LRIP)
- To review maturity of associated Support Product (including Training System).
- To review feedback from deployment of the product together with Support and Training Products
- To verify the effectiveness of manufacturing process during Full Rate Production (FRP)
- Verification of configuration of all manufactured instances of the Product.

Gate 7: The questions below indicate the goals that must be reached:

- Is the proposed Solution including recurring and non-recurring costs affordable to the Customer?
- Is there a Through Life Management Plan (TLMP) for the (Product/Project) Solution which outlines the future capability development plans?
- Have the Training requirements been evaluated and does the proposed Solution take this into account?
- Have all aspects of Equipment delivery been assessed and does the proposed Solution take this into account?
- Have Personnel requirements been assessed and does the proposed Solution take this into account?
- Have Information requirements been evaluated and does the proposed Solution take this into account?
- Have the Customer's Doctrine & Concept requirements been evaluated and does the proposed Solution take this into account?
- Have the Organisational aspects been considered and does the proposed Solution take this into account?
- Have the Infrastructure requirements been evaluated and does the proposed Solution take this into account?
- Have Logistics requirements been assessed and does the proposed Solution take this into account?
- Has Interoperability been assessed and does the proposed Solution take this into account?

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- Have all Contributors to Capability been covered by the Solution including the full Support Solution?

- Are there mechanisms in place to monitor the progress of the Through Life Management Plan?

Gate 8: The following goals must be reached:

- For decommissioning, maturity measure could address the progress of activities towards an agreed decommissioned state; status of removed/decommissioned sub-products; progress on mitigation of hazards associated with decommissioning or the storage of the decommissioned Product.

- For re-manufacture, the maturity management approach is to consider the maturities of the component sub-Products to be incorporated into the renewed Product.

2.1.2.2 The Specific Supply Life Cycle

In the specific experience of the application of the engineered to order projects by the company under review, the timeliness, configuration, price and specifications with the profile requirements of the client proofed to be of paramount importance.

The standard product under consideration for this research is a complex, design to order land based weapon system. This acquisition phase for such a product typically stretches from two to five years in time. BAE Systems, Land Systems South Africa (LSSA, 2013)[45] defined a specific engineer to order process depicted in figure 2-9.

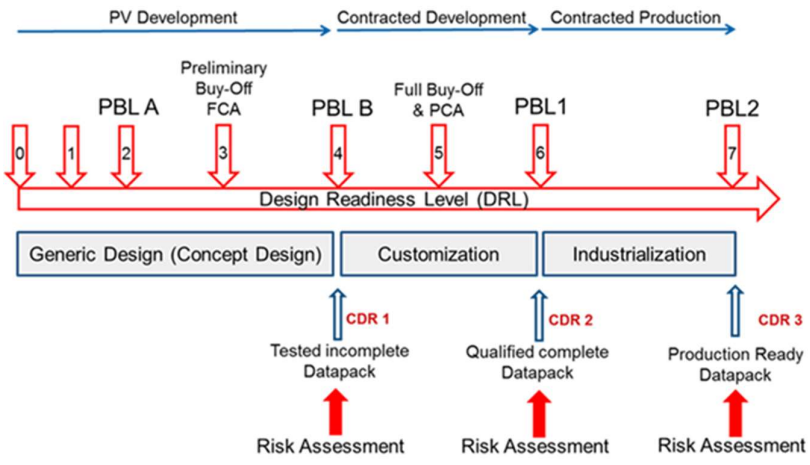

Figure 2-9: The Engineer to Order Product Life Cycle (LSSA, 2013)

The engineer to order product life cycle consists out of four distinct phases namely:

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[45] BAE Systems, Land Systems South Africa (LSSA). (2013). *Internal Best Practice*.

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1. The development of a generic or base vehicle. This can also be the previous model produced. The knowledge attributes of the base product must reach a minimum level of maturity to obtain an acceptable risk level to continue with potential contracting.
2. The customisation phase where the design is completed against the stated commitments. This phase's main aim is to mature the product's knowledge attributes. If the customisation is extensive, it will increase the technical risk level and lower the current design maturity level as measured against the demanded performance.
3. The industrialisation as well as the successful production of the customised product; This phase is primarily orientated to mature the knowledge attributes of the processes used during the production phase.
4. The after sales support of the product when fielded; The knowledge attributes required for the continued service and support is matured during this phase.

The design readiness levels depicted in table 2-1 defines the state of the design that must exist at each readiness level.

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Table 2-1: The Design Readiness Levels (DRL) (LSSA, 2013)

DRL Level	Requirement
0	Concept layout, rough sketches, proposal level
1	First order CAD design, high-level design calculations, selection of high-value items
2	Detail design layout, detail design calculations, selection of all components, prototype data pack
3	Build prototype, de-risk, primary aggregate buy off, functionally tested, capture upgrades, Functional Configuration Audit
4	Updated data packs, to build baseline, build generic model, qualification tests against original performance characteristics completed, product market ready
5	Functional design complete, FCA complete, OEM sign off for installations such as engine, gearbox, axles and steering completely
6	Physical Configuration Audit (PCA) complete, data pack complete, qualification against contractual baseline complete, start of pre-production
7	Production readiness complete, data pack updated from industrialisation, supplier process qualified, MRP Master data complete, manufacturing data pack qualified, start of production

2.1.3 Summary of Critical Success Factors

These key success factor studies' results show an unreasonably low level of correlation that may be due to a variety of reasons. The basic grouping of these success factors always comes back to process, people and technology – the three corner stones of capability (McNaughton, 2017).

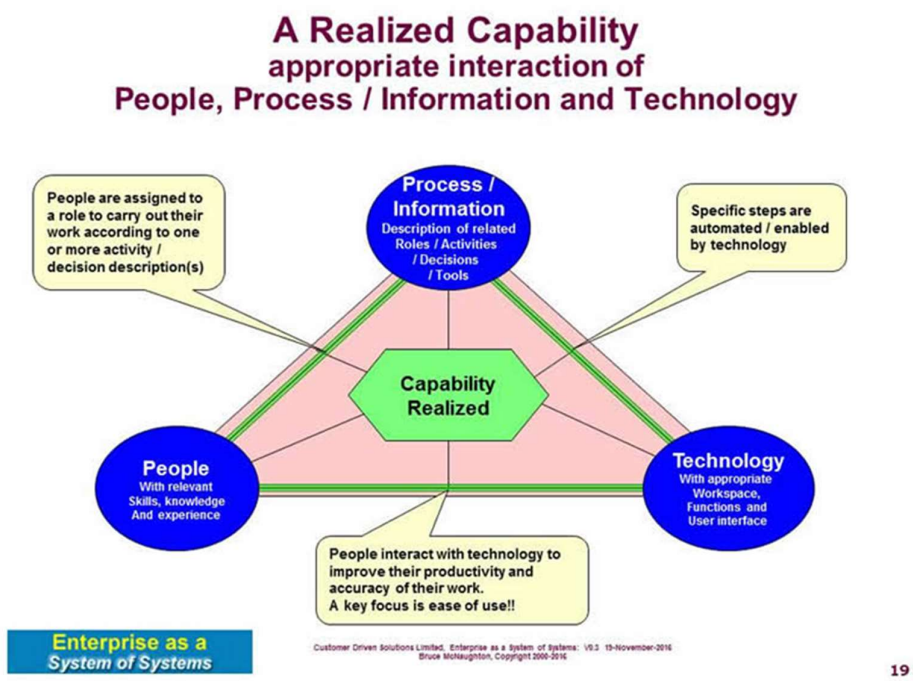

Figure 2-10: A Realised Capability (McNaughton, 2017)

Critical success factors for successful execution of complex weapon supply processes

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therefore also hinges on the process as defined in the previous paragraphs, the technology that enables the process and, finally, the human with all the factors that he or she can contribute to the outcome.

This research views the problem from an industry perspective and focusses on the people (human) factor's specific contribution in leadership, relationship, wisdom and culture. It will augment the studies that have gone before.

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2.2 Product Domain: Technology and Product Development Life Cycles

2.2.1 Defining a Product or Service

To develop the product domain in the Interactive Supply Framework, it will be necessary to look at the definition of technology first.

2.2.1.1 Definition of Technology

The word technology refers to the making, modification, usage and knowledge of tools, machines, techniques, crafts, systems and methods of organisation. These actions are performed to solve a problem, improve a pre-existing solution to a problem, achieve a goal, handle an applied input/output relation or perform a specific function. It can also refer to the collection of such tools, including machinery, modifications, arrangements and procedures (Wikipedia, 2017)[46].

Oxford Dictionaries (2017)[47]: Technology:

- *'The application of scientific knowledge for practical purposes, especially in industry: advances in computer technology [count noun]: recycling technologies*
- *Machinery and devices developed from scientific knowledge: it will reduce the industry's ability to spend money on new technology*
- *The branch of knowledge dealing with engineering or applied sciences.'*

Merriam-Webster Dictionary (2017)[48]: Technology:

- The practical application of knowledge especially in an area: Engineering <medical technology>
- A capability is given by the actual application of knowledge <a car's fuel-saving technology>
- A manner of accomplishing a task especially using technical processes, methods, or knowledge <new technologies for information storage>
- The specialised aspects of a field of endeavour <educational technology>

Technology can, therefore, be described as the practical application of knowledge that will generate the means of problem-solving to perform a specific function.

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[46] *Technology,* Wikipedia (2017) The Free Encyclopaedia. Available at: http://www.wikipedia.com/dictionary/technology [Accessed June 2017].
[47] *Technology*, English Oxford Living Dictionaries (2017) British and World English. Available at: http://oxforddictionaries.com/definition/english/technology [Accessed June 2017].
[48] *Technology*, Merriam-Webster (2017) Unabridged Dictionary. Available at: http://www.merriam-webster.com/dictionary/technology [Accessed June 2017].

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2.2.1.2 Definition of Product

Business Dictionary (2017)[49]:

- *'A good, idea, method, information, object or service created because of a process and serves a need or satisfies a want. It has a combination of tangible and intangible attributes (benefits, features, functions, uses) that a seller offers a buyer for purchase. For example, a vendor of a toothbrush not only offers the physical product but also the idea that the consumer will be improving the health of their teeth.*
- *Marketing: A good or service that most closely meets the requirements of a market and yields enough profit to justify its continued existence. If cars are manufactured, companies such as Michelin that produce tires fill the market need and continue to be profitable.'*

The free Dictionary (2017)[50] defines a product as:

- A commodity offered for sale; *'good business depends on having good merchandise"; "that store offers a variety of products.'*
- An artefact that has been created by someone or some process; *'they improve their product every year"; "they export most of their agricultural production.'*

A product or service is, therefore, best described as an artefact (idea, method, information, object or service) presented for sale and best described by its tangible and intangible knowledge attributes.

2.2.2 The Life Cycle Concepts

Underpinning the product domain is the concept of life cycles. This concept will be investigated as a generic framework as well as its application in technology and product development. The product development life cycle is broadened into an engineering life cycle spanning the complete process of acquisition, deployment and phase out of a typical weapon system.

2.2.2.1 The S-Curve

S-curves are useful to contextualise maturity and strategic positioning of objects which map the growth of revenue or productivity against time.

According to Aït-El-Hadj (1992)[51], the life cycle of technology can be considered in four phases, namely: The technology rise, growth, maturity and saturation phases.

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[49] *Product,* BusinessDictionary.com. WebFinance, Inc. (2017). Available at: http://www.businessdictionary.com/definition/product.html [Accessed June 2017].
[50] *Product,* The Free Dictionary (2017) Copyright © 2003-2017 Farlex, Inc. Available at: http://www.thefreedictionary.com/product [Accessed June 2017].
[51] Aït-El-Hadj, S. (1992). Technoshifts: Meeting the challenge of technological change, Productivity Press, Massachusetts.

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Narayanan (2001)[52] states that the life cycle of innovations can be described using the S-Curve. In the early stage of innovation, growth is relatively slow as the new product establishes itself. At some point, customers begin to demand, and the revenue from the product increases more rapidly. New incremental innovations or changes to the product allow growth to continue during this time. Towards the end of its life cycle, growth slows down and may even begin to decline. In the later stages, no amount of new investment in that product will yield a normal rate of return. The S-Curve is derived from half of a statistically normal distribution curve. With the stages combined, this forms the classic **S-Curve** profile as defined in figure 2-11 below:

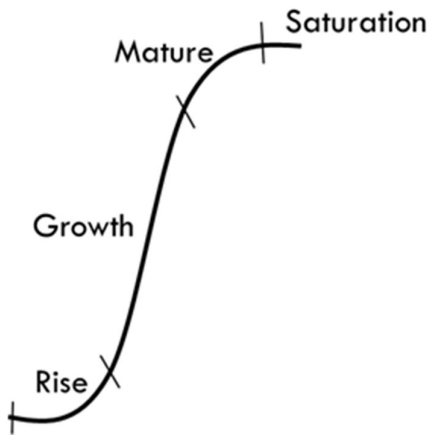

Figure 2-11: The Life Cycle defined as an S-Curve (Narayanan, 2001)

2.2.2.2 Technology Life Cycle

The Technology Life Cycle (TLC) (Boundless, 2016)[53] describes the commercial gain of a product through the cost of research and development phase and the financial return during its 'vital life'. Some technologies have a long lifespan (with minor variations in technology incorporated with time) while in other cases, the lifespan is quite short.

The TLC associated with a product or technological service is different from product lifecycle (PLC) dealt with in product life-cycle management. The Product Life Cycle is concerned with the life of a product in the marketplace, the timing of introduction, the marketing measures taken and the assosiated business costs. The technology underlying the product may be quite marginal, but the process of creating and managing its life as a branded product will be very different.

---

[52] Narayanan, V.K. (2001) *Managing technology and innovation for Competitive Advantage*. Englewood Cliffs, NJ: Prentice Hall.

[53] Boundless Management (2016) *The Technology Life Cycle.* Available at: https://www.boundless.com/management/textbooks/boundless-management-textbook/organizational-culture-and-innovation-4/technology-and-innovation-37/the-technology-life-cycle-202-3486/ Bondless.com [Accessed June 2017].

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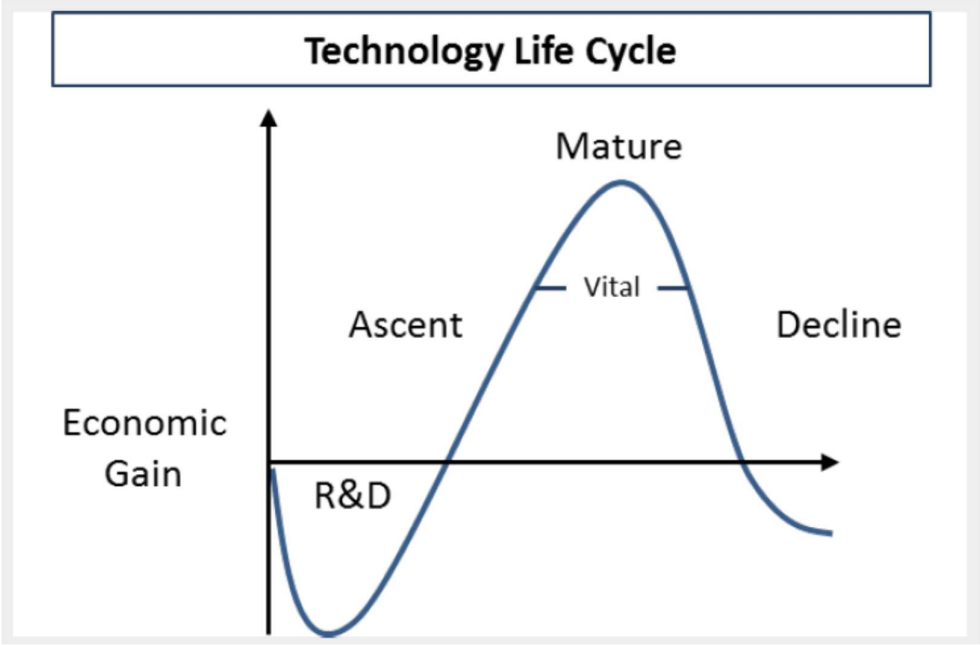

Figure 2-12: The Technology Life Cycle (TLC) (Anderson & Walker, 2013)

Anderson & Walker (2013)[54] in their article *'Technology Turnarounds… Where Moore's Law Meets Less Cash Flow'* present a framework for situational analysis, turnaround strategies and tactics to address the financial challenges.

'The technology life cycle is concerned with the time and cost of developing the technology, the timeline of recovering cost and modes of making the technology yield a profit proportionate to the costs and risks involved. The TLC may further be protected during its cycle with patents and trademarks seeking to lengthen the cycle and to maximise the profit from it.'

[54] Anderson. R. & Walker, S. (2013) *Technology Turnarounds… Where Moore's Law Meets Less Cash-Flow.* Available at: http://www.abfjournal.com/articles/technology-turnarounds-where-moores-law-meets-less-cash-flow - June 17. [Accessed June 2017].

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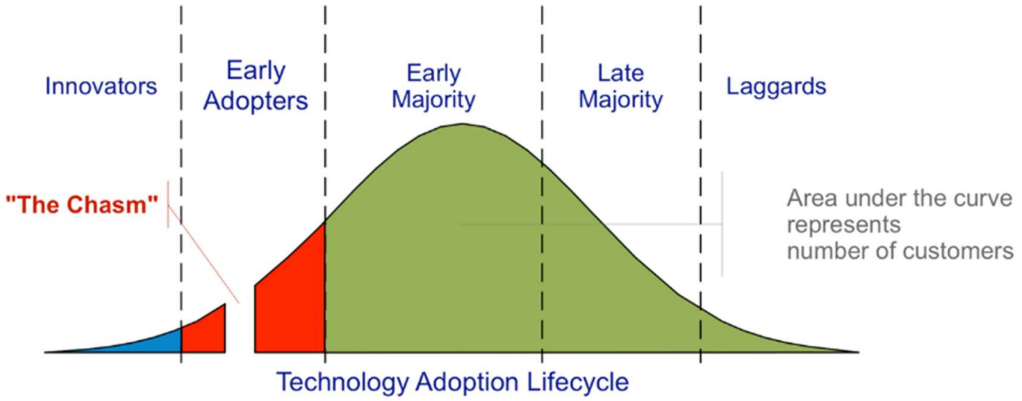

Figure 2-13: The Technology Adoption Life Cycle (Boundless, 2016)

After considering the new products and the new investments in technology one must also take into account customer acceptance of the new technology. In figure 2-13 we indicate the phased technology adoption and the realisation of a "chasm" in the early adopters' phase as a potential pitfall for failure (Boundless, 2016).

An enterprise generating a new product should consider the following factors:

- The relative size of the investment
- The expected life cycle of the underlying technology
- The expectation that the customers will adopt the product

By considering all the aspects listed above, the enterprise will be able to exercise a view of the future to predict a positive result and a healthy return on investment. This future review is part of the product portfolio and strategic management process.

Jayalath (2010)[55] defines the technology phase as a research and development and a vital life phase after which the technology is no longer useful. One can visualise that the elaboration of a specific technology's knowledge is through the application of the basic engineering change cycle.

A standard Technology Readiness Level Scale was initially developed by NASA and later adapted for application in the acquisition process of the US Army through their Technology Program Management Model (Tan et al., 2011)[56]. The Technology Readiness Level Scale, is depicted below in figure 2-14.

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[55] Jayalath, C. (2010) *Understanding S-curve of Technology and Innovation.* Available at: https://cssc0der.com/understanding-the-s-curve-of-technology-innovation/ [Accessed 15 October 2012].

[56] Tan, W., Sauser, B.J. & Ramirez-Marquez, J.E. (2011) *Analysing Component Importance in Multifunction Multi-capability Systems Developmental Maturity Assessment*. IEEE Transactions on Engineering Management, 2011, 58, 2, 275.

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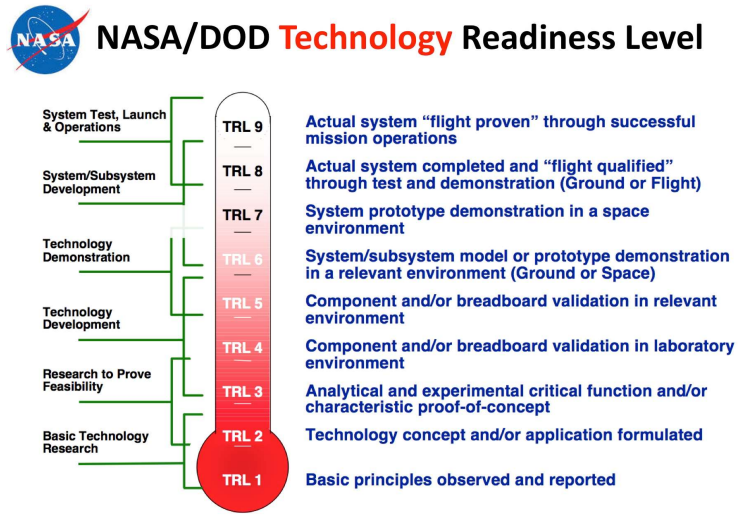

Figure 2-14: The Technology Readiness Levels for NASA (Tan et al., 2011)

Adaptations of this technology readiness scale are also used to define the required maturity level (and technical risk) during the execution of the acquisition process.

2.2.2.3 The Product Life Cycle

The product was defined previously in the following way: A product or service is best described as an artefact (idea, method, information, object or service) presented for sale and best described by its tangible and intangible knowledge attributes.

The Product Life Cycle (PLC) as defined by Noyen (2004) describes the whole life cycle of a product, from the first idea to the disposal of the product. The PLC can be divided into several phases as shown below in figure 2-15:

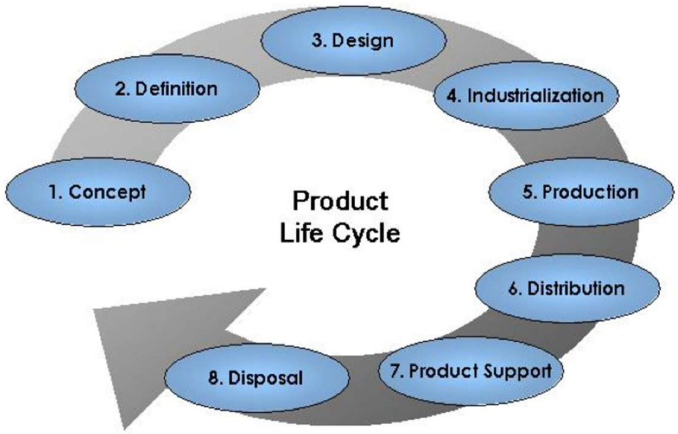

Figure 2-15: The Product Life Cycle. (Noyen, 2004)

2.2.3 Product Portfolio Strategy

By reviewing the future development life cycles of all the goods together and by making the

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right investment and strategic choices, one can ensure that the future products will be ready and available for the future markets in time. This product portfolio strategy is one part of the strategic management process of an enterprise.

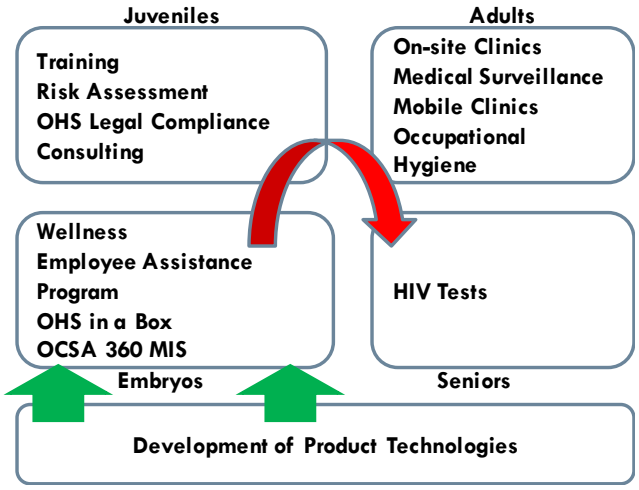

Figure 2-16: The Product Portfolio Management Process (Pretorius, 2014)

As an example the product portfolio management process for a medical service provider (Pretorius, 2014)[57] is shown in figure 2-16. The following principles of this roadmap are demonstrated:

- The product in the product portfolio will grow from embryo stage, through the juvenile stage, to adult and finally to senior stage
- Some products will mature quicker than others
- Not all the goods will complete the cycle successfully, and one can expect infant mortality to occur
- Some products can be revitalised through successful midlife upgrade programs and can, therefore, move back in the life cycle
- One needs to move focus away from the senior stage as the return on investment is inherently low in this phase
- The embryo product stage is fed by the development of new product technologies
- The process must be strategically managed through particular investment.

According to Leavy (2010)[58], the value proposition to the customers must be considered as an integral part of the strategic planning process.

[57] Pretorius, G. (2014) *OCSA Strategic Plan*. Compiled for the company Occupational Care South Africa.
[58] Leavy, B. (2010) *Masterclass - A system for Innovating Business Models for Breakaway Growth.* 38(6), pp. 5–8.

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> *'At its most basic, the strategy has two fundamental concerns – value creation and value capture. Traditional perspectives that focus primarily on how to create sustainable sources of competitive advantage are mostly concerned with value capture. Value innovation, while concerned with both creation and capture, shifts the primary focus in strategy development back to customers rather than competitors, and to the challenge of how to create game-changing breakthroughs in the value-to-cost ratio.'*

The product portfolio development in the proposed strategic planning model is subservient to the customer value proposition. The development of a solution to need is required. A product that is driven purely by technology capability as the focus, may not be able to serve the need of the customer.

2.2.4 The Engineering Management Plan

The consequential phases of the engineering life cycle define an increasing maturity level of knowledge of the item under development. The knowledge is defined as a set of technical States or baselines indicating the growth in design maturity levels of the product. It is important to note that the design maturity levels increase as the technical risk levels decrease.

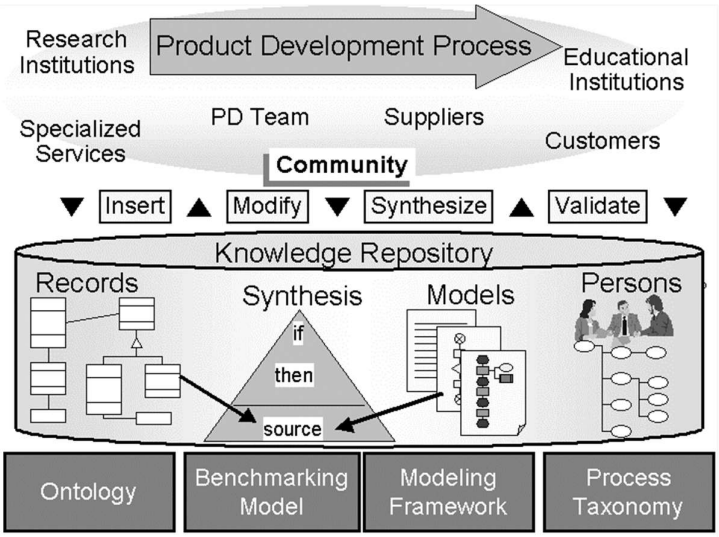

Figure 2-17: The Architecture of Explicit Knowledge applied to Product Development Processes (Rozenfeld & Eversheim, 2002)

Rozenfeld & Eversheim (2002)[59] defines an architecture for shared management of explicit knowledge during the product development processes represented in figure 2-17 above. The engineering management activities for the supply of a specific product design is documented in the product's engineering management plan.

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[59] Rozenfeld, H. & Eversheim, W. (2002) *An Architecture for Shared Management of Applied to Product Development Processes*. CIRP Annals 51(1): 413–416.

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Yin et al. (2015)[60] defined a 'human–machine integrated automating design paradigm' shown pictorially in figure 2-18 below.

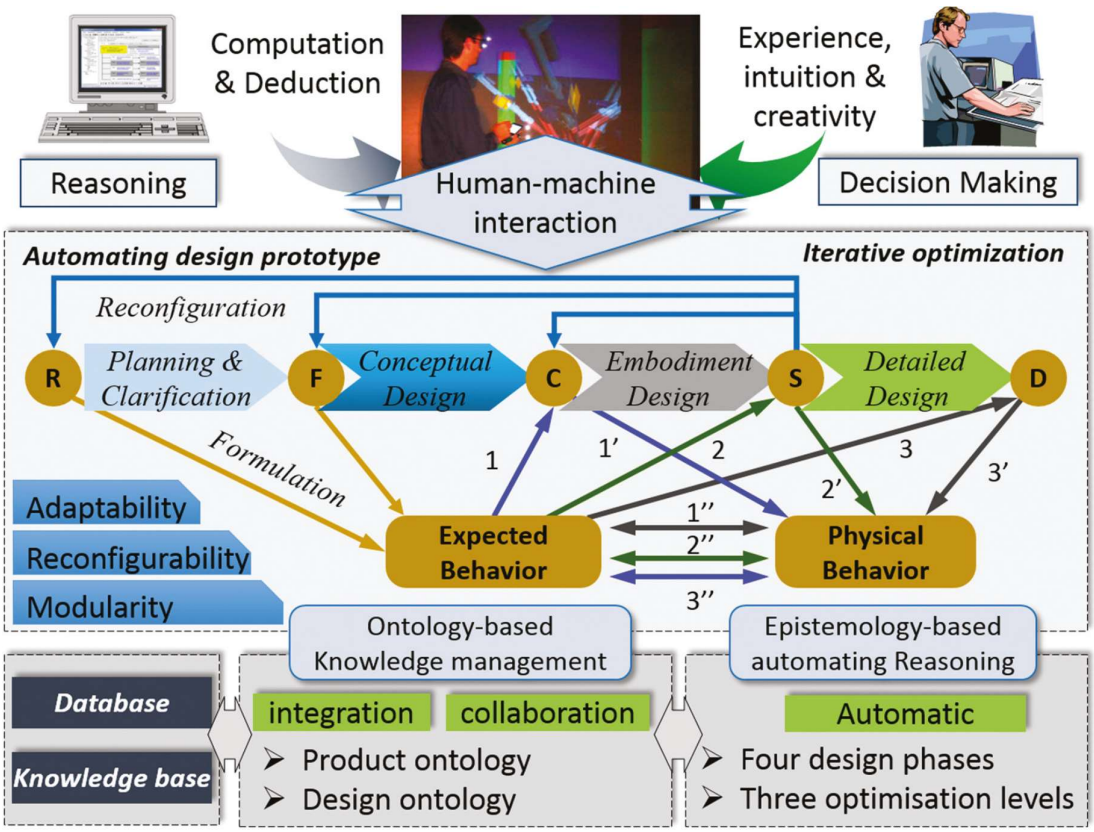

Figure 2-18: Human–Machine Integrated Automating Design Paradigm (Yin et al., 2015)

Yin et al. (2015) hold that the *'paradigm of human–machine integrated automating design emphasises the integration of machine's massive computation and logical deduction abilities and human's experience, intuition and creativity, whereas automating design is essentially machine-centred with the goal of completely emancipate human from the design workloads.'*

It is mainly composed of three areas:

- the prototype of the integrated automating design
- the ontological modelling of knowledge management
- the epistemology-based automating rationale, and intelligent human–machine interface.

2.2.5 The Product Development Statement of Work (SOW)

In his part of the framework, all the actions are defined to design, build, test and service the artefacts in a statement of work. This includes the supply chain activities, all the physical material handling and assembly as well as the direct delivery of any service during the life

[60] Yin, Y.H., Nee, A.Y.C., Ong, S.K., Zhu J.Y., Gu P.H. & Chen, L.J. (2015) *Automating design with intelligent human–machine integration.* CIRP Annals - Manufacturing Technology 64 (2015): 655–677.

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cycle of the product. The Military Handbook of the USA Department of Defence is formally defined in the MIL-HDBK-245D (1996)[61] *'guides that enable personnel to create a completed contract Statement of Work (SOW) applicable to any material acquisition life-cycle phase.'*

2.2.6 The Design Process

Our knowledge of the artefact increases during the design process. This design process is normally represented as a logical series of events. However, in the interest of a broader application of the Interactive Supply Framework one needs to study a few of these processes to reduce it to a basic process principle.

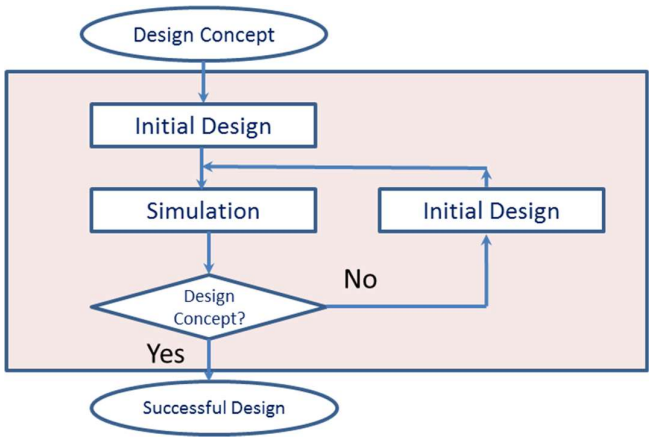

Figure 2-19: The Basic Design Loop (Brown & Vranesic, 2009)

In his logic diagram in figure 2-19 about the primary design loop, Brown & Vranesic, (2009)[62] define the logic of events as follows:

> *"Any design process comprises a basic sequence of tasks that are performed in various situations. Assuming that we have an initial concept about what should be achieved in the design process, the first step is to generate an initial layout. The next step is the simulation of the design at hand. If the simulation reveals some errors, then the design must be changed to overcome the problems. The redesigned version is again simulated to determine whether the errors have disappeared. This loop is repeated until the simulation indicates a successful design."*

This process defines an initial design, a simulation of conception, assessment and feedback control as sub-elements of the process. The basic design loop, as presented by Brown & Vranesic (2009), will be complete with an additional feedback loop to enable the rejection of the initial design as well.

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[61] MIL-HDBK-245D, Department of Defense Handbook (1996) *Preparation of Statement of Work (SoW).* Available at: http://everyspec.com/MIL-HDBK/MIL-HDBK-0200-0299/MIL-HDBK-245D_1888/ [Accessed Jan 2014].

[62] Brown, S. & Vranesic, Z. (2009) *Fundamentals of Digital Logic with VHDL Design.* Third Edition, Published by McGraw-Hill, p. 30.

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Roozenburg & Eekels (1995) defined the Basic Design Cycle as:

- *'Point of departure in product design is the function of the new product, i.e. the intended behaviour in the widest sense of the word*
- *In the analysis phase the designer forms an idea of the problems around such a new product idea (the problem statement) and formulates the criteria that the design solution should meet*
- *The second step in the basic design cycle is the generation of a provisional design proposal. The word 'synthesis' means the combining of separate things, ideas, etc., into a complete whole.*
- *Simulation is a deductive subprocess. Simulation is: forming an image of the behaviour and properties of the designed product by reasoning and/or testing models, preceding the actual manufacturing and use of the product.*
- *Evaluation is establishing the 'value' or 'quality' of the provisional design.*
- *Then follows the decision: continue (elaborate the design proposal) or try again (generate a better design proposal). Usually, the first provisional design will not be bull's eye and the designer will have to return to the synthesis step, to do better in a second, third or tenth time.'*

The same authors, in an earlier logic diagram on the reasoning by designers, identified the needs and value driven part of the process. This model is diagrammatically depicted in figure 2-20 below.

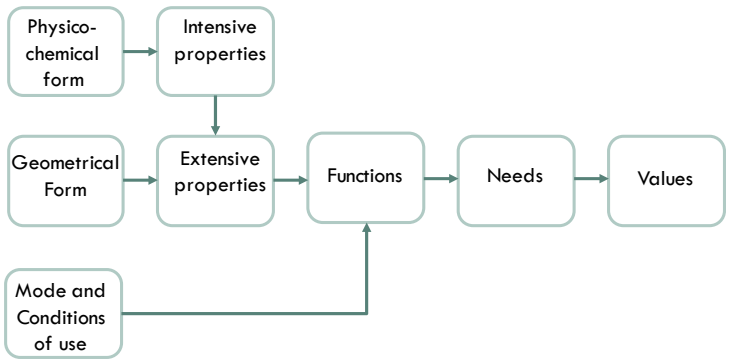

Figure 2-20: Model of Reasoning by Designers (Roozenburg & Eekels, 1995)

The Engineering Design Cycle and the Product Life Cycle (PLC) must not be confused with one another. The Engineering Design Cycle, as defined above by Roozenburg & Eekels (1995), is a continuous process used to forward or migrate the product's knowledge attributes through its life cycle (PLC) up to the point where more effort does not result in a more useful product knowledge i.e. the end of life or saturation condition.

This process contains some distinct sub-processes such as understanding the problem, generating a solution, testing the solution against the problem, establishing the value of the solution and deciding if the solution is good enough or if one needs to take corrective action by designing a different solution.

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2.2.6.1 The Plan, Do, Check, Act (PDCA) Cycle

The Plan Do Check Act Four-step process (PDCA,1936)[63] is used in quality control and elsewhere in the industry (known as the Shewart Cycle or Deming Wheel) as a simplified method for achieving improvements. See figure 2-21.

Figure 2-21: The Shewart Cycle (PDCA, 1936)

'The four steps are:

(1) Plan: Determine what needs to be done, when, how, and by whom.

(2) Do: Carry out the plan, on a small-scale first.

(3) Check: analyse the results of implementing the plan.

(4) Act: take appropriate steps to close the gap between planned and actual results.

Named after its proposer, the US mathematician Dr Walter Shewart (1891-1967). Also called Deming cycle, Deming wheel, or plan do check act (PDCA) cycle.'

Basic engineering design, in essence, is nothing other than taking an artefact's current knowledge (problem, requirement, unwanted status), deciding how to go about changing it, actually changing the knowledge base, measuring the effectiveness of the modification and repeating the process if the outcome was not acceptable. This process is also commonly known as an Engineering or Design Cycle and is equally applicable to technologies, products and processes.

From the above, it is clear that the PDCA Cycle is just another way of defining a Basic Engineering Cycle. This PDCA Cycle can, therefore, be used to indicate changes in the status of knowledge of an artefact during its life spanning from an idea right up to a full fledged system.

The knowledge artefact advances in its knowledge status by the continuous application of the PDCA Process (Vietze, 2013)[64] as defined in figure 2-22:

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[63] The PDCA Cycle (1936) The Shewhart Cycle - The Deming Wheel - Plan-Do-Check-Act. Available at: http://www.saferpak.com/pdsa.htm [Accessed May 2016].

[64] Vietze, J. (2013) *The PDCA Process.* Available at: https://upload.wikimedia.org/wikipedia/commons/a/a8/PDCA_Process.png [Accessed May 2016].

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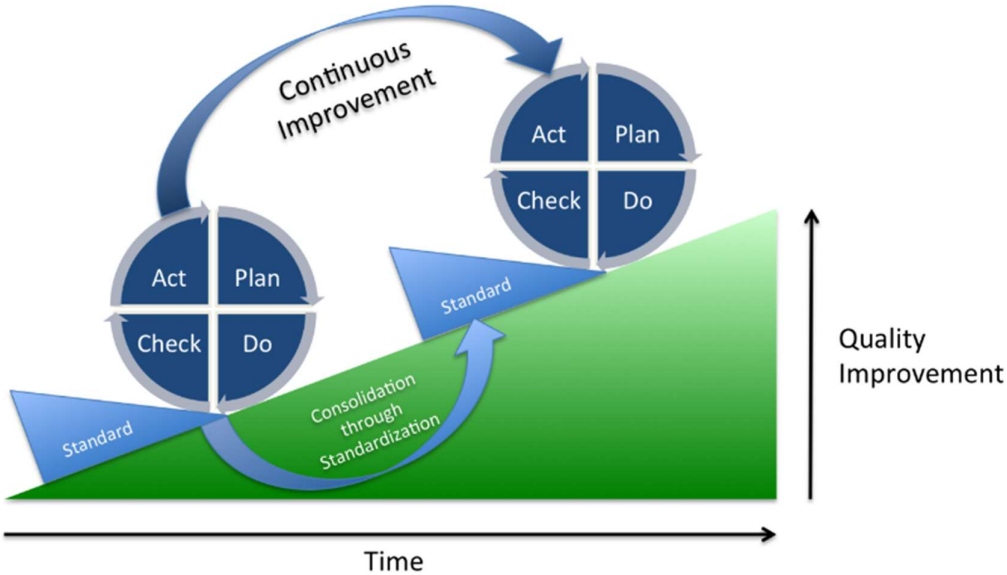

Figure 2-22: Continuous Improvement of the PDCA Process (Vietze, 2013)

This process of continuous improvement seeks to churn the PDCA Cycle and thereby increase the knowledge status of the artefact. Consolidation is done through the establishment of a new standard at this point that again acts as the baseline for the next PDCA Cycle to advance to the next standard yet again. If the re-standardisation is not done the whole process will slip back to the previously established standard, and the improvement will be lost.

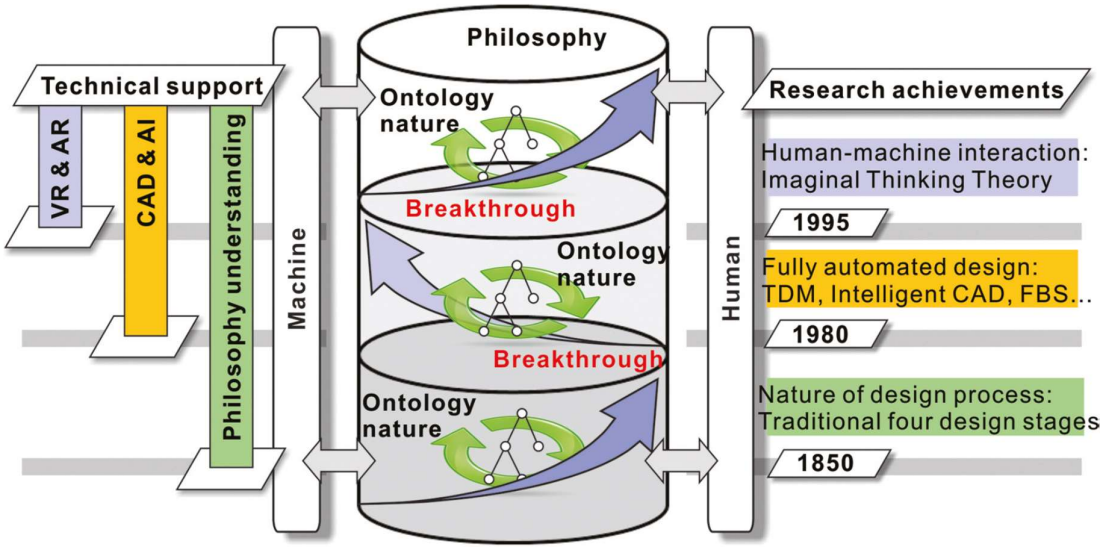

Figure 2-23: The Upward Spiral Characteristics of Automating Design (Yin et al., 2015)

Yin et al. (2015) defined the upward spiral of the automated design process whereby the *'human–machine integrated automating design paradigm is reviewed continuously based on a proposed prototype of human–machine integrated design, from the aspects of ontology-based knowledge management with local-to-global ontology transitions, and epistemology-*

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based upward-spiral cognitive process of coupled design ideation.' The upwards spiral is shown in the figure 2-23 above.

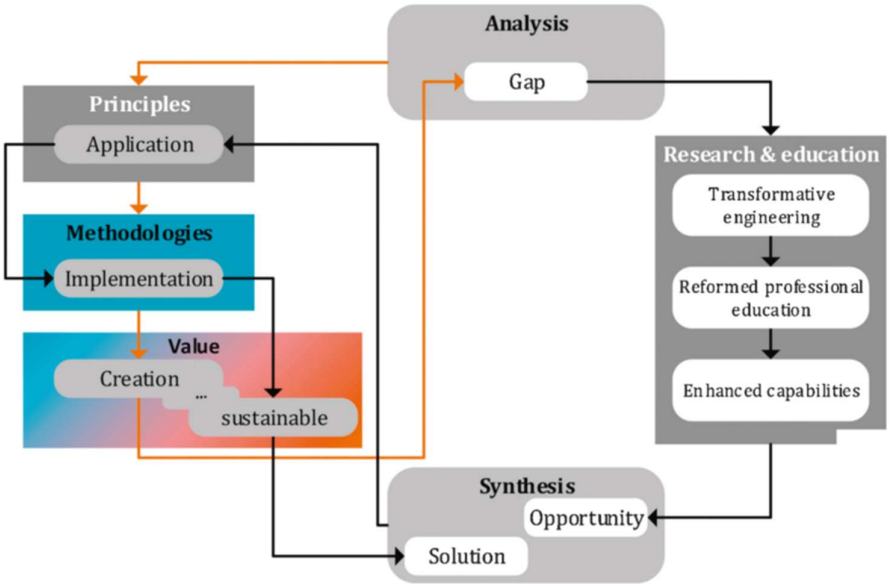

Figure 2-24: Manufacturing Architecture for Sustainable Value Creation (Bilge et al., 2016)

Bilge et al. (2016)[65] defined a manufacturing architecture in figure 2-24 for '*sustainable value creation'* where the value creation flows from analysis, as shown by orange arrows, to synthesis, as shown by black arrows, iteratively.

[65] Bilge, P., Seliger, G., Badurdeen, F. & Jawahir, I.S. (2016) *A novel Frame work for Achieving Sustainable Value Creation through Industrial Engineering Principles.* Procedia CIRP 40: 516–523.

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2.3 Enterprise Domain: The Enterprise Life Cycle and Processes

2.3.1 Defining the Enterprise

Literature defines the enterprise in many ways:

The Free Dictionary's thesaurus legend (2017)[66] contains the following definitions and examples:

- Enterprise - a purposeful or industrious undertaking (especially one that requires effort or boldness); *'he had doubts about the whole enterprise.'*
- Enterprise - an organisation created for business ventures; *'a growing enterprise must have a bold leader; Industrious, systematic activity, especially when directed toward profit; Private enterprise is basic to capitalism'*.

The Merriam-Webster (2017)[67] dictionary defines an Enterprise as:

- *'A project or undertaking that is especially difficult, complicated, or risky*
- *Readiness to engage in daring or difficult action: initiative <showed great enterprise in dealing with the crisis>*
- *A unit of economic organisation or activity; especially a business organisation.'*

Dictionary.com (2017)[68] has the following definitions for an enterprise:

- *'A project was undertaken or to be undertaken, especially one that is important or difficult or that requires boldness or energy: To keep the peace is a difficult enterprise.*
- *Participation or engagement in such projects: Our country was formed by the enterprise of resolute men and women.*
- *Boldness or readiness in undertaking; adventurous spirit; Ingenuity.*
- *A company organised for commercial purposes; Business firm.'*

The Oxford Dictionary (2017)[69] defines the enterprise as:

- *'A project or undertaking, especially a bold or complex one*
- *Initiative and resourcefulness: success came quickly, thanks to a mixture of talent, enterprise, and luck.*
- *A business or company: a state-owned enterprise.*

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[66] *Enterprise,* The Free Dictionary (2017) Copyright © 2003-2017 Farlex, Inc. Available at: http://www.thefreedictionary.com/enterprise [Accessed May 2016].
[67] *Enterprise,* Merriam-Webster (2017) *Unabridged Dictionary.* Available at: http://www.merriam-webster.com/dictionary/enterprise [Accessed May 2016].
[68] *Enterprise,* Dictionary.com. (2017) *The American Heritage® Dictionary of Idioms* by C.A. Houghton Mifflin Company. Available at: http://www.dictionary.com/browse/enterprise [Accessed May 2016].
[69] *Enterprise,* English Oxford Living Dictionaries (2017) British and World English. Available at: http://oxforddictionaries.com/definition/english/enterprise [Accessed May 2016].

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- *Entrepreneurial economic activity: an economic environment which encourages enterprise [as modifier]: local enterprise agencies.'*

In summary, the enterprise is a purposeful or industrious undertaking that is especially difficult, complicated, or risky showing readiness to engage in bold action that requires boldness and energy, which is organised for commercial purposes and having initiative and resourcefulness to reach its intended goals.

2.3.2 Enterprise Life Cycle

2.3.2.1 The Phases of the Enterprise Life Cycle

The evolutionary perspective of a firm is considered along four main stages of its growth and evolution (Chandrasekhar, 2013)[70] as Early Firm Growth, High Growth Phase, Inflexion Point, and Maturity Stage.

- *'Early Firm Growth – This early phase of firm growth would commence with the founding of the firm and would extend until a new venture has survived its early period in business and is poised for further growth.*

- *High Growth Phase – This phase of a new venture evolution would commence when a venture has gained a certain amount of legitimacy and has developed a set of client relationships and has instituted a business model for further growth.*

- *Inflexion Point – Firms in their high growth phase are likely to encounter changing demographic trends, changing customer preferences, and new technological breakthroughs brought about by current and new competitors. At these junctures, firms would have to predict a future or a range of future possibilities and make strategic decisions.*

- *Maturity Stage – Firms that have evolved through all the previous stages and have achieved dominant market shares in a certain business or certain businesses are likely to encounter saturated market demand nationally and/or globally. Such firms are likely to contemplate entering new businesses or creating new markets.'*

The Enterprise Life Cycle as defined by Noyen (2004) have six distinctive steps depicted in Figure 2-25 below.

[70] Chandrasekhar, G. R. (2013) *Unravelling Firm Competitiveness: An Evolutionary Perspective*. ACR Vol. 21 (1&2), 2013 21, 5–14.

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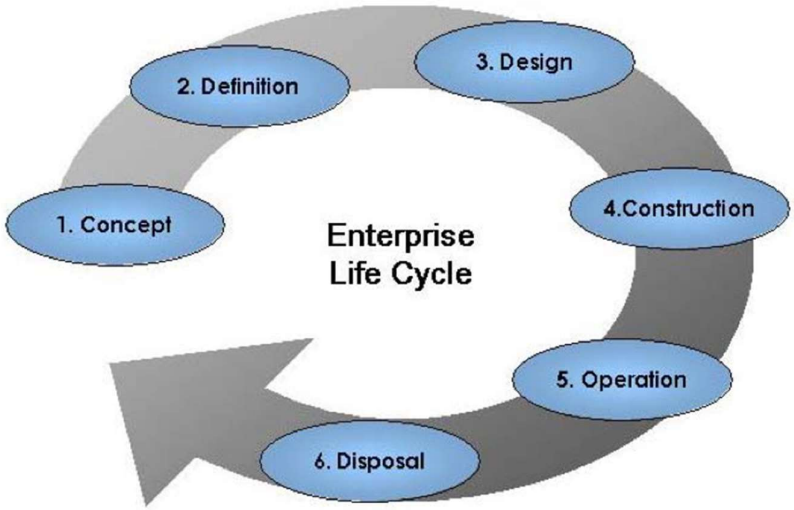

Figure 2-25: The Enterprise Life Cycle. (Noyen, 2004)

2.3.2.2 The Recurring Enterprise Life Cycle

Ward, (2003)[71] in his description of the leadership lifecycle, defines the standard enterprise life cycle as having the following distinct phases with real transition points between them:

- The Creation Phase
- The Growth Phase
- The Maturity Phase
- The Turnaround Phase
- The Decline Phase

[71] Ward, A. (2004) *The Leadership Life cycle, Matching Leaders to Evolving Organizations*. Palgrave Macmillan.

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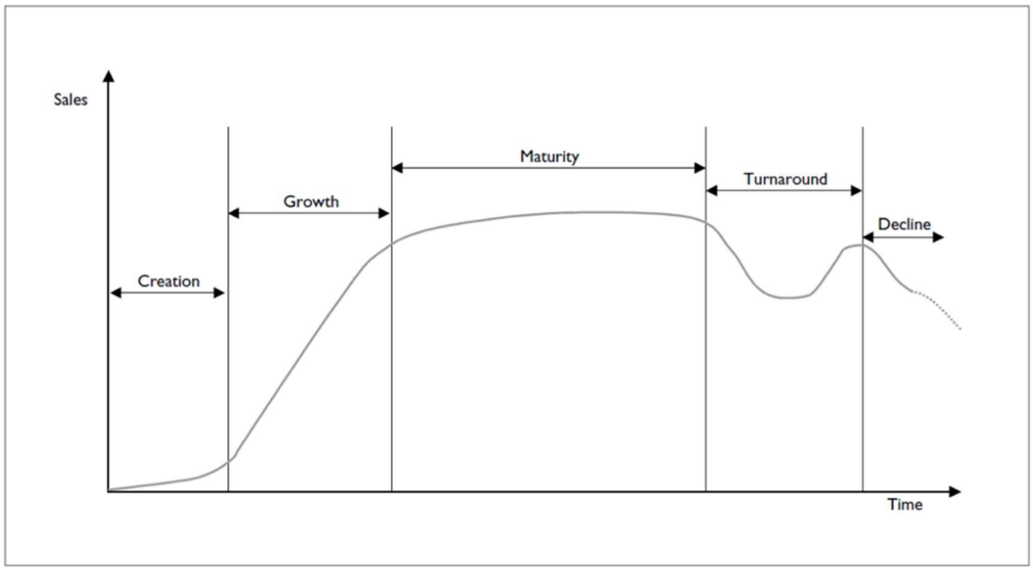

Figure 2-26: Enterprise Life Cycle (Ward, 2004)

Adizes (2006)[72] defines ten stages of the enterprise lifecycles as shown in figure 2-27:

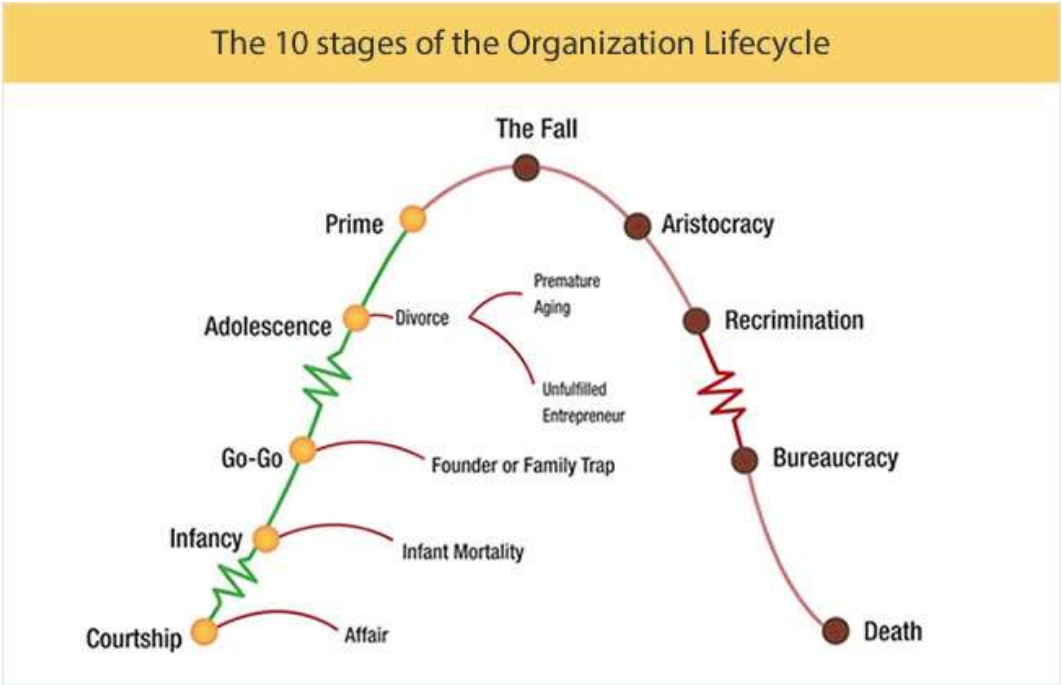

Figure 2-27: Enterprise Lifecycle (Adizes, 2006)

[72] The Adizes Institute (2006) The Corporate Life Cycle. Available at: http://mexico.adizes.com/corporate_lifecycle_overview.html [Accessed May 2016].

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Stage 1: Courtship

The passionate stage when the idea develops but without taking the plunge. This phase can be railroaded using an affair.

Stage 2: Infancy

The baby is born and nurtured into life, or infant mortality occurs.

Stage 3: Go- Go

The juvenile needs to go on a learning and exploration spree.

Stage 4: Adolescence Stage

When a love-hate relationship develops between the founder and people operating the company, the enterprise here goes through a transformation from a family type business to a structured business, and this may result in a divorce where the company prematurely age or where the entrepreneur is unfulfilled.

Stage 5: Prime

In this juncture the enterprise is most effective and efficient but will lose some of its ability to innovate.

Stage 6: The Fall

For the first time, the business starts to decline and, if not renewed, will go through the following stages of:

Stages 7 to 10:

Aristocracy, Recrimination, Bureaucracy and eventual Death.

From the above one must endeavour to re-create the enterprise before it reaches the end of life stage.

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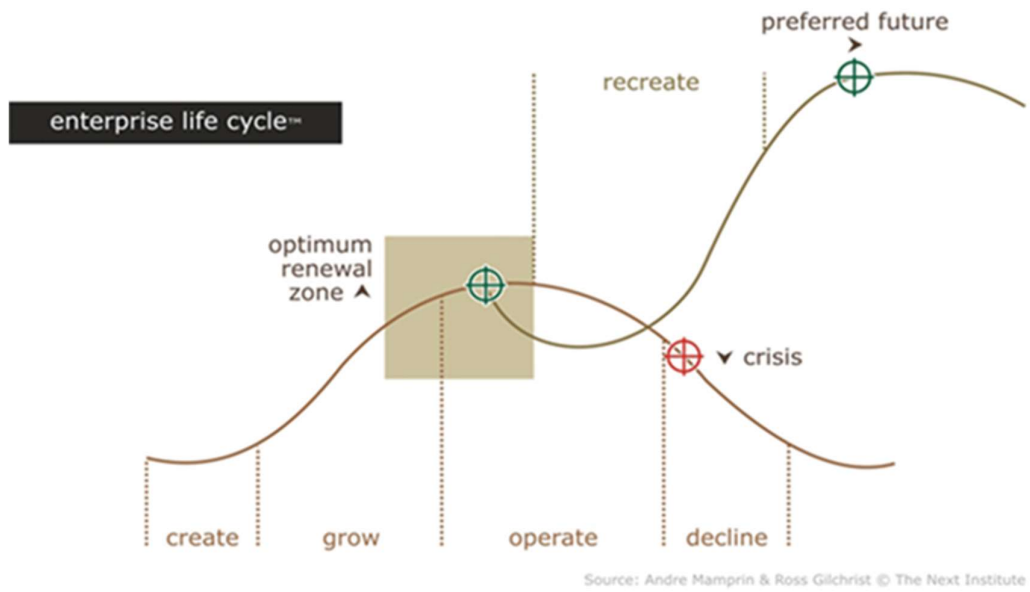

Figure 2-28: The Enterprise Life Cycle as defined by the Next Institute (2011)

The Enterprise Life Cycle Curve (The Next Institute, 2011)[73] commences initially with slow growth in financial performance as shown in figure 2-28 above. After a first big success, the curve exhibits increased growth as more successes realise. In the operating phase where the focus is on optimal return, the curve begins to level out. If renewal is not induced at this point, the decline will follow.

The optimum renewal period is where the momentum is still strong with a significant growth element present. A renewal strategy at this point yields the best results with the least impact because 'free creative energy' in the enterprise is ring-fenced and readily available for the turn-around project.

If one waits too long and the enterprise moves into a decline, the 'free energy' will be consumed by a firefighting mode, the intervention becomes more difficult, and crisis may result.

The ability to re-create and renew (innovate) in the optimum period, has become a fundamental requirement for a sustainable enterprise.

2.3.3 The Enterprise's Strategic Plan

An enterprise is usually goal orientated and will need a strategy and plan to realise this goal within the constraints of the environment, resources and time available.

[73] The Next Institute (2011) *Enterprise Life Cycle.* Available at: http://thenext.ca/senior-teams/enterprise-life-cycle.php [Accessed August 2013].

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Mahr (2010)[74] investigated the mix from the distinct strategic emphases of Information Technology, Organisation and Strategy.

Miles & Snow (1978)[75] defined the strategic options as a choice between a prospector and a defender's strategies.

Porter (1985)[76] called the general strategies 'Cost Leadership' (no frills), 'Differentiation' (creating uniquely desirable products and services) and 'Focus' (offering a specialised service in a niche market). He then subdivided the Focus strategy into two parts: 'Cost Focus' and 'Differentiation Focus'.

March (1991)[77] makes a distinction between exploitative and exploratory kinds of organisational learning. He also states that the choice between the two is made in decisions about competitive strategy. This distinction is often interpreted as a strategy typology.

As it is not the intention to investigate strategic management per se, additional reading can be found in the footnote below (Various, 2004 to 2007)[78].

Traditionally the two strategy principles can be summarised as value creation and value capture.

Leavy (2010) defines a third principle to considered as value innovation. Value innovation includes the possibility for both creation and capture but focuses primarily on its strategy considerations back to customers and not the competitors, so as to challenge and create game-changing breakthroughs in the value-to-cost ratio of the business.

Leavy also concluded that a common theme of value innovation does not necessarily require technological breakthrough but nearly always needs a new business model as the game changing factor.

The Strategic Management Process (Johnson et al., 2008)[79] may be reduced to the following four steps:

- **A strong Customer Value Proposition (CVP),** which *''describes how a company creates value for a given set of customers at a given price.''*
- **A profit formula**, which *''defines the way the company will capture value, based on the four variables most critical to profit generation – revenue model, cost structure, target unit margin and resource velocity.''*

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[74] Mahr, F. (2010) *Aligning Information Technology, Organisation and Strategy, Effects on Firm Performance.* 1st Edition 2010, All rights reserved © Gabler Verlag, I Springer Fachmedien Wiesbaden GmbH, 2010.
[75] Miles, R.E. & Snow, C.E. (1978) *Organizational Strategy, Structure, and Process.* McGraw-Hill; New York, US.
[76] Porter, M.E. (1985) *Competitive Advantage.* Free Press: New York, US.
[77] March, J.G. (1991) *Exploration and Exploitation in Organizational Learning.* Organization Science 2(1): 71-87.
[78] *Various* (2004 to 2007) (Auh & Mengue, 2005; Gibson & Birkinshaw, 2004; He & Wong, 2004; Lubatkin et al., 2006; Thornhill & White, 2007; Uotila et al., 2009; Venkatraman et al., 2007).
[79] Johnson, M.W., Clayton M.C. & Henning, K. (2008) *Reinventing Your Business Model.* Harvard Business Review 86, no. 12 (December 2008).

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- **The key resources** using which *"value is delivered to the customer and the company (the CVP and the profit formula) in a ''repeatable, scalable fashion,'' providing the ''essence of a company's competitive advantage.''*
- **The key processes** using which *"value is delivered to the customer and the company (the CVP and the profit formula) in a ''repeatable, scalable fashion,'' providing the ''essence of a company's competitive advantage.''*

Underpinning this framework is a complex inter-dependency of these four elements. Successful enterprises developed systems in which these elements interact.

2.3.4 Enterprise Competitiveness and Agility

Joan Magretta (2012)[80] in her book *Understanding Michael E Porter* defines Strategy as follows; *'Strategy explains how an organisation, faced with competition, will achieve superior performance.'*

Enterprise strategic planning can not only consider the market, the product or its operation but must re-integrate these elements into the four steps defined by Leavy (2010).

No research on the topic of competitiveness, innovation and strategy will be complete without the study of Michael E Porter's work on these issues. Joan Magretta (2012) has done exactly that and, in order not to lose any essence in interpretation, she is quoted verbatim below:

> *'I start with competition in Part 1 for the simple reason that if there were no competition, there would be no need for strategy. Competitive rivalry is a relentless process working against a company's ability to find and maintain an advantage. In Part 1, we'll do the important prep work for strategy, spelling out how competition works and dispelling the most popular, and misleading, misconceptions about competition and competitive advantage.*
>
> *Chapter 1. Competition: The Right Mind-Set. Misconceptions of what competition is and how it works give rise to mistakes in strategy. The most common error of all is that competitive success comes from "being the best." This mind-set is highly intuitive. It is also self-destructive, leading to a zero-sum race to the bottom. Only by competing to be unique can an organisation achieve sustained, superior performance.*
>
> *Chapter 2. The Five Forces: Competing for Profits. We'll see that competition is much more than a direct contest between rivals over who gets the sale. It's a broader struggle over profits, a tug-of-war over who will capture the value an industry creates. Porter's best-known framework, the five forces, helps you visualise the competition for profits at work in every industry. Any assessment of your competitive arena must start here. Using the five forces to declare an industry attractive or unattractive isn't*

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[80] Magretta, J. (2012) *Understanding Michael Porter - The Essential Guide to Competition and Strategy*, Boston, MA: Harvard Business Review Press.

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the point, although that's a common misperception. Instead, use the framework to gain insight about your industry's performance and your own.

Chapter 3. Competitive Advantage: The Value Chain and Your P&L. Managers use the term competitive advantage so loosely that it has come to mean almost anything an organisation thinks it is good at. Porter's definition is more rigorously grounded in economic fundamentals. Properly understood, competitive advantage allows you to follow the precise link between the value you create, how you create it (your value chain), and how you perform (your P & L).'

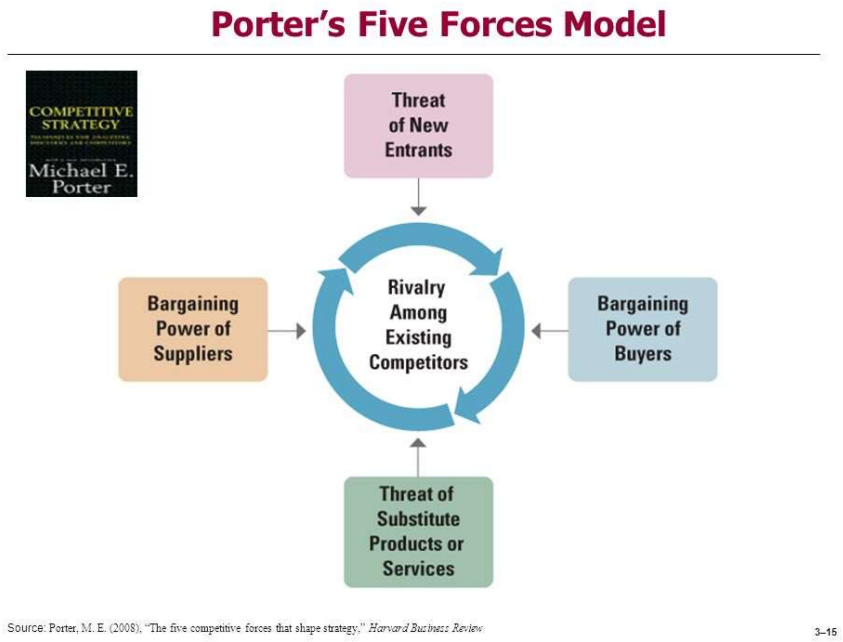

Figure 2-29: The Five Competitive Forces That Shape Strategy (Porter, 2008)[81]

The layman's understanding of Competitive Advantage is that it is an instrument used to beat one's enemies. Porter, on the other hand, defines Competitive Advantage as *'creating value',* and by doing so, differentiate the enterprise from its rivals. The value chain will be a differentiator and the outcome profitability better than the industry average the enterprise operates within.

[81] Porter, M.E. (2008) *The Five Competitive Forces That Shape Strategy*. Special Issue on HBS Centennial. Harvard Business Review 86, no. 1 (January 2008): 78–93.

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2.3.4.1 A Competitiveness Assessment Model

The World Economic Forum (WEF, 2008)[82] located in Switzerland, has laid the groundwork about the measurement of competitiveness. The WEF considers 12 major pillars/measurement categories to quantify competitiveness at a macro (country) level:

- Pillar 1: well-functioning public and private institutions
- Pillar 2: proper infrastructure
- Pillar 3: a stable macroeconomic framework
- Pillar 4: good health and primary education
- Pillar 5: higher education and training
- Pillar 6: efficient product markets
- Pillar 7: efficient labour markets
- Pillar 8: efficient financial markets
- Pillar 9: the ability to harness the benefits of existing technologies
- Pillar 10: market size
- Pillar 11: producing new and different goods using the most sophisticated production processes
- Pillar 12: through innovation.

The contribution to success in the macro (country) level, however, happens at the micro (enterprise) level. To understand the enterprise's competitive position, one must be able to measure the competitiveness of the company. This need has given rise to models and frameworks that intend to assess the enterprise's competitiveness position. Such a framework is depicted in figure 2-30 below where Cetindamar & Kilitcioglu (2013)[83] defined three such pillars:

- Pillar 1: Outcome Indicators are contributing 40% of the value of the competitiveness factor. The outcome indicators are defining elements contributing to customer and society, growth, export, value-add and profit.
- Pillar 2: The Application of Resources contributes to 30% of the indicator. These resources include human resources, technology innovation and design as well as money.
- Pillar 3: The managerial process and capability count for the remaining 30% and include the ability to develop processes and systems, leadership as well as the

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[82] Chikan, A. (2008) *National and firm competitiveness: a general research model.* Competitiveness Review, Vol. 18 Nos 1/2, 20-8.

[83] Cetindamar, D. & Kilitcioglu, H. (2013) *Measuring the competitiveness of a firm for an Award System.* Competitiveness Review: An International Business Journal Incorporating Journal of Global Competitiveness, 23(1), 7–22.

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sustainability of the strategies.

Major awards available in the world like *'The Most Competitive Company of the Year'* given in the UK, *'The International Growth European Federation of Quality Management (EFQM) Excellence Award'* in Europe as well as the *'Malcolm Baldrige National Quality Award'* in the United States are all based on similarly structured approaches.

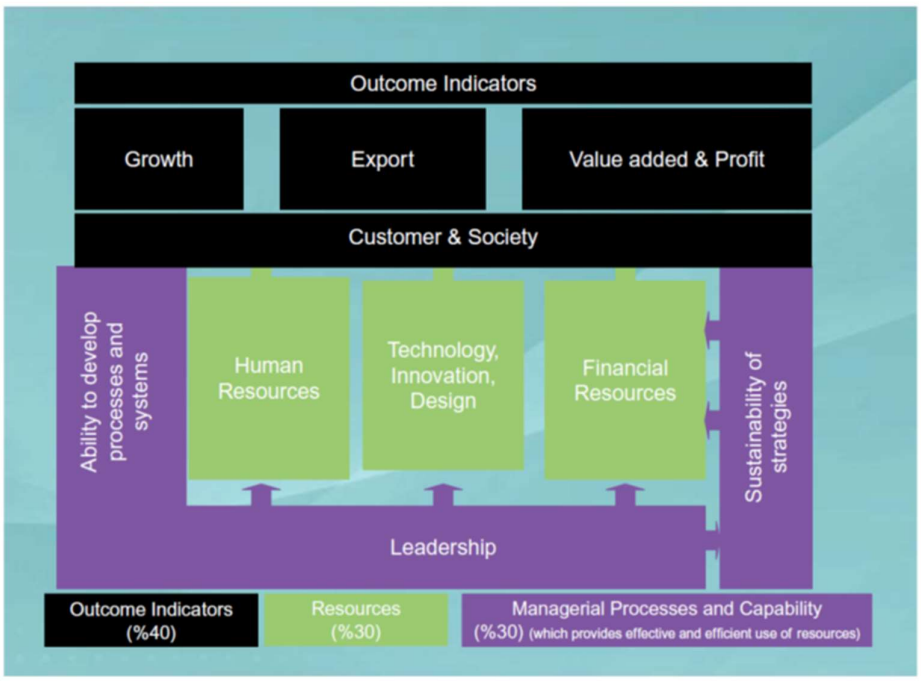

Figure 2-30: Measurement of Competitiveness of an Enterprise (Cetindamar et al., 2013)

2.3.4.2 An Ontology-Based Competitiveness Model

An alternative way to analyse the competitiveness of a firm is to use ontologies or roadmaps. According to Deliyska & Stoenchev (2010)[84] the ontology schema of firm competitiveness has several levels as defined in figure 2-31 as follows:

- The upper level of **meta-ontology** used for expressing high-level concepts of competitiveness as a rule;
- The second tier of **domain ontologies** used for declaring domain-dependent concepts and relationships but still independent from the specific physical environment;
- The third level of **application ontologies** characterised by the instantiation of the concepts described at the second level and related to firm competitiveness in specific business sectors;

[84] Deliyska, B. & Stoenchev, N. (2010) *Ontology-Based Model of Firm Competitiveness*. Editors: Venkov, G., Pasheva, V., & Kovacheva, R., CP1293, Application of Mathematics in Engineering and Economics – AMEE-10. Copyright 2010 American Institute of Physics, pp. 271–278.

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- The bottom level is covering **task ontologies** about methods and algorithms of firm competitiveness calculation.

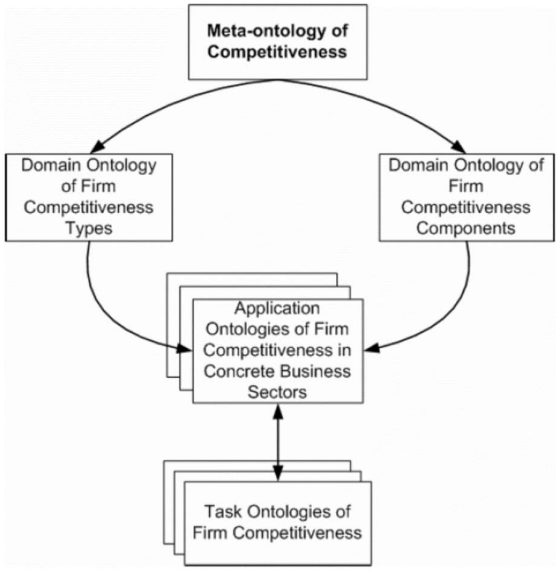

Figure 2-31: Ontology-Based Model of Firm Competitiveness (Haiguang et al., 2011)

These various levels of ontologies are used to develop detail roadmaps for a specific case. Haiguang et al. (2011)[85] defines four typical application patterns of the roadmaps. One can set the application of roadmaps in a Generic, a Partial and a Specific and an Incidence hierarchy based on this framework of ontologies.

2.3.4.3 An Innovation Capability Maturity Model

Katz's (2006)[86] consolidation of the innovation themes in literature rendered the following definition for innovation: *'the successful generation, development and implementation of new and novel ideas, WHICH introduce new products, processes and/or strategies to a company OR enhances current products, processes and/or strategies LEADING TO commercial success and possible market leadership AND creating value for stakeholders, driving economic growth and improving standards of living'* (capitals original).

Essmann & Du Preez (2009)[87] identified one prominent innovation principle that unifies this extensive literature on innovation: *'innovation is crucial for creating and sustaining organisational competitive advantage.'*

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[85] Haiguang, F., Hongyun, W. & Ronghuai, H. (2011) *A Roadmap of System Environment to Ubiquitous Learning and its Application Patterns*. Information Technology and Artificial Intelligence Conference (ITAIC), 2011 6th IEEE Joint International , vol.2, no., pp.168,171, 20-22.
[86] Katz, B. (2006) *The Integration of Project Management Processes with a Methodology to Manage a Radical Innovation Project.* Master"s Thesis in Industrial Engineering, Stellenbosch University.
[87] Essmann, H. & du Preez, N.D. (2009) *An Innovation Capability Maturity Model: Development and Initial Application*. Department of Industrial Engineering, S.U. ICIMT, pp. 1–15.

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They also identified the organisational ingredients of innovation capability and incorporated them into an Innovation Capability Maturity Model called the ICMM V2 based on the original Capability Maturity Models of the Software Engineering Institute, Carnegie Mellon University (2002)[88]. This model is depicted in figure 2-32 below:

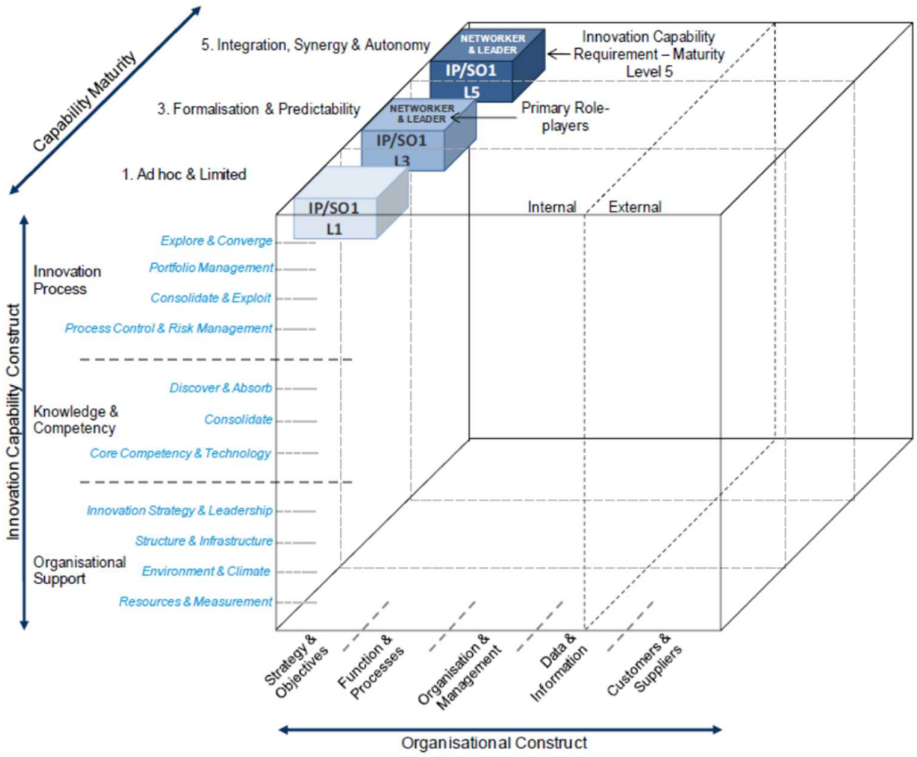

Figure 2-32: ICMM v2 framework (Essmann & Du Preez, 2009)

The Integrated Competitiveness Maturity Model consists of three main elements.

- The first is a framework that provides the model with the required functional structure for defining Capability Maturity ranging from level 1 to level 5.
- The second element addresses the core processes needed to innovation capability – aptly named Innovation Capability Construct. These processes are organised around the Organisational Support, the Knowledge and Competencies, as well as the Innovation process.
- The third facet of the model deals with the Organisational Construct that is required for innovation.

[88] CMMI Product Team. (2002) *Capability Maturity Model® Integration (CMMI®), Version 1.1, CMMI® for Systems Engineering, Software Engineering, Integrated Product and Process Development, and Supplier Sourcing* (CMMI-SE/SW/IPPD/SS, v1.1). Carnegie-Mellon Software Engineering Institute, Pittsburgh.

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2.3.4.4 Agility

Teece (2007)[89] defines agility (dynamic capabilities) as the capacity to '*recognise and shape opportunities and threats, to seize opportunities, and to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets.*'

The acquisition and deployment of these tangible and intangible dynamic capabilities (figure 2-33) lie at the core of enterprise success (and failure) as reflected in the Interactive Supply Framework in the next chapter.

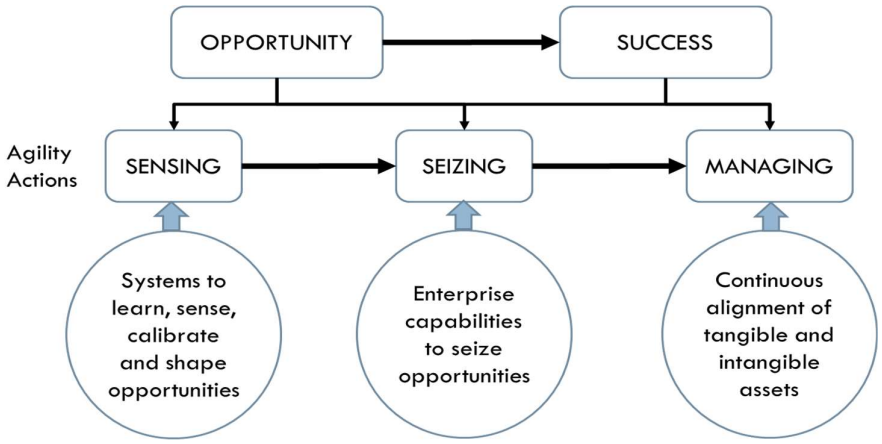

Figure 2-33: Agility (Dynamic Capabilities) Framework (Teece, 2007)

For the Agility Framework to function, the enterprise must use sensing, seizing and reconfiguring mechanisms to direct and apply its financial resources in line with marketplace requirements and opportunities.

Dynamic capability, as defined above by Teece (2007), is a meta-competence that overarches operational competence. It allows the enterprise not only to invent but also to innovate profitably. These required managerial agility attributes that support the dynamic capabilities cannot be outsourced. Understanding and implementing the processes and structures that support dynamic capabilities are enterprise specific and require intimate knowledge of both the enterprise and the environment in which the enterprise cooperates and competes.

2.3.5 Enterprise's Operational Fitness

Dierickx & Cool (1989)[90] identified the importance of processes for efficiency and effectiveness of intercompany coordination to achieve the enterprise's objectives. The operational processes are part of the conceptual foundation for developing a framework needed to understand the evolution of firm competitiveness.

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[89] Teece, D.J. (2007) *Explicating Dynamic Capabilities: The Nature and Micro Foundations of (Sustainable) Enterprise Performance.* Strategic Management Journal, (August), pp. 1319–1350.
[90] Dierickx, I., & Cool, K. (1989). *Asset Stock Accumulation and Sustainability of Competitive Advantage.* Management Science, pp. 35, 1504 – 11.

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A few examples are:

- Process Waste Management through the application of Lean Principles
- Visible Control Systems
- Quality Improvement Drives (Get to Green Plans)
- Productivity Drives
- Application of Quality Standards
- The core of the South African Business Excellence Model
- People Development
- Supply Chain Development
- The deployment and application of knowledge as part a Knowledge Management Process

Schumpeter (1934)[91], previously defined the following factors relevant to enterprise development and success:

- The introduction of new products
- The introduction of new methods of production
- The opening of new markets
- Development of new sources of supply for raw materials or other inputs
- Creation of new market structures in the industry

If one considers the Global Competitiveness between countries it must be recognised that the enterprises within those countries contribute towards its competitive position. The World Economic Forum (2010)[92] identifies the following enhancement factors indicated as:

Basic requirements

- Institutions
- Infrastructure

Efficiency Enhancers

- Macroeconomic environment
- Higher Education and Training
- Goods market efficiency
- Labour market efficiency

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[91] Schumpeter, J.A. (1934) *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle.* London: Oxford Univ. Press.
[92] World Economic Forum (2010) *WEF the Global Competitiveness Report* GCR, WEF Pub. 2010.

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- Financial market development
- Technological readiness

Innovation and sophistication factors

- Business sophistication
- Innovation

As can be deducted from the above non-exhaustive list there is a legion of approaches that can be applied to solve the operational fitness problem.

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2.4 Customer Domain: Strategic Activities and Market Dynamics

2.4.1 Customer Defined

Investopedia (2017)[93] defines a customer as '*An individual or business that purchases the goods or services produced by a business. The customer is the end goal of businesses since it is the customer who pays for supply and creates demand. Businesses will often compete through advertisements or sales to attract a larger customer base.'*

The Business Dictionary (2017)[94] holds two specific definitions:

External customer: *'A party that receives or consumes products (goods or services) and can choose between different products and suppliers.'*

Internal Customer: *'Entity within a firm who establishes the requirement of a process (accounting, for example) and receives the output of that process (a financial statement, for example) from one or more internal or external suppliers.'*

The Interactive Supply Framework sees an external customer as an entity that acquires products and services from an enterprise to satisfy a real or perceived need measured against a stated or intrinsic value system. True customer value realisation is the required result.

The three-tier view of the customer domain namely market strategies, market dynamics and customer value realisation is reviewed below.

2.4.2 The Market Strategy vs. The Product and Enterprise Life Cycle.

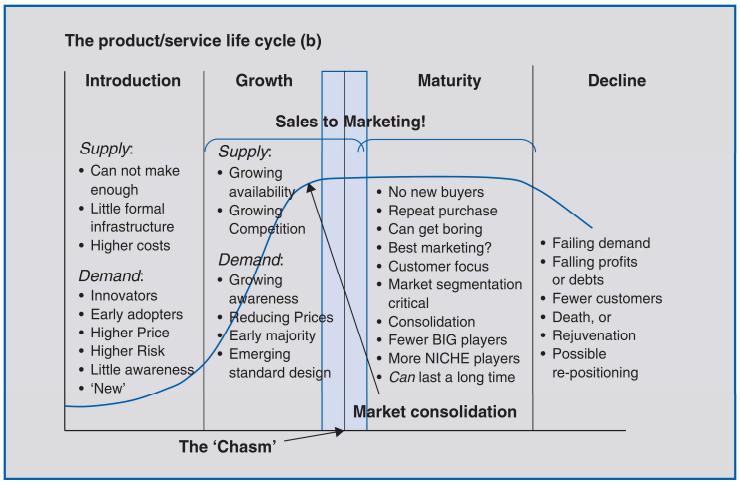

Figure 2-34: The Enterprise Life Cycle and the effect on Supply and Demand. (Fifield, 2008)

Figure 2-34 defines the market consolidation superimposed on the enterprise life cycle.

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[93] *Customer,* (2017) Investopedia LLC. Available at: http://www.investopedia.com/terms/c/customer.asp [Accessed September 2015].

[94] *Customer,* (2017) BusinessDictionary.com. WebFinance, Inc. Available at: http://www.businessdictionary.com/definition/customer.html#ixzz3moYxmJMX [Accessed September 2015].

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In this figure, a 'Chasm' that defines the transition point between sales to marketing coincides with the transition between the growth and maturity phases of the enterprise life cycle (Fifield, 2008)[95].

The maturity of the market introduces a whole new challenge for a growing business as in the period of rapid growth the marketing function needs to focus on:

- The management of the product or service
- Managing the sales operation
- Managing the growth of the enterprise.

When the market matures, however, the entire focus moves from an internal effort towards the customer. In this period, the enterprise should focus on:

- Understanding the customer's needs
- Concentrating on the selected market segments only
- Understanding what makes the product or service unique
- Taking care of the company brand created
- Aligning all the business functions to the constantly evolving customer needs.

The skill set required for this new focus is vastly different to the one necessary for the growth phase and gives rise to the chasm as defined before and ultimately can lead to the company's demise.

2.4.3 The Historical development of the Marketing Strategies

Saren and Steward (2014)[96] in the Marketing Pathfinder describes the marketing strategy development approaches during the past years as:

- ***Functionalist:*** *'The functionalist approach studies marketing behaviour as a system and tries to establish ways of making it work better, more efficiently. It is associated with the great marketing theory pioneer, Wroe Alderson (1957)[97], writing in the 1950s and 1960s. Academic study and development of marketing as a separate discipline is primarily a twentieth-century occurrence. It corresponds to the increasing distance of the producer from the final consumers, over whom manufacturers have thus lost control and influence, with distributors, agents and retailers filling the gap.'*

- ***Managerialist:*** *'The next development shifts the focus from a functionalist-systems approach to analysing markets to one which focused on managerial and buyer behaviour. The managerial and buyer behaviour view of the 1960s and 1970s*

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[95] Fifield, P. (2008) *Marketing Strategy Masterclass: Implementing Marketing Strategy.* Oxford UK: Butterworth-Heinemann, pp. 37 - 40.

[96] Saren, M. & Stewart, D. (2014) *The Marketing Pathfinder, Key Concepts and Cases for Marketing Strategy and Decision Making.* (S. Cummings & D. Angwin, Eds.). West Essex, UK: Wiley.

[97] Alderson, W. (1957) *Dynamic Marketing Behaviour: A Functionalist Theory of Marketing.* Homewood, IL: Richard D. Irwin.

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studied individual firms and consumers to discover how to control their market behaviour to maximise their profit (firms) and satisfaction (consumers). The buyer behaviourist view regarded the consumer as a conditioned organism, open to reconditioning and treated as a "behaving machine", performing cognitive functions within a black box (Shankar & Horton, 1999)[98] *Managerial Marketing attempts to influence the behaviour of this "buyer machine" through manipulating the so-called marketing mix or 4Ps of product, place, promotion and price.'*

- ***Collaborative:*** *'Another view of marketing's boundary management role highlights the fact that buyers and sellers do not only compete for the best deal, they must also often collaborate. This emphasis developed mainly due to the wider influence of the business thinking and culture of firms from the Far East and Asia.' Webster (1992)*[99]

- ***Relational:*** *'The move towards the relational approach to managing marketing boundaries began to become popular in the early 1990s when some academic authors and marketing practitioners began to criticise the materialist- marketing mix approach for its essential product orientation as opposed to customer orientation.' Grönroos (1994)*[100]

The relational approach to marketing by Möller & Halinen (2000) from a combination of ideas in business development, information technology-enabled developments, and the wider application of some main features have developed further due to some reasons:

- Fragmentation of mass markets due to the enabling information and communication technologies,
- Our ability to collect and analyse more data about groups and individual customers,
- The drive to higher levels of product quality that causes companies to seek competitive advantage in different ways,
- Ever increasing and more demanding customers and
- Rapidly changing customer buying patterns.

2.4.4 Marketing Principles and Fundamentals

There are ten fundamentals in marketing to consider, according to Della Mura (2009)[101].

- ***'The only action creates action*** *– what marketing is and why one needs it*
- ***Know your business*** *– what it is, how it is, where it is heading*
- ***Know your market*** *– the four 'C' words that can determine your success*

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[98] Shankar, A. & Horton, B. (1999) *Ambient Media: Advertisings now media opportunity?* International Journal of Advertising, 18(3): 305–321.
[99] Webster F.E. (1992) *The Changing Role of Marketing in the Corporation, Journal of Marketing.* 56, October 1–17.
[100] Grönroos, C. (1994) *Quo Vadis, Marketing? Toward a Relationship Marketing Paradigm.* Journal of Marketing Management, 10, 347–360.
[101] Della Mura, J. (2009) *Marketing Tool Kit.* 1st Edition. Oxford, UK: Published by How to Content, A division of How to Books Ltd.

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- ***Know thine enemy*** *– your customers will know them, shouldn't you?*
- ***Knowledge is power*** *– making your market research work*
- ***Choosing the right customers*** *– find the best ones, know what they want*
- ***Pick your destination*** *– weigh the options and set your agenda*
- ***Planning for success*** *– forget the plans, but don't ignore the planning*
- ***Raise your flag*** *– help customers to see you and understand you*
- ***Shout from the rooftops*** *– the crucial role of marketing communications'.*

Della Mura (2009) also defined the following *'Stepping Stones to Success in the Marketing Domain*:

- **Building a brilliant brand** – creating great value from great values. *'Build customer loyalty with credible trust and warm reassurance, not bribes and offers. It is about creating great value from great values.'*
- **Measuring performance** – what works, what doesn't and what next? *'Conscientious assessment of day-to-day activity or marketing effort will help you identify what works, what doesn't and what next.'*
- **Think strategically** – know why you're doing it before you do it. *'There's an advantage to be had in knowing exactly why you are doing what – preferably before you do it.'*
- **Sales and selling** – *'the cold facts about warming up sales.'*

The road to success of the future organisation will, therefore, be customer-focused, as opposed to product or technology focused, and will include, by a market-information competence, links to the customer's real needs to enable the organisation's processes to deliver true value.

Hooley et al. (2008)[102] defined a set of six marketing principles, namely:

- **Principle 1: Focus on the customer:** The first principle originates from the marketing concept itself. We recognise that the objectives of the organisation will be supported if one concentrates on the customer.
- **Principle 2: Only compete where you can establish a competitive advantage:** It is sensible to pick markets and opportunities where the propensity for success is very high.
- **Principle 3: Customers do not buy products:** The customer always seeks a solution to a specific problem and not a product or service. Customers do not buy products; they buy what the product can do – the problem it solves.

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[102] Hooley, G., Piercy, N. F. & Nicoulaud, B. (2008) *Marketing Strategy and Competitive Positioning.* 4th Edition. Edinburgh Gate, Harlow, Essex, UK: Pearson Education Limited.

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- **Principle 4:** Marketing is too important to leave it to the marketing department: Marketing is everyone's job in the organisation.
- **Principle 5: Markets are heterogeneous:** Markets consist out of different organisations, and individuals within these organisations and can be many layers deep.
- **Principle 6: Markets and customers are constantly changing:** Markets are dynamic, and all products have a limited life span that suddenly expires when a new or better way of servicing the need of the customer appears.

2.4.5 Marketing Processes

Webster (1997)[103] describes marketing as *'the design and management of all business processes necessary to define, develop and deliver value to customers.'*

He further suggests that these marketing processes should include the following:

- **Value-defining processes:** processes that allow the organisation to understand the environment in which it conducts its business better, to apply its resources and capabilities with more focus, to enhance its position in the marketplace and to assess the value it creates.
- **Value-developing processes:** processes that create value, such as a procurement strategy, new product development, design of distribution channels, vendor selection, strategic partnerships, pricing strategy and, ultimately, the development of the value proposition for customers.
- **Value-delivering processes:** processes that deliver value to customers including service delivery, customer relationship management, management of distribution and logistics, communications processes, customer support services and the deployment of the field support.

2.4.5.1 Dynamic marketing capabilities

The generation and application of dynamic capabilities are part of the resource-based strategy literature today. Broadly speaking dynamic capabilities are defined as the ability to create new resources in changing markets, since vibrant marketing capabilities create new marketing resources to recognise, react to and embrace change. The ability to continuously pair market needs in an ever-changing competitive market with the company products forms the basis for an effective marketing strategy.

Following the typology suggested by Wang & Ahmed (2007)[104], dynamic capabilities are split into three main groups: absorptive capability, adaptive capability and innovative capability shown in figure 2-35 below.

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[103] Webster, F.E. (1997) *The Future Role of Marketing in The Organization.* in D.R. Lehmann and K.E. Jocz (editors), Reflections on the Futures of Marketing, Cambridge, MA: Marketing Science Institute.
[104] Wang, C.L. & Ahmed, P.K. (2007) *Dynamic Capabilities: A Review and Research Agenda.* International Journal of Management Reviews, 9 (1), 31–51.

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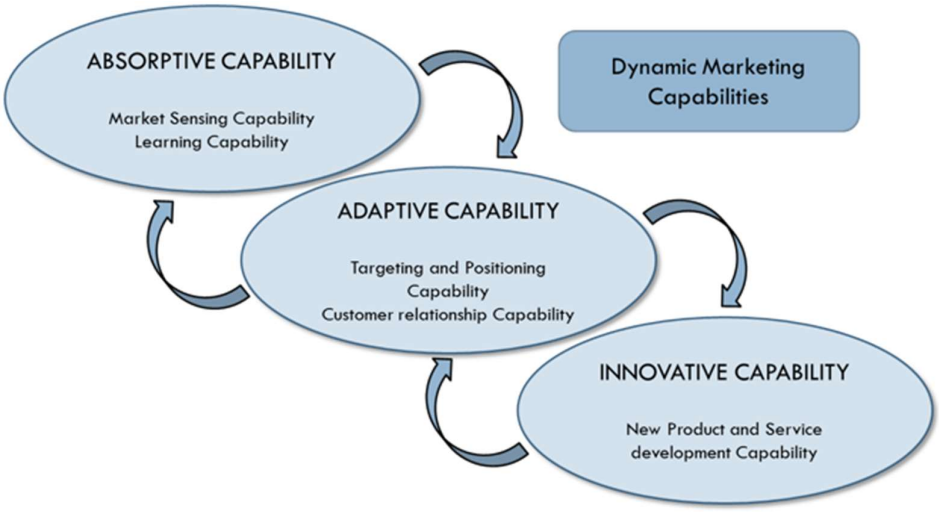

Figure 2-35: Dynamic Marketing Capabilities (Wang & Ahmed, 2007)

Absorptive capabilities

The ability to identify value from new information on the current market and to assimilate it, is defined as the process of absorptive marketing capability. This process focuses on the acquisition and understanding of market intelligence and includes the two capabilities of:

- **Market Sensing:** The ability to understanding the changes in the marketplace regarding product demand, customers, competitors and wider macro-environmental factors is an essential part of a dynamic marketing strategy.
- **Learning:** The capability to learn is essential to maintain long-term competitive advantages over the competition. Continuous learning is required for surviving in the dynamic and competitive market as it makes the firm capable of acquiring and assimilating external knowledge.

Adaptive capabilities

Adaptive capabilities focus on the process to identify and capitalise on new and emerging market opportunities. Adaptation implies doing things differently in reaction to external stimuli and includes the following capabilities:

- **Market targeting and positioning:** Market targeting and positioning capabilities are defined as the ability to identify new opportunities and to decide on best-fit market targets, where the firm's resources and capabilities are in support and aligned for the best result.
- **Customer relationship management:** Customer relationship management process includes the acquisition, retention, expansion and, when needed, the termination of customer relationships. The ability to kindle and manipulate healthy customer relationships forms one of the key elements of the Interactive Supply Framework.

Innovative marketing capabilities

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New product and service development: As defined before, the ability to innovate and develop the next generation of goods and services is the cornerstone of any enterprise. Effective new product development includes both needs based (customer sensing) capability as well as appropriate R&D skills to perform this task successfully.

2.4.6 Customer Interface

2.4.6.1 Customer Relationship Management Cycle

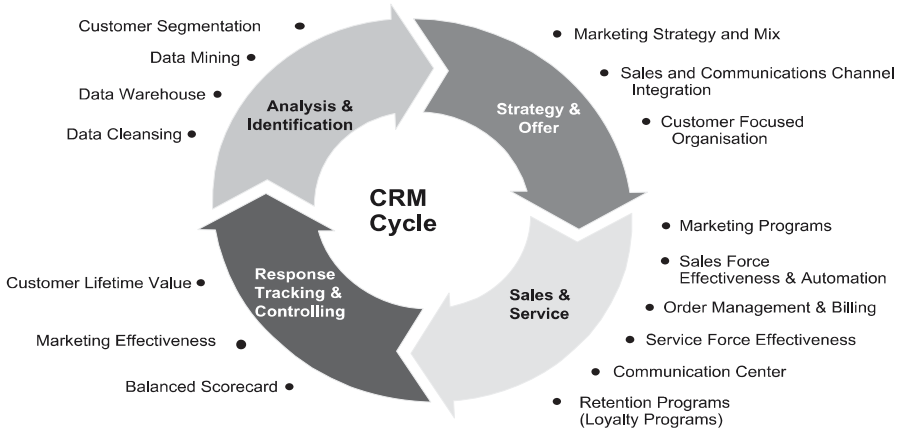

Figure 2-36: Customer Relationship Management Cycle (Strauss, 2008)

The cultivation and maintenance of a sustainable customer relationship are depicted as the Customer Relationship Management or CRM process in figure 2-36 above (Strauss, 2008)[105]

This CRM cycle consists of the following phases:

- Analysis and Identification
- Strategy and Offer
- Sales and Service
- Response Tracking and Controlling.

Specific tools, processes and databases are available to support the CRM phases.

[105] Strauss, R.E. (2008) *Marketing Planning by Design, Systematic Planning for Successful Marketing Strategy*. A John Wiley & Sons, Ltd., Publication.

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2.4.6.2 Value Chain Marketing (VCM)

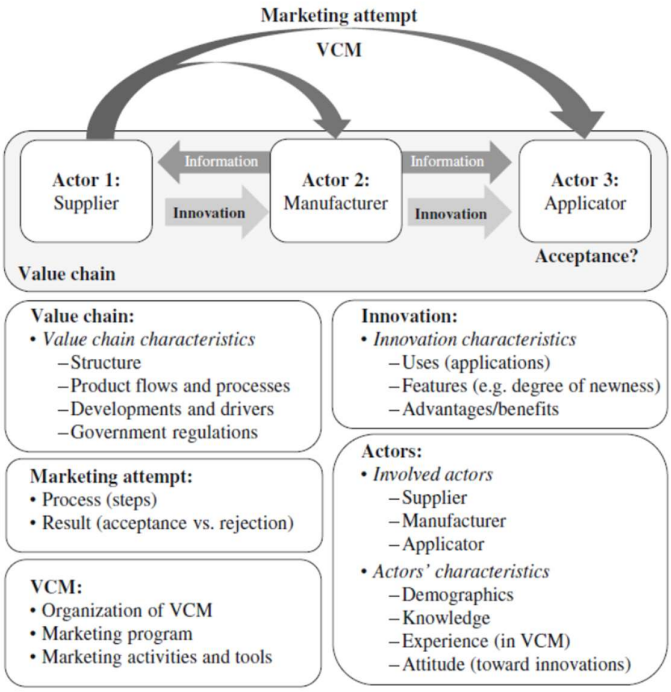

Figure 2-37: Conceptual framework of Value Chain Marketing VCM (Mesak & Darrat, 2003)

Mesak & Darrat (2003)[106], as well as Jones & Ritz (1991), [107] concluded that products that do not satisfy the real customers' needs would not succeed. This notion gave rise to the value chain marketing concept where the downstream custom is involved in defining the product or service.

2.4.6.3 Integrated Marketing Communication (IMC)

The new marketing paradigm is defined as Integrated Marketing Communication by the Business School, University Nankai, Tianjin People's Republic of China (Shin, 2013)[108]. Therefore, integrated marketing communications (IMC) revised Jerome McCarthy's 4Ps (Product, Price, Place, Promotion) and Robert F. Lauterborn's 4Cs theory (Consumer, Cost, Communication, Convenience). The IMC theory aims to satisfy the needs of the complicated and ever-changing marketplace, and it may be that the age of the "Communication Synergy" has arrived.

We conclude that marketing is the result of integrated and interactive communication between enterprises and their customer base.

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[106] Mesak, H.I. & Darrat, A.F. (2003) *An Empirical Inquiry into New Subscriber Services under Interdependent Adoption Processes.* 6(2): pp. 180–192.

[107] Jones, J.M. & Ritz, C.J. (1991) *Incorporating Distribution into New Product Diffusion Models.* 8(2): pp. 91–112.

[108] Shin, K. (2013) *The Executor of Integrated Marketing Communications Strategy: Marcom Manager's Working Model.* Heidelberg, New York, Dordrecht, London: Springer.

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In practice, the application of IMC has morphed to a strategic level and it has become widely used in all the stakeholder interactive relationship management processes. Robert Dilenschneider (1991)[109] believes that the market environment factors are the driving factors for the emergence of IMC theory, from the two perspectives, inside and outside, while Thomas Duncan (2002)[110] concludes that the external driving factors to the emergence of IMC consist of the increasingly complex relationships.

Sound customer relationship management and the need to supply value to the customer have caused customer communication to be indispensable. IMC therefore becomes an important channel for the company to deliver perceived and real value to the customers. According to Duncan & Everett (1993)[111] the strategic integration of the various communications functions used by marketing is what makes IMC a new approach to reaching consumers and other stakeholders. The application of an IMC program defines one basic communications strategy for each major target audience.

Duncan & Moriarty (1999)[112] proposed an alternative and more comprehensive view:

- **A value field of interactions**

  The notion that companies exist within a linear value chain has changed to a value field where all stakeholders interact simultaneously. All these interactions from suppliers, distributors and even competitors affect the brand value.

- **Stakeholders overlap**

  Stakeholders overlap and interact and can even be the same person as the employee stakeholder group where an individual may also be a customer, an investor and a voter in the local community. The only consistent message in such a complex world is one that is based on the company's core values that do not change over time.

- **Integrity builds trust**

  Integration means unity of effort or purpose. An integrated organisation interaction is more consistent, its reputation clearer and its stakeholders more trustful. Integration, therefore, produces integrity by working together rather than as a collection of disjointed parts. Integrated functions are perceived as being more trustworthy thus building and sustaining relationships.

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[109] Dilenschneider, R.L. (1991) *Marketing Communications in the Post Advertising Era.* Public Relations Journal 17(Fall): 227–236.

[110] Duncan, T.R. (2002) *IMC: Using Advertising and Promotion to Build Brands*. McGraw–Hill/Irwin, New York.

[111] Duncan, T.R. & Everett, S.E. (1993) *Client Perceptions of Integrated Marketing Communications*. J Advertising Res 33(3): 30–39.

[112] Duncan, T.R. & Moriarty, S.E. (1999) *A Communication-Based Marketing Model for Managing Relationships*. J Mark 62: pp. 1–13.

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- **Brand equity equals support**

  Just as brand value is the result of a brand's loyal customers, brand equity is the product of a company's stakeholder decisions and actions.

  All stakeholders, not just customers, choose to what extent they support a company and its brand. People choose where they work; investors choose investment opportunities, and customers have an ever-increasing choice of what they purchase. In other words, peoples' choice causes them to be stakeholders.

  Being stakeholders give them the right to understand and influence what a company does. A brand, therefore, exists in people's minds; they own it, as much as it is owned by the business and its owners.

- **Profitability is the relationship bottom-line**

  There are two main processes to consider for optimisation of profitability. One can simply increase revenue from sales or decrease costs. Therefore, all stakeholders can affect the bottom line as their actions can have an impact on costs, as well as revenues.

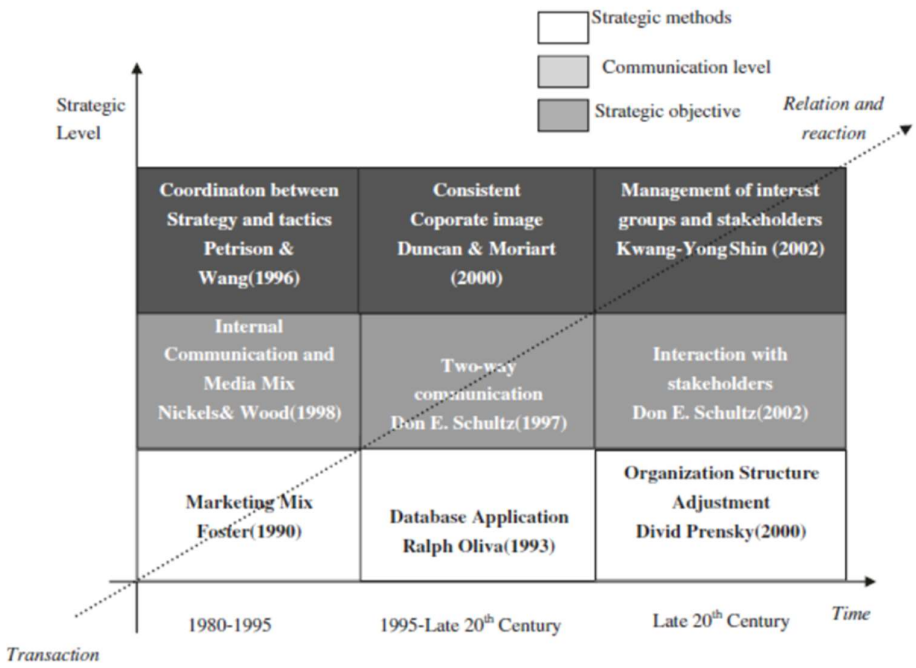

Figure 2-38: Clear IMC Theory Development. (Qu, 2005)

Qu (2005)[113] postulates a possible way of implementing the IMC theory within an enterprise, based on a study of all the marketing models previously defined. This model is consistent in that it also uses the strategic to transactional (operational) continuum as the basis, as does the Interactive Supply Framework. This IMC theory development is shown

[113] Qu, F. (2005) *Research on the Implementation Mechanism of IMC Strategy.* MA thesis Department of Business Administration, Nankai University, Tianjin.

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in figure 2-38.

2.4.6.4 Customer Relationship Management (CRM)

The executives and leaders in the organisation of the business environment and the organisation's relationship with its customers, define the approach adopted to manage the marketing touch points of any organisation.

Increasingly, business leaders agree that customers are their most valuable assets going into the future and view customer relationships as extremely important and of real value.

The notion of mutually beneficial exchanges (or interactive events) is more important if Vargo & Lusch (2004)[114] are correct in stating that the customer is always a *'co-creator of value'*.

Payne (2000)[115] defined the difference between transactional and relationship marketing in Table 2-2 below.

Table 2-2: Transactional vs. Relationship Marketing Approaches (Payne, 2000)

Transactional Marketing	Relationship Marketing
Focus on single sales	Focus on customer retention
Orientation to product feature	Orientation to customer value
Short timescale	Long timescale
Little emphasis on customer service	High customer service emphasis
Moderate customer contact	High customer contact
Quality is primarily a concern of production	Quality is the concern of all
Limited customer commitment	High customer commitment

According to Srivastava et. al. (1999)[116], the formation and maintenance of relationships with external marketplace stakeholders' entities in a business-to-customer (B2C) context are typically captured by the concept of customer relationship management (CRM).

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[114] Vargo, S. & Lusch, R. (2004) *Evolving to a New Dominant Logic for Marketing.* Journal of Marketing, 4, January, 1–17.

[115] Payne, A. (2000) *Relationship Marketing: Managing Multiple Markets.* In Cranfield School of Management, Marketing Management: A Relationship Marketing Perspective. MacMillan Press Ltd.

[116] Srivastava R.K., Shervani, T.K. & Fahey, L. (1999) *Marketing, Business Processes, and Shareholder Value: An Organizationally Embedded View of Marketing Activities and the Discipline of Marketing.* Journal of Marketing, 63, 168–179.

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2.4.6.5 Understanding the Customer

Figure 2-39: Understanding the Customer, the key Questions (Saren and Steward, 2014)

In figure 2-39 we show that understanding the customer includes specific answers to six general questions (Saren & Steward, 2014).

The six general questions are:

- Who buys and who consumes?
- What are their criteria used for decision making?
- When do they intend to buy or use the product?
- Why do they buy or use the product?
- Where do they prefer to purchase the product?
- How do they intend using this product?

From the answers to the above questions, the enterprise will be able to know their customer and start a positive relationship which, as seen before, is an essential requirement for success.

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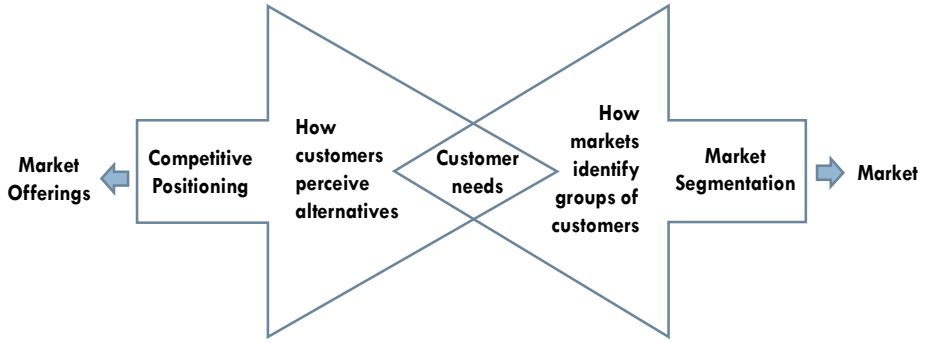

Figure 2-40: Competitive Positioning and Market Segmentation (Saren & Steward, 2014)

Saren & Steward (2014) describe the relationship of competitive positioning and market segmentation in figure 2-40 above.

- **Competitive positioning:** Customers' viewpoint of alternative offerings in the marketplace.
- **Market segmentation:** Segregation of the market as viewed from the marketer with a distinct difference between the groups.
- **Customer needs:** The needs of the customer identified by the combined view of the competitive products and market segregation or grouping of similar product offerings. In defining these requirements, the most basic form of segregation focuses on the customer value that matters most to different types of customers, while the best competitive positions are those where customers realise that a product offering is the one they want because it best meets their needs.

2.4.7 Customer Value Realised

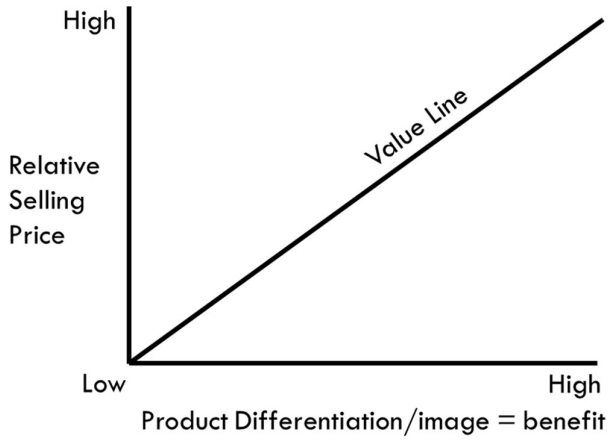

Figure 2-41: Customer values. (Source: Adapted from Leszinski & Marn, 1997)

In figure 2-41 Leszinski & Marn (1997)[117] defines the customer value based on the

[117] Leszinski, R. & Marn, M. (1997) *Setting Value, not Price.* McKinsey Quarterly, February.

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combination of the relative selling price to the customer and the product differentiation and image factors thereby defining a real benefit to the customer.

Weiber & Weber (2001)[118] define the Life Time Value to the customer as a summation of the following factors:

- Attributable revenue from transactions with the customer in a given period
- Attributable cost of the revenue during the same period
- The non-transaction based attributable costs of business relationship in the same period
- Length of the business relationship.

$$CLV_C = \sum_{t=1}^{T} \frac{\left(\sum_{U=1}^{U} R_{cut} - C_{cut}\right) - C_{ct}}{(1+r)^{t-1}}$$

where

CLV_C	CLV for customer (c)
R_{cut}	Attributable revenue from transaction u with customer c in period t
C_{cut}	Attributable costs of transaction u with customer c in period t
C_{ct}	Non-transaction based, attributable costs of the business relationship with customer c in period t
T	Length of the business relationship in periods
U	Number of transactions in a period
r	Hurdle rate

Figure 2-42: Calculation of the Customer Lifetime Value (Weiber & Weber, 2001)

From the above formula in figure 2-42, derived by Weiber & Weber (2001), one can identify the transactions as well as the non-transactional relationship with the customer as having a contribution towards the customer lifetime value. In other words, interactive events as well as a healthy business relationship's contribution to success is implied.

[118] Weiber, R. & Weber, M.R. (2001) *Customer Lifetime Value als Entscheidungsgrösse im CRM*. in Weiber, R. (ed.), Handbuch Electronic Business. Wiesbaden, pp. 473 – 503.

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2.5 Knowledge Management, Knowledge Representation and the Value of Knowledge

The Data, Information, Knowledge and Wisdom (DIKW) Pyramid was reviewed to add to the interpretation of these terms used in this dissertation. As the attributes of the product during the product- and enterprise life cycles require data presented in a relational way, one can use information as the base term. During each review milestone the information must also be evaluated in a specific context of operation and user value system hence the base term used in this dissertation is knowledge. This notion also supports the further investigation of wisdom as a human intervention factor into the process of acquisition and supply of a complex weapon system.

2.5.1 An Aristotelian View of Knowledge

A lot of our current understanding of knowledge today originated from the discussions and debates of ancient Greek philosophers such as Socrates, Plato and Aristotle. Trying to pin down the knowledge construct and to define the process of knowing itself, dominated their thinking. For these ancient Greek philosophers, knowledge was a homogenous construct that ultimately was representative of the truth. Thus, knowledge was truth (Schwartz, 2006)[119].

The Aristotelian truths are not based on any hierarchy. They are presented as discrete types of knowledge to classify all possible facets of the concept knowledge as follows:

2.5.1.1 Epistémé: Factual or Scientific Knowledge

Epistémé is pure knowledge, such as that knowledge based or derived from mathematics or logic. Like scientific knowledge, epistémé encompasses knowledge of cause and effect and deduction (Parry, 2003)[120].

2.5.1.2 Téchné: Skills-Based Technical and Action-Oriented Knowledge

Téchné is about things that change. Harnessing téchné is at once one of the most challenging and most fruitful of knowledge-management pursuits. An organisation is a primary place where one would find the bearer of téchné relevant to that organisation, and it is precisely that knowledge that the organisation seeks to encapsulate and re-use. Téchné also reflects the dynamic nature of knowledge including artificial intelligence and decision-support systems.

2.5.1.3 Phrónésis: Experiential Self-Knowledge or Practical Wisdom Based on Experience

Phrónésis is practical knowledge used to getting things done. In Aristotle's view, phrónésis is acquired through hands-on training and experiencing the actions learned. From a learning-through-action perspective, phrónésis differs from téchné regarding the knowledge that can be acquired. The Aristotelian view would be that téchné can be taught from practitioner to

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[119] Schwartz, D.G. (2006) *Encyclopaedia of Knowledge Management*. Bar-Ilan University, Israel. Idea Group Reference, Hershey. London. Melbourne. Singapore, p. 10.

[120] Parry, R. (2003) *Episteme and techne.* In E. N. Zalta (Ed.), The Stanford Encyclopaedia of Philosophy.

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student, whereas phrónésis can only shared through actual mutual experience. The value of knowledge, focusing on the knowledge-action value chain has its roots in phrónésis (Sveiby,1997)[121].

2.5.1.4 Noûs: Intuition

Noûs is the intuitive side of knowledge, as well as a large part of tacit knowledge (although there is tacit knowledge of téchné and phrónésis). Noûs is not restricted to the knowledge of first principles but is viewed by Aristotle as a way in which one can become aware of first principles.

2.5.1.5 Sophía: Theoretical Knowledge of Universal Truths or First Principles

Sophía represents the universal and necessary characteristics of knowledge. Sophía is firmly planted in the philosophical and theoretical domains. Scientific discovery argumentation and proof of theorems are all in the realm of sophía.

2.5.2 The Data, Information, Knowledge and Wisdom (DIKW) Pyramid

To obtain a clearer view of the DIKW Pyramid, the author cites DBours's blog (2017)[122] that contribute the following insights towards our understanding of the relationship between Data, Information, Knowledge and Wisdom:

The DIKW pyramid is a model that represents the functional relationships between data, information, knowledge, and wisdom as shown in figure 2-43 below.

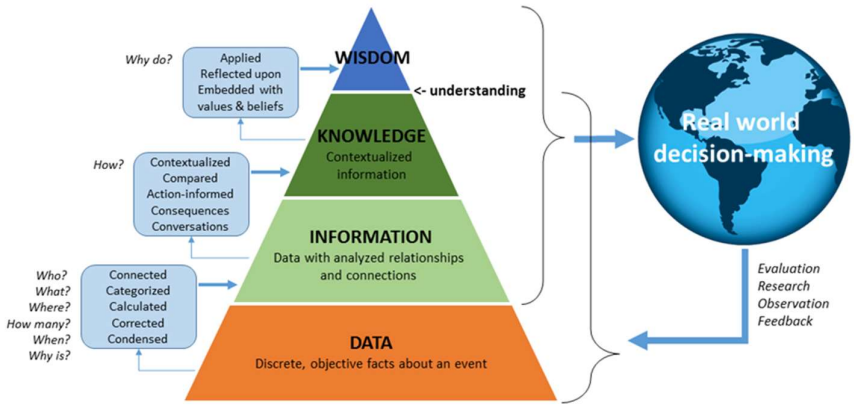

Figure 2-43: Data, Information, Knowledge to Wisdom DIKW Pyramid (DBours, 2017)

'Data comes in the form of raw observations and measurements as raw facts or chunks of facts about the state of the real world, as a symbol that attempts to capture the true picture of a real event.

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[121] Sveiby, K.E. (1997) *The New Organizational Wealth: Managing & Measuring Knowledge based Assets.* San Francisco: Berrett-Koehler Publishers.

[122] DBours Blog (2017) *The Answer is 42. On Data, Information and Knowledge.* Available at: https://www.climate-eval.org/blog/answer-42-data-information-and-knowledge [Accessed June 2017].

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Information is created by analysing relationships and connections between the data. It can answer simple 'Who/What/Where/How many/When/Why' is style questions. Information is a message with an (implied) audience and a purpose. Quite often, when we talk about 'data science' or 'data-driven decision-making' it is information and not data that feeds into the actual decision-making.

Knowledge is perhaps the concept hardest to define, and definitions may refer to information having been processed, organised or structured in some way, or else as being applied or put into action. Knowledge (explicit as well as tacit) is created by using the information for action. Knowledge answers the 'How' question. Knowledge is contextualised; a local practice or relationship that works, and can be shared by properly sharing the context that makes the information become knowledge.

Wisdom is created through the use of knowledge, through knowledge users' communication, and through reflection, i.e. by embedding values, beliefs and experience into knowledge. Wisdom answers the 'Why do' question as it relates to actions. In a sense, it is what helps us make a better-informed decision between two seemingly similar choices, or what helps us to apply knowledge toward the attainment of a common or higher good.

Any of these terms are relative concepts and knowledge can be considered as information (data) on a higher, more abstract domain-of-application level. An example: When humans make decisions and use information for action we tend to talk about knowledge.'

Sharma (2008)[123] states that *'In Knowledge Management, Russell Ackoff [is]often cited as the initiator of the DIKW hierarchy'*. His 1988 Presidential Address to the International Society for General Systems Research (ISGSR) is listed as the earliest mention of the DIWK hierarchy. Ackoff's (1989)[124] presidential address was printed in a 1989 article - From Data to Wisdom - and it does not cite any earlier sources of the hierarchy.

However, Sharma (2008) in his continued searching for the origins of DIKW, finds Milan Zeleny to be an earlier reference. In his article on Management Support Systems, Zeleny (1987)[125] details the DIKW hierarchy. Zeleny (1987) builds the knowledge hierarchy by: *'equating Data, Information, Knowledge and Wisdom to various knowledge forms: "know-nothing", "know-what", "know-how" and "know-why" respectively.'*

The study field of design also refers to the same DIKW hierarchy. Michael Cooley's book (1987)[126]: Architecture or Bee? '*builds the DIKW hierarchy during his discussion of tacit knowledge and common sense.'* Cooley (1987) also did not cite any earlier reference to the DIKW hierarchy and trail of the origin also ended here.

It is in the Information Science domain that the hierarchy is mentioned as early as 1982

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[123] Sharma, N. (2008) *The Origin of Data Information Knowledge Wisdom (DIKW) Hierarchy.* Available at: https://www.researchgate.net/publication/292335202 [Updated: February 4, 2008]
[124] Ackoff, R.L. (1989) *From Data to Wisdom.* Journal of Applied Systems Analysis 16 (1989): 3-9.
[125] Zeleny, M. (1987) *Management Support Systems: Towards Integrated Knowledge Management.* Human Systems Management 7, no 1 (1987): 59-70.
[126] Cooley, M. (1987) *Architecture or Bee?* London: The Hogarth Press, 1987.

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when Harlan Cleveland (1982)[127] wrote about it in a Futurist article. Cleveland's article also mentions the *'Information - Knowledge - Wisdom'* hierarchy in detail and gives an example.

2.5.2.1 The origin of the DIKW Pyramid

The first mention of this implied relationship in the DIKW pyramid is neither in the Knowledge Management field, nor Information Sciences, but in poetry. Cleveland (1982) cites T.S. Eliot as the person who suggested the hierarchy first. He named it *'the T.S. Eliot hierarchy'*. The poet T.S. Eliot was the first to mention the *'DIKW hierarchy'* without even calling it by that name. In 1934 Eliot[128] wrote in *'The Rock.'*

"Where is the Life we have lost in living?

Where is the wisdom we have lost in knowledge?

Where is the knowledge we have lost in information?"

2.5.3 Modern Definition of Knowledge

In the contemporary era, one finds the following definitions and descriptions of the term knowledge:

- Knowledge as state of mind, where knowledge is described as '*a state or fact of knowing*' with knowing being a condition of '*understanding gained through experience or study; the sum or range of what has been perceived, discovered, or learned*' (Schubert et al., 1998)[129].
- Knowledge as an object (a thing) that can be stored in knowledge repositories (organisational memories) and manipulated (Stein & Zwass,1995)[130], (Wijnhoven, 2000)[131].
- Knowledge as a process of simultaneously knowing and acting (Brown & Duguid, 2000)[132].
- Knowledge as capability or resource, where knowledge is viewed as a capability or resource with the potential for improving organisational performance (Carlsson, 2001)[133].
- Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new

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[127] Cleveland, H. (1982) *Information as Resource.* The Futurist, December 1982, 34-39.
[128] Eliot, T.S. (1934) *The Rock.* Faber & Faber.
[129] Schubert, P., Lincke, D. & Schmid, B. (1998) *A Global Knowledge Medium as a Virtual Community: The Net Academy Concept*. In Proceedings of the Americas Conference of AIS, August, 618-620.
[130] Stein, E.W. & Zwass, V. (1995). *Actualizing Organizational Memory with Information Systems.* Information Systems Research, 6(2), pp. 85-117.
[131] Wijnhoven, F. (2000) *Managing Dynamic Organizational Memories: Instruments for Knowledge Management*. Boxwood Press, Pacific Grove, CA, and Twente University Press, Enschede.
[132] Brown, J.S. & Duguid, P. (2000) *The Social Life of Information.* Harvard Business School Press, Boston, MA.
[133] Carlsson, S A. (2001) *Knowledge Management in Network Contexts.* Management Review, 616-627.

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experiences and information. It originates and is applied in the minds of knowledge workers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms (Davenport & Prusak,1998)[134].

- Knowledge can exist as an object, in essentially two forms: explicit or documented and formal knowledge - that is, "know-what" - and tacit or experiential - that is, "know-how" (Polyani,1958)[135], (Nonaka & Takeuchi,1995)[136] and (Beckman,1999)[137]. Thus, we have an interesting duality in knowledge management (Wickramasinghe, 2005)[138] that some have called a contradiction (Schultze,1998)[139] and others describe as the *"loose-tight"* nature of knowledge management (Malhotra, 2000)[140].

Observing the relationship between noûs and tacit knowledge, we note that there are two fundamental approaches to dealing with tacit knowledge in knowledge management.

- The first approach is to attempt to externalise the tacit knowledge through interventions and representation methods to create explicit knowledge items.
- The second method is to recognise that the tacit knowledge will and should remain tacit, but that the goal of knowledge management is to enable the organisation to identify and reach the owner of the tacit knowledge efficiently and effectively.

These approaches lead to the employment of information technologies to support organisational communications, forums, communities, relationship networks and the abundance of Internet-enabled interactions developed over the past decades.

2.5.4 Knowledge Artefacts

Knowledge artefacts are *'documents, memories, norms, values, and other things that represent the inputs to, and outputs of, the knowledge-enabled activities of agents'* (Newman, 2003)[141].

Cognitive knowledge artefact: This refers to awareness and understanding of an aspect of our real or metaphysical world. It is commonly referred to simply as knowledge.

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[134] Davenport, T. H. & Prusak, L. (1998). Working knowledge: how organizations manage what they know. Boston, Ma: Harvard Business School Press, p. 5.
[135] Polyani, M. (1958). *Personal knowledge: Towards a Post Critical Philosophy.* Chicago: University Press Chicago.
[136] Nonaka, I. & Takeuchi, H. (1995) *The Knowledge Creating Company.* Oxford University Press.
[137] Beckman, T. (1999). The current state of knowledge. In Liebowitz (Ed.), Knowledge management handbook. London: CRC Press.
[138] Wickramasinghe, N. (2005) *The Phenomenon of Duality: A Key to Facilitate the Transition from Knowledge Management to Wisdom for Inquiring Organizations.* In J. Courtney.
[139] Schultze, U. (1998) *Investigating the Contradictions in Knowledge Management.* Proceedings of IFIP.
[140] Malhotra, Y. (2000) *Knowledge Management and New Organizational Form.* In Y. Malhotra (Ed.), Knowledge management and virtual organizations. Hershey, PA: Idea Group Publishing.
[141] Newman, B.D. (2003) *Agents, Artefacts, and Transformations: The Foundations of Knowledge Flows.* In Clyde W. Holsapple (Ed.), Handbook on knowledge management 1: Knowledge matters, pp. 301-316. Berlin: Springer-Verlag.

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Physical knowledge artefact: This is a "*representation of the associated cognitive knowledge artefact*" according to Newman (2003).

The definitions of knowledge vary widely in approach, and no single definition is dominant. It may be easier to standardise the definition of the knowledge item describing the attributes of an artefact and not the knowledge itself.

2.5.5 Knowledge Management

2.5.5.1 The Knowledge Management Concept

Schwartz (2006) in his knowledge management (KM) Encyclopaedia, defines a complete onion layer model of Knowledge Management as depicted in figure 2-44 as follows:

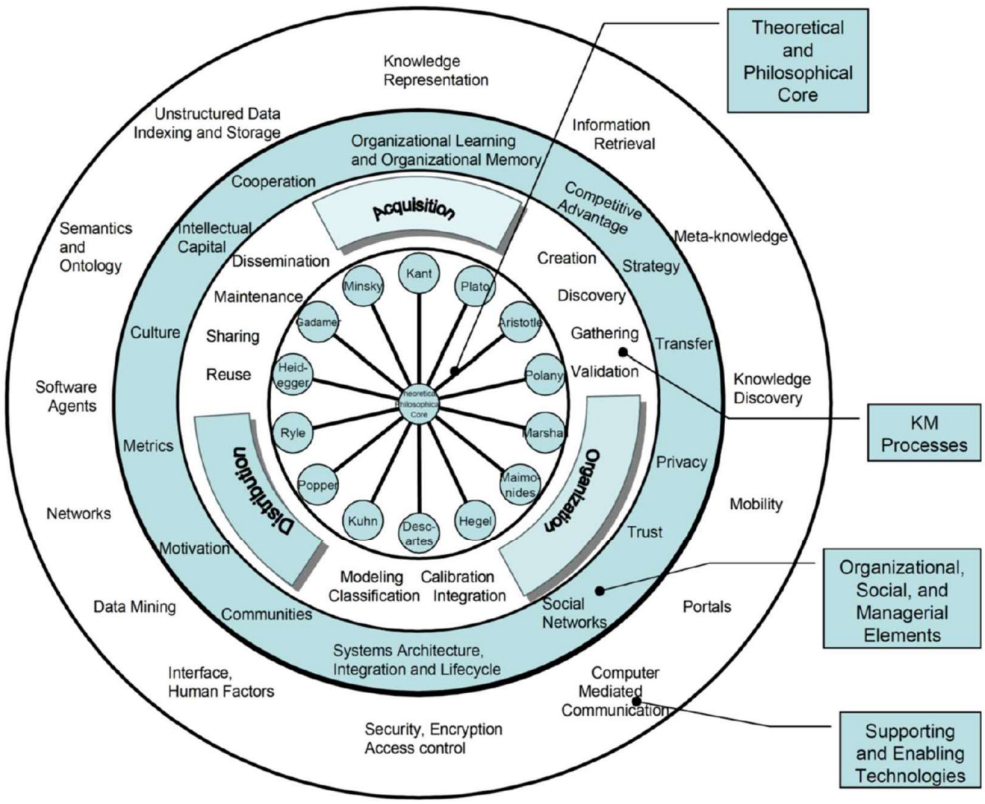

Figure 2-44: Onion Layer Model of Knowledge Management (Schwartz, 2006)

- The Theoretical and Philosophical core
- The Knowledge Management processes
- The Organisational, Social and Managerial elements
- Supporting and Enabling Technologies

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Benjamins et al. (1998)[142] state that Knowledge Management is not a product or a solution that an organisation can buy off the shelf or assemble from various components. It is a process implemented over a period, which has as much to do with human interrelationships as it must do with business practices and information technology. The process of managing knowledge involves the following actions:

- **Knowledge gathering**: acquisition and collection of knowledge managed.
- **Knowledge organisation and structuring**: imposing a structure on the knowledge acquired to manage it effectively.
- **Knowledge refinement**: correcting, updating, adding, deleting knowledge in short: maintaining knowledge.
- **Knowledge distribution**: bringing the knowledge to the professionals who need it.

Carlsson et al. (2001) define Knowledge Management as *'the explicit and systematic management of vital knowledge and its associated processes of creating, gathering, organising, diffusion, use and exploitation. It requires turning personal knowledge into corporate knowledge that can be widely shared throughout an organisation and appropriately applied.'*

Irrespective of which knowledge creation perspective is adopted, it is important for effective knowledge creation to realise, firstly that knowledge is a multifaceted construct and knowledge management is a multi-dimensional approach and consequently, the individual steps of knowledge management should also exhibit this multi-dimensionality.

Given the importance of knowledge management in today's knowledge-based economy, it is indeed useful to combine the people-driven and technology-driven perspectives into an integrative, all-encompassing meta-framework. In doing so one will capture the subtle nuances and complexities of knowledge creation, and hence realise the synergistic effect of the respective strengths of these frameworks (Wickramasinghe & Mills, 2001)[143].

Nicolas Perry & Alain Bernard (2014)[144] state that *'knowledge management actors can be divided into three main research groups*' as shown in the figure 2-43 below.

- *'These actors theorise on the concept of knowledge, its states, and its dynamics in connection with the philosophy point of view of the knowledge. They guide the methodologies to carry out the steps of knowledge management.*
- *Actors from Science and Technology of Information and Communication: They develop computing environments to model, capitalise and manipulate knowledge. It*

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[142] Benjamins, R. V., Fensel, D. & Perez, G. A. (1998) *Knowledge Management through Ontologies*. in Proceedings of the 2nd International Conference on Practical Aspects of Knowledge Management PAKM98, vol. 29, no. 3, 5, 1-12.

[143] Wickramasinghe, N. & Mills, G. (2001) *MARS: The Electronic Medical Record System. The Core of the Kaiser Galaxy*. International Journal of Healthcare Technology Management, 3(5/6), 406-423.

[144] Perry, N. & Bernard, A. (2014) *Knowledge Management.* Knowledge Management Chapter January 2014, DOI:10.1007/978-3-642-20617-7_6458. Uploaded to: https://www.researchgate.net/publication/314702057 [by Nicolas Perry on 28 June 2017].

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opens the field of Artificial Intelligence and Decision Support Systems. They work for the evolution of tools and languages that support the automation of knowledge and its transcripts.

- *Actors from Engineering Sciences. They work in the formalisation and integration of business expertise to optimise a business process or integrate it into a business environment. They are developing and deploying knowledge-based environments and synthesise theoretical propositions pragmatically, tools and technologies available and operational requirements in the areas of engineering.'*

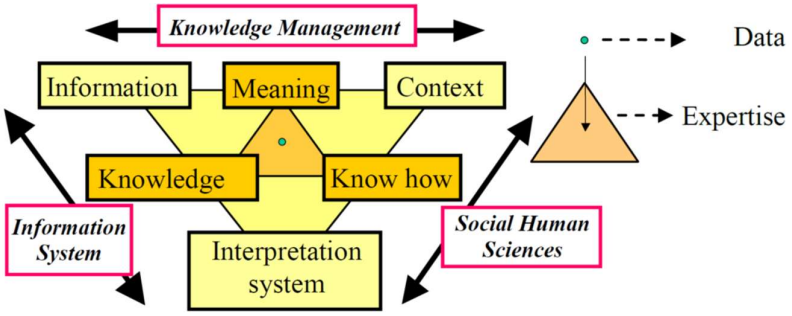

Figure 2-45: Research domain in connection with KM and their main interest topics (Perry & Bernard, 2014)

In summary, knowledge management as used in this dissertation involves connecting people with people, as well as people with information. It is a management philosophy, which combines good practice in purposeful information management with a culture of organisational learning to improve business performance.

Gregory, S.A. (1966)[145] states that *'the maturity of science about a body of knowledge (for instance the knowledge about designing) is characterised by a gradation of behaviour which may be expected, and which causes that knowledge to be reckoned as scientific. This relates to the epistemology of the knowledge, the theory of the methods or grounds of knowledge, the ways of knowing. This behaviour and the state of organisation of the body of knowledge may range through:*

(1) description of phenomena (natural history phase);

(2) categorization regarding apparently significant concepts;

(3) ordered categorization whose pattern may be deemed a model (the evolutionary taxonomy or periodic table phase);

(4) isolation and test of phenomena, with implied reproducibility by independent observers;

(5) quantification (classical physics phase).'

[145] Gregory, S.A. (1966) *Design Science in The Design Method.* London: Butterworths, 1966, pp. 323-330.

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Hubka & Eder (1996)[146] define the characteristics of designs as *'**novel**, **complex** as iteration is always necessary, no design problem is simple enough to fit within the mental limitations of short-term memory in humans.*

*Designing usually takes place in answer to a perceived **need**. Especially in engineering, designing is **goal-directed**. Goals include attempting to resolve an issue, usually to achieve **satisfaction for the customers**.*

Technical knowledge** is knowledge about **artificial objects (artefacts) *(existing in a branch of industry or a domain of activity) which have been created and produced to accomplish certain **goals**.'*

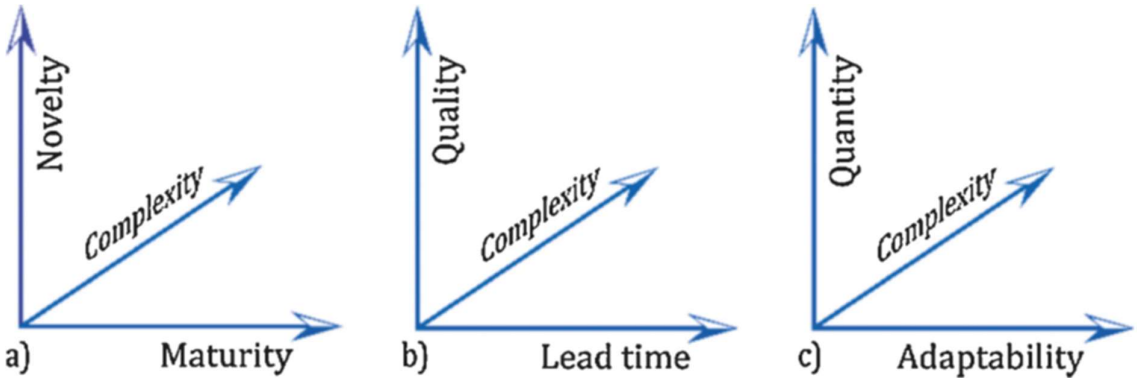

Figure 2-46: Different ways to Characterise Products (Lutters et al., 2014)

Lutters et al., (2014)[147] postulate an evolution of models to characterise products (describe the knowledge attributes of the products). One of the significant assumptions is the '*mutually independence constraint of the properties'* of the co-ordinate system used. This coordinate model shown as figure 2-46 above.

'Novelty' is defined as the innovation parameter, whereas ***'maturity'*** is the condition of the design, and ***'complexity'*** is related to the level of technical risk prevalent in the design. The evolution of systems may skew this model.

An alternative model, where the design of the product is related to the competitive insistence on '*higher **quality**, increasing **complexity** and lower **lead times***', is shown in the same figure 2-46 above. However, in this model "quality' may prove not to be robust enough term as it is open for interpretation and lead time is dependent on the manufacturing process and not the product definition.

If one views the description of the product characteristics from the customer then, the

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[146] Hubka, V. & Eder, W.E. (1996) *Design Science, Introduction to the Needs, Scope and Organization of Engineering Design Knowledge.* Springer-Verlag London Limited 1996, pp. 13 -15.
[147] Lutters, E., Van Houten, F.J.A.M., Bernard, A., Mermoz, E., Schutte, C.S.L. (2014) *Tools and techniques for Product Design.* CIRP Annals - Manufacturing Technology 63 (2014): 607–630, Contents lists available at ScienceDirect.

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product can be '***valued'*** against its **direct needs** and the previous issues can be overcome by the following model: '*The first property is* ***complexity*** *pending the* ***entire product lifecycle,*** *the* ***adaptability*** *of products and the* ***quantity*** *of product.'*

Wang & Tseng (2014)[148] defines the process whereby the customer influences the design through the '*tolerances of customers' requirements'*. This concept is also known as trade-off studies with the main aim of optimising the design compared to a known user value system and shown in figure 2-47 below.

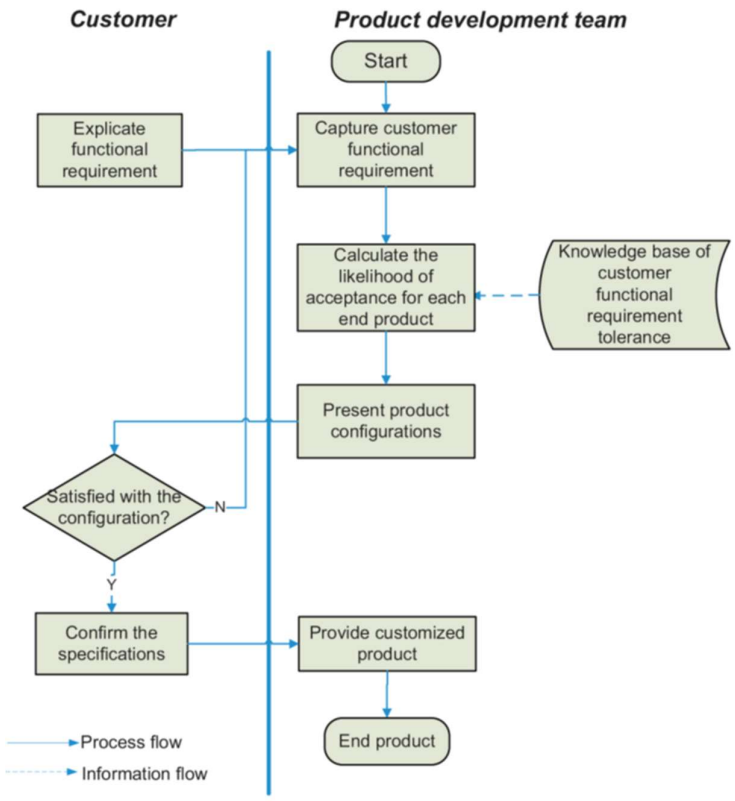

Figure 2-47: Process of Product Customization by Leveraging on Tolerance of Functional Requirements (Wang & Tseng, 2014)

The response of customer requirement tolerance measures how much a customer values different attribute choice within the acceptable range of the attribute. The customer may perceive different values or satisfaction levels to different product attribute options. Some choices are highly preferred or desired. Others may be just satisfactory.

Lutters, Dankers, Oude Luttikhuis, & de Lange (2014)[149] state that, due to the complexity of the different stake holder's value systems, as well as the dynamic change of needs, it will be beneficial to *'achieve awareness of the entire product development cycle and the subordination of individual interest to a higher purpose'* To this end a holistic overview is

[148] Wang, Y. & Tseng, M. (2014) *Incorporating tolerances of customers' requirements for customized products.* CIRP Annals - Manufacturing Technology 63 (2014):129–132.
[149] Lutters, E., Dankers, W., Oude Luttikhuis, E. & de Lange, J. (2014) *Network based requirement specification.* CIRP Annals - Manufacturing Technology 63 (2014): 133–136.

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needed to provide insight into the *'entire set of decisions, alternatives, justifications, trade-offs and interrelations'.* About the major acquisition processes, this notion defines the need for the existence of the DoDAF, MODAF and NAF architectural frameworks viewed from the product life cycle perspective.

2.5.5.2 Ontologies

"Ontology comprises the explicitly articulated and shared concepts of a knowledge community or domain" according to Buchholz (2006)[150].

Ontologies: Modern philosophers (Sowa, 2000)[151] such as Kant, Peirce, Husserl, Whitehead, and Heidegger attempted to understand reality through categorisation and logic. Much of their philosophical groundwork forms the basis of ontology as it presently understood in practical applications for automated systems of information. The mathematician and logician, Stanislaw Lesniewski, on the other hand, supplied a key component of the computerised sense of ontology when he used *'an artificial formal language to represent his formal theory of parts (mereology).'* He thereby *'inaugurated philosophy's use of artificial languages and formal logic in expressing ontologies'* (Mayhew & Siebert, 2004)[152].

The philosophical sense of the word ontology, with its long and rich history, is the basis of the philosophical and logical ontology of the computer application sense of the word. G.H. Mealy's '*Another Look at Data'*, is a paper dealing with *'the foundations of data modelling* (Smith, 2004)[153]. In today's world, computerised ontologies define or capture some aspect of a specific domain like medicine or engineering.

Formal Ontologies: Ontologies attempt to capture conceptually the building blocks of the mind by modelling our knowledge of reality. This modeling is done by providing a specific vocabulary for things, ideas, actions, relations, and approved behaviours to generate a humanlike thinking ability. Ontologies with these capabilities are termed formal ontologies.

Informal Ontologies: Informal ontologies have only some of these attributes of formal ontologies (Sowa, 2000) for selected groups of topics relevant to a specific area of interest. When these subjects are arranged within a hierarchy, one normally refers to them as taxonomies or directories. When definitions are added, they are known as thesauri or glossaries.

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[150] Buchholz, W. (2006) *Ontology, Bentley College, USA. Encyclopaedia of Knowledge Management.* Bar-Ilan University, Israel, p. 694.
[151] Sowa, J. (2000) *Knowledge Representation: Logical, Philosophical, and Computational Foundations.*
[152] Mayhew, D. & Siebert, D. (2004) *Ontology: The Discipline and the Tool.* In G. Büchel, B. Klein, & T. Roth- Berghofer (Eds.), Proceedings of the First Workshop on Philosophy and Informatics, pp. 57-64.
[153] Smith, B. (2004) Ontology and information systems. Retrieved November 24, 2004. Available at: http://ontology.buffalo.edu/ontology.doc [Accessed April 2015].

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2.5.5.3 Knowledge Value Chains

The stringing together of knowledge in a predetermined process (ontology) gives rise to the concept of knowledge value chains. This principle will be demonstrated by the example of the first knowledge value chain defined below.

The Knowledge Chain Model (KCM) identifies nine key activities that knowledge-driven enterprises can perform in ways that yield competitive advantage. (Holsapple and Singh, 2001)[154] These activities derived from an ontology of knowledge management phenomena were collaboratively engineered with an international array of KM practitioners and authors (Joshi, 1998)[155], (Holsapple & Joshi, 2002)[156], (Holsapple & Joshi, 2003)[157], (Holsapple & Joshi, 2004)[158].

Like Porter's Value Chain Model, the KCM is a basic tool for diagnosing competitive advantage and finding ways to enhance it. To show the principles of the KCM, the Original Knowledge Value Chain shown in Figure 2-48.

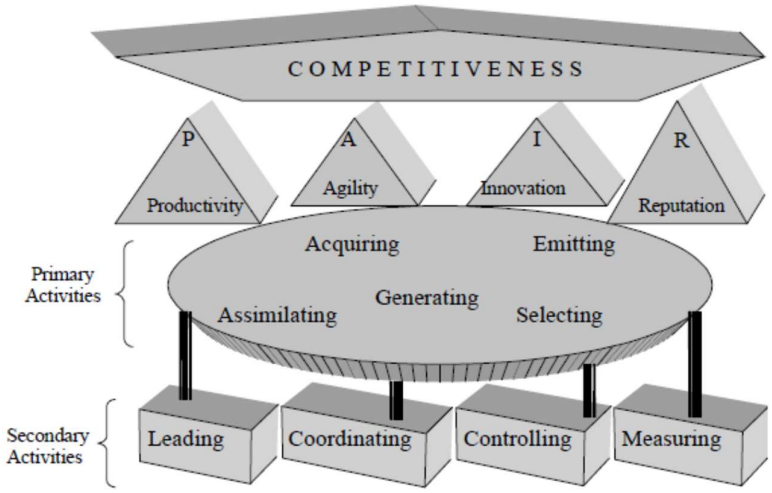

Figure 2-48: The Original Knowledge Value Chain (Holsapple & Singh, 2001)

The Knowledge Chain Model includes five primary activities that an organisation's knowledge processors perform in manipulating knowledge assets. These five activities are

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[154] Holsapple, C.W. & Singh, M. (2001) *The Knowledge Chain Model: Activities for Competitiveness.* Expert Systems with Applications, 20(1).
[155] Joshi, K.D. (1998) *An Investigation of Knowledge Management Characteristics.* Synthesis, Delphi study, analysis. PhD Dissertation, Carol M. Gatton College of Business and Economics, University of Kentucky, USA.
[156] Holsapple, C.W. & Joshi, K.D. (2002) *A Collaborative Approach to Ontology Design*. Communications of the ACM, 45(2).
[157] Holsapple, C.W. & Joshi, K.D. (2003) *A Knowledge Management Ontology.* In C.W. Holsapple (Ed.), Handbook on knowledge management: Knowledge matters. Berlin/Heidelberg: Springer-Verlag.
[158] Holsapple, C.W. & Joshi, K.D. (2004) *A Formal Knowledge Management Ontology Conduct, Activities, Resources, and Influences.* Journal of the American Society for Information Science and Technology, 55(7).

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identified in the KM ontology as the five generic KM activities involved within knowledge management episodes: acquiring, selecting, generating, assimilating, and emitting knowledge. Also, the KCM includes four secondary activities that support and guide the performance of the primary activities. These four KM activities are identified in the KM ontology as managerial (or people) influences on the conduct of knowledge management: leading, coordinating, controlling and measuring knowledge management initiatives. The KCM recognises four ways in which improvements in the design and execution of KM activities can aid competitiveness: better productivity, greater agility, greater innovation and enhanced reputation. Later in the research, we will again review enabler factors based on human interaction in the process.

2.5.5.4 The Future of Knowledge Management

O'Leary (2016)[159], in his article on the future of knowledge management, investigates whether knowledge management as a concept has reached the end of its useful life or whether the concept is simply evolving with the availability of instant social media.

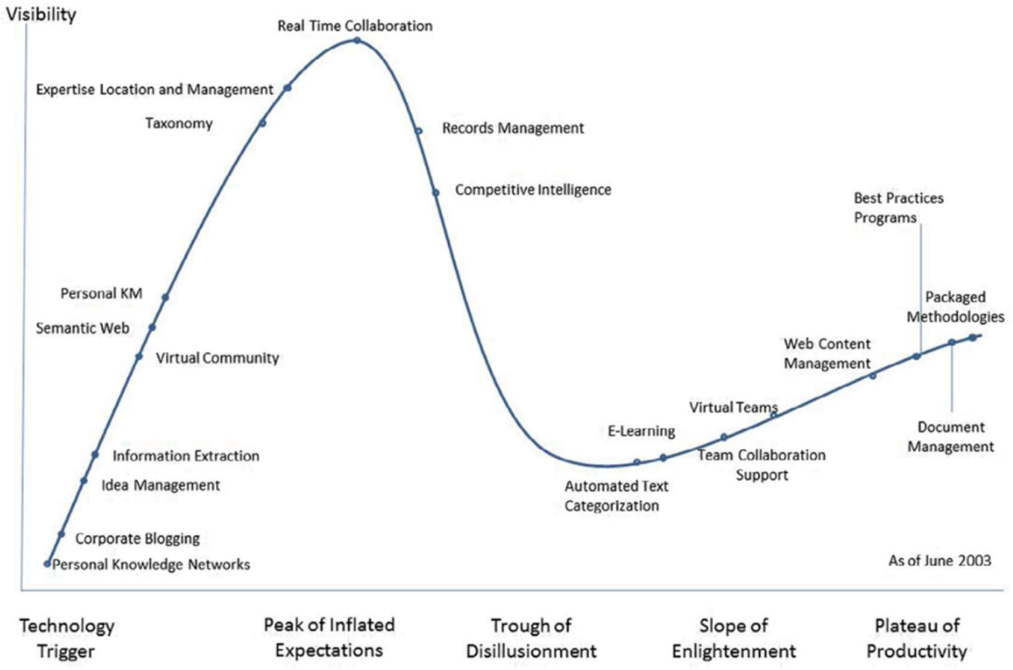

Figure 2-49: Knowledge Management Hype Cycle (Caldwell et al., 2003)

The Knowledge Management Hype Cycle, shown in figure 2-49 as defined by Caldwell et.al. (2003)[160], already indicated that the knowledge management concept reached its

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[159] O'Leary, D. E. (2016) *Is Knowledge Management Dead (or dying)?* , Journal of Decision Systems, 25:sup1, 512-526.

[160] Caldwell, F., Linden, A., Miklovic, D., Morello, D., Knox, R. E., Logan, D., ... Shegda, K.M. (2003) *Hype cycle for knowledge management.* Available at: http://www.bus.umich.edu/KresgePublic/Journals/Gartner/research/115400/115434/115434.html [Accessed

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plateau of productivity in 2003. If one analyses the Google search traffic on this topic from 2004 to 2015 on both the collaboration and content, it becomes clear that both graphs have indeed stabilised and that much traffic is still evident with regard to content searches on knowledge management shown in figure 2-50 below. Please note that the vertical axis indicates relative traffic level of Google searches performed.

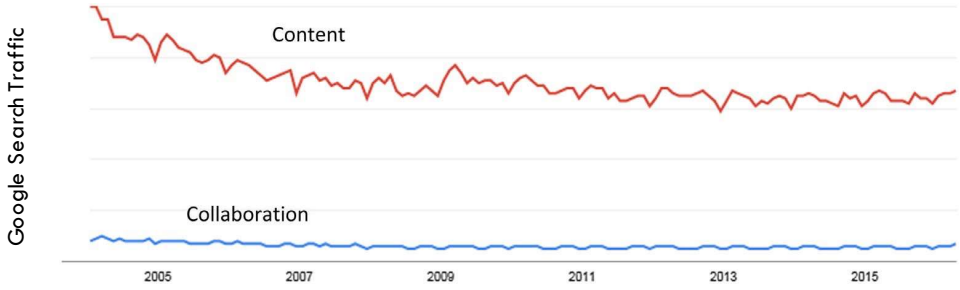

Figure 2-50: Google Search Traffic - Knowledge Management for Content and Collaboration (O'Leary, 2016)

Davenport's (2015)[161] recent proclamation that *"knowledge management was either dying or on its last breath"* is indeed not true. Gartner (Mann et al., 2010)[162] (Tombs, 2004)[163] (and Davenport, 2015) had a potential concern about the survival of the knowledge management concept. O'Leary (2016) investigated these concerns and concluded that there is indeed life left in knowledge management and that organisations do need knowledge management. Knowledge management does create value for an enterprise and is evolving as different data management capability are created.

2.5.5.5 About Big Data Analytics

According to Monnappa at '*Simple Learn Solutions'* (2016)[164] one can differentiate between the following data manipulation types:

Data Science is a study field that is concerned with everything that relates to data cleansing, preparation and analysis.

Data Analytics involves automating insights into a specific data set as well as queries and

June 2003].

[161] Davenport, T. (2015) *Whatever Happened to Knowledge Management?* January 24, The Wall Street Journal, CIO Report. Available at: http://blogs.wsj.com/cio/2015/06/24/whatever-happened-to- knowledge-management/ [Accessed June 2017].
[162] Mann, J., Rozwell, C., & Drakos, N. (2010) *Gartner's view on Knowledge Management.* 9 September 2010 Gartner Research ID number: G00175604
[163] Tombs, K. (2004) *Knowledge Management is Dead: Long live Records Management.* Records Management Journal, 14, 90–93.
[164] Monnappa, A. (2016) *Data vs Big Data vs Data Analytics: Data is Growing Faster than Ever Before.* Simple Learn Solutions. Available at: https://www.simplilearn.com/data-science-vs-big-data-vs-data-analytics-article [Accessed June 2017].

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data aggregation procedures.

Big Data analyses insights not limited to a specific dataset but based on the data traffic on the worldwide web that can be used to analyse trends and insights which can lead to better strategic decisions.

IBM Analytics (2017)[165] combines **Big Data and Analytics** and defines it as *'the use of advanced analytic techniques against extensive, diverse data sets that include different types such as structured/unstructured and streaming/batch, and different sizes from terabytes to zettabytes. Big data is a term applied to data sets whose size or type is beyond the ability of traditional relational databases to capture, manage, and process the data with low-latency'* named **Big Data Analytics**.

2.5.5.6 Knowledge Management Summary

The practical management objectives are: to convert human capital (individual learning/team capabilities) to structural capital (organisational knowledge or *'what is left when people go home'*, such as documented processes and knowledge bases) and thereby move from tacit to explicit. This transformation reduces the risk of losing valuable knowledge if people leave the organisation (Corrall,1999)[166]. Knowledge management involves four key steps: creating/generating knowledge, representing/storing knowledge, accessing using/re-using knowledge and disseminating/transferring knowledge (Davenport & Prusak,1998).

2.5.6 Knowledge Representation

Eppler & Burkhard (2006)[167] generated a **Framework for Knowledge Visualisation** as follows:

For an efficient creation and transfer of knowledge through visualisation, at least three perspectives are considered. These perspectives answer three key questions about visualising knowledge, namely:

What type of knowledge is visualised (object)?

Why should that knowledge be visualised (purpose)?

How can the knowledge be represented (method)?

The answers to these three questions are obviously highly interconnected. Listing possible answers to these key questions leads to a first conceptual framework that can provide an overview of the knowledge visualisation field.

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[165] IBM Analytics (2017) *Big Data: Employ the Most Effective Big Data Technology.* Available at: https://www-01.ibm.com/software/data/bigdata/ [Accessed June 2017].
[166] Corrall, S. (1999) *Knowledge Management - Are We in the Knowledge Management Business?* Ariadne, vol. 18, no. 1.
[167] Eppler, M.J. & Burkhard, R.A. (2006) *Knowledge Visualization.* Encyclopaedia of Knowledge Management, Bar-Ilan University, Israel, p. 551.

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Table 2-3: Three Perspectives of Knowledge Visualisation (Eppler & Burkhard, 2006)

Knowledge Type (What?)	Visualisation Goal (why?)	Visualisation Format (how?)
Know-what	Transferring	Heuristic Sketches
Know-how	Creating	Conceptual Diagrams
Know-why	Learning	Visual Metaphors
Know-where	Codifying	Knowledge Animation
Know-who	Finding	Knowledge Maps
	Assessing	Domain Structures

Dori (2006)[168] defined the **Object-Process Methodology (OPM)** as a vehicle for knowledge representation and management that perfectly meets the formality and intuition requirements through a unique combination of graphics and natural language. **Function, structure, and behaviour** are the three most important aspects that systems exhibit. The function is the top-level utility that the system provides its beneficiaries with who use it or are affected by it, either directly or indirectly. The system's function is enabled by its architecture - the combination of structure and behaviour. The system's architecture is what allows it to function to benefit its users. The elements of the OPM ontology, shown in Figure 2-51, are divided into three groups: **entities, structural relations, and procedural links.**

Figure 2-51: Object-Process Methodology (OPM) (Dori, 2006)

Copyright © 2006, Idea Group Inc.

According to Kristensson et al. (2006)[169], the Space-Time cube representation in the figure 2-52 below is an information visualisation technique where spatiotemporal data points are mapped into a cube. Fast and correct analysis of such information is necessary in, for instance, geospatial and social visualisation applications.

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[168] Dori, D. (2006) *Object-Process Methodology.* Technion, Israel Institute of Technology, Israel and Massachusetts Institute of Technology, USA. Encyclopaedia of Knowledge Management, Bar-Ilan University, Israel, p. 683.

[169] Kristensson, P.O., Dahlback, N. Anundi, D., Bjornstad, M., Gillberg, H., Haraldsson, J., Martensson, I., Nordvall, M. & Stahl, J., (2007) *The Trade-offs with Space Time Cube Representation of Spatiotemporal Patterns*, pp. 1–15.

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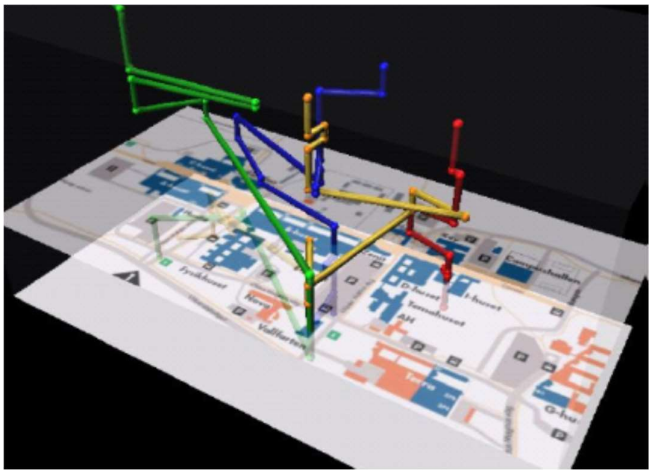

Figure 2-52: Space Time Cube of different people walking (Kristensson et al., 2007)

The space-time cube shown in figure 2-52 displays spatiotemporal data inside a cube, sometimes called an "aquarium". The height axis is used to denote time. The space-time cube was originally proposed by Hagerstand (1975)[170] and has since been mainly used to display geospatial data.

Suh (1990)[171] starts his reasoning about **Design Ideality** with the introduction of four domains of the design world, depicted in figure 2-53. These domains are: the customer domain, characterized by needs or attributes (CN); the functional domain where these attributes are expressed in functional requirements and constraints (FR); the physical domain where design parameters (DP) are conceived to satisfy the FR's and finally, the process domain where manufacturing process variables (PV) are needed to make the product specified by the DP's.

During the design process, one proceeds from the customer domain to the functional domain to the physical domain and finally to where the product is built in the process domain.

[170] Hagerstrand, T. (1975) *Space, Time and Human Conditions, Dynamic Allocation of Urban Space.* A. Karlquist, L. Lundquist and F. Snickars, eds., Farnborough: Saxon House, p. 3.
[171] Suh, N.P. (1990) *The Principles of Design.* Oxford University Press, Oxford, New York.

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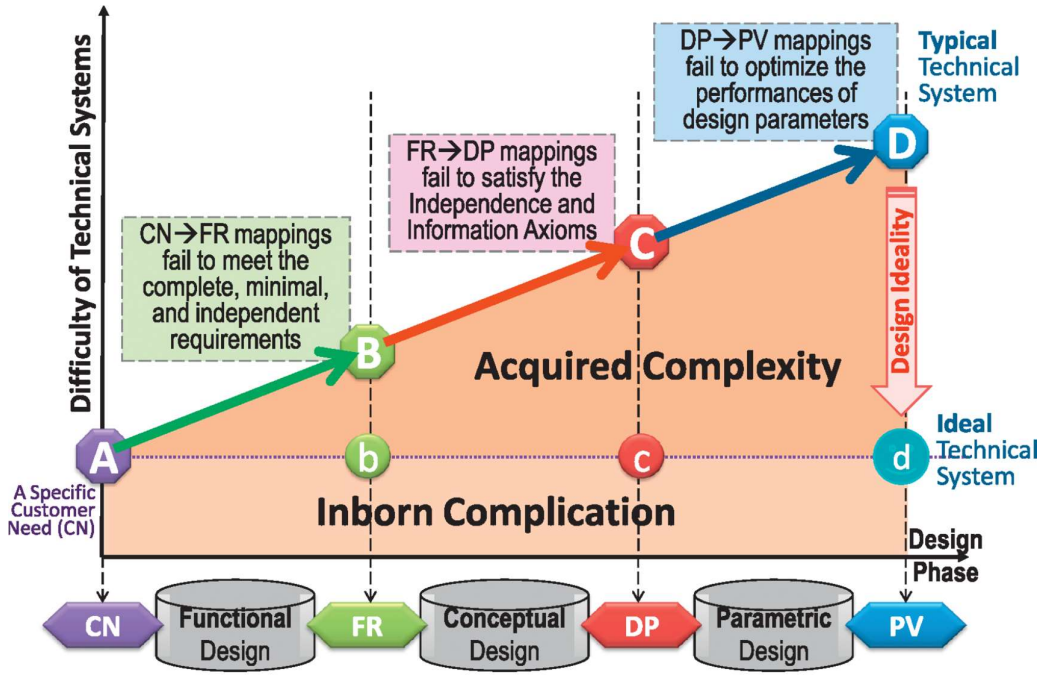

Figure 2-53: Achieving design ideality of technical systems (Suh, 1990)

2.5.6.1 Standardising Knowledge Representation

As seen from the above, as well as from previous work by MW Pretorius (1998)[172], it has become clear that a structural, functional and a time element can be derived from common denominators or items in the various knowledge models studied as shown in figure 2-54.

[172] Pretorius, M.W. (1998) *'n Model vir die Taksering van nuwe Tegnologie vir die Vervaardiging Onderneming*. Verhandeling voorgelê vir die Graad Philosophiae Doctor (Ingenieurs); Universiteit van Pretoria.

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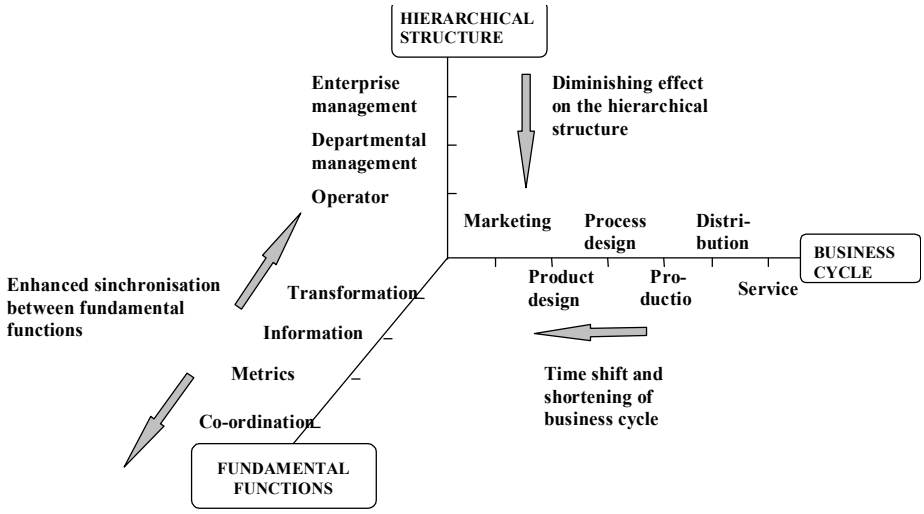

Figure 2-54: Technology Assessment Model (Pretorius, M.W., 1998)

The general functional breakdown of a business process, according to Pretorius is transformation, information, measurement and coordination which, together with an input and an output form the elements of a generic process.

2.5.6.2 The Structural System Hierarchy

The structural domain of the framework consists of the scoping of the artefact as well as its physical decomposition up to the level of description required.

This component can take many forms like a system breakdown structure, a work breakdown structure, an information structure or even a physical structure like an atom that can be decomposed into a set of neutrons, protons and electrons. This element defines the 'what' component of the artefact's attributes.

2.5.6.3 The Functional Breakdown

In both the design methodology of Pahl & Beitz, (1996)[173] and Suh's (1990) axiomatic design, function decomposition plays a vital role because this determines the functional structure, hence the fundamentals of design solutions.

This basic process definition is also confirmed by Chen & Guan (2011)[174] in their mapping of the innovative production process, shown in figure 2-55, from accumulative advantage to economic outcomes.

This process defines the conceptual path framework of causal effects in a typical technological innovation production process (IPP) based on systems thinking.

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[173] Pahl, G. & Beitz, W. (1996) *Engineering Design: Systematic Approach.* Springer-Verlag, Berlin, 2nd revised edition edited by Wallace, K.

[174] Chen, K. & Guan, J. (2011) *Mapping the Innovation Production Process from Accumulative Advantage to Economic Outcomes: A path Modelling Approach.* Technovation, vol. 31, no. 7, pp. 336–346.

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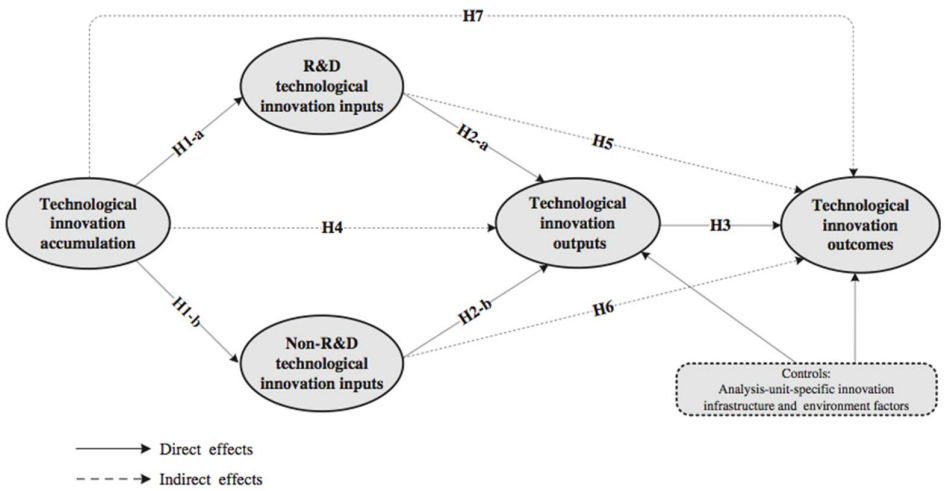

Figure 2-55: A Technological Innovation Production Process IPP (Chen & Guan, 2011)

This component defines the 'how' attributes of the artefact under review.

2.5.6.4 The Time or Logic Component

Rozenfeld & Eversheim (2002) argued that product development is primarily a knowledge creation process. Therefore the knowledge management system links product development and knowledge evolution through the life cycle phases in context with the maturity state of the artefact.

The time (or transformation if time is not linear) domain is used to indicate the change process as well as the current or future state of the artefact's attributes.

A typical description of the life cycle process and/or status of a product at any given point in time can be part of such a description. This 'when' component is also used to define an age, maturity and any attribute related to the passing of time, or logic, to be able to fully define the attributes of an artefact.

2.5.6.5 The Combined View – The Knowledge Cube

In searching for common concepts from all the knowledge representation models studied and after reviewing all the above knowledge frameworks, we observe the existence of the following elements as defined in table 2-4 below.

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Table 2-4: Knowledge Domains in various Knowledge Frameworks

		Knowledge Attribute Domains			
Knowledge Frameworks	**Reference**	**Structure**	**Function**	**Process**	**Customer**
Framework for Knowledge Visualisation	Eppler & Burkhard	○ What type of knowledge is visualized (object)?		● How can the knowledge be represented (method)?	● Why should that knowledge be visualized (purpose)?
Object-Process Methodology (OPM)	Dori	● The system's function is enabled by its architecture—the combination of structure and behaviour	●	○	
••Space / Time Cube	Hagerstand, Kristensson	○ Spatiotemporal data		○ The height axis is used to denote time	
Design-Centric Complexity (DCC)	Nam-Pyo Suh	● Design parameters (DP) are conceived	● Attributes are expressed in functional requirements and constraints (FRs, Cs)	● Manufacturing process variables (PV) are needed to make the product	● The customer domain is characterized by needs or attributes (CA)
Technology Assessment Model	MW Pretorius	● Hierachical Structure	● Fundamental Functions	● Business Cycle	
innovation production process (IPP) based on systems thinking.	Chen	○ Technology Innovation Accumulation Data and Model		○ Hypothesis Tests	● Technological Innovation Outcomes
An architecture based on which solutions can be implemented in order to share explicit knowledge among partners.	Rozenfeld and Eversheim	○ Knowledge Respository in Ontologies, Benchmarking Models, Modeling Framework and Process Taxonomy	● Insert, Modify, Synthesize and Validate	● Product Development Process	● Development of a Knowledge Management Community
Four Domains	Shu	● Design parameters (DP) are conceived	● Attributes are expressed in functional requirements and constraints (FRs, Cs),	● Manufacturing process variables (PV) are needed to make the product specified	● Customer domain is characterized by needs or attributes (CA),
		● Complete Fit		○ Partial Fit	

- The definition and use of "structure" of the knowledge about the artefact are present in all eight models listed above. (The **what** component)
- The use of the description of the function of the knowledge about the artefact is evident in six of the eight models. (The **how** component)
- The process embedded or defined by the knowledge being represented is also evident in all eight models. (The **when** component)
- The use of the knowledge by a customer as the value realised is evident in five of the eight models. (The **value** of knowledge)

It can be concluded from the above analysis that structural, functional and process components of the knowledge artefact can be identified as common denominators or elements in the various knowledge models studied. The previous work by MW Pretorius (1998) supports this view.

These common denominators can now form part of a knowledge presenting framework called the Knowledge Cube. The Knowledge Cube can be used as the breakdown of the description of any knowledge artefact (cognitive or physical) in a standardised way.

Figure 2-56 defines the Knowledge Cube domains of the 'What', 'When', 'How' of a

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Knowledge Artefact's attributes:

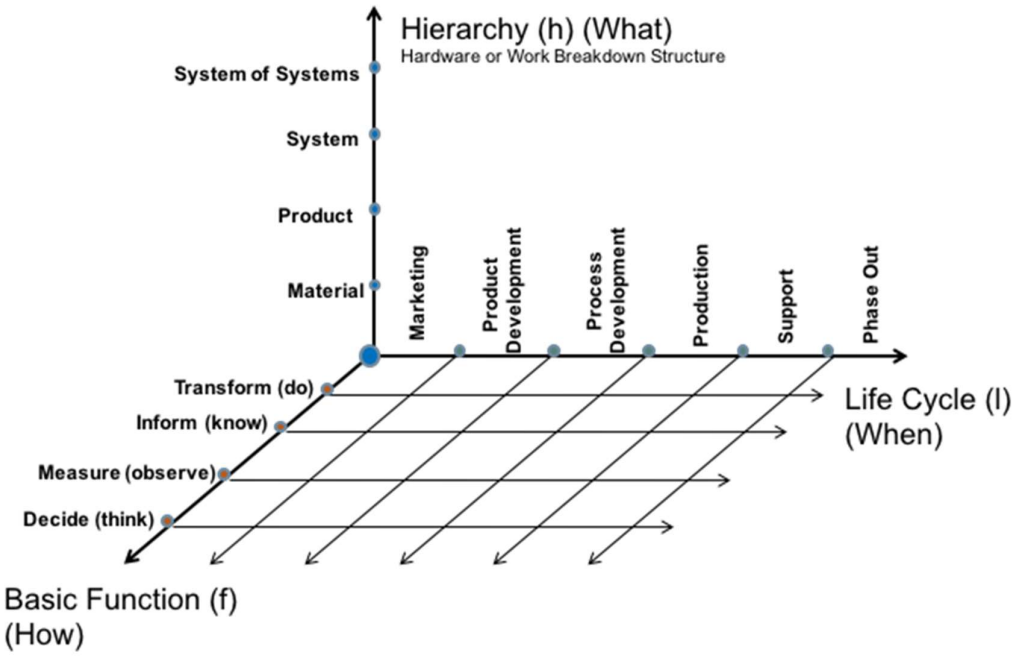

Figure 2-56: The Knowledge Cube (Pretorius & Du Preez, 2011)

To give substance to the knowledge item, a framework for the uniform representation of knowledge attributes of a product or service was developed. This framework is named the Knowledge Cube or KC (Pretorius & Du Preez, 2011)[175]. Figure 2-56 depicts the proposed knowledge Cube's three domains as the basic function; a hierarchy as well as a life cycle or logic as areas used to describe the knowledge of an item.

The three elements of the knowledge cube are depicted in a three-dimensional view. The intention is not to define an interrelationship between these domains but rather to display an artefact's knowledge attributes from different viewpoints. It is further postulated that these three domains are sufficient to cover all attributes of an artefact (big or small, simple or complex, real or abstract). It should be possible to define the idea of an idea as an artefact as well as a very complex weapon system like an armoured combat vehicle with its associated support systems by means of this Knowledge Cube.

In addition to the Knowledge Cube presenting the knowledge attributes of an artefact, the use of the knowledge adds to the entire knowledge construct. The same knowledge item in the hands of different customers representing alternative usage will result in a different value for the specific user. It is for this reason that the value of knowledge is defined outside of the knowledge cube.

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[175] Pretorius, G.D.P. & Du Preez, N.D. (2011) *The Knowledge Cube, A Universal Framework to describe all Knowledge Items.* COMA 13.

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This concept of the value of the knowledge is defined in the next paragraph and in more detail in a later chapter as the outcome of the Interactive Supply Framework termed '*customer value realised*'.

2.5.7 The Value of Knowledge

2.5.7.1 The Definition of Value

According to the Webster Dictionary, value is defined as:

- Fair return or equivalent in goods, services or money for something exchanged.
- The monetary worth of something: marketable price
- Relative worth, utility or importance <a good value at the price> <the value of base stealing in baseball> <had nothing of value to say>
- Something (as a principle or quality) intrinsically valuable or desirable <sought material values instead of human values —W.H. Jones>

The duality depicted in the above definitions of value is crucial since the meanings of the word reflect on the quantitative vs. qualitative tensions incorporated in the concept of value in the economy.

Not surprisingly, managers interested in getting their arms around the intellectual capital are searching for ways to describe, measure and manage their intangible assets with an emphasis on capturing their favourable effects on the bottom line and on shareholder values (McElroy, 2002)[176].

The importance of the connection to intellectual capital (IC) is a catalyst for the industry to invest in research and the implementation of knowledge management (KM) and IC. This brings the short and medium-term benefits that organisations and management so often seek, but brings us all the long-term benefits from the blossoming of KM, knowledge and knowledge on knowledge.

Any capital or currency is dependent upon its market: so is intellectual capital. Its value, like any currency, is in the eyes of the beholder. Diamonds may be worthless on a deserted, isolated island, or they may bring their worth as a tool to start a fire, multiplying perhaps their true value to our Robinson Crusoe beyond any market value.

The value of knowledge implemented toward action in one context (or having the potential to be) may be worthless in another. The operative meaning is that things that are valuable do not necessarily have intrinsic value (Ariely, 2006)[177].

It is perhaps wise to divorce the term value from knowledge as value only realises in specific application profiles for a single knowledge item. Knowledge items realise different values when measured against the proposed value system for their specific applications.

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[176] McElroy, M. W. (2002) *Social innovation capital.* Journal of Intellectual Capital, 3(1), 30-39.
[177] Ariely, G. (2006) *Intellectual Capital and Knowledge Management.* University of Westminster, UK and Interdisciplinary Center Herzliya, Israel. Encyclopedia of Knowledge Management, Bar-Ilan University, Israel, p. 281.

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2.5.7.2 An example of a simplified User Value System.

According to Park et.al. (2002)[178] it has been recognised that the design process needs cost models that:

- Consider the complete life cycle of products
- Can be used at the very early stages of design
- Can provide information to designers in a timely manner and in a form, that can be understood and used.

The product Life Cycle Cost (LCC) is mainly determined by early design decisions. But, at early conceptual design stages, as designers, we do not know the expenses incurred in subsequent life cycle phases.

Park et al. (2002) have suggested an approximate LCC method for predicting the product LCC, especially focusing on energy cost and maintenance cost, in the conceptual design stage. Three areas critical to the preliminary validation of the approach were developed: model outputs in the form of the LCC factors; model inputs in the shape of a compact, meaningful and understandable set of product attributes; and the ability to predict the product LCC.

Involving users in research, design and innovation processes constitutes a fast-growing topic of interest for which approaches, methods and tools are abundantly described in the literature (Salminen et al., 2011)[179]. A Living Lab (2015)[180] is an open research and innovation ecosystem that directs user communities towards co-creation principles and where stakeholders apply various user involvement methods and tools. However, an appropriate assessment method for evaluating the degree of users' involvement in R&D within Living Labs must still be created.

The product is not worth making unless it is worth buying. Therefore these two questions are related. But it is hard to predict what the demand for a product will be before that product is tested in the market. Therefore, back in 1986, Eric von Hippel, a professor at MIT's Sloan School of Management, offered a way to think about innovation in the guise of a formula:

$$b = (v \times r) - c - d$$

The b represents the customer's benefit, which ultimately determines demand. The company would calculate b this way:

- How much of its business (dollar volume, or v) would the innovation contribute?

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[178] Park, J.-H., Seo, K.-K., Wallace, D., Lee, K.-I. (2002) *Approximate Product Life Cycle Costing Method for the Conceptual Product Design*. CIRP Annals - Manufacturing Technology, 51(1): 421–424.
[179] Salminen, J., Konsti-Laakso, S., Pallot, M., Trousse, B. & Senach, B. (2011) *Evaluating User Involvement within Living Labs through the use of a Domain Landscape.* ICE Conference 2011.
[180] Living Lab (2015) *Blog on Living Lab.* Available at: https://openlivinglabsdays15.files.wordpress.com/2015/03/screen-shot-2015-03-17-at-15-21-00.png. [Accessed June 2015].

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- How much would this new technology increase the profit margin (rate of profit, r) of that business?
- What is the change cost (c) of switching?
- And what is the loss in "old benefits" (d) when the company abandons its current way of doing things?

From the above basic equation, knowledge will only realise value when applied to a specific opportunity.

2.5.7.3 Summary of knowledge and knowledge management

Knowledge attributes of an artefact are continuously being enhanced during life cycles of the product development; the enterprise that makes it, as well as the value it will reach in the hands of the user. The journey of this value add currency starts with an idea, the lightest form of knowledge about an artefact and ends when the customer is delighted with the outcome at the end of its useful life.

This section defined the concept of knowledge, its management frameworks as well as different ways of representing the knowledge of an artefact and concluded by generating a knowledge cube to standardise the way to view, represent and value knowledge.

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2.6 Human Related Enabling Factors

The human interaction within an organisation is very complex and cannot be segregated into specific functions. For example, a leader needs relationships, communication, teamwork, knowledge, sound judgement, and similar attributes to affect his leadership within an organisation. Similarly, communication cannot be isolated as it requires at least two parties to be successful which implies some sort of relationship at play.

Creativity, on the other hand, is practised within a specific framework or culture as defined below by Dubina et.al. (2016)[181].

"Creativity in the "West" is associated with breaking or rejecting traditions; it is considered a discontinuous, revolutionary, relatively rapid and insightful process. Creativity is based on and involves individual traits; it is expressive, emotional, and somewhat spontaneous. Creativity is often understood as creative thinking, which should be task and method focused. Creativity is contextually pragmatic in problem-solving and it often tends to look outward towards "progress".

Creativity in the "East" is associated with respecting traditions and does not run contrary to them. It is a continuous, evolutionary, and slow process requiring much effort, hard work, repetition, attention, and a strong knowledge base. Creativity builds on and involves collective effort and a more structured, team-oriented approach. Creativity is understood to be socially utilitarian since the aspects of social influence on creativity are most important—creativity should help society, improve society, and contribute to society."

According to Pirson et.al. (2014)[182] *"Trust is, however, commonly viewed as the key enabler for cooperation, motivation, and innovation, all of which are required to achieve an organisation's peak performance and its eventual success."*

A non-exhaustive list of potential human factors, for potential inclusion in the framework is:

- Innovation
- Creativity

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[181] Dubina, I.N., Ramos, S.J. & Ramos, H. (2016) *Culture as a Driving Force of Individual and Organizational Behaviour.* Dubina, I.N., Carayannis E.G. (eds.), Creativity, Innovation, and Entrepreneurship Across Cultures, Innovation, Technology, and Knowledge Management. Springer Science+Business Media LLC New York.

[182] Pirson, M., Steinvorth, U., Largacha-Martinez, C. & Dierksmeier, D. (2014) *From Capitalistic to Humanistic Business*. Macmillan Distribution Ltd, Houndmills, Basingstoke, Hampshire RG21 6XS, England.

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- Entrepreneurship
- Leadership
- Knowledge
- Wisdom
- Judgement
- Communication
- Teamwork
- Collaboration
- Group Thinking
- Culture
- Relationships
- Trust
- Respect
- Flexibility
- Passion
- Caring
- Quick decision making
- Ethics
- Learning
- Dignity

Hartley & Bruckmann (2002)[183] argue as follows:

> *'But how important is communication to the organisation's well-being? Is there enough evidence to support the claims that 'business communication is a critical success factor for any organisation (Misiura, 1996, p.6)[184] or that good management depends on effective communication? (Bovee & Thill, 1995, p.15)[185] The answer is clearly 'yes': research overwhelmingly suggests that improved internal communication brings large scale organisational benefits (Tourish, 1997, p.109)[186].'*

The interrelationships of all the human factors listed above vs. the chosen factors to study

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[183] Hartley, P. & Bruckmann, C.G. (2002) *Business Communication.* Edition published in the Taylor & Francis e-Library, 2007.
[184] Misiura, S. (1996) *Business Communication.* Oxford: Butterworth-Heinemann.
[185] Bovee, C.L. & Thill, J.V. (1995) *Business Communication Today*. 4th edition. New York: McGraw-Hill.
[186] Tourish, D. (1997) *Transforming Internal Corporate Communications: The Power of Symbolic Gestures and Barriers to Change.* Corporate Communications: An International journal 2(3):109–116.

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have been incorporated in a relation table and resulted in table 2-5.

Table 2-5: Human Factors Inter-relation

Human factors	Leadership	Relationship	Wisdom	Culture
Innovation				
Creativity				
Entrepreneurship				
Leadership				
Knowledge				
Wisdom				
Judgement				
Communication				
Teamwork				
Collaboration				
Group Thinking				
Culture				
Relationships				
Trust				
Respect				
Flexibility				
Passion				
Caring				
Quick decision making				
Ethics				
Learning				
Dignity	Alternative View on Human Factors			

Supportive Primary

This analysis indicates that, except for dignity, the proposed human factors identified for the case study will result in a holistic view of the possible contribution of the human in the supply process.

Bob Seelert (2009)[187] identifies **leadership** as a critical factor contributing towards successful client interaction: *"Leadership is intangible. The first step is earning the trust of people you work with. Everything else follows from that."*

Soupios & Mourdoukoutas (2015)[188] define the need to investigate **relationships** with their statement *"We are convinced that enduring success is ultimately traceable to those*

[187] Seelert, B. Chairman, Saatchi & Saatchi. (2009) *Start with the Answer, and other Wisdom for Aspiring Leaders.* John Wiley & Sons, Inc., p.147.
[188] Soupios, M.A. & Mourdoukoutas, P. (2015) *The Ten Golden Rules of Leadership.* Classical Wisdom for Modern Leaders, M. A. American Management Association, pp. 128-9.

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extraordinary men and women who, by their personal insights and integrity, are able to command the loyalties and commitments of their subordinates. To our way of thinking, failure to see matters in these terms constitutes the real naïveté as well as the greatest impediment to building a meaningful enterprise."

According to Briskin et al. (2009)[189] *"change happens on a macro systems level but also on a micro level—one conversation at a time, one group at a time, one new idea spawned among a group of committed people, setting off a chain reaction of new possibilities*". They conclude that collective wisdom is the human ability of finding alternative ways in pursuing "*wise action*". Wise action is defined as the capability to exercise good judgment and to reflect real understanding of the issue at hand. Collective **wisdom** results in unexpected and positive results that hold more value than any single individual can contribute.

Courtney et al. (2005)[190] studied the social learning at the Australian Defence Organization (ADO) to identify factors that will enable the generation and transfer of knowledge to contribute to the creation of organisational culture in support of continuous learning. These factors are described as *"common identity, moral, problem-solving, team building, performance management, workplace design, organisational culture, records keeping, information exchange, IT infrastructure, professional training, and induction and enculturation."* It will be important to understand the contribution of **corporate culture** to the success of the project.

Culture is a fundamental indicator of human behaviour. Aristotle once said, *"What is honoured in a culture will be cultivated there."* (Raina, 1999)[191]

Culture derives from the Roman (Latin) "colere" to *"cultivate, take care, tend and preserve*", and these are still what we mean when we use the term culture.

During the preceding years of working in a complex organisation, the author observed that the effect of leadership, relationships, collective wisdom and company culture did have some role to play in the success of a project. We now investigate these specific human related factors as follows:

As human nature, like the human being is complex, one does not expect the human factors to be all inclusive nor do we believe that they will be completely independent or mutually exclusive.

The Interactive Supply Framework will not be complete without the introduction of the human into the process. To define the various human interfaces into the process concisely, the author defined four specific areas for research:

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[189] Briskin, A., Erickson, S., Ott, J. & Callanan, T. (2009) *The Power of Collective Wisdom and the Trap of Collective Folly.* Berrett-Koehler Publishers, pp. 5, 8, 20, 24.
[190] Courtney, J.F., Haynes, J.D. & Paradice, D.B. (2005) *Inquiring Organizations: Moving from Knowledge Management to Wisdom*. Idea Group Publishing, pp. 316-317.
[191] Raina, M. K. (1999) *Cross-cultural Differences.* In M. A. Runco & S. R. Pritzker (Eds.), Encyclopedia of creativity (Vol. 1, pp. 452–464). San Diego, CA: Academic Press.

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- Leadership
- Relationships
- Wisdom
- Culture

2.6.1 Leadership

The leadership factors are considered by investigating the macro leadership styles within an organisation in different life cycle phases of the organisation as well as the transition effects between phases. For this reason, we will investigate the Adizes (2017)[192] and Ward (2004) management or leadership models.

2.6.1.1 Understanding the Adizes Management Model

Adizes defines business administration, management, executive and leadership roles as the same process only packaged differently. There is no perfect person, and it is all right to have weaknesses sometimes. He defines leadership as the ability *"to get the different people to work together synergistically by complementing each other's differences in a culture of mutual respect and trust."*

Respect is when you recognise the right of the other person to be different and trust is when you believe that the other person has your interest at heart.

Adizes also defined four specific management (leadership) styles as depicted in figure 2-57 below. He proposes that the fundamental management function for any team, department, enterprise, family, or even country, can be defined by just four basic styles as defined below:

If a company can develop these four roles, then it should be successful over the short term (operational) as well as in the long run (tactical and strategic). The understanding of these functions and how to develop them in the enterprise is therefore essential knowledge for management (leadership).

[192] Adizes, I. (2017) *PAEI Management Roles.* Available at: http://www.comindwork.com/weekly/2015-03-30/productivity/paei-management-roles-adizes [Accessed June 2017].

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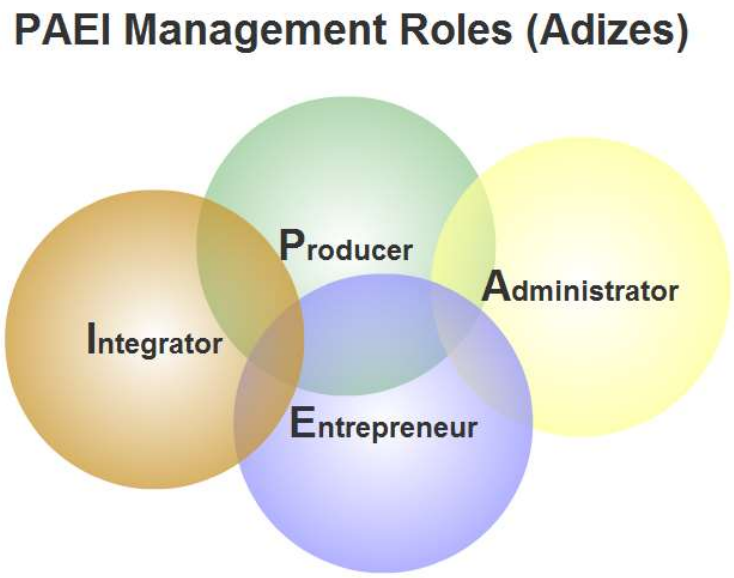

Figure 2-57: Adizes Management Styles (PAEI) (Adizes, 2017)

The four roles of management are as follows quoted directly from Adizes (2017)

- ***"Role #1 - Produce:*** *is usually very busy most of the time, demonstrating high energy and focused on getting real results and fast. Producer dislikes for future tasks or theoretical explanations of what should be achieved.*

- ***Role #2 - Administer:*** *is concerned about the process of achieving the goal, will not act until he understands how something is going to be achieved. Administrator hates uncertainty, and you will hardly see his improvisation.*

- ***Role #3 - Entrepreneur:*** *does a wild dreamer want some great results later in the future, rather than a concrete result right today. He will often prefer bigger potential results in the far future rather than the result for tomorrow. The entrepreneur gets easily excited by some new technologies or new ways of work.*

- ***Role #4 - Integrate:*** *is an excellent organiser and team-builder in the company, he will happily manage interpersonal conflicts, improve relationships between internal and external team members.*

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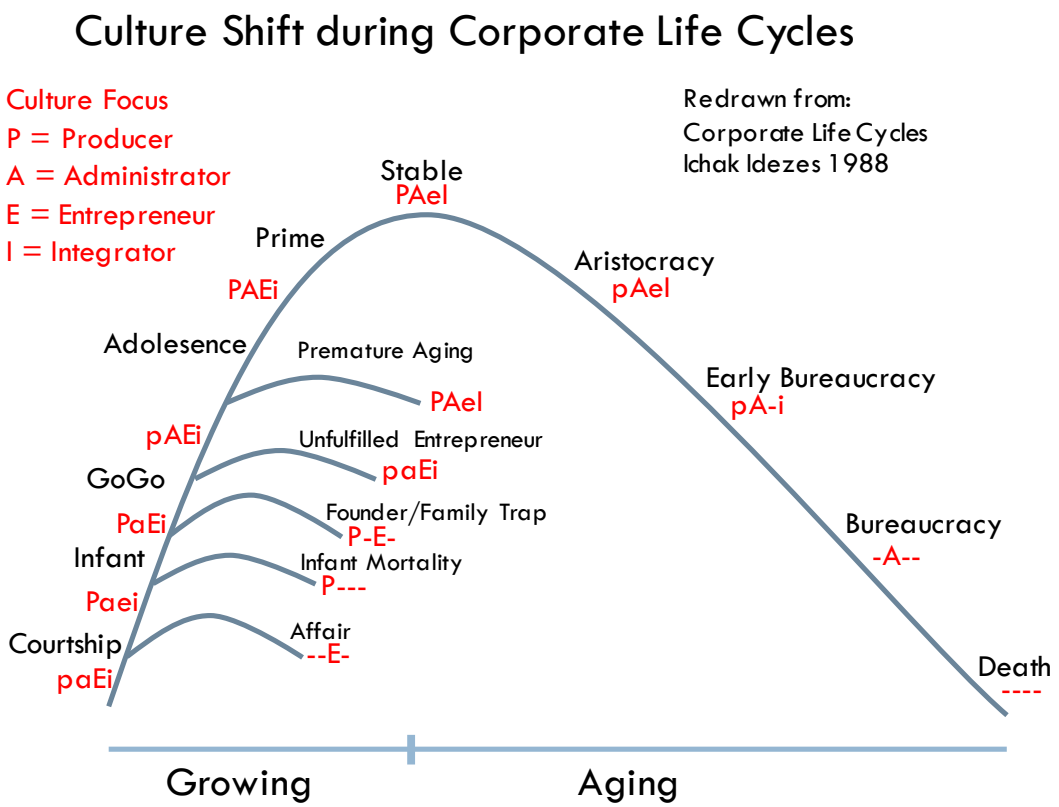

Figure 2-58: Applying the PAEI roles to the Life cycle of the Enterprise. (Adizes, 1988)[193]

The required mixture of management (leadership) needed depends on where in the corporate life cycle the enterprise finds itself (refer to figure 2-58 above).

For example, during Courtship, the focus is on the Entrepreneur, whereas during the Infant stage the Producer role is more in focus. In the Go-Go stage, both roles are the focus (entrepreneur and producer), whereas in Adolescence the Administrator and Entrepreneur roles are the key focus.

2.6.1.2 The Leadership Life Cycle by Ward (2004)

Management styles have been studied by many authors over the past years. As is the case with other models, the Ward model is based on the ground breaking work of Carl Jung. Common to all Jungian-based frameworks are the four basic management styles. Leadership styles defined by Ward (2004) as specified in figure 2-59 below:

[193] Adizes, I. (1988) *Corporate Life Cycles and Management Roles.* Available at: https://www.pinterest.com/pin/292593307014444449/ [Accessed June 2017].

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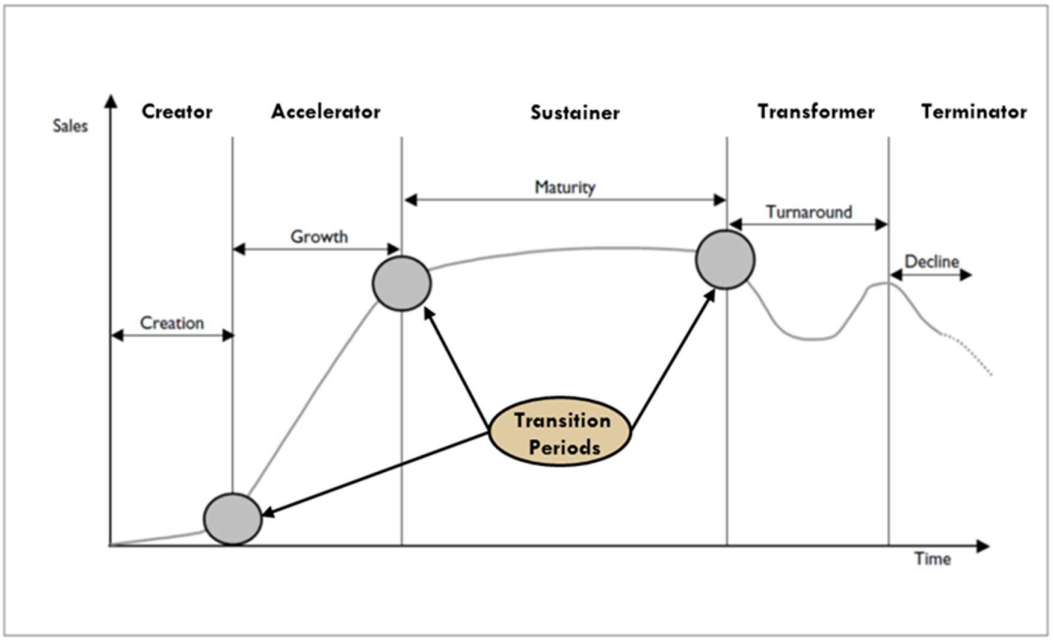

Figure 2-59: Transition Points in the Leadership Life Cycle. (Ward, 2004)

Ward (2004), through the study of companies at different stages of the organisation's life cycle, concluded that there are unique challenges facing organisations and its leadership at each transition between the various stages. Consequently, it requires significantly different managerial and leadership skills to lead an organisation at these various transitional periods. Hence the Leadership Life Cycle with the Creator, Accelerator, Sustainer, Transformer and Terminator roles that are required for success.

The Classic Phases of the Enterprise Life Cycle are defined as:

- The Creation or Start-Up Phase
- The Growth Phase
- The Operational or Maturity Phase
- The Turn-around Phase
- The Decline or Re-Development Phase

2.6.1.3 Total Leadership by Friedman

Friedman (2009)[194] postulates that a balance between the different life dimensions is a requirement for real leadership as defined in the table below:

[194] Friedman, S.D. (2009) *Be a Better Leader, Have a Richer Life.* Harvard Business Review. April 2008.

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Table 2-6: Total Leadership by Friedman (2009)

Experiment: Exercise three mornings a week with spouse.

Life Dimension	Experiment's Goals	How I Will Measure Success	Implementation Steps
Work	Improved alertness and productivity	No caffeine to get through the day; more productive sales calls	• Get doctor's feedback on exercise plan. • Join gym. • Set alarm earlier on exercise days. • Tell coworkers, family, and friends about my plan, how I need their help, and how it will benefit them.
Home	Increased closeness with spouse	Fewer arguments with spouse	
Community	Greater strength to participate in athletic fundraising events with friends	Three 10K fundraising walks completed by end of year	
Self	Improved self-esteem	Greater confidence	

'Traditional thinking puts work and the rest of our lives against each other. But taking quick steps to integrate work, home, community, and self will make you a more productive leader and a more fulfilled person.'

2.6.1.4 Fundamental Stages and Leadership by Van der Erve

Van der Erve (2004)[195] defines leadership and the fundamental stages of company development as depicted diagrammatically in figure 2-60 as:

- Discover and innovate
- Nurture niches
- Specialise and optimise
- Confront and shake up

This is a similar view as defined by Adizes with his PAEI leadership roles.

[195] Van der Erve, M. (2004) *Temporal leadership, Evolution Management.* Grez-Doiceau, Belgium European Business Review Vol. 16 No. 6, 605-617 Emerald Group Publishing Limited.

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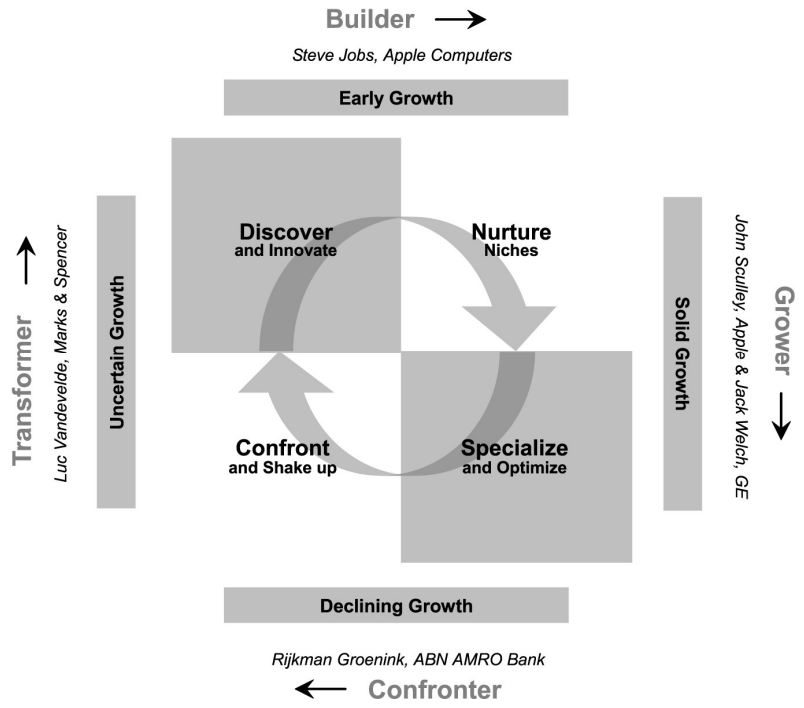

Figure 2-60: Leadership and Stages of Company Development (Van der Erve, 2004)

2.6.1.5 Managing Oneself by Peter Drucker

"Success in the knowledge economy comes to those who know themselves—their strengths, their values, and how they best perform."

Drucker (1999)[196] postulates that success will only come to those who know themselves so that they can face the demands of being a leader by answering the following questions:

- What are my Strengths?
- How do I Work?
- What are my Values?
- Where do I Belong?
- What can I Contribute?

By performing this self-examination, you will be able to operate from a combination of your strengths and self-knowledge. This will enable you to achieve true, and lasting, excellence.

2.6.1.6 Putting Leadership Back into Strategy by Cynthia Montgomery

Montgomery (2008)[197] states that *"A CEO must be the steward of a living strategy that defines what the firm is and what it will become."*

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[196] Drucker, P. (1999) *Managing Oneself.* Harvard Business Review. January 2005.
[197] Montgomery, C.A. (2008) *Putting Leadership Back into Strategy.* Harvard Business Review. January 2008.

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Table 2-7: The Missing Dimension by Montgomery (2008)

The Missing Dimension

Over the past few decades strategy has become a plan that positions a company in its external landscape. That's not enough. Strategy should also guide the development of the company—its identity and purpose—over time.

The Prevailing Approach: **Strategy as a Set Solution**		What Is Missing: **Strategy as a Dynamic Process**
A long-term sustainable competitive advantage	**Goal**	Creation of value
The CEO and strategy consultants	**Leadership**	CEO as chief strategist; the job cannot be outsourced
Unchanging plan that derives from an analytical, left-brain exercise	**Form**	Organic process that is adaptive, holistic, and open-ended
Intense period of formulation followed by prolonged period of implementation	**Time Frame**	Everyday, continuous, unending
Defending an established strategy through time	**Ongoing Activity**	Fostering competitive advantages and developing the company through time

Montgomery concludes with the following statement about the corporate leader:

"The need to create and re-create reasons for a company's continued existence sets the strategist apart from every other individual in the company."

2.6.1.7 Seven Transformations of Leadership by Rooke & Torbert (2004)

Rooke & Torbert (2004)[198] concluded that leaders exhibit different styles in which they interpret their environment and react when faced with a challenge. From the research of thousands of various leaders, seven types of action logics were observed. In their estimation,

[198] Rooke, D. & Torbert, W.R. (2004) *Seven Transformations of Leadership.* Harvard Business Review. April 2005.

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Opportunist and Diplomat action logics were the less efficient for organisational leadership. The most efficient was the Strategist and Alchemist roles. Understanding your own default action logic is the first step toward developing a more effective leadership style.

Rooke & Torbert postulate seven different ways of leading as listed in the table below.

Table 2-8: Seven Ways of Leading by Rooke and Torbert (2004)

Action Logic	Characteristics	Strengths	% of research sample profiling at this action logic
Opportunist	*Wins any way possible.* Self-oriented; manipulative; "might makes right."	Good in emergencies and in sales opportunities.	5%
Diplomat	*Avoids overt conflict.* Wants to belong; obeys group norms; rarely rocks the boat.	Good as supportive glue within an office; helps bring people together.	12%
Expert	*Rules by logic and expertise.* Seeks rational efficiency.	Good as an individual contributor.	38%
Achiever	*Meets strategic goals.* Effectively achieves goals through teams; juggles managerial duties and market demands.	Well suited to managerial roles; action and goal oriented.	30%
Individualist	*Interweaves competing personal and company action logics.* Creates unique structures to resolve gaps between strategy and performance.	Effective in venture and consulting roles.	10%
Strategist	*Generates organizational and personal transformations.* Exercises the power of mutual inquiry, vigilance, and vulnerability for both the short and long term.	Effective as a transformational leader.	4%
Alchemist	*Generates social transformations.* Integrates material, spiritual, and societal transformation.	Good at leading society-wide transformations.	1%

2.6.1.8 A Leader's Framework for Decision Making by Snowden and Boone (2007)

Snowden & Boone (2007)[199] defined the Cynefin framework to support leaders when they determine the current environmental context so as to make appropriate decisions about how to respond. Each of the domains requires alternative actions. As an example, '*Simple and Complicated contexts assume an ordered universe, where cause-and-effect relationships are perceptible, and right answers can be determined based on the facts. Complex and chaotic contexts are unordered—there is no immediately apparent relationship between*

[199] Snowden, D.J. & Boone, M.E. (2007) *The Cynefin Framework.* Harvard Business Review. November 2007.

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cause and effect, and the way forward is determined based on emerging patterns.'

The '*ordered world*' is the world of fact-based leadership while the '*unordered world*' represents pattern- based management, as shown in figure 2-61.

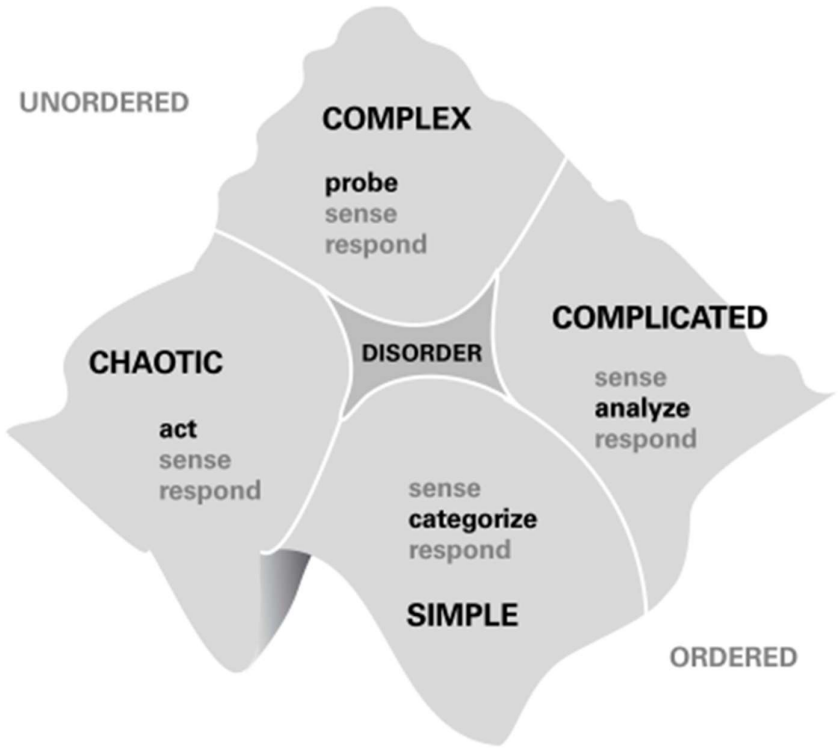

Figure 2-61: The Cynefin Framework (Snowden & Boone, 2007)

The very basis of the fifth context "*disorder*" makes it very difficult to realise that you are part of it. In this case, all perspectives jostle for prominence; factional leaders will argue with one another and disorder rules. The way out of this problem is to break down the process into constituent parts and assign each to one of the other four realms.

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Table 2-9: A Leaders Guide to Decision Making by Snowden & Boone (2007)

Decisions in Multiple Contexts: A Leader's Guide

Effective leaders learn to shift their decision-making styles to match changing business environments. Simple, complicated, complex, and chaotic contexts each call for different managerial responses. By correctly identifying the governing context, staying aware of danger signals, and avoiding inappropriate reactions, managers can lead effectively in a variety of situations.

	THE CONTEXT'S CHARACTERISTICS	THE LEADER'S JOB	DANGER SIGNALS	RESPONSE TO DANGER SIGNALS
SIMPLE	Repeating patterns and consistent events Clear cause-and-effect relationships evident to everyone; right answer exists Known knowns Fact-based management	Sense, categorize, respond Ensure that proper processes are in place Delegate Use best practices Communicate in clear, direct ways Understand that extensive interactive communication may not be necessary	Complacency and comfort Desire to make complex problems simple Entrained thinking No challenge of received wisdom Overreliance on best practice if context shifts	Create communication channels to challenge orthodoxy Stay connected without micromanaging Don't assume things are simple Recognize both the value and the limitations of best practice
COMPLICATED	Expert diagnosis required Cause-and-effect relationships discoverable but not immediately apparent to everyone; more than one right answer possible Known unknowns Fact-based management	Sense, analyze, respond Create panels of experts Listen to conflicting advice	Experts overconfident in their own solutions or in the efficacy of past solutions Analysis paralysis Expert panels Viewpoints of nonexperts excluded	Encourage external and internal stakeholders to challenge expert opinions to combat entrained thinking Use experiments and games to force people to think outside the familiar
COMPLEX	Flux and unpredictability No right answers; emergent instructive patterns Unknown unknowns Many competing ideas A need for creative and innovative approaches Pattern-based leadership	Probe, sense, respond Create environments and experiments that allow patterns to emerge Increase levels of interaction and communication Use methods that can help generate ideas: Open up discussion (as through large group methods); set barriers; stimulate attractors; encourage dissent and diversity; and manage starting conditions and monitor for emergence	Temptation to fall back into habitual, command-and-control mode Temptation to look for facts rather than allowing patterns to emerge Desire for accelerated resolution of problems or exploitation of opportunities	Be patient and allow time for reflection Use approaches that encourage interaction so patterns can emerge
CHAOTIC	High turbulence No clear cause-and-effect relationships, so no point in looking for right answers Unknowables Many decisions to make and no time to think High tension Pattern-based leadership	Act, sense, respond Look for what works instead of seeking right answers Take immediate action to reestablish order (command and control) Provide clear, direct communication	Applying a command-and-control approach longer than needed "Cult of the leader" Missed opportunity for innovation Chaos unabated	Set up mechanisms (such as parallel teams) to take advantage of opportunities afforded by a chaotic environment Encourage advisers to challenge your point of view once the crisis has abated Work to shift the context from chaotic to complex

'In the complex environment of the current business world, leaders need to know when to share power and when to wield it alone, when to look to the wisdom of the group and when to take their own counsel. A deep understanding of context, the ability to embrace complexity and paradox, and a willingness to flexibly change leadership style will be required for leaders who want to make things happen in a time of increasing uncertainty.'

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2.6.1.9 How Successful Leaders Think by Roger Martin (2007)

Martin (2007)[200] defined four steps that leaders must embrace. These are:

- Determining Salience
- Analyzing Causality
- Envisioning the Decision Architecture
- Achieving Resolution

He also classified two groups of thinkers namely:

- Conventional Thinkers
- Integrative Thinkers

The conventional thinker seeks simplicity and is often forced to make unattractive trade-offs. By contrast, the integrative thinker welcomes complexity as this allows the crafting of new solutions.

Table 2-10: Conventional versus Integrative Thinking (Martin, 2007)

	1 Determining Salience →	2 Analyzing Causality →	3 Envisioning the Decision Architecture →	4 Achieving Resolution
CONVENTIONAL THINKERS	Focus only on obviously relevant features	Consider one-way, linear relationships between variables, in which more of A produces more of B	Break problems into pieces and work on them separately or sequentially	Make either-or choices; settle for best available options
INTEGRATIVE THINKERS	**Seek less obvious but potentially relevant factors**	**Consider multidirectional and nonlinear relationships among variables**	**See problems as a whole, examining how the parts fit together and how decisions affect one another**	**Creatively resolve tensions among opposing ideas; generate innovative outcomes**

> *'Integrative thinkers don't mind a messy problem. In fact, they welcome complexity, because that's where the best answers come from.'*

2.6.1.10 Leadership in China

As the world is a global business place, it is also important to look at the way the second largest economy, China understands and practices these leadership issues. Gallo (2011)[201] postulates that, given the complexity of China and its culture, it is almost impossible to compile a truly complete dissertation on Chinese business leadership. A few things to consider are:

China focused research about leadership on demographic variables such as geography, age, gender, place of higher education, and experience obtained in the West. The also focus on:

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[200] Martin, R. (2007) *How Successful Leaders Think.* Harvard Business Review. June 2007.
[201] Gallo, F.T. (2011) *Business Leadership in China, How to Blend Best Western Practices with Chinese Wisdom.* John Wiley & Sons (Asia) Pte. Ltd, p. 220.

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'Testing of well-respected Western leadership models for their applicability in China; leadership development programs designed specifically for China; and scrutiny of all other leadership areas. These areas include functional knowledge, strategic leadership, and leading in different organisational structure types.

Cultural understanding is becoming more individual-specific to include cultural intelligence (CQ). Companies with a multi- cultural makeup or a global focus may want to examine ways to identify CQ in leadership candidates before assigning them to such positions in China.

A specific model for leading businesses in China may soon be available. Such a model may help both Westerners and Easterners become successful leaders in China.'

Tan (2012)[202] identified different leadership styles for different life cycle phases applied to the Chinese private companies. Figure 2-62 below defines these management styles.

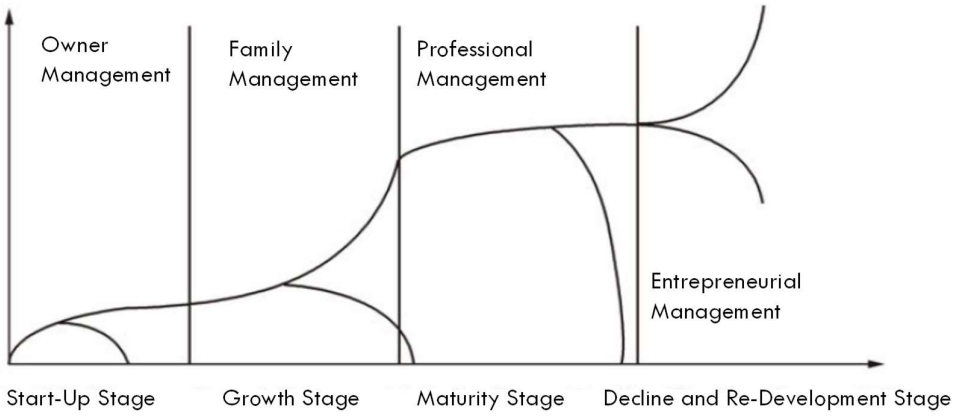

Figure 2-62: Management Styles in Chinese Private Companies (Tan, 2012)

2.6.1.11 Leadership Summary

From all the diverse and sometimes controversial leadership frameworks described in the above paragraphs, the author would like to confirm the view of Adizes as he defines leadership as the ability: *'to get the different people to work together synergistically by complementing each other's differences in a culture of mutual respect and trust.'*

For the Interactive Supply Framework and Leadership in context, it is important to note the following:

- **Different leadership roles** are required for effective management in each life cycle

[202] Tan, J. (2012) *Private Enterprise Management Mode based on the Life Cycle Theory.* International Business and Management. 5(2), 83.

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phase of the enterprise as defined by most models.

- The **propensity for failure** is higher in the **transition periods** between phases, and special care must be taken in this process.

During the turn-around and late re-creation phases two distinct forces are opposed i.e.:

- Cost saving and the consequential load on people during the down turn phase.
- The need for free energy and the different leadership style required for the re-creation of the enterprise.
- One person cannot be a super leader all the time, catering for all situations during all the phases of the company. It is, therefore, important to realise that:
- Leadership means to get the different people to work together synergistically
- It's all right to change the top management of an enterprise to fit the transition or life cycle phase it needs to operate and be successful in.

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2.6.2 Relationships

It was determined that customer relationships, as defined in the review on marketing, are indeed one of the cornerstones for a healthy growing business. It is also evident that the belief system alignment of the company's people at various levels with those of the customer environment is an important area to review.

2.6.2.1 Belief System

The belief system is the actual set of precepts from which you live your daily life, those who govern your thoughts, words, and actions as defined by Fringe Wisdom (Woods, 2014)[203]. As no complete alignment between the belief systems of the customer, as well as the supplier, at all levels, is realistically possible, one needs to focus on areas of miss-alignment that have the potential to turn an Interactive Event into a failure. According to the literature (Hussain, 2013)[204], the business belief system comprises of the following four elements:

- **The response,** Behavioural Performance, Action, Inaction – How people respond to what is happening.
- **Cognitions**, Mindsets, Clarity, Perceptions – How people think of what is happening.
- **Philosophy**, Core Beliefs, Personal Values – The meaning people attach to what is going on.
- **Emotional Climate**, Emotional Climate, Relationship Management, Emotional Information – How people feel about what is going on.

Figure 2-63 below depicts how the belief system is contextualised within a company's processes.

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[203] Woods, K, (2014) *Your Belief System.* Available at: http://www.fringewisdom.com/your_belief_system.php. Copyright © 1997-2012, Karl Woods All Rights Reserved [Updated 11 October 2014].

[204] Hussain, S. (2013) *The Business Belief System.* Available at: http://sahrahussain.com/2013/11/10/theory-vine-app-and-obessesive-compulsive-disorder-ocd/ [Accessed November 2013].

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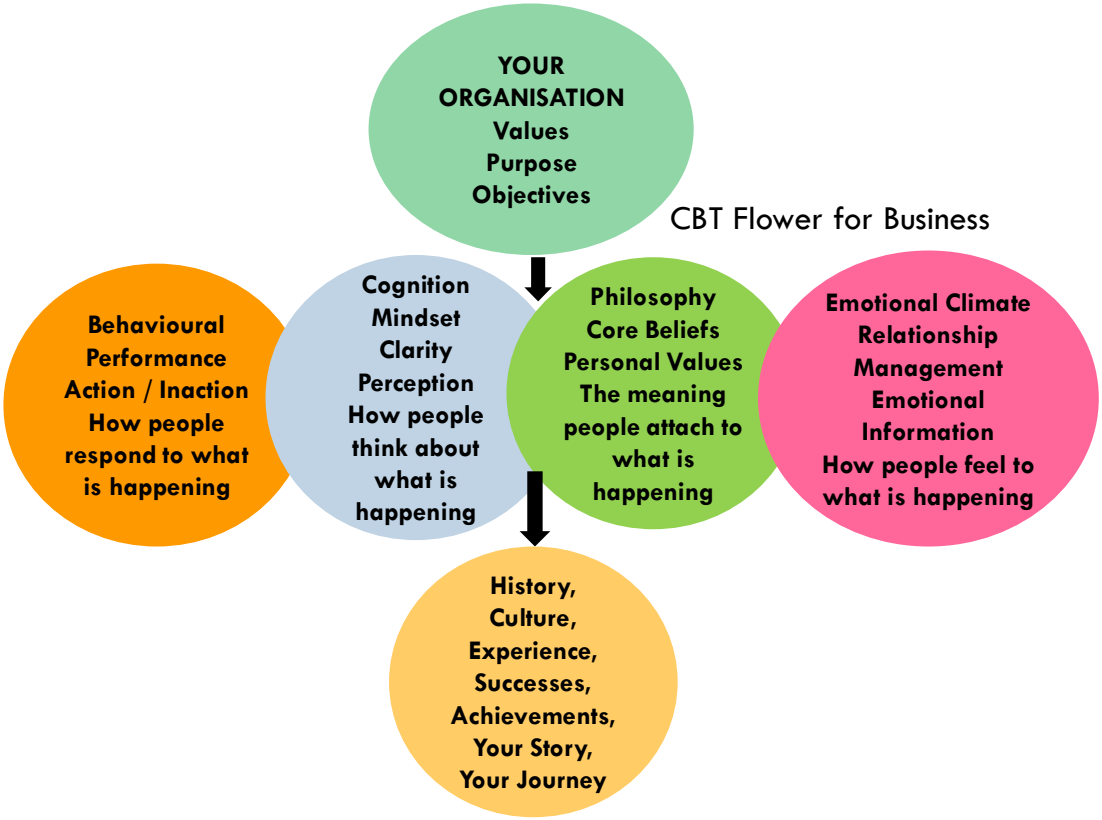

Figure 2-63: The Cognitive Behavioural Theory Flower for Business (Hussain, 2013)

The classic cognitive behaviour model started with Albert Ellis (1965)[205], who defined the Rational Emotive Behavioural Theory (REBT) in the early 1960's. He postulated that the human tendency is towards people being *'responsible hedonistic because they strive to remain alive and to achieve some degree of happiness.'* Humans are also susceptible to adopting irrational beliefs and behaviours which can get in the way of them achieving their goals. This idea was already articulated about 2000 years ago by the Greek philosopher Epictetus[206], whose words illustrate this belief, *'People are disturbed not by events, but by the views which they take of them.'*

The history of cognitive behavioural therapy will be incomplete without the mention of Albert Bandura, the famous psychologist from Stanford, who has given us the social cognitive theory of learning (Simon and Pajares 2001). This theory is defined as:

> *'A study that is descriptive about how the concept of cognition plays a major role in determining the behavioural pattern of a person.'*

This cognitive behaviour theory can be further elucidated by considering the meaning of cognition, which is to know, to conceptualise, to recognise as a thought process that grasps knowledge. It includes the way we understand, remember, and reason about, developing

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[205] Bandura, A. (1965) *Influence of model's reinforcement contingencies on the acquisition of imitative responses.* Journal of Personality and Social Psychology, 1, pp. 589-95.
[206] Epictetus (2017) *BrainyQuote.com, Xplore Inc.* Available at: https://www.brainyquote.com/quotes/quotes/e/epictetus104206.html [Accessed June 30, 2017].

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beliefs and retaining knowledge.

To understand Cognitive Behaviour Theory as applied to the business environment, we first need to consider the basic cognitive behavioural sequence, that can be described as follows (Hayes, 2004)[207], (Mulhauser, 2013)[208]:

Activities or Events (A) followed by thoughts based on our Belief System (B) followed by a Consequential behaviour (C) because of our emotions (the ABC model applied in business as defined below in figure 2-64.)

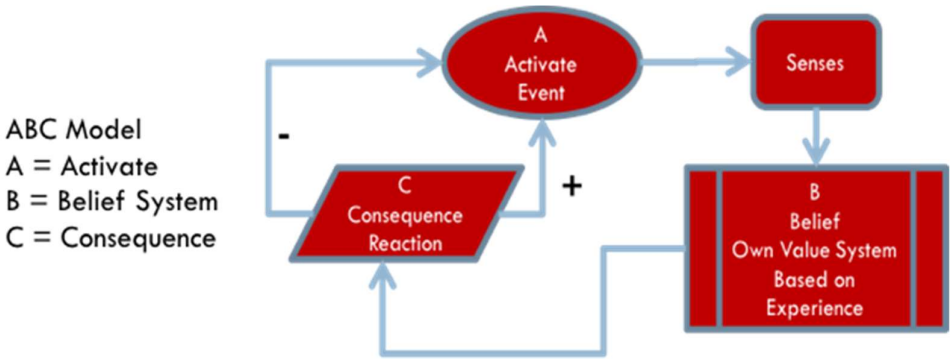

Figure 2-64: Cognitive Behaviour Theory (derived from Hayes, 2004)

When we view the ABC model as a process, we get the Cognitive Behavioural Sequence also depicted in figure 2-65 below (DaPsyche, 2017)[209].

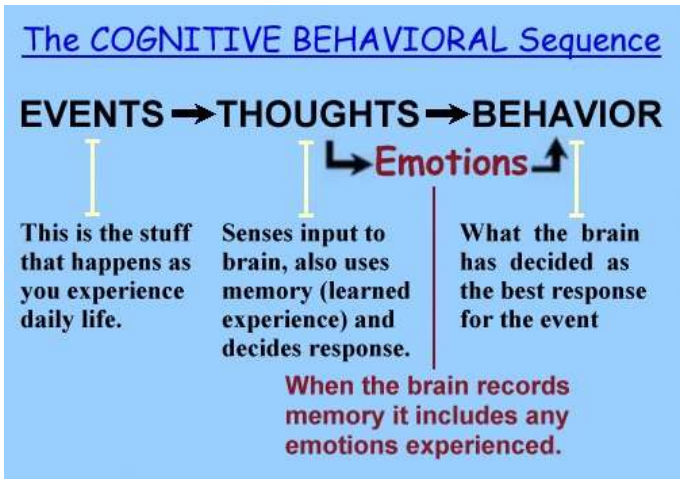

Figure 2-65: The Cognitive Behavioural Sequence (DaPhysic, 2017)

2.6.2.2 The Customer, Company Relationship Roadmap

One can now combine the healthy relationships required with the act of bringing a product

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[207] Hayes, C.S. (2004) *Acceptance and commitment therapy, relational frame theory, and the third wave of behavioral and cognitive therapies*. Behaviour Therapy Volume 35, Issue 4, Autumn 2004, 639-665.
[208] Mulhauser, G. (2013) *An Introduction to Rational Emotive Behaviour Therapy.* Available at: http://counsellingresource.com/lib/therapy/types/rational-emotive/ [accessed August 2013].
[209] DaPsyche, (2017) *Mental Health: Cognitive Behavioural Therapy (CBT).* Available at: http://dapsyche.com/cognitive-behavioral-therapy-cbt/ [Accessed June 2017].

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to a customer. Saren & Stewart (2014) in their Marketing Pathfinder Map, define the crucial function of relational exchange between the firm and the buyer as the key that makes this roadmap work.

The following factors gave rise to the relational approach to marketing:

- Information and communication technologies that fragment the mass markets
- More data about individual customers can be collected and analysed
- The demand for higher levels of product quality resulting in companies seeking competitive advantage by different means
- Customers are more demanding, and
- Customer buying patterns are changing rapidly.

Möller & Halinen (2000) defined the origin of the relational approach to marketing as:

- Developed from a combination of ideas in business to business marketing
- Information technology-enabled developments in database and direct marketing
- The wider application of some main features of services marketing.

By utilising these developments in technologies and relationship marketing thinking, companies have sought alternative means to establish and maintain relationships with customers. The goal is to retain customers in these relationships. It requires a fundamental shift in marketing from a focus on transactions (i.e. sales) to relationships (i.e. retention) as companies move from short-term transaction-oriented marketing activities to long-term relationship-building. The fundamental differences between these approaches are shown in the table below:

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Table 2-11: Transactional vs. Relationship Marketing Approaches (Paine 2000)

Transactional Marketing	Relationship Marketing
Focus on single sales	Focus on customer retention
Orientation to product feature	Orientation to customer value
Short timescale	Long timescale
Little emphasis on customer service Moderate customer contact	High customer service emphasis High customer contact
Quality is primarily a concern of production Limited customer commitment	Quality is the concern of all High customer commitment

Source: Adapted from Payne (2000)

The Relationship Marketing Approach has its explicit focus on marketer–supplier relationships and the subsequent dynamics of these relationships. Both the seller and customer must be active participants in these relationships, as opposed to the transactional marketing view which defines the marketer as the active agent and the customer as being passive in the process. The main task for the marketing function is that of managing these relationships with customers and others and not only the sale of products, channels, organisations, etc.

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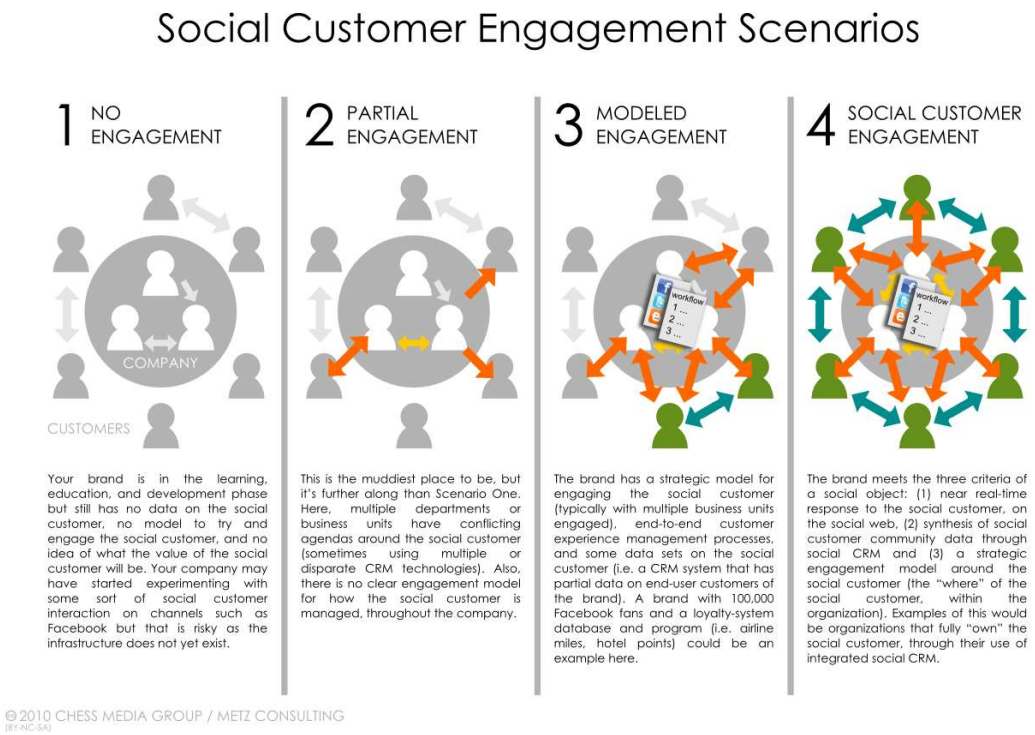

Figure 2-66: Social Customer Engagement Scenarios (Metz, 2011)

In this regard, Adam Metz has described how an organisation's social customer engagement may evolve (Metz 2011)[210] in figure 2-66: He defined four stages of engagement as follows:

- No engagement: The organisation embarked on ongoing education themselves about social customer engagement.
- Partial engagement: Parts of organisation do not always agree on the value outcomes of social customer engagement.
- Modelled engagement: The organisation has developed and is implementing a strategic model in support of customer engagement.
- Social customer engagement: The organisation has a very solid understanding of the social customer and the mutually beneficial business value that this engagement brings.

[210] Metz, A. (2011) *The Social Customer: How Brands Can Use Social CRM to Acquire, Monetize, and Retain Fans, Friends, and Followers.* McGraw-Hill Education; 1st Edition September 6, 2011.

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2.6.3 Wisdom

Management is defined as a series of decisions combined with supportive actions. Knowledge, on the other hand, exists as tacit knowledge within the people as well as explicit knowledge within the enterprise (Mohammad, 2010)[211].

Knowledge Management is one of the key factors that drive competitiveness within a business (Greiner et al., 2007)[212]. The making of informed decisions by combining good insight based on experience and one's own belief system, augmented by appropriate knowledge levels, gives rise to the concept of wisdom (Jardim-Goncalves et al., 2009)[213].

Decision-Making (Gan & Zhu, 2007)[214] is defined as '*a selection of alternative choices based on incomplete information which maximises probable achievement of goals in light of established values. Practically, the process is constrained by limited information and competing interests among participants in the organisation.'*

Gan (2005) defined the concept of collective wisdom as defined in figure 2-67 below.

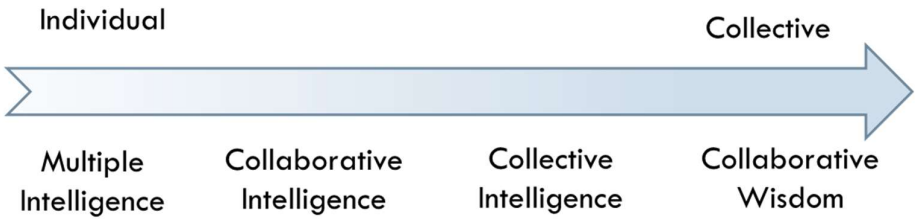

Figure 2-67: From Intelligence to Wisdom (Gan, 2005)[215]

2.6.3.1 The First Definition of Wisdom

The early Stoics (Brouwer, 2014)[216] said about wisdom that

> *"[i] wisdom is knowledge of human and divine matters, and*
>
> *[ii] philosophy, exercise of fitting expertise;*
>
> *[iii] the single and supremely fitting expertise is excellence,*

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[211] Mohammad, A. H. (2010) *Developing a Theoretical Framework for Knowledge Acquisition.* European Journal of Scientific Research, 42(3), 439–449.
[212] Greiner, M. E., Böhmann, T., & Krcmar, H. (2007) *A Strategy for Knowledge Management.* Journal of Knowledge Management, 11(6), 3–15.
[213] Jardim-Goncalves, R., Sarraipa, J., Agostinho, C., & Panetto, H. (2009) *Knowledge Framework for Intelligent Manufacturing Systems.* Journal of Intelligent Manufacturing, 6(3), 725–735.
[214] Gan, Y. & Zhu, Z. (2007) *A Learning Framework for Knowledge Building and Collective Wisdom Advancement in Virtual Learning Communities*. Educational Technology & Society, 10 (1), 206-226.
[215] Gan, Y. C. (2005) *Knowledge Building and Collective Wisdom Advancement in Virtual Learning Communities: Perspective on the Integration of Knowledge Management and e-Learning*. Beijing, China: China Educational Science Publishing House.
[216] Brouwer, R. (2014) *The Stoic Sage, The Early Stoics on Wisdom, Sagehood and Socrates.* Cambridge Classical Studies University Printing House, Cambridge, United Kingdom, p. 8.

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[iv] and excellences at their most general are three: in nature, in behaviour, in reasoning.

[v] For this reason philosophy is also divided into three parts: physical, ethical and logical.

[vi] Physical is when we investigate the world and the matters in the world, ethical is that which is occupied with human life, logical is that concerned with reasoning – the last they also call dialectical."

2.6.3.2 The Second Definition of Wisdom

The second explicit definition of wisdom survived in the corpus of writings of the physician Galen (129–199) and can be distilled from the Aëtius passage. He defines wisdom as *"the exercise of fitting expertise of the best life for human beings, saying that philosophy is exercise, and calling wisdom fitting expertise, which is also a cognition of human and divine matters."* (Brouwer, 2014).

2.6.3.3 The Modern Definition of Wisdom

Briskin et al. (2009) defined the use of the following terms related to the concept:

- **Wisdom —** *'Exercising sound judgment; reflects high under- standing of people and of situations. Considerate of multiple perspectives and forms of intelligence. Wisdom in groups is demonstrated by insight, wisdom, clarity, objectivity, and discernment rooted in deep caring and compassion.*
- **Collective** — *'A number of persons or things considered as one group or whole; marked by connection among or with the members of a group.'*
- **Folly** — *'Lacking good sense or normal prudence and fore- sight, a continuum of behaviours ranging from personally foolish behaviour to criminality, evil, and depravity.'*
- **Power —** *'The ability, strength, and capacity to do something, including the ability to bring about change.'*
- **Trap** — '*Something by which one is caught or stopped unawares; a position or situation from which it's hard or impossible to escape.'*

Wisdom indicates that we are part of something greater than ourselves alone. At a single and team level, we link wisdom with *"thoughtfulness, an ability to reflect deeply on personal experience, and a capacity for applying discretion and intuitive understanding."* Wisdom is a form of knowledge marked by our ability to identify the inter-relationships and their attributes in each situation. By considering multiple viewpoints and forms of intelligence, wisdom often shows up in unplanned insights and new ways of understanding. In a team, this can come in the shape of *emergence*, something original or unexpected that moves the whole group forward or ties together disparate elements of a situation. By this definition, wisdom is therefore associated with accumulated philosophic and/or scientific learning but is distinguished by qualities of reverence and respect for life.

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Beyond the Intellect, Beyond the Individual — The term collective wisdom reflects a quality of team understanding that is neither from the intellect alone nor of any individual alone. When this *"knowing and sense of right action emerges, it does so from deep within the individual participants, from within the collective awareness of the group, and from within the larger field of spiritual, cultural, and institutional forces that surround any group activity."*

By this definition, the practice of creating a new product or defining a new process is much more chaotic than the theory indicates.

Bob Seelert (2009) in his book on wisdom postulates that the concept of business and that of wisdom are rarely used in the same argument. This, however, is unfortunate because all successful executives—from the CEO to recruit, whether they know it or not, are on a *'journey of acquiring and applying wisdom in their careers'*. The business provides us with a very rich base for acquiring and enjoying the benefits of true wisdom in the following areas:

- Planning and other essentials of business strategy
- business operations: looking beyond the obvious
- finance and economics, or dollars and sense
- lessons in leadership
- building culture through communications
- personal style and spirit

Bob's formula for success is defined as: *'One part brains and two parts common sense is the right formula for success in a consumer business.'*

2.6.3.4 Business Wisdom in China

The topic of how to blend western practices with Eastern (Chinese) wisdom is worth investigating.

Western leadership traits are, for the most part, based on a relationship between the leader and his or her team members. These might include traits such as honesty, the ability to build trust, empathy, emotional intelligence, courage, and the encouragement of teamwork and ethical work practices.

Gallo (2011) in his work on the Western Business Practices in China identified that traits such as ***Wu*** (profound insight), and ***Zhong Yong*** (not going to extremes) were so ingrained in the Chinese culture that they were using them without realising the fact. Chinese employees, as a result, will look for the same traits in Western competencies in a leader and will also distinguish their own leaders based on other traits that are uniquely Chinese. When the Chinese do so, they are integrating Western best practices with Chinese wisdom, and indirectness.

Wu is based on Buddhism and refers to the leader's ability to understand an issue from its

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core. The Chinese character for ***Wu*** **(悟)** includes pictures of the five senses, implying that the senses are all used in obtaining this level of understanding. The Japanese, in turn, refer to this concept as satori, which is a form of enlightenment. While the Chinese use ***Wu*** more in a business sense than a mystical sense, it nevertheless implies this profound level of understanding.

Zhong Yong **(中 庸)** is a Confucian concept whose literal meaning is *'to be in the middle'*. But the actual meaning for leaders is *'to not go to extremes'*. As a result, the Chinese leaders often seek consensus from their top management. This in principle is a safer approach than taking an extreme position. The Daoist ideas of balance and harmony can also be linked to this concept.

A further trait required from Chinese leaders is patriotism. While the business leaders require allegiance to the firm, the Chinese society also expects allegiance to China.

Leaders in China express themselves much less directly than those in the West. This practice of indirectness implies thoughtfulness, respect for others and allows room for renegotiation after the fact. A more direct approach is too final and inflexible.

Other traits like customer sacrifice, striving to be humanistic, and holding a long-term view are also part of the Chinese way of doing business.

Tan (2012) indicates that the Chinese national experts consider clear strategies, improved governance, scientific decision making, smooth handover and social responsibility when they redesign the business leadership role in the transition from the family owned business into a professionally run enterprise.

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2.6.4 Organisational Culture

Organisational culture is the behaviour of humans within an organisation and the meaning that people attach to those behaviours. Culture includes the organisation's vision, values, norms, systems, symbols, language, assumptions, beliefs, and habits. (Wikipedia.org 2015)[217].

2.6.4.1 Definitions of Organisational Culture (Wikipedia, 2015)

- Culture refers to the cumulative deposit of knowledge, experience, beliefs, values, attitudes, meanings, hierarchies, religion, notions of time, roles, spatial relations, concepts of the universe, and material objects and possessions acquired by a group of people during generations through individual and group striving.
- Culture is the systems of knowledge shared by a relatively large group of people.
- Culture is communication; communication is culture.
- Culture in its broadest sense is cultivated behaviour; that is the totality of a person's learned, accumulated experience which is socially transmitted, or more briefly, behaviour through social learning.
- A culture is a way of life of a group of people--the behaviours, beliefs, values, and symbols that they accept, generally without thinking about them, and that are passed along by communication and imitation from one generation to the next.
- Culture is symbolic communication. Some of its symbols include a group's skills, knowledge, attitudes, values, and motives. The meanings of the symbols are learned and deliberately perpetuated in society through its institutions.
- Culture consists of patterns, explicit and implicit, of and for behaviour acquired and transmitted by symbols, constituting the distinctive achievement of human groups, including their embodiments in artefacts; the essential core of culture consists of traditional ideas and especially their attached values; culture systems may, on the one hand, be considered as products of action, or, on the contrary, as conditioning influences upon further action.
- Culture is the sum of the total of the learned behaviour of a group of people that are generally considered to be the tradition of that people and are transmitted from generation to generation.
- Culture is a collective programming of the mind that distinguishes the members of one group

This industrial belief system manifests itself in different corporate culture forms like:

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[217] *Organizational culture,* Wikipedia (2015) The Free Encyclopaedia. Available at: http://en.wikipedia.org/wiki/Organizational_culture [Accessed January 2015].

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- An Innovation Culture, stemming from the need for urgent renewal at the forefront of technologically based competition. (Mortara & Minshall, 2011)[218]
- A learning-based culture with the underlying premise of natural growth for an enterprise. (Gottschalk, 2006)[219]

Although this breakdown compartmentalises specific cultures, the reality on the ground consists of a combination of the above with one or more taking the dominant role.

2.6.4.2 Corporate Culture because of Leadership Roles.

Adizes' (Entrepreneur to CEO, 2013)[220] different leadership roles in various life cycle phases result in the change in corporate culture within these phases as defined in the figure 2-68 below:

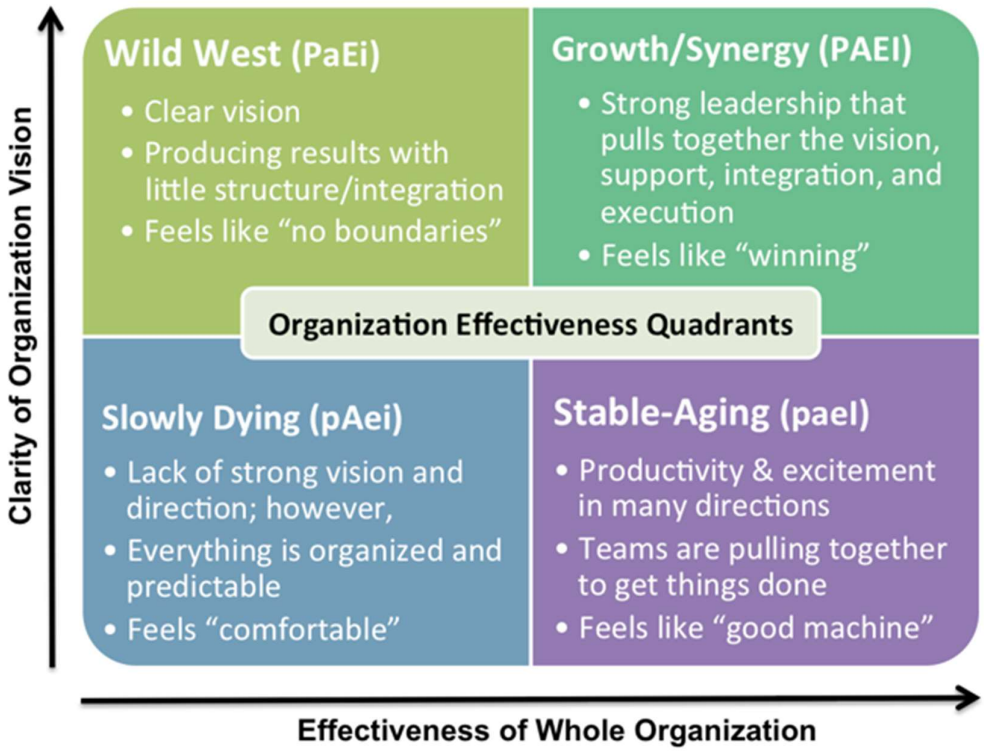

Figure 2-68: Effect of leadership role change on Corporate Culture (Entrepreneur to CEO, 2013)

This diagram shows that, as the leadership process changes or progresses through the company life cycle phases, so will the culture practised at the time changes. It can also be deduced that the practised culture is defined by the leader at the time.

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[218] Mortara, L., & Minshall, T. (2011) *Technovation How do large multinational companies implement open innovation. Technovation*. 31(10-11), 586–597. /j.technovation.

[219] Gottschalk, P. (2006) *Case Studies in Knowledge Management.* Knowledge Management Research, 4(1), 75–76. /palgrave.kmrp.

[220] Entrepreneur to CEO (2013) *Organization Effectiveness Quadrants – Where Does Your Current Organization or Group Fit?* Available at: http://www.frometoc.com/blog/organization-effectiveness-quadrants-where-does-your-current-organization-or-group-fit/ [Accessed June 2017].

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2.6.4.3 Conceptual Foundations of Inquiring Organisations

The application of knowledge management leads us to the definition of an inquiring organisation as defined by Courtney et al. (2005) This is a learning-oriented organisation that strives to include both the creation and the management of knowledge as part of its capabilities. Churchman's (1971)[221] definition of knowledge creation forms the philosophical base of an inquiring organisation's core competence. Leibniz, Locke, Kant, Hegel & Singer's viewpoints are particularly suited to the process of knowledge creation and knowledge management.

In today's information-intensive business environments, various organisational forms to manage knowledge and operate successfully have evolved. The organisation format has consequences for the ability to engage in organisational learning. Organisations that strive toward a learning orientation but also try to maintain flexibility may do well to consider the practices of other inquiring organisations.

The five inquirers and organisations and information systems based on them are described briefly in Table 2-12.

Table 2-12: Five Inquiring Systems Attributes (Churchman, 1971)

	Leibniz	Locke	Kant	Hegel	Singer
Input	None	Elementary observations	Some empirical	Some empirical	Units and standards
Given	Built-in axioms	Built-in labels (properties)	Space-time framework Theories	Theories	System of measurement
Process	Formal logic Sentence generator	Assign labels to inputs Communication	Construct models from theories Interpret data Choose best model	Construct theses, antithesis Dialectic	Strategy of agreement Sweeping-in
Output	Fact nets Tautologies Contingent truths	Taxonomy	Fact Nets	Synthesis	New standard Exoteric knowledge Simplistic optimism
Guarantor	Internal consistency	Consensus	Fit between data and model	Objective Observer	Replicability Hegelian over-observer

Hall (1966)[222] summarises the relationship between learning and culture as follows: *'Once people have learned to learn in a specific way it becomes challenging to learn in any other*

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[221] Churchman, C.W. (1971) *The Design of Inquiring Systems: Basic Concepts of Systems and Organizations.* New York: Basic Books.
[222] Hall, E. T. (1966) The Hidden Dimension. Garden City, NY: Doubleday, p. 47.

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way...Culture reflects the way one learns.'

Koren et al. (2016)[223] stipulate that the *'work-culture of an industrial firm has a profound impact on the selection of the right production system configuration when cost, throughput, and maintenance capability are weighted in the analysis.'*

Cultural differences in workplaces are exemplified by the development of Lean Manufacturing practices in Japan (Jovane, 2003)[224], now widely adopted in the U.S. and globally. Team-based solutions to production problems are undertaken by '*Kaizen'* teams composed of frontline workers supported by management (Dombrowski & Mielke, 2013)[225].

2.6.4.4 Other Types of Corporate Culture

In the larger conglomerates of the western world the standardisation of business planning, risk management, business and technical governance, standardised policies, processes and procedures defines a specific and unique way of conducting oneself and, in doing so, creates a corporate driven culture to be practised. In a worldwide enterprise this forcefit or prescribed culture will, in most cases turn out to be sub-optimal and the expectation is that this will not significantly contribute towards success as defined before.

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[223] Koren, Y., Gu, X. & Freiheit, T. (2016) *The Impact of Corporate Culture on Manufacturing System Design*. CIRP Annals - Manufacturing Technology 65 (2016): 413–416.
[224] Jovane, F., Koren, Y. & Boer, C.R. (2003) *Present and Future of Flexible Automation: Towards New Paradigms.* CIRP Annals – Manufacturing Technology 52(2): 543– 560.
[225] Dombrowski, U. & Mielke, T. (2013) *Lean Leadership – Fundamental Principles and their Application*. Procedia CIRP 7: 569–574.

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2.7 Literature Summary and Conclusion

The literature reviews reflected in this chapter, revealed a few insights as follows:

2.7.1 The Acquisition and Supply Processes

- An **extensive activity** is ongoing to integrate, automate, standardise and better the process of acquiring weapon systems in the USA, UK and NATO.
- The major arms supply enterprises have their **own versions** of the **supply processes** practiced by them, but this is not usually in the public domain.
- The **growth of knowledge** throughout the process drives the design maturity of the system being acquired.
- The **Architectural Frameworks** effectively integrate the acquisition process into the rest of the defence operations.
- **Lessons learned** studies **list some elements** of the **human factors** as either the cause of failure or the opportunity for success.
- **Critical success factors** for successful execution of complex weapon supply processes capability hinges around the **process,** the **technology** that enables the process and, finally, t**he human** with all the factors that he or she can contribute to the outcome.

This research views the problem from the **industry (supply) perspective** and focusses on the **people (human) factor's specific contribution in leadership, relationship, wisdom and culture** towards a successful outcome.

2.7.2 Product

- **Life Cycle** is defined as a concept applied to technology, product development.
- There is a need for **product strategies** and management through the application of engineering management concepts, paradigms and plans.
- The **specific design process** is driven by a ch**ange process (PDCA Cycle)** to take the product from one state of maturity to the next level of maturity as defined by the knowledge attributes of the product. This process of **knowledge enrichment** allows the use and definition of product baselines and review gates during the product development phase of the supply process.
- This principle, in turn, can be **expanded** to the **process knowledge** during the industrialisation, and production and support phases.

The ability to identify acquisition gates where the **technical risk** is defined and **diminished** and where the **product knowledge maturity** is assessed throughout the product life cycle is a major insight. The life cycle process gates as identified by BAE Systems is a case in point. It is also important to note that one normally refers to the 'product maturity' but in fact imply the knowledge attribute maturity of the product when stating the status of the

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design.

2.7.3 Enterprise

- The enterprise also has a **specific life cycle** as defined by Adizes and Ward and others.
- The enterprise **needs renewal before it reaches maturity**, to ensure a continuum of its effective life.
- The **management (leadership) styles** required for optimum performance in **each phase** are **different.**
- The enterprise is directed by a **specific strategy** supported by the strategic activities to make it happen.
- At the heart of the company lies its ability to be **competitive, innovative and agile** to seize and exploit the opportunity that crosses its path.
- All the western world's quality **'awards'** are based on assessment models that characterise the **ability to perform business**.

The **innovation, competitiveness and agility** of the successful enterprise are the noted learning moment in this review. Specifically, Teece's (2007) **Dynamic Capabilities Framework** needs to be highlighted.

2.7.4 Customer

- The **product, enterprise and market strategies are one** as defined by many scholars of the strategic management process.
- Marketing as a process has evolved into a **customer inclusive process** which in turn also drives the need for a healthy relationship management process.
- This process is ultimately defined in the **Customer Relationship Management** (CRM) model (Straus, 2008), the **Value Chain Marketing** (VCM) concept (Mesak & Darrat, 2003), **Integrated Marketing Communication** (IMC) (Qu, 2005) and finally by **Understanding the Customer** (Saren & Steward, 2014).
- The **value for the customer** identifies the transactions as well as the **non-transactional relationship** with the customer, as having a contribution towards the customer life time value.

The ultimate lesson of the literary review on the customer lies in the constant and persistent message that a **healthy business relationship** is identified the cornerstone and a pre-requisite for a growing enterprise. One would expect that this research will identify relationships as a major contributor to success.

2.7.5 Knowledge, Knowledge Management, Knowledge Representation

- Knowledge was initially defined by the Greek Philosophers but later linked into the **DIKW Pyramid** where data, information, knowledge and wisdom are discussed

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together as one concept.

- Nicolas Perry & Alain Bernard (2014) state that **knowledge management actors** can be divided into three main research groups but **effectively represent only different views** of the knowledge construct:
    - Actors from Science Organisations and Change.
    - Actors from Science and Technology of Information and Communication.
    - Actors from Engineering Sciences.
- Lutters et al., (2014) describe the knowledge attributes of the products in a mutually independent constraint of the properties of the coordinate system. The customer **values** the **product knowledge attributes** against his **direct needs** about the following areas; **complexity (**including the entire product lifecycle), the **adaptability** of products and **quantity** of products.
- Broadly speaking, **knowledge management** involves four key steps: creating/generating knowledge, representing/storing knowledge, accessing using/reusing knowledge and disseminating/transferring knowledge (Davenport & Prusak,1998).
- In the endeavour to find a **standardised** way to **present knowledge** after reviewing several Knowledge Frameworks, the following generic components were identified:
    - The definition and use of the **structure** of the knowledge about the artefact. (The what component)
    - The purpose of the description of the **function** of the knowledge about the artefact. (The how component)
    - The **process** embedded or defined by the knowledge being represented. (The when component)
    - The **use** of the knowledge by a customer as the value realised. (The value of knowledge)
- This result gave rise to the formulation of the **Knowledge Cube** concept (Pretorius & Du Preez, 2011) to be used to describe knowledge of an artefact in a standardised way. The same knowledge item in the hands of different customers representing alternative usage will result in a different value for the specific user. It is for this reason that the value of knowledge is defined outside of the knowledge cube to divorce the term **value** from **knowledge** as it only realises the value in specific application profiles for a single knowledge item.

Knowledge attributes of an artefact are continuously being enhanced during life cycles of the product development; the enterprise that makes it, as well as the value it will reach in the hands of the user. The journey of this '**value-add'** currency starts with an idea, the lightest form of knowledge about an artefact and ends when the customer is satisfied with the outcome at the end of the system's useful life.

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2.7.6 Human Factors

The human interaction within an organisation is very complex and cannot be segregated into specific functions. This analysis of Human Factors inter-relation indicates that, except for dignity, the proposed human factors identified for the case study will result in a holistic view of the possible contribution of the human into the supply process.

2.7.6.1 Leadership

- Bob Seelert (2009) identifies **leadership** as a critical factor.
- The Adizes (2017) and Ward (2004) management or leadership models:
  - The **four roles of management** are quoted directly from Adizes (2017).
  - Ward (2004), the Leadership Life Cycle with the **Creator, Accelerator, Sustainer, Transformer and Terminator roles** that are required for success.
- Snowden & Boone (2007) defined the **Cynefin framework** to support leaders to determine the current environmental context to make appropriate decisions about how to respond.
- Tan (2012) identified **different leadership styles** for **different life cycle phases** applied to the **Chinese** private companies.

From all the diverse and sometimes controversial leadership frameworks described in the above paragraphs, the author would like to confirm the view of Adizes as he defines leadership as the ability: *'to get the different people to work together synergistically by complementing each other's differences in a culture of mutual respect and trust.*' The **various roles** required during **various stages of the enterprise life cycles** also need further research.

2.7.6.2 Relationships

- Soupios & Mourdoukoutas (2015) define the need to investigate **relationships** as an essential element in an enterprise.
- According to the literature (Hussain, 2013), a **business belief system** comprises of the following four elements:
  - **The response**, Behavioural Performance, Action, Inaction – How people respond to what is happening.
  - **Cognitions**, Mindsets, Clarity, Perceptions – How people think of what is happening.
  - **Philosophy**, Core Beliefs, Personal Values – The meaning people attach to what is going on.
  - **Emotion**, Emotional Climate, Relationship Management, Emotional Information – How people feel about what is happening.
- To understand **Cognitive Behaviour Theory** as applied to the business

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environment, we first need to consider the basic cognitive behavioural sequence (Hayes, 2004), (Mulhauser, 2013).

- How to evolve your **social customer engagement** as defined by Adam Metz (2011) He defined four stages of engagement as follows:
    - No engagement: The organisation embarked on ongoing education themselves about social customer engagement.
    - Partial engagement: Parts of organisation do not always agree on the value outcomes of social customer engagement.
    - Modelled engagement: The organisation has developed and is implementing a strategic model in support of customer engagement.
    - Social customer engagement: The organisation has a very solid understanding of the social customer and the mutually beneficial business value that this engagement brings.

As is the case in the previous literary reviews, this review also defines the need for **actual relationship building** between the enterprise and the customer. With the social customer engagement construct, Metz sets out a staged approach to this issue. The author identified that the methodology of the **Interactive Events** and the way it works as a **Relationship Framework** also warrants further attention.

2.7.6.3 Wisdom

- **Collective wisdom** manifests in unexpected and positive results that hold more value than any single individual can contribute (Briskin et al., 2009).
- Bob Seelert (2009) in his book on wisdom, postulates that the concept of business and that of wisdom are rarely used in the same argument. This, however, is unfortunate because all successful executives, from the CEO to the recruit, whether they know it or not, are on a '**journey of acquiring and applying wisdom** in their careers'.
- Wisdom is a **form of knowledge** marked by our ability to identify the inter-relationships and their attributes in each situation.
- **Business Wisdom in China**: Gallo (2011) in his work on Western Business Practices in China identified that traits such as **Wu (profound insight),** and **Zhong Yong (not going to extremes)** that differ radically from western concepts.

The integration of information in context, combined with appropriate experience or tacit knowledge, gives rise to the ability to make **sound decisions** that are defined as **wisdom**. If one harnesses a team of likeminded individuals in such a fashion, then it delivers **collective wisdom.** This is clearly a status to strive for.

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2.7.6.4 Culture

- According to Courtney et al. (2005), it is important to understand the contribution of **corporate culture** on the success of the project.
- Organisational culture is the **behaviour** of **humans** within an organisation and the **meaning** that people attach to those behaviours.
- Hall (1966) summarises the relationship between learning and culture as follows: 'Once people have learned to learn in a specific way it becomes challenging to learn in any other way...**Culture reflects the way one learns**.'
- Churchman's (1971) **definition of knowledge creation** forms the **philosophical base** of an **inquiring organisation's** core competence.
- Adizes (Entrepreneur to CEO, 2013) defines **different leadership roles** in various **life cycle phases** results in the **change in corporate culture** within these phases.
- In the larger conglomerates of the western world the standardisation of business planning, risk management, business and technical governance, standardised policies, processes and procedures defines a specific and unique way of conducting oneself and, in doing so, creates a **corporate driven culture** to be practised.

It is the view of the author that the organisational culture contributes to a regulated, risk averse corporate entity and that this status is directly opposed to the innovation and agility required by the ever-changing customer and user environment. There is **no expectation** that the **culture as practised in BAE Systems**, will be isolated as the **main contributor to success.**

The following research questions are hereby answered:

1. **What process is considered as the acquisition process of a complex system?**
2. **What attributes define a successful outcome of the acquisition process?**
3. **What are the processes embedded into the supply framework of a complex system to the acquisition process required by the customer?**
4. **What are the potential human interactive enabling factors that can play a role in the enhancement of the successful outcome of a complex weapon acquisition process?**

2.7.7 The Next Chapter

The information obtained in this literary review will be employed to further investigate the knowledge growth process, the relationship framework and ultimately the definition of the Interactive Supply Framework. This Interactive Supply Framework will enable the case study research to isolate the effect of the human factors catalytic effect (Listed as the Enabler Domain) on the processes conducted as part of the supply framework (listed as the Executable Domain).

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Chapter 3 will contain the following elements to:

- Investigate the Knowledge Growth through the Supply Phases.
- Develop the Interactive Supply Framework's Executable Factors.
- Develop the Interactive Supply Framework's Enabler Factors.
- Review of the Embedded Processes within the Integrated Supply Framework.

The above will then give rise to the active case study research to be defined in chapter 4.

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Chapter 3
The Interactive Supply Framework

This chapter will be employed to further investigate the knowledge growth through the life cycle phases, the definition of the Executable Factors of the Interactive Supply Framework, and the definition of the Relationship Framework as part of the Enabling Factors of the Interactive Supply Framework. This Interactive Supply Framework will then be assembled and the embedded processes identified as defined in figure 3-1 below.

This Interactive Supply Framework will enable the case study research in chapter 4 to isolate the effect of the human factors catalytic effect (Listed as the Enabler Factors) on the processes conducted as part of the supplied framework (listed as the Executable Factors).

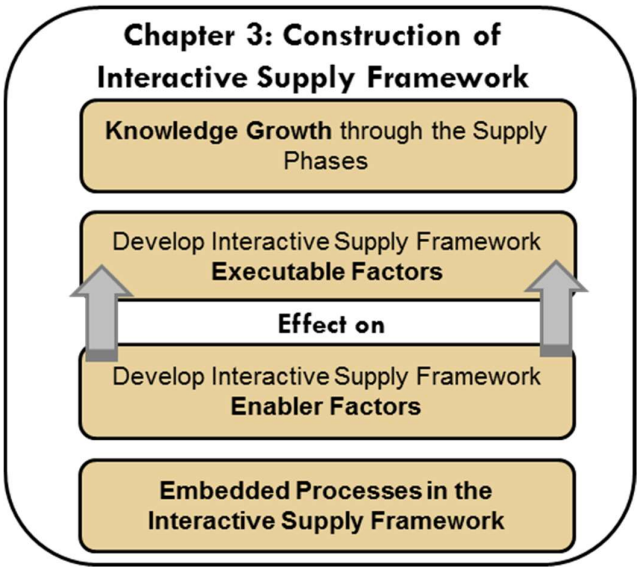

Figure 3-1: Constructing the Interactive Supply Framework

3.1 Knowledge Growth in the Supply Process

The author realised that the added value currency throughout this process is the knowledge attributes of the product and service. The increase of the maturity level of the knowledge during the life cycles of technology, product development and enterprise development, will be investigated, as it progresses through the different life cycle phases as defined in the previous chapters and shown in figure 1-3. This journey is labelled as the Knowledge Migration Framework. As part of this framework, the knowledge maturity growth process steps are pictorially presented in figure 3-2 below.

During the investigation of the steps of this knowledge maturity growth process, a virtual case study will be submitted. The knowledge cube that was defined earlier will be used to

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demonstrate this journey of knowledge growth.

The knowledge growth process depicted in figure 3-2 consist of the following steps:

- The formulation of an idea as the most basic definition of a knowledge item.
- The understanding of the general engineering or change cycle to be deployed.
- The life cycles of technology, product development and their related context to be followed in the development of the product.
- The life cycle of the enterprise and the implied processes that will be used to produce the product.
- The customer value realised as the outcome of the process.

The identification of the driving force behind the knowledge growth of the product was previously defined as the change management process reflected as the PDCA Cycle in its most basic form.

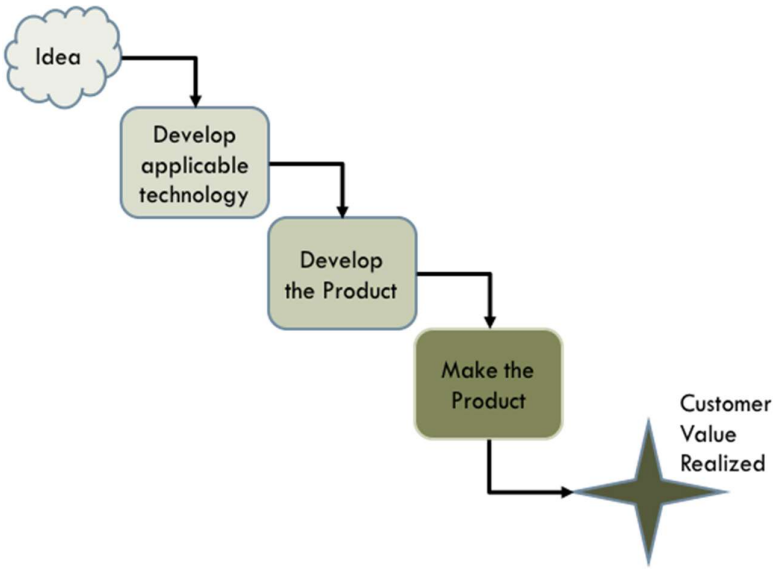

Figure 3-2: The Knowledge Growth Process Steps

3.1.1 The Generic Engineering Design Cycle

Even in the most complex of enterprise engineering models and frameworks, one can deduce the basic steps of planning, doing, checking and acting i.e. the PDCA Cycle (The Shewart Cycle, PDCA, 1936). The increase in knowledge is obtained using the application of the basic engineering or design cycle. This increase in knowledge will allow the life cycle of technology to move forward from an idea into a successfully demonstrated concept, hence the notion of knowledge maturity. The impetus for process knowledge enrichment during the Enterprise Life Cycle is thus supplied by the churning of the PDCA Process (Continuous Improvement of the PDCA Process, Vietze, 2013).

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3.1.2 Generic Knowledge Growth Process through a Life Cycle

The application of the basic engineering cycle as a means to propagate a knowledge item, represented by the Knowledge Cube (Pretorius & Du Preez, 2011), during the artefact's life cycle defined as an S-Curve (Narayanan, 2001) is shown below as figure 3-3. The PDCA Cycle can be used for demonstration purposes.

During this propagation, the knowledge about the artefact is continuously being enriched by the application of the PDCA Cycle, up to the point where more effort does no longer result in more knowledge. At this point, saturation or maturity is reached. Another possible termination point of this process might be the project timelines or budget restrictions regardless of the fact that the optimum amount of knowledge has been distilled.

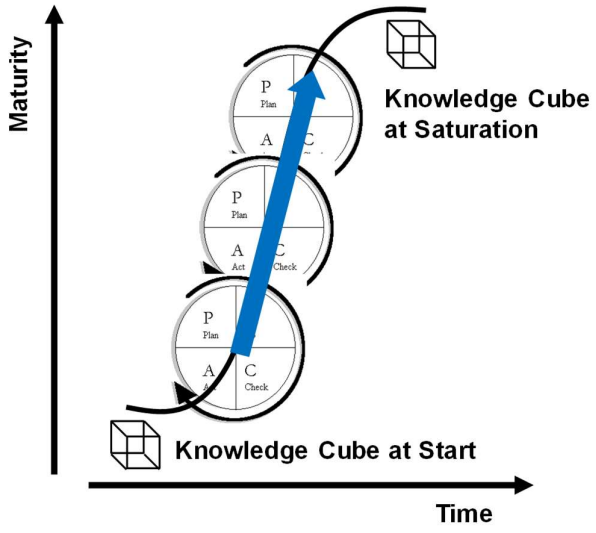

Figure 3-3: The Migration of a Knowledge Item through a Life Cycle (Pretorius & Du Preez, 2013)

To further investigate the propagation of a knowledge item through the life cycle, one needs to investigate different applications of life cycles concerning technology, product development as well as the life cycle of an enterprise.

3.1.3 The Technology, Product and Enterprise S-Curves

The typical life cycle of the technology, product and enterprise can be depicted in a set of consecutive S-Curves. The Technology Readiness Scale (Tan et al., 2011) status points defined in the theoretical life cycles can be used as an indication of the maturity level of the knowledge item attributes as shown in figure 3-4 below.

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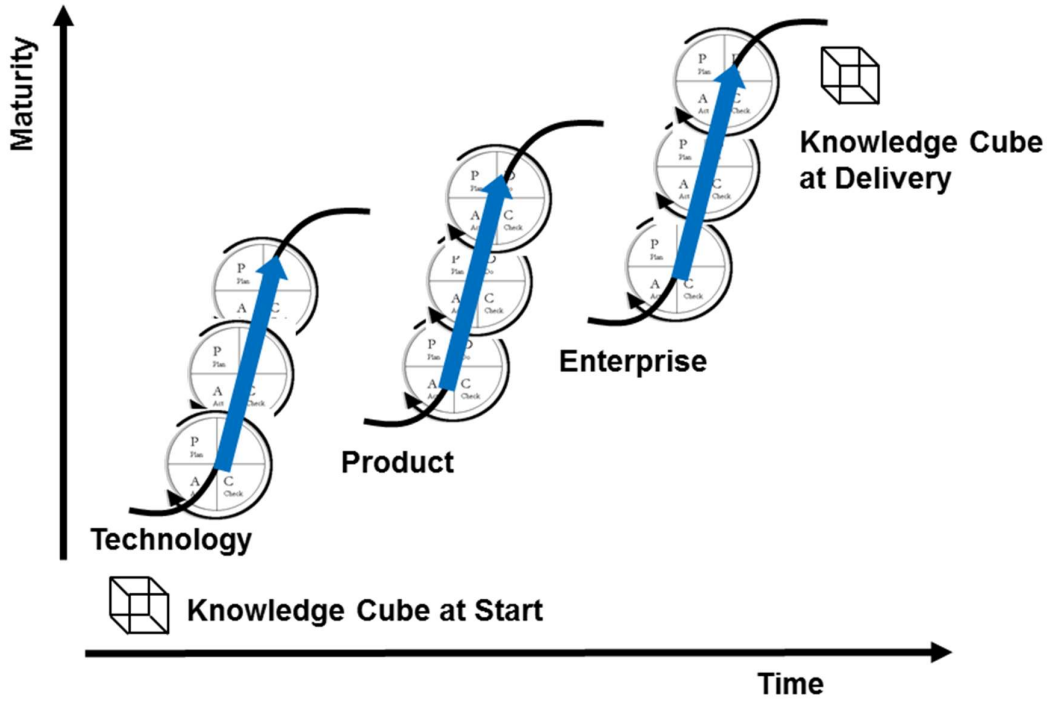

Figure 3-4: Knowledge Growth viewed as the Combined Life Cycles (Pretorius & Du Preez, 2013)

3.1.4 The Knowledge Growth Framework

By the combination of all of the above into the three consecutive life cycles of technology, product development and the enterprise, and by the definition of the common process that drives the change in the knowledge artefact throughout these cycles as the continuous use of the PDCA Cycle, one can identify specific instances or gates in the process that warrant further investigation. The specific gates are defined as:

- **Gate A:** The journey of knowledge growth starts in the early life cycle of technology development as an idea. At the outset of the technology curve, we define an idea as the most immature knowledge item moving up to proven technologies at the top of its life cycle.
- **Gate B:** As the technology matures the knowledge of the technology can now be used in the design phase. Gate B status is therefore at the end of the mature technology and at the start of the design phase. The product development starts with a mature technology status built into a product concept and evolves through the product development life cycle to produce a mature or proven design
- **Gate C:** This knowledge maturity status is reached when the product design is complete and properly qualified at the end of the development phase. This coincides with the start of the production phase where the knowledge of the process to produce the product is developed.

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- **Gate D:** At this stage, the value of the product knowledge is realised. The enterprise life cycle, in turn, starts with the mature design and endeavours to develop the knowledge of the processes to be used for the successful supply of the system at the top of its life cycle. The end of the production phase delivers the system to the user and leads into a support phase which has been omitted for clarity purposes.

The process as defined above is diagrammatically shown in figure 3-5 as the Knowledge Growth Framework (Pretorius & Du Preez, 2013).

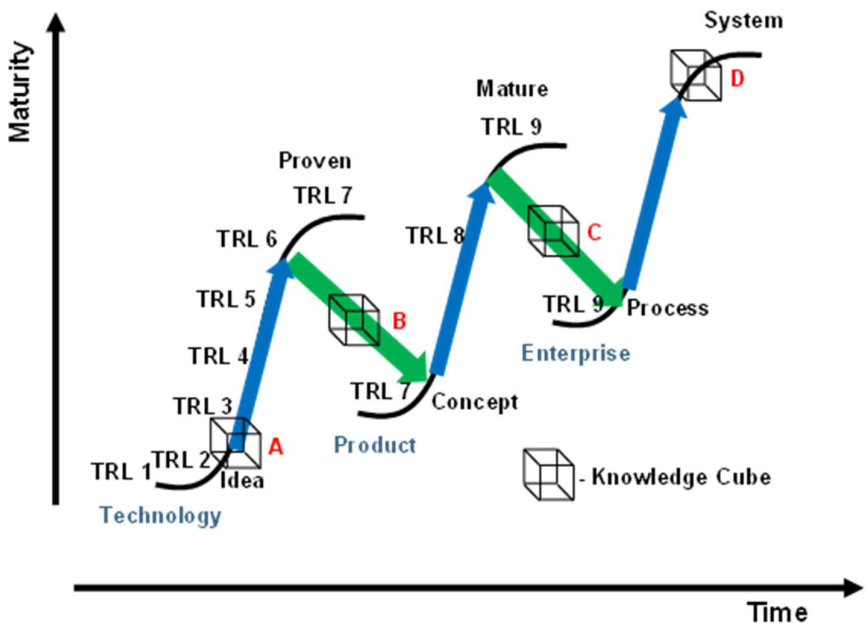

Figure 3-5: The Knowledge Growth Framework (Pretorius & Du Preez, 2013)

The NASA scale of technology readiness levels was applied to this framework as TRL 1 to 9 in the various life cycles.

In a virtual case study, the status of the knowledge cube will be defined at points A, B, C and D to demonstrate the growth of the knowledge attributes of the idea, technology, product and system.

If the life cycles are moved close together or made to overlap, the framework will change the angles of the green arrows (defining the move from one life cycle to the next) and this, in turn, will be an indication of the level of concurrency in the framework application.

3.1.5 A Virtual Case Study

The virtual case study of the knowledge artefact under investigation starts with an idea for the active protection (counterblast) against a blast mine threat. This is built into an armoured vehicle during the design and production phases. This solution eventually finds its way into a specific vehicle sold by the enterprise as a user system and eventually is supported in the

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customer environment during the mature stages of the company life. This is defined in figure 3-6 below.

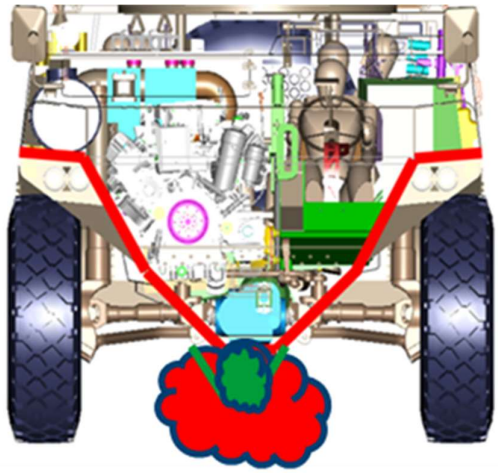

Figure 3-6:The Counterblast Idea

3.1.5.1 Gate A: Knowledge Status - An Idea developed into a Technology

The structural domain of the idea based knowledge cube at this point is defined as the scope, topic or description of the idea. In this case study, the idea to defeat a landmine blast using a counter explosion which forms a hydraulic wedge will clearly define the "what" component of the idea.

The knowledge cube's functional domain where the main function is to survive can be subdivided to reach the next level function i.e. to protect. The further sub-functions will typically be to sense an explosion, to decide to react and to activate the counter explosion. This is the "how" domain.

The third knowledge cube domain is a description of the timeline (figure 3-7) where the initial blast takes 30 microseconds to develop before sensing, the activation of the sensor within another 20 microseconds and the activation of the counter blast within another 30 microseconds giving the initial blast the time to raise about 500 mm before the counterblast is effected. This represents the "when" function. This 500 mm also represents the typical height of an armoured vehicle from the ground and is an obvious constraint for the idea to work.

Figure 3-7: The Timeline Requirement

When one considers two different applications of the idea, one for a standard commercial truck and the other for an armoured combat vehicle, to assess the value that the idea can deliver, the following outcome can be envisaged:

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Although the normal commercial truck is more than 500 mm high, it is not blast-proof, and the occupants will be worse off after the event, and the application of the idea has therefore very little value.

In the instance of the armoured combat vehicle, the effect of such a system can be as much as 30% on the acceleration of the vehicle during a blast, depending on other attributes of the vehicle and will carry real value for the soldiers to survive.

This idea must be developed into a functional system working together to demonstrate the required results for the idea to work. This will, in all cases, be necessary for the application of any idea.

3.1.5.2 Gate B: Knowledge Status - A Technology Introduction in Vehicle Concept

After the application of various technology development cycles, one eventually gets to a proven technology at TRL 7. At this point, the technology is proven and ready to be incorporated into a specific vehicle concept. This is the knowledge cube status at Gate B.

The "what" domain of the knowledge cube at point B is represented as the scope of the technology under consideration and the decomposition of the technology into underlying technologies. This breakdown is done to define the required technologies for the successful operation of the main function. In the specific case study, the technology that will enable sensing an explosion within 30 microseconds from 500mm needs to be mature. This technology can be based on Electro Magnetic Pulse, Optic or Radar principles and must be able to perform in muddy, dusty or submerged conditions.

In the "how" domain all the subfunctions that need to be performed are defined. This may include the function to the sensor, the packaging, the signal filters as well as amplifying the signal, etc. Through the application of the system engineering process as defined by Blanchard & Fabrycky (1981), a relationship between the physical and functional domains will be established when the functional allocation to hardware is performed to establish the required performance levels of each piece of hardware and the interfaces that exist between them.

The "when" domain defines the current maturity state of the technology as well as the historical and future processes it still must go through after integration into a product design. This will typically include the logic of the first demonstration of principle, laboratory (engineering) tests to refine the technology as well as formal qualification tests to demonstrate functionality in the field, reliability and safety to name but a few.

Similarly, as in the previous case, the value of the technology as established when applied to a specific solution must be considered. In this case, the design philosophy of the vehicle to evaluate the potential value of the chosen design above other considerations is used to establish value. This is a typical engineering trade-off study during development.

It does not take a lot of imagination to deduce the fact that the integration of technology into a product design is done through the application of a design cycle. The knowledge about the product and its functionality is enriched through the application of this cycle, simply defined as the PDCA Cycle, and will lead to a better understanding of the product and its functions.

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3.1.5.3 Gate C: Knowledge Status - The Product introduced in an Enterprise

The status of the knowledge of the product at Gate C is representative of an armoured fighting vehicle fully developed and qualified.

The definition of the vehicle, as well as all the main subsystems and components of the vehicle i.e. the hull, the hydraulic system, the pneumatic system, the suspension, the driveline, the electrical system, internal fittings, the air conditioning system as well as the payload in mass, interface and centre of gravity are all included. This physical decomposition again is defined in the "what" domain. When we plan work on such a vehicle, a work breakdown structure in conjunction with the hardware breakdown structure will also be defined. This can further be developed into a contract work breakdown structure when considering sub-contracting work for the next phase.

To understand how the vehicle works, one needs to define the different functions that such a vehicle needs to be able to perform its mission or series of missions. This is classically broken down into mobility, fire power, (Command, Control, Communication, Information and Intelligence) C^3I^2, carrying of special payload and survivability. These functions are usually further decomposed to such a level that each one can be allocated to a single piece of hardware, work breakdown element or sub contract. This decomposition is also performed using the system engineering process referred to before.

The typical roadmap of the project life cycle will be used to define the "when" domain. In a classic acquisition process performed under the military standards, the concept, definition, full-scale development, production, deployment and phase out components will be planned in the most concurrent way possible. The maturity level of the product design expressed is a typical knowledge attribute defined under the time domain.

When different armies procure an armoured combat vehicle, they normally publish a weighted user value system that will be used to measure the level of acceptance. This value system will contain a financial element with regard to capital and operational costs, technical performance against the requirement specification, reliability, counter trade and other non-technical factors.

Again, it must be noted here that the same product will score differently for different user value systems, thus confirming that the artefact's attributes are not dependent on the applied value system.

The development of a product into maturity is done through the application of an engineering cycle of the product. Throughout the development phase of the product, the quality and the quantity of the product knowledge grows. The product knowledge therefore 'migrates' towards maturity as defined before. Again, it was shown that the PCDA Cycle is a good basic representative of an engineering cycle.

3.1.5.4 Gate D: Knowledge Status - The End of Life Conditions of the Product System

The knowledge status at the end of life of the system at Gate D is defined by the combination of various products and services into a fighting vehicle-based weapon system. The first level of breakdown is usually the products (vehicle, weapon system, communication equipment)

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and their associated support systems. As in the previous example, the work breakdown structure, as well as the contract breakdown structure, are both parts of the "what" domain. In this specific case, the amount of sales of the product in the enterprise's sales in its next business cycle is of interest.

It is necessary to have a clear understanding of the specific mission this product has to perform in the makeup of the user defence system, to enable us to understand the alternative product strategies that can enhance the extension of life for the enterprise. The enterprise's functional design must consider the future demands; this may lead to a company re-design to focus on the after sales or support of the product as these form a major part of the future business of the enterprise. This product and enterprise descriptive decomposition form part of the "how" domain.

As seen from the end of life of the enterprise, the specific contribution in the next business cycle to be obtained from the specific product depicts the "when" domain.

The actual value of owning an enterprise is measured in the successful execution of the various contracts within the boundaries of affordability and efficiency, in other words, the sustained ability to make a profit in the next business cycle. As demonstrated, this is the result of a specific application of the artefact throughout its life, starting at innovation through the successful incorporation into a product and ending in the strategic make-over of the enterprise to face the future business challenges.

This process is typically defined as the Enterprise Engineering Cycle and holds the process as the basis for the renewal of knowledge or learning. This is the classic application of process renewal based on the PDCA Cycle.

3.1.6 Conclusion on Knowledge Growth

As discussed in each example above, the knowledge base will be enhanced through the application of the PDCA Cycle or its equivalent, in all the life cycles shown. Without the application of such a process, the level of knowledge and understanding at that specific point in time will remain stagnant.

One can, therefore, conclude that the change agent that causes the knowledge artefact to migrate through the various life cycles is the application of the engineering change process in various forms.

The complexity and maturity level of the knowledge item both grow with the progress of the migration process. There are a knowledge continuum and dependency evident through and between the various life cycles. Similarly, as the knowledge matures the unknowns become known entities and the technical risk diminishes.

As the migration progresses and subsequently the complexity increases, more players get involved in the sharing of the knowledge of the artefact and this, in turn, causes potential knowledge gaps to open. This is especially the case where a new participant with limited exposure to the process joins the stakeholder groupings.

The integrated life cycles feed on knowledge work in a continuum as discussed above. One

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can also conceive a pre-planned knowledge migration through the various life cycles of the Knowledge Migration Framework by taking pre-determined shortcuts in the processes, thereby defining a specific concurrent knowledge migration path. This will require an excellent understanding of this migration process as the inherent technical risk of such a plan must also be timeously managed. This process is documented in the base line management portion of the engineering management plan of the specific product or system acquisition.

The knowledge work continuum also evolves over time and, by definition, has its unique life cycle as well. To shorten the time scale involved, as is required by the need for competitiveness, one can utilise this knowledge continuum to evaluate and shorten the series processes.

Some critical questions to be analysed during the proposed case study execution will be:

- What is the best knowledge migration process (PDCA Cycle) to be followed in each case study to optimise the learning experience vs. time required?
- What is the best way to manage technical risk and how to apply the parallel risk abatement programs to lower the risk profile?
- Identifying the best points in the process to consolidate the knowledge base into a formal baseline of technical data to minimise both risk and time throughout the process.
- The integration required (or the jump) between S-Curves and how to best bridge this gap?

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3.2 The Interactive Supply Framework - Executable Factors

3.2.1 The Evolution for Success

The following steps are used to define a generic **Interactive Supply Framework** used in the execution of the provision of a complex system.

Step 1: Defining Success

Figure 3-8 below defines the roadmap to follow in the successful start-up process of a generic enterprise. The model also identifies the knowledge items, planning horizon, strategies, marketing, realisation and success. This model, however, does not include any human interaction or any life cycle phases with the processes of the enterprise.

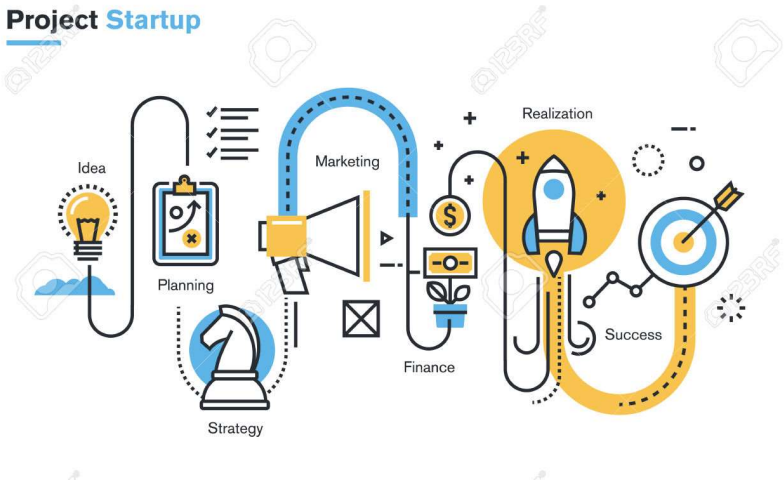

Figure 3-8: The Enterprise Start-up Model (Shutterstock, 2017)[226]

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The question *"what constitutes success for an organisation"* must now be investigated. The Library Unit Guides (2016)[227] define the creative enterprise success factors as:

- ***"Opportunity recognition:*** *the project creates, discovers, or recognises an opportunity to meet a need or want. There is demand (or will be) for the creative product or service.*
- ***Value-add:*** *the project adds sufficient value for the stakeholders in one or more ways (e.g., commercial, cultural, social, environmental, personal).*
- ***Stakeholder Management:*** *the needs of internal and external stakeholders are considered & their perspectives and input included appropriately.*

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[226] Shutterstock (2017) *Flat Line Illustration of Business Project Start-Up Process, from Idea Through Planning and Strategy, Marketing, Finance, to Realization and Success.* Available at: http://www.shutterstock.com/pic-325958591/stock-vector-flat-line-illustration-of-business-project-startup-process-from-idea-through-planning-and-strategy.html [Accessed June 2017].

[227] Library Unit Guides (2016) *The 5 Creative Enterprise Success Factors.* Available at: http://libguides.library.qut.edu.au/c.php?g=427248&p=2925622 [Accessed June 2017].

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- ***Resourcing:*** *the required resources are available, or can be made so.*
- ***Innovation:*** *the project does something new regarding its product (or service), processes, or position."*

Adizes (2014)[228] defines success as a function of the energy or effort spent on external integration and inversely to the effort or energy devoted to fixing the disintegration within the company as defined in the formula in figure 3-9 below:

$$\text{Success} = f\left\{\frac{\text{External Integration}}{\text{Internal DISintegration}}\right\}$$

Figure 3-9: Success according to Adizes (2014)

'External integration is the way in which the organisation in any system, is integrated with its environment. No system, person, family, business or country, exists in a vacuum.

Internal DISintegration is all the internal fighting that occurs in organisations: The rumours, misunderstandings, back stabbings, frustrations with the job and turnover of people, among other manifestations of disintegration.'

As the process also requires the knowledge of a product or service to present to the market, the author identified a third effort or energy component that is needed to develop and de-risk the awareness of the product or service by augmenting the Adizes formula for success in figure 3-10 as follows:

$$\text{Success} = f\left\{\frac{\text{External Integration}}{\text{Internal DISintegration}}\right\} \times \text{Knowledge Item}$$

Figure 3-10: The Real Road to Success adapted from Adizes (2014)

The above formula defines three specific areas where effort must be expended to contribute towards the success of an enterprise. These are:

- The **Product** knowledge maturity
- The **Enterprise** operation effectiveness and efficiency
- The **Customer** Environment

These three elements will form the first level breakdown of the executable processes within the interactive supply process.

Step 2: The Generic Supply Roadmap

The second phase in this process is the definition of a generic supply roadmap developed through the integration of all the above factors and understanding their inter-dependencies within a successful enterprise.

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[228] Adizes, I. (2014) *The Secret of Success of any System.* Available at: http://www.ichakadizes.com/the-secret-of-success-of-any-system/ [Accessed June 2017].

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The success of an enterprise is measured as the continuous enhancement of the company's value through growth (aimed at a future profit) and the realisation of profit today in combination with the value generated for the customer.

This gives rise to a three-domain roadmap as the basis for the energy or effort required for the success of the supply process defined earlier and is depicted in Figure 3-11 below:

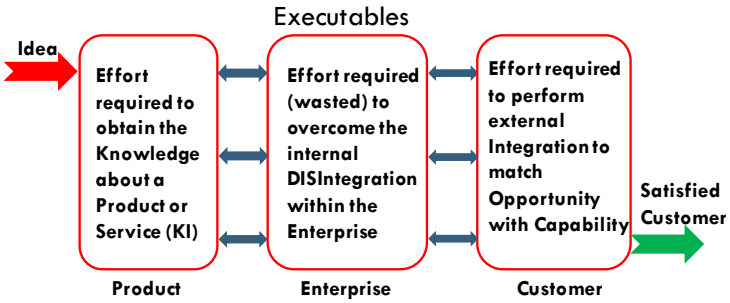

Figure 3-11: The Three Executable Domains

Step 3: Defining the Executable Domain

One always needs to balance the effort going into the success of a company, keeping in mind short vs. long term effects. To this end, the author defines three distinct planning horizons as being operational, tactical and strategic in nature. In figure 3-12 these planning horizons have now been added further to enable the study of the efforts required in each domain.

The acquisition process is prescribed by the military acquisition agencies as the customer process. In response, a company supplying a complex system to a customer environment uses his supply process mapped against the customer's acquisition process.

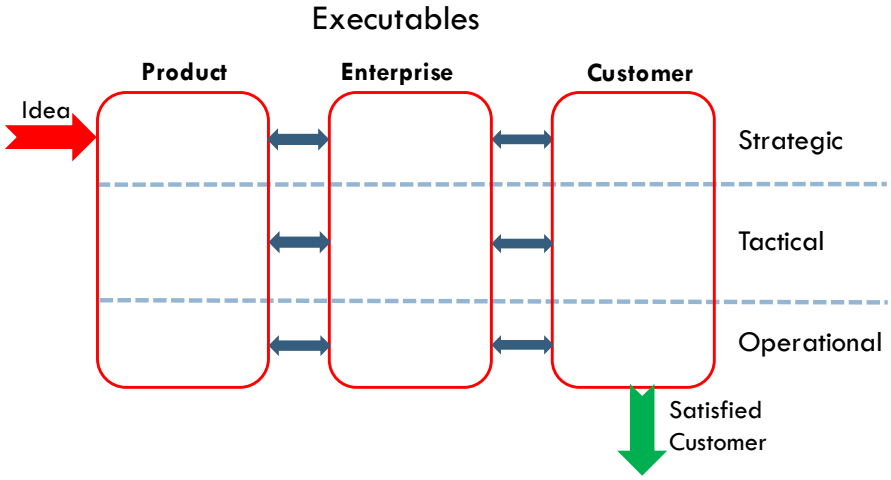

Figure 3-12: The Interactive Supply Framework Executable Factors

The next part of the build-up of the Interactive Supply Framework is to complete the nine sub-domains (or executable factors) with specific processes that happen within these sub-domains by considering all the literature review information on each topic.

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3.2.2 The Product Domain

"Sure, what we do has to make commercial sense, but it's never the starting point. We start with the product and the user experience." Steve Jobs

3.2.2.1 The Product's Planning Horizon

The Product Domain in the Interactive Supply Framework contains three distinct parts differentiated by the length of the planning horizon under consideration.

These three levels of the product domain (strategic, tactical, and operational) are described in more detail in the sections below.

The product domain, starting from a strategic view where the idea is transformed by means of a product portfolio strategy, developed through its life cycle into a qualified product as well as the physical construct of the product, is shown in the figure 3-13 below.

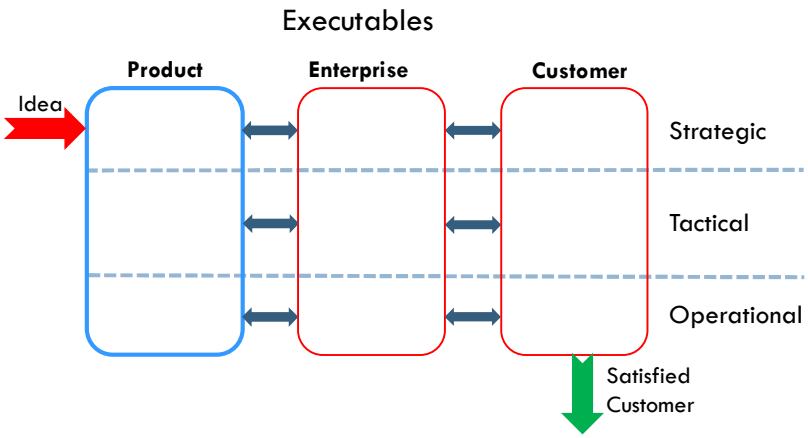

Figure 3-13: The Product or Service Domain

- The **strategic planning** of a product is usually defined as a **Product Portfolio Strategy** (refer section 2.2.3) for an enterprise: the strategic considerations where the vision of the artefacts to be developed are considered and defined in a product portfolio strategy in support of the strategy of the enterprise and for the benefit of the value proposition towards the customer. This planning horizon is longer than two years and would normally cover a five to ten-year horizon. The product portfolio strategy includes the analysis of the market requirements and trends, the technology that is required to produce the future products to meet this demand as well as a strategic decision to promote the best fit product for the opportunity.

- During the **tactical planning** horizon of two to five years, product development results in its knowledge attributes being matured over time. This is the area of tactical manoeuvring to prepare for the future operations and includes the generation, growth (quantity and quality) and maturity of knowledge about the artefact under consideration. In the case of the acquisition process, these milestones strung together, form the **Engineering Management Plan** as defined in section 2.2.4 in the literature review. The technology and product life cycles are used to set the roadmap for product knowledge growth in the Engineering Management Plan.

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This includes the product knowledge maturity and technical risk management.

- Section 2.2.5 defined the **operational** part of the product or service delivery planning horizon of zero to one year where current operations of things happening today are described and where all the tangible items are defined, made, sold, etc. This results in the real definition, build and qualification of the product and its associated development processes. These processes are defined in the **Development Statement of Work** for each segment of the acquisition process and normally forms part of the supply contracts. Finally, and to complete the development statement of work, the engineering design cycle, the design process and the change management process are defined.

Having considered all the planning horizons, the design cycles, technology and engineering life cycles in the literature study in chapter 2, the product domain can be further contextualised with the next level of breakdown, as defined in the integrated product domain shown below in figure 3-14.

Figure 3-14: The Integrated Product Domain

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3.2.3 The Enterprise Domain

"Give me a place to stand on, and I will move the Earth," said Archimedes.

At the centre of the Interactive Supply Framework is the enterprise, as defined in figure 3-15 below, that needs to use the knowledge of the product or service generated in the product domain and transform it into a tangible asset to allow the customer to realise his own value from the use or application of the product or service. This is not a simple process and is best described in terms of the strategic, tactical and operational processes within the enterprise. This section reviews these aspects and will again conclude with a re-assembly of the concepts into the enterprise domain part of the framework.

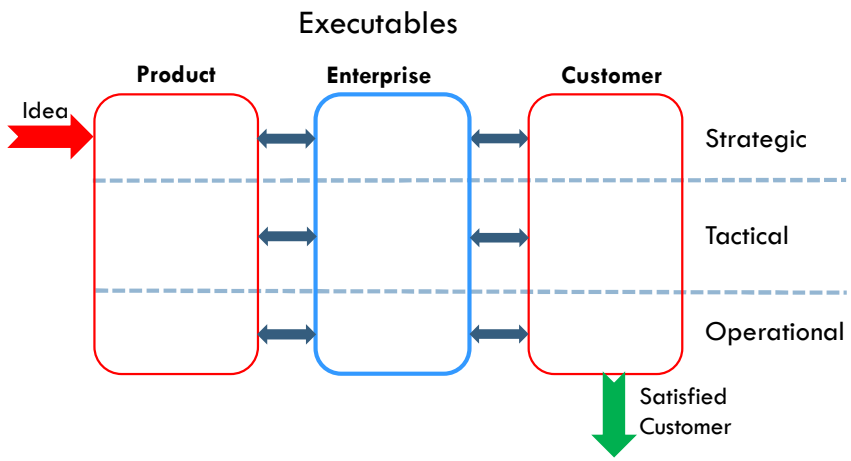

Figure 3-15: The Enterprise Domain

Section 2.3.1 defined the enterprise as a purposeful or industrious undertaking that is especially difficult, complicated, or risky, and shows readiness to engage in bold action that requires boldness and energy, which is organised for commercial purposes and applies initiative and resourcefulness in order to reach its intended goal.

The strategic planning process that needs to drive, steer and energise the enterprise was defined. Leavy (2010) states that, at its most basic, strategy has two fundamental concerns – value creation and value capture. Traditional perspectives that focus primarily on how to create sustainable sources of competitive advantage are mainly concerned with value capture. Value innovation, while concerned with both creation and capture, shifts the primary focus in strategy development back to customers rather than competitors, and to the challenge of how to create game-changing breakthroughs in the value-to-cost ratio. The full power of this '*deceptively simple framework'* lies in '*the complex interdependencies of the parts,*' and fruitful businesses tend to '*devise stable systems in which these elements interact in consistent and complementary ways'*.

Competitiveness, innovation and agility as specific constructs to be considered in the functioning of a successful enterprise, were also investigated . From the above, the author believes that the agility framework is not yet fully developed and may still deliver fascinating concepts to be considered in the future (Teece, 2007)

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The operational side of the enterprise, where operational fitness and efficiencies are paramount concepts, embodies the short-term actions (Section 2.3.5).

The enterprise life cycle was investigated, where it was deduced that a company life cycle is made up out of specific and distinct phases with specific transformations between the phases that may cause early failure (Ward, 2004 & Adizes, 1988).

The enterprise domain of the Interactive Supply Framework can be summarised as having three distinct layers of strategic direction and, tactical agility innovation and competitiveness as well as operational fitness and efficiency to deliver the valued product and service to the customer as shown in figure 3-16 below.

Figure 3-16: The Enterprise Domain

3.2.4 The Customer Domain

"A satisfied customer is the best business strategy of all" Michael LeBoeuf.

In the continued development of the Interactive Supply Framework, the customer domain will be viewed next. The customer domain is of extreme importance as it is here that the perception of success or failure originates. The value of our product and process knowledge will also be realised by the customer in his use of the actual product delivered (section 2.4.7 on customer value realisation).

The strategic activities related to the market, the market dynamics to affect a sale as well as the actual delivery of the product or service to obtain customer satisfaction will be investigated (sections 2.4.4 & 5). Figure 3-17 defines the context of the customer domain in

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relation to the complete Interactive Supply Framework.

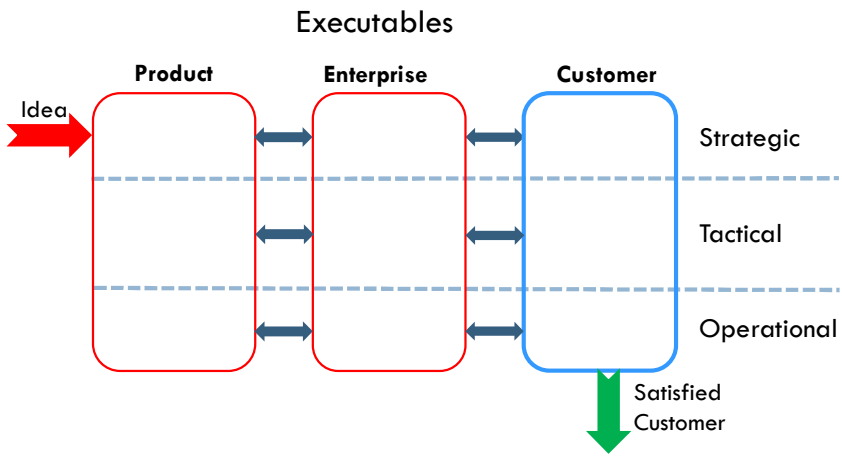

Figure 3-17: The Customer

3.2.4.1 Customer Value Realisation

The customer normally defines mandatory attributes as well as a weighted scale for the required functional performance for a specific project as a value system. In an engineer-to-order project, the customer also contracts a future commitment to the product performance. This is usually defined in a performance matrix against stated requirements and a timeline. Alignment of the offered product's attributes is based on subjective and objective elements combined in the three-dimensional space against the customer requirement set. Competitive product analysis is also done within this framework.

The three domains of presenting a knowledge item are defined as a structural or hierarchical view, a functional view as well as logic or timeline view as shown in the previous paragraph. One can superimpose the required vs. the achieved attributes of the knowledge item during its application and define the values and expectation gaps in the various views as specified in figure 3-18 below:

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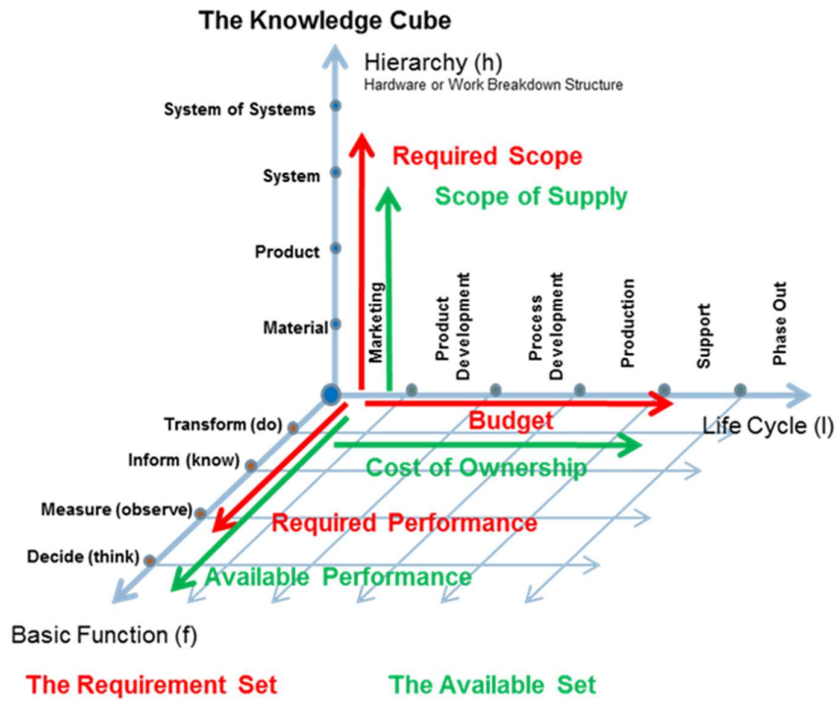

Figure 3-18: The Knowledge Cube Generic Value System (Pretorius and Du Preez, 2011)

As can be seen from the above it is always critical to meet, but not exceed, the customer expectations in all the areas. We need to involve the customer through continuous engagement to understand his real needs and value system as this may differ from the explicit knowledge available during the process. The continuous interaction is defined as events where the supplier can demonstrate success and, in themselves, can also contribute towards the satisfaction of the customer as this interaction is the only way in a complex product environment to obtain and react to the real (and perceived) value system of the customer.

If one considers the Knowledge Cube defined before, and one superimposes the required vs. the achieved attributes of the knowledge item during its application, one can define the following values and expectation gaps:

- **The structural domain:**
  - The required scope of supply that the customer needs
  - The actual scope of supply that the supplier delivered.

The gap between these two elements that can lead to:

  - An expensive acquisition process with more than the required content in the case of oversupply or
  - An unhappy customer with specific needs still not satisfied in the case of undersupply.

- **The life cycle domain**

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- The budgeted cost of ownership during the life cycle of the product
- The actual cost of ownership in the same period
- The additional cost or savings realised when actual cost is compared to budgeted cost.

- **The functional domain**
  - The specified functions that the product should be able to perform
  - The demonstrated functions of the product
  - The gaps still required or additional functions demonstrated but not needed.

The continuous interaction is defined as Interactive Events and, in themselves, can also contribute towards the satisfaction of the customer as this is the only way in a complex product environment to obtain and react to the real value system of the customer.

The customer domain in the Interactive Supply Framework consists of the following content as shown in figure 3-19 below:

3.2.4.2 Strategic content: Business Development Strategy

In the Business Development Strategy as defined in Chapter 2, a few frameworks and models were studied to define marketing or business development strategies. These include the following concepts (2.4.2 The Market Strategy vs. The Product and Enterprise Life Cycle):

- Market analysis
- List of available opportunities
- Customer Value Proposition.

3.2.4.3 Tactical Content: Market Dynamics

The tactical content of the marketing dynamics was studied (section 2) using various marketing approach models. The author realised that the relationships definitely play a major role in these frameworks as defined in the appropriately named CRM or Customer Relationship Management. The Market Strategy vs. The Product and Enterprise Life Cycle were also reviewed as well as the customer relationship cycle which results in the following market dynamics components in the Interactive Supply Framework:

- Competitor analysis
- Specific Marketing Campaigns
- Planned Order Book.

3.2.4.4 Operational Content: Customer Value Realisation

Chapter 2 section 2.4.1 defined the customer and in the previous paragraph, the different viewpoints to set the customer value, eventually with the knowledge cube framework as a basis.

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The activities in the operational part of the customer domain can be grouped as follows:

- Physical Marketing Activities
- Relationship Building Activities
- Delivery of the Product and Service.

The Customer domain of the Interactive Supply Framework can be summarised as having three distinct layers of business development strategy, market dynamics as well as market delivery as shown in figure 3-19 below.

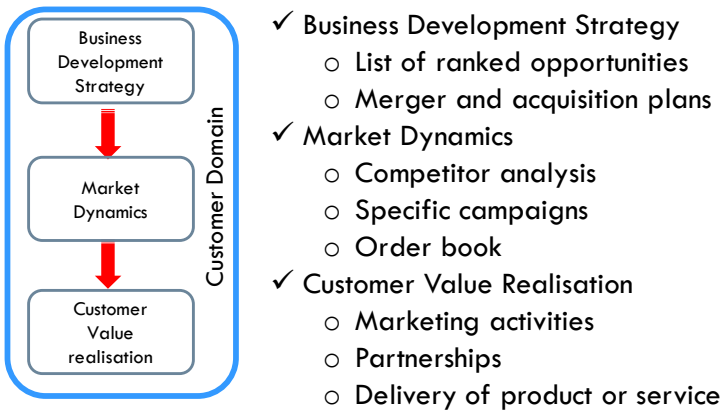

Figure 3-19: The Customer Domain

3.2.5 The Interactive Supply Framework Executable Factors Defined

By combining the product, enterprise and customer domains one can set out the Executable Factors of the Interactive Supply Framework in a more detailed way:

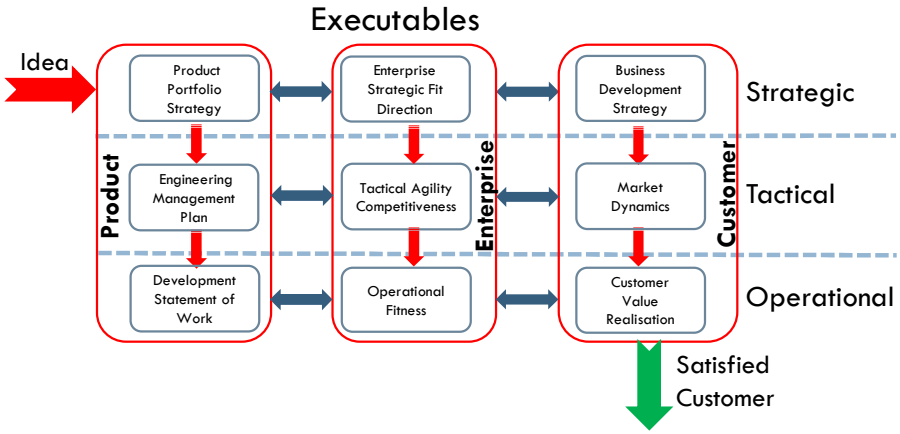

Figure 3-20: The Executable Factors Defined

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3.3 The Interactive Supply Framework - Enabling Factors

The 5-step process to define the Interactive Supply Framework continues with the consideration of step 4 focussed on the human factors.

Step 4: Defining the Human Interactive Enabling Factors

Building the Interactive Supply Framework takes into consideration the effect of the human interacting within the nine sub-domains in the executable domains.

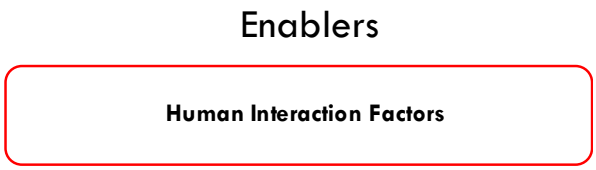

Figure 3-21: The Human Factors

As is the nature of the complex human one does not expect these factors to be all inclusive, nor do one believe that they will be independent or mutually exclusive.

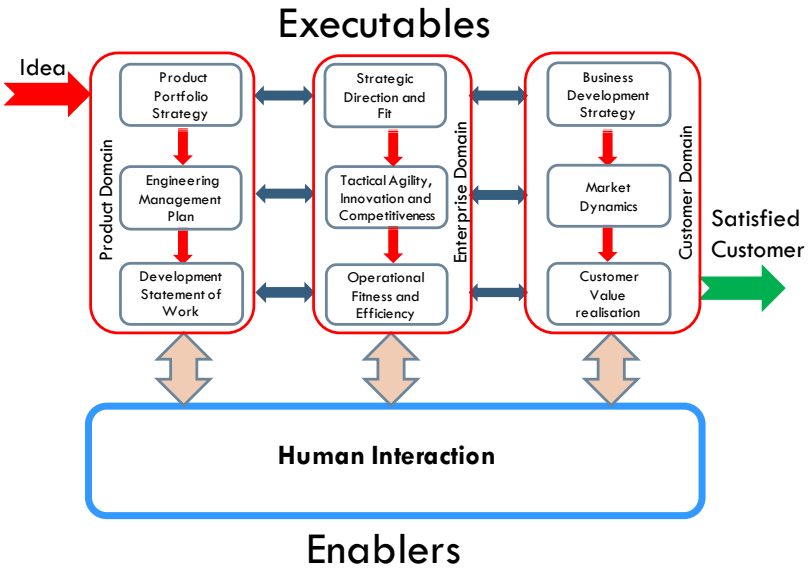

Figure 3-22: The Human Interactive Enabler Factor Interaction

The human interaction potential on the Interactive Supply Framework's Executable Factors forms the essence of this research. Specific attention to the concepts of Leadership, Relationships, Wisdom and Culture that define the Human Interactive Enabling Factors of the framework will be discussed. A change in these human contributions is expected to have an influence on the success of the project.

3.3.1 Leadership Factors

"If your actions inspire others to dream more, learn more, do more and become more, you are a leader" John Quincy Adams

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Ward (2004), through the study of companies at different stages of the organisation's life cycle, concluded that there are unique challenges facing organisations and their leadership at each transition between the various stages. Consequently, it requires significantly different managerial and leadership skills to lead an organisation at these various transitional periods. Hence the Leadership Life Cycle with the Creator, Accelerator, Sustainer, Transformer and Terminator roles that are required for success.

The Classic Phases of the Enterprise Life Cycle are defined as:

- The Creation or Start-Up Phase
- The Growth Phase
- The Operational or Maturity Phase
- The Turn-around Phase
- The Decline or Re-Development Phase

The characteristics of each of the five leadership roles are defined in table 3-1 below. As can be seen from the table, the roles are complementary, and it cannot be expected from a single individual to be able to perform all these roles when required to do so. The real sticking point in this model is the transition between roles requested by the leadership that can and normally do cause friction, dis-function and even early extinction of an enterprise (Ward 2004).

The real issue identified by this model is the transition period between the phases where the leadership role should change to fit the development needs of the enterprise to make it be successful and grow. The roles identified by Ward do not define a specific personality type but rather a leadership trait within a person. It is, therefore, possible for a leader to span more than one development phase of the enterprise. The transition between phases should be the focal point of the leadership of the company.

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Table 3-1: The Leadership Roles as adapted from Ward (2004)

Creation	Growth	Maturity	Turn Around	Decline
Creator	**Accelerator**	**Sustainer**	**Transformer**	**Terminator**
Provide the Creative Spark of Energy	Puts the pedal to the metal to accelerate along the exponential growth path	Creator and/or accelerator will be destructive in this phase	Recreating from an existing declining base	The organisation comes to a natural end or the owner whishes to disinvest
Leaders' sense of vision for the company	Translates the creator's mission into systems and routines to enable the growth without bursting at the seams	Structure and predictability becomes more necessary and consistency overtakes flexibility as the more essential quality	Halt the decline of the organisation by changing the direction (vision) and redefining the mission	Guide the organisation to its natural end
Intense passion for the mission that energises all around them	High degree of focus and direction	Reducing chaos and steadying the pace	Overcoming resistance to change within the organisation is the hardest task	The timeframe of the organisation switches from long term horizons to short term objectives
Instill sense of urgency into the company	Needs to be adept at communicating internally and externally	External communication takes up an increasing amount of time thus good communication skills is required	Needs to put the newly defined vision into context of the transformation of the old mission and overcome the failures of the past	Strategic orientation moves from growth to maintenance to value realisation
Focus on Strategic Priority of getting products or service to the market	Needs to balance the internal needs of robust systems with external needs to communicate and to understand the external market as well as the financial requirements	Initiate only incremental change and reiterate and refine the mission	Use the crisis of the srark threat of extinction to provide the impetus to overcome the inertial forces of the status quo	Paramount leadership challenge is addressing the uncertainties of the future and to allay the employees fears
Comfortable in dealing in environment with little structure and rapid change		Challenge lies in maintaining the enthusiasm of the organisation to keep focus on an unchanged mission for a long period of time		A major challenge is in retaining the focus of the employees required for the winding down or selling of the organisation
Needs to adapt constantly whilst maintain focus on the strategic goal		Passion is one of unbridled enthusiasm to keep the troops in the trenches motivated		

3.3.1.1 Macro Leadership: Correct style for Phase of Enterprise

The work of Ward (2004), Adizes (2017) and Tan (2012) all define distinct roles of the leaders or managers that are the best fit to the specific enterprise life cycle phase. Table 3-1 above represents a description of these specific roles as needed in the different enterprise phases. The case study will investigate the actual application of this fit.

3.3.1.2 Innovative use of the Relationship Framework

Section 3.3.2 below defines a Relationship Framework that can be used to enhance the effect of a sound relationship strategy and action plan for the success of the project. The leadership factor in this section investigates the prophylactic application of relationship in a supply project.

3.3.1.3 Micro Leadership for One on One/Many

This applied leadership in the micro environment i.e. in a team context as well as the leader / team member interaction will also be investigated in the case study to follow.

3.3.2 Relationship Factor

Literature study identified the relationship factor as one of the human factors that should play a role in the success of a project. To investigate this factor in more depth, the author has formulated, with the support of the Stiglingh (2014)[229], a Relationship Framework based on the application of the Cognitive Behavioural Theory.

[229] Stighlingh, W. (2014) *Unpublished Work*. Obtained through interactive consultation.

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3.3.2.1 Cognitive Behavioural Model for the Supplier and the Customer

The relationship factor as discussed in section 2.6.2 is further defined by a Relationship Framework as part of the, yet to be published, work of Stiglingh (2014) where he sets out a relationship model built on four pillars namely:

- **Communication**
- **Honesty**
- **Respect**
- **Trust**

Trust forms the core of the model. However, like honesty, respect and trust are all values to live by. Communication during any Interactive Event is the only tool available to influence the customer's experience of any of the other values.

The human interaction is depicted by a Relationship Framework as postulated by the author and Stiglingh (2014) whereby the combined ABC model (Activity, Belief and Consequence) (Hayes, 2004 & DaPhysic, 2017) of both the customer and the supplier are considered as depicted in figure 3-23 below.

From this framework, it follows that a positive consequence must be sought through careful planning of subsequent Interactive Event actions as well as a careful choice of the teams interacting with the customer.

In this Relationship Framework, the consequence of the supplier's intended Interactive Event activity, in turn, causes an activity for the customer. It follows that a positive consequence must be sought through careful planning of the Interactive Event actions. If one wants a positive consequence for the customer, it will be advantageous if the supplier's and the customer's belief systems are closely aligned.

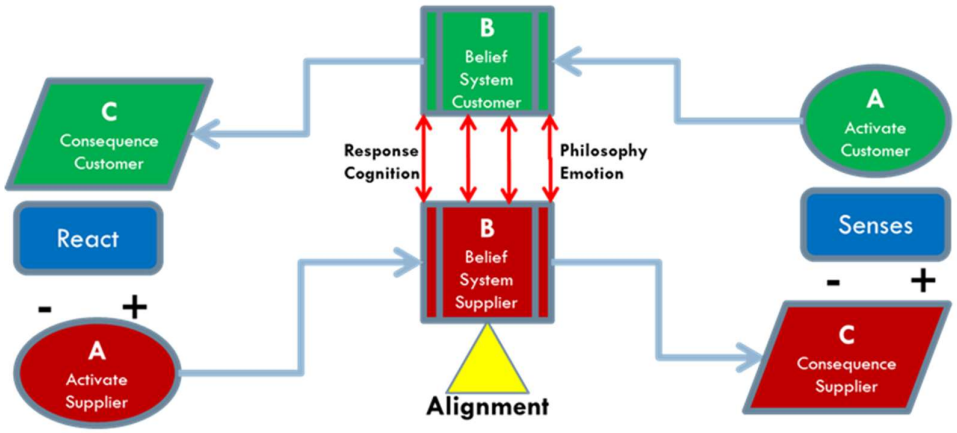

Figure 3-23: The Relationship Framework adapted from Stiglingh (2014)

3.3.2.2 Levels of Interaction

In addition to the above, one needs to consider the different interactions between the parties

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at play. The experience of the author recognises the following levels of interaction between a multinational corporate exporting through an inter-mediator multinational corporate to a third country's procurement agency:

- Country to country, recognising the cultural difference between the two nations.
- Multinational corporate cultures represented by their respective senior management team's strategic visions.
- The difference between the belief systems of the project managers on all sides with regard to the understanding of good project performance.
- The difference between all the technical representative's value systems with regard to specific technical issues.
- The different view of acceptable quality between all the quality assurance representatives (QAR).

As no complete alignment between the belief systems of the customer and a supplier, at all levels as defined above, is realistically possible, one needs to focus on areas of serious miss-alignment that have the potential to turn an Interactive Event into a failure.

Although it is not feasible to predict a 100% fit between the parties' personnel's belief systems at all levels, it remains important to select the best-fit Program-, Engineering Managers and Quality Assurance Representatives. These persons ideally should share a common belief system between themselves as well with their counterparts in the intermediator and customer environments. It is at these levels where most of the influencing is done.

3.3.2.3 Application of the Relationship Framework

The following interactions can be derived from the Relationship Framework:

- If you sense what the customer wants (his necessary consequence), you can pre-plan your influencing activities (potential interactive events) to comply, without the customer realising this.
- Alignment between the belief systems regarding Response, Cognition, Philosophy and Emotion is essential. Social interaction is used to increase this alignment.
- The pre-planned timing of your consequence in order for the customer to sense and inevitably start his own ABC cycle will lead to a consequence for him.
- Your reaction to his consequence will start the chain again, resulting in a positive or negative spiral.
- The ABC cycle is part of human nature and will happen automatically. It is your choice to use it in a positive way.

As described earlier, this Relationship Framework is one of the major contributing factors to the Interactive Event. As the Interactive Events happen throughout the engineering / project life cycle as part of the Interactive Supply Framework, it follows that the continued

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application of the Relationship Framework during the engineering / project life cycle is a definitive factor in success or failure of the project and eventually the enterprise.

The case of supplying the same vehicle to the same requirement (war theatre) to a NATO based army through different customers, presented an excellent case study to isolate the effect of the relationships. One project was very successful and the other a complete failure that eventually resulted in the cancellation of a contract.

The case study specifically focuses on the contribution of business relationships towards the success or failure of a specific project. Success is defined as realising the customer value in combination with the realisation of the monetary awards for the enterprise and its owners. Failure is the inability to deliver either the user value or to make a loss on the project or if both conditions occur (section 2.1.1).

3.3.2.4 The Role of Relationship during Consequential Interactive Events

In figure 3-23, we defined the Relationship Framework based on the ABC Model. The components of the belief system (Hussain, 2013) that we need to consider during consequential Interactive Events are:

- **Behavioural** Performance, Action, Inaction – How people respond to what is happening.
- **Cognition**, Mindsets, Clarity, Perceptions – How people think of what is happening.
- **Philosophy**, Core Beliefs, Personal Values – The meaning people attach to what is going on.
- **Emotional** Climate, Relationship Management, Emotional Information – How people feel about what is going on.

These components will be used in the investigation of each case study as to the prevalence of alignment or misalignment between the three parties in these relationships at the different levels of interaction. Matrixes were generated investigating the alignment (or misalignment) of belief system elements, between all sides and at all levels for both the case studies. These matrixes are defined in Tables 3-2 and 3-3 respectively.

3.3.2.5 Case Studies on the effect of Relationships

Case Study A – Selling to the US Government

The USA had a real need for a vehicle that was necessary to protect their troops against Improvised Explosive Devices (IED's) and landmine threats as their Humvee vehicle proved to be incapable. Although the Mine Protected Vehicle (MPV), at the time, did not fulfil all the requirements, the customer was prepared to allow design improvements during production. The USA also did their protection qualification against their own classified standard.

The product was immature at the start of the contract, with an enormous challenge of delivering circa 150 vehicles within nine months, inclusive of development. These facts caused a concurrent development process with a specific break in points in the production.

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It was a high-risk real challenge for the company. It also attracted management focus and resulted in a team effort throughout the enterprise.

The following facts are relevant:

- **Final Customer:** US Department of Defense to be used as part of NATO forces in Afghanistan
- **Intermediary:** International Weapon System Supplier – Canadian Branch
- **Supplier:** South African Military System Supplier - Supplier, was in the start-up and growth phases of the enterprise life cycle.
- **Product:** Mine Protected Vehicle (MPV)– eventually 3000+ vehicles fielded.
- **Environment:** At war with sufficiently appropriated funds and a real need for protection.
- **Risk:** Extremely challenging in both production schedule and product maturity.
- **Project Outcome:** The customer effectively deployed the MPV vehicles in Afghanistan where it saved many American soldiers' lives. The expected value of the customer was realised. In addition, the company and its owners enjoyed a very decent profit from this project. It can be stated that the project outcome was extremely successful for all parties.

Follow-up contracts were as challenging, demanding up to 10 vehicles' production per day. The challenge also represents the growth phase of the supply company. The processes established during this phase formed the basis for a very successful maturity phase. This eventually led to the production and delivery of more than 3000 vehicles.

A positive Interactive Event spiral was established. During this whole period continued formal and informal interaction with Intermediate Weapon System Supplier's Canadian Branch and the USA Department of Defense's (DoD) Tactical Acquisition Command (TACOM) were maintained resulting in an open, honest communication process between all parties. This project was a success.

Belief System alignment

The alignment of the different levels of the belief system for the USA DoD are defined as follows:

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Table 3-2: USA DOD Contract

	USA DoD Contract - Analysis of Belief System Alignment						
Level of Interaction	**Belief System Element**	**Supplier in SA**	**Align**	**Intermediary Canadian Branch**	**Align**	**Customer USA DoD**	**Outcome**
Country	Response						
	Cognition						
	Philosophy						Slight political misalignment between Supplier and USA
	Emotion						Supplier, Canadian Branch and USA cultures closely aligned
Enterprise	Response	Slow autocratic response of a big enterprise		Slow autocratic response of a big enterprise		Slow autocratic response of a military organisation	Normal for this type of business
	Cognition						
	Philosophy	Supplier HQ in Washington DC support for USA DoD war-effort in Afghanistan		Canadian Branch support for USA DoD war-effort in Afghanistan		Tactical Supply Command (TACOM) support for USA DoD war-effort in Afghanistan	Huge alignment supports and overrides other misalignments
	Emotion						
Program Management	Response	Professional response to requirements		Quick contractual feed back		Good informal relationship established with TACOM PM	Communication between Supplier and End User possible with various visits
	Cognition						
	Philosophy	Teamwork through informal success events		Teamwork through informal success events		Teamwork through informal success events	Trust relationship established through informal interaction
	Emotion	Emotional Maturity		Professionalism		Professionalism	Slight misalignment as a result of high stress due to severe time pressure
Engineering Management	Response	Supplier Eng Manager very quick in adapting to new requirements		Canadian Branch System Engineer very supportive		TACOM share some feedback from the Afghan theatre	Product mature in record time
	Cognition						
	Philosophy	Take on the challenge		Supportive to fill the gaps left by Supplier		Need solutions badly Open for changes	Driven by common goal
	Emotion						
Quality Representative	Response						
	Cognition						
	Philosophy	Open sharing of information to establish quality standard		In process feedback with in plant QAR		USA Government acceptance agency requirement established	Resultant is the acceptance by USA Agency of the Supplier QAR as formal product buy-off due to trust relationship
	Emotion						
	Area of potential conflict			Alignment			
				Slight misalignment			
	Area of agreement			Misalignment			

This matrix was compiled by considering the potential issues or positive points between the groups that interact within the reference of the elements of the belief system.

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Case Study B – Selling to the Spanish Government.

The Spanish Ministry of Defence (MOD) originally wanted the same product for the same role in the same war that the USA DoD received. The project was deemed a low-risk project and did not get the same management focus as the USA contracts. It was left for a program manager to run. The project happened in the mature or early decline phases of the company at the end of the USA MPV vehicle delivery.

The following facts are relevant:

- **Final Customer:** Spanish Ministry of Defence to be used as part of NATO forces in Afghanistan
- **Intermediary:** International Weapon System Supplier – European Branch
- **Supplier:** South African Military System Supplier - The provider in a mature to early decline phases of the enterprise life cycle.
- **Product:** Mine Protected Vehicle (MPV) after 3000+ vehicles built but later re-defined for Spanish specific 120-vehicle requirements.
- **Environment:** At war as part of NATO with insufficient funds.
- **Risk:** Low risk with the product mature – initially perceived to be the same as MPV.
- **Project Outcome:** Customer expected value did not realise, and money was lost by the supplier. The last phase production order was eventually cancelled, and vehicles returned to the vendor. This project was a failure.

This contract was executed in three phases, two of which were successfully delivered, however with increasing difficulty and within the growth in feedback from the field to tenfold that of the USA contract. The 20 vehicles of the third phase were also physically delivered but never accepted and were eventually returned.

Management intervention came too late, and all the quick reaction to the particular and unreasonable queries by the Spanish MoD's Quality Assurance Representative only resulted in showing up the inherent flaws in the product quality. The quality problems only exaggerated the complete breakdown of the trust relationship and eventually led to the cancellation of the third-phase contract.

The negative interactive events started with the initial lack of relationship building and eventually spiralled out of control.

In the case of Spain, the expectation was that of a mature NATO based product although the contracts clearly stated otherwise. The expectation gap was the result of the difficult language barrier as International Weapon System Supplier's European Branch had some inclination to speak English; the Spanish MOD only used Spanish as their means of communication. It was still the same product for the same role in the same war but in the hands of a different Army.

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Belief System alignment

The alignment of the different levels of the belief system for the Spanish MOD are defined as follows:

Table 3-3: Spanish MoD Contract

	Spanish MoD Contract - Analysis of Belief System Alignment						
Level of Interaction	Belief System Element	Supplier in SA	Align	Intermediary European Branch	Align	Customer SPAIN MoD	Outcome
Country	Response						
	Cognition	Language problem between English and Spanish		Language problem between English and Spanish		Language problem between English and Spanish	MoD only speak Spanish
	Philosophy						
	Emotion	Potential Problem to be monitored					Eventual emotional issues surfaced with project team
Enterprise	Response	Slow autocratic response of a big enterprise		Slow autocratic response of a big enterprise		Slow autocratic response of a military organisation	Normal for this type of business
	Cognition						
	Philosophy	Normal export business of known product		Position in Spain as main supplier		Make do within active EU austerity measures	Different Philosophies driving the project
	Emotion						
Program Management	Response	Program manager go by the book		English vs Spanish language problem		English vs Spanish language barrier	Communication between SA and End User not possible due to language barrier
	Cognition						
	Philosophy	Program manager set in his ways		Program Manager complete opposite			Immediate communication breakdown
	Emotion	Emotional Intelligence very low		The emotional reaction of the Spanish People inevitable		The emotional reaction of the Spanish People inevitable	This misalignment is identified as the leading factor in destroying the trust relationship
Engineering Management	Response	English vs Spanish language barrier		English vs Spanish language barrier		English vs Spanish language barrier	Late understanding of actual requirement
	Cognition						
	Philosophy	Product sold as non NATO qualified (USA tested)		Contract non NATO but later changed to NATO		Spanish MoD expect NATO Standard	Expectation of product qualification status against NATO Standards not met
	Emotion						
Quality Representative	Response	Supplier response very fast but to late				Government QAR required unreasonable response	Supplier tried to please with unrealistic compromises
	Cognition	Supplier QAR does not understand the emotional reaction		European Branch caught in the middle and opted in favour of Spanish MOD		QAR used as medium to cancel the last contract	Happened after trust relationship was destroyed
	Philosophy	Supplier ready to compromise				QAR non negotiable	No deal possible
	Emotion					Severe emotional demonstration	Breakdown of communication
	Area of potential conflict			Alignment			
				Slight misalignment			
	Area of agreement			Misalignment			

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Discussion

In both cases, the as-designed beam axle suspension was upgraded to withstand the severity of the terrain in Afghanistan. In the event of the USA, it resulted in a successful retrofit program with an independent suspension solution. However, in the case of Spain, the South African supplier had to retrofit, at his cost, a more robust uniquely designed solid beam axle solution primarily due to the relationship breakdown and the resultant position the customer took in demanding a solution. The retrofit was supported by the position the supplier took to try and fix this relationship, albeit too late.

Other Factors

Some other contributing factors to the success or failure of the two case studies were:

- The cultural and communication differences between the three parties were a contributor towards the failure in the case of Spain.
- During the third phase production, the Spanish government had severe austerity measures placed on them by the rest of the EU, and this factor must have also played a role in the cancellation of the order.
- In the case of the USA supply, all three parties have their corporate head offices inside the USA with the result that there was a shared understanding of the support of the American Forces in Afghanistan. The alignment of the belief systems caused a "top cover" with aligned decision-making on any issue that had the potential to derail the project.
- In the case of Spain, each company had his own, but different, understanding and philosophy of its reason to make a success of the project. The misalignment of the belief systems resulted in various decisions by the parties when presented with issues. No "top cover" was available.
- The difference between the Canadian vs. European Branches of the International Weapon System Supplier: in Spain role and attitude was an unexpected complication. Both groups are part of the same international organisation, however, in the execution of their roles as system supplier the following differences were evident:
    - In the case of the USA, the Canadian Branch filled the capability gaps that the vendor left and, as a result, presented a single solution to the acquiring agency – TACOM.
    - The European Spanish Branch, on the other hand, pointed to the capability gaps and tried to distance themselves from the results, obviously without success.

It is also interesting to note that the high-risk challenging project received proper managerial attention from the onset whereas the low-risk project essentially failed in the initial stages of the relationship building process due to management focus being elsewhere.

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Interpretation of the Results

Below is a summary of the interpretation of the case study results:

Case Study A Results– Selling to the US Government.

The USA supply is an example of an optimal combination of factors contributing to maximise the success of the project in the start-up and growth phases of the enterprise. In summary, these factors were:

- Top cover provided by the three enterprises sharing the same philosophy related to the alignment of belief systems.
- The first successful relationship is built at the project team level.
- The high-risk project resulted at the beginning of senior management focus by the supplier in their start-up and growth phases of the enterprise life cycle.
- Professional response by the Canadian Branch of Company A as the system supplier.

Case Study B Results – Selling to the Spanish Government.

Factors have been identified in the Spanish project that caused catastrophic failure in the execution of the project and how to prevent it through the recognition of early warning signs:

- No established top cover for a satisfactory resolution of issues to misalignment of the belief systems at the corporate level.
- High emotional energy during the formal project Interactive Events, as a result of cultural differences.
- Lack of relationship building and breakdown of communication at the project level.
- Misfit of personalities on the program.
- Deemed low-risk project and subsequent early lack of management focus during mature and early decline enterprise life cycle phases.
- Lack of professionalism by the European Branch as the system supplier.
- Recognised product performance expectation gap at the Spanish MOD.
- Severe pressure by the Spanish government on its budget.

Table 3-4 presents a summary of the contribution of the various factors emanating from the Knowledge Cube Framework as well as the Relationship Framework and indicates their contributions towards the success or failure of the two projects.

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Table 3-4: Interpretation of the Contributing Factors

Case Study Interpretation of Specific Factors Contribution to Success							
	Relationship Model		Knowledge Cube User Value			Other Factors	Outcome
Factor	Belief System Alignment	Personnel Fit	Functional Fit	Scope of Supply	Life Cycle Cost	Budget	
Case Study A USA	↑	↑	↑	→	↑	↑	↑
Case Study B SPAIN	↓	↓	↑	→	→	↓	↓
Interpretation	Good relationships on all levels prevalent with USA whereas bad relationships and personnel misfit occurred in the early stages of the Spanish project.		No distinct difference can be discerned regarding the actual fit of the product to the requirement. In the case of Spain the expectation was for a NATO standard vehicle although the initial contracts stated otherwise.			The pressure on Spain during the last production phase may have been the main factor causing failure.	Bad relations and/or lack of budget caused the eventual failure of the project.

It can be determined, from the above results, that the effect of good and bad relationships does influence the outcome of a supply project. Additional case studies will be presented to demonstrate this effect.

3.3.3 Wisdom Factors

In section 2.6.3.3 **wisdom** is defined as *'Exercising sound judgment; reflects significant under- standing of people and of situations. Considerate of multiple perspectives and forms of intelligence. Wisdom in groups is demonstrated by insight, wisdom, clarity, objectivity, and discernment rooted in deep caring and compassion'* (Briskin et al., 2009).

In the DIKW Pyramid Model (section 2.5.2, DBours, 2017) wisdom is also defined as an *'applied form of knowledge through sound decision making. Wisdom is created through the use of knowledge, through knowledge users' communication, and through reflection, i.e. by embedding values, beliefs and experience into knowledge. Wisdom answers the 'Why do' question as it relates to actions. In a sense, it is what helps us make a better-informed decision between two seemingly similar choices, or what helps us to apply knowledge toward the attainment of a common or higher good.'*

3.3.3.1 State of Knowledge

Knowledge can exist as an object, in essentially two forms: explicit or documented and formal knowledge - that is, "know-what" - and tacit or experiential - that is, "know-how" (Polyani,1958), (Nonaka & Takeuchi,1995) and (Beckman,1999).

- Explicit Knowledge is the formalised knowledge that can be managed and stored outside of the human brain.
- Tacit Knowledge is the knowledge that walks around within the human brain and can be enhanced through education and training.

3.3.3.2 Management of Knowledge

The knowledge management process is well defined in the literature (Schwartz, 2006) and

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has many facets to consider.

3.3.3.3 Customer Decision Making

The ability to influence the decision making by the customer is a sign of the level of control that the enterprise has over its environment.

3.3.3.4 Enterprise Decision Making

The integration of information in context, combined with appropriate experience or tacit knowledge, gives rise to the ability to make **sound decisions** that are defined as **wisdom**. If one harnesses a team of likeminded individuals in such a fashion, then it delivers **collective wisdom.** This is clearly a state to strive for.

3.3.4 Culture Factors

3.3.4.1 Innovation Culture

Churchman's (1971) definition of knowledge creation forms the philosophical base of an inquiring organisation's core competence.

3.3.4.2 Learning Culture

Hall (1966) summarises the relationship between learning and culture as follows: 'Once people have learned to learn in a specific way it becomes challenging to learn in any other way...Culture reflects the way one learns.'

3.3.4.3 Empowerment Culture

Adizes (Entrepreneur to CEO, 2013) defines different leadership roles in various life cycle phases results in the change in corporate culture within these phases.

3.3.4.4 Corporate or Forced Culture

According to Courtney et al. (2005), it is important to understand the contribution of organizational culture on the success of the project. Organisational culture is the behaviours of humans within an organisation and the meaning that people attach to those behaviours. In the larger conglomerates of the western world the standardisation of business planning, risk management, business and technical governance, standardised policies, processes and procedures defines a specific and unique way of conducting oneself and, in doing so, creates a corporate driven culture to be practised.

It is the view of the author that the corporate culture contributes to a regulated, risk averse corporate entity and that this status is directly opposed to the innovation and agility required by the ever-changing customer and user environment. There is no expectation that the culture as practised in BAE Systems will be isolated as the main contributor to success.

The human factors defined in the preceding sections on leadership, relationship, wisdom and culture are pictorially shown in figure 3-24 below.

The elements shown will be used to define the potential interaction with the executable factors shown in the previous section.

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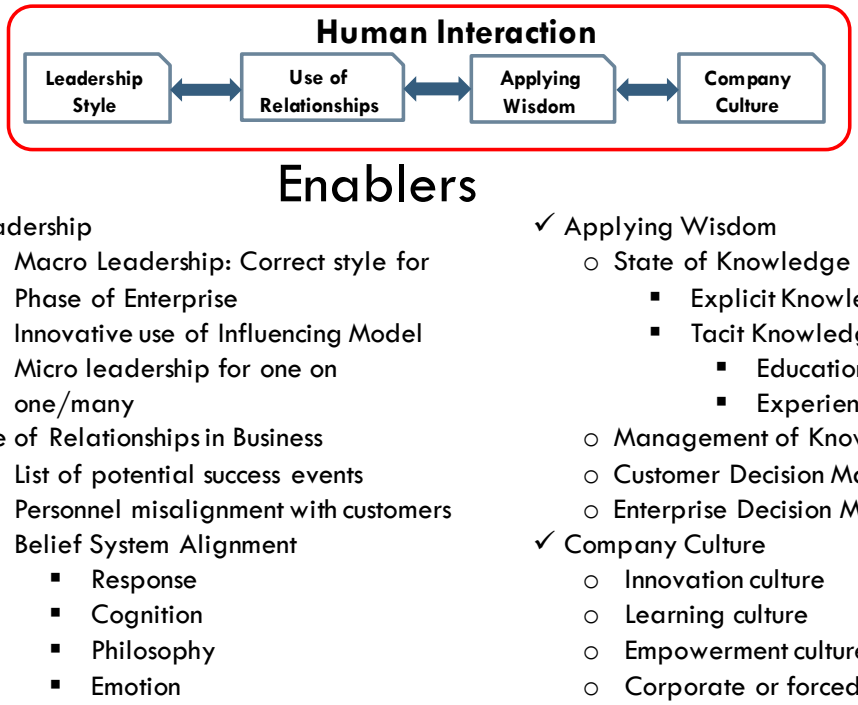

Figure 3-24: The Enablers Domain

3.4 The Interactive Supply Framework

The term, the Interactive Supply Framework was coined to refer, in this dissertation, to the framework that ensures comprehensiveness and interoperability between stakeholders in the entire product life cycle.

3.4.1 The Interactive Supply Framework Compiled

Step 5: Compiling the Interactive Supply Framework

In summary, the elements of the Interactive Supply Framework will be grouped into three categories as defined in figure 3-25 below:

- **The Executables:** All the factors related to the direct running of a business that needs to be deployed to a minimum required level. The enterprise can influence these factors directly or indirectly.
- **The Enablers:** All the human factors that can, or will influence the executable factors, directly or indirectly, to enhance the positive result of the enterprise. These factors are not mandatory but may enable the executable factors to increase the propensity for success or failure.
- **The Interactive Supply Framework:** Together, the executable factors, as well as the enabler factors, defined in figure 3-25, will form the Interactive Supply Framework roadmap.

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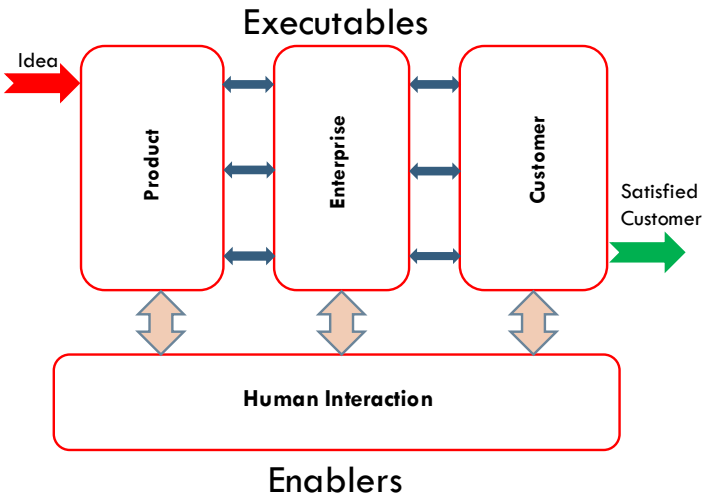

Figure 3-25: The Generic Interactive Supply Framework

By constructing the Interactive Supply Framework in this fashion, one can investigate the effect of the human interaction factors' contribution towards the success of the enterprise in a complex project acquisition environment in support of the research aim to understand the catalytic contribution of the human factors of leadership, relationship, wisdom and culture in the supply of a complex weapon system into a prescribed acquisition process.

The various life cycles must also be considered in conjunction with the Interactive Supply Framework as defined in figure 3-26 below.

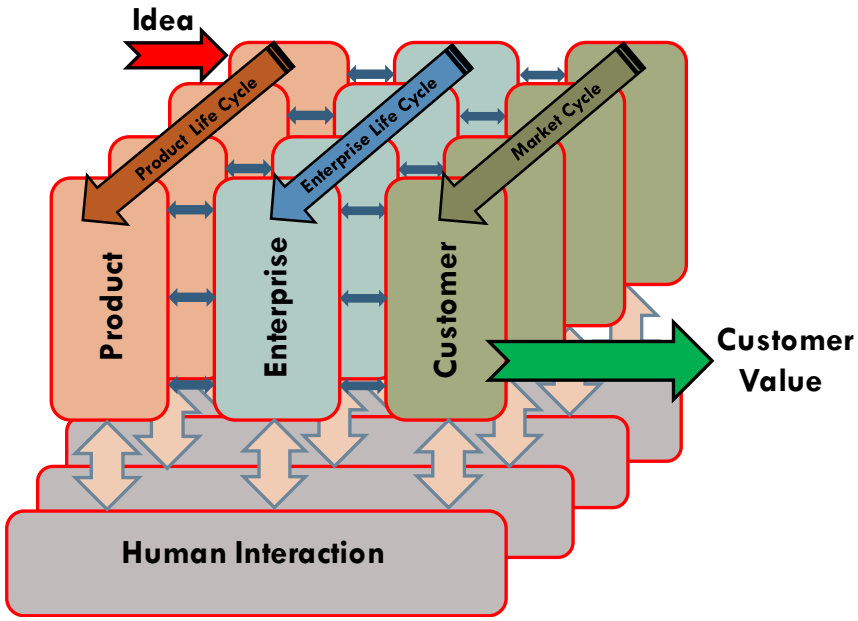

Figure 3-26: The Generic Interactive Supply Framework with Life Cycles

The Interactive Supply Framework is more complicated when one considers the life cycles of product development, the enterprise and the marketplace together with the human interaction at each phase.

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This is even more complicated when we consider the process of concurrent engineering where the sequence of events of the acquisition process is also scrambled.

3.4.1.1 The Holistic View of the Problem Statement

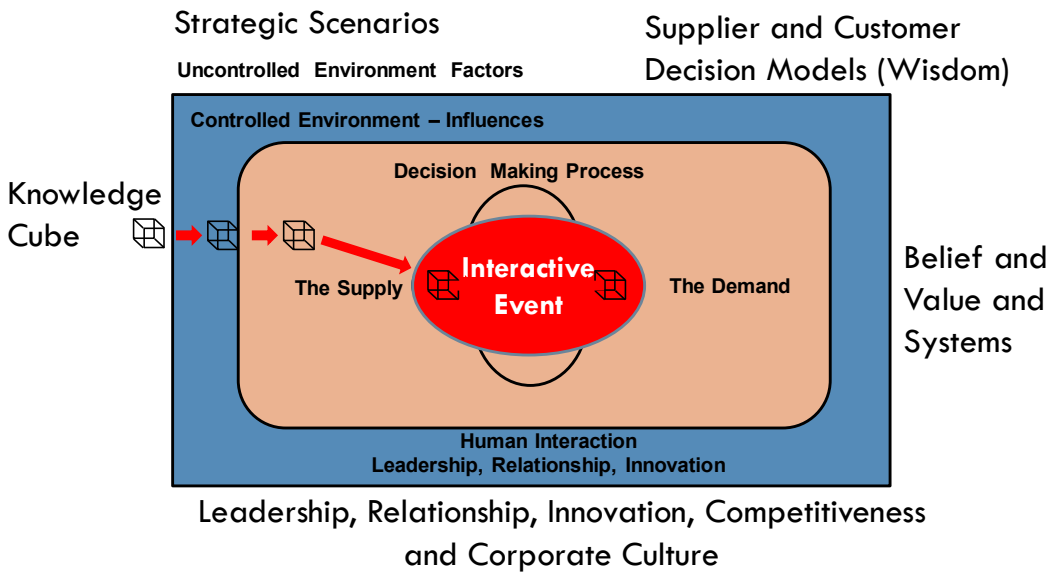

Figure 3-27: The Simplistic Problem Statement View

The simplified problem statement depicted in figure 3-27 can now be enhanced with all the components defined above as shown in figure 3-28 below. In the beginning of the research process the author defined the problem statement as the investigation of events surrounding the interaction between the supplier and the customer when knowledge item is discussed, communicated or demonstrated. This interactive event was expected to be influenced by decisions (wisdom), leadership, relationships and corporate culture. This, in turn, resulted in the definition of the research question being investigated in this dissertation.

In figure 3-38 the complexities of the different life cycles, the sequential interactive events and the customer's value and belief systems were added.

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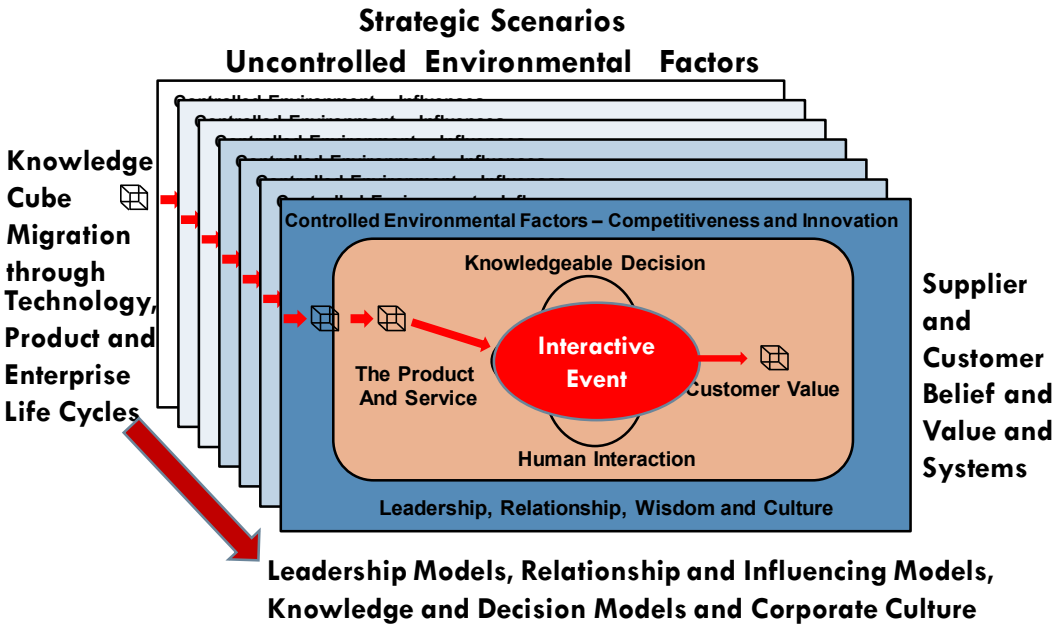

Figure 3-28: The Holistic Problem Statement View with Life Cycles

The combination of the executables and the enablers result in the populated view of the Interactive Supply Framework is shown in figure 3-29 below.

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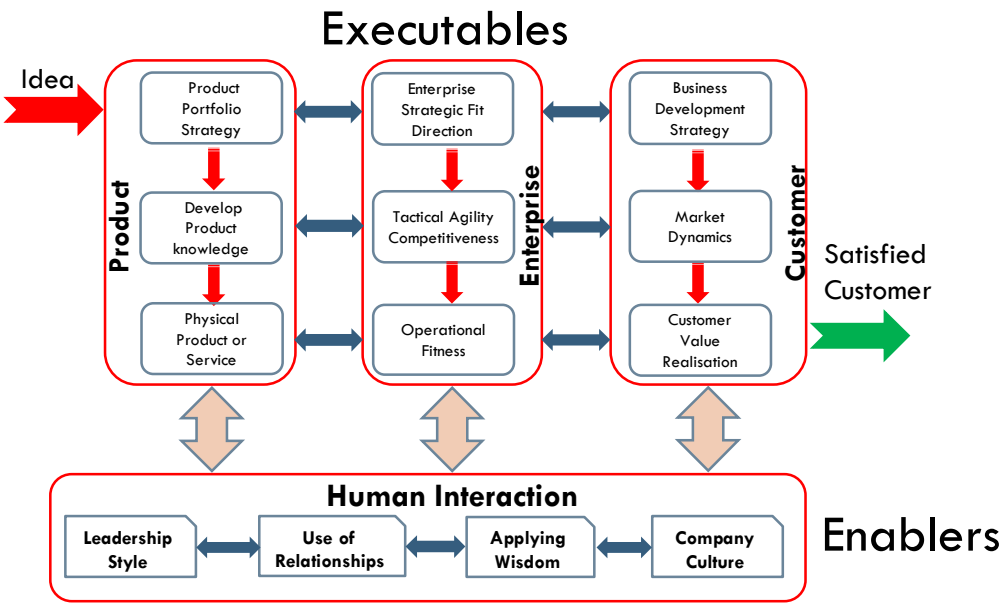

- ✓ Leadership
  - Macro Leadership: Correct style for Phase of Enterprise
  - Innovative use of Influencing Model
  - Micro leadership for one on one/many
- ✓ Use of Relationships in Business
  - List of potential success events
  - Personnel misalignment with customers
  - Belief System Alignment
    - Response
    - Cognition
    - Philosophy
    - Emotion
- ✓ Applying Wisdom
  - State of Knowledge
    - Explicit Knowledge
    - Tacit Knowledge
      - Education
      - Experience
  - Management of Knowledge
  - Customer Decision Making
  - Enterprise Decision Making
- ✓ Company Culture
  - Innovation culture
  - Learning culture
  - Empowerment culture
  - Corporate or forced culture

Figure 3-29: The Interactive Supply Framework

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3.5 The Embedded Processes

The Interactive Supply Framework presents the possibility to map a series of 'embedded' processes contained within it. These processes are:

Process 1: The Strategic Planning Process

Process 2: The Competitiveness Review

Process 3: Operational Management

Process 4: Product Development

Process 5: Project Management

Process 6: Business Development.

The above processes will be superimposed onto the Interactive Supply Framework to obtain a better understanding of the supply process.

3.5.1 Process 1: The Strategic Planning Process (from sections 2.2.3, 2.3.3 & 2.4.3)

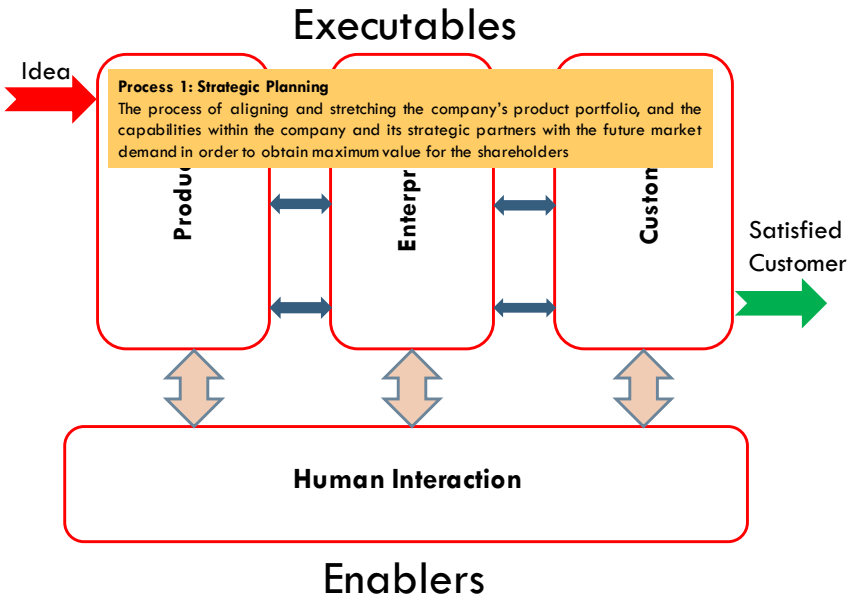

Figure 3-30: The Strategic Planning Process

The first embedded process that is recognised as the strategic planning process.

According to Leavy (2010), the strategic planning process is defined as:

"At its most basic, the strategy has two fundamental concerns – value creation and value capture. Traditional perspectives that focus primarily on how to create sustainable sources of competitive advantage are essentially concerned with value capture. Value innovation, while concerned with both creation and capture, shifts the primary focus in strategy development back to customers rather than competitors, and to the challenge of how to create game-changing breakthroughs in the value-to-cost ratio."

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The strategic scenario sketches that define the external factors, the product portfolio, the enterprise vision, mission, values and strategic actions, as well as the business development strategy, combined forms part of the strategic planning process of the company.

3.5.2 Process 2: The Competitiveness Review (from sections 2.2.4, 2.3.4, 2.4.4 & 5)

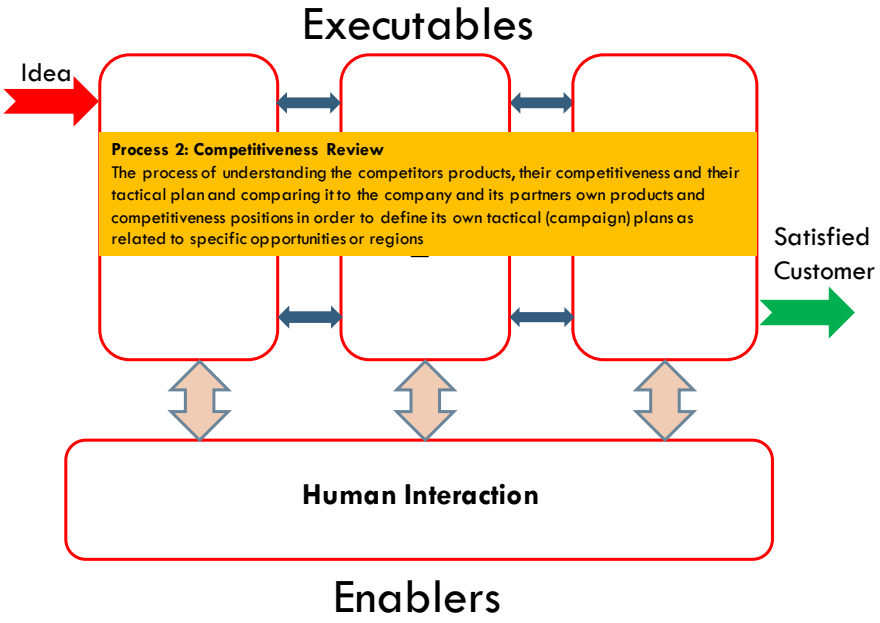

Figure 3-31: The Competitiveness Review Process

To understand the enterprise's competitive position, one must be able to measure the competitiveness of the enterprise. This need has given rise to models and frameworks that intend to assess the enterprise's competitiveness position.

Major awards available in the world like '*The Most Competitive Company of the Year*' given in the UK, '*The International Growth European Federation of Quality Management (EFQM) Excellence Award*' in Europe as well as the '*Malcolm Baldrige National Quality Award*' in the United States are all based on similarly structured approaches.

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3.5.3 Process 3: Operational Management (from sections 2.2.5 & 6, 2.3.5, 2.4.6 & 7)

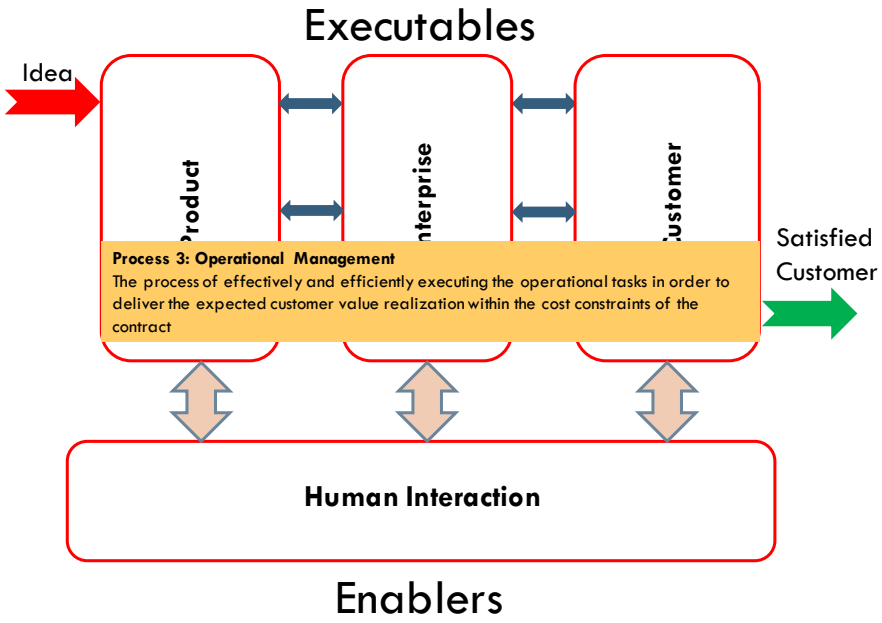

Figure 3-32: The Operational Management Process

The operational management process integrates the supply of components and services through an external supply chain, the value-add processes within the company as well as the presentation and deployment or use of the product and or service. The result of the operational management process is the realised value creation by the customer through the application of the product or service acquired. This, hopefully, leads to a satisfied customer.

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3.5.4 Process 4: Product Development (from section 2.2.4 to 2.2.6)

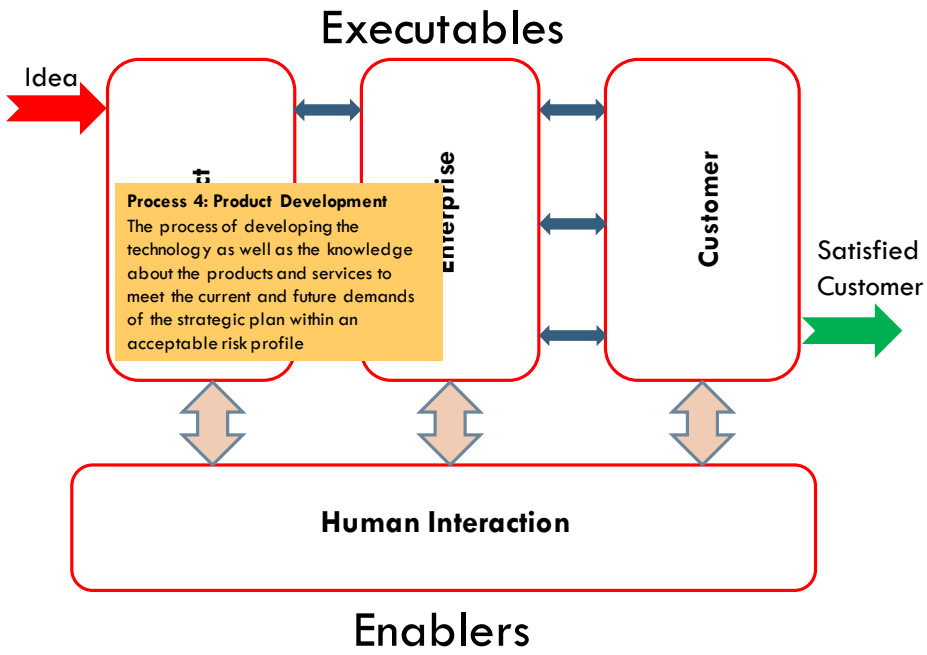

Figure 3-33: The Product Development Process

Product development can be described as the knowledge creation process of a knowledge artefact. In the language of the military system supplier, this results in specific baselines or milestones of knowledge maturity at different stages of the design process. The typical design maturity model is depicted below.

The common product under consideration for this research is a complex, design to order land based weapon system typically stretching from two to five years in time. It is, therefore, necessary to consider a specific process of an engineer to order product life cycle as defined by BAE Land Systems (2013).

The engineer to order product life cycle consist out of four distinct phases namely:

- The development of a generic or base vehicle. This can also be the previous model produced. The knowledge attributes of the base product must reach a minimum level of maturity to obtain an acceptable risk level to continue with potential contracting.
- The customisation phase where the design is completed against the stated commitments – This phase's main aim is to mature the product's knowledge attributes. If the customisation is extensive, it will increase the technical risk level and lower the current design maturity level as measured against the demanded performance.
- The industrialisation as well as the successful production of the customised product – This phase is primarily orientated to mature the knowledge attributes of the processes used during the production phase.

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- The after sales support of the product when fielded – The knowledge attributes required for the continued service and support is matured during this phase.

The sequential phases of the engineering life cycle define an increasing maturity level of knowledge of the item under development. This is defined as a set of technical states or baselines indicating the growth in Design Maturity Levels of the product. It is important to note that as the design maturity levels increase the technical risk levels decrease.

In engineered to order projects, the alignment of the proposed configuration, price and specifications with the profile requirements of the client is of paramount importance for customer value realisation.

3.5.5 Process 5: Project Management (from sections 2.2.4 & 5, 2.3.4 & 5, 2.4.5 to 7)

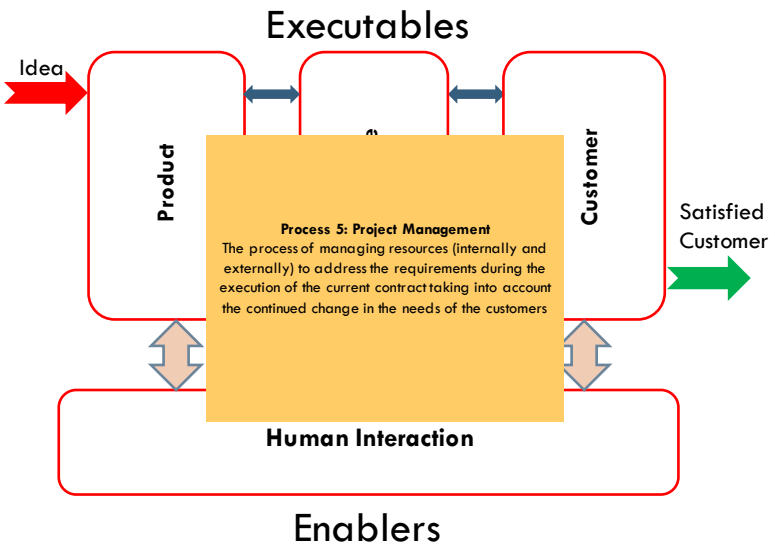

Figure 3-34: The Project Management Process

"97 Things Every Project Manager Should Know" by Davis[230] is a collection of wisdom from project managers, software developers, and a wide range of other occupation holders from all around the world who are successful in managing their teams to success.

The classic project management reference PMBOK[231] or Project Management Body of Knowledge defines project management as:

"Projects, within programs or portfolios, are a means of achieving organisational goals and objectives, often in the context of a strategic plan. Although a group of projects within a program can have discrete benefits, they can also contribute to the advantages of the

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[230] Davis, B. (2009) *97 Things Every Project Manager Should Know*. Collective Wisdom from the Experts. O' Reilly.

[231] Project Management Institute (2013) *A Guide to Project Management Body of Knowledge.* PMBOK Guide 5th Edition. Available at: http://www.pmi.org/PMBOK-Guide-and-Standards/~/media/PDF/Standards/PMBOK_Guide_5th_Errata_2ndPrinting.ashx [Accessed June 2017].

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program, to the objectives of the portfolio, and to the strategic plan of the organisation.

Organizations manage portfolios based on their strategic plan. One goal of portfolio management is to maximise the value of the portfolio through careful examination of its components—the constituent programs, projects, and other related work. Those components contributing the least to the portfolio's strategic objectives may be excluded. In this way, an organisation's strategic plan becomes the primary factor guiding investments in projects. At the same time, projects provide feedback to programs and portfolios using status reports, lessons learned, and change requests that may help to identify impacts to other projects, programs, or portfolios. The needs of the projects, including the resource needs, are rolled up and communicated back to the portfolio level, which in turn sets the direction for organisational planning."

In summary, the project management process is the "glue" that ensures a success by integrating the effort of all parties at all levels within and outside of the enterprise.

3.5.6 Process 6: Business Development Process (from sections 2.4.2 to 7)

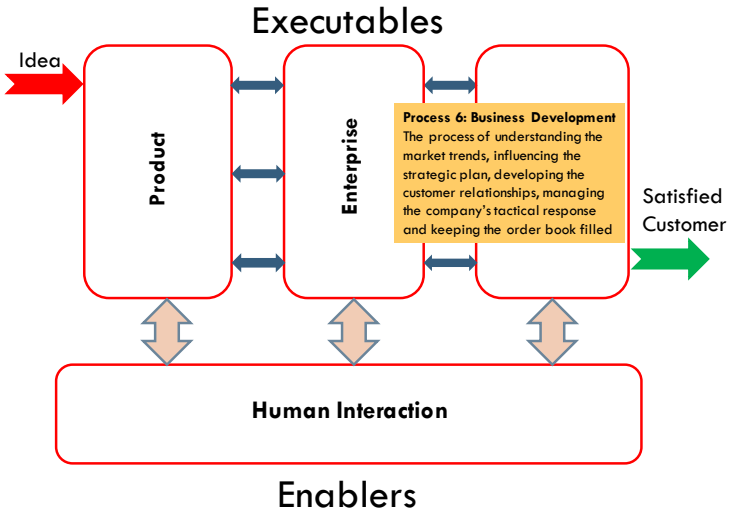

Figure 3-35: The Business Development Process

The Business Development Process is best practised through the classic Customer Relationship Management Cycle defined before. The cultivation and maintenance of sustainable customer relationships are part of the Customer Relationship Management or CRM process. This CRM cycle consists out of the following phases:

- Analysis and Identification
- Strategy and Offer
- Sales and Service
- Response Tracking and Controlling.

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3.6 Conclusion and Summary

The Interactive Supply Framework, as set out in this chapter, was conceived in the following build-up process.

3.6.1 Knowledge Growth in the Supply Process

This process started with the investigation of the knowledge growth through the life cycles of the technology, product development and enterprise phases. In doing so, the Knowledge Migration Framework was conceived and demonstrated by means of a virtual case study.

3.6.2 The Interactive Supply Framework

This was followed by the construction of the Interactive Supply Framework through five process steps as follows:

Step 1: Defining Success

It started at the definition of success (Adizes, 2014), added the effort to have the knowledge of a product to sell and thereby identified the three executable domains of product, enterprise and customer.

Step 2: The Generic Supply Roadmap

The second step in this process was the definition of a generic supply roadmap starting with an idea developed through the integration of all the above factors and understanding their inter-dependencies within a successful enterprise and concluding with a product / service supplied to the customer. This gave rise to a three-domain roadmap as the basis for the energy or effort required for the success of the supply process defined earlier and which is depicted in Figure 3-11.

Step 3: Defining the Executable Domain Factors

The next part of the build-up of the Interactive Supply Framework was to complete the nine sub-domains (or executable factors) with specific processes that happen within these sub-domains by considering all the literature review information on each topic. This resulted in the Executable Factors defined in figure 3-20.

Step 4: Defining the Human Interactive Enabling Factors

Step 4 of building the Interactive Supply Framework took into consideration the effect of the human interacting within the nine sub-domains in the executable domains. The result of this step is shown in figure 3-24.

Special mention must be made of the Relationship Framework (Stighlingh, 2014) and the mini case studies that were performed to understand and demonstrate its application.

Step 5: Compiling the Interactive Supply Framework

In summary, the elements of the Interactive Supply Framework were grouped into three categories as defined in figure 3-25:

- **The Executables:** All the factors related to the direct running of a business that

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needs to be deployed to a minimum required level. The enterprise can influence these factors directly or indirectly.

- **The Enablers:** All the human factors that can, or will influence the executable factors, directly or indirectly, to enhance the positive result of the enterprise. These factors are not mandatory but may enable the executable factors to increase the propensity for success or failure.
- **The Interactive Supply Framework:** Together, the executable factors, as well as the enabler factors, defined in figure 3-29, form the Interactive Supply Framework roadmap.

3.6.3 The Embedded Processes

The Interactive Supply Framework presents the possibility to map a series of 'embedded' processes contained within. These processes are:

Process 1: The Strategic Planning Process

Process 2: The Competitiveness Review

Process 3: Operational Management

Process 4: Product Development

Process 5: Project Management

Process 6: Business Development.

Each of the above processes relates back to the literature review conducted in chapter 2 and this relationship is shown for each process under discussion.

3.6.4 The Research Questions

The following research questions are hereby answered:

3. What are the processes embedded into the supply framework of a complex system to the acquisition process required by the customer?

5. How can a conceptual framework be constructed that combines all the executable and enabling elements of the process an enterprise needs to execute to supply a complex military vehicle system?

3.6.5 The Next Chapter

This Interactive Supply Framework will now enable the case study research to isolate the human factors' catalytic effect (Listed as the Enabler Domain) on the processes conducted as part of the supply framework (listed as the Executable Domain).

Chapter 4 will contain the following elements:

- The Research Problem
- The Research Approach

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- The introduction of the Case Study
- The Case Study Research
- Triangulation of the Results
- The Interpretation of the Results

The above will then give rise to the research conclusions and recommendations to be defined in chapter 5.

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Chapter 4
Case Studies Analysis and Enabler Factor Investigation

This chapter will be employed to investigate the actual case study of the supply of three different products and services to three distinct customers worldwide (DoD, NATO based and Africa based) from the South African based firm call BAE Systems, Land Systems South Africa.

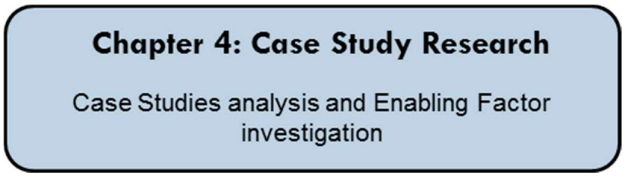

Figure 4-1: The Case Study Research

Chapter 4 will contain the following elements:

- The Research Problem
- The Research Approach
- The introduction of the Case Study
- The Case Study Research
- The summary Case Study Results
- Triangulation of the Results

4.1 The Research Problem

As discussed in chapter 1, the research conducted on the acquisition process success factors during the execution of the acquisition process in the US (Clowley, 2016) as well as reforms to the process (National Defence Industry Association, 2014) in the UK, have not sufficiently addressed the human factor and their affected and associated complex internal relationships within the process.

As describe in chapter 1, the k**ey research question** to be addressed by this study is as follows:

What is the contribution of the human enabling factors of leadership, relationship, wisdom and culture towards the success of a project or enterprise during the acquisition phase of a complex system, when interacting with a customer?

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As this research question is compounded the following supplementary research questions were defined and used in the analysis and confirmation of the research results:

1. What process is considered as the acquisition process of a complex system?
2. What attributes define a successful outcome of the acquisition process?
3. What are the processes embedded into the supply framework of a complex system to the acquisition process required by the customer?
4. What are the potential human interactive enabling factors that can play a role in the enhancement of the successful outcome of a complex weapon acquisition process?
5. How can a conceptual framework be constructed that combines all the executable and enabling elements of the process an enterprise needs to execute to supply a complex military vehicle system?

As indicated at the end of chapters 2 and 3, the additional research questions no 1 to 5 have been answered. The remainder supplementary question no 6 will be addressed through the case study research.

6. How are these specific enabling factors contributing towards success?

This result will then be used to confirm the theory as well as the overall research question as stated above.

The case study specifically focusses on the area of interface within the Interactive Supply Framework between the Executable and the Enabler Factors as depicted in figure 4-2 below.

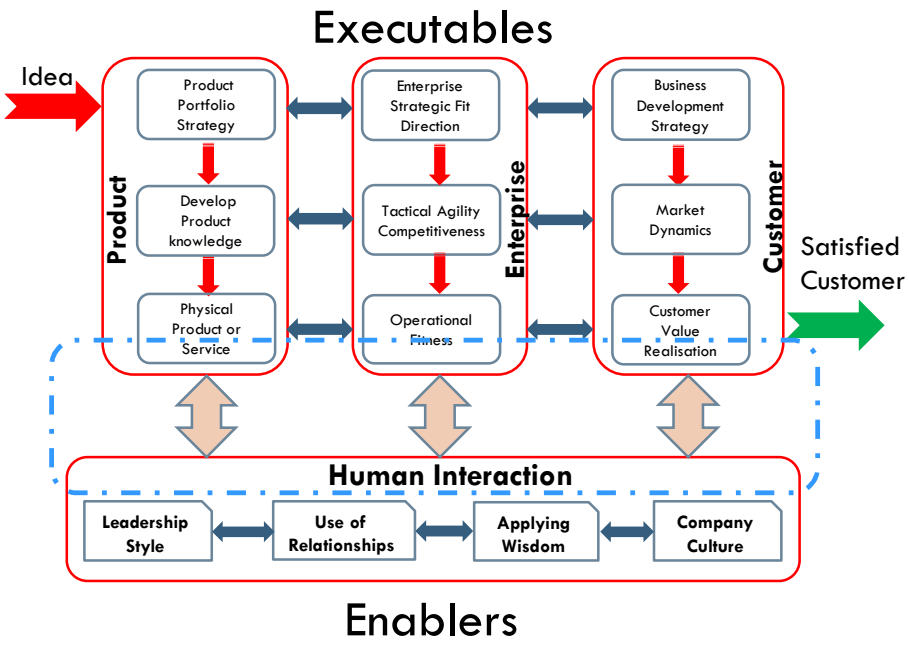

Figure 4-2: The Interaction between the Enablers and the Executables

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4.2 The Research Approach

The research approach was defined in section 1.5.2 through the application of Hinkelmann & Witschel (2011) and Saunders & Tosey (2013) to result in proposed research structures as follows:

- The deductive approach focuses on understanding the essential characteristics of small samples of qualitative data:
  - develop a theory
  - derive a framework in support of the theory.
  - make observations about the framework.
  - obtain a confirmation or rejection of the theory through the interpretation of the observations about the framework.
- As the effect of the life cycles of both the product, the enterprise as well as the acquisition processes under consideration, this research will identify different instances of data sets of the same product at various phases of both the product and the enterprise life cycles.
- The actual data collection will be done through the application of a questionnaire:
  - structured from a predefined set of questions.
  - collecting qualitative data from a predetermined population of potential respondents.
  - with a statistical evaluation of detection of patterns, trends, and related features.

4.2.1 Pitfalls and Concerns in Doing Case Study Research

Despite the proven application of case studies, the case study method has not achieved widespread recognition as a primary research method.

Some authors believe that case studies are used for exploration of the research problem and that other more analytical methods should be utilised for the "real" research. This traditional view of sequential social science inquiries is completely outdated. Both experiments and surveys have their own initial and consequential modes. All the methods can, therefore, cover the entire research process from initial exploration to the completion of full and final studies, without calling for any other methods.

A lack of trust in the credibility of a case study author's procedures also contributes to potential bias as well as the ability to expand and to generalise the results of the case studies.

Successful case study research needs to address these challenges by using more systematic procedures (Yin, 2009)[232]. Case study research must involve systematic data collection and

[232] Yin, R.K. (2009) *Case Study Research, Design and Methods.* 4th Edition, Sage Publications, pp. 40–45.

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analysis procedures, and case study findings can be generalised to other situations through analytic and not statistical generalisation.

4.2.2 Three Steps in Designing Case Studies

The research case studies must be explicitly "designed" in support of the research question. This is done by the following three steps:

4.2.2.1 Step 1. Defining the "Case."

The case this research is studying is the influence that the human has in the process of designing, producing and supporting the supply of a relatively complex military vehicle or vehicles in support of the success or failure of the specific project. This case is limited to the study of the effect of the human interactive enabler factors on the executable factors within the Interactive Supply Framework as defined earlier. The own contribution of the executable factors is not part of this study and can be a natural extension of this work.

4.2.2.2 Step 2. Selecting One of Four Types of Case Study Designs

The different possible types of case studies were considered to define the most appropriate approach for this study.

The traditional methodology according to Cosmos Corporation (1996)[233] is to decide between a holistic or a multiple case study approach as well as the embedded sub-levels within the case study.

This framework of case studies is shown in Table 4-1 below.

[233] COSMOS Corporation. (1996) *The National Science Foundation's Fast Lane System Baseline Data Collection: Cross-case report.* Bethesda, MD: Author.

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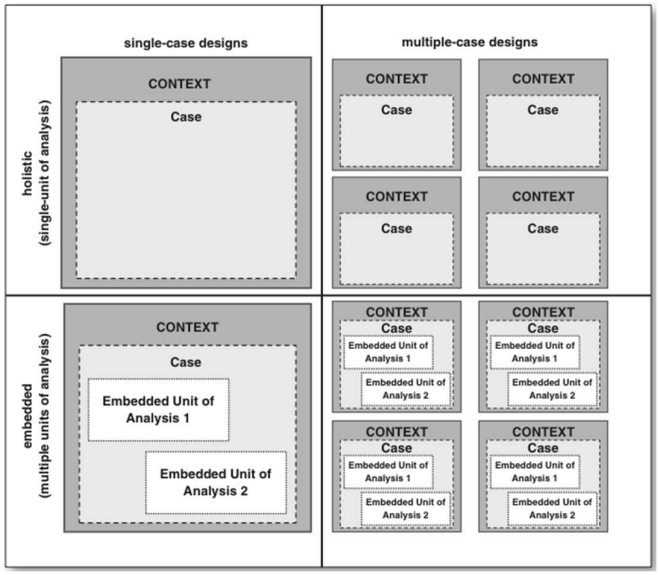
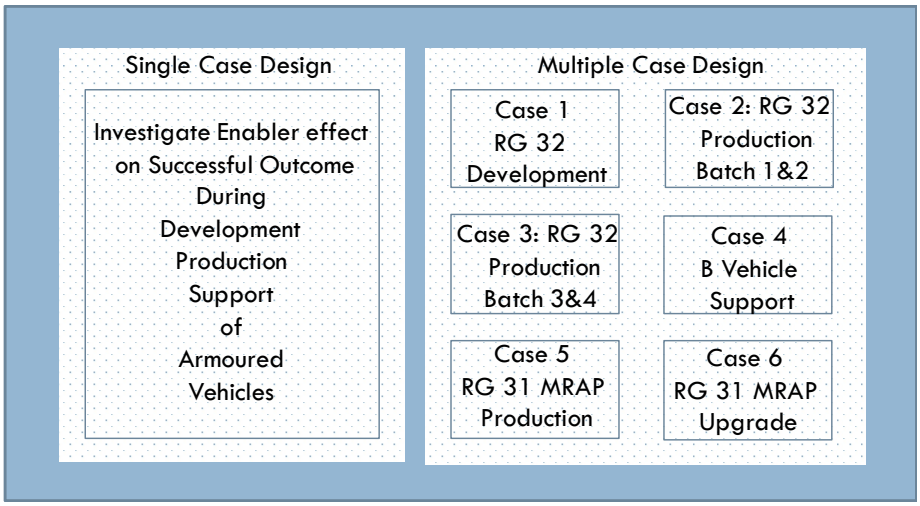
Table 4-1: Case Study Framework - Cosmos Corporation (1996)



The case study is limited to a single company where multiple projects are run for different customers, and the single case study design supported with multiple sub-cases was defined in section 1.5.3 as the appropriate approach to this study. In this way, the author can view the results of the complete company per phase as well as being able to analyse specific factors playing a role in the success of each project. The case study framework is defined in table 4-2 below:

Table 4-2: Case Study Design



In this design, one can test for (direct) replication for projects having similar outcomes or predict and test for contrast in the predicted conflicting results (theoretical replication).

4.2.2.3 Step 3. Selecting the Data Collection Process

The Data collection strategy used a case study methodology to study:

- empirical investigation of a contemporary phenomenon within its real-life context.

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- for gaining a rich understanding of the context of the research and the processes being enacted.

4.2.3 The Generic Questionnaire Development

This questionnaire was developed by interrogating the potential influence of each of the Human Enabler Factors on each of the Executable Factors in the quest to establish the facts around the potential interaction between these factors. These principle interactions are defined in Table 4-3 below:

Table 4-3: The Questionnaire Development

Enablers		Executables		
Human Interaction Domain		Product Domain	Enterprise Domain	Customer Domain
1	Leadership	Questions on possible Influence of Leadership on Product Domain	Questions on possible Influence of Leadership on Enterprise Domain	Questions on possible Influence of Leadership on Customer Domain
2	Use of Relationships in Business	Questions on possible Influence of Relationships on Product Domain	Questions on possible Influence of Relationships on Enterprise Domain	Questions on possible Influence of Relationships on Customer Domain
3	Applying Wisdom	Questions on possible Influence of Wisdom on Product Domain	Questions on possible Influence of Wisdom on Enterprise Domain	Questions on possible Influence of Wisdom on Customer Domain
4	Company Culture	Questions on possible Influence of Culture on Product Domain	Questions on possible Influence of Culture on Enterprise Domain	Questions on possible Influence of Culture on Customer Domain

The theory as presented in the previous chapters was used in the development to cover all the facets of the Interactive Supply Framework in both the executable and enabler domains.

The development of the questionnaire stems from the direct comparison between the executable and enabler factors in a specific matrix to identify the specific potential influences and thereby the areas of research interest. Each of the sub-factors of each enabler function was tested against each sub-factor of each executable function to formulate a specific question to interrogate the possible influence the enabler had on the outcome of the specific executable factor. This resulted in a series of eighty questions that were taken up into the questionnaire.

4.2.4 The Specific Questionnaire Development

As defined before, the specific potential areas where the enabler factors could have a possible effect on the executable factors were identified through the application of a comparative matrix. After this identification, specific questions were developed to interrogate this potential interaction (Glasow, 2005)[234], (University of Wisconsin – Madison, 2010)[235]. This approach is defined in table 4-4 below:

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[234] Glasow, P.A. (2005) *Fundamentals of Survey Research Methodology.* MITRE, Washington Center McLean, Virginia, pp. 2-5 to 2-10.

[235] University of Wisconsin – Madison (2010) *Office of Quality Improvement, Survey Fundamentals, A Guide to Designing and Implementing Surveys,* pp. 6 – 13.

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Table 4-4: The Questionnaire Development Matrix

Research Questionnaire						
Enablers				Executables		
Human Interaction Domain				Product Domain		
				Product Portfolio Strategy	Engineering Development Plan	Development Statement of Work
1	Leadership					
1,1		Macro Leadership Style				
1,2		Innovative use of Influencing Model			Was pro-active influencing used during the development process by the engineering management	Was pro-active influencing used during the procurement process by the procurement management
1,3		Micro leadership for one on one/many			What was the contribution of the engineering management's relationships towards the success of the project	What was the contribution level of the supply chain management's relationships to the project success.
2	Use of Relationships in Business					
2,1		List of potential success events		Does a product strategy document exist	1. Was there a list of planned reviews on the product development 2. Was there a formal sign off on the design of the product 3. Were the technical committee meetings held	Was there a list of planned interactions with the supplier base prior to contracting
2,2		Personnel misalignment with customers			How well did the engineering team get on with the customer's technical team	
2,3		Belief System Alignment			Which of the following areas did the company's technical team not see eye to eye with the customer a. Acceptable response to a request b. Understanding of a problem or issue c. The way they thought about an issue d. The way they felt about an issue	
3	Applying Wisdom					
3,1		State of Knowledge			Rate the effect of the company's product knowledge on the success of the project	
3.1.1			Explicit Knowledge		How good was the company's documented product knowledge i.e. fictional design, data pack and specifications	
3.1.2			Tacit Knowledge		How good was the people of the company's product knowledge	
3,2			Management of Knowledge		Rate the level of maturity of the company's technical knowledge management process	
3,3		Customer Decision Making				
3,4		Enterprise Decision Making			Rate the level of good vs bad decisions by the technical team of the company	
4	Company Culture					
4,1		Innovation culture			What level of contribution to the project success can be related back to the innovation culture practiced by the company's technical function	
4,2		Learning culture			What level of contribution to the project success can be related back to the learning culture practiced by the company's technical function	
4,3		Empowerment culture			What level of contribution to the project success can be related back to the empowerment culture practiced by the company's technical function	
4,4		Corporate or forced culture			What level of contribution to the project success can be related back to the corporate culture through the LCM process practiced by the company's technical function	

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Research Questionnaire						
Enablers				Executables		
Human Interaction Domain				Enterprise Domain		
				Strategic Direction and Fit	Tactical Agility, Innovation and Competitiveness	Operational Fitness and Efficiency
1	Leadership					
1,1		Macro Leadership Style		Which of the following were the company's strategic leadership style prevalent during the project execution a. Provide the creative spark of energy b. Puts the pedal to the metal to accelerate along the exponential growth path c. Reducing chaos and steadying the pace d. Use the crisis of the stark threat of extinction to provide the impetus to the change process e. Strategic orientation moves from growth to maintenance to value realisation		
1,2		Innovative use of Influencing Model		Was pro-active influencing used during the project execution by the senior management	Was pro-active influencing used during the project execution by the project management	Was pro-active influencing used during the production process by the operations management
1,3		Micro leadership for one on one/many		What was the contribution of the senior management's relationships towards the success of the project	What was the program management's relationships contribution towards the success of the project	What was the operations management's relationships contribution towards the success of the project
2	Use of Relationships in Business					
2,1		List of potential success events			Were there formal program meetings held	Were production readiness audits performed
2,2		Personnel misalignment with customers		How well did the company's senior management get on with the customer's senior management	How well did the project team get on with the customer's project team	How well did the operational / quality team get along with the customer's quality team
2,3		Belief System Alignment		Which of the following areas did the company's senior management not see eye to eye with the customer's senior management a. Acceptable response to a request b. Understanding of a problem or issue c. The way they thought about an issue d. The way they felt about an issue	Which of the following areas did the company's project team not see eye to eye with the customer a. Acceptable response to a request b. Understanding of a problem or issue c. The way they thought about an issue d. The way they felt about an issue	Which of the following areas did the company's operational and quality teams not see eye to eye with the customer a. Acceptable response to a request b. Understanding of a problem or issue c. The way they thought about an issue d. The way they felt about an issue
3	Applying Wisdom					
3,1		State of Knowledge			Rate the effect of the company's contract knowledge on the success of the project	
3.1.1			Explicit Knowledge		How good was the company's documented contractual knowledge i.e. formal contractual adherence history	
3.1.2			Tacit Knowledge		How good was the people of the company's contractual knowledge	
3,2			Management of Knowledge		Rate the level of maturity of the company's project knowledge management process	
3,3		Customer Decision Making				
3,4		Enterprise Decision Making		Rate the level of good vs bad decisions by the senior management of the company	Rate the level of good vs bad decisions by the project team of the company	Rate the level of good vs bad decisions by the operational team of the company
4	Company Culture					
4,1		Innovation culture			What level of contribution to the project success can be related back to the innovation culture practiced the company's project function	What level of contribution to the project success can be related back to the innovation culture practiced the company's operational function
4,2		Learning culture			What level of contribution to the project success can be related back to the learning culture practiced the company's project function	What level of contribution to the project success can be related back to the learning culture practiced the company's operational function
4,3		Empowerment culture			What level of contribution to the project success can be related back to the empowerment culture practiced the company's project function	What level of contribution to the project success can be related back to the empowerment culture practiced the company's operational function
4,4		Corporate or forced culture			What level of contribution to the project success can be related back to the corporate culture through the LCM process practiced the company's project function	What level of contribution to the project success can be related back to the corporate culture through the LCM process practiced the company's operational function

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Research Questionnaire						
Enablers				Executables		
Human Interaction Domain				Customer Domain		
				Business Development Strategy	Market Dynamics	Customer Value Realisation
1	Leadership					
1,1		Macro Leadership Style				
1,2		Innovative use of Influencing Model			Was pro-active influencing used during the marketing process by the company's contracting function	Was pro-active influencing used during the Quality Assurance process
1,3		Micro leadership for one on one/many			What was the contribution of the marketing function's relationship to the success of the project	What was the quality management's relationships contribution towards the success of the project
2	Use of Relationships in Business					
2,1		List of potential success events		Did a campaign strategy exist prior to contracting		
2,2		Personnel misalignment with customers		Rate the difficulty to do business with of the customer senior management	Rate the difficulty to do business with of the customer project team	Rate the difficulty to do business with of the customer's technical teams Rate the difficulty to do business with of the customer's quality teams
2,3		Belief System Alignment				
3	Applying Wisdom					
3,1		State of Knowledge			Rate the effect of the customer's contract knowledge on the success of the project	Rate the effect of the customer's technical knowledge on the success of the project
3.1.1			Explicit Knowledge		How good was the customer's documented contractual knowledge i.e. formal contractual adherence history	How good was the customer's documented product knowledge i.e. functional design, data pack and specifications
3.1.2			Tacit Knowledge		How good was the people of the customer's contractual knowledge	How good was the people of the customer's product knowledge
3,2			Management of Knowledge		Rate the level of maturity of the customer's project knowledge management process	Rate the level of maturity of the customer's technical knowledge management process
3,3		Customer Decision Making		Rate the level of good vs bad decisions by the senior management of the customer	Rate the level of good vs bad decisions by the project management of the customer	Rate the level of good vs bad decisions by the quality team of the customer
3,4		Enterprise Decision Making				Rate the level of good vs bad decisions by the quality team of the company
4	Company Culture					
4,1		Innovation culture			What level of contribution to the project success can be related back to the innovation culture practiced by the customer's technical function	What level of contribution to the project success can be related back to the innovation culture practiced by the customer's quality function
4,2		Learning culture			What level of contribution to the project success can be related back to the learning culture practiced the customer's project function	What level of contribution to the project success can be related back to the learning culture practiced by the customer's quality function
4,3		Empowerment culture				
4,4		Corporate or forced culture				

The questionnaire developed through this process resulted in the data ordered in such a

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fashion that a single case analysis can be performed as well as a specific multi-case comparison of the results against the backdrop of the resultant success of each project when a specific enterprise life cycle phase is considered.

Example Questions: A few questions are listed below to demonstrate the questionnaire design approach:

4.2.4.1 Leadership Influence on Enterprise:

Leadership (Macro Leadership Style) influence on Enterprise (Strategic Plan):

Q1.1 Which of the following was the company's strategic leadership style prevalent during the project execution?

a. Provide the creative spark of energy.

b. Put the pedal to the metal to accelerate along the exponential growth path.

c. Reduce chaos and steadying the pace.

d. Use the crisis of the severe threat of extinction to provide the impetus to the change process.

e. Move strategic orientation from growth to maintenance to value realisation.

Each of the above choices defines a different leadership role characteristic as listed in Table 3 1: The Leadership Roles as adapted from Ward (2004) and the answer can be directly related to one of these roles.

The questionnaire also identified the specific enterprise phase and case, as meta data related to the reply given. This allows the data to show the best fit of the leadership style of a specific case in a specific enterprise phase against the theoretical expectation as defined by Ward (2004).

4.2.4.2 Relationship Influence on Product

Relationship (belief system misalignment of technical teams) influence on Product (Engineering Management Plan):

Q2.4a In which of the following areas did the company's technical team not see eye to eye with the customer?

a. Acceptable response to a request

b. Understanding of the problem or the issue

c. The way they thought about the issue

d. The way they felt about the issue

e. None of the above.

Each of the above choices defines a different belief system element (section 3.3.2.4) as:

- **Behavioural** Performance, Action, Inaction – How people respond to what is happening

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- **Cognition**, Mindsets, Clarity, Perceptions – How people think of what is happening
- **Philosophy**, Core Beliefs, Personal Values – The meaning people attach to what is happening
- **Emotional** Climate, Relationship Management, Emotional Information – How people feel about what is happening

and this data will enable the author to interrogate the status of the relationship between the company and the technical team of the customer per case, phase and product (customer) to understand the underlying belief system issues.

4.2.4.3 Culture Influence on Enterprise

Culture (Corporate Culture as defined by the BAE Systems Life Cycle Management Process LCM) influence on the Enterprise Agility (Project Management Team):

Q4.4b: Did the corporate culture through the LCM process practised by the company's project function make a significant contribution to the project success?

1. Strongly Disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree.

This result manifests on a 5-point Likert (1932)[236] scale to form the basis of the statistical analysis process where combinations and permutations of data set to be analysed are possible.

The above questions are only a few examples of the eighty questions contained in the questionnaire and the data to illustrate the thought processes that were followed in the compilation of the questionnaire.

These questions, along with some more generic questions, were compiled into a list of eighty questions in a questionnaire. A series of scales were defined and applied to the questions to quantify the answers to each question as well as to compare the results with one another. This Generic Questionnaire is included as Appendix A.

[236] Likert, R. (1932) *A Technique for the Measurement of Attitudes.* Archives of Psychology: pp. 1-55.

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4.3 Introduction to the Case Study

The company where the case studies occurred has been in the military vehicle design, production and support business since early 1960's. The product range of an installed fleet includes main battle tanks, mobile artillery vehicles, armour combat vehicles, infantry fighting vehicles, protected battle taxi's, protected patrol vehicles, support vehicles as well as special security vehicles. This company's products have also been sold worldwide including Africa, North America, Europe (North, East and South), Middle East, Asia and Australia. During the period of review, the company was owned by the international military supplier enterprise BAE Systems. The three vehicles represented in the case study are the RG32, a protected patrol vehicle designed and sold to the Swedish and Finnish Armed Forces, the Samil logistic truck range where more than 10 000 were in service in South Africa and a protected battle taxi represented by the RG31 family of vehicles sold and upgraded for the US Armed Forces as the MRAP solution.

The specific case study is based on the engineer to order acquisition process as defined in chapter three and practised by the company under review. In addition, the specific case study is limited to the events in one organisation to demonstrate the effect and not to deliver absolute proof of specific phenomena. As seen from the literature studies the roadmap is very dependent on the life cycles of the product as well as the enterprise. Specific sub-cases were therefore defined to cover the development, production as well as support in the product life cycle. In designing the questionnaire, a specific enterprise life cycle status identifier was always included. In this way, the case study results can also be shown against these life cycles.

When observed from the customer viewpoint the cases were also chosen to include the USA, European and Local customers always reflecting a specific project that was executed to completion.

As hindsight always results in perfect vision, the sub-cases chosen were defined against a known successful outcome of each one. Their successful outcome was rated on a Likert scale of 1 to 6 where 1 sets out the worst outcome and 6 the best result. If one combines the outcome indications for financial results as well as customer satisfaction, one ends up with a success rating per project. This is defined in table 4-5 below:

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Table 4-5: Summary of Case Studies

Case no:	*Project Name*	*Description*	*Customer*	*Product Life Cycle*	*Enterprise Life Cycle*	*Specific Attributes*	*Financial Outcome*	*Customer Satisfaction*	*Success Rating*
1	RG 32 Development	Develop of new vehicle against a specific user requirement	Europe	Development	Growth	New Customer and New Product. User very satisfied with outcome	Medium	Very High	4
2	RG 32 Production Batch 1&2	Production of first two batches of vehicles	Europe	Production	Maturity	Production runs resulted in new level of quality demand for enterprise	Low	Medium	3
3	RG 32 Production Batch 3&4	Production of final two batches of vehicles	Europe	Production	Decline	Quality expectation gap grew out of control resulting in "Pain Plan" by customer	Very Low	Very Low	1
4	B Vehicle Support	Support of ageing B vehicle fleet for the South African Army	South Africa	Support	Maturity	Need to support local customer with low budget	Low	Low	2
5	RG 31 MRAP Production	Supply of Urgent Operational Requirement	USA	Production	Growth	Urgent Operational Need in Iraq to save lives	High	Very High	5
6	RG 31 MRAP Upgrade	Midlife Upgrade of the MRAP fleet returning form Theatre	USA	Support	Maturity	Re-use of vehicles as part of USA army inventory	Very High	Very High	6

The cases listed above span the life cycle of the enterprise from growth through to maturity and finally decline. It is also set against the backdrop of the USA and NATO forces' activities in Iraq and Afghanistan where both the RG 31 and RG 32 were successfully deployed by the various military forces.

4.3.1 Case 1: RG 32 Development (2004 - 2005)

The development of the RG 32 started as an evolutionary development process from a previous inferior design obtained through the acquisition and amalgamation of companies. A specific successful marketing campaign resulted in a complete design to order project with the Swedish government procurement agency. This development was performed against a specific user specification and resulted in an entirely new vehicle definition.

Within a two-year period, the team concluded the development process to the point where the senior project officer wrote a poem to thank the development team in Swedish, composed a tune for it and promptly sang it in the design review meeting. This was the highlight of the entire program.

This project was conducted in the growth phase of the company.

In summary, a lot of Interactive Events happened with the relationship between the customer and the supplier teams. The results of the survey should, therefore, confirm this insight. The project's customer satisfaction is rated very high. As this was a development contract, the financial outcome was quite normal. The economic factor is rated as medium. Together the success status of the project is rated at 4 out of a possible 6 on the Success Rating.

4.3.2 Case 2: RG 32 Production Batch 1&2 (2007 - 2008)

The next project in the RG 32 program was the production of two batches of 100 vehicles each. During this time, the project leadership was moved to a program manager who brought his own value set to bear on proceedings. This changed the frequency of the Interactive Events between the customer and the company teams as an observed example.

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This project was conducted mainly in the mature phase of the company.

From the onset, it was evident that an expectation gap existed regarding the quality requirements of the Swedish government procurement agency and the supply of goods by the South African based supply chain and its production capability. This culminated in a series of rework activities within the customer environment.

After the first 100 vehicles, an extensive action was launched by the company, and they were successful in closing this expectation gap. This made the successful delivery of the second batch of vehicles possible.

The customer satisfaction rating is set at medium and due to the extensive rework in the customer environment; the financial outcome is rated as low as well. This results in an overall success rating of only 3 out of a possible 6 on the Success Rating.

4.3.3 Case 3: RG 32 Production Batch 3&4 (2010 - 2013)

After a production gap of more than one year, two new batches of vehicle orders were concluded with the customer. These vehicles were needed for urgent use in Afghanistan.

In this process, the customer program team changed as well, which resulted in a new dynamic interaction and relationship between the customer and the company teams. This result was that very few Interactive Events were performed.

Due to the discontinuity of the supply chain and the production of batches 1&2 and 3&4 the quality level of supply again dropped. This annoyed the customer and caused a lot of negative Interactive Events. Like a self-fulfilling prophecy, the vehicles were also very late in delivery, and this caused high-level interaction between the customer general staff and the company's corporate headquarters in the USA with the resultant pressure on the company to perform.

The customer decided to apply a "pain plan" whereby all items were severely scrutinised in South Africa by an expert quality team from Sweden. This again caused a downward spiral of the high cost of rework, late deliveries, etc. The customer was not satisfied, and this rating is set very low.

Due to the additional cost indicated above, the financial outcome was also rated at very low, resulting in a very poor overall success (failure) rating of 1 out of a possible 6 on the Success Rating.

To add insult to injury, this project was conducted in the decline phase of the company.

4.3.4 Case 4: B Vehicle Fleet Support (2005 - 2014)

The South African customer purchased a fleet of logistic trucks in the previous century and needed to keep up the maintenance on them as the replacement programs were not funded.

The company set up a wide range of support centres throughout the country close to the user bases to support these ageing vehicles and conducted the maintenance business at a very low-cost base. In the scenario of low funding and high demand due to the ageing fleet, the company did quite well to hold this program together.

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As can be seen, this project is run through all the phases of the company.

In summary, the customer satisfaction rating was low, and the financial outcome also low, which results in an overall success rating of 2 out of a possible 6 on the Success Rating.

4.3.5 Case 5: RG 31 MRAP Initial Production (2007)

During the Iraq war, the USA realised that their Humvee unarmoured fleet of vehicles was not capable of withstanding the Improvised Explosive Devices (IED's) and that they needed an urgent solution.

One of the solutions they decided on was the RG 31 Mine Protected Vehicle design owned by the company being researched. The company was challenged to produce circa 150 vehicles within a nine-month period as this was an urgent purchase program from the USA. It took on this challenge and proceeded to produce the vehicles successfully on time.

A second significant weapon system supply conglomerate in Canada had been appointed as the agent to supply the RG 31 before, and they took on the role of system supplier for this opportunity. This was a small blessing in disguise as:

The Canadians effectively provided a buffer between the very volatile USA procurement and the South African company.

The South African company could focus on getting the job done in time.

The customer was in the middle of a war and due to the practical approach this situation necessitated, nit-picking quality demands were not made by both the USA and the Canadian Conglomerate which obviously suited the intrinsic quality capability of the South African supply chain and the company being researched.

The products were built in time, shipped and deployed, where it saved a lot of USA soldiers' lives. The customer was delighted with the project outcome. This project was performed in the late growth phase of the company.

The focus of the USA was on functionality and time, and not on cost, which resulted in a financially favourable outcome of the program. This economic factor is rated as high.

Although this study only focusses on the start-up project of the MRAP program, many more vehicles were built and delivered to the customer in the subsequent phases. The overall success rating is 5 out of a possible 6 on the Success Rating.

4.3.6 Case 6: RG 31 MRAP Upgrade (2010 - 2012)

As indicated above more than a thousand RG 31 MRAP vehicles were built for the USA army and deployed in Iraq and Afghanistan where they performed very well. This resulted in the decision of the USA to keep this fleet of RG 31 MRAP vehicles and to perform a midlife upgrade program on them before they were shipped back to the USA.

This project was conducted in the mature and early decline phases of the company.

By this time, the USA customer was delighted with the RG 31 vehicle's performance, and this remains rated as very high.

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The company was contracted to deliver extensive upgrade kits for these vehicles and promptly proceeded to do so.

The supply of spares has a higher potential for profit than for a complete vehicle which resulted in a very lucrative project with excellent financial performance. The financial outcome is therefore rated as very high which causes the overall success rating of the project to be 6 out of a possible 6 on the Success Rating.

The cases put forward represent a variety of success and failure stories and provide some insight in the effect (positive or negative) of the human interaction on the processes.

The following chapter will specifically focus on the role of leadership, relationships, wisdom and culture on the success or failure of all the cases presented.

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4.4 The Case Study Research

As the company is of finite size, the total number of possible knowledgeable respondents identified, that worked on each project, were numbered at 143 candidates. This includes some duplication as some respondents worked on more than one project. (Pretorius, Du Preez & Louw, 2016)[237].

4.4.1 Case Study Data Collection

The questionnaire above was sent to this predetermined list of respondents, and a response was obtained from 120 of the identified potential respondents. This represents a success rate of 83% of all respondents approached. One of the respondents' questionnaire was incomplete, and it was decided to disregard this input completely so as not to bias any of the analysis results. The rest of the 119 respondents' results were summarised in an answer sheet attached as Appendix B - The List of Respondents.

The detailed questionnaire responses were reworked into a results table where each question is represented by a Column and each respondent by a Row. This summary results matrix is included as Appendix C - The Summary Answer Sheet.

According to Yin (2009), there are a variety of common sources of Case Study Data defined as:

- Direct Observations (e.g. Human actions or physical environment)
- Interviews (e.g. Open-ended conversations with the principal participants)
- Archival Records (e.g. Student records)
- Documents (e.g. Newspaper articles, letters, e-mails, reports)
- Participant Observations (e.g. Case study survey respondents)
- Physical Artefacts (e.g. Computer database)

As each answer was defined by a fixed predetermined answer set, which ranged from word choice, yes or no, and a specific Likert scale (1932) of 1 to 5, the results could be combined into one results table, included as Appendix C to this dissertation.

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[237] Pretorius, G.D.P., Du Preez, N.D & Louw, L. (2016) *An Investigation into The Contribution of Various Human Factors towards the Successful Outcome of a Complex Weapon System Acquisition Process.* SAIIE27 Proceedings, 25th – 27th of October 2016, Stonehenge, South Africa © 2016 SAIIE.

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Table 4-6: Analysis of Questionnaire Data

Analysis from the Questionnaire Data			
Enabler	**Nr**	**Description**	**Question Reference**
Leadership	1	Confirm that the the correct leadership style was used	Q0.3; Q1.1
	2	Confirm the prevalence of pro-active influencing	Q1.2a; Q1.3a; Q1.4a; Q1.5a; Q1.6a; Q1.7a; Q1.8a
Relationship	3	Confirm the contribution of the relationship factor	Q1.2b; Q1.3b; Q1.4b; Q1.5b; Q1.6b; Q1.8b
	4	Prevalence of success events	Q2.1a; Q2.1b; Q2.1c; Q2.1d; Q2.1e; Q2.1f; Q2.1g; Q2.1h;
	5	Personnel misalignment with customers	Q2.2a; Q2.2b; Q2.2c; Q2.2d; Q2.2e
	6	Customer difficult to do business with	Q2.3a; Q2.3b; Q2.3c; Q2.3d
	7	Belief System Alignment	Q2.4a; Q2.4b; Q2.4c; Q2.4d
Wisdom	8	Enterprise's Product Knowledge	Q3.1a; Q3.1b; Q3.1c; Q3.1d;
	9	Enterprise's Contract Knowledge	Q3.2a; Q3.2b; Q3.2c; Q3.2d;
	10	Customer's Project Knowledge	Q3.3a; Q3.3b; Q3.3c; Q3.3d;
	11	Customer's Technical Knowledge	Q3.4a; Q3.4b; Q3.4c; Q3.4d;
	12	Customer's Decision Making	Q3.5a; Q3.5b; Q3.5c;
	13	Company's Decision Making	Q3.6a; Q3.6b; Q3.6c; Q3.6d; Q3.6e
Culture	14	Innovation culture	Q4.1a; Q4.1b; Q4.1c; Q4.1d; Q4.1e;
	15	Learning Culture	Q4.2a; Q4.2b; Q4.2c; Q4.2d; Q4.2e;
	16	Empowerment Culture	Q4.3a; Q4.3b; Q4.3c
	17	Corporate or forced culture	Q4.4a; Q4.4b; Q4.4c
All Factors	18	All Factors contribution	2; 3; 5; 6; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17

The questionnaire was designed with specific questions related to the influence of specific sub factors on the success of the cases. Table 4-6 identifies and relates each question to the four enabler factors of leadership, relationship, wisdom and culture.

4.4.2 The Case Study Statistical Data Analysis

The analysis was done in the following sequence:

- All Cases viewed together:
    - Leadership factors contribute to success in a graphical analysis
    - A statistical analysis of the combination of Relationship, Wisdom and Culture viewed together
    - A statistical analysis of the Relationship factors contribute to success
    - A statistical analysis of the Wisdom factors contribute to success
    - A statistical analysis of the Culture factors contribute to success.
- This analysis was repeated for the following Enterprise Phases:

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- Growth Phase
- Mature Phase
- Turn Around Phase.

- The analysis was again repeated for specific products and customers:
  - RG 32 (Customer is Sweden)
  - RG 31 (Customer is the USA).
- A more detail analysis was conducted on the breakdown of the relationship factor detail, to understand the underlying factors driving the Relationship Framework presented in section 3.3.2.

The detailed statistical analysis as listed above is presented as Appendix D to this dissertation.

In the case where the data is presented in the Likert scale format, the following statistical analytic approach is used. The effect of relationship, wisdom and culture factors are thus analysed to define the most influential factor on the success of the projects. The steps followed are:

4.4.2.1 The Initial Regression Model

The first step in the analysis involves the compilation of the influence of the relevant questions on the possible outcome of the cases defined in the "generic" regression model below:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q1 + \beta_2 Q2 + \beta_3 Q3 \ldots\ldots\ldots\ldots. + \beta_n Qn$$

where:

$y_{ProjectSuccess}$ = Project Success Rating from 1 to 6

β_0= Correction factor

β_1= Contribution factor related to question 1

β_n= Contribution factor related to question n

Using the R software (2014),[238] one can test for the validity of the Gauss-Markov Assumptions to define that the Ordinary Least Squares (OLS) regression is reliable:

4.4.2.2 Multicollinearity

The next step is to test the data for Multicollinearity.

The Gauss-Markov assumptions state that there must be low to no multi- collinearity

[238] The R Foundation (2014) *The R Project for Statistical Computing.* Available at: https://www.r-project.org [Accessed Jan 2015].

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between the independent variables of the model. The underlying problem is multicollinearity results in unstable parameter estimates which make it very difficult to assess the effect of independent variables on dependent variables.

4.4.2.3 Heteroscedasticity

The test for Homo or Heteroscedasticity is performed next. Homoscedasticity describes a situation in which the error term (that is, the "noise" or random disturbance in the relationship between the independent variables and the dependent variable) is the same across all values of the independent variables.

The revised model with no multicollinearity is now tested for Heteroscedasticity. Heteroscedasticity is tested on the revised model using the Breusch-Pagan test, with the below hypothesis:

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we ran the test and the results are shown below:

```
> bptest(Relationships)

        studentized Breusch-Pagan test

data:  Relationships
BP = 10.541, df = 12, p-value = 0.5686
```

The p-value of the Breusch-Pagan test, in this case, is 0.5685 which is significantly higher than 0.05. We can, therefore, not reject the H_0 and assume the model is homoscedastic.

4.4.2.4 Stochastic Regressors

The Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms. Correlation of regressors to the residual should be close to if not equal to zero.

4.4.2.5 Hypothesis Test

The Hypothesis Test is then carried out which results in the ranked significance of the factors influencing the outcome with a 95% level of certainty. For any hypothesis test, the decision rule is:

If p-value < 0.05 of significance (alpha); then null hypothesis is rejected.

If p-value > 0.05 of significance (alpha); then we fail to reject the null hypothesis.

This presents the outcome of the research question posed as: **What are these specific enabling factors contributing to success?**

4.4.3 The Graphical Analysis

In the cases where the data collection resulted in a predetermined intelligent choice or yes

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or no answer, the occurrences of these results against a preselected data set were used as an indicator in a graphical format.

4.5 Case Study Results: Enabler Factor Effect on Success

4.5.1 Leadership Factors contributing to Success: Results

The questionnaire questions set up as a specific indication or yes or no answers will simply be analysed by means of graphic results. This is done to observe prevalence and effect of the leadership styles on the success of the projects in the various phases of the enterprise.

4.5.1.1 Leadership Style Factor: All Cases

The confirmation of leadership style practised during the different enterprise phases as defined by Ward (2004) and shown in figure 4-3 below resulted in a close correlation overall.

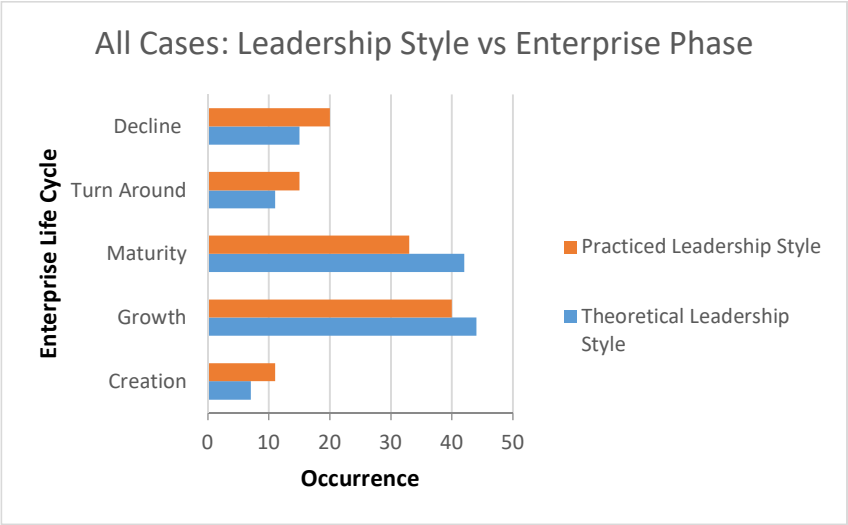

Figure 4-3: All Cases: Mapping Leadership Style on the Enterprise Phase

The occurrence of the different leadership styles was obtained by the analysis of the answers of question 1.1 as defined in section 4.2.4.1 per enterprise phase and comparing the results with the expected or theoretical leadership style per enterprise phase.

Considering all the cases together results in a reasonable resemblance of alignment between the required and the observed leadership styles.

Leadership Factors: RG 32

The RG 32 cases (1, 2 and 3) were all challenged in its execution by the customer and required specific leadership focus in both the development and the two production phases.

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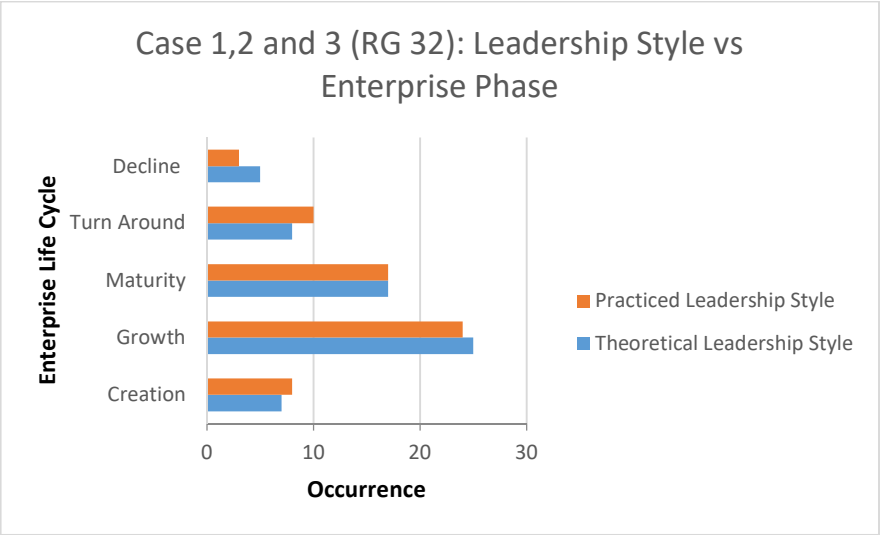

Figure 4-4: Case 1, 2 and 3 (RG 32): Mapping Leadership Style on the Enterprise Phase

The almost perfect alignment between the theoretical enterprise phase and the observed leadership style as defined in figure 4-4, can be explained by this excellent management focus during the execution of the RG 32 project:

Leadership Factors: B Vehicle Support

The B vehicle support contract was a project being executed in the background of the company's activities and as such only attracted leadership focus on an infrequent basis.

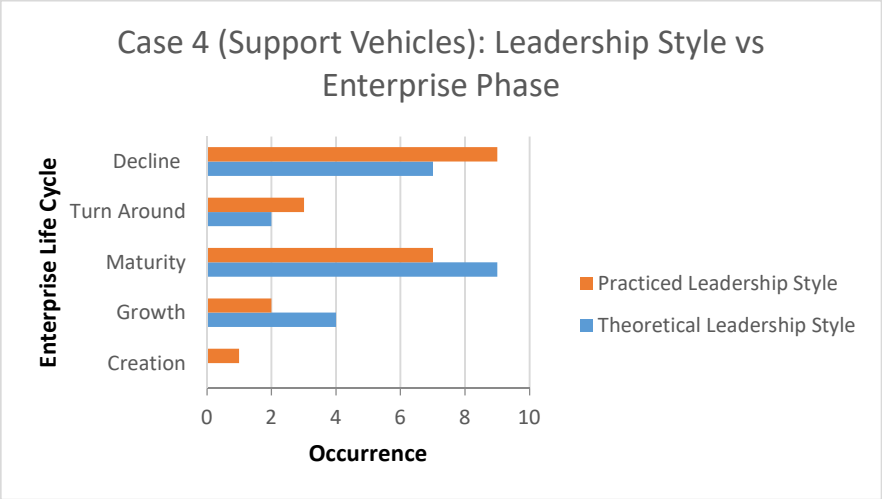

Figure 4-5: Case 4 (Support Vehicles): Mapping Leadership Style on the Enterprise Phase

The observed result defined in figure 4-5 shows that there is not a good relationship between the theory and the infrequent application.

Leadership Factors: RG 31

The RG 31 (cases 5 and 6) resulted in a stress-free high return business also not requiring a lot of leadership focus at all. This effectively lulled the company into a less stress-free environment also resulting in an observed mismatch between the theory and the practical

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application of leadership.

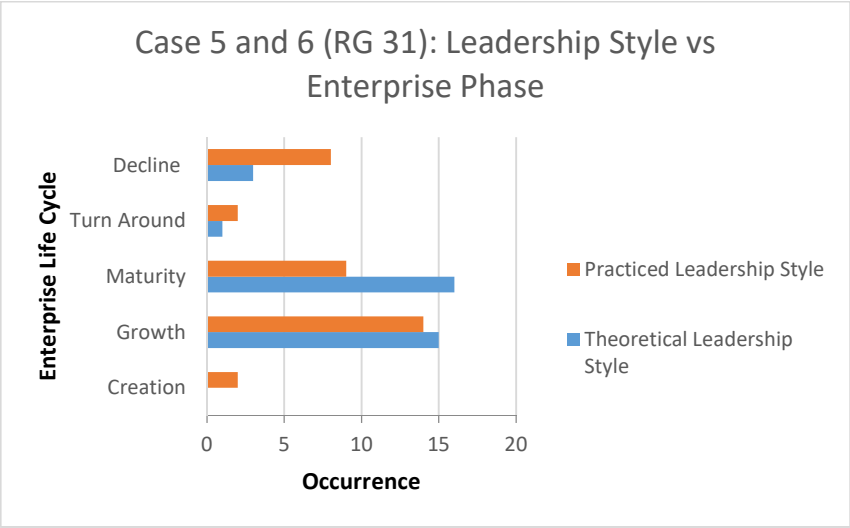

Figure 4-6: Case 5 and 6 (RG 31): Mapping Leadership Style on the Enterprise Phase

The observed result defined in figure 4-6 shows that there is not a good relationship between the theory and the infrequent application.

4.5.1.2 Leadership Factor: Prevalence of Proactive Influencing

The data related to the questions about the leadership employing proactive influencing results are indicated in table 4-7 and figure 4-7 below.

Table 4-7: Leadership Proactive Influencing Factor

Cases	Engineering	Procurement	Senior Man	Project Man	Ops Man	Marketing	Quality
Case 1 RG 32 Dev	17	9	15	15	6	7	10
Case 2 RG 32 Prod 1	15	4	11	13	5	7	10
Case 3 RG 32 Prod 2	18	5	12	13	6	8	15
Case 4 B Vehicle Fleet Support	12	5	11	15	9	9	11
Case 5 RG 31 MRAP Prod	15	8	14	14	11	10	11
Case 6 RG 31 MRAP Support	15	12	13	17	14	6	11
All Cases	92	43	76	87	43	47	68
	Q1.2a	Q1.3a	Q1.4a	Q1.5a	Q1.6a	Q1.7a	Q1.8a

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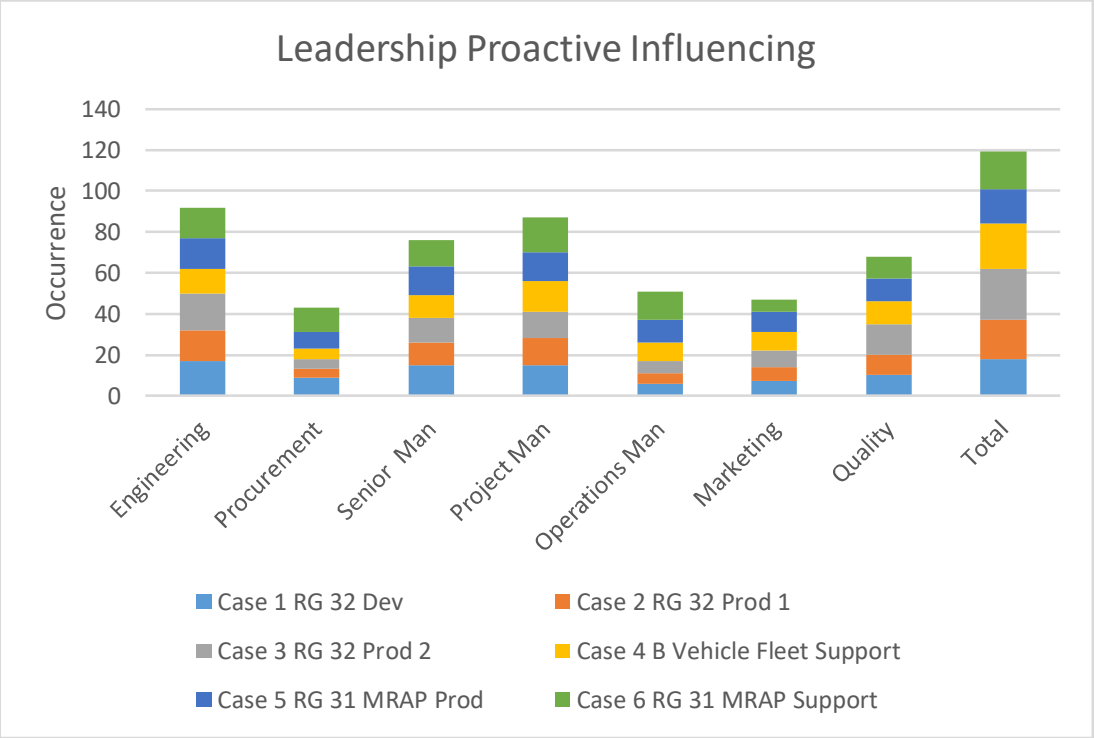

Figure 4-7: Leadership Proactive Influencing: All Cases

The following observations can be made from this analysis:

- The occurrence of premeditated influencing is very high at 78% from engineering, 73% by project management and 64% by senior management.
- All three functions of engineering, project and senior management report an equal spread of the use of influencing in all the cases under review, which indicates a general trend in the company.
- The use of proactive influence by operations and quality is, as expected, relative to the other functions.
- The procurement and marketing functions show the lowest level of the utilisation of the influencing factor specifically in the cases of the RG32 project. This may indicate a systemic shortcoming that should be investigated further.

4.5.1.3 Summary: Leadership Contribution

The take away from this analysis is the remarkable alignment of the leadership style required versus practised as observed in the cases 1, 2 and 3 i.e. the RG 32 program delivered to Sweden, where the prevalence of a very demanding customer required continuous interaction between the company leadership and the execution team. This, however, did not lead to success as the last RG 32, Case 3, is rated the lowest in terms of success.

The second take away is the high prevalence of the use of proactive influencing by engineering and project management and the relatively low use of this factor by the marketing and procurement functions.

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From this data analysis, one can therefore not state that the theoretical (true) leadership style or proactive influencing had any significant bearing on the success of a project. It seems that these factors are deployed to prevent failure rather than enhance success.

4.5.2 Relationship, Culture and Wisdom

The final combined regression model after the application of the statistical analysis of relationship, culture and wisdom is:

$$y_{ProjectSuccess} = \beta_0 + 0.394616Q2.2b - 0.461729Q2.2d - 0.443415Q2.3d + 0.285867Q3.2c + 0.541832Q3.5b$$

Therefore, the strongest factors that contribute to success or failure relate to the following questions, summarised in table 4-8 and figure 4-8:

Table 4-8: Overall Contribution Factors

Question	Question Nr	Contribution Value	Question Topic
The customer's project management made very good decisions	3.5b	0,54	Wisdom: Customer Project Team
The operational / quality team got along very well with the customer's quality team	2.2d	-0,46	Relationship: Customer Quality Team
It is very difficulty to do business with the customer's quality team	2.3d	-0,44	Relationship: Customer Quality Team
The company's senior management got on very well with the customer's senior management	2.2b	0,39	Relationship: Customer Senior Management
The people of the company knew the contract well	3.2c	0,29	Wisdom: Company Project Team

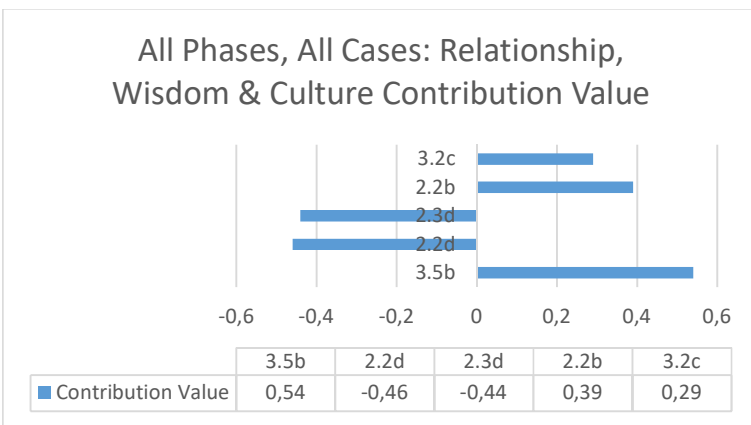

Figure 4-8: All Phases, All Cases: Overall Contribution Factors

4.5.2.1 Summary: Relationship, Culture and Wisdom Contribution

The results indicate that significant contributors to the success or failure of the projects were two factors based on wisdom of the customer and the company's project teams, as well as a very negative contribution from the relationship with the customer quality teams and a positive relationship between the customer and company's senior management. No significant contribution towards a successful outcome was found in the culture factor by any of the participants.

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4.5.3 Relationship Factors Only

The final model, after Gauss Markov (GM) assumptions for relationships, are:

$$y_{ProjectSuccess} = 3.0068 + 0.35705Q2.2b + 0.32719Q2.2c - 0.34272Q2.2d - 0.42618Q2.3d$$

Therefore, the strongest factors that contribute to success or failure relates to the following questions defined in table 4-9 and figure 4-9:

Table 4-9: Relationship Contribution Factors

Question	Question Nr	Contribution Value	Question Topic
The company's senior management got on very well with the customer's senior management	2.2b	0,36	Relationship: Customer Senior Management
The project team team got on very well with the customer's project team	2.2c	0,33	Relationship: Project Team
The operational / quality team got along very well with the customer's quality team	2.2d	-0,34	Relationship: Customer Quality Team
It is very difficulty to do business with the customer's quality team	2.3d	-0,43	Relationship: Customer Senior Management

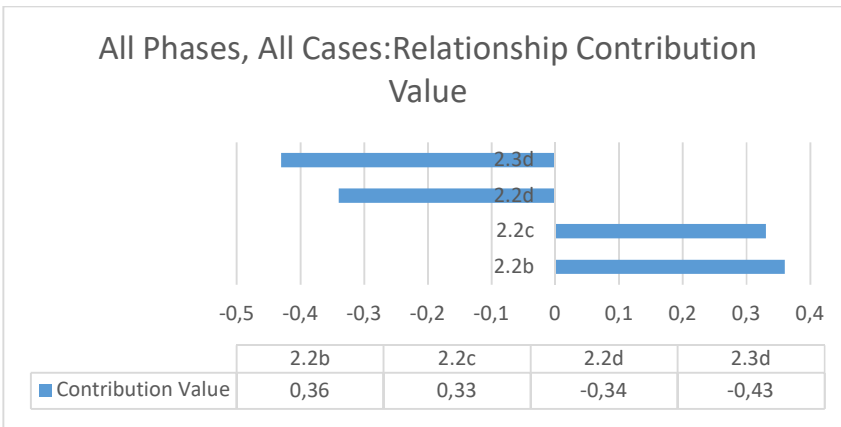

Figure 4-9: All Phases, All Cases Relationship Contribution Factors

The results indicate that the most dominant factors are based on a positive relationship with the project and senior management and a negative contribution from the relationship between the operational team and the customer quality team. It also indicates that the customer quality team were tough to deal with.

4.5.4 Wisdom Factors Only

The final regression model after GM Assumptions for wisdom is:

$$y_{ProjectSuccess} = 0.44434Q3.1b - 0.54046Q3.4a + 0.42356Q3.4b + 0.60456Q3.5b$$

As depicted in table 4-10 and figure 4-10 below the respondents agree on explicit product knowledge, as both the customer and the company contributed significantly towards the success of the case.

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Table 4-10: Wisdom Contribution Factors

Question	Question Nr	Contribution Value	Question Topic
The company's documented product knowledge i.e. functional design, data pack and specifications were well defined	3.1b	0,44	Wisdom: Company's Project Team Expicit Knowledge
The customer's product knowledge contributed significantly towards the success of the project	3.4a	-0,54	Wisdom: Customer Project Team Tacit Knowledge
The customer's documented product knowledge i.e. functional design, data pack and specifications were well defined	3.4b	0,42	Wisdom: Customer Project Team Expicit Knowledge
The customer's project management made very good decisions	3.5b	0,6	Wisdom: Customer Project Team Decisions

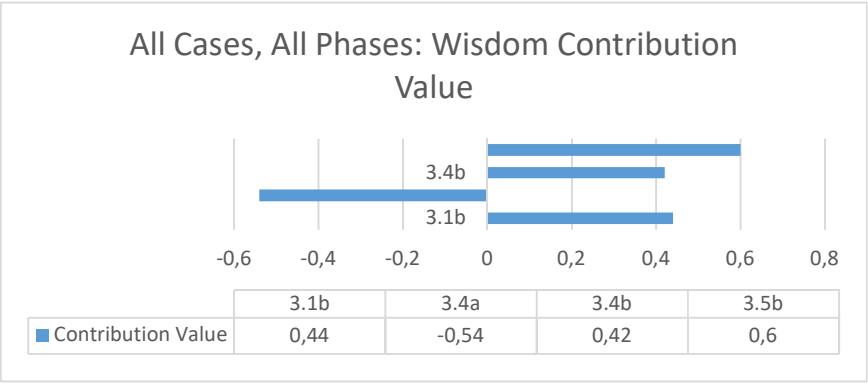

Figure 4-10: All Phases, All Cases Wisdom Contribution Factors

The study also shows that the customer's tacit knowledge of the products contributed towards the failure of the project. This will be further analysed by segregating the RG 32 and RG 31 data. Important to note that in the case of the RG 32, the company lost the design engineer and were at the mercy of the customer's engineers tacit knowledge.

The study also shows that significant contribution came from the customer's project decision making. The further analysis will demonstrate the origin of these values.

4.5.5 Culture Factors Only

Hypothesis testing was done by comparing the p-values to significance level, set at 95% (α=0.05). Any regressor with a p-value less than 0.05 is significant for the regression model. No regressor, however, played a major role in the 95% confidence interval in the success of a project, and the hypothesis test is rejected. Even at p-value set at 90% (α=0.10), no contribution passed the hypothesis test.

One can, therefore, conclude that the culture of the organisation did not significantly influence the success of the projects under study.

4.5.6 Case Study Initial Results Summary

The following initial overall results are in evidence:

- **Leadership:** From this data analysis, one cannot state that the theoretical (true)

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leadership style or proactive influencing had any significant bearing on the success of a project. It seems that these factors are deployed to prevent failure rather than enhance success.

- **Relationship:** The most dominant factors are based on a positive relationship with the project and senior management and a negative contribution from the relationship between the operational team and the customer quality team. These specific contributions were all within the company's control with the senior and project management having a positive effect and the quality and operational teams a negative impact.
- **Wisdom:** The study also shows that a significant contribution came from the customer's project decision making, explicit, and tacit product knowledge. The company's explicit knowledge of the product also contributed.
- **Culture:** The culture of the organisation did not significantly influence the success of the projects under study.

From the above, of all the factors controlled by the company, the relationship factor is the dominant contributor to success or prevention of failure.

The effect of the specific enterprise phase, specific product/customer and detail of the relationship factors will be investigated next. To further this aim, the statistical analysis was repeated for the Growth, Mature and Turn Around Phases.

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4.6 The Effect of the Enterprise Phase

The statistical analysis was repeated for the growth, mature and turn-around phases to investigate the effect of the specific phase of the enterprise's contribution to success.

4.6.1 Relationship

The significance of the relationship factor was determined by repeating the statistical analysis per phase of the company to identify trends in the results. The results of this analysis are defined in Table 4-11 below:

Table 4-11: Relationship Factors per Enterprise Phase

Relationship during the Start-up Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No results due to too small sample			
Relationship during the Growth Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
It is very difficulty to do business with the customer's technical team	2.3c	-0,85	Relationship: Technical
It is very difficulty to do business with the customer's quality team	2.3d	-0,9	Relationship: Quality
Relationship during the Mature Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
It is very difficulty to do business with the customer project team	2.3b	-0,57	Relationship: Project Team
The operational / quality team got along very well with the customer's quality team	2.2d	-0,71	Relationship: Quality Team
Relationship during the Turn Around Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No results due to too small sample			

All the relationship factors show a reasonably consistent level of contribution throughout the phases. However, due to the severe size and negativity of these factors indicating an influence in the failure outcome of the case, this result may be related to RG 32. This will be confirmed in the further analysis below.

4.6.2 Wisdom

The significance of the wisdom factor was determined by repeating the statistical analysis per phase of the enterprise to identify trends in the results. The results of this analysis are defined in Table 4-12 below:

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Table 4-12: Wisdom Factors per Enterprise Phase

Wisdom during the Start-up Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No results due to too small sample			

Wisdom during the Growth Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
The customer's documented contract knowledge were well defined	3.3b	-0,76	Wisdom: Customer Contract Knowledge
The customer's documented product knowledge i.e. functional design, data pack and specifications were well defined	3.4b	0,8	Wisdom: Customer Explicit Product Knowledge
The customer's senior management made very good decisions	3.5a	0,82	Wisdom: Customer Senior Management Decisions
The company's operational team made very good decisions	3.6d	0,65	Wisdom: Company Operational Team Decisions

Wisdom during the Mature Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
The company's documented product knowledge i.e. functional design, data pack and specifications were well defined	3.1b	0,89	Wisdom: Company 's explicit product knowledge
The customer's contract knowledge contributed significantly towards the success of the project	3.3a	1,05	Wisdom: The Customer' s Contract Knowledge
The people of the customer knew the product well	3.4c	-0,91	Wisdom: The Customer' s Product Knowledge
The customer's senior management made very good decisions	3.5a	0,59	Wisdom: Customer' s Senior Management Decisions
The customer's project management made very good decisions	3.5b	0,8	Wisdom: Customer' s Project Management Decisions
The customer's quality team made very good decisions	3.5c	1,1	Wisdom: Customer' s Quality Team Decisions

Wisdom during the Turn Around Phase of the Enterprise			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No results due to too small sample			

In this analysis, the negative influence of the customer contract knowledge in the growth phase as well as the customer product knowledge in the mature phase may well be related to the RG 32 project as well. The rest of the wisdom factors became even more dominant in the mature phase and may be linked to the RG 31 project that was dominated by success in this period.

4.6.3 Organisational Culture

The significance of the culture factor was determined by repeating the statistical analysis per phase of the enterprise to identify trends in the results. The results of this analysis are defined in Table 4-13 below:

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Table 4-13: Culture Factors per Enterprise Phase

Culture during the Start-up Phase of the Enterprise			
Question	Question Nr	Contribution Value	Question Topic
No results due to too small sample			
Culture during the Growth Phase of the Enterprise			
Question	Question Nr	Contribution Value	Question Topic
No Significant Factor			
Culture during the Mature Phase of the Enterprise			
Question	Question Nr	Contribution Value	Question Topic
No Significant Factor			
Culture during the Turn Around Phase of the Enterprise			
Question	Question Nr	Contribution Value	Question Topic
No results due to too small sample			

As in the previous results on the contribution of the culture factor, no signs were detected in the data set during both the growth and the mature phases.

4.6.4 Conclusion on the effect of the Enterprise Phase

The following results of the effect of the enterprise phase are in evidence:

4.6.4.1 Growth Phase

- **Relationship:** The relationship factors show a reasonably consistent level of contribution, between 0.85 and 0.9, throughout the growth phase. However, due to the severe size and negativity of the contribution, it is assumed that the influence happened in the failure outcome of the RG 32 cases.
- **Wisdom:** the negative influence of the customer contract knowledge in the growth phase as well as the customer product knowledge in the mature phase are also related to the RG 32 project.
- **Culture:** No significance was detected in the data set.

4.6.4.2 Mature Phase

- **Relationship:** The negative contributions of the relationships with the project team, the operational team as well as the quality teams all indicate a relation to the RG 32 problems experienced in the first production phase (case 2).
- **Wisdom:** The rest of the wisdom factors became even more dominant in the mature phase and may be related to the RG 31 project that were dominated success in this period.
- **Culture:** No significance was detected in the data set.

From the data analysis above one cannot determine any relationship between the enterprise phases and the propensity for success or the prevention of failure.

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4.7 The Effect of a Specific Customer

The effect of the two major customers were investigated and resulted in the following:

4.7.1 RG 31 supplied to the USA

The significance of the all the factors were determined by repeating the statistical analysis for the RG 31 project to identify trends in the results. The results of this analysis are defined in table 4-14 below:

Table 4-14: Significant Factors during the RG 31 Project Execution

Relationship during the RG 31 Project			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No Significant Factor were identified			
Wisdom during the RG 31 Project			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No Significant Factor were identified			
Culture during the RG 31 Project			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No Significant Factor were identified			

This surprising result indicate that no single factor could be identified between relationship, wisdom or culture as having a major contribution to the success of the RG 31 project. It must be noted that the factors are being compared to the specific dataset used (in this case RG 31 data only) and this result simply indicates that not one factor could statistically be identified as dominant or significant in this data set.

4.7.2 RG 32 Supplied to Sweden

The significance of the all the factors were determined by repeating the statistical analysis for the RG 32 project to identify trends in the results. The results of this analysis are defined in table 4-15 below:

Table 4-15: Significant Factors during the RG 32 Project Execution

Relationship during the RG 32 Project			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
The project team team got on very well with the customer's project team	2.2c	0,47	Relationship: Project Teams
The operational / quality team got along very well with the customer's quality team	2.2d	-0,31	Relationship: Quality Teams
Wisdom during the RG 32 Project			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
The customer's senior management made very good decisions	3.5b	0,67	Wisdom: Customer Senior Management
Culture during the RG 32 Project			
Question	**Question Nr**	**Contribution Value**	**Question Topic**
No Significant Factor were identified			

The results about the wisdom factor indicate that the customer's senior management had a significant contribution to the outcome of the project. The RG 32 specific results on

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relationship show that relationships, as both a positive and a negative contribution, were identified as being significant in the project outcome and warrant even a deeper analysis to understand the root cause of the relationship contribution.

4.7.3 Conclusion

- **RG 31 to the USA:** This analysis did not identify any dominant factor, and it is assumed that both relationships and wisdom factors did contribute to the very successful project.
- **RG 32 to Sweden:** The data analysis does show a significant contribution from the relationship between the project teams of the company and the customer, a negative contribution between the quality teams (which can be related to a specific individual) and the finding that the customer's senior management decision making was a significant influence.

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4.8 Detailed RG 32 Relationship Investigation

4.8.1 The Belief System Alignment Effect

For further clarity on the contribution of the relationship factor in the execution and outcome of the RG 32 project, the relationship model was used, where the alignment of the belief systems was an indication of the soundness of the relationship. The answers to questions 2.4a, 2.4b, 2.4c and 2.4d present a clear indication of the occurrence of the four elements of the belief system as follows:

- Response
- Understanding
- Philosophy
- Emotion

It must be noted that these questions were defined in the negative form, for example, question 2.4a: *"In which of the following areas did the company's technical team not see eye to eye with the customer?"* and a high incidence in the data set presents a potential problem for the relationship.

The complete dataset results are shown to evaluate the RG 32 in relation to all the data as a visual representation in figure 4-11:

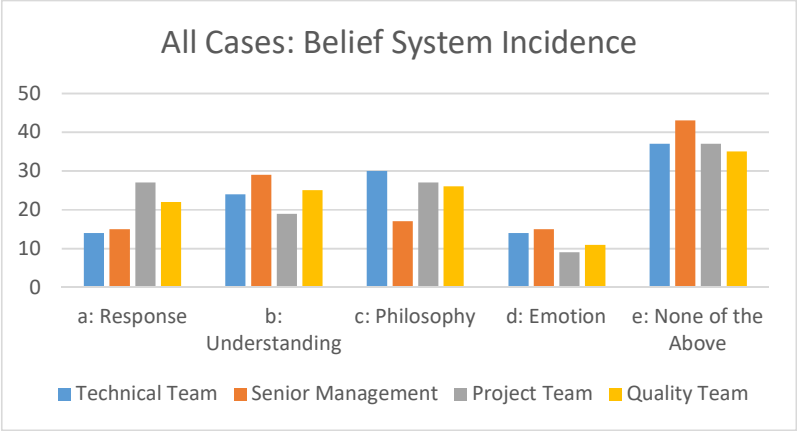

Figure 4-11: All Cases Belief System Incidence

As expected the data presents a mixed result with the emotional element is the best indicator of a successful relationship. Quite a lot of 'none of the above' answers were obtained due to the negative way the questions were presented. If no problem existed, then the expected answer will be "none of the above". The data of the RG 32 project (all cases) are presented next as figure 4-12:

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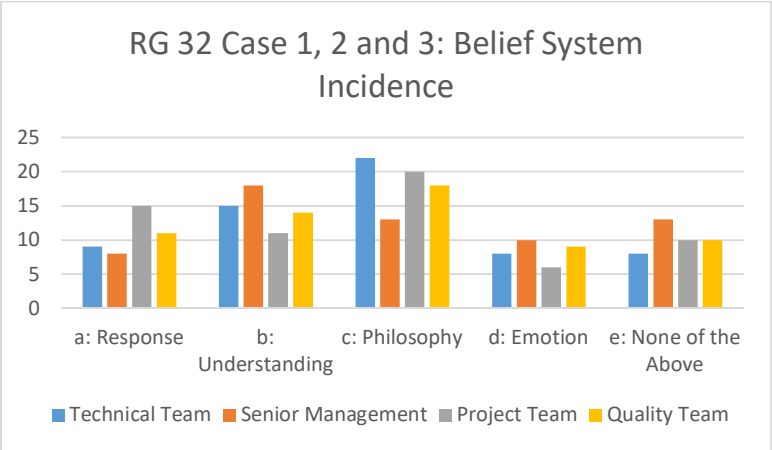

Figure 4-12: RG 32: All Cases Belief System Incidence

From this dataset, we observe a move away from "none of the above" towards philosophy as the dominant element in the potential relationship problem. The explanation of this phenomenon may be found in the difference between the South African and the Swedish cultures as this was the first contract the company entered into with the Swedish customer. It is also an indication of a possible problem with regard to relationships on the project. As defined earlier, the three RG 32 cases happened consecutively over a period of a few years and to observe the movement of these three cases as it evolved in time, it will also be presented in a following way as figures 4-13, 4-14 and 4-15 below:

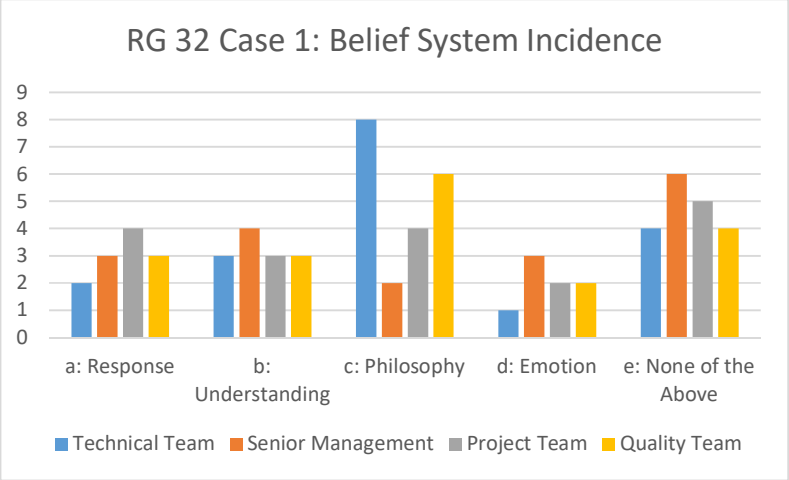

Figure 4-13: RG 32 Development: Case 1 Belief System Incidence

At the onset of the project, the following observations can be made:

a. The technical team had a difference in philosophy during the development contract.

b. The quality team also showed a smaller difference of philosophy.

c. The response, understanding and emotion elements did not demonstrate any dominance.

The next case represents the production of the first 200 vehicles where some problems existed regarding the expected quality standards and the actual quality standards delivered.

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This resulted in a lot of rework in Sweden. The supplier project manager was also changed.

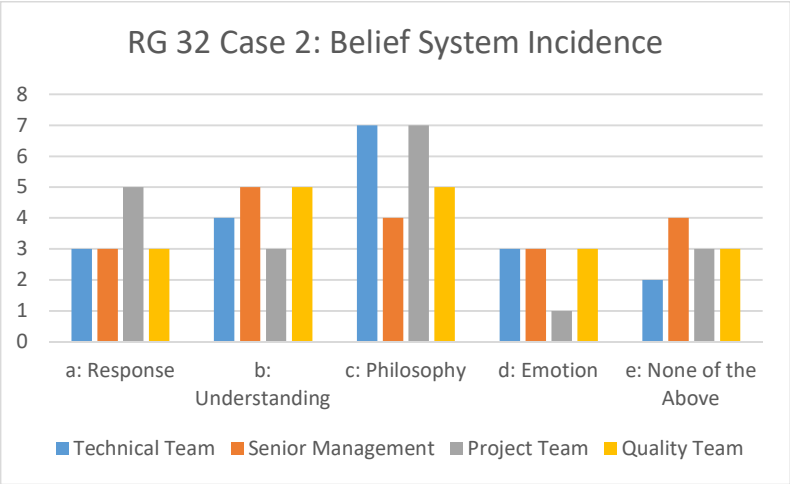

Figure 4-14: RG 32 First Production Run: Case 2 Belief System Incidence

In case 2 the following observations can be made:

a. The project team joined the technical and quality teams in showing a difference in philosophy. During this time, the program manager was replaced.

b. The senior management as well as the quality teams show an upwards movement in the lack of understanding in their respective relationships.

c. The first element of response by the project team is evident in the data.

In case 3 the next tranche of 200 vehicles was produced. As can be observed, this project went from good to bad, to worse, between cases 1, 2 and 3. In this period a new customer project manager was introduced.

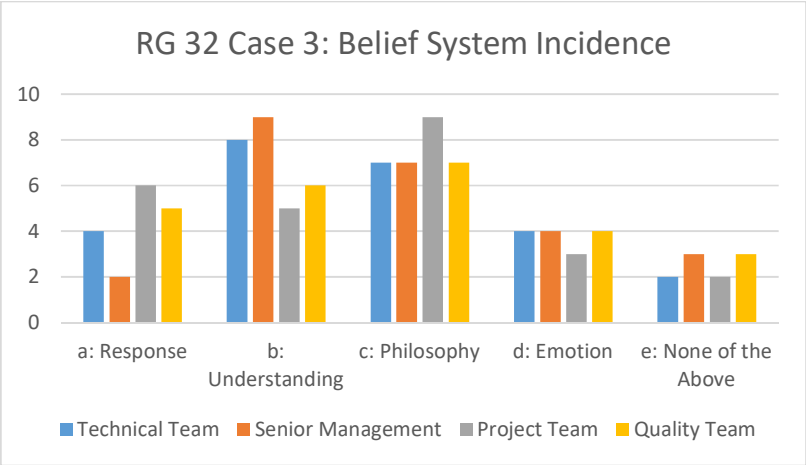

Figure 4-15: RG 32 Second Production Run: Case 3 Belief System Incidence

In the results of case 3 the following observations can be made:

a. A higher incidence of all the elements is observed as a move away from *"none of the above*" to one of the belief system elements.

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b. The project team's response increased from case 2 as a potential contributor to the relationship.

c. A real problem exists in the understanding of all teams but it is surprisingly higher in the senior management team.

d. The project team still presents a higher incidence regarding the philosophy factor and all four teams demonstrate a persistent philosophical difference between them and the Swedish customer.

4.8.2 Conclusion

From all the above one can, through the analysis of this data, explain the progressive worsening of the relationship between the company and this customer. We have observed that the deterioration of the relationships between the different teams can be traced to the observed change in their belief system elements. This demonstrated the functionality of the Relationship Framework defined in chapter 3.

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4.9 Summary of the Results

The results of the case study are summarised in tabular form in Table 4-16 below:

Table 4-16: Results of the Case Study

Enabling Factor	Case Study Results
Leadership	Close correlation between the theory of the specific leadership style against the leadership style observed
Relationship	The positive relationship with the customer's senior management and project management was observed. There was also a very negative result regarding the customer quality team's relationship with the operational team of the company contributing towards failure.
Wisdom	The contribution of explicit knowledge from both the customer and the company's teams were defined as having a positive influence on the outcome. However, when the customer's tacit knowledge became more dominant than the company's tacit knowledge it resulted in a negative influence. It also helps if the customer makes robust decisions to promote the project as a whole
Culture	No correlation between culture and company success was evident in the case studies under review

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4.10 Triangulation of the Case Study Results

Triangulation (Yin, 2009) is using simple multiple sources of data to ensure reliability, e.g. triangulating qualitative data from questionnaires and using qualitative data from semi-structured interviews and experience.

The author was inherently part of the senior management of the company being studied, and his insights will be utilised in the interpretation and confirmation of the results. Furthermore, to conclude a triangulation (Yin, 2009) of the results, interviews with the executive management were also conducted to soundboard the results documented in this chapter.

The following Table 4-17 summarises the case study outcome, compares it to the executive management opinion of the outcome and confirms it with the authors own experiences about the cases that were investigated.

Table 4-17: Triangulation of the Results

Enabling Domain	Case Study Results	Company Executive	Author
Leadership	Close correlation between the theory of the specific leadership style against the leadership style observed.	Agree with the outcome. Leadership style needs to be adapted depending on circumstances. This can create confusion since employees sometimes find the change in "character" of the leader difficult to understand.	Leadership style was constantly adapted for a specific application. The author concurs with the observation of a close correlation between the ideal and actual leadership styles as practised on RG 32.
Relationship	The positive relationship with the customer's senior and project management was observed. There was also a very negative result regarding the customer quality team's relationship with the operational team of the company contributing towards failure.	Agree with the outcome: Excellent relationships between Management and the Customer remains the single most important factor during difficult times on any contract. The value of a "good" contract is secondary. The opposite is true in terms of the respective QA teams, where pre-agreed quality standards usually ensure a successful relationship between the QA teams.	In the case of the RG 31 and early RG 32 development, the company had excellent relationships with both customers. This observation agrees with the view that good relationships at both the senior management and the program management level significantly contributed to the success of these cases. The negative contribution of the customer quality team's relationships can be identified with the RG 32 production cases as well as the B vehicle support program where both the Swedish and local embedded quality teams did not contribute towards success.

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Enabling Domain	Case Study Results	Company Executive	Author
Wisdom	The contribution of explicit knowledge with both the customer and the company's teams were defined as having a positive influence on the outcome. However, when the customer's tacit knowledge became more dominant than the company's tacit knowledge it resulted in a negative influence. It also helps if the customer makes robust decisions to promote the project as a whole	The retention of tacit knowledge on both the technical and commercial aspects of a project is a key factor, amongst others, for successful project execution.	The company and both the RG 31 and RG 32 customers had an extensive process of defining the explicit knowledge of the product. The loss of the senior design engineer on the RG 32 after development, left an imbalance of tacit know-how between the customer and the company's technical teams. This was exploited by the customer's team resulting in a negative influence towards success. The RG 31 customer, on the other hand, demonstrated very sound judgement and decision making, and this contributed towards the success of these two cases.
Culture	No correlation between culture and company success was evident in the case studies under review	Partially agree with the outcome: Company culture is usually enforced and cultivated from "above". Strong governance and policy enhance a strong culture which is needed when a project experiences greatest challenges, especially if corporate interference is at stake. Cultural differences between the company and the customer can, however, lead to friction and/or conflict and sometimes need careful management.	The underlying culture of learning and the "forced " BAE Systems corporate culture, did contribute to inherent capability and order within the company. However, there is not one significant event that the author can recall that had a direct bearing on the success of these cases. The case study observation is supported by the views of the author.

The various results and opinions defined in the table 4-17 above indicate a close correlation between the case study results, the company executive as well as the experience of the author who worked at the same company for thirty-three years. During the last decade, the author was part of the executive.

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Chapter 5
Summary, Conclusions and Recommendations

The summary, conclusions and recommendations of this research project will be reflected in this chapter.

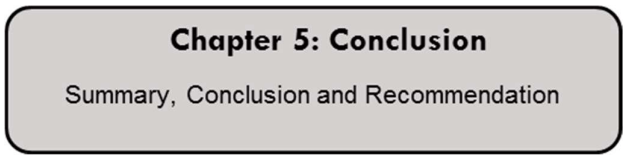

Figure 5-1: Summary, Conclusion and Recommendation

It will also describe how the research met each of its initial objectives and questions as described in chapter 1. The results found to be the study results will be critically analysed and the key contributions identified and described. Finally, recommendations will be made to take this study forward and to identify spin off research possible from this knowledge base.

5.1 Research Summary

The topic of this study is to obtain a better understanding of the catalytic effect that the human can bring to bear on the supply process of a complex system. The author's interest in this effect started from the observations and practices of performing engineering, program and strategic management roles within an organisation supplying military systems to the USA, UK, NATO and the Middle East regions through his 35-year career. This problem is defined as the consideration of a framework surrounding an interactive event shown below in figure 5-2.

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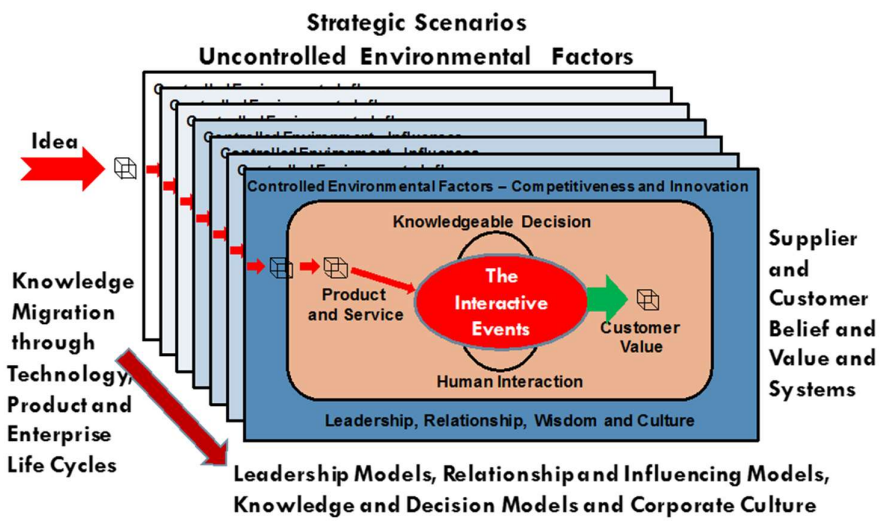

Figure 5-2: The Interactive Events

The acquisition processes, as defined by the USA Department of Defence, the UK's Ministry of Defence and the NATO Acquisition Agencies, represent an excellent example of the requirements set upon such a supply process. This research started with the exploration of the previously defined success factors and lessons learned for failed programs as experienced by the Acquisition Agencies.

It was soon realised that the supply process is all about the maturing process of the knowledge of the attributes of the system to be provided and the resultant diminishing of the technical risk during the process. The author defined a standardised method to represent knowledge and its value as experienced by the customer. This is specified in figure 5-3 below.

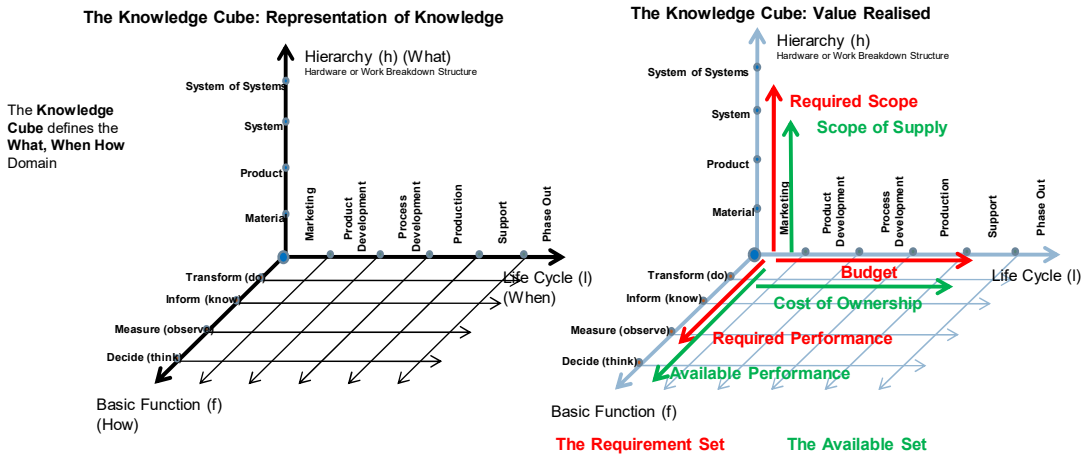

Figure 5-3: The Knowledge Cube and its Value Realised

In the search for a 'generic' supply process, the author defined a framework of executable domain processes that considers the establishment of a product and its associated knowledge, the different processes within a typical enterprise in the execution of the supply

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of the product defined, as well as all the considerations about the customer environment and the different frameworks and models that are available in this area. This supply process starts with an idea and concludes when the customer value is realised resulting in a satisfied customer. The resultant Executable Domain Framework is depicted as figure 5-4 below:

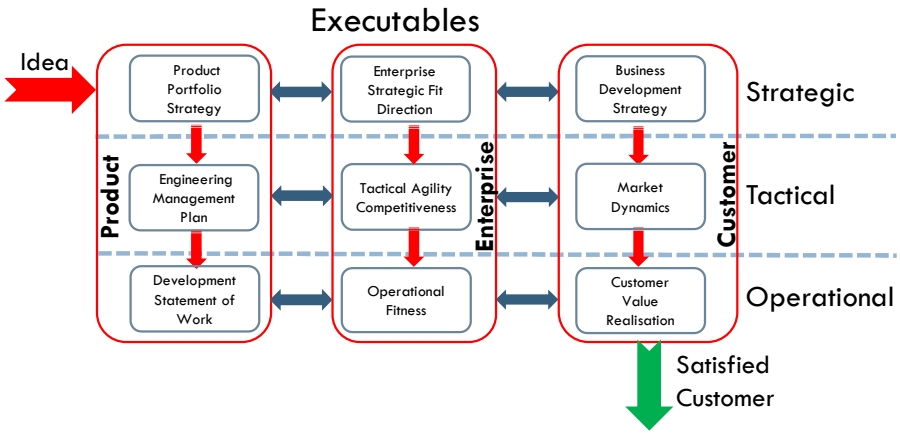

Figure 5-4: The Executable Domain

The migration of the knowledge through the executable domain was defined where it was realised that the impetus of the knowledge growth process was caused by the application of a change management process. This was represented as the knowledge migration framework, a concept conceived by the author. The application of the knowledge migration framework was tested by means of a virtual case study through the life cycles of technology, product development and enterprise evolution. The Knowledge Migration Framework is shown in figure 5-5 below:

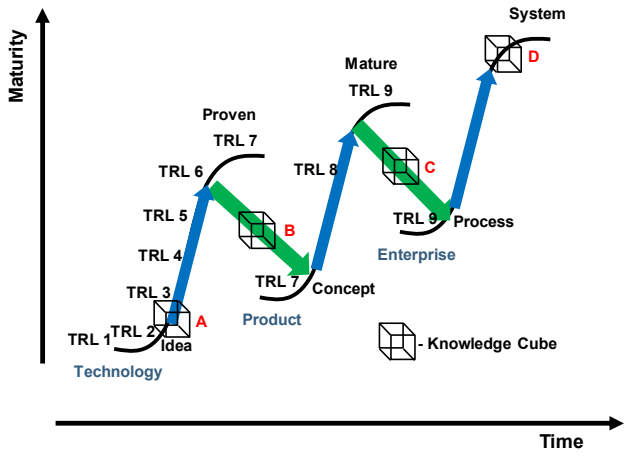

Figure 5-5: The Knowledge Migration Framework

To define all the different human factors that can possibly play a part in the execution of the supply process is virtually impossible. The author, therefore, relied on his experience and identified four human factors of interest as:

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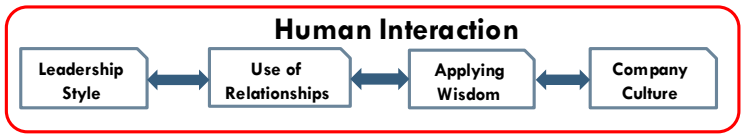
- **leadership** as demonstrated by the senior management,
- sound business **relationships** formed with the customer environment,
- **wisdom** defined as good decision making within the knowledge and experience context, and
- the corporate **culture** practised within the supply organisation.

The author also showed his interpretation of the interrelationship between these and a horde of other human factors which confirms that the selection of these four factors will automatically also consider most other human factors directly or indirectly. The human factors are depicted as figure 5-6 as the Enabler Domain below:



Enablers

- ✓ Leadership
  - Macro Leadership: Correct style for Phase of Enterprise
  - Innovative use of Influencing Model
  - Micro leadership for one on one/many
- ✓ Use of Relationships in Business
  - List of potential success events
  - Personnel misalignment with customers
  - Belief System Alignment
    - Response
    - Cognition
    - Philosophy
    - Emotion
- ✓ Applying Wisdom
  - State of Knowledge
    - Explicit Knowledge
    - Tacit Knowledge
      - Education
      - Experience
  - Management of Knowledge
  - Customer Decision Making
  - Enterprise Decision Making
- ✓ Company Culture
  - Innovation culture
  - Learning culture
  - Empowerment culture
  - Corporate or forced culture

Figure 5-6: The Human Factors as the Enabler Domain

In the process of developing an understanding of the above factors, a relationship framework was co-defined between Stighlingh (2014) and the author. This is based on the application of human interaction whereby the combined ABC model (Activity, Belief and Consequence) (Hayes, 2004 & DaPhysic, 2017) of both the customer and the supplier are considered when acting upon one another. The alignment of the two parties' belief systems is an indication of a good or a bad relationship that exists between them. The Relationship Framework is shown in figure 5-7 below.

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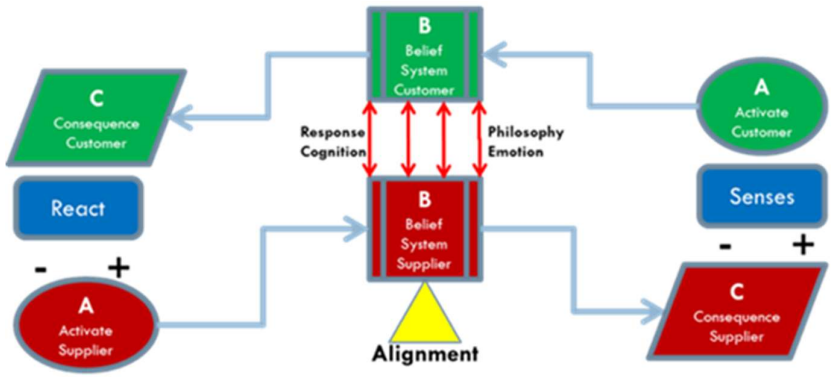

Figure 5-7: The Relationship Framework

The functionality and application of this framework was tested by the application of a case study involving the supply of the same vehicle to the USA DOD as well as the Spanish MOD for the same application in the same war in Afghanistan, thereby isolating the relationships and a few other factors to observe the effect.

The combination of the Executable Domain with the Enabler Domain allows the potential to isolate and study the interaction between these two domains. The resultant Interactive Supply Framework is shown below in Figure 5-8.

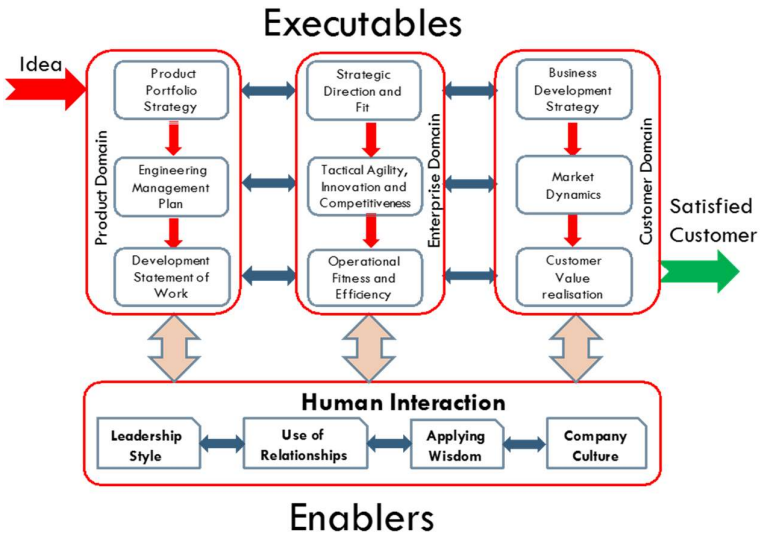

Figure 5-8: The Interactive Supply Framework

This Interactive Supply Framework contains several underlying processes. Six of these were identified and discussed. They are:

- the Strategic Planning Process
- the Competitiveness Review Process
- the Operational Management Process
- the Product Development Process

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- the Project Management Process and
- the Business Development Process.

Finally, a case study comprising of six cases, representing three projects, over four different phases of the enterprise and product life cycles, was conducted through the application of a Yin (2009) based questionnaire to collect the data. This questionnaire was aimed at the investigation and understanding of the effect of the human intervention on the success of the project and the enterprise as defined in the detail of the Executable and Enabler Domains. This case study is limited to one business in South Africa with a finite amount of knowledge workers available for the research and only presented an indication of the effect of the human intervention. The results of the case study will be shown in the next section.

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5.2 Research Conclusion

5.2.1 Summary Results

This research was concluded by evaluating the research outcome against the research question. This was done against the background of specific enabler factors within the bounds of the specific company, and the cases studied. This result is summarised in table 5-1 as follows:

Table 5-1: Results of the Case Study

Enabling Factor	Case Study Results
Leadership	Close correlation between the theory of the specific leadership style against the leadership style observed
Relationship	The positive relationship with the customer's senior and project management was observed. There was also a very negative result regarding the customer quality team's relationship with the operational team of the company, contributing towards failure.
Wisdom	The contribution of explicit knowledge from both the customer and the company's teams were defined as having a positive influence on the outcome. However, when the customer's tacit knowledge became more dominant than the company's tacit knowledge it resulted in a negative influence. It also helps if the customer makes robust decisions to promote the project as a whole.
Culture	No correlation between culture and company success was evident in the case studies under review.

The Interactive Supply Framework can be used to establish the potential contribution of any of the defined factors within the various processes. It also facilitates understanding of the contribution of the most appropriate factors in a specific scenario.

5.2.2 Evaluating and Refining the Analysis Results

The study resulted in a context diagram defining the factors to be executed in the process towards success as measured by the customer's as well as other stakeholders' perceived value realised in an organisation delivering a complex product like a weapon system.

In addition, the potential human interaction relating to these factors was identified as leadership, relationships, wisdom and culture. The specific case studies were performed to define the most dominant enabler factor contributing towards a positive result.

The results indicate that the relationships between the company and the customer are the most dominant contributing factor to success when all cases are considered simultaneously and that the inverse is also true in that a poor relationship with the customer's quality teams had a very negative influence on the outcome.

It also shows that culture and specifically forced corporate culture did not have a significant contribution to the success of the outcome.

The k**ey research question** addressed by this study is defined as follows:

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What is the contribution of the human enabling factors of leadership, relationship, wisdom and culture towards the success of a project or enterprise during the acquisition phase of a complex system, when interacting with a customer?

As this research question is compounded the following supplementary research questions were defined and were used in the analysis and confirmation of the research results. This adds more structure to the research process in support of the final response to the research question as stated. The additional research question set and considered are:

1. **What process is considered as the acquisition process of a complex system?**

   In section 2.1 the acquisition processes of the USA DoD, the UK's MOD and the NATO were discussed as the primary examples of the Western Worlds way to procure military systems.

2. **What attributes define a successful outcome of the acquisition process?**

   The author also discussed the many factors for successful acquisition as well as the factors that led to cancellation of programs in section 2.1.1.

3. **What are the processes embedded into the supply framework of a complex system to the acquisition process required by the customer?**

   The literary review in Chapter 2 defined all the potential process regarding products, the enterprise, the customer and knowledge management as the value add currency during the supply process.

4. **What are the potential human interactive enabling factors that can play a role in the enhancement of the successful outcome of a complex weapon acquisition process?**

   In section 2.6 the author considered the potential human factors to be studied as they may have the potential to influence the outcome of the supply process. These were defined as leadership, relationship, wisdom and culture.

5. **How can a conceptual framework be constructed that combines all the executable and enabling elements of the process an enterprise needs to execute to supply a complex military vehicle system?**

   Chapter 3 was dedicated to developing and define the different elements of the Interactive Supply Framework.

6. **How are these specific enabling factors contributing towards success?**

   In Chapter 4 a set of six cases were considered which included three different acquisition agencies, four specific enterprise life cycles, four specific product life cycles all being executed by one company as part of a global enterprise and spanning about ten years.

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The author's interpretation of the outcome of the case study is contained in table 5-2 below.

Table 5-2: Interpretation of the Results of the Case Study

Enabling Factor	Case Study Results	Author's General Interpretation
Leadership	Close correlation between the theory of the specific leadership style against the leadership style observed	Leadership style was constantly adapted for a specific application. The author concurs with the observation of a close correlation between the ideal and actual leadership styles when a program is under stress and a less visible correlation when everything goes according to plan.
Relationship	The positive relationship with the customer's senior and project management was observed. There was also a very negative result regarding the customer quality team's relationship with the operational team of the company contributing towards failure.	The author agrees with the observation that good relationships at both the senior management and the program management level significantly contributed to the success of the supply process This also holds true in the negative where a bad relationship do influence the potential for failure.
Wisdom	The contribution of explicit knowledge by both the customer and the company's teams were defined as having a positive influence on the outcome. However, when the customer's tacit knowledge becomes more dominant than the company's tacit knowledge it resulted in a negative influence. It also helps if the customer makes robust decisions to promote the project.	The need for a company a to have an extensive process of defining the explicit knowledge of a product is very important as this is an indication of progress throughout the supply process. The tacit know-how of the product at all parties should also be maintained as a disruption in continuity will also have an adverse effect on the supply process outcome. The customer and the supplier must always endeavour to make informed decisions as this willcontribute towards the success of the supply process.
Culture	No correlation between culture and company success was evident in the case studies under review.	From the case studies, it also became evident that no significant contribution could be identified by the practice of a corporate governance culture, however the sound governance is a prerequisite of any supply process.

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The status of the research goals set in chapter 1, is summarised in Table 5-3 below:

Table 5-3: Status of the Research Goals

Research Goal Number	The Research Goal	Status of the Research Goal
a	The acquisition processes of the USA DoD, the UK MOD as well as the NATO Forces of a complex weapon system will be investigated.	This goal was reached and demonstrated in chapters 1&2.
b	The attributes that define a successful outcome of the acquisition process will be investigated and defined.	This goal was reached and demonstrated in chapters 1&2.
c	The elements of, and processes embedded in, the execution of the supply framework as practised by the enterprise will be investigated and formulated.	This goal was reached and demonstrated in chapter 2.
d	The potential human interactive catalytic or enabling factors that can play a role in the enhancement of the successful supply of a complex weapon system will be investigated and formulated.	This goal was reached and demonstrated in chapter 2.
e	A conceptual Interactive Supply Framework will be constructed that combines all the executable and enabling factors of the process an enterprise need to execute to supply a complex military vehicle system. This Interactive Supply Framework will enable the research to investigate the selected human factors' effect on the executable part of the supply process.	This goal was reached and demonstrated in chapter 3.
f	Specific enabling human factors' contribution towards success will be investigated in a real-life case study. This will present a qualitative understanding of the contribution of each human factor.	This goal was reached and demonstrated in chapter 4.
Main Aim	The main objective of this research is to understand the catalytic contribution of the human factors of leadership, relationship, wisdom and culture in the supply of a complex weapon system into a prescribed acquisition process.	This goal was reached and demonstrated in chapter 5.

5.2.3 Contribution and Benefits of the Research

In chapter 1 the author identified the following potential benefits of this research in the following way:

'This research, when concluded, will deliver better insight into the factors that can be used to increase the propensity of a project's success as well as the growth in the wealth of the enterprise that supplies the product.'

This insight was obtained as summarised in table 5-2. A few learning moments during this

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process are:

- The understanding of the key success factors as experienced by the USA, UK and NATO.
- The overall insight of all the different processes that make up the supply process, defined as the Executable Factors in this dissertation.
- The realisation that the value add currency is knowledge about the artefact and grow throughout the supply processes by means of the application of a change management process.
- The fact that the knowledge of an artefact only realises its value with a specific application.
- The specific need for a change in the leadership role during the different phases of the enterprise life cycle. The transition periods between these phases need special attention from the leadership.
- The mechanism of the relationship framework and the application of a premeditated series of interactive events that is shown to contribute to success or to negate other negative factors that prevent success. This premeditated process can be futher developed to engineer success.
- The fact that a forced corporate governance process like the BAE Systems Life Cycle Management process, cannot be isolated as a significant contributor of success or failure

'The research will also contribute towards the knowledge base of the effect of some of the success factors as a continuum of previous research as shown before. This dissertation will contribute towards our understanding of the catalytic effect of the human in the supply of a complex system. This result will present the possible application of the dominant factor(s) in a predetermined way so that propensity for success may increase for future projects.'

The previous research as conducted by the different acquisition stakeholders, is augmented by this contribution to the knowledge pool. The new insights as defined above can be further investigated, matured and generalised to become even a more valuable contribution.

'All enterprises would like to benefit from an increase in wealth that accompanies the execution of a successful supply project. In a similar fashion, all customers and end users would like to receive good value for money products to satisfy their needs within their technical requirements, budget and timeline constraints.'

The ability to influence the outcome of a project in a positive way was demonstrated through the case studies on the application of the Relationship Framework, that showed a direct correlation between success, failure and the misalignment of the party's belief system elements.

The following frameworks resulted directly from this research work:

- The concept of an Interactive Event was established and defined in figure 5-2.

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- The Knowledge Cube shown in figure 5-3 was defined as a standard way of representing the knowledge attributes of an artefact including its value construct.
- The migration of knowledge framework through the life cycles of technology, product development and enterprise evolution, was defined and depicted as figure 5-5.
- The formulation of the Relationship Framework based on a dual ABC model was co-defined by the author and Stighlingh (2014). This is shown in figure 5-7.
- The Interactive Supply Framework was the direct result of the research done as part of this study. This framework is represented as figures 5-4, 5-6 and 5-8.

These frameworks can now be further matured and applied as business development models.

The Interactive Supply Framework can also be used to establish the potential contribution of any of the defined factors within the various processes. It also facilitates understanding of the contribution of the most appropriate factors in a specific scenario. This could be of significant benefit to senior management.

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5.3 Recommendation

5.3.1 Expanding the Analysis Results of the Current Data Available

More analysis with the collected data to potentially test alternative hypotheses is possible, as the data includes markers of product and enterprise phases, for example. These and other markers in the data can give rise to a stratified analysis where only data from a certain product development phase is analysed, for example.

This research project was limited to the investigation of the enablers' influence on the executable factors within the Interactive Supply Framework. This limitation opens a potential for much wider future research based on this framework and the interrelationships between its parts, for instance:

- The interaction between the product, enterprise and customer domains.
- The migration from the strategic, tactical and operational flow.
- The investigation of any of the embedded processes integrating specific areas of the framework.
- The area of agility contributing towards success.
- Other Human Interactive Enabling Factors as defining the human influence.

The above is only a short list of all the potential further expansion of this framework as it in principle includes all normal business processes as well as all possible human interactions with these business processes.

5.3.2 Expanding the Research within the Current Interactive Supply Framework

The scope of this study is limited by the availability of the finite list of respondents, the specific products supplied to the South African Procurement Agency (Armscor), the DOD (USA) as well as a NATO based country (FMV in Sweden) under their ever-evolving acquisition processes as defined earlier.

The product case studies were chosen to reflect the development, industrialisation, production and support phases to be able to investigate the effect of the product life cycle.

To study the effect of the enterprise life cycle, the case studies were also selected in the growth, stability and turn-around phases of the company.

The study was further limited to the South African business entity, the BAE Systems group and only products from this entity of activity was selected. The results also only reflect the actual supply process as practised in the company.

The underlying assumption of this research was that the required processes are indeed carried out as defined by the various models and that the human interaction acts as a catalyst on the process for increased success (or failure) during the average five to twenty years of the acquisition of armoured vehicles and systems.

If this research is broadened, with a much wider sample of data by means of considering

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more products and more companies worldwide, the author believes that a better insight can be reached.

5.3.3 Future Application of the Interactive Supply Framework

The application of the Interactive Supply Framework as an Enterprise Health Check Tool can be used to analyse a company or corporation in order to identify the shortcomings. The Interactive Supply Framework is based on general literature and as such can also be applied in other business areas where similar case studies can be investigated for instance:

- Information Technology
- Engineering
- Manufacturing
- Mining
- Agriculture
- Direct Service
- Indirect Service

This is obviously not an exhaustive list but is only meant as a suggestion for future expansion and application of the Interactive Supply Framework.

5.3.4 Dignity as the New Concept

After this research was concluded the latest thinking on dignity as the all-inclusive factor of human interaction into an organisation was published in 2017 by Kostera & Pirson[239]. These authors focus on '*dignity within organisational contexts'* and explore *'practices that either undermine, deny, remedy or protect human dignity'.* While this reference has presented a short glimpse into ongoing research, it seeks to spark more such research. While dignity arguably is a base concept relevant for better organising practices, much needs to be understood, formalised, and explored.

Immanuel Kant (1724–1804)[240], asserted that human beings could be described in terms of dignity, precisely because they are capable of *'morality and agency'.* Persons are ends in themselves, not just a means of producing value. He famously wrote:

"Everything has either a price or a dignity. Whatever has a price can be replaced by something else as its equivalent; on the other hand, whatever is above all price, and therefore admits of no equivalent, has a dignity." - Immanuel Kant

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5.4 Conclusion

This dissertation has now concluded, having reached the point where the following have been presented within the bounds of the case study: the endeavour to understand all aspects of the contribution of the human interactive enabling factors towards the success of an enterprise, when the return on capital is above the norm and simultaneously the customer has realised his value in dealing with the enterprise.

As shown before, this is only the beginning of this quest for knowledge and more understanding of the problem statement should be explored. This work must be revisited in future research and redirected if new insights are obtained. After all, such is the nature of the academic process, and the quest for knowledge should continue unabated.

The following future research topics will broaden our understanding about conducting successful projects and enterprises:

- The study of the interrelationships between the different parts of the executable factors in the framework.
- The study of the application of the Interactive Supply Framework in the non-military and non-complex business environments.
- The further development of the relationship model in all relevant human interface applications.
- The study of knowledge growth in relation to risk of a specific product under development.

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Special Citation List

A special citation list was extracted from the formal list to highlight the specific contribution of each of these references towards the research.

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Appendix A

Appendix A contains the generic Questionnaire and the list of respondents

A.1 Questionnaire

	Hi All
	If you read this you have been selected to take part in a survey in order to analise specific contributions to success of six specific projects at Land Systems OMC. These projects are:
	1. RG 32 as developed for Sweden
	2. The Series 1 and 2 Production of the RG 32 for Sweden
	3. The Series 3 and 4 Production of the RG 32 for Sweden
	4. The continued support of the B vehicles for the SANDF
	5. The RG 31 innitial Production run for the USA MRAP requirement.
	6. The Mobility Upgrade programs for the RG 31 MRAP Fleet.
	You are requested to complete the Questionnaire for each of the above projects only if you were involved (directly or indirectly) in any of them. If you were involved in only two then you need to complete only two answer sheets.
	You will find the proposed answers if you right click in the pink answer blocks. All you need to do is to pick the most likely answer in your opinion.
	Please note - there are no right or wrong answers only a representation of your experience.
	Once completed you must please save the answer sheet (this file completed) under the following file name configuration
	Research Questionnaire_4_Name_Project number
	Example: Research Questionnaire_4_Gert_1
	is my answer sheet for project number 1.
	I thank you kindly for your contribution to a better understanding of the contribution of specific factors towards success in a company like Land Systems OMC.
	If you have any doubt please contact me at the number below.
	Gert Pretorius
	823330199

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	Research Questionnaire	Project Nr: 1,2,3,4,5,6
Nr	Question	Name: Position:
	General Questions	
Q0.1	What best describes the business unit under review?	a. Global, b. National Corporate, c. National One Business, d. Single Program, e. Single Contract
Q0.2	In which business sector is the business unit operating?	a. Information Technology, b. Engineering, c. Manufactoring, d. Mining, e. Agriculture, f. Direct Service, g. Indirect Service, h. Other
Q0.3	Which enterprise life cycle best describe the status during the time under review?	a. Creation, b. Growth, c. Maturity, d. Turn Around, e. Decline
Q0.4	What is the complexity level of the product or service under review?	a. Systems of Systems, b. Systems, c. Products, d. Subsystems, e. Components
Q0.5	Which product category best fits the description of the product or service under review?	a. Knowledge, b. Plant Machinery, c. Automotive, d. Mining Products, e. Comodities, f. Direct Service, g. Indirect Service, h. Other
Q0.6	What is the status of the product's life cycle under review?	a. Idea, b. Technology Mature, c. Concept Creation, d. Development and Qualification, e. Manufacture and Production, f. Support in Operation, g. Phase out
Q1.1	Which of the following were the company's strategic leadership style prevalent during the project execution?	a. Provide the spark of energy, b. Puts the pedal to the metal to accelerate along the exponential growth path, c. Reduce Chaos and steadying the pace, d. Use the stark threat of extinction to provide impetus for change, e. Strategic orientation moves from growth to
Q2.4a	Which of the following areas did the company's technical team not see eye to eye with the customer?	a. Acceptable response to a request, b. Understanding of the problem or the issue, c. The way they thought about the issue, d. The way they felt about the issue, e. None of the above
Q2.4b	Which of the following areas did the company's senior management not see eye to eye with the customer's senior management?	a. Acceptable response to a request, b. Understanding of the problem or the issue, c. The way they thought about the issue, d. The way they felt about the issue, e. None of the above
Q2.4c	Which of the following areas did the company's project team not see eye to eye with the customer?	a. Acceptable response to a request, b. Understanding of the problem or the issue, c. The way they thought about the issue, d. The way they felt about the issue, e. None of the above
Q2.4d	Which of the following areas did the company's operational and quality teams not see eye to eye with the customer?	a. Acceptable response to a request, b. Understanding of the problem or the issue, c. The way they thought about the issue, d. The way they felt about the issue, e. None of the above
	Yes / No Questions	

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	Research Questionnaire	Project Nr: 1,2,3,4,5,6
Nr	Question	Name: Position:
	Yes / No Questions	
Q1.2a	Was pro-active influencing used during the development process by the engineering management?	Yes, No
Q1.3a	Was pro-active influencing used during the procurement process by the procurement management?	Yes, No
Q1.4a	Was pro-active influencing used during the project execution by the senior management?	Yes, No
Q1.5a	Was pro-active influencing used during the project execution by the project management?	Yes, No
Q1.6a	Was pro-active influencing used during the production process by the operations management?	Yes, No
Q1.7a	Was pro-active influencing used during the marketing process by the company's contracting function?	Yes, No
Q1.8a	Was pro-active influencing used during the Quality Assurance process?	Yes, No
Q2.1a	Does or did a product strategy document exist?	Yes, No
Q2.1b	Was there a list of planned reviews on the product development?	Yes, No
Q2.1c	Was there a formal sign off on the design of the product?	Yes, No
Q2.1d	Were the technical committee meetings held?	Yes, No
Q2.1e	Was there a list of planned interactions with the supplier base prior to contracting?	Yes, No
Q2.1f	Were there formal program meetings held?	Yes, No
Q2.1g	Were production readiness audits performed?	Yes, No
Q2.1h	Did a campaign strategy exist prior to contracting?	Yes, No

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	Research Questionnaire	Project Nr: 1,2,3,4,5,6
Nr	Question	Name: Position:
	To what level do you agree with the following statements?	
Q1.2b	The contribution of the engineering management's relationships towards the success of the project were significant	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q1.3b	The contribution of the supply chain management's relationships to the project success were significant	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q1.4b	The contribution of the senior management's relationships towards the success of the project were significant	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q1.5b	The program management's relationships contribution towards the success of the project were significant	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q1.6b	The operations management's relationships contribution towards the success of the project were significant	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q1.8b	The quality management's relationships contribution towards the success of the project were significant	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.2a	The engineering team got on very well with the customer's technical team	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.2b	The company's senior management got on very well with the customer's senior management	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.2c	The project team team got on very well with the customer's project team	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.2d	The operational / quality team got along very well with the customer's quality team	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.3a	It is very difficulty to do business with the customer senior management	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.3b	It is very difficulty to do business with the customer project team	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.3c	It is very difficulty to do business with the customer's technical team	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q2.3d	It is very difficulty to do business with the customer's quality team	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree

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	Research Questionnaire	Project Nr: 1,2,3,4,5,6
Nr	Question	Name: Position:
	To what level do you agree with the following statements?	
Q3.1a	The company's product knowledge contributed significantly towards the success of the project	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.1b	The company's documented product knowledge i.e. functional design, data pack and specifications were well defined	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.1c	The people of the company knew the product well	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.1d	The company's product knowledge management process is very mature	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.2a	The company's contract knowledge contributed significantly towards the success of the project	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.2b	The company's documented contract knowledge were well defined	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.2c	The people of the company knew the contract well	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.2d	The company's project knowledge management process is very mature	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.3a	The customer's contract knowledge contributed significantly towards the success of the project	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.3b	The customer's documented contract knowledge were well defined	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.3c	The people of the customer knew the contract well	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.3d	The customer's project knowledge management process is very mature	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.4a	The customer's product knowledge contributed significantly towards the success of the project	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.b	The customer's documented product knowledge i.e. functional design, data pack and specifications were well defined	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.4c	The people of the customer knew the product well	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.4d	The customer's product knowledge management process is very mature	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.5a	The customer's senior management made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.5b	The customer's project management made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.5c	The customer's quality team made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.6a	The company's technical team made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.6b	The company's senior management made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.6c	The company's project team made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.6d	The company's operational team made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q3.6e	The company's quality team made very good decisions	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree

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	Research Questionnaire	Project Nr: 1,2,3,4,5,6
Nr	Question	Name: Position:
	To what level do you agree with the following statements?	
Q4.1a	The innovation culture practiced by the company's technical function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.1b	The innovation culture practiced by the company's project function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.1c	The innovation culture practiced by the company's operational function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.1d	The innovation culture practiced by the customer's technical function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.1e	The innovation culture practiced by the customer's quality function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.2a	The learning culture practiced by the company's technical function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.2b	The learning culture practiced by the company's project function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.2c	The learning culture practiced by the company's operational function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.2d	The learning culture practiced by the customer's technical function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.2e	The learning culture practiced by the customer's quality function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.3a	The empowerment culture practiced by the company's technical function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.3b	The empowerment culture practiced by the company's project function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.3c	The empowerment culture practiced by the company's operational function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.4a	The corporate culture through the LCM process practiced by the company's technical function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.4b	The corporate culture through the LCM process practiced by the company's project function made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree
Q4.4c	The corporate culture through the LCM process practiced by the company's senior management made a significant contribution to the project success	1- Strongly Disagree, 2- Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5- Strongly Agree

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A.2 List of Respondents

Name	RG32M Development	S1 and S2 Production	S3 en S4 Production	B-Vehicle Support	RG31 First contracts	RG31 Mobility Upgrade	Incidence	
Internal Knowledge Workers							**Planned**	**Actual**
Douglas Masuku			X	X		X	3	3
Richard Swanepoel	X	X	X	X			4	4
Costa Papacostantis	X	X	X	X			4	4
Andries Els			X		X	X	3	3
Gary Santiero	X				X		2	
Tonie Botes				X			1	1
Andre Botha			X				1	1
Christo Snyman						X	1	1
Tinus Bekker					X		1	1
Neels van Niekerk	X	X	X	X	X	X	6	6
Jacques Vos	X		X		X		3	3
Theuns Visser	X	X	X		X		4	4
Dawie Grobbelaar	X					X	2	2
Gerhard Fourie	X	X	X		X		4	2
Johan van der Merwe	X	X	X			X	4	2
Vic Becker	X	X	X		X		4	4
Howard Thacker		X	X				2	2
Tossie Diedericks		X	X	X	X		4	4
Sean du Plessis			X				1	1
Jabez le Roux			X		X	X	3	3
Buks de Klerk				X			1	1
George Loots				X			1	1
Clement Dube				X			1	1
Percy Ndaba		``		X			1	1
Andre Joubert				X			1	1
Andre Venter				X			1	1
Wim Deufel						X	1	1
Wynand Viljoen						X	1	1
SUBTOTAL PLANNED	10	9	15	12	10	9	65	59
Actual	9	7	13	12	9	9		

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Name	RG32M Development	S1 and S2 Production	S3 en S4 Production	B-Vehicle Support	RG31 First contracts	RG31 Mobility Upgrade	Incidence	
Executive								
Johan Steyn	X	X	X	X	X	X	6	6
Odwa Mhlwana		X	X	X	X	X	5	5
Piet Kruger		X	X	X	X	X	5	5
Steven Magobolo			X	X		X	3	
Carene Geldenhuys			X			X	2	2
Natasha Pheiffer			X				1	1
Abri du Plessis			X	X		X	3	3
SUBTOTAL PLANNED	1	3	7	5	3	6	25	22
Actual	1	3	6	4	3	5		
External Knowledge Workers								
Gert Pretorius	X	X	X	X	X	X	6	6
Koos Zietsman	X	X					2	2
Bertus Hechter	X	X			X		3	3
Peter van Rensburg		X	X				2	
Rebecca Darby			X				1	1
Thami Mbele		X		X	X		3	
Uli Fischer				X			1	1
Hannes Eybers		X	X				2	2
Paul Edwards	X	X	X	X	X	X	6	6
Ajith Gopal		X	X				2	2
Roelof Blignaut					X	X	2	2
Genl Jooste				X			1	1
Tony Savides	X				X		2	2
Alwyn Dippenaar		X	X			X	3	
Jan Potgieter (Cummins)			X			X	2	2
Willie Alers	X	X					2	2
Hagen Nieberding	X						1	1
Brent Baker					X		1	
Pieter Grundling	X	X			X		3	3
Flip Pieterse	X	X	X	X	X	X	6	
Robbie Menkveld		X	X	X			3	3
SUBTOTAL PLANNED	9	13	10	7	9	6	54	39
Actual	8	9	7	5	6	4		
GRAND TOTAL PLANNED	20	25	32	24	22	21	144	
GRAND TOTAL ACTUAL	18	19	26	21	18	18		120

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Appendix B

Results of Questionnaire

Respondent Nr	Position	Classification	Project	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6
1	Manager Procurement	Internal	3	National One Business	Manufacturing	Maturity	System	Indirect Services	Manufacture or Production
2	Manager Procurement	Internal	4	National One Business	Manufacturing	Decline	System	Indirect Services	Phase-out
3	Manager Procurement	Internal	6	National One Business	Manufacturing	Growth	System	Indirect Services	Manufacture or Production
4	Configuration Manager	Internal	1	Global	Engineering	Turnaround	Product	Automotive	Support in Operation
5	Configuration Manager	Internal	2	Single Contract / Project	Manufacturing	Turnaround	Product	Automotive	Manufacture or Production
6	Configuration Manager	Internal	3	Global	Engineering	Maturity	Product	Automotive	Manufacture or Production
7	Configuration Manager	Internal	4	National One Business	Indirect Services	Maturity	Component	Indirect Services	Support in Operation
8	Design engineer	Internal	1	National One Business	Engineering	Growth	System	Automotive	Development and Qualification
9	Engineering Manager	Internal	2	National One Business	Engineering	Growth	System	Automotive	Manufacture or Production
10	Design engineer	Internal	3	National One Business	Engineering	Maturity	System	Automotive	Manufacture or Production
11	Engineering Manager	Internal	4	National One Business	Engineering	Growth	System	Automotive	Manufacture or Production
12	Manager CAD	Internal	6	Single Program	Engineering	Growth	Product	Automotive	Development and Qualification
13	Manager CAD	Internal	4	National One Business	Engineering	Growth	Product	Automotive	Development and Qualification
14	Technical Business Development	Internal	5	National One Business	Engineering	Growth	Product	Automotive	Development and Qualification
15	Process Technitian	Internal	4	Single Contract / Project	Manufacturing	Turnaround	Product	Automotive	Support in Operation
16	Systems Engineer	Internal	3	National One Business	Engineering	Maturity	Product	Automotive	Manufacture or Production
17	Engineering Manager	Internal	6	National One Business	Manufacturing	Maturity	Sub System	Automotive	Support in Operation
18	Program Manager	Internal	5	National One Business	Manufacturing	Decline	Product	Automotive	Manufacture or Production
19	Manager Engineering Design	Internal	1	National One Business	Manufacturing	Maturity	Product	Automotive	Development and Qualification
20	Manager Engineering Design	Internal	2	National One Business	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
21	Manager Engineering Design	Internal	3	National One Business	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
22	Manager Engineering Design	Internal	4	National One Business	Manufacturing	Maturity	Product	Automotive	Support in Operation
23	Manager Engineering Design	Internal	5	National One Business	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
24	Manager Engineering Design	Internal	6	National One Business	Manufacturing	Maturity	Product	Automotive	Support in Operation
25	Engineering Manager	Internal	1	National One Business	Engineering	Decline	Product	Automotive	Development and Qualification
26	Manager Engineering	Internal	3	National One Business	Engineering	Decline	Product	Automotive	Manufacture or Production
27	Manager Engineering	Internal	5	National One Business	Engineering	Decline	Product	Automotive	Manufacture or Production
28	Principal Test Technician	Internal	1	National One Business	Engineering	Creation	Product	Automotive	Concept Creation
29	Principal Test Technician	Internal	2	National One Business	Engineering	Growth	Product	Automotive	Development and Qualification
30	Principal Test Technician	Internal	3	National One Business	Engineering	Growth	Product	Automotive	Development and Qualification
31	Principal Test Technician	Internal	5	Single Contract / Project	Engineering	Growth	Product	Automotive	Technology Maturity
32	Test and Evaluation Manager	Internal	1	National One Business	Engineering	Growth	System	Automotive	Development and Qualification
33	Test and Evaluation Manager	Internal	6	National One Business	Engineering	Maturity	Product	Automotive	Support in Operation
34	Test Technician	Internal	1	National One Business	Engineering	Maturity	Sub System	Automotive	Support in Operation
35	Test Technician	Internal	5	National One Business	Engineering	Maturity	System	Automotive	Phase-out
36	Engineering Manager	Internal	1	Single Contract / Project	Engineering	Growth	Product	Automotive	Manufacture or Production
37	Engineering Manager	Internal	6	National One Business	Engineering	Growth	Product	Automotive	Manufacture or Production
38	Manager Engineer	Internal	1	National One Business	Manufacturing	Growth	Product	Automotive	Development and Qualification
39	Manager Engineer	Internal	2	National One Business	Manufacturing	Growth	Product	Automotive	Manufacture or Production
40	Manager Quality Assurance	Internal	3	National One Business	Manufacturing	Maturity	Product	Automotive	Manufacture or Production

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Respondent Nr	Position	Classification	Project	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6
41	Manager Quality Assurance	Internal	4	National One Business	Manufacturing	Growth	Product	Automotive	Manufacture or Production
42	Technical Publications Manager	Internal	2	National One Business	Engineering	Maturity	Product	Automotive	Manufacture or Production
43	Technical Publications Manager	Internal	3	National One Business	Engineering	Maturity	Product	Automotive	Manufacture or Production
44	Production Team Leader	Internal	2	National One Business	Engineering	Growth	Product	Automotive	Manufacture or Production
45	Production Team Leader	Internal	3	National One Business	Engineering	Turnaround	Product	Automotive	Manufacture or Production
46	Production Team Leader	Internal	4	National One Business	Engineering	Decline	Product	Automotive	Manufacture or Production
47	Production Team Leader	Internal	5	National One Business	Engineering	Growth	Product	Automotive	Manufacture or Production
48	Project Manager	Internal	3	National One Business	Manufacturing	Decline	Product	Automotive	Manufacture or Production
49	Program Manager	Internal	3	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
50	Program Manager	Internal	5	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
51	Program Manager	Internal	6	Global	Manufacturing	Growth	Sub System	Automotive	Manufacture or Production
52	Program Manager	Internal	4	National One Business	Direct Services	Decline	Product	Automotive	Support in Operation
53	Project Technician	Internal	4	National One Business	Engineering	Decline	Product	Automotive	Support in Operation
54	Engineering Manager	Internal	4	National One Business	Engineering	Maturity	System	Automotive	Support in Operation
55	Manager Local Programs	Internal	4	National One Business	Engineering	Turnaround	Product	Automotive	Support in Operation
56	Program Manager	Internal	4	National Corporate	Other	Decline	Product	Automotive	Support in Operation
57	Program Manager	Internal	4	National One Business	Direct Services	Maturity	Product	Automotive	Support in Operation
58	Project Engineer	Internal	6	Single Contract / Project	Manufacturing	Maturity	Product	Automotive	Support in Operation
59	Project Manager	Internal	6	Global	Manufacturing	Maturity	Sub System	Automotive	Support in Operation
60	Program Manager	External	1	National One Business	Engineering	Creation	Product	Automotive	Concept Creation
61	Program Manager	External	2	National One Business	Engineering	Growth	Product	Automotive	Manufacture or Production
62	Engineering Director	External	3	National One Business	Engineering	Growth	Product	Automotive	Manufacture or Production
63	Engineering Director	External	4	National One Business	Engineering	Maturity	Product	Automotive	Support in Operation
64	Engineering Director	External	5	National One Business	Engineering	Growth	Product	Automotive	Development and Qualification
65	Engineering Director	External	6	National One Business	Engineering	Decline	Product	Automotive	Phase-out
66	Chief Design Engineer	External	1	National One Business	Engineering	Creation	System	Automotive	Concept Creation
67	Chief Design Engineer	External	2	National One Business	Engineering	Growth	System	Automotive	Manufacture or Production
68	Manager Product Development	External	1	National One Business	Manufacturing	Creation	Product	Automotive	Development and Qualification
69	Manager Product Development	External	2	National One Business	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
70	Manager Product Development	External	5	National One Business	Manufacturing	Growth	Product	Automotive	Manufacture or Production
71	Project Manager	External	3	National Corporate	Manufacturing	Turnaround	System of Sy	Other	Manufacture or Production
72	Manager Dealer Support	External	4	Global	Manufacturing	Maturity	System	Automotive	Support in Operation
73	Qality Engineer	External	2	Single Contract / Project	Manufacturing	Growth	Product	Automotive	Development and Qualification
74	Qality Engineer	External	3	National One Business	Manufacturing	Turnaround	Product	Automotive	Manufacture or Production
75	Manager, Commercial	External	1	National One Business	Manufacturing	Creation	System	Automotive	Development and Qualification
76	Manager, Commercial	External	2	National One Business	Manufacturing	Growth	System	Automotive	Manufacture or Production
77	Manager, Commercial	External	3	National One Business	Manufacturing	Growth	System	Automotive	Manufacture or Production
78	Manager, Commercial	External	4	National One Business	Manufacturing	Decline	System	Automotive	Support in Operation
79	Manager, Commercial	External	5	National One Business	Manufacturing	Maturity	System	Automotive	Manufacture or Production
80	Manager, Commercial	External	6	National One Business	Manufacturing	Maturity	System of Sy	Automotive	Support in Operation

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Respondent Nr	Position	Classification	Project	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6
81	Engineering Manager	External	2	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
82	Engineering Manager	External	3	Global	Manufacturing	Decline	Product	Automotive	Manufacture or Production
83	Senior Design Engineer	External	3	Global	Engineering	Maturity	Product	Automotive	Support in Operation
84	Senior Design Engineer	External	6	Global	Manufacturing	Maturity	System of Sy	Automotive	Support in Operation
85	Program Manager	External	1	National One Business	Engineering	Creation	System	Automotive	Development and Qualification
86	Program Manager	External	2	National One Business	Manufacturing	Growth	System	Automotive	Manufacture or Production
87	Senior Design Engineer	External	1	Single Contract / Project	Engineering	Creation	System	Automotive	Development and Qualification
88	Manager Procurement	External	1	National One Business	Manufacturing	Growth	Product	Knowledge	Manufacture or Production
89	Manager Procurement	External	2	National One Business	Manufacturing	Growth	Product	Knowledge	Manufacture or Production
90	Manager Procurement	External	5	National One Business	Manufacturing	Growth	Product	Knowledge	Manufacture or Production
91	Manager Log	External	2	National One Business	Manufacturing	Growth	System	Automotive	Manufacture or Production
92	Manager Log	External	3	National One Business	Manufacturing	Turnaround	System	Automotive	Manufacture or Production
93	Manager Log	External	4	National One Business	Manufacturing	Maturity	System	Automotive	Support in Operation
94	Director of Programmes	External	5	Global	Engineering	Growth	Product	Automotive	Manufacture or Production
95	Director of Programmes	External	6	Global	Engineering	Maturity	Sub System	Automotive	Support in Operation
96	Business Development Director	External	1	National One Business	Manufacturing	Maturity	System	Automotive	Manufacture or Production
97	Business Development Director	External	5	National One Business	Manufacturing	Maturity	System	Automotive	Manufacture or Production
98	Business Development Director	External	3	National One Business	Manufacturing	Decline	Product	Automotive	Support in Operation
99	Managing Director	Executive	1	Global	Manufacturing	Growth	Product	Automotive	Development and Qualification
100	Managing Director	Executive	2	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
101	Managing Director	Executive	3	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
102	Managing Director	Executive	4	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
103	Managing Director	Executive	5	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
104	Managing Director	Executive	6	Global	Manufacturing	Growth	Product	Automotive	Manufacture or Production
105	Financial Director	Executive	2	Global	Manufacturing	Turnaround	Product	Automotive	Manufacture or Production
106	Financial Director	Executive	3	Global	Manufacturing	Turnaround	Product	Automotive	Manufacture or Production
107	Financial Director	Executive	4	Global	Manufacturing	Decline	Product	Automotive	Support in Operation
108	Financial Director	Executive	5	Global	Manufacturing	Turnaround	Product	Automotive	Development and Qualification
109	Financial Director	Executive	6	Global	Manufacturing	Maturity	Sub System	Automotive	Support in Operation
110	Operations Director	Executive	2	Global	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
111	Operations Director	Executive	3	Global	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
112	Operations Director	Executive	4	Global	Manufacturing	Maturity	Product	Automotive	Support in Operation
113	Operations Director	Executive	5	Global	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
114	Operations Director	Executive	6	Global	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
115	Business Development Director	Executive	3	National One Business	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
116	Programs&Engineering Director	Executive	3	Global	Manufacturing	Maturity	Product	Automotive	Manufacture or Production
117	Programs&Engineering Director	Executive	4	Global	Manufacturing	Maturity	Product	Automotive	Support in Operation
118	Programs&Engineering Director	Executive	6	Global	Manufacturing	Maturity	Product	Automotive	Support in Operation
119	Company Secretary	Executive	3	National One Business	Manufacturing	Growth	Product	Automotive	Manufacture or Production
120	Company Secretary	Executive	6	National One Business	Manufacturing	Growth	Product	Automotive	Manufacture or Production

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Respondent Nr	Position	Classification	Project	Q1.1	Q2.4a	Q2.4b	Q2.4c	Q2.4d
1	Manager Procurement	Internal	3	c	a	c	b	c
2	Manager Procurement	Internal	4	d	e	e	c	b
3	Manager Procurement	Internal	6	c	e	e	e	e
4	Configuration Manager	Internal	1	b	e	e	e	e
5	Configuration Manager	Internal	2	d	e	e	e	e
6	Configuration Manager	Internal	3	d	e	e	e	e
7	Configuration Manager	Internal	4	e	e	e	e	e
8	Design engineer	Internal	1	b	a	a	a	a
9	Engineering Manager	Internal	2	b	a	a	c	d
10	Design engineer	Internal	3	c	d	b	b	d
11	Engineering Manager	Internal	4	b	a	a	a	a
12	Manager CAD	Internal	6	e	e	e	a	a
13	Manager CAD	Internal	4	e	c	c	c	c
14	Technical Business Development	Internal	5	e	c	c	c	c
15	Process Technitian	Internal	4	d	e	e	e	e
16	Systems Engineer	Internal	3	b	d	e	c	c
17	Engineering Manager	Internal	6	c	e	e	e	e
18	Program Manager	Internal	5	e	e	e	e	e
19	Manager Engineering Design	Internal	1	d	c	b	a	a
20	Manager Engineering Design	Internal	2	d	c	b	a	a
21	Manager Engineering Design	Internal	3	e	c	b	a	a
22	Manager Engineering Design	Internal	4	e	c	b	a	a
23	Manager Engineering Design	Internal	5	e	c	b	a	a
24	Manager Engineering Design	Internal	6	e	c	b	a	a
25	Engineering Manager	Internal	1	a	b	c	d	e
26	Manager Engineering	Internal	3	d	b	c	d	e
27	Manager Engineering	Internal	5	c	c	d	d	e
28	Principal Test Technician	Internal	1	b	a	d	c	c
29	Principal Test Technician	Internal	2	b	a	d	c	c
30	Principal Test Technician	Internal	3	b	a	d	c	c
31	Principal Test Technician	Internal	5	b	a	a	c	a
32	Test and Evaluation Manager	Internal	1	a	e	e	e	e
33	Test and Evaluation Manager	Internal	6	a	e	e	e	e
34	Test Technician	Internal	1	b	c	a	d	c
35	Test Technician	Internal	5	b	b	a	b	b
36	Engineering Manager	Internal	1	a	d	e	b	b
37	Engineering Manager	Internal	6	b	e	a	a	e
38	Manager Engineer	Internal	1	a	e	e	e	c
39	Manager Engineer	Internal	2	c	c	e	b	c
40	Manager Quality Assurance	Internal	3	b	b	e	d	a

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Respondent Nr	Position	Classification	Project	Q1.1	Q2.4a	Q2.4b	Q2.4c	Q2.4d
41	Manager Quality Assurance	Internal	4	a	e	e	e	e
42	Technical Publications Manager	Internal	2	b	b	a	a	c
43	Technical Publications Manager	Internal	3	b	b	a	a	c
44	Production Team Leader	Internal	2	c	b	b	e	b
45	Production Team Leader	Internal	3	d	b	b	e	b
46	Production Team Leader	Internal	4	e	b	b	e	b
47	Production Team Leader	Internal	5	b	b	b	e	b
48	Project Manager	Internal	3	b	d	d	c	d
49	Program Manager	Internal	3	c	b	b	a	b
50	Program Manager	Internal	5	b	e	e	c	a
51	Program Manager	Internal	6	b	e	e	a	a
52	Program Manager	Internal	4	c	e	d	d	e
53	Project Technician	Internal	4	c	b	d	a	e
54	Engineering Manager	Internal	4	c	b	d	c	d
55	Manager Local Programs	Internal	4	e	b	b	b	a
56	Program Manager	Internal	4	d	a	e	a	c
57	Program Manager	Internal	4	e	b	b	b	a
58	Project Engineer	Internal	6	e	e	e	e	c
59	Project Manager	Internal	6	e	e	e	e	b
60	Program Manager	External	1	a	e	e	e	e
61	Program Manager	External	2	b	a	a	a	b
62	Engineering Director	External	3	d	a	b	a	a
63	Engineering Director	External	4	c	a	c	e	e
64	Engineering Director	External	5	b	e	e	e	e
65	Engineering Director	External	6	c	e	e	e	e
66	Chief Design Engineer	External	1	b	c	b	e	d
67	Chief Design Engineer	External	2	b	c	b	c	d
68	Manager Product Development	External	1	b	b	d	a	d
69	Manager Product Development	External	2	d	d	d	d	d
70	Manager Product Development	External	5	d	b	d	d	c
71	Project Manager	External	3	d	c	c	c	c
72	Manager Dealer Support	External	4	c	b	b	b	b
73	Qality Engineer	External	2	b	e	e	e	e
74	Qality Engineer	External	3	c	c	b	a	e
75	Manager, Commercial	External	1	c	c	e	b	c
76	Manager, Commercial	External	2	b	c	d	c	a
77	Manager, Commercial	External	3	b	c	d	c	a
78	Manager, Commercial	External	4	e	d	e	e	e
79	Manager, Commercial	External	5	b	e	e	e	e
80	Manager, Commercial	External	6	c	e	e	e	e

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Respondent Nr	Position	Classification	Project	Q1.1	Q2.4a	Q2.4b	Q2.4c	Q2.4d
81	Engineering Manager	External	2	b	b	e	b	e
82	Engineering Manager	External	3	c	e	a	c	d
83	Senior Design Engineer	External	3	c	b	c	c	d
84	Senior Design Engineer	External	6	b	e	e	e	e
85	Program Manager	External	1	e	c	a	c	a
86	Program Manager	External	2	e	c	c	c	a
87	Senior Design Engineer	External	1	c	c	d	c	b
88	Manager Procurement	External	1	c	c	b	a	c
89	Manager Procurement	External	2	c	c	b	a	c
90	Manager Procurement	External	5	c	a	a	a	a
91	Manager Log	External	2	d	d	c	a	b
92	Manager Log	External	3	c	c	c	d	c
93	Manager Log	External	4	b	d	b	c	c
94	Director of Programmes	External	5	b	e	e	b	c
95	Director of Programmes	External	6	c	e	e	e	e
96	Business Development Director	External	1	b	c	b	b	c
97	Business Development Director	External	5	b	c	b	b	c
98	Business Development Director	External	3	c	b	b	b	a
99	Managing Director	Executive	1	a	b	c	c	b
100	Managing Director	Executive	2	a	b	c	b	b
101	Managing Director	Executive	3	a	b	c	b	b
102	Managing Director	Executive	4	c	c	b	b	b
103	Managing Director	Executive	5	b	e	e	e	b
104	Managing Director	Executive	6	b	e	e	e	b
105	Financial Director	Executive	2	b	c	b	c	c
106	Financial Director	Executive	3	b	c	b	c	c
107	Financial Director	Executive	4	e	e	a	a	e
108	Financial Director	Executive	5	a	d	a	a	b
109	Financial Director	Executive	6	e	e	e	e	e
110	Operations Director	Executive	2	c	d	c	c	b
111	Operations Director	Executive	3	c	d	c	c	b
112	Operations Director	Executive	4	e	d	e	e	e
113	Operations Director	Executive	5	c	d	e	e	e
114	Operations Director	Executive	6	d	d	e	e	e
115	Business Development Director	Executive	3	b	a	d	b	b
116	Programs&Engineering Director	Executive	3	c	c	b	b	b
117	Programs&Engineering Director	Executive	4	c	e	c	b	b
118	Programs&Engineering Director	Executive	6	c	e	e	e	d
119	Company Secretary	Executive	3	b	a	d	a	b
120	Company Secretary	Executive	6	b	e	e	e	e

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Respondent Nr	Q1.2a	Q1.3a	Q1.4a	Q1.5a	Q1.6a	Q1.7a	Q1.8a	Q2.1a	Q2.1b	Q2.1c	Q2.1d	Q2.1e	Q2.1f	Q2.1g	Q2.1h
1	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
2	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	No	No
3	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
4	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No
5	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	No	No	No
6	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	No	No	No
7	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No
8	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	Yes	No	No	No	No	No	Yes	Yes	No	No	Yes	No	Yes	No	Yes
11	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	Yes	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
13	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
14	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
15	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
16	No	No	No	No	No	No	No	Yes	No	No	Yes	No	Yes	No	No
17	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
18	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
19	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No	No	No	No
20	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No
21	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No
22	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No
23	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No
24	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No
25	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
26	Yes	No	Yes	No	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes	No
27	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
28	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	No	Yes	No	Yes	No	No
29	Yes	No	No	Yes	No	No	Yes	No	Yes	No	Yes	No	Yes	No	No
30	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No	Yes	No	Yes	No	No
31	Yes	No	Yes	Yes	No	No	No	No	No	No	Yes	No	Yes	No	No
32	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
33	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
34	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
35	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
36	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No	No
37	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	No	No
38	Yes	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes
39	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
40	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Respondent Nr	Q1.2a	Q1.3a	Q1.4a	Q1.5a	Q1.6a	Q1.7a	Q1.8a	Q2.1a	Q2.1b	Q2.1c	Q2.1d	Q2.1e	Q2.1f	Q2.1g	Q2.1h
41	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
42	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
43	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
44	Yes	No	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No
45	Yes	No	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No
46	Yes	No	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No
47	Yes	No	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No
48	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No
49	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes	No
50	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes		Yes	Yes
51	Yes	Yes	No		No	No	No	Yes	Yes	Yes	No	No	No	Yes	No
52	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	No
53	No	Yes	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No	No
54	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	No	No
55	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
56	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
57	No	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	Yes	No	No
58	No	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
59	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
60	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
61	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
62	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
63	No	No	No	No	No	No	Yes	No	No	No	Yes	No	Yes	No	No
64	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No
65	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
66	Yes	No	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
67	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
68	Yes	No	Yes	No	No	No	No	No	No	Yes	Yes	No	Yes	No	No
69	Yes	No	Yes	No	No	No	No	No	Yes	Yes	Yes	No	Yes	No	No
70	Yes	No	Yes	No	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	No
71	No	No	No	No	No	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No
72	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
73	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
74	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
75	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
76	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
77	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
78	No	No	No	Yes	No	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No
79	No	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	No	No
80	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes

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Respondent Nr	Q1.2a	Q1.3a	Q1.4a	Q1.5a	Q1.6a	Q1.7a	Q1.8a	Q2.1a	Q2.1b	Q2.1c	Q2.1d	Q2.1e	Q2.1f	Q2.1g	Q2.1h
81	No	No	No	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	No	No
82	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
83	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
84	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
85	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
86	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
87	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
88	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
89	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
90	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
91	No	No	No	No	No	Yes	No	No	No	No	Yes	No	Yes	No	No
92	No	No	No	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No	No
93	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No	No
94	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
95	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
96	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
97	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
98	Yes	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
99	No	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No
100	No	No	No	Yes	No	No	No	No	No	Yes	No	No	Yes	No	No
101	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
102	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No
103	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	No	No
104	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
105	Yes	No	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes
106	Yes	No	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes
107	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
108	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
109	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
110	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
111	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
112	No	No	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
113	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
114	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
115								No	Yes	Yes					
116	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
117	No	No	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No
118	No	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No
119	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No
120	No	No	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	No	No

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Respondent Nr	Q1.2b	Q1.3b	Q1.4b	Q1.5b	Q1.6b	Q1.8b	Q2.2a	Q2.2b	Q2.2c	Q2.2d	Q2.3a	Q2.3b	Q2.3c	Q2.3d
1	4	2	4	4	4	4	4	4	3	2	4	4	4	4
2	4	4	2	4	4	4	3	4	4	4	2	2	3	2
3	4	4	4	4	4	4	4	4	4	4	2	2	2	2
4	4	3	4	4	4	4	4	4	4	3	3	3	3	3
5	4	3	3	3	3	4	3	3	3	3	3	3	3	3
6	4	3	4	3	4	4	3	3	4	3	3	3	3	3
7	2	2	4	4	3	4	3	3	3	3	2	2	3	3
8	5	2	5	5	2	4	5	5	5	5	3	2	2	3
9	5	2	4	4	2	4	5	5	5	5	3	2	2	4
10	4	2	3	3	2	4	4	3	3	4	3	3	2	4
11	5	2	4	4	3	4	5	5	5	5	2	2	2	2
12	5	4	4	4	3	4	5	4	4	3	1	2	1	2
13	5	4	5	3	4	3	4	3	4	4	3	2	2	2
14	5	4	5	3	4	3	4	3	4	4	3	2	2	2
15	3	3	2	5	2	2	4	2	4	3	3	3	2	2
16	2	2	3	3	1	3	4	3	3	4	3	4	2	2
17	5	4	4	5	3	3	5	5	5	5	1	1	1	2
18	4	4	5	5	4	4	5	5	5	5	1	1	1	1
19	2	4	2	3	1	3	5	4	4	2	2	2	1	5
20	3	4	2	3	1	3	5	3	4	2	2	2	1	3
21	3	4	2	3	1	3	5	3	4	2	2	2	1	5
22	3	4	2	3	1	3	3	3	4	2	2	2	1	3
23	3	5	2	4	1	3	5	4	4	2	2	2	1	3
24	3	4	2	3	1	3	5	3	4	2	2	2	1	3
25	4	1	4	3	3	4	5	4	4	4	3	2	1	2
26	4	1	2	1	3	4	5	2	1	4	4	4	2	2
27	4	1	4	4	4	4	5	4	4	4	1	2	1	2
28	4	2	3	4	2	3	4	4	4	3	3	4	4	4
29	4	2	3	4	2	3	4	4	4	3	3	4	4	4
30	4	2	3	4	2	4	3	3	4	3	3	3	4	4
31	4	3	3	3	2	4	4	4	4	4	3	3	4	2
32	5	4	4	4	4	4	5	3	4	3	4	2	2	4
33	5	4	3	4	4	4	5	3	4	3	2	2	2	2
34	4	4	3	3	4	4	3	3	3	3	4	4	3	3
35	44	4	4	4	4	4	3	3	3	4	3	3	3	3
36	4	3	4	4	4	4	5	3	4	2	2	2	1	2
37	5	4	3	4	4	4	5	4	4	3	2	2	1	3
38	3	2	4	5	2	3	4	4	5	4	2	4	4	4
39	3	2	3	3	2	4	4	4	5	4	2	4	3	4
40	3	3	2	2	2	4	3	4	2	4	2	3	4	4

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Respondent Nr	Q1.2b	Q1.3b	Q1.4b	Q1.5b	Q1.6b	Q1.8b	Q2.2a	Q2.2b	Q2.2c	Q2.2d	Q2.3a	Q2.3b	Q2.3c	Q2.3d
41	4	4	3	4	4	4	4	4	4	4	2	2	2	1
42	4	3	4	3	3	3	3	3	2	3	3	3	3	3
43	4	3	4	3	3	3	3	3	2	3	3	3	3	3
44	3	1	2	3	3	3	3	2	2	3	2	2	3	3
45	3	1	2	3	3	3	3	2	2	3	2	2	3	3
46	3	1	2	3	3	3	3	2	2	3	2	2	3	3
47	3	1	2	3	3	3	3	2	2	3	2	2	3	3
48	4	2	3	3	4	4	4	2	3	4	4	4	2	2
49	4	1	4		4	4	2	1	1	2	5	4	4	5
50	4	4	4	4	4	4	5	3	4	4	2	2	1	2
51	4	2	3		4	4	5	4	5	4	1	2	2	1
52	4	2	4	4	3	4	4	4	5	5	5	1	1	4
53	2	2	3	3	4	2	4	4	5	2	4	3	2	3
54	4	4	4	4	4	4	4	4	4	2	4	2	4	4
55	5	4	5	5	5	4	5	4	5	5	5	1	3	2
56	4	2	4	4	4	4	4	4	4	4	2	2	2	2
57	2	1	2	4	3	4	3	2	2	3	4	2	2	3
58	4	4	2	5	2	4	5	4	5	4	2	2	2	2
59	4	4	4	4	4	4	5	4	4	4	2	2	2	2
60	5	1	3	4	2	3	5	3	5	4	2	1	2	3
61	5	1	3	3	4	4	4	3	4	3	2	3	4	4
62	5	2	2	4	1	5	4	3	3	3	2	5	4	5
63	3	4	2	4	4	5	3	1	3	2	5	1	3	4
64	4	4	5	5	4	5	4	5	5	5	1	1	2	1
65	4	5	5	5	5	5	4	5	5	5	1	1	1	1
66	4	2	4	4	4	3	4	4	4	2	2	2	1	2
67	4	2	4	4	4	2	5	4	4	2	4	2	2	5
68	4	2	4	3	3	3	4	4	4	2	3	2	2	4
69	4	3	4	3	3	3	4	4	3	2	3	4	2	4
70	4	4	4	4	4	4	4	3	4	4	2	2	2	2
71	5	1	2	3	2	4	4	1	2	3	4	4	5	5
72	4	4	4	5	4	5	4	4	4	4	3	2	2	2
73	3	3	3	4	2	4	5	4	4	5	3	3	2	3
74	4	4	4	5	3	5	5	3	5	5	3	2	2	2
75	4	3	3	4	4	4	4	4	4	3	2	3	4	3
76	4	3	4	4	4	4	4	4	4	4	2	3	4	3
77	4	3	4	4	4	3	4	4	4	4	2	3	4	3
78	3	3	2	4	4	4	3	2	4	4	4	3	3	3
79	4	4	4	4	4	4	4	4	4	4	2	2	2	2
80	4	4	4	4	4	4	4	4	4	4	2	2	2	2

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Respondent Nr	Q1.2b	Q1.3b	Q1.4b	Q1.5b	Q1.6b	Q1.8b	Q2.2a	Q2.2b	Q2.2c	Q2.2d	Q2.3a	Q2.3b	Q2.3c	Q2.3d
81	4	3	3	4	2	5	4	3	3	4	3	1	1	1
82	4	3	4	4	2	5	5	3	2	4	3	1	1	1
83	4	3	3	4	3	3	4	3	4	3	3	4	2	3
84	4	4	3	4	3	3	5	4	4	5	1	2	1	2
85	5	5	5	5	5	5	5	4	5	5	2	2	2	4
86	5	5	5	5	5	5	5	4	5	5	2	2	2	4
87	5	4	5	5	4	4	5	3	4	4	2	2	1	2
88	4	5	4	3	5	4	2	4	4	3	2	2	2	4
89	4	5	4	3	5	4	4	4	4	3	2	2	2	4
90	4	5	4	4	5	4	4	4	4	4	2	2	2	2
91	2	4	2	2	3	4	4	2	4	3	2	2	3	3
92	2	4	2	3	3	4	4	3	4	3	2	2	3	3
93	3	4	4	4	3	3	4	4	4	4	4	3	2	2
94	4	5	4	3	4	4	4	3	4	4	2	2	2	2
95	3	3	4	5	4	3	4	3	4	4	2	2	2	2
96	5	5	5	5	5	5	5	4	5	4	3	2	3	2
97	5	5	5	5	5	5	5	4	4	4	2	2	2	2
98	4	3	3	4	4	4	3	2	4	4	3	2	2	2
99	2	2	4	4	2	2	4	4	4	4	2	4	2	5
100	2	2	4	4	2	2	4	4	4	4	2	4	2	5
101	2	2	4	4	4	4	4	4	4	4	2	4	2	5
102	2	2	3	4	3	4	4	4	4	4	4	2	2	2
103	4	4	4	4	4	5	4	4	4	4	2	2	2	2
104	5	5	4	4	5	5	5	4	4	5	2	2	2	2
105	4	3	4	4	3	2	3	5	4	3	2	3	3	4
106	4	3	4	4	3	2	3	5	4	3	2	3	3	4
107	4	5	5	5	4	4	4	5	5	5	2	2	2	2
108	4	5	5	5	4	4	4	5	5	5	2	2	2	2
109	4	5	5	5	4	4	4	5	5	5	1	1	1	1
110	4	4	4	4	4	4	3	2	2	2	5	5	4	5
111	4	4	4	4	4	4	4	2	2	2	5	5	4	5
112	3	4	4	4	4	4	4	4	4	4	2	4	4	3
113	3	4	4	4	4	4	4	4	4	4	2	4	4	3
114	4	4	4	4	4	4	4	4	4	4	2	2	2	2
115											4			
116	3	2	3	4	3	4	3	3	2	2	2	4	3	4
117	3	2	3	4	3	4	3	4	4	3	2	2	2	3
118	4	3	4	4	3	4	4	4	4	4	1	1	1	2
119	3	3	3	3	3	3	3	3	3	3	5	5	3	4
120	3	3	4	4	4	4	3	5	4	3	2	2	3	3

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Respondent Nr	Q3.1a	Q3.1b	Q3.1c	Q3.1d	Q3.2a	Q3.2b	Q3.2c	Q3.2d	Q3.3a	Q3.3b	Q3.3c	Q3.3d	Q3.4a	Q3.4b	Q3.4c	Q3.4d	Q3.5a	Q3.5b	Q3.5c	Q3.6a	Q3.6b	Q3.6c	Q3.6d	Q3.6e
1	1	2	4	3	2	2	2	2	4	4	4	4	4	4	4	4	4	4	3	5	4	4	4	4
2	4	2	4	2	4	4	3	2	4	4	4	4	4	4	4	3	4	4	4	4	3	4	4	4
3	4	4	4	3	4	4	3	2	3	3	4	4	3	4	4	3	4	4	4	4	4	4	4	4
4	4	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3
5	4	4	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	4
6	4	4	4	4	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	4	4	4	4	4
7	2	1	2	2	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
8	5	3	4	3	3	3	3	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	4
9	5	3	4	3	3	3	3	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	4
10	4	3	4	3	3	3	3	3	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3
11	5	3	4	3	3	3	3	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	4
12	5	5	4	4	3	3	2	4	4	3	3	5	4	4	5	4	5	4	3	4	5	4	4	3
13	5	5	5	4	4	4	2	3	4	3	3	4	4	4	4	4	5	4	3	4	4	4	4	3
14	5	5	5	4	4	4	2	3	4	3	3	4	4	4	4	4	5	4	3	4	4	4	4	3
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17	4	4	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
18	4	4	3	3	4	3	2	3	4	5	5	5	4	3	4	4	4	4	4	4	4	4	4	4
19	4	4	5	2	2	3	2	2	3	3	4	2	4	2	4	3	3	4	3	4	2	4	1	4
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22	4	4	5	2	2	3	2	2	3	3	4	2	4	2	4	3	2	2	3	4	2	4	1	4
23	4	4	5	2	2	3	2	2	3	3	4	2	4	2	4	3	2	2	3	4	3	4	1	4
24	4	4	5	2	2	3	2	2	3	3	4	2	4	2	4	3	3	4	3	4	2	4	1	4
25	4	4	4	1	1	1	3	1	1	4	4	3	3	4	2	3	3	3	4	4	3	3	3	4
26	4	4	4	1	1	1	1	1	1	4	4	3	3	4	4	3	3	2	2	4	3	3	2	4
27	5	5	5	2	1	1	4	1	4	5	4	4	2	4	2	4	4	4	4	5	4	4	4	4
28	4	4	4	3	3	3	2	4	3	2	3	3	3	2	3	3	3	3	3	4	3	3	2	3
29	4	4	4	3	3	3	2	4	3	2	3	3	3	2	3	3	2	2	3	4	3	3	2	3
30	4	4	4	3	3	3	2	4	3	2	4	4	4	2	3	3	2	3	4	4	3	3	2	4
31	4	4	4	3	3	3	2	3	2	3	3	3	3	3	3	4	4	4	4	4	3	4	2	4
32	5	5	4	3	2	3	3	2	3	3	4	3	3	4	4	3	3	4	4	4	3	5	4	3
33	5	5	4	3	4	3	3	2	3	3	4	4	3	4	4	4	3	4	4	4	3	5	4	4
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35	5	4	4	4	3	3	4	4	4	4	4	5	5	4	4	3	4	3	4	4	4	4	4	4
36	4	4	2	3	3	3	2	2	2	3	3	3	3	4	4	3	3	3	2	4	4	4	3	4
37	4	5	4	3	4	3	4	3	2	4	3	3	2	4	4	3	4	4	4	4	4	4	4	4
38	2	3	2	2	3	2	4	4	2	4	3	2	4	3	2	2	3	3	2	3	3	3	3	3
39	4	4	4	4	3	4	4	4	3	4	4	3	4	3	4	4	3	3	3	2	2	3	3	3
40	4	4	5	4	3	4	3	4	3	4	4	3	5	4	4	4	3	3	2	2	2	2	3	4

Respondent Nr	Q3.1a	Q3.1b	Q3.1c	Q3.1d	Q3.2a	Q3.2b	Q3.2c	Q3.2d	Q3.3a	Q3.3b	Q3.3c	Q3.3d	Q3.4a	Q3.4b	Q3.4c	Q3.4d	Q3.5a	Q3.5b	Q3.5c	Q3.6a	Q3.6b	Q3.6c	Q3.6d	Q3.6e
41	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
42	4	2	4	3	3	2	1	4	4	4	4	4	5	4	5	3	3	3	4	4	3	4	3	4
43	4	2	4	3	3	2	1	4	4	4	4	4	5	4	5	3	3	3	4	4	3	4	3	4
44	1	1	1	2	2	2	1	2	2	2	3	3	2	3	3	3	3	3	2	3	2	2	2	2
45	1	1	2	2	2	2	1	2	2	2	3	3	2	3	3	3	3	3	2	3	2	2	2	2
46	1	1	2	2	2	2	1	2	2	2	3	3	2	3	3	3	3	3	2	3	2	2	2	2
47	1	1	2	2	2	2	1	2	2	2	3	3	2	3	3	3	3	3	2	3	2	2	2	2
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49	3	2	4	3	3	1	2	3	1	1	2	2	3	2	4	3	2	2	1	2	2	2	2	2
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52	5	4	4	5	4	4	3	4	5	2	5	3	5	1	5	2	2	5	2	5	4	4	3	4
53	5	3	4	4	4	4	4	3	3	4	4	4	2	2	3	3	4	2	4	4	4	4	3	2
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55	4	4	3	2	4	3	4	2	4	4	4	3	3	1	4	3	4	4	5	5	5	4	4	4
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67	4	4	4	2	4	4	4	2	4	4	4	4	4	4	4	4	4	3	4	4	4	4	2	2
68	4	3	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3	2	2
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79	4	4	4	4	4	4	4	4	3	4	4	3	4	4	4	4	3	4	4	4	4	4	4	4
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Respondent Nr	Q3.1a	Q3.1b	Q3.1c	Q3.1d	Q3.2a	Q3.2b	Q3.2c	Q3.2d	Q3.3a	Q3.3b	Q3.3c	Q3.3d	Q3.4a	Q3.4b	Q3.4c	Q3.4d	Q3.5a	Q3.5b	Q3.5c	Q3.6a	Q3.6b	Q3.6c	Q3.6d	Q3.6e
81	5	2	5	2	1	1	1	3	3	5	5	3	5	4	5	3	3	4	4	2	3	4	4	5
82	5	5	5	4	1	1	1	4	1	5	5	3	5	5	5	3	3	4	4	4	2	2	1	5
83	4	4	4	3	3	3	3	3	2	3	3	3	4	4	5	4	2	2	4	3	3	3	3	3
84	5	4	5	4	4	5	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	3	3
85	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	4	5
86	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	4	5
87	5	4	4	2	3	3	3	2	3	4	4	3	4	3	4	3	4	4	3	4	4	4	4	3
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92	4	4	4	2	2	2	2	3	3	2	2	3	4	2	2	2	4	4	4	3	2	3	3	4
93	4	3	4	4	4	4	3	4	4	3	4	3	3	4	3	4	1	2	3	4	4	4	3	4
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100	5	4	5	3	3	4	2	3	4	2	2	2	3	2	2	3	3	2	3	2	2	2	2	4
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103	5	5	4	3	5	4	4	3	4	2	4	4	4	3	4	3	5	4	4	4	4	4	4	4
104	5	5	4	3	5	4	4	3	4	2	4	4	4	3	4	3	5	4	4	4	4	4	4	4
105	5	3	4	2	2	2	2	2	4	3	3	4	3	3	4	3	4	4	3	4	4	4	3	4
106	5	3	4	2	2	2	2	2	4	3	3	4	3	3	4	3	4	4	3	4	4	4	3	4
107	5	2	4	2	5	2	5	4	4	4	5	4	4	3	5	4	4	4	4	4	4	4	3	4
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110	4	2	4	2	3	3	2	3	2	2	3	3	2	2	2	2	2	2	1	2	2	2	2	2
111	4	3	4	4	3	3	2	3	2	4	3	3	2	2	2	2	2	2	1	3	3	3	3	2
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113	4	3	4	4	3	3	2	3	2	4	4	2	2	2	2	2	3	3	3	3	3	3	3	3
114	4	3	4	4	3	3	2	4	3	3	4	2	2	2	2	2	3	3	3	3	3	3	3	3
115	4	3	4																					
116	4	3	4	4	3	3	4	3	2	2	3	2	4	3	4	3	3	2	2	3	3	3	2	3
117	4	3	4	2	3	3	4	3	4	4	4	3	4	2	4	3	3	2	4	4	4	4	3	3
118	4	4	4	4	3	3	4	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
119	4	2	4	3	1	1	1	2	1	1	1	1	2	3	3	3	3	3	3	3	3	3	3	3
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Respondent Nr	Q4.1a	Q4.1b	Q4.1c	Q4.1d	Q4.1e	Q4.2a	Q4.2b	Q4.2c	Q4.2d	Q4.2e	Q4.3a	Q4.3b	Q4.3c	Q4.4a	Q4.4b	Q4.4c
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2	4	4	4	3	4	4	4	4	3	3	4	4	4	2	2	2
3	2	4	4	4	3	4	4	4	3	3	4	4	4	4	4	4
4	4	4	3	3	4	4	3	3	3	3	4	3	3	3	3	3
5	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3
6	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3
7	2	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1
8	5	5	4	5	5	5	4	3	5	4	5	4	3	3	3	3
9	5	4	4	5	4	5	4	3	5	4	5	4	3	3	3	3
10	4	3	2	4	2	3	2	2	3	2	3	2	2	3	3	3
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12	5	4	3	5	3	5	4	3	5	3	4	4	3	5	5	5
13	5	4	3	4	3	4	4	4	5	3	2	3	3	4	4	4
14	5	4	3	4	3	4	4	4	5	3	2	3	3	4	4	4
15	4	4	2	2	2	4	4	3	2	4	2	2	2	2	2	2
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17	4	5	4	4	4	4	4	4	4	4	3	3	3	3	3	3
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19	5	4	2	4	3	5	3	1	4	3	5	2	1	3	2	1
20	5	2	2	4	3	5	3	1	4	3	5	2	1	3	2	1
21	5	2	2	4	3	5	3	1	4	2	5	2	1	3	2	1
22	5	2	2	1	3	5	3	1	1	3	5	2	1	1	1	1
23	5	2	2	4	3	5	3	1	4	3	5	2	1	3	2	1
24	5	4	2	4	3	5	3	1	4	3	5	2	1	3	2	1
25	4	2	2	3	3	4	4	4	3	3	3	3	3	2	1	1
26	4	2	2	3	3	4	4	4	4	2	3	3	3	4	1	1
27	4	2	2	3	3	4	3	4	4	4	3	3	3	4	4	4
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29	4	3	3	3	4	3	4	2	4	4	3	3	3	4	4	4
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31	3	2	2	3	4	4	3	2	3	4	2	3	2	4	4	3
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33	5	5	3	5	4	5	5	4	4	4	5	5	3	3	3	3
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36	4	3	4	3	2	4	4	3	4	3	4	3	4	4	3	4
37	5	3	4	2	3	4	4	4	5	4	4	4	4	4	3	4
38	4	4	4	4	2	4	4	4	4	4	4	5	3	2	2	2
39	4	4	4	4	4	4	4	4	4	4	4	4	2	3	3	3
40	2	2	3	2	3	2	2	2	3	4	3	3	2	4	4	4

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Respondent Nr	Q4.1a	Q4.1b	Q4.1c	Q4.1d	Q4.1e	Q4.2a	Q4.2b	Q4.2c	Q4.2d	Q4.2e	Q4.3a	Q4.3b	Q4.3c	Q4.4a	Q4.4b	Q4.4c
41	4	3	4	4	4	4	3	4	4	4	3	3	2	4	4	4
42	3	2	2	4	4	3	2	3	3	3	3	3	3	2	2	3
43	3	2	2	4	4	3	2	3	3	3	3	3	3	2	2	3
44	2	2	2	2	3	2	2	1	1	1	1	1	1	2	2	2
45	2	2	2	2	3	2	2	1	1	1	1	1	1	2	2	2
46	2	2	2	2	3	2	2	1	1	1	1	1	1	2	2	2
47	2	2	2	2	3	2	2	1	1	1	1	1	1	2	2	2
48	4	4	3	4	4	4	4	2	4	4	3	3	3	2	2	3
49	4	3	3	2	2	4	3	4	3	2	4	3	4	1	2	1
50	5	3	4	4	4	4	3	4	4	4	4	4	4	2	2	3
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53	2	3	3	4	2	4	4	3	2	3	1	1	1	4	3	3
54	4	4	4	4	2	4	4	4	4	4	4	4	4	2	2	2
55	5	4	3	1	4	2	4	3	3	1	3	4	3	5	5	5
56	4	4	4	2	2	3	4	4	4	2	2	3	3	4	4	4
57	2	3	2	2	3	3	2	1	3	3	2	1	2	2	3	2
58	4	4	2	5	2	4	5	2	4	2	4	4	2	4	4	5
59	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3
60	5	5	3	5	2	5	5	2	5	3	5	4	2	5	5	5
61	5	5	4	5	4	5	5	5	5	4	4	2	2	5	4	4
62	5	3	1	1	1	5	3	1	4	1	4	2	2	5	4	4
63	2	2	2	4	2	2	3	4	3	4	1	4	4	3	3	3
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65	4	5	5	4	4	5	5	5	5	5	5	5	5	4	4	4
66	4	4	2	2	3	4	4	4	4	4	5	4	4	2	2	2
67	4	4	2	4	2	4	4	4	4	4	5	4	4	4	4	4
68	4	2	4	3	3	4	3	4	4	2	4	4	4	3	3	3
69	4	3	4	4	2	4	4	4	3	2	4	4	4	3	3	3
70	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4
71	2	2	2	4	3	4	4	4	4	3	2	3	2	1	1	1
72	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4
73	3	3	3	4	4	4	4	5	4	5	2	2	3	3	3	3
74	3	4	3	4	4	5	4	4	4	5	2	2	3	3	3	3
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76	4	4	4	4	4	4	4	3	4	4	3	4	4	4	4	4
77	4	4	4	4	4	4	4	3	4	4	3	4	4	4	4	4
78	3	3	3	3	3	4	4	4	3	3	3	2	3	4	4	4
79	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	3
80	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

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Respondent Nr	Q4.1a	Q4.1b	Q4.1c	Q4.1d	Q4.1e	Q4.2a	Q4.2b	Q4.2c	Q4.2d	Q4.2e	Q4.3a	Q4.3b	Q4.3c	Q4.4a	Q4.4b	Q4.4c
81	5	3	4	3	2	3	3	2	4	3	4	4	4	1	2	2
82	5	3	2	3	2	3	2	2	2	4	4	4	4	5	4	2
83	5	3	3	4	5	4	4	3	4	4	2	4	2	4	3	3
84	4	3	4	5	5	4	4	3	4	5	3	3	3	4	3	3
85	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
86	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
87	4	3	3	3	2	4	3	2	3	2	4	4	4	4	4	2
88	4	4	4	3	2	4	4	4	4	4	2	4	4	2	2	2
89	4	4	4	3	2	4	4	4	4	4	2	4	4	2	2	2
90	4	4	4	3	4	4	4	4	4	4	2	4	4	2	2	2
91	2	2	2	2	2	3	4	4	4	4	1	1	2	2	2	2
92	3	2	2	3	3	3	4	4	3	3	1	1	2	1	1	1
93	3	3	2	2	2	2	2	2	2	2	3	3	3	2	2	2
94	5	4	5	3	4	4	4	4	4	4	4	4	4	5	4	5
95	3	4	4	3	4	4	4	4	4	4	2	4	4	3	3	3
96	5	4	5	4	4	4	3	4	4	5	4	4	5	4	4	4
97	5	4	5	4	4	4	3	5	4	5	4	4	5	4	4	4
98	3	4	4	3	3	4	3	4	4	4	4	4	4	3	3	2
99	3	2	2	2	2	4	4	3	3	3	2	2	2	2	2	2
100	3	2	2	2	2	4	4	3	3	3	2	2	2	2	2	2
101	3	2	2	2	2	4	4	4	4	3	2	2	2	3	4	4
102	3	2	2	2	2	4	4	4	4	3	2	2	2	3	2	2
103	4	3	4	4	3	4	4	4	4	4	2	2	2	3	4	4
104	4	3	4	4	3	4	4	4	4	4	2	2	2	3	4	4
105	5	5	4	3	2	5	5	5	4	2	5	5	3	2	2	3
106	5	5	4	3	2	5	5	5	4	2	5	5	3	2	2	3
107	5	5	4	2	2	5	5	5	4	2	5	5	3	2	2	3
108	5	5	4	2	2	5	5	5	4	2	5	5	3	2	2	3
109	5	5	4	5	5	5	5	5	4	2	5	5	3	2	2	3
110	2	2	2	2	2	2	3	3	2	2	2	2	2	3	3	3
111	2	2	2	2	2	2	3	3	2	2	2	2	2	3	3	3
112	2	2	2	2	2	2	3	3	2	2	2	2	2	3	3	3
113	2	2	2	2	2	2	3	3	2	2	2	2	2	3	3	3
114	2	2	2	2	2	2	3	3	2	2	2	2	2	3	3	3
115														4	4	4
116	3	3	2	2	2	4	4	4	2	2	4	4	3	3	3	3
117	2	3	2	2	2	4	4	3	3	3	4	4	3	3	3	3
118	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4
119	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	4
120	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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Appendix C

Statistical Analysis

C1: Statistical Analysis All Cases: All projects together culture, Wisdom and Relationships

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2c + \beta_4 Q2.2d + \beta_5 Q2.3a + \beta_6 Q2.3b + \beta_7 Q2.3c + \beta_8 Q2.3d + \beta_9 Q2.4a + \beta_{10} Q2.4b + \beta_{11} Q2.4c + \beta_{12} Q2.4d + \beta_{13} Q3.1a + \beta_{14} Q3.1b + \beta_{15} Q3.1c + \beta_{16} Q3.1d + \beta_{17} Q3.2a + \beta_{18} Q3.2b + \beta_{19} Q3.2c + \beta_{20} Q3.2d + \beta_{21} Q3.3a + \beta_{22} Q3.3b + \beta_{23} Q3.3c + \beta_{24} Q3.3d + \beta_{25} Q3.4a + \beta_{26} Q3.4b + \beta_{27} Q3.4c + \beta_{28} Q3.4d + \beta_{29} Q3.5a + \beta_{30} Q3.5b + \beta_{31} Q3.5c + \beta_{32} Q3.6a + \beta_{33} Q3.6b + \beta_{34} Q3.6c + \beta_{35} Q3.6d + \beta_{36} Q3.6e + \beta_{37} Q4.1a + \beta_{38} Q4.1b + \beta_{39} Q4.1c + \beta_{40} Q4.1d + \beta_{41} Q4.1e + \beta_{42} Q4.2a + \beta_{43} Q4.2b + \beta_{44} Q4.2c + \beta_{45} Q4.2d + \beta_{46} Q4.3a + \beta_{47} Q4.3b + \beta_{48} Q4.3c + \beta_{49} Q4.4a + \beta_{50} Q4.4b + \beta_{51} Q4.4c$$

```
Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d + Q2.4a + Q2.4b + Q2.4c + Q2.4d + Q3.1a +
    Q3.1b + Q3.1c + Q3.1d + Q3.2a + Q3.2b + Q3.2c + Q3.2d + Q3.3a +
    Q3.3b + Q3.3c + Q3.3d + Q3.4a + Q3.4b + Q3.4c + Q3.4d + Q3.5a +
    Q3.5b + Q3.5c + Q3.6a + Q3.6b + Q3.6c + Q3.6d + Q3.6e + Q4.1a +
    Q4.1b + Q4.1c + Q4.1d + Q4.1e + Q4.2a + Q4.2b + Q4.2c + Q4.2d +
    Q4.3a + Q4.3b + Q4.3c + Q4.4a + Q4.4b + Q4.4c, data = all3)

Residuals:
    Min      1Q  Median      3Q     Max
-2.6739 -0.5560  0.0371  0.6496  3.3408

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.66593    2.25895   1.623   0.1095
Q2.2a        0.46749    0.33203   1.408   0.1639
Q2.2b        0.30953    0.33420   0.926   0.3578
Q2.2c        0.13278    0.40512   0.328   0.7442
Q2.2d       -0.30279    0.28956  -1.046   0.2996
Q2.3a       -0.26635    0.21229  -1.255   0.2141
Q2.3b       -0.21755    0.33351  -0.652   0.5165
Q2.3c       -0.27634    0.30330  -0.911   0.3656
Q2.3d       -0.37960    0.22782  -1.666   0.1005
Q2.4a        0.01294    0.17890   0.072   0.9425
Q2.4b        0.09764    0.19613   0.498   0.6203
Q2.4c        0.23162    0.19345   1.197   0.2355
Q2.4d       -0.13327    0.17050  -0.782   0.4373
Q3.1a       -0.13316    0.36037  -0.370   0.7129
Q3.1b        0.13494    0.32302   0.418   0.6775
Q3.1c        0.56601    0.27141   2.085   0.0410 *
Q3.1d        0.05196    0.29184   0.178   0.8592
Q3.2a        0.72542    0.33890   2.141   0.0361 *
```

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```
Q3.2b       -0.60868    0.38654  -1.575   0.1202
Q3.2c        0.19804    0.21892   0.905   0.3690
Q3.2d        0.20038    0.30556   0.656   0.5143
Q3.3a        0.19930    0.33590   0.593   0.5550
Q3.3b       -0.34807    0.33336  -1.044   0.3003
Q3.3c       -0.10755    0.30294  -0.355   0.7237
Q3.3d       -0.20337    0.34257  -0.594   0.5548
Q3.4a       -0.23726    0.34771  -0.682   0.4974
Q3.4b        0.07215    0.29646   0.243   0.8085
Q3.4c       -0.21646    0.36789  -0.588   0.5583
Q3.4d       -0.37164    0.39081  -0.951   0.3452
Q3.5a        0.09265    0.35488   0.261   0.7949
Q3.5b        0.51136    0.34766   1.471   0.1462
Q3.5c       -0.34657    0.30003  -1.155   0.2523
Q3.6a       -0.34291    0.40783  -0.841   0.4035
Q3.6b        0.01841    0.37765   0.049   0.9613
Q3.6c        0.41630    0.52668   0.790   0.4322
Q3.6d        0.18925    0.34032   0.556   0.5801
Q3.6e       -0.34598    0.34410  -1.005   0.3184
Q4.1a       -0.22467    0.31328  -0.717   0.4759
Q4.1b        0.24428    0.31823   0.768   0.4455
Q4.1c       -0.18988    0.30501  -0.623   0.5358
Q4.1d       -0.13751    0.27457  -0.501   0.6182
Q4.1e        0.40714    0.26886   1.514   0.1348
Q4.2a        0.35883    0.47338   0.758   0.4512
Q4.2b       -0.34705    0.42369  -0.819   0.4157
Q4.2c       -0.27279    0.28337  -0.963   0.3393
Q4.2d       -0.22519    0.29831  -0.755   0.4530
Q4.3a       -0.15791    0.32885  -0.480   0.6327
Q4.3b        0.22495    0.36786   0.612   0.5430
Q4.3c        0.09364    0.34488   0.272   0.7868
Q4.4a        0.61890    0.39720   1.558   0.1240
Q4.4b       -0.88938    0.59052  -1.506   0.1369
Q4.4c        0.34279    0.44014   0.779   0.4389
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.35 on 65 degrees of freedom
Multiple R-squared:  0.6491,    Adjusted R-squared:  0.3737
F-statistic: 2.357 on 51 and 65 DF,  p-value: 0.0005872
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Three)
    Q2.2a     Q2.2b     Q2.2c     Q2.2d     Q2.3a     Q2.3b     Q2.3c     Q2.3d
 3.851712  5.697468  8.213458  4.640301  2.696667  6.909038  5.651828  3.802640
    Q2.4a     Q2.4b     Q2.4c     Q2.4d     Q3.1a     Q3.1b     Q3.1c     Q3.1d
 3.977136  5.415447  5.631763  4.099770  6.641786  7.054590  3.649302  5.283212
    Q3.2a     Q3.2b     Q3.2c     Q3.2d     Q3.3a     Q3.3b     Q3.3c     Q3.3d
 8.437092  8.672786  3.915339  4.593777  6.098287  5.575203  3.429364  5.863129
    Q3.4a     Q3.4b     Q3.4c     Q3.4d     Q3.5a     Q3.5b     Q3.5c     Q3.6a
 6.285263  5.989093  7.572678  5.942255  6.055817  5.946946  4.330302  5.340202
    Q3.6b     Q3.6c     Q3.6d     Q3.6e     Q4.1a     Q4.1b     Q4.1c     Q4.1d
 7.269859  9.176725  6.929977  4.566516  6.734096  6.524932  5.774148  4.962724
    Q4.1e     Q4.2a     Q4.2b     Q4.2c     Q4.2d     Q4.3a     Q4.3b     Q4.3c
 3.978133 11.040398  7.743367  6.700521  5.091785 10.092095 10.515634  8.165517
    Q4.4a     Q4.4b     Q4.4c
10.173709 21.614561 13.487855
```

We remove the variable with the highest VIF value and re-run to the test until no variable has a VIF value above 5. We will proceed with modified linear regression model

The variables with a VIF Value higher than 5:

Q2.2b, Q2.2c, Q2.3b, Q2.3c, Q2.4b, Q2.4c, Q3.1a, Q3.1b, Q3.1d, Q3.2a, Q3.2b, Q3.3a, Q3.3b, Q3.3d, Q3.4a, Q3.4b, Q3.4c, Q3.4d, Q3.5a, Q3.5b, Q3.6a, Q3.6b, Q3.6c, Q3.6d, Q4.1a, Q4.1b, Q4.1c, Q4.2a, Q4.2b, Q4.2c, Q4.2d, Q4.3a, Q4.3b, Q4.3c, Q4.4a, Q4.4b, Q4.4c

```
> vif(Three)
   Q2.2a    Q2.2b    Q2.2d    Q2.3a    Q2.3c    Q2.3d    Q2.4a    Q2.4b    Q2.4c
2.995329 2.944639 2.766650 2.422183 3.115415 2.832511 2.767934 3.360815 3.407224
   Q2.4d    Q3.1a    Q3.1c    Q3.1d    Q3.2b    Q3.2c    Q3.2d    Q3.3a    Q3.3b
3.110778 4.163305 2.701030 3.187047 3.285417 3.004610 3.090514 4.147419 3.116850
   Q3.3c    Q3.3d    Q3.4a    Q3.4b    Q3.4c    Q3.4d    Q3.5a    Q3.5b    Q3.5c
2.810283 4.151304 3.848127 4.368528 4.067495 4.155081 3.843083 2.984130 3.079848
   Q3.6a    Q3.6b    Q3.6d    Q3.6e    Q4.1a    Q4.1b    Q4.1d    Q4.1e    Q4.2c
3.013189 5.365301 4.127861 2.625554 4.489981 3.531710 3.440910 3.067322 3.489732
   Q4.2d    Q4.3c    Q4.4a
4.082395 3.168925 2.696770
```

Revised model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2d + \beta_4 Q2.3a + \beta_5 Q2.3c + \beta_6 Q2.3d + \beta_7 Q2.4a + \beta_8 Q2.4b + \beta_9 Q2.4c + \beta_{10} Q2.4d + \beta_{11} Q3.1a + \beta_{12} Q3.1c + \beta_{13} Q3.1d + \beta_{14} Q3.2b + \beta_{15} Q3.2c + \beta_{16} Q3.2d + \beta_{17} Q3.3a + \beta_{18} Q3.3b + \beta_{19} Q3.3c + \beta_{20} Q3.3d + \beta_{21} Q3.4a + \beta_{22} Q3.4b + \beta_{23} Q3.4c + \beta_{24} Q3.4d + \beta_{25} Q3.5a + \beta_{26} Q3.5b + \beta_{27} Q3.5c + \beta_{28} Q3.6a + \beta_{29} Q3.6b + \beta_{30} Q3.6d + \beta_{31} Q3.6e + \beta_{32} Q4.1a + \beta_{33} Q4.1b + \beta_{34} Q4.1d + \beta_{35} Q4.1e + \beta_{36} Q4.2c + \beta_{37} Q4.2d + \beta_{38} Q4.3c + \beta_{39} Q4.4a$$

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

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```
> bptest(Three)

        studentized Breusch-Pagan test

data:  Three
BP = 36.959, df = 39, p-value = 0.5633
```

The P-value of the BP test is 0.5633 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

```
> cor(resid(Three),all3$Q2.2a)
[1] 9.682666e-17
> cor(resid(Three),all3$Q2.2b)
[1] 1.874704e-16
> cor(resid(Three),all3$Q2.2d)
[1] 3.64129e-17
> cor(resid(Three),all3$Q2.3a)
[1] -1.584895e-18
> cor(resid(Three),all3$Q2.3c)
[1] 4.974245e-17
> cor(resid(Three),all3$Q2.3d)
[1] 2.946721e-17
> cor(resid(Three),all3$Q2.4a)
[1] -1.343791e-16
> cor(resid(Three),all3$Q2.4b)
[1] -6.75668e-17
> cor(resid(Three),all3$Q2.4c)
[1] -1.047605e-16
> cor(resid(Three),all3$Q2.4d)
[1] -2.444768e-16
> cor(resid(Three),all3$Q3.1a)
[1] 3.640236e-16
> cor(resid(Three),all3$Q3.1c)
[1] 2.109859e-16
> cor(resid(Three),all3$Q3.1d)
[1] 8.697759e-17
> cor(resid(Three),all3$Q3.2b)
[1] 5.712771e-17
> cor(resid(Three),all3$Q3.2c)
[1] 4.235285e-17
> cor(resid(Three),all3$Q3.2d)
[1] -6.232818e-17
> cor(resid(Three),all3$Q3.3a)
[1] 6.334817e-17
> cor(resid(Three),all3$Q3.3b)
[1] -4.65591e-17
> cor(resid(Three),all3$Q3.3c)
[1] 1.721575e-16
> cor(resid(Three),all3$Q3.3d)
[1] 5.009957e-17
```

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```
> cor(resid(Three),all3$Q3.4a)
[1] 3.946952e-17
> cor(resid(Three),all3$Q3.4b)
[1] -2.369062e-16
> cor(resid(Three),all3$Q3.4c)
[1] 1.525723e-16
> cor(resid(Three),all3$Q3.4d)
[1] -4.91271e-17
> cor(resid(Three),all3$Q3.5a)
[1] -1.853043e-17
> cor(resid(Three),all3$Q3.5b)
[1] -1.088576e-16
> cor(resid(Three),all3$Q3.5c)
[1] 8.42498e-17
> cor(resid(Three),all3$Q3.6a)
[1] 5.417989e-17
> cor(resid(Three),all3$Q3.6b)
[1] 9.0038e-17
> cor(resid(Three),all3$Q3.6d)
[1] -7.187767e-17
> cor(resid(Three),all3$Q3.6e)
[1] 1.203226e-16
> cor(resid(Three),all3$Q4.1a)
[1] 1.505689e-17
> cor(resid(Three),all3$Q4.1b)
[1] 6.409122e-17
> cor(resid(Three),all3$Q4.1d)
[1] -2.857234e-16
> cor(resid(Three),all3$Q4.1e)
[1] -1.041671e-16
> cor(resid(Three),all3$Q4.2c)
[1] 6.244607e-17
> cor(resid(Three),all3$Q4.2d)
[1] 2.821779e-18
> cor(resid(Three),all3$Q4.3c)
[1] -6.413297e-17
> cor(resid(Three),all3$Q4.4a)
[1] 3.695237e-17
>
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).

Any regressor with a P-Value less than 0.15 is significant for the OLS Regression Model.

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	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	3.225448	1.971621	1.636	0.1059	
Q2.2a	0.388440	0.289754	1.341	0.1840	
Q2.2b	0.394616	0.237764	1.660	0.1010	
Q2.2d	-0.461729	0.221262	-2.087	0.0402	*
Q2.3a	-0.276540	0.199108	-1.389	0.1689	
Q2.3c	-0.316018	0.222843	-1.418	0.1602	
Q2.3d	-0.443415	0.194583	-2.279	0.0255	*
Q2.4a	0.109886	0.147695	0.744	0.4591	
Q2.4b	-0.053019	0.152903	-0.347	0.7297	
Q2.4c	0.163876	0.148908	1.101	0.2745	
Q2.4d	-0.036556	0.146979	-0.249	0.8042	
Q3.1a	0.011164	0.282352	0.040	0.9686	
Q3.1c	0.255095	0.231075	1.104	0.2731	
Q3.1d	-0.093700	0.224315	-0.418	0.6773	
Q3.2b	0.088162	0.235439	0.374	0.7091	
Q3.2c	0.285867	0.189786	1.506	0.1361	
Q3.2d	0.310154	0.248021	1.251	0.2149	
Q3.3a	0.043507	0.274130	0.159	0.8743	
Q3.3b	-0.297567	0.246666	-1.206	0.2314	
Q3.3c	-0.094834	0.271387	-0.349	0.7277	
Q3.3d	-0.159672	0.285259	-0.560	0.5773	
Q3.4a	-0.318649	0.269241	-1.184	0.2403	
Q3.4b	0.106381	0.250564	0.425	0.6723	
Q3.4c	-0.005691	0.266817	-0.021	0.9830	
Q3.4d	-0.273758	0.323405	-0.846	0.3999	
Q3.5a	0.116541	0.279766	0.417	0.6782	
Q3.5b	0.541832	0.243715	2.223	0.0291	*
Q3.5c	-0.171177	0.250400	-0.684	0.4963	
Q3.6a	-0.145108	0.303162	-0.479	0.6335	
Q3.6b	0.093910	0.321060	0.292	0.7707	
Q3.6d	0.366279	0.259924	1.409	0.1628	
Q3.6e	-0.120429	0.258202	-0.466	0.6422	
Q4.1a	-0.117848	0.253154	-0.466	0.6429	
Q4.1b	0.076774	0.231692	0.331	0.7413	
Q4.1d	-0.154424	0.226254	-0.683	0.4970	
Q4.1e	0.295344	0.233629	1.264	0.2100	
Q4.2c	-0.230970	0.202374	-1.141	0.2573	
Q4.2d	-0.047126	0.264332	-0.178	0.8590	
Q4.3c	-0.107998	0.212618	-0.508	0.6129	
Q4.4a	0.141643	0.202372	0.700	0.4861	

Final model after GM Assumptions, the final model at 90% confidence level is:

$$y_{ProjectSuccess} = \beta_0 + 0.394616Q2.2b - 0.461729Q2.2d - 0.443415Q2.3d + 0.285867Q3.2c + 0.541832Q3.5b$$

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All Projects, Relationship

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2c + \beta_4 Q2.2d + \beta_5 Q2.3a + \beta_6 Q2.3b + \beta_7 Q2.3c + \beta_8 Q2.3d + \beta_9 Q2.4a + \beta_{10} Q2.4b + \beta_{11} Q2.4c + \beta_{12} Q2.4d$$

```
Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d + Q2.4a + Q2.4b + Q2.4c + Q2.4d, data = all3)

Residuals:
    Min      1Q  Median      3Q     Max
-2.6386 -0.9022 -0.0351  1.1494  3.1895

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.00682    1.32333   2.272   0.0251 *
Q2.2a        0.14759    0.20503   0.720   0.4732
Q2.2b        0.35705    0.19843   1.799   0.0749 .
Q2.2c        0.32719    0.22027   1.485   0.1405
Q2.2d       -0.34272    0.17535  -1.954   0.0533 .
Q2.3a       -0.17553    0.15896  -1.104   0.2720
Q2.3b       -0.19358    0.18436  -1.050   0.2961
Q2.3c       -0.15635    0.18557  -0.843   0.4014
Q2.3d       -0.42618    0.16359  -2.605   0.0105 *
Q2.4a        0.09973    0.12076   0.826   0.4108
Q2.4b        0.05344    0.11857   0.451   0.6531
Q2.4c        0.29434    0.12186   2.415   0.0175 *
Q2.4d       -0.15383    0.10982  -1.401   0.1643
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.321 on 104 degrees of freedom
Multiple R-squared:  0.4626,    Adjusted R-squared:  0.4006
F-statistic:  7.46 on 12 and 104 DF,  p-value: 9.397e-10
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Relationships)
   Q2.2a    Q2.2b    Q2.2c    Q2.2d    Q2.3a    Q2.3b    Q2.3c    Q2.3d    Q2.4a
1.534440 2.098538 2.536810 1.777954 1.579604 2.205655 2.210540 2.048400 1.893201
   Q2.4b    Q2.4c    Q2.4d
2.067652 2.334788 1.776987
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Relationships)

        studentized Breusch-Pagan test

data:  Relationships
BP = 10.541, df = 12, p-value = 0.5686
```

The P-value of the BP test is 0.5685 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

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```
> cor(resid(Relationships),all3$Q2.2a)
[1] 8.43718e-17
> cor(resid(Relationships),all3$Q2.2b)
[1] 1.797669e-16
> cor(resid(Relationships),all3$Q2.2c)
[1] 1.824196e-16
> cor(resid(Relationships),all3$Q2.2d)
[1] -5.744933e-18
> cor(resid(Relationships),all3$Q2.3d)
[1] 1.299122e-17
> cor(resid(Relationships),all3$Q2.3a)
[1] 1.015664e-17
> cor(resid(Relationships),all3$Q2.3b)
[1] 2.600407e-18
> cor(resid(Relationships),all3$Q2.3c)
[1] 1.927149e-18
> cor(resid(Relationships),all3$Q2.4a)
[1] -3.769703e-17
> cor(resid(Relationships),all3$Q2.4b)
[1] -3.942947e-17
> cor(resid(Relationships),all3$Q2.4c)
[1] -1.096423e-16
> cor(resid(Relationships),all3$Q2.4d)
[1] -1.685287e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).

Any regressor with a P-Value less than 0.15 is significant for the OLS Regression Model.

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.00682    1.32333   2.272   0.0251 *
Q2.2a        0.14759    0.20503   0.720   0.4732
Q2.2b        0.35705    0.19843   1.799   0.0749 .
Q2.2c        0.32719    0.22027   1.485   0.1405
Q2.2d       -0.34272    0.17535  -1.954   0.0533 .
Q2.3a       -0.17553    0.15896  -1.104   0.2720
Q2.3b       -0.19358    0.18436  -1.050   0.2961
Q2.3c       -0.15635    0.18557  -0.843   0.4014
Q2.3d       -0.42618    0.16359  -2.605   0.0105 *
Q2.4a        0.09973    0.12076   0.826   0.4108
Q2.4b        0.05344    0.11857   0.451   0.6531
Q2.4c        0.29434    0.12186   2.415   0.0175 *
Q2.4d       -0.15383    0.10982  -1.401   0.1643
```

Final model after GM Assumptions, the final model for relationships at a 90% confidence level is:

$$y_{ProjectSuccess} = 3.0068 + 0.35705Q2.2b + 0.32719Q2.2c - 0.34272Q2.2d - 0.42618Q2.3d - 0.29434Q2.4c$$

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All Projects, Wisdom

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q3.1a + \beta_2 Q3.1b + \beta_3 Q3.1c + \beta_4 Q3.1d + \beta_5 Q3.2a + \beta_6 Q3.2b + \beta_7 Q3.2c + \beta_8 Q3.2d + \beta_9 Q3.3a + \beta_{10} Q3.3b + \beta_{11} Q3.3c + \beta_{12} Q3.3d + \beta_{13} Q3.4a + \beta_{14} Q3.4b + \beta_{15} Q3.4c + \beta_{16} Q3.4d + \beta_{17} Q3.5a + \beta_{18} Q3.5b + \beta_{19} Q3.5c + \beta_{20} Q3.6a + \beta_{21} Q3.6b + \beta_{22} Q3.6c + \beta_{23} Q3.6d + \beta_{24} Q3.6e$$

```
> summary(Wisdom)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2a +
    Q3.2b + Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a +
    Q3.4b + Q3.4c + Q3.4d + Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6b +
    Q3.6c + Q3.6d + Q3.6e, data = all)

Residuals:
    Min      1Q  Median      3Q     Max
-3.5707 -0.9503  0.0558  0.8238  2.7150

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.24514    1.28682   0.191   0.8493
Q3.1a       -0.36278    0.25778  -1.407   0.1628
Q3.1b        0.58905    0.23332   2.525   0.0133 *
Q3.1c        0.10183    0.24589   0.414   0.6798
Q3.1d       -0.40197    0.23107  -1.740   0.0853 .
Q3.2a        0.26165    0.27910   0.937   0.3510
Q3.2b        0.14854    0.31341   0.474   0.6367
Q3.2c        0.06257    0.18166   0.344   0.7313
Q3.2d        0.43418    0.24691   1.758   0.0821 .
Q3.3a        0.11822    0.27653   0.428   0.6700
Q3.3b       -0.18063    0.24656  -0.733   0.4657
Q3.3c        0.20140    0.27345   0.737   0.4633
Q3.3d       -0.34279    0.28218  -1.215   0.2276
Q3.4a       -0.63388    0.27505  -2.305   0.0235 *
Q3.4b        0.46384    0.23441   1.979   0.0509 .
Q3.4c       -0.07992    0.27106  -0.295   0.7688
Q3.4d       -0.38243    0.33273  -1.149   0.2534
Q3.5a        0.21970    0.25439   0.864   0.3901
Q3.5b        0.58086    0.23544   2.467   0.0155 *
Q3.5c        0.08794    0.23508   0.374   0.7092
Q3.6a       -0.30175    0.35281  -0.855   0.3947
Q3.6b        0.07576    0.30195   0.251   0.8025
Q3.6c        0.63182    0.40056   1.577   0.1182
Q3.6d       -0.08023    0.22967  -0.349   0.7277
Q3.6e       -0.18078    0.26408  -0.685   0.4954
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Wisdom)
   Q3.1a    Q3.1b    Q3.1c    Q3.1d    Q3.2a    Q3.2b    Q3.2c    Q3.2d    Q3.3a
2.865731 3.092025 2.526705 2.774876 4.753721 4.749961 2.259725 2.530443 3.466352
   Q3.3b    Q3.3c    Q3.3d    Q3.4a    Q3.4b    Q3.4c    Q3.4d    Q3.5a    Q3.5b
2.558059 2.351374 3.334391 3.304521 3.142344 3.460683 3.604407 2.597482 2.281088
   Q3.5c    Q3.6a    Q3.6b    Q3.6c    Q3.6d    Q3.6e
2.223030 3.361135 3.885720 4.439703 2.625108 2.252552
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Wisdom)

        studentized Breusch-Pagan test

data:  Wisdom
BP = 15.685, df = 24, p-value = 0.8991
```

The P-value of the BP test is 0.8991 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

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Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.
Correlation of regressors to the residual should be close to if not equal to zero.
This can be done in R software.

```
> cor(resid(Relationships),all$Q1.2b)
[1] 2.139968e-16
> cor(resid(Relationships),all$Q1.3b)
[1] 1.778358e-16
> cor(resid(Relationships),all$Q1.4b)
[1] -1.121961e-16
> cor(resid(Relationships),all$Q1.5b)
[1] -3.233124e-17
> cor(resid(Relationships),all$Q1.6b)
[1] -2.558202e-18
> cor(resid(Relationships),all$Q1.8b)
[1] -2.481284e-17
> cor(resid(Relationships),all$Q2.1a)
[1] -1.540396e-16
> cor(resid(Relationships),all$Q2.1b)
[1] -2.891953e-17
> cor(resid(Relationships),all$Q2.1c)
[1] -9.380119e-17
> cor(resid(Relationships),all$Q2.1d)
[1] -2.14681e-16
> cor(resid(Relationships),all$Q2.2a)
[1] 4.578863e-19
> cor(resid(Relationships),all$Q2.2b)
[1] -2.122149e-17
> cor(resid(Relationships),all$Q2.2c)
[1] -8.793407e-17
> cor(resid(Relationships),all$Q2.2d)
[1] 1.363637e-16
> cor(resid(Relationships),all$Q2.1e)
[1] -2.765984e-16
> cor(resid(Relationships),all$Q2.1f)
[1] -1.992438e-16
> cor(resid(Relationships),all$Q2.1g)
[1] -3.338847e-17
> cor(resid(Relationships),all$Q2.1g)
[1] -3.338847e-17
> cor(resid(Relationships),all$Q2.1h)
[1] -2.783314e-17
> cor(resid(Relationships),all$Q2.3a)
[1] -3.270538e-17
> cor(resid(Relationships),all$Q2.3b)
[1] 4.54345e-17
> cor(resid(Relationships),all$Q2.3c)
[1] 1.614605e-16
> cor(resid(Relationships),all$Q2.3d)
[1] 1.593418e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor
Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.98560	1.70141	1.167	0.2462	
Q1.2b	0.26613	0.21407	1.243	0.2169	
Q1.3b	0.22606	0.14182	1.594	0.1143	
Q1.4b	-0.24280	0.24077	-1.008	0.3159	
Q1.5b	0.23281	0.23410	0.994	0.3226	
Q1.6b	0.41631	0.19081	2.182	0.0316	*
Q1.8b	-0.20847	0.24124	-0.864	0.3897	
Q2.1a	-0.34117	0.38804	-0.879	0.3815	
Q2.1b	-0.47624	0.46925	-1.015	0.3128	
Q2.1c	-0.20074	0.42286	-0.475	0.6361	
Q2.1d	-0.77376	0.60623	-1.276	0.2050	
Q2.2a	0.39465	0.24475	1.612	0.1103	
Q2.2b	0.20992	0.22986	0.913	0.3635	
Q2.2c	0.03441	0.23715	0.145	0.8850	
Q2.2d	-0.14075	0.20697	-0.680	0.4982	
Q2.1e	-0.06636	0.33637	-0.197	0.8440	
Q2.1f	0.84197	0.63940	1.317	0.1911	
Q2.1g	0.19798	0.37759	0.524	0.6013	
Q2.1h	0.33909	0.33297	1.018	0.3111	
Q2.3a	-0.33859	0.16000	-2.116	0.0370	*
Q2.3b	-0.12579	0.20235	-0.622	0.5357	
Q2.3c	-0.12039	0.20751	-0.580	0.5632	
Q2.3d	-0.38636	0.16555	-2.334	0.0218	*

Final model after GM Assumptions, the final model for Wisdom at a 90% confidence level is:

$$y_{ProjectSuccess} = 1.99 + 0.27Q1.3b + 0.42Q1.6b + 0.39Q2.2a - 0.34Q2.3a - 0.39Q2.3d$$

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All projects, Culture

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q4.1a + \beta_2 Q4.1b + \beta_3 Q4.1c + \beta_4 Q4.1d + \beta_5 Q4.1e + \beta_6 Q4.2a + \beta_7 Q4.2b + \beta_8 Q4.2c + \beta_9 Q4.2d + \beta_{10} Q4.2e + \beta_{11} Q4.3a + \beta_{12} Q4.3b + \beta_{13} Q4.3c + \beta_{14} Q4.4a + \beta_{15} Q4.4b + \beta_{16} Q4.4c$$

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2d + Q4.2e + Q4.3a + Q4.3b + Q4.3c +
    Q4.4a + Q4.4b + Q4.4c, data = all3)

Residuals:
   Min     1Q Median     3Q    Max
-2.917 -1.269  0.009  1.358  3.303

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.64713    1.02563   0.631    0.530
Q4.1a        0.02332    0.26131   0.089    0.929
Q4.1b        0.05364    0.29391   0.183    0.856
Q4.1c        0.32037    0.27656   1.158    0.249
Q4.1d        0.01296    0.22760   0.057    0.955
Q4.1e        0.15700    0.23289   0.674    0.502
Q4.2a        0.04252    0.36962   0.115    0.909
Q4.2b        0.10724    0.37402   0.287    0.775
Q4.2c        0.02849    0.25044   0.114    0.910
Q4.2d       -0.15566    0.31259  -0.498    0.620
Q4.2e        0.01377    0.25278   0.054    0.957
Q4.3a        0.05592    0.24786   0.226    0.822
Q4.3b        0.08827    0.32869   0.269    0.789
Q4.3c       -0.14673    0.32408  -0.453    0.652
Q4.4a       -0.02561    0.35416  -0.072    0.942
Q4.4b        0.32625    0.50640   0.644    0.521
Q4.4c       -0.06321    0.35806  -0.177    0.860

Residual standard error: 1.724 on 100 degrees of freedom
Multiple R-squared:   0.12,     Adjusted R-squared:  -0.02085
F-statistic: 0.8519 on 16 and 100 DF,  p-value: 0.6247
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Culture)
    Q4.1a     Q4.1b     Q4.1c     Q4.1d     Q4.1e     Q4.2a     Q4.2b     Q4.2c     Q4.2d
 2.866497 3.411399 2.909032 2.036458 1.586721 3.979294 3.701087 3.195114 3.202058
    Q4.3a     Q4.3b     Q4.3c     Q4.4a     Q4.4b     Q4.4c
 3.427159 5.019700 3.920450 4.801414 9.071118 5.244098
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Culture)

        studentized Breusch-Pagan test

data:  Culture
BP = 11.997, df = 15, p-value = 0.6793
```

The P-value of the BP test is 0.6793 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

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```
> cor(resid(Culture),all3$Q4.1a)
[1] -2.484339e-17
> cor(resid(Culture),all3$Q4.1b)
[1] -3.05288e-16
> cor(resid(Culture),all3$Q4.1c)
[1] -7.138477e-18
> cor(resid(Culture),all3$Q4.1d)
[1] -5.672496e-16
> cor(resid(Culture),all3$Q4.1e)
[1] -2.887812e-16
> cor(resid(Culture),all3$Q4.2a)
[1] 3.202547e-16
> cor(resid(Culture),all3$Q4.2b)
[1] 5.819327e-16
> cor(resid(Culture),all3$Q4.2c)
[1] 2.377514e-16
> cor(resid(Culture),all3$Q4.2d)
[1] -5.357525e-17
> cor(resid(Culture),all3$Q4.3a)
[1] -4.557342e-16
> cor(resid(Culture),all3$Q4.3b)
[1] -2.127647e-16
> cor(resid(Culture),all3$Q4.3c)
[1] -1.159753e-16
> cor(resid(Culture),all3$Q4.4a)
[1] -2.486028e-16
> cor(resid(Culture),all3$Q4.4b)
[1] -6.820839e-17
> cor(resid(Culture),all3$Q4.4c)
[1] 5.388313e-17
```

All regressors correlation with the residual is close to zero – no stochastic regressor Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.64440    1.01933   0.632    0.529
Q4.1a        0.02259    0.25967   0.087    0.931
Q4.1b        0.05316    0.29233   0.182    0.856
Q4.1c        0.31986    0.27504   1.163    0.248
Q4.1d        0.01498    0.22345   0.067    0.947
Q4.1e        0.16163    0.21572   0.749    0.455
Q4.2a        0.04636    0.36105   0.128    0.898
Q4.2b        0.10698    0.37213   0.287    0.774
Q4.2c        0.02944    0.24859   0.118    0.906
Q4.2d       -0.15127    0.30053  -0.503    0.616
Q4.3a        0.05376    0.24346   0.221    0.826
Q4.3b        0.08542    0.32289   0.265    0.792
Q4.3c       -0.14078    0.30360  -0.464    0.644
Q4.4a       -0.02908    0.34666  -0.084    0.933
Q4.4b        0.33353    0.48601   0.686    0.494
Q4.4c       -0.06722    0.34866  -0.193    0.848
```

It can be seen that no regressor plays a significant role in the 90% confidence interval in the success of a project.
This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and culture.

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C2: Enterprise Phases
Growth, Relationships, All projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2c + \beta_4 Q2.2d + \beta_5 Q2.3a + \beta_6 Q2.3b + \beta_7 Q2.3c + \beta_8 Q2.3d + \beta_9 Q2.4a + \beta_{10} Q2.4b + \beta_{11} Q2.4c + \beta_{12} Q2.4d$$

```
> Relationships <- lm(Project~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a + Q2.3b + Q2.3
c + Q2.3d + Q2.4a + Q2.4b + Q2.4c + Q2.4d, data = growth)
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d + Q2.4a + Q2.4b + Q2.4c + Q2.4d, data = growth)

Residuals:
    Min      1Q  Median      3Q     Max
-2.7144 -0.6678 -0.1050  1.0047  1.6869

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.03459    2.19378   3.662 0.000992 ***
Q2.2a       -0.53907    0.38396  -1.404 0.170946
Q2.2b        0.29744    0.39750   0.748 0.460323
Q2.2c        0.52410    0.56862   0.922 0.364287
Q2.2d       -0.72711    0.39155  -1.857 0.073493 .
Q2.3a       -0.05361    0.29402  -0.182 0.856581
Q2.3b        0.66363    0.41018   1.618 0.116511
Q2.3c       -0.85498    0.35255  -2.425 0.021759 *
Q2.3d       -0.89657    0.29096  -3.081 0.004483 **
Q2.4a        0.42556    0.22869   1.861 0.072929 .
Q2.4b       -0.48775    0.22652  -2.153 0.039750 *
Q2.4c        0.48498    0.22234   2.181 0.037417 *
Q2.4d       -0.25381    0.19582  -1.296 0.205143
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.271 on 29 degrees of freedom
Multiple R-squared:  0.5676,    Adjusted R-squared:  0.3886
F-statistic: 3.172 on 12 and 29 DF,  p-value: 0.005406
```

Guass Markov Assumptions to test that the OLS regression is reliable:
A. Multi-collinearity
GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Relationships)
   Q2.2a    Q2.2b    Q2.2c    Q2.2d    Q2.3a    Q2.3b    Q2.3c    Q2.3d    Q2.4a
1.863050 2.444103 3.604431 2.479950 1.386916 4.009147 2.780233 2.987160 3.270608
   Q2.4b    Q2.4c    Q2.4d
3.039376 2.912878 1.931461
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.
B. Heteroscedasticity
The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

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```
> bptest(Relationships)

        studentized Breusch-Pagan test

data:  Relationships
BP = 13.322, df = 12, p-value = 0.3461
```

The P-value of the BP test is 0.3461 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.
C. Stochastic Regressors
Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.
Correlation of regressors to the residual should be close to if not equal to zero.
This can be done in R software.

```
> cor(resid(Relationships),growth$Q2.2a)
[1] 4.042223e-16
> cor(resid(Relationships),growth$Q2.2b)
[1] 2.856088e-16
> cor(resid(Relationships),growth$Q2.2c)
[1] 3.566028e-16
> cor(resid(Relationships),growth$Q2.2d)
[1] 3.217227e-16
> cor(resid(Relationships),growth$Q2.3a)
[1] 3.066623e-16
> cor(resid(Relationships),growth$Q2.3b)
[1] 1.342028e-16
> cor(resid(Relationships),growth$Q2.3c)
[1] 2.173561e-16
> cor(resid(Relationships),growth$Q2.3d)
[1] 3.828022e-17
> cor(resid(Relationships),growth$Q2.4a)
[1] 1.756765e-16
> cor(resid(Relationships),growth$Q2.4b)
[1] 1.105879e-16
> cor(resid(Relationships),growth$Q2.4c)
[1] 1.349737e-16
> cor(resid(Relationships),growth$Q2.4d)
[1] 1.122975e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor
Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d + Q2.4a + Q2.4b + Q2.4c + Q2.4d, data = growth)

Residuals:
    Min      1Q  Median      3Q     Max
-2.7144 -0.6678 -0.1050  1.0047  1.6869

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.03459    2.19378   3.662 0.000992 ***
Q2.2a       -0.53907    0.38396  -1.404 0.170946
Q2.2b        0.29744    0.39750   0.748 0.460323
Q2.2c        0.52410    0.56862   0.922 0.364287
Q2.2d       -0.72711    0.39155  -1.857 0.073493 .
Q2.3a       -0.05361    0.29402  -0.182 0.856581
Q2.3b        0.66363    0.41018   1.618 0.116511
Q2.3c       -0.85498    0.35255  -2.425 0.021759 *
Q2.3d       -0.89657    0.29096  -3.081 0.004483 **
Q2.4a        0.42556    0.22869   1.861 0.072929 .
Q2.4b       -0.48775    0.22652  -2.153 0.039750 *
Q2.4c        0.48498    0.22234   2.181 0.037417 *
Q2.4d       -0.25381    0.19582  -1.296 0.205143
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.271 on 29 degrees of freedom
Multiple R-squared:  0.5676,    Adjusted R-squared:  0.3886
```

Final model after GM Assumptions, the final model for relationships at a 90% confidence level is:

$$y_{ProjectSuccess} = 8.03459 - 0.85498Q2.3c - 0.89657Q2.3d + 0.42556Q2.4a - 0.48775Q2.4b + 0.48498Q2.4c$$

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Growth, Wisdom, All projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q3.1a + \beta_2 Q3.1b + \beta_3 Q3.1c + \beta_4 Q3.1d + \beta_5 Q3.2a + \beta_6 Q3.2b + \beta_7 Q3.2c + \beta_8 Q3.2d + \beta_9 Q3.3a + \beta_{10} Q3.3b + \beta_{11} Q3.3c + \beta_{12} Q3.3d + \beta_{13} Q3.4a + \beta_{14} Q3.4b + \beta_{15} Q3.4c + \beta_{16} Q3.4d + \beta_{17} Q3.5a + \beta_{18} Q3.5b + \beta_{19} Q3.5c + \beta_{20} Q3.6a + \beta_{21} Q3.6b + \beta_{22} Q3.6c + \beta_{23} Q3.6d + \beta_{24} Q3.6e$$

```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2a +
    Q3.2b + Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a +
    Q3.4b + Q3.4c + Q3.4d + Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6b +
    Q3.6c + Q3.6d + Q3.6e, data = growth)

Residuals:
     Min       1Q   Median       3Q      Max
-1.64213 -0.90705  0.02045  0.64097  2.10504

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.57193    3.99582   0.894    0.384
Q3.1a       -0.35021    0.91990  -0.381    0.708
Q3.1b        0.25600    0.60109   0.426    0.676
Q3.1c        0.67971    0.66478   1.022    0.321
Q3.1d       -0.77312    0.61798  -1.251    0.228
Q3.2a       -0.38978    0.79581  -0.490    0.631
Q3.2b       -0.05236    1.31690  -0.040    0.969
Q3.2c        0.71114    0.73626   0.966    0.348
Q3.2d       -0.08576    0.81788  -0.105    0.918
Q3.3a       -0.50459    0.85577  -0.590    0.563
Q3.3b       -0.67671    0.55020  -1.230    0.235
Q3.3c       -0.51711    1.00115  -0.517    0.612
Q3.3d        1.22791    1.41172   0.870    0.397
Q3.4a       -0.53894    0.76042  -0.709    0.488
Q3.4b        0.18723    0.88201   0.212    0.834
Q3.4c       -0.15252    0.99663  -0.153    0.880
Q3.4d       -0.47189    0.84699  -0.557    0.585
Q3.5a        0.60506    0.93586   0.647    0.527
Q3.5b        0.53739    1.38161   0.389    0.702
Q3.5c       -0.65987    1.37369  -0.480    0.637
Q3.6a       -0.21498    1.15345  -0.186    0.854
Q3.6b        0.02090    1.06467   0.020    0.985
Q3.6c       -0.12124    1.49343  -0.081    0.936
Q3.6d        0.69482    0.52003   1.336    0.199
Q3.6e        0.50954    0.52612   0.968    0.346
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software and remove variables with VIF value higher than 5 from the model.

```
> vif(Knowledge)
   Q3.1a    Q3.1b    Q3.1c    Q3.1d    Q3.2c    Q3.2d    Q3.3a    Q3.3b    Q3.3c
4.778922 3.860074 3.471559 3.322522 2.633984 1.958297 3.288638 3.030455 2.725994
   Q3.4a    Q3.4b    Q3.4d    Q3.5a    Q3.5c    Q3.6a    Q3.6d    Q3.6e
3.105420 4.112831 4.108239 2.657285 3.541339 2.309759 1.875603 2.006829
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

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```
> bptest(Knowledge)

        studentized Breusch-Pagan test

data:  Knowledge
BP = 20.788, df = 17, p-value = 0.2359
```

The P-value of the BP test is 0.2359 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

```
> cor(resid(Knowledge),growth$Q3.1a)
[1] 1.456139e-16
> cor(resid(Knowledge),growth$Q3.1b)
[1] -2.542412e-17
> cor(resid(Knowledge),growth$Q3.1c)
[1] 1.28918e-16
> cor(resid(Knowledge),growth$Q3.1d)
[1] 3.522391e-17
> cor(resid(Knowledge),growth$Q3.2c)
[1] -3.533895e-17
> cor(resid(Knowledge),growth$Q3.2d)
[1] 1.410991e-16
> cor(resid(Knowledge),growth$Q3.3a)
[1] 6.687115e-17
> cor(resid(Knowledge),growth$Q3.3b)
[1] 1.714147e-16
> cor(resid(Knowledge),growth$Q3.3c)
[1] 2.115444e-16
> cor(resid(Knowledge),growth$Q3.4a)
[1] 1.994042e-16
> cor(resid(Knowledge),growth$Q3.4b)
[1] 8.0428e-17
> cor(resid(Knowledge),growth$Q3.4d)
[1] 7.117478e-17
> cor(resid(Knowledge),growth$Q3.5a)
[1] 5.690785e-17
> cor(resid(Knowledge),growth$Q3.5c)
[1] 6.595153e-17
> cor(resid(Knowledge),growth$Q3.6a)
[1] 1.497801e-18
> cor(resid(Knowledge),growth$Q3.6d)
[1] 7.104411e-17
> cor(resid(Knowledge),growth$Q3.6e)
[1] 2.900482e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

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```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2c +
    Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.4a + Q3.4b + Q3.4d + Q3.5a +
    Q3.5c + Q3.6a + Q3.6d + Q3.6e, data = growth)

Residuals:
     Min       1Q   Median       3Q      Max
-1.70589 -0.84568  0.02034  0.73599  2.14317

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   1.6777     1.7942   0.935   0.3591
Q3.1a        -0.7979     0.4757  -1.677   0.1064
Q3.1b         0.3671     0.3854   0.953   0.3503
Q3.1c         0.2901     0.3771   0.769   0.4491
Q3.1d        -0.3551     0.4563  -0.778   0.4440
Q3.2c         0.1405     0.3130   0.449   0.6576
Q3.2d         0.1150     0.3869   0.297   0.7688
Q3.3a        -0.1928     0.4495  -0.429   0.6719
Q3.3b        -0.7637     0.3909  -1.954   0.0625 .
Q3.3c        -0.2429     0.4360  -0.557   0.5826
Q3.4a        -0.1170     0.4524  -0.259   0.7981
Q3.4b         0.8027     0.4364   1.839   0.0783 .
Q3.4d        -0.6291     0.5159  -1.220   0.2345
Q3.5a         0.8201     0.4236   1.936   0.0647 .
Q3.5c         0.1404     0.4936   0.284   0.7786
Q3.6a        -0.0763     0.4383  -0.174   0.8632
Q3.6d         0.6516     0.3261   1.998   0.0572 .
Q3.6e         0.4225     0.3756   1.125   0.2718
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.35 on 24 degrees of freedom
Multiple R-squared:  0.5963,    Adjusted R-squared:  0.3103
F-statistic: 2.085 on 17 and 24 DF,  p-value: 0.04838
```

Final model after GM Assumptions, the final model for wisdom at a 90% confidence level is:

$$y_{ProjectSuccess} = -0.7637Q3.3b + 0.8027Q3.4b + 0.8201Q3.5a + 0.6516Q3.6d$$

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Growth, Culture, All projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q4.1a + \beta_2 Q4.1b + \beta_3 Q4.1c + \beta_4 Q4.1d + \beta_5 Q4.1e + \beta_6 Q4.2a + \beta_7 Q4.2b + \beta_8 Q4.2c + \beta_9 Q4.2d + \beta_{10} Q4.2e + \beta_{11} Q4.3a + \beta_{12} Q4.3b + \beta_{13} Q4.3c + \beta_{14} Q4.4a + \beta_{15} Q4.4b + \beta_{16} Q4.4c$$

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2d + Q4.2e + Q4.3a + Q4.3b + Q4.3c +
    Q4.4a + Q4.4b + Q4.4c, data = growth)

Residuals:
   Min     1Q Median     3Q    Max
-2.700 -1.092 -0.039  1.111  2.658

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   2.4551     2.2944   1.070    0.295
Q4.1a         0.1239     0.6600   0.188    0.853
Q4.1b        -0.5966     0.7287  -0.819    0.421
Q4.1c         0.3862     0.5047   0.765    0.451
Q4.1d         0.4703     0.6321   0.744    0.464
Q4.1e         0.0262     0.5400   0.049    0.962
Q4.2a         0.3886     0.7317   0.531    0.600
Q4.2b        -0.1459     0.9387  -0.155    0.878
Q4.2c         0.4886     0.5589   0.874    0.390
Q4.2d        -0.5547     0.7628  -0.727    0.474
Q4.2e        -0.5212     0.7691  -0.678    0.504
Q4.3a        -0.5510     0.4842  -1.138    0.266
Q4.3b         0.8018     0.6574   1.220    0.234
Q4.3c        -0.2707     0.6269  -0.432    0.670
Q4.4a         0.3502     0.7696   0.455    0.653
Q4.4b        -0.8150     1.2436  -0.655    0.518
Q4.4c         0.7148     1.1877   0.602    0.553

Residual standard error: 1.795 on 25 degrees of freedom
Multiple R-squared:  0.2564,    Adjusted R-squared:  -0.2195
F-statistic: 0.5387 on 16 and 25 DF,  p-value: 0.8992
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Culture)
   Q4.1a    Q4.1b    Q4.1c    Q4.1d    Q4.1e    Q4.2a    Q4.2b    Q4.2c    Q4.2e
2.522651 5.488235 2.773768 4.224459 2.796494 3.294085 4.682627 3.484125 4.855446
   Q4.3a    Q4.3b    Q4.3c    Q4.4b
3.236556 5.525020 3.915869 1.539000
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Culture)

        studentized Breusch-Pagan test

data:  Culture
BP = 13.926, df = 13, p-value = 0.3791
```

The P-value of the BP test is 0.3791 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms. Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

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```
> cor(resid(Culture),growth$Q4.1a)
[1] 1.547652e-16
> cor(resid(Culture),growth$Q4.1b)
[1] 2.62592e-16
> cor(resid(Culture),growth$Q4.1c)
[1] 1.502116e-16
> cor(resid(Culture),growth$Q4.1d)
[1] 1.722476e-16
> cor(resid(Culture),growth$Q4.1e)
[1] 1.8739e-16
> cor(resid(Culture),growth$Q4.2a)
[1] 3.337302e-16
> cor(resid(Culture),growth$Q4.2b)
[1] 3.139149e-16
> cor(resid(Culture),growth$Q4.2c)
[1] 2.915219e-16
> cor(resid(Culture),growth$Q4.2e)
[1] 2.064263e-16
> cor(resid(Culture),growth$Q4.3a)
[1] 1.312916e-16
> cor(resid(Culture),growth$Q4.3b)
[1] 1.864727e-16
> cor(resid(Culture),growth$Q4.3c)
[1] -2.655234e-18
> cor(resid(Culture),growth$Q4.4b)
[1] 2.801515e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 10% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2e + Q4.3a + Q4.3b + Q4.3c + Q4.4b,
    data = growth)

Residuals:
     Min       1Q   Median       3Q      Max
-2.78409 -1.06534 -0.03549  1.12069  2.39497

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   2.5902     2.1258   1.218    0.233
Q4.1a        -0.1130     0.4478  -0.252    0.803
Q4.1b        -0.6038     0.6740  -0.896    0.378
Q4.1c         0.4675     0.4631   1.009    0.321
Q4.1d         0.1988     0.5237   0.379    0.707
Q4.1e         0.2740     0.4680   0.585    0.563
Q4.2a         0.2692     0.6717   0.401    0.692
Q4.2b        -0.2910     0.8895  -0.327    0.746
Q4.2c         0.6705     0.4869   1.377    0.179
Q4.2e        -0.9225     0.6532  -1.412    0.169
Q4.3a        -0.3251     0.4018  -0.809    0.425
Q4.3b         0.7137     0.5860   1.218    0.233
Q4.3c        -0.1276     0.5649  -0.226    0.823
Q4.4b         0.1278     0.3608   0.354    0.726

Residual standard error: 1.736 on 28 degrees of freedom
Multiple R-squared:  0.2209,    Adjusted R-squared:  -0.1409
F-statistic: 0.6105 on 13 and 28 DF,  p-value: 0.8249
```

It can be seen that no regressor plays a significant role in the 90 percent confidence interval in the success of a project.

This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and culture.

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Maturity, Relationships, All projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2c + \beta_4 Q2.2d + \beta_5 Q2.3a + \beta_6 Q2.3b + \beta_7 Q2.3c + \beta_8 Q2.3d + \beta_9 Q2.4a + \beta_{10} Q2.4b + \beta_{11} Q2.4c + \beta_{12} Q2.4d$$

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d, data = maturity)

Residuals:
     Min       1Q   Median       3Q      Max
-2.27817 -0.72853  0.01937  0.76496  2.21138

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.29657    2.89518   1.484   0.1473
Q2.2a        0.61813    0.39920   1.548   0.1311
Q2.2b       -0.20822    0.43243  -0.482   0.6333
Q2.2c        0.21529    0.44315   0.486   0.6303
Q2.2d        0.09414    0.36960   0.255   0.8005
Q2.3a       -0.28900    0.33264  -0.869   0.3912
Q2.3b       -0.57350    0.29759  -1.927   0.0626 .
Q2.3c        0.32676    0.33685   0.970   0.3391
Q2.3d       -0.71186    0.38299  -1.859   0.0720 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.374 on 33 degrees of freedom
Multiple R-squared:  0.5966,    Adjusted R-squared:  0.4988
F-statistic: 6.101 on 8 and 33 DF,  p-value: 7.849e-05
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Relationships)
   Q2.2a    Q2.2b    Q2.2c    Q2.2d    Q2.3a    Q2.3b    Q2.3c    Q2.3d
2.107761 2.614803 3.357596 2.865991 2.702330 2.162897 2.582369 3.255010
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test,

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

with the below hypothesis.

Using R software, we run the test and the results shown below:

```
> bptest(Relationships)

        studentized Breusch-Pagan test

data:  Relationships
BP = 11.444, df = 8, p-value = 0.1778
```

The P-value of the BP test is 0.1778 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms. Correlation of regressors to the residual should be close to if not equal to zero. This can be done in R software.

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```
> cor(resid(Relationships),growth$Q2.2a)
[1] 4.042223e-16
> cor(resid(Relationships),growth$Q2.2b)
[1] 2.856088e-16
> cor(resid(Relationships),growth$Q2.2c)
[1] 3.566028e-16
> cor(resid(Relationships),growth$Q2.2d)
[1] 3.217227e-16
> cor(resid(Relationships),growth$Q2.3a)
[1] 3.066623e-16
> cor(resid(Relationships),growth$Q2.3b)
[1] 1.342028e-16
> cor(resid(Relationships),growth$Q2.3c)
[1] 2.173561e-16
> cor(resid(Relationships),growth$Q2.3d)
[1] 3.828022e-17
> cor(resid(Relationships),growth$Q2.4a)
[1] 1.756765e-16
> cor(resid(Relationships),growth$Q2.4b)
[1] 1.105879e-16
> cor(resid(Relationships),growth$Q2.4c)
[1] 1.349737e-16
> cor(resid(Relationships),growth$Q2.4d)
[1] 1.122975e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d, data = maturity)

Residuals:
     Min       1Q   Median       3Q      Max
-2.27817 -0.72853  0.01937  0.76496  2.21138

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.29657    2.89518   1.484   0.1473
Q2.2a        0.61813    0.39920   1.548   0.1311
Q2.2b       -0.20822    0.43243  -0.482   0.6333
Q2.2c        0.21529    0.44315   0.486   0.6303
Q2.2d        0.09414    0.36960   0.255   0.8005
Q2.3a       -0.28900    0.33264  -0.869   0.3912
Q2.3b       -0.57350    0.29759  -1.927   0.0626 .
Q2.3c        0.32676    0.33685   0.970   0.3391
Q2.3d       -0.71186    0.38299  -1.859   0.0720 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.374 on 33 degrees of freedom
Multiple R-squared:  0.5966,    Adjusted R-squared:  0.4988
F-statistic: 6.101 on 8 and 33 DF,  p-value: 7.849e-05
```

Final model after GM Assumptions, the final model for relationships at a 90% confidence level is:

$$y_{ProjectSuccess} = -0.57350Q2.3b - 0.71186Q2.3d$$

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Maturity, Wisdom, All projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q3.1a + \beta_2 Q3.1b + \beta_3 Q3.1c + \beta_4 Q3.1d + \beta_5 Q3.2a + \beta_6 Q3.2b + \beta_7 Q3.2c + \beta_8 Q3.2d + \beta_9 Q3.3a + \beta_{10} Q3.3b + \beta_{11} Q3.3c + \beta_{12} Q3.3d + \beta_{13} Q3.4a + \beta_{14} Q3.4b + \beta_{15} Q3.4c + \beta_{16} Q3.4d + \beta_{17} Q3.5a + \beta_{18} Q3.5b + \beta_{19} Q3.5c + \beta_{20} Q3.6a + \beta_{21} Q3.6b + \beta_{22} Q3.6c + \beta_{23} Q3.6d + \beta_{24} Q3.6e$$

```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2a +
    Q3.2b + Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a +
    Q3.4b + Q3.4c + Q3.4d + Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6b +
    Q3.6c + Q3.6d + Q3.6e, data = maturity)

Residuals:
    Min      1Q  Median      3Q     Max
-2.3780 -0.3106  0.1217  0.4846  1.2219

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -3.99707    3.26572  -1.224   0.2377
Q3.1a       -0.02547    0.57721  -0.044   0.9653
Q3.1b        0.91310    0.58542   1.560   0.1372
Q3.1c        0.25111    0.57879   0.434   0.6698
Q3.1d       -0.44026    0.46918  -0.938   0.3612
Q3.2a       -0.01416    0.83130  -0.017   0.9866
Q3.2b       -0.19654    0.67523  -0.291   0.7745
Q3.2c       -0.10977    0.52434  -0.209   0.8367
Q3.2d        1.01919    0.62595   1.628   0.1219
Q3.3a        0.33820    0.61951   0.546   0.5922
Q3.3b       -0.36049    0.70912  -0.508   0.6177
Q3.3c        0.13654    0.56405   0.242   0.8116
Q3.3d        0.30282    0.57159   0.530   0.6031
Q3.4a       -0.77212    0.70892  -1.089   0.2913
Q3.4b       -0.37695    0.79765  -0.473   0.6425
Q3.4c       -0.89021    0.54352  -1.638   0.1198
Q3.4d        0.36636    0.85212   0.430   0.6726
Q3.5a        0.89203    0.45480   1.961   0.0664 .
Q3.5b        0.88670    0.45401   1.953   0.0675 .
Q3.5c        0.58315    0.55942   1.042   0.3118
Q3.6a       -1.90160    0.78989  -2.407   0.0277 *
Q3.6b        1.33733    0.90837   1.472   0.1592
Q3.6c        1.54122    1.03239   1.493   0.1538
Q3.6d       -1.28042    0.55714  -2.298   0.0345 *
Q3.6e        0.31771    0.91716   0.346   0.7333
---
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software and remove variables with VIF value higher than 5 from the model.

```
> vif(Knowledge)
   Q3.1a    Q3.1b    Q3.1c    Q3.1d    Q3.2b    Q3.2c    Q3.2d    Q3.3a    Q3.3b
2.317673 4.962768 3.276410 4.521016 3.245389 4.051041 5.295507 4.389276 4.676244
   Q3.3c    Q3.3d    Q3.4a    Q3.4c    Q3.5a    Q3.5b    Q3.5c    Q3.6a    Q3.6d
2.688225 2.956078 4.891496 4.553519 2.246699 2.826708 4.405224 2.916098 4.483650
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Knowledge)

        studentized Breusch-Pagan test

data:  Knowledge
BP = 6.4086, df = 18, p-value = 0.9942
```

The P-value of the BP test is 0.9942 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

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Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.
Correlation of regressors to the residual should be close to if not equal to zero.
This can be done in R software.

```
> cor(resid(Knowledge),growth$Q3.1a)
[1] 1.456139e-16
> cor(resid(Knowledge),growth$Q3.1b)
[1] -2.542412e-17
> cor(resid(Knowledge),growth$Q3.1c)
[1] 1.28918e-16
> cor(resid(Knowledge),growth$Q3.1d)
[1] 3.522391e-17
> cor(resid(Knowledge),growth$Q3.2c)
[1] -3.533895e-17
> cor(resid(Knowledge),growth$Q3.2d)
[1] 1.410991e-16
> cor(resid(Knowledge),growth$Q3.3a)
[1] 6.687115e-17
> cor(resid(Knowledge),growth$Q3.3b)
[1] 1.714147e-16
> cor(resid(Knowledge),growth$Q3.3c)
[1] 2.115444e-16
> cor(resid(Knowledge),growth$Q3.4a)
[1] 1.994042e-16
> cor(resid(Knowledge),growth$Q3.4b)
[1] 8.0428e-17
> cor(resid(Knowledge),growth$Q3.4d)
[1] 7.117478e-17
> cor(resid(Knowledge),growth$Q3.5a)
[1] 5.690785e-17
> cor(resid(Knowledge),growth$Q3.5c)
[1] 6.595153e-17
> cor(resid(Knowledge),growth$Q3.6a)
[1] 1.497801e-18
> cor(resid(Knowledge),growth$Q3.6d)
[1] 7.104411e-17
> cor(resid(Knowledge),growth$Q3.6e)
[1] 2.900482e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor
Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2b +
    Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a + Q3.4c +
    Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6d, data = maturity)

Residuals:
    Min      1Q  Median      3Q     Max
-2.0532 -0.5005  0.2324  0.5855  2.1286

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.91048    2.14271  -0.425   0.6748
Q3.1a        0.04177    0.36573   0.114   0.9101
Q3.1b        0.89367    0.44343   2.015   0.0557 .
Q3.1c        0.22187    0.49261   0.450   0.6566
Q3.1d       -0.39713    0.39193  -1.013   0.3215
Q3.2b       -0.02503    0.42514  -0.059   0.9536
Q3.2c        0.11184    0.35846   0.312   0.7578
Q3.2d        0.54396    0.51570   1.055   0.3025
Q3.3a        1.04608    0.44945   2.327   0.0291 *
Q3.3b       -0.43691    0.53683  -0.814   0.4241
Q3.3c        0.03455    0.50945   0.068   0.9465
Q3.3d       -0.25132    0.35699  -0.704   0.4885
Q3.4a       -0.77981    0.47427  -1.644   0.1137
Q3.4c       -0.91176    0.43654  -2.089   0.0480 *
Q3.5a        0.59547    0.31737   1.876   0.0734 .
Q3.5b        0.79809    0.34483   2.314   0.0299 *
Q3.5c        1.09849    0.43000   2.555   0.0177 *
Q3.6a       -0.45282    0.42599  -1.063   0.2988
Q3.6d       -0.47961    0.35719  -1.343   0.1925
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.168 on 23 degrees of freedom
Multiple R-squared:  0.797,     Adjusted R-squared:  0.6382
F-statistic: 5.018 on 18 and 23 DF,  p-value: 0.0002054
```

Final model after GM Assumptions, the final model for wisdom at a 90% confidence level is:

$$y_{ProjectSuccess} = 0.89367Q3.1b + 1.04608Q3.3a - 0.91176Q3.4c + 0.59547Q3.5a + 0.79809Q3.5b + 1.09849Q3.5c$$

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Maturity, Culture, All projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q4.1a + \beta_2 Q4.1b + \beta_3 Q4.1c + \beta_4 Q4.1d + \beta_5 Q4.1e + \beta_6 Q4.2a + \beta_7 Q4.2b + \beta_8 Q4.2c + \beta_9 Q4.2d + \beta_{10} Q4.2e + \beta_{11} Q4.3a + \beta_{12} Q4.3b + \beta_{13} Q4.3c + \beta_{14} Q4.4a + \beta_{15} Q4.4b + \beta_{16} Q4.4c$$

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2d + Q4.2e + Q4.3a + Q4.3b + Q4.3c +
    Q4.4a + Q4.4b + Q4.4c, data = maturity)

Residuals:
    Min      1Q  Median      3Q     Max
-4.2446 -0.6678  0.0603  0.8123  2.7676

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -2.6118     2.1502  -1.215   0.2358
Q4.1a         0.4897     0.5527   0.886   0.3841
Q4.1b         0.9411     0.6073   1.550   0.1338
Q4.1c        -1.0459     0.7978  -1.311   0.2018
Q4.1d        -0.1661     0.5926  -0.280   0.7815
Q4.1e         0.7127     0.5546   1.285   0.2105
Q4.2a        -1.8057     1.0215  -1.768   0.0893 .
Q4.2b         2.2465     0.9556   2.351   0.0269 *
Q4.2c        -0.2862     0.7329  -0.390   0.6995
Q4.2d         0.1581     0.9123   0.173   0.8638
Q4.2e         0.4492     0.5782   0.777   0.4445
Q4.3a         0.7989     0.6077   1.315   0.2005
Q4.3b        -1.6571     0.8530  -1.943   0.0634 .
Q4.3c         1.1511     0.9749   1.181   0.2488
Q4.4a         0.2647     1.2986   0.204   0.8401
Q4.4b        -0.1392     1.7853  -0.078   0.9385
Q4.4c        -0.1549     0.8162  -0.190   0.8510
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.821 on 25 degrees of freedom
Multiple R-squared:  0.4636,    Adjusted R-squared:  0.1203
F-statistic:  1.35 on 16 and 25 DF,  p-value: 0.2437
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software

```
> vif(Culture)
   Q4.1a    Q4.1b    Q4.1c    Q4.1d    Q4.1e    Q4.2b    Q4.2e    Q4.3a    Q4.3b
3.168969 2.944959 3.125382 1.929199 2.410419 2.878870 2.609088 2.741978 3.935935
   Q4.4a    Q4.4c
2.253763 3.304008
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Culture)

        studentized Breusch-Pagan test

data:  Culture
BP = 7.8833, df = 11, p-value = 0.7237
```

The P-value of the BP test is 0.7237 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero. This can be done in R software.

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```
> cor(resid(Culture),maturity$Q4.1a)
[1] -2.09203e-16
> cor(resid(Culture),maturity$Q4.1b)
[1] -4.955038e-16
> cor(resid(Culture),maturity$Q4.1c)
[1] -1.969066e-16
> cor(resid(Culture),maturity$Q4.1d)
[1] -2.905282e-16
> cor(resid(Culture),maturity$Q4.1e)
[1] -3.005312e-16
> cor(resid(Culture),maturity$Q4.2b)
[1] -3.879699e-16
> cor(resid(Culture),maturity$Q4.2e)
[1] -3.951081e-16
> cor(resid(Culture),maturity$Q4.3a)
[1] -4.539125e-16
> cor(resid(Culture),maturity$Q4.3b)
[1] -3.907801e-16
> cor(resid(Culture),maturity$Q4.4a)
[1] -3.351443e-16
> cor(resid(Culture),maturity$Q4.4c)
[1] -3.896452e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2b + Q4.2e + Q4.3a + Q4.3b + Q4.4a + Q4.4c, data = maturity)

Residuals:
    Min      1Q  Median      3Q     Max
-3.4023 -0.8447  0.1325  1.2131  3.1505

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.49881    1.79363  -0.836   0.4100
Q4.1a       -0.14125    0.42562  -0.332   0.7423
Q4.1b        0.96025    0.48700   1.972   0.0579 .
Q4.1c       -0.14360    0.48207  -0.298   0.7678
Q4.1d       -0.07703    0.37453  -0.206   0.8384
Q4.1e        0.20872    0.45209   0.462   0.6476
Q4.2b        0.85342    0.56110   1.521   0.1387
Q4.2e        0.25856    0.47516   0.544   0.5904
Q4.3a        0.05350    0.41774   0.128   0.8989
Q4.3b       -0.76949    0.54938  -1.401   0.1716
Q4.4a        0.30365    0.52733   0.576   0.5690
Q4.4c        0.05928    0.51172   0.116   0.9086
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.791 on 30 degrees of freedom
Multiple R-squared:  0.377,     Adjusted R-squared:  0.1486
F-statistic:  1.65 on 11 and 30 DF,  p-value: 0.1348
```

It can be seen that no regressor plays a significant role in the 90 percent confidence interval in the success of a project.

This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and culture.

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C3 Project RG31
Relationships, RG31 projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2c + \beta_4 Q2.2d + \beta_5 Q2.3a + \beta_6 Q2.3b + \beta_7 Q2.3c + \beta_8 Q2.3d + \beta_9 Q2.4a + \beta_{10} Q2.4b + \beta_{11} Q2.4c + \beta_{12} Q2.4d$$

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d, data = rg31)

Residuals:
     Min       1Q   Median       3Q      Max
-0.81387 -0.38533 -0.01579  0.39221  0.63729

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.70711    1.80073   2.614   0.0149 *
Q2.2a        0.11665    0.22292   0.523   0.6054
Q2.2b        0.02261    0.23735   0.095   0.9249
Q2.2c        0.11744    0.33838   0.347   0.7314
Q2.2d       -0.03064    0.18888  -0.162   0.8725
Q2.3a       -0.15553    0.26607  -0.585   0.5641
Q2.3b       -0.29001    0.33054  -0.877   0.3886
Q2.3c        0.04094    0.24965   0.164   0.8711
Q2.3d        0.29156    0.34042   0.856   0.3999
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5252 on 25 degrees of freedom
Multiple R-squared:  0.1888,    Adjusted R-squared:  -0.07075
F-statistic: 0.7274 on 8 and 25 DF,  p-value: 0.6663
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Relationships)
   Q2.2a    Q2.2b    Q2.2c    Q2.2d    Q2.3a    Q2.3b    Q2.3c    Q2.3d
2.421815 3.826984 4.786582 2.712676 2.808506 4.707145 5.031424 4.510782
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Relationships)

        studentized Breusch-Pagan test

data:  Relationships
BP = 7.6588, df = 8, p-value = 0.4675
```

The P-valu of the BP test is 0.4675 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms. Correlation of regressors to the residual should be close to if not equal to zero. This can be done in R software.

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```
> cor(resid(Relationships),growth$Q2.2a)
[1] 4.042223e-16
> cor(resid(Relationships),growth$Q2.2b)
[1] 2.856088e-16
> cor(resid(Relationships),growth$Q2.2c)
[1] 3.566028e-16
> cor(resid(Relationships),growth$Q2.2d)
[1] 3.217227e-16
> cor(resid(Relationships),growth$Q2.3a)
[1] 3.066623e-16
> cor(resid(Relationships),growth$Q2.3b)
[1] 1.342028e-16
> cor(resid(Relationships),growth$Q2.3c)
[1] 2.173561e-16
> cor(resid(Relationships),growth$Q2.3d)
[1] 3.828022e-17
> cor(resid(Relationships),growth$Q2.4a)
[1] 1.756765e-16
> cor(resid(Relationships),growth$Q2.4b)
[1] 1.105879e-16
> cor(resid(Relationships),growth$Q2.4c)
[1] 1.349737e-16
> cor(resid(Relationships),growth$Q2.4d)
[1] 1.122975e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d, data = rg31)

Residuals:
     Min       1Q   Median       3Q      Max
-0.81387 -0.38533 -0.01579  0.39221  0.63729

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.70711    1.80073   2.614   0.0149 *
Q2.2a        0.11665    0.22292   0.523   0.6054
Q2.2b        0.02261    0.23735   0.095   0.9249
Q2.2c        0.11744    0.33838   0.347   0.7314
Q2.2d       -0.03064    0.18888  -0.162   0.8725
Q2.3a       -0.15553    0.26607  -0.585   0.5641
Q2.3b       -0.29001    0.33054  -0.877   0.3886
Q2.3c        0.04094    0.24965   0.164   0.8711
Q2.3d        0.29156    0.34042   0.856   0.3999
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5252 on 25 degrees of freedom
Multiple R-squared:  0.1888,    Adjusted R-squared:  -0.07075
F-statistic: 0.7274 on 8 and 25 DF,  p-value: 0.6663
```

It can be seen that no regressor plays a significant role in the 90 percent confidence interval in the success of a project.

This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and Relationships.

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Wisdom, RG31 projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q3.1a + \beta_2 Q3.1b + \beta_3 Q3.1c + \beta_4 Q3.1d + \beta_5 Q3.2a + \beta_6 Q3.2b + \beta_7 Q3.2c + \beta_8 Q3.2d + \beta_9 Q3.3a + \beta_{10} Q3.3b + \beta_{11} Q3.3c + \beta_{12} Q3.3d + \beta_{13} Q3.4a + \beta_{14} Q3.4b + \beta_{15} Q3.4c + \beta_{16} Q3.4d + \beta_{17} Q3.5a + \beta_{18} Q3.5b + \beta_{19} Q3.5c + \beta_{20} Q3.6a + \beta_{21} Q3.6b + \beta_{22} Q3.6c + \beta_{23} Q3.6d + \beta_{24} Q3.6e$$

```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2a +
    Q3.2b + Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a +
    Q3.4b + Q3.4c + Q3.4d + Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6b +
    Q3.6c + Q3.6d + Q3.6e, data = rg31)

Residuals:
     Min       1Q   Median       3Q      Max
-0.65590 -0.12427  0.00489  0.16268  0.52711

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  6.499941   2.267751   2.866   0.0186 *
Q3.1a       -0.136848   0.301255  -0.454   0.6604
Q3.1b        0.341235   0.274162   1.245   0.2447
Q3.1c       -0.247116   0.463377  -0.533   0.6067
Q3.1d        0.146300   0.314419   0.465   0.6528
Q3.2a        0.548024   0.391678   1.399   0.1953
Q3.2b       -0.488511   0.313731  -1.557   0.1539
Q3.2c       -0.273837   0.253261  -1.081   0.3077
Q3.2d        0.067458   0.269956   0.250   0.8083
Q3.3a        0.972046   0.448366   2.168   0.0583 .
Q3.3b       -0.039125   0.253496  -0.154   0.8807
Q3.3c       -0.489818   0.449463  -1.090   0.3041
Q3.3d       -0.053305   0.443629  -0.120   0.9070
Q3.4a       -0.004473   0.244758  -0.018   0.9858
Q3.4b        0.715186   0.337245   2.121   0.0630 .
Q3.4c       -0.056122   0.283519  -0.198   0.8475
Q3.4d       -1.305025   0.504665  -2.586   0.0294 *
Q3.5a       -1.023725   0.654005  -1.565   0.1519
Q3.5b        1.179346   0.577560   2.042   0.0715 .
Q3.5c        0.424067   0.492913   0.860   0.4119
Q3.6a        0.110547   0.643782   0.172   0.8675
Q3.6b        0.266639   0.397370   0.671   0.5191
Q3.6c        0.084366   0.565203   0.149   0.8846
Q3.6d       -0.707461   0.479675  -1.475   0.1743
Q3.6e       -0.286611   0.461997  -0.620   0.5504
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software and remove variables with VIF value higher than 5 from the model.

```
> vif(Knowledge)
   Q3.1a    Q3.1b    Q3.1c    Q3.2a    Q3.2b    Q3.2c    Q3.2d    Q3.3a    Q3.3b
4.673380 3.583576 6.524073 5.972180 3.292775 3.353437 2.779157 5.531043 3.306375
   Q3.3c    Q3.3d    Q3.4a    Q3.4c    Q3.5b    Q3.6a    Q3.6b    Q3.6c    Q3.6d
3.490252 9.051942 4.934059 4.551109 2.646244 3.994065 4.968498 3.777447 5.545840
   Q3.6e
3.220274
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

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```
> bptest(Knowledge)

        studentized Breusch-Pagan test

data:  Knowledge
BP = 13.766, df = 19, p-value = 0.7972
```

The P-value of the BP test is 0.7972 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.
C. Stochastic Regressors
Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.
Correlation of regressors to the residual should be close to if not equal to zero.
This can be done in R software.

```
> cor(resid(Knowledge),growth$Q3.1a)
[1] 1.456139e-16
> cor(resid(Knowledge),growth$Q3.1b)
[1] -2.542412e-17
> cor(resid(Knowledge),growth$Q3.1c)
[1] 1.28918e-16
> cor(resid(Knowledge),growth$Q3.1d)
[1] 3.522391e-17
> cor(resid(Knowledge),growth$Q3.2c)
[1] -3.533895e-17
> cor(resid(Knowledge),growth$Q3.2d)
[1] 1.410991e-16
> cor(resid(Knowledge),growth$Q3.3a)
[1] 6.687115e-17
> cor(resid(Knowledge),growth$Q3.3b)
[1] 1.714147e-16
> cor(resid(Knowledge),growth$Q3.3c)
[1] 2.115444e-16
> cor(resid(Knowledge),growth$Q3.4a)
[1] 1.994042e-16
> cor(resid(Knowledge),growth$Q3.4b)
[1] 8.0428e-17
> cor(resid(Knowledge),growth$Q3.4d)
[1] 7.117478e-17
> cor(resid(Knowledge),growth$Q3.5a)
[1] 5.690785e-17
> cor(resid(Knowledge),growth$Q3.5c)
[1] 6.595153e-17
> cor(resid(Knowledge),growth$Q3.6a)
[1] 1.497801e-18
> cor(resid(Knowledge),growth$Q3.6d)
[1] 7.104411e-17
> cor(resid(Knowledge),growth$Q3.6e)
[1] 2.900482e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor
Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

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```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.2a + Q3.2b +
    Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a + Q3.4c +
    Q3.5b + Q3.6a + Q3.6b + Q3.6c + Q3.6d + Q3.6e, data = rg31)

Residuals:
     Min       1Q   Median       3Q      Max
-0.81612 -0.16709  0.02699  0.29238  0.58991

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  5.875612   1.974385   2.976    0.010 *
Q3.1a       -0.179115   0.281190  -0.637    0.534
Q3.1b        0.183923   0.211737   0.869    0.400
Q3.1c        0.005937   0.444282   0.013    0.990
Q3.2a       -0.080706   0.240459  -0.336    0.742
Q3.2b        0.035477   0.209238   0.170    0.868
Q3.2c        0.148108   0.175383   0.844    0.413
Q3.2d       -0.007832   0.199881  -0.039    0.969
Q3.3a        0.208133   0.323971   0.642    0.531
Q3.3b       -0.015941   0.239963  -0.066    0.948
Q3.3c        0.002413   0.336763   0.007    0.994
Q3.3d       -0.223164   0.351482  -0.635    0.536
Q3.4a       -0.007240   0.269116  -0.027    0.979
Q3.4c        0.130771   0.276698   0.473    0.644
Q3.5b        0.194766   0.299878   0.649    0.527
Q3.6a       -0.576648   0.529428  -1.089    0.294
Q3.6b       -0.169677   0.326432  -0.520    0.611
Q3.6c        0.463101   0.399290   1.160    0.266
Q3.6d        0.150010   0.282529   0.531    0.604
Q3.6e       -0.299346   0.371993  -0.805    0.434
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5906 on 14 degrees of freedom
Multiple R-squared:  0.4255,    Adjusted R-squared:  -0.3543
F-statistic: 0.5457 on 19 and 14 DF,  p-value: 0.8911
```

It can be seen that no regressor plays a significant role in the 90 percent confidence interval in the success of a project.
This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and wisdom.

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Culture, RG31 projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q4.1a + \beta_2 Q4.1b + \beta_3 Q4.1c + \beta_4 Q4.1d + \beta_5 Q4.1e + \beta_6 Q4.2a + \beta_7 Q4.2b + \beta_8 Q4.2c + \beta_9 Q4.2d + \beta_{10} Q4.2e + \beta_{11} Q4.3a + \beta_{12} Q4.3b + \beta_{13} Q4.3c + \beta_{14} Q4.4a + \beta_{15} Q4.4b + \beta_{16} Q4.4c$$

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2d + Q4.2e + Q4.3a + Q4.3b + Q4.3c +
    Q4.4a + Q4.4b + Q4.4c, data = rg31)

Residuals:
    Min      1Q  Median      3Q     Max
-0.8211 -0.2166 -0.0486  0.2714  0.7253

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  5.45891    0.90550   6.029 1.36e-05 ***
Q4.1a       -0.49080    0.22680  -2.164    0.045 *
Q4.1b        0.13724    0.19593   0.700    0.493
Q4.1c       -0.03387    0.23818  -0.142    0.889
Q4.1d        0.09730    0.17127   0.568    0.577
Q4.1e        0.17821    0.23507   0.758    0.459
Q4.2a       -0.37164    0.36769  -1.011    0.326
Q4.2b        0.04739    0.41203   0.115    0.910
Q4.2c       -0.19415    0.22075  -0.879    0.391
Q4.2d        0.57482    0.32079   1.792    0.091 .
Q4.2e        0.05880    0.22734   0.259    0.799
Q4.3a        0.28591    0.18270   1.565    0.136
Q4.3b       -0.02673    0.39024  -0.068    0.946
Q4.3c       -0.11872    0.45630  -0.260    0.798
Q4.4a       -0.16192    0.35618  -0.455    0.655
Q4.4b       -0.21542    0.42024  -0.513    0.615
Q4.4c        0.29613    0.28848   1.027    0.319
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5096 on 17 degrees of freedom
Multiple R-squared:  0.4807,    Adjusted R-squared:  -0.00811
F-statistic: 0.9834 on 16 and 17 DF,  p-value: 0.5113
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Culture)
   Q4.1a    Q4.1b    Q4.1c    Q4.1d    Q4.1e    Q4.2a    Q4.2b    Q4.2c    Q4.2e
2.599250 3.834283 4.143325 2.439419 3.224237 5.634683 4.563452 4.305470 3.603296
   Q4.3a    Q4.3b    Q4.4b
3.506049 4.289157 1.738820
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Culture)

        studentized Breusch-Pagan test

data:  Culture
BP = 6.7158, df = 12, p-value = 0.8758
```

The P-value of the BP test is 0.8758 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

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```
> cor(resid(Culture),maturity$Q4.1a)
[1] -2.09203e-16
> cor(resid(Culture),maturity$Q4.1b)
[1] -4.955038e-16
> cor(resid(Culture),maturity$Q4.1c)
[1] -1.969066e-16
> cor(resid(Culture),maturity$Q4.1d)
[1] -2.905282e-16
> cor(resid(Culture),maturity$Q4.1e)
[1] -3.005312e-16
> cor(resid(Culture),maturity$Q4.2b)
[1] -3.879699e-16
> cor(resid(Culture),maturity$Q4.2e)
[1] -3.951081e-16
> cor(resid(Culture),maturity$Q4.3a)
[1] -4.539125e-16
> cor(resid(Culture),maturity$Q4.3b)
[1] -3.907801e-16
> cor(resid(Culture),maturity$Q4.4a)
[1] -3.351443e-16
> cor(resid(Culture),maturity$Q4.4c)
[1] -3.896452e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2e + Q4.3a + Q4.3b + Q4.4b, data = rg31)

Residuals:
     Min       1Q   Median       3Q      Max
-0.73276 -0.32837 -0.02396  0.30814  0.81567

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.861766   0.757314   6.420 2.31e-06 ***
Q4.1a       -0.183618   0.145323  -1.264    0.220
Q4.1b        0.074097   0.179078   0.414    0.683
Q4.1c        0.001651   0.191134   0.009    0.993
Q4.1d        0.127154   0.152132   0.836    0.413
Q4.1e        0.022905   0.205855   0.111    0.912
Q4.2a       -0.188088   0.261937  -0.718    0.481
Q4.2b        0.329118   0.250006   1.316    0.202
Q4.2c       -0.139981   0.169001  -0.828    0.417
Q4.2e        0.095042   0.172339   0.551    0.587
Q4.3a        0.146378   0.148864   0.983    0.337
Q4.3b       -0.035746   0.182807  -0.196    0.847
Q4.4b       -0.046053   0.140965  -0.327    0.747
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5176 on 21 degrees of freedom
Multiple R-squared:  0.3382,    Adjusted R-squared:  -0.04002
F-statistic: 0.8942 on 12 and 21 DF,  p-value: 0.5664
```

It can be seen that no regressor plays a significant role in the 90 percent confidence interval in the success of a project.

This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and culture.

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Relationships, RG32 projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q2.2a + \beta_2 Q2.2b + \beta_3 Q2.2c + \beta_4 Q2.2d + \beta_5 Q2.3a + \beta_6 Q2.3b + \beta_7 Q2.3c + \beta_8 Q2.3d + \beta_9 Q2.4a + \beta_{10} Q2.4b + \beta_{11} Q2.4c + \beta_{12} Q2.4d$$

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d, data = rg32)

Residuals:
    Min      1Q  Median      3Q     Max
-1.7003 -0.7658 -0.2157  0.9104  2.1525

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.50786    1.41699   0.358   0.7215
Q2.2a        0.13212    0.24363   0.542   0.5900
Q2.2b        0.33201    0.21841   1.520   0.1347
Q2.2c        0.46991    0.21680   2.168   0.0349 *
Q2.2d       -0.31961    0.18691  -1.710   0.0934 .
Q2.3a        0.12934    0.21670   0.597   0.5533
Q2.3b       -0.11546    0.20217  -0.571   0.5704
Q2.3c       -0.04329    0.18862  -0.230   0.8194
Q2.3d       -0.14310    0.17584  -0.814   0.4196
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.118 on 51 degrees of freedom
Multiple R-squared:  0.309,     Adjusted R-squared:  0.2007
F-statistic: 2.851 on 8 and 51 DF,  p-value: 0.01068
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Relationships)
    Q2.2a     Q2.2b     Q2.2c     Q2.2d     Q2.3a     Q2.3b     Q2.3c     Q2.3d
 1.707783  1.687590  2.189601  1.370243  1.451386  2.035001  1.839743  1.652176
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis.

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Relationships)

        studentized Breusch-Pagan test

data:  Relationships
BP = 10.105, df = 8, p-value = 0.2577
```

The P-value of the BP test is 0.2577 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

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```
> cor(resid(Relationships),growth$Q2.2a)
[1] 4.042223e-16
> cor(resid(Relationships),growth$Q2.2b)
[1] 2.856088e-16
> cor(resid(Relationships),growth$Q2.2c)
[1] 3.566028e-16
> cor(resid(Relationships),growth$Q2.2d)
[1] 3.217227e-16
> cor(resid(Relationships),growth$Q2.3a)
[1] 3.066623e-16
> cor(resid(Relationships),growth$Q2.3b)
[1] 1.342028e-16
> cor(resid(Relationships),growth$Q2.3c)
[1] 2.173561e-16
> cor(resid(Relationships),growth$Q2.3d)
[1] 3.828022e-17
> cor(resid(Relationships),growth$Q2.4a)
[1] 1.756765e-16
> cor(resid(Relationships),growth$Q2.4b)
[1] 1.105879e-16
> cor(resid(Relationships),growth$Q2.4c)
[1] 1.349737e-16
> cor(resid(Relationships),growth$Q2.4d)
[1] 1.122975e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor
Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Relationships)

Call:
lm(formula = Project ~ Q2.2a + Q2.2b + Q2.2c + Q2.2d + Q2.3a +
    Q2.3b + Q2.3c + Q2.3d, data = rg32)

Residuals:
    Min      1Q  Median      3Q     Max
-1.7003 -0.7658 -0.2157  0.9104  2.1525

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.50786    1.41699   0.358   0.7215
Q2.2a        0.13212    0.24363   0.542   0.5900
Q2.2b        0.33201    0.21841   1.520   0.1347
Q2.2c        0.46991    0.21680   2.168   0.0349 *
Q2.2d       -0.31961    0.18691  -1.710   0.0934 .
Q2.3a        0.12934    0.21670   0.597   0.5533
Q2.3b       -0.11546    0.20217  -0.571   0.5704
Q2.3c       -0.04329    0.18862  -0.230   0.8194
Q2.3d       -0.14310    0.17584  -0.814   0.4196
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.118 on 51 degrees of freedom
Multiple R-squared:  0.309,     Adjusted R-squared:  0.2007
F-statistic: 2.851 on 8 and 51 DF,  p-value: 0.01068
```

Final model after GM Assumptions, the final model for wisdom at a 90% confidence level is:

$$y_{ProjectSuccess} = 0.46991Q2.2c - 0.31961Q2.2d$$

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Wisdom, RG32 projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q3.1a + \beta_2 Q3.1b + \beta_3 Q3.1c + \beta_4 Q3.1d + \beta_5 Q3.2a + \beta_6 Q3.2b + \beta_7 Q3.2c + \beta_8 Q3.2d + \beta_9 Q3.3a + \beta_{10} Q3.3b + \beta_{11} Q3.3c + \beta_{12} Q3.3d + \beta_{13} Q3.4a + \beta_{14} Q3.4b + \beta_{15} Q3.4c + \beta_{16} Q3.4d + \beta_{17} Q3.5a + \beta_{18} Q3.5b + \beta_{19} Q3.5c + \beta_{20} Q3.6a + \beta_{21} Q3.6b + \beta_{22} Q3.6c + \beta_{23} Q3.6d + \beta_{24} Q3.6e$$

```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2a +
    Q3.2b + Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a +
    Q3.4b + Q3.4c + Q3.4d + Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6b +
    Q3.6c + Q3.6d + Q3.6e, data = rg32)

Residuals:
     Min       1Q   Median       3Q      Max
-1.63476 -0.67546 -0.09213  0.59767  1.91882

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.93938    1.50833   1.286   0.2070
Q3.1a        0.23401    0.33075   0.707   0.4839
Q3.1b        0.26189    0.33599   0.779   0.4409
Q3.1c       -0.29301    0.26881  -1.090   0.2831
Q3.1d       -0.27466    0.33611  -0.817   0.4194
Q3.2a       -0.05195    0.43010  -0.121   0.9046
Q3.2b        0.11204    0.51864   0.216   0.8302
Q3.2c        0.15970    0.25780   0.619   0.5396
Q3.2d        0.38034    0.30624   1.242   0.2225
Q3.3a        0.01393    0.37448   0.037   0.9705
Q3.3b       -0.17521    0.33490  -0.523   0.6041
Q3.3c        0.12991    0.46417   0.280   0.7812
Q3.3d       -0.32931    0.37543  -0.877   0.3864
Q3.4a       -0.35732    0.45135  -0.792   0.4339
Q3.4b        0.53096    0.33169   1.601   0.1184
Q3.4c       -0.43623    0.46165  -0.945   0.3512
Q3.4d        0.05524    0.61462   0.090   0.9289
Q3.5a       -0.14624    0.42954  -0.340   0.7356
Q3.5b        0.57587    0.30706   1.875   0.0691 .
Q3.5c       -0.09787    0.28227  -0.347   0.7309
Q3.6a       -0.38239    0.39321  -0.972   0.3375
Q3.6b       -0.06927    0.45972  -0.151   0.8811
Q3.6c        0.82265    0.60570   1.358   0.1831
Q3.6d       -0.35036    0.28928  -1.211   0.2340
Q3.6e       -0.14747    0.34387  -0.429   0.6707
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software and remove variables with VIF value higher than 5 from the model.

```
> vif(Knowledge)
   Q3.1a    Q3.1b    Q3.1c    Q3.1d    Q3.2b    Q3.2c    Q3.2d    Q3.3a    Q3.3b
2.493177 4.152925 2.771792 3.065924 4.166877 3.218620 2.826150 4.235918 3.705861
   Q3.3c    Q3.3d    Q3.4a    Q3.4b    Q3.4c    Q3.5a    Q3.5b    Q3.5c    Q3.6a
4.562678 3.486055 5.445228 3.060132 4.335304 2.453418 2.464419 2.419613 1.890793
   Q3.6d    Q3.6e
2.086792 3.599174
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

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```
> bptest(Knowledge)

        studentized Breusch-Pagan test

data:  Knowledge
BP = 11.427, df = 20, p-value = 0.9344
```

The P-value of the BP test is 0.9344 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.
C. Stochastic Regressors
Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.
Correlation of regressors to the residual should be close to if not equal to zero.
This can be done in R software.

```
> cor(resid(Knowledge),growth$Q3.1a)
[1] 1.456139e-16
> cor(resid(Knowledge),growth$Q3.1b)
[1] -2.542412e-17
> cor(resid(Knowledge),growth$Q3.1c)
[1] 1.28918e-16
> cor(resid(Knowledge),growth$Q3.1d)
[1] 3.522391e-17
> cor(resid(Knowledge),growth$Q3.2c)
[1] -3.533895e-17
> cor(resid(Knowledge),growth$Q3.2d)
[1] 1.410991e-16
> cor(resid(Knowledge),growth$Q3.3a)
[1] 6.687115e-17
> cor(resid(Knowledge),growth$Q3.3b)
[1] 1.714147e-16
> cor(resid(Knowledge),growth$Q3.3c)
[1] 2.115444e-16
> cor(resid(Knowledge),growth$Q3.4a)
[1] 1.994042e-16
> cor(resid(Knowledge),growth$Q3.4b)
[1] 8.0428e-17
> cor(resid(Knowledge),growth$Q3.4d)
[1] 7.117478e-17
> cor(resid(Knowledge),growth$Q3.5a)
[1] 5.690785e-17
> cor(resid(Knowledge),growth$Q3.5c)
[1] 6.595153e-17
> cor(resid(Knowledge),growth$Q3.6a)
[1] 1.497801e-18
> cor(resid(Knowledge),growth$Q3.6d)
[1] 7.104411e-17
> cor(resid(Knowledge),growth$Q3.6e)
[1] 2.900482e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor
Hypothesis Testing
Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).
Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

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```
> summary(Knowledge)

Call:
lm(formula = Project ~ Q3.1a + Q3.1b + Q3.1c + Q3.1d + Q3.2b +
    Q3.2c + Q3.2d + Q3.3a + Q3.3b + Q3.3c + Q3.3d + Q3.4a + Q3.4b +
    Q3.4c + Q3.5a + Q3.5b + Q3.5c + Q3.6a + Q3.6d + Q3.6e, data = rg32)

Residuals:
    Min      1Q  Median      3Q     Max
-1.6676 -0.7151 -0.2157  0.6933  1.7125

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.81226    1.32538   1.367   0.1793
Q3.1a        0.38766    0.25345   1.530   0.1342
Q3.1b        0.24935    0.31956   0.780   0.4399
Q3.1c       -0.37617    0.24661  -1.525   0.1352
Q3.1d       -0.40124    0.27462  -1.461   0.1520
Q3.2b        0.14133    0.30907   0.457   0.6500
Q3.2c        0.25420    0.23555   1.079   0.2871
Q3.2d        0.29986    0.26631   1.126   0.2671
Q3.3a        0.20748    0.31473   0.659   0.5136
Q3.3b       -0.04066    0.30779  -0.132   0.8956
Q3.3c        0.24996    0.40841   0.612   0.5441
Q3.3d       -0.52465    0.32158  -1.631   0.1108
Q3.4a       -0.44271    0.36737  -1.205   0.2354
Q3.4b        0.32387    0.26643   1.216   0.2315
Q3.4c       -0.14313    0.30585  -0.468   0.6424
Q3.5a       -0.24552    0.34006  -0.722   0.4746
Q3.5b        0.67376    0.25778   2.614   0.0127 *
Q3.5c       -0.09049    0.24721  -0.366   0.7163
Q3.6a       -0.02278    0.25158  -0.091   0.9283
Q3.6d       -0.19188    0.22526  -0.852   0.3995
Q3.6e       -0.12298    0.30945  -0.397   0.6932
---
```

Final model after GM Assumptions, the final model for wisdom at a 90% confidence level is:

$$y_{ProjectSuccess} = 0.67376Q3.5b$$

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Culture, RG32 projects

Initial Regression Model:

$$y_{ProjectSuccess} = \beta_0 + \beta_1 Q4.1a + \beta_2 Q4.1b + \beta_3 Q4.1c + \beta_4 Q4.1d + \beta_5 Q4.1e + \beta_6 Q4.2a + \beta_7 Q4.2b + \beta_8 Q4.2c + \beta_9 Q4.2d + \beta_{10} Q4.2e + \beta_{11} Q4.3a + \beta_{12} Q4.3b + \beta_{13} Q4.3c + \beta_{14} Q4.4a + \beta_{15} Q4.4b + \beta_{16} Q4.4c$$

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2d + Q4.2e + Q4.3a + Q4.3b + Q4.3c +
    Q4.4a + Q4.4b + Q4.4c, data = rg32)

Residuals:
    Min      1Q  Median      3Q     Max
-1.6822 -0.8845 -0.3482  1.1036  1.9844

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.037120   1.107856   0.034    0.973
Q4.1a        0.231360   0.335402   0.690    0.494
Q4.1b        0.007045   0.330096   0.021    0.983
Q4.1c        0.028610   0.289320   0.099    0.922
Q4.1d       -0.114498   0.293067  -0.391    0.698
Q4.1e        0.058606   0.262106   0.224    0.824
Q4.2a        0.030268   0.411419   0.074    0.942
Q4.2b        0.257325   0.371472   0.693    0.492
Q4.2c       -0.121371   0.263836  -0.460    0.648
Q4.2d       -0.054817   0.436205  -0.126    0.901
Q4.2e        0.109462   0.318860   0.343    0.733
Q4.3a        0.158532   0.270449   0.586    0.561
Q4.3b       -0.047625   0.320618  -0.149    0.883
Q4.3c        0.244180   0.314739   0.776    0.442
Q4.4a       -0.293096   0.383908  -0.763    0.449
Q4.4b        0.359532   0.571516   0.629    0.533
Q4.4c       -0.234165   0.375381  -0.624    0.536

Residual standard error: 1.324 on 43 degrees of freedom
Multiple R-squared:  0.182,     Adjusted R-squared:  -0.1223
F-statistic: 0.598 on 16 and 43 DF,  p-value: 0.8677
```

Guass Markov Assumptions to test that the OLS regression is reliable:

A. Multi-collinearity

GM assumptions state that there must be low to none multi- collinearity between the independent variables of the model. We can test this with R software.

```
> vif(Culture)
   Q4.1a    Q4.1b    Q4.1c    Q4.1d    Q4.1e    Q4.2a    Q4.2b    Q4.2c    Q4.2d
3.608515 4.090595 2.790940 2.761331 2.160712 4.180456 3.475455 3.077877 4.779944
   Q4.2e    Q4.3a    Q4.3b    Q4.3c    Q4.4a    Q4.4c
3.210724 3.609517 4.340953 3.600029 2.396496 2.667723
```

There are no variables with a VIF Value higher than 5, therefore, we can assume that multi-collinearity does not exist within the model.

B. Heteroscedasticity

The revised model with no multi-collinearity is now test for Heteroskedasticity. Heteroskedasticity is tested on the revised model using Breusch-Pagan test, with the below hypothesis

$$H_0: Homoscedasticity$$

$$H_1: Heteroscedasticity$$

Using R software, we run the test and the results shown below:

```
> bptest(Culture)

        studentized Breusch-Pagan test

data:  Culture
BP = 15.004, df = 15, p-value = 0.4511
```

The P-value of the BP test is 0.4511 which is significantly higher than 0.05. We can therefore, not reject the H_0 and assume the model is homoscedastic.

C. Stochastic Regressors

Gauss-Markov theorem requires any of the explanatory variables to be uncorrelated with the error terms.

Correlation of regressors to the residual should be close to if not equal to zero.

This can be done in R software.

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```
> cor(resid(Culture),maturity$Q4.1a)
[1] -2.09203e-16
> cor(resid(Culture),maturity$Q4.1b)
[1] -4.955038e-16
> cor(resid(Culture),maturity$Q4.1c)
[1] -1.969066e-16
> cor(resid(Culture),maturity$Q4.1d)
[1] -2.905282e-16
> cor(resid(Culture),maturity$Q4.1e)
[1] -3.005312e-16
> cor(resid(Culture),maturity$Q4.2b)
[1] -3.879699e-16
> cor(resid(Culture),maturity$Q4.2e)
[1] -3.951081e-16
> cor(resid(Culture),maturity$Q4.3a)
[1] -4.539125e-16
> cor(resid(Culture),maturity$Q4.3b)
[1] -3.907801e-16
> cor(resid(Culture),maturity$Q4.4a)
[1] -3.351443e-16
> cor(resid(Culture),maturity$Q4.4c)
[1] -3.896452e-16
```

All regressors correlation with the residual is close to zero – no stochastic regressor

Hypothesis Testing

Hypothesis testing by comparing the p-values to significance level, set at 90% (α=0.10).

Any regressor with a P-Value less than 0.10 is significant for the OLS Regression Model.

```
> summary(Culture)

Call:
lm(formula = Project ~ Q4.1a + Q4.1b + Q4.1c + Q4.1d + Q4.1e +
    Q4.2a + Q4.2b + Q4.2c + Q4.2d + Q4.2e + Q4.3a + Q4.3b + Q4.3c +
    Q4.4a + Q4.4c, data = rg32)

Residuals:
    Min      1Q  Median      3Q     Max
-1.7539 -0.9091 -0.3900  1.1080  1.9908

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.14718    1.08642   0.135    0.893
Q4.1a        0.19149    0.32709   0.585    0.561
Q4.1b        0.02219    0.32695   0.068    0.946
Q4.1c        0.06462    0.28165   0.229    0.820
Q4.1d       -0.11812    0.29099  -0.406    0.687
Q4.1e        0.01871    0.25256   0.074    0.941
Q4.2a        0.04209    0.40816   0.103    0.918
Q4.2b        0.25267    0.36884   0.685    0.497
Q4.2c       -0.16143    0.25427  -0.635    0.529
Q4.2d       -0.10615    0.42555  -0.249    0.804
Q4.2e        0.17760    0.29783   0.596    0.554
Q4.3a        0.17997    0.26645   0.675    0.503
Q4.3b       -0.03914    0.31813  -0.123    0.903
Q4.3c        0.24242    0.31256   0.776    0.442
Q4.4a       -0.11232    0.25281  -0.444    0.659
Q4.4c       -0.06908    0.26656  -0.259    0.797

Residual standard error: 1.315 on 44 degrees of freedom
Multiple R-squared:  0.1745,    Adjusted R-squared:  -0.1069
F-statistic:  0.62 on 15 and 44 DF,  p-value: 0.8424
```

It can be seen that no regressor plays a significant role in the 90 percent confidence interval in the success of a project.

This tell us that there is can be no statistical model in the 90 percent confidence interval to find a correlation between the project success and culture.