



The Interaction of Human, Information and Technology Components in Real Time Physical Asset Management

Christiaan Grové

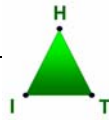
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Thesis presented in partial fulfilment of the requirements for the degree of
Masters of Industrial Engineering at the University of Stellenbosch.

Study leader: Konrad von Leipzig

28 May 2007



DECLARATION

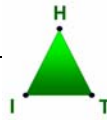
I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

Ek, die ondergetekende verklaar hiermee dat die werk gedoen in hierdie tesis my eie oorspronklike werk is wat nog nie voorheen gedeeltelik of volledig by enige universiteit vir 'n graad aangebied is nie.



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SYNOPSIS

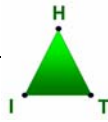
The last untapped margin of improvement in the manufacturing process is believed to be the improvement of physical asset maintenance. The latest opportunity is to move this process to a real time system.

Although in recent years it has become somewhat of a cliché, the successful management of the human factor is one of the most critical components, and also one of the most difficult to manage, in all improvement projects. By combining the groundbreaking opportunity in Asset Performance Management with an enthusiasm for people and process improvement, the focus of this research is found. The motivation stems from a realization that Asset Performance Management will undergo radical changes and that it would not be sufficient to apply the traditional methods of managing change to the younger generations, that are currently entering the workforce and that would have to run this improved system.

The industry trend was studied in order to better facilitate a solution that would suit this natural evolution. Specifically, trends were studied on Human, Information and Technology levels since background studies have shown that these three components are key to the Physical Asset Performance Management scenario. Through an in-depth literature study, the answers to the predetermined research questions were determined.

To guide companies through the transition towards the real time enterprise as well as improve overall machine performance (research origin), the HIT Interaction model for real time Physical Asset Performance Management is proposed. A structure is also facilitated by which companies can be evaluated in terms of the stages of readiness for real time operation. This enables them to establish where they currently are and what strategic steps to take in order to reach the next level.

The concept is based on Gartner's Agility, with Business Activity Monitoring, Change Facilitation and Service Delivery as key interaction drivers. This is a descriptive model of a situation that will evolve through the next five to ten years. Real time Asset Performance Management will come into its own by 2010 and companies that recognize the trend of the industry towards the real time paradigm, can use the proposed HIT model to re-engineer their processes accordingly.

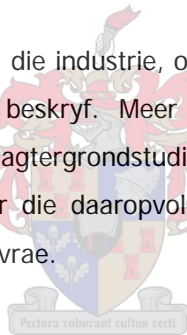


OPSOMMING

Die verbetering van fisiese bate instandhouding kan gesien word as een van die laaste geleenthede om 'n mededingende voorsprong in die vervaardigingsproses te bewerkstellig. Die nuutste geleentheid is om hierdie stelsel op te hef na 'n intydse struktuur (*real time*).

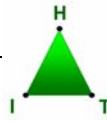
In die afgelope jare is dit al as 'n cliché beskou, maar die suksesvolle bestuur van menslike faktore is een van die moeilikste en tog een van die mees kritiese punte om aan te raak in enige maatskappy. Die fokus van hierdie navorsing word gevind in 'n kombinasie tussen die baanbrekende geleentheid in batebestuur en 'n entoesiasme vir mense en prosesverbetering. Die motivering is gegrond in die besef dat die bestuur van bate werkverrigting radikale veranderinge sal ondergaan en dat dit nie meer voldoende sal wees om die tradisionele metodes van veranderingsbestuur toe te pas op die jonger generasies wat hierdie verandering sal moet bestuur nie.

'n Studie is gemaak van die tendense in die industrie, om sodoende 'n oplossing daar te stel wat hierdie natuurlike evolusie die beste sal beskryf. Meer spesifiek – tendense van mense, inligting en tegnologie is bestudeer, aangesien agtergrondstudies getoon het dat hierdie die essensiële komponente van batebestuur is. Deur die daaropvolgende literatuurstudie, is die antwoorde verkry tot die voorafgestelde navorsingsvrae.



Die *HIT Interaction Model* vir intydse fisiese batebestuur, word as oplossing voorgestel. Dit sal maatskappye lei deur die oorgangsfase na die intydse omgewing, asook 'n merkwaardige verbetering op algehele masjien werkverrigting bewerkstellig. 'n Struktuur word ook voorgestel waardeur maatskappye hulself kan evalueer in terme van gereedheid vir die intydse bestuursomgewing. Dit sal hulle in staat stel om te bepaal op watter vlak hulle tans is, en ook watter strategiese stappe geneem moet word om die volgende vlak te bereik.

Die konsep is gebaseer op Gartner se *Agility*, met *Business Activity Monitoring*, *Change Facilitation* en *Service Delivery* as sentrale interaksie drywers. Hierdie is 'n beskrywende model van 'n situasie wat oor die volgende vyf tot tien jaar tot stand sal kom en maatskappye wat hierdie tendense herken, sal die voorgestelde model pro-aktief gebruik om hulle prosesse dienoreenkomstig aan te pas.



ACKNOWLEDGEMENTS

My sincere thanks and deepest appreciation to the following people, without whose help and support, this thesis would not have seen the light!

- Adriaan Scheeres, for the opportunity to base this thesis at PRAGMA and for all the advice, guidance and *catch-up* talks throughout the study period. Also to Marie Liebenberg for always finding a spot to fit an appointment into his busy schedule.
- My study leader, Konrad von Leipzig, for his general guidance and academic support.
- My family and friends for all their support and bearing with me throughout the countless hours of reading and writing.
- The team at PRAGMA:
 - Wyhan Jooste, for his guidance and conversations about the real time environment.
 - Attie, Morné, Albert, Hylton, Nicom, Stuart, Helgard and Marthinus for their time and assistance during the validation of the model.

**I am only one,
But I am one.
I cannot do everything,
But I can do something.
What I can do, I should do,
And what I should do,
By the grace of God,
I will do.**

- Edward Everette Hale

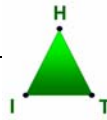
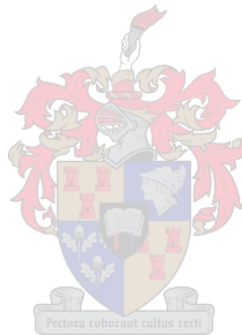
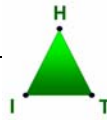


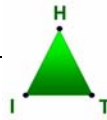
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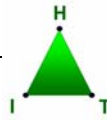




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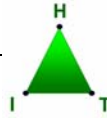


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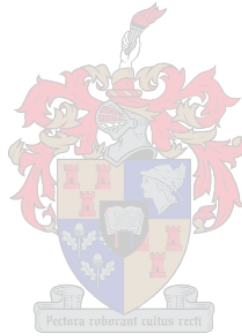
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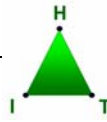
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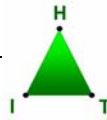
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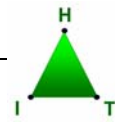


GLOSSARY

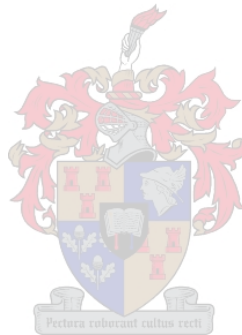
TERM		DEFINITION	SOURCE
Agility		Agility is the ability of an organization to sense environmental change and respond efficiently and effectively to that change.	[36]
Asset		It is the basic unit of maintenance, referring to a physical item such as machines, equipment or a building.	[58] [25]
Asset Management		The systematic planning and control of a physical resource throughout its life. This may include the specification, design, and construction of the asset, its operation, maintenance and modification while in use, and its disposal when no longer required.	[25]
Asset Utilization	(AU)	The ratio of actual output to the output that could be achieved if a plant ran at its maximum capacity for 365 days per year while producing 100% quality product.	[29]
Business Activity Monitoring	(BAM)	The concept of providing real-time access to critical business performance indicators to improve the speed and effectiveness of business operations.	[31]
Business Process Fusion	(BPF)	The transformation of business activities that is achieved by integrating previously autonomous business processes to create a new scope of management capabilities.	[15]
Business Process Management	(BPM)	The design, execution and optimization of automated processes – everything from line-of-business processes such as work orders, customer interactions, payroll processing, order processing and regulatory compliance initiatives to core mission-critical processes such as payment remittance, billing, product development and logistics.	[30]

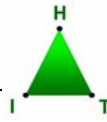


High Performance Workplace	(HPW)	A physical or virtual environment designed to make workers as effective as possible in supporting business goals and providing value. A high-performance workplace results from continually balancing investment in people, process, physical environment and technology, to measurably enhance the ability of workers to learn, discover, innovate, team and lead, and to achieve efficiency and financial benefit.	[52]
Maintenance		Any activity carried out on an asset in order to ensure that the asset continues to perform its intended functions, or to repair the equipment. <i>Note: Modifications are not maintenance, even though they may be carried out by maintenance personnel.</i>	[25]
Predictive Maintenance		Maintenance techniques that inspect an asset to predict if a failure will occur.	[58]
Preventive Maintenance		A series of tasks that either extends the life of an asset, or that detects that an asset has had critical wear and is going to fail or break down.	[58]
PQCDSM		A measurement which outlines the targets of TPM. It stands for Productivity, Quality, Cost, Delivery, Safety and Morale.	[28]
Real Time Infrastructure	(RTI)	An IT infrastructure shared across customers, business units or applications, where business policies and service-level agreements drive dynamic and automatic optimization of the IT infrastructure, thus reducing costs while increasing agility and quality of service.	[14]
Total Productive Management	(TPM)	A maintenance system set up to eliminate all of the barriers to production. It uses autonomous maintenance teams to carry out most maintenance activities.	[58]



Voice over IP (VoIP) A set of protocols and technologies for routing voice communications over the Internet, where IP refers to Internet Protocol. [24]





1. INTRODUCTION

1.1 BACKGROUND

40% of CEOs see Asset Utilization as a key focus in strengthening financial performance in the coming years.

- IBM Research Report

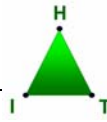
Improved maintenance helps to increase revenues by increasing equipment performance – It helps to improve return on assets by reducing the need for expensive capital upgrades to increase output.

- Sandy Dunn [48]

The Industrial Engineer's outlook on the maintenance function is in the form of physical Asset Performance Management. PRAGMA, a leading South African company that specializes in this field, is currently re-engineering its outsourced Asset Performance Management service. This service focuses mainly on manufacturing companies that do not have the resources to implement an Asset Performance Management solution. The re-engineered service will aim to connect clients to their assets in real time, 24/7.

As suggested by background literature as well as practical experience gained during hands-on work done at PRAGMA, inadequate management of maintenance is the root cause of most physical asset disasters. A very practical South African example is the recent case of Koeberg power station in the Western Cape. It was suggested in the media that inferior maintenance was one of the causes of lengthy downtimes of the power station, which resulted in long periods of power cuts and even greater financial losses – not only to the electrical supplier, but also to large companies and even the small business owner.

According to leading experts, the last untapped margin of improvement in the manufacturing process is to improve the efficiency and effectiveness of physical asset maintenance – a substantial part of the Asset Performance Management strategy. The latest opportunity for improvement is to move the process of physical asset maintenance to a real time system – exactly what PRAGMA aims to achieve within the next five years by using real time information management as main tool.

**There is nothing permanent except change.**

- Heraclitus (Greek Philosopher – 6th Century BC)

A great paradox in today's business world is that one of the few things that can be relied on to remain constant, is the need for change. Yet today, even the need for change itself, is changing. The pressure to strive for constant improvement in what is done and the way that it is done, is increasing in intensity as companies are forced to battle in ever-more competitive global marketplaces. Although in recent years it has become somewhat of a cliché, the successful management of the human factor is one of the most critical components, and also one of the most difficult to manage, in all improvement projects. The importance of this key component is on a regular basis being underestimated.

By combining the groundbreaking opportunity in Asset Performance Management with an enthusiasm for people and process improvement, the focus of this research is found. The motivation stems from a realization that Asset Performance Management will undergo radical changes and that it would not be sufficient to apply the traditional methods of managing change to the younger generations, that are currently entering the workforce and that would have to run this improved system.

The research will be mainly theory based, in order to encompass the whole scenario and eliminate a possible company-specific solution. The involvement of PRAGMA will therefore be two-fold:

- The current strategic vision of PRAGMA will be used as starting point of the research as well as an indication of the trend in the physical Asset Management industry.
- A subset of PRAGMA's clients will be used in order to evaluate and validate the results of the research.

Figure 1 indicates where this research fits into the physical Asset Management environment by indicating the improvement opportunity and the aligned change factors that are needed to accomplish this.

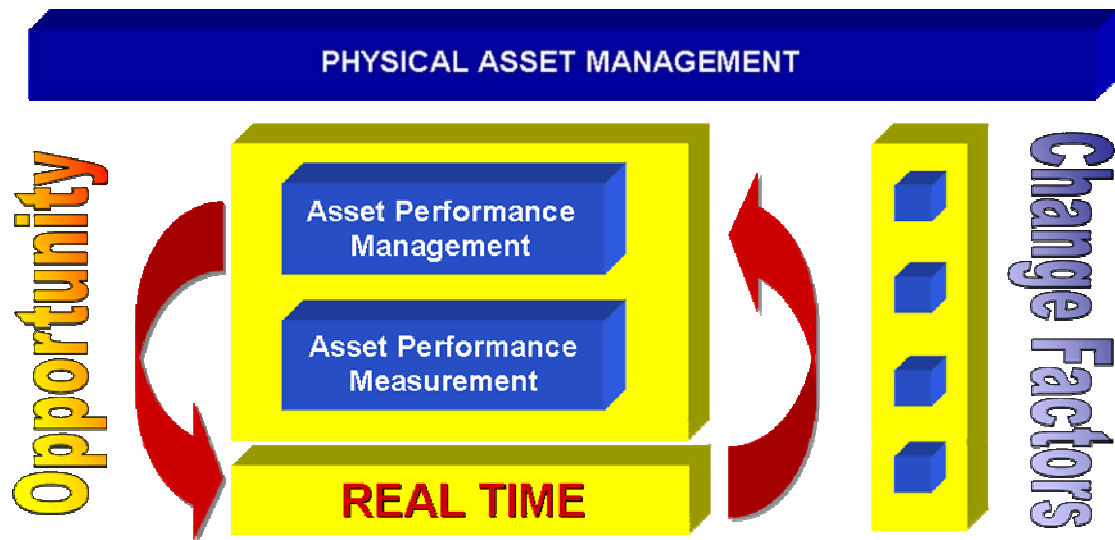
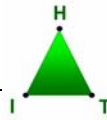


Figure 1 Research environment

1.2 RESEARCH PROBLEM

From what has been observed in industry and researched in literature, the requirements of real time Asset Performance Management became evident (see Chapter 4 for development and Appendix D). There are three main components that will be researched: Human factors, Information management and Technology challenges. It is further believed that interactions exist between pairs of components to such an extent that it can be graphically represented as in Figure 2 (see Chapter 5 for interaction description):

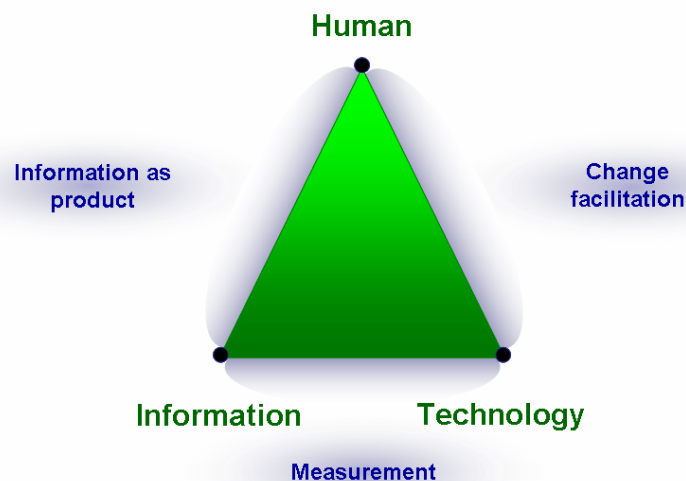
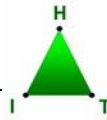


Figure 2 Initial interaction proposal



This model will be further referred to as the *HIT Interaction model*, derived from Human-Information-Technology Interaction. The challenge here is to describe this interaction and the management thereof, within the real time Asset Performance Management field. An added complexity is the AS-IS situation of these three components which has to be kept in mind in order to develop a model that is realistic and true to what the industry trend is.

- Information management (specifically in the Asset Performance Management field), is a very slow process especially if a company needs to outsource the service. The whole process of capturing data in the company, sending it to be analyzed and then receiving a report with usable information, can take up to four weeks – this is mainly due to the fact that the present system is paper based and a lot of errors and unclear data slip into the capturing process.
- Technology levels in smaller manufacturing companies are minimal or non-existing. This means that whatever real time solution is put on the table, it has to be kept in mind that these companies will not necessarily buy into the solution, simply because they have been operating in the same way for years, and cannot understand the benefits thereof.
- The AS-IS situation of the Human component, is best described by the following graph (Figure 3), comparing the *Rate of Change* (red curve) and *Rate of Learning* (green curve) over *Time*:

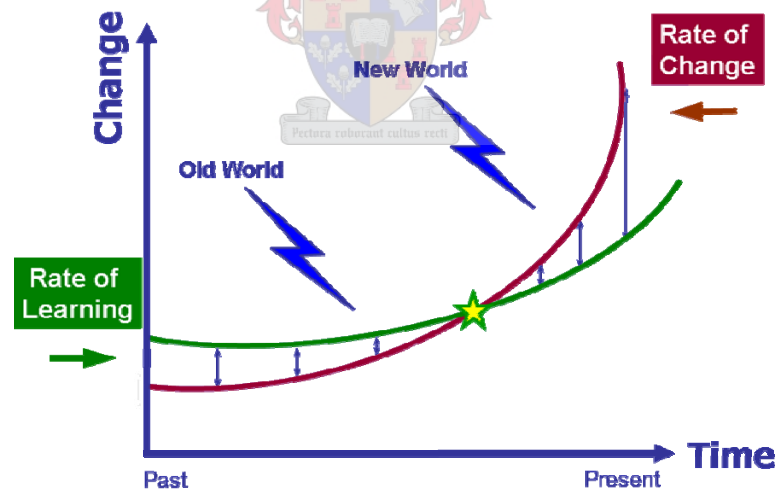
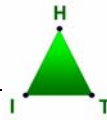


Figure 3 *Rate of change vs. Rate of learning over time*

Obeng [1]

In the past (Old World), the *rate of change* in technology and processes was very small and people had the time to adjust to the change at their own pace – resulting in an equally low *rate of learning*. In recent years (New World) changes in the business environment have come about almost yearly and even monthly in some cases and people



simply do not have the same chance to adapt to the new technology levels and ways of operating as they have had in the past. The *rate of change* has thus far surpassed the *rate of learning*, leaving a workforce behind that, in a number of cases, is confused and resists new ideas – all in a futile effort to cling to the old ways of doing things.

One key trend, which plays directly into the hand of the requirements for real time physical Asset Performance Management, is the generational shift that the industry is experiencing. The traditionally conservative thinking Baby Boomers are exiting the workforce and the more open minded Generation X is taking the positions of management. Generation Y is coming of age and they are able to adapt relatively easily to the knowledge and technological challenges set to them – making them one of the most agile workforces that have ever been around.

The bottom line of this research problem is to understand the interactions between the three main components in physical Asset Performance Management and thus the following research questions will have to be answered for the specified levels:

- **Information and Technology:** *What is measured?* and *With what is it measured?*

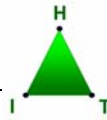
Effectively this interaction asks how information is retrieved from a process and how it is represented in the real time scenario. Typically the answer will involve how the management of this interaction can be formally described and what kind of technology the industry is looking at when managing information in the real time Asset Performance Management scenario.

- **Human and Technology:** *How is the change facilitated?*

In most cases, people inherently resist change. Without going into a conventional change management solution, this question will give the answer as to how change is facilitated in the new world, i.e. the real time Asset Performance Management scenario. The rationale being that as the younger generations are taking over the workforce, the ways in which people are managed and motivated will also change. The answer to this question will give an indication as to how the workforce will look in the future and also how change will be facilitated therein.

- **Human and Information:** *What is the value of real time information?*

Even if the mindset of the people is right and the information is effectively retrieved from processes, the question still remains what the value of this information is. For example, in the AS-IS state of the industry, it would typically take a full day's work to compile an extensive report on the asset performance of a facility. When using real time technology,



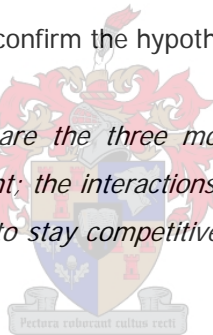
the information is readily available and such a report could be compiled within a few minutes. Client concerns are raised and the question is asked why this report still has to cost the same as the old report and what kind of value was added to justify the new cost?

By only implementing the most recent technology, a company will only observe minor improvements since the people will not necessarily embrace the change it brings. In turn, only employing well trained and motivated people does not necessarily put the company in a higher performance bracket, since the people need the appropriate technology and the correct information at the right time in order to make the right decisions. By pushing only one of the components, a company will have only minor improvements – the key is in a structured approach that will keep the improvements in all three components balanced.

1.3 RESEARCH OBJECTIVES

The first objective of this research is to confirm the hypothesis on which the research is based:

Human, Information and Technology are the three most essential components in real time Physical Asset Performance Management; the interactions between the component pairs have to be in constant balance for a company to stay competitive and adjust sufficiently in a constantly changing world.

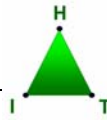


The second objective is in support of the hypothesis:

To describe the HIT Interactions for real time physical Asset Performance Management, so that it can be used by companies wanting to enter this environment as a descriptive guideline to improve overall machine performance by effectively managing personnel, information and technology.

In achieving these two objectives the research study will have been successful. In order to achieve the objectives, the following goals will have to be realized:

- A comprehensive literature study on the topic, in order to establish whether the three components are in fact essential to the real time Asset Performance Management scenario and if so, what the interactions between them are. This will include the following:

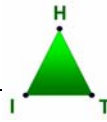


- Research on what each of the separate components contributes to the industry in order to understand the trend of each (establishing a TO-BE scenario).
 - Studying possible answers to the proposed questions through focused literature study on the interactions between the component pairs.
- Defining a TO-BE situation, in order to get a relative point to which the industry is moving. Even though the industry is constantly changing and the TO-BE will continuously shift forward, this will serve as a basis from where model validation can be done.
- Facilitating a structure to evaluate companies in terms of the stages of readiness for real time operation, in order to achieve the status of a fully operational real time enterprise.

1.4 RATIONALE FOR STUDY

As stated earlier, one of the last untapped margins for improvement in the Asset Performance Management industry is to elevate it to a real time system. Companies moving into this new environment will constantly encounter questions about the management of people, information and technological requirements. This thesis specifically addresses these three components as well as the interaction with each other, within the real time Asset Performance Management industry. Companies that wish to stay competitive in this market can use this research in order to understand the balance between the components. With this in mind they will be able to better formulate their strategic management vision for the future.

From the literature study, it is evident that the ways of managing people is drastically changing. With this change, also enters a workforce that is exceptionally capable of handling the challenges set to them with minimal resistance to the constant change and adaptation it requires. The two interactions of the Human component with Technology and Information, and the somewhat familiar interaction of Information and Technology is a fascinating study, and it is essential for any company wanting to leapfrog into the front end competitive section of their market, to understand this interaction and to embrace the change the future brings. Research is done on front end improvement opportunities – more specifically, understanding the complex interaction between three components that are essential to real time Asset Performance Management. A new perspective is yielded by researching the interaction of the Human component with two of the most fundamental components in this field, namely Information and Technology. A complete research perspective is formed, by looking at the current (AS-IS) as well as the future (TO-BE) situation and a method is facilitated to evaluate the movement between the two.



2. INDUSTRY TRENDS OF COMPONENTS

In this chapter the general trend of the industry is established. It starts off with Asset Management itself, to show that there is indeed a future for this function. The trends in the three proposed components, human factors, information management and technology advances, are then sketched. This has to be done before any other studies, in order to verify that the three components have been chosen correctly. Background studies have shown that the three components are essential to the Asset Management scenario (see Chapter 4 for development). By studying the industry, and looking at where it is heading (trends), one can better facilitate a solution that would suit this natural evolution of the industry. The trends are based on an extensive literature study, of which only a few key sources will be directly mentioned in the text. The trends are focused on the real time Asset Performance Management environment, which will be formally defined through the focused literature study of Chapter 3.

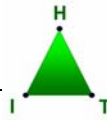
Each of the sections in this chapter also serves as a justification as to why the component is essential to the specified environment. It also discusses what is currently observed in the industry as well as what the future of the component looks like. The chapter concludes with a summary, sketching the TO-BE scenario.

2.1 THE FUTURE OF ASSET MANAGEMENT

Taking into account that Total Productive Management (TPM) is a concept that has been developed over 40 years ago (see par. 3.2) and that Asset Management is based on these principles, the question arises if there is a future for Asset Management in a manufacturing world that has drastically changed since the development of TPM?

Palarchio [2] answers this question when he looks at the future of Asset Management towards 2010, where he states that the profession will be more important than ever before, and that it will be more tightly linked to enterprise performance. The Asset Management function will be most visible as *physical* asset management, rather than under the traditional label, and the following trends can be expected:

- Customer expectations of the products industry will continue to increase at a faster rate.
- Advances in technology are resulting in manufacturing equipment that continues to rise in complexity and thus become more complex to maintain.



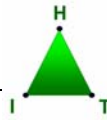
- The suppliers of training, consulting, software, and hardware directed towards maintenance and reliability improvement are experiencing a growing rate of up to 20 percent a year.
- The opportunity to improve the efficiency and the effectiveness by which manufacturing equipment is maintained is being viewed as one of the last untapped margins of improvement in the industry.

It is in the last point, where a new frontier for improvement has been found – not only will the future be physical Asset Management, it will be real time physical Asset Management. The inclination is to merge the solid working principles of old-school Asset Management, with the enormous advances in technology and supply a solution to the industry that manages the performance of assets in real time. This could be either in the form of a key performance indicator based dashboard on a computer screen, digital displays throughout the factory or even real time updates to management through e-mail or cellular phones.

The trends in the in physical Asset Management could have a very positive outcome for maintenance practitioners. By acting upon the trends in an organized, pro-active manner a common approach to the practice of maintenance can be developed and value creation for industry and the economy will be achieved which will elevate the importance of physical Asset Management in 2010. The Society for Maintenance and Reliability Professionals envisions physical Asset Management in 2010 as follows (as quoted by Palarchio [2]):

- Incorporation of standards in physical Asset Management that encompass all required practices to maximize total financial and functional value over the complete life cycle of the physical asset. Examples of standards would include design, capital procurement, installation and commissioning, staffing, spare parts procurement and storing, all maintenance and reliability business practices and life cycle costing.
- Annual participation in professional education sessions will be required to maintain certification.
- Standardization and integration of physical Asset Management technologies in the form of software, hardware, and associated practices.

Frequently evaluating the readiness of technologies presents manufacturers with a constant challenge. Gartner's hype cycle reports present the relative degree of *hype vs. hope* associated with key information technologies, plus IT-driven and IT-enabled practices and programs that will have significant implications for manufacturers in the coming years. Different technologies are



plotted on a hype cycle graph so that it can be compared with each other in terms of where it currently stands in the development process and where it will be within a given amount of years. Detailed tables for the definitions of the components and phases are available in Appendix A.

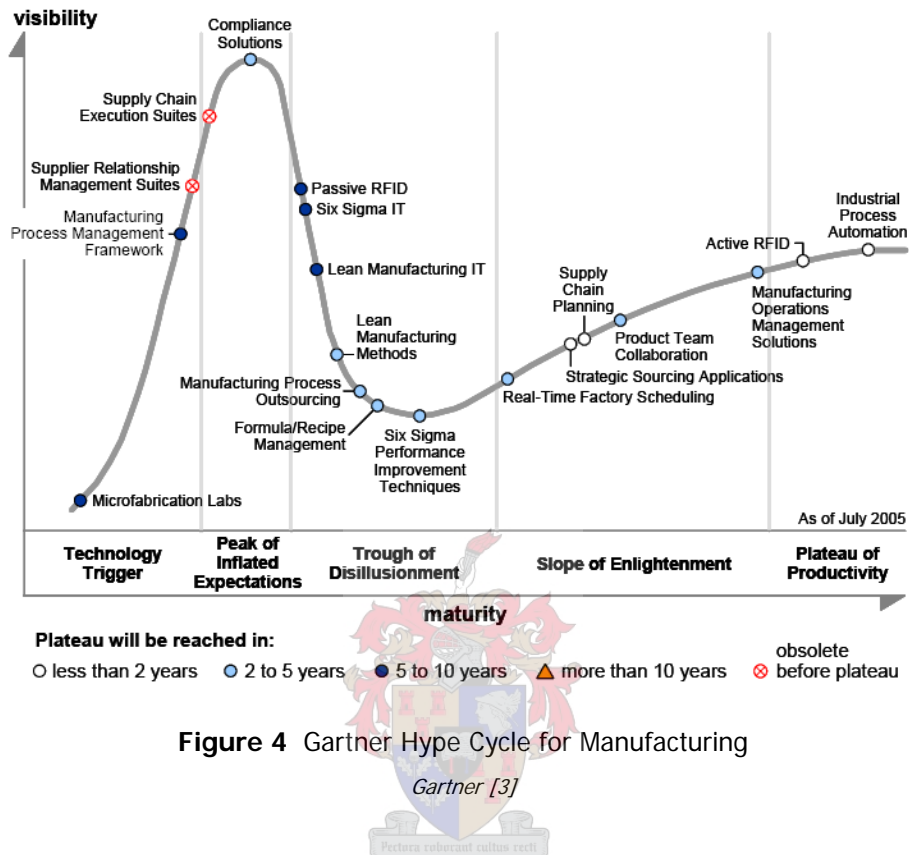
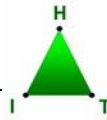


Figure 4 Gartner Hype Cycle for Manufacturing

The Gartner hype cycle for manufacturing [3] (Figure 4) shows that there will be a definite need for real time physical Asset Management – The indicator being *Real Time Factory Scheduling*. This involves evolving traditionally batch-centric production scheduling solutions to become real time solutions driven by actual production. When production scheduling is done in real time, the production process will be adapting to changing situations on a much faster pace. To keep up with the change, maintenance teams will need to know, also in real time, whether the machines are in working order and when maintenance is needed. Managers would be able to see if production is keeping up with the schedule, but they would also want to know what the state of their assets is.

Real Time Factory Scheduling is on the *Slope of Enlightenment*. This means that focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. It is in a phase where commercial, off-the-shelf methodologies and tools are available which would ease the



development process. Scheduling is a mature market, and this is a natural evolution that links actual production status from shop-floor control with the scheduling application. The next logical step is to do the same kind of development for Asset Management – moving the current paper based systems to a real time system and evolve it to a methodology that is commercially available.

2.2 THE HUMAN COMPONENT

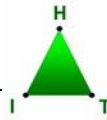
This rationale of this section is that as the younger generations are entering the workforce, the managerial styles also have to adapt. It looks at the generational shift that is occurring in the workplace, with specific attention to managerial and motivational techniques. The work characteristics of different generational groups are an important issue for companies to look at. It is obvious that people with different work characteristics will be more productive with different leadership styles; therefore the different work characteristics and the corresponding leadership styles are important areas of research for leaders who must lead and motivate diverse generational groups within their businesses.

Techniques that are currently used to manage the new generations were developed solely to suit the frame of mind of the workforce of twenty and thirty years ago. People of today live in relatively better socio-economic environments, where freedom of choice is promoted. In this environment, younger generations are enabled and encouraged to follow their own minds and do not need to fall in the same rut as their seniors, as was the case with the older generations. Consequently, they strive to find new ways of doing things and it is herein that a lot of conflict is founded, since the older generations cannot grasp the way in which new generations operate in the workplace, and why it is that what worked for them, suddenly does not apply anymore.

2.2.1 THE GENERATIONAL SHIFT

Four generations can be defined, which can still be observed in the industry today: The Silent Generation, the Baby Boomers, Generation X and Generation Y. The Silent Generation is almost totally out of the workforce and Generation Y is just entering the workforce, thus the Baby Boomers and Generation X are the dominant groups.

The Silent Generation was born before and during the Great Depression and World War II. They are conservative, hard working and structured people who prefer rules, order and formal hierarchies in the business in which they operate [4]. These people have lived through some of

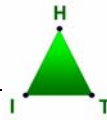


the toughest periods that humanity has experienced during the past 80 years and their conservative outlook on life reflects this. The people from this generation, who are still in the workforce, are typically between 65 and 70 years old and most of them are fast moving towards retirement.

Baby Boomers are the post World War II generation and were born between 1945 and 1964 – a group that has been the source of many important cultural and economic changes [5]. They are diligent people, who prefer a stable working environment. They are hard workers and are generally very loyal to their employer. Baby Boomers are team-people who care about creating a fair and level playing field for all. They expect to work with other people (group structure) and also accept a formalized chain of command. They expect that their managers give direction and lead them towards the organizational goal. According to Codrington [4] the Baby Boomers are the *sex, drugs and rock 'n roll set* that grew up during a time of grand visions. They invented the 60-hour work week and *Thank God, it's Monday!* On the other hand, they are not very technologically adapted, nor do they (in general) like technology. It is from this perspective that the Baby Boomers are currently struggling in the workplace, since there has been such a technological revolution over the past ten to fifteen years.

Generation X was born between 1965 and 1980 and grew up during the era of extreme crises, ranging from Watergate to the collapse of communism [5]. In some cases, Generation X is referred to as the *Baby Busters*, due to the decrease of births from that of the Baby Boomers. These people need alternatives, options and flexibility. They dislike close supervision, prefer freedom to take initiative and operate well under an output-driven system. Codrington [6] lists 25 general sentences that define Generation X. Some of the attributes listed, include: great value of relationships and individualism; extremely self-sufficient, sceptical of institutions, risk takers and usually observed as stressed out and organized to death; they know the power of the media and are incredibly ambitious. These people are also up to date with technology and are eager to obtain more knowledge and application into their work. Their technological capability is due to the fact that they grew up in a rapidly changing environment with great amounts of information available.

Since Generation X had completely different childhood conditions (mostly better), political and social environments than that of the Silent era, it is obvious that their way of living and reacting to life would be clearly distinguishable from that of the older generations. Quite a few paradigm shifts can be observed when comparing Generation X to others – one of which is loyalty.



Generation X is loyal to their profession, as opposed to being loyal to their employer – traits of the Silent Generation and Baby Boomers. In contrast to the Baby Boomers, they work to live and do not live to work, thus the emphasis is on personal satisfaction rather than job satisfaction. Generation X tend to look for opportunities to better themselves (e.g. training courses), whereas Baby Boomers need to be encouraged to take advantage of such opportunities.

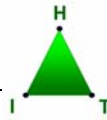
Interestingly enough, beside their work values and loyalty, Generation X have also broken the traditional Maslow hierarchy of needs structure and challenged its individual development progress schemes [5]. Baby Boomers have tended to follow this scheme (starting from education, then career, marriage and promotion), which has moved them towards self-achievement. Generation X tends to compress the original Maslow process. They need self-achievement from their job as well as basic needs at the same time, and they do not want their work to impact negatively on their quality of life. As a result, they are less devoted to their jobs, and less job involvement occurs. Table 1 compares work characteristics of the Baby Boomers and Generation X.

WORK CHARACTERISTICS	BABY BOOMERS	GENERATION X
Values	Work hard	Personal satisfaction
	Loyal to employer	Loyal to skills
	Teamwork	Prefers to work alone
	Chain of command	Individual is first
	Wants to manage	No need to lead
	Technically challenged	Technically savvy
Attitudes	Job promotion	Job satisfaction
	Loyal to employer	Loyal to skills
	Balance of work and family	Quality of life
	Formality (authority)	Informality
	Commitment	Negotiation
	Corporate paternalism	Empowerment
Expectations	Money and recognition award	Educational reward
	Job security	Job challenged
	Liberal	Pragmatic
	Sense of entitlement	Entrepreneurial
	Highly competitive	Extreme individuality
	Step by step promotion	Quick promotion
	Authority	Flexible/Freedom
	Employee	Ownership

Table 1 Comparison of work characteristics: Baby Boomers and Generation X

Hui-Chun, et al. [5]

Since a large proportion of the workforce today is under the age of 35 (Generation X), they are very much aware of the changes in the labour market, and therefore their values and attitudes often reflect their living environment. They are increasingly well educated, independent and eager to constantly upgrade their skills. These characteristics require a totally different leadership style than that applied to older generations, who had fewer skills and less education.



Adding to this, the knowledge and skills required by today's workplace have become more complex, since most countries (America, Australia, Taiwan, etc.) have moved from the *industrial economy* to the *service economy* and now the trend is towards the *knowledge economy*. As more and more professions become knowledge based, the need for traditional leadership styles will disappear in the near future.

For a leadership style to be effective in the modern workplace, it needs to move away from the traditional hierarchical position-based structure, to a more knowledge-based structure [5]. This is due to the fact that knowledge workers do not see themselves as subordinates or employees anymore, but rather as associates of the organization. Knowledge workers need to collaborate with their leaders rather than be managed by them, therefore McGregor's traditional Theory X or Theory Y way of management is not applicable anymore. To give some perspective, Cook and Hunsaker [7] define these theories as follows:

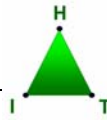
- Theory X is a managerial assumption that people act only to realize their basic needs and therefore do not voluntarily contribute to organizational aims.
- Theory Y suggests a managerial assumption that people are motivated by higher-order growth needs and they will therefore act responsibly to accomplish organizational objectives.

Table 2 shows the changing nature of the workforce and the associated changes to the type of leadership style required for the defined generations. The top part of the table shows which generations were present in which economy type. The middle part shows how the characteristics of workers changed on a continuum, from industrial workers to knowledge workers and the bottom part shows the corresponding change in leadership theories and styles.

	ECONOMY TYPE		
	INDUSTRIAL (up to 1980)	SERVICE (1980 - 2000)	KNOWLEDGE-BASED (2000 - onwards)
Baby Boomers Generation X Generation Y			
Industrial workers → Service workers → Knowledge workers			
CHANGE IN LEADERSHIP STYLE	Emphasis on Theory X (workers need to be controlled and supervised)	Emphasis on Theory Y (interpersonal communication, conflict resolution skills)	Emphasis on collaborative and knowledge-bases leadership
	Present in workplace		

Table 2 Changing nature of the workforce and associated changes in leadership style

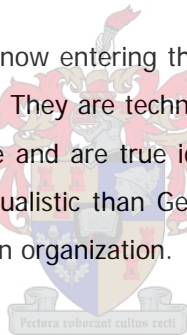
Hui-Chun, et al. [5]



When looking at the table, what has been discussed earlier is now apparent – the Baby Boomers have lived through the most radical changes in both the world (on social level), as well as in their workplace (on economical level). In no way idealizing this generation, because like all the others before it, it had its fair share of skeletons in the closet, but there has to be some kind of admiration for them to have been able to go through all these changes, and still emerge at the end with successful businesses, careers and in some cases well balanced families.

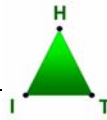
The Baby Boomers settled in workplaces at a time when corporate loyalty was highly valued and they expected long careers in the same organization in return for this loyalty. These expectations however, have been dealt a severe blow in the last 15 years. Generation X on the other hand, entered a workforce around 1985 – 1990 and have only experienced a predominantly service oriented economy. This people focus has made the X Generation more aware of their rights and skills and less concerned with corporate loyalty or job status, as was the case in the industrial era.

When comparing Generation Y, who is now entering the workforce, to the above said, they are entering mainly as knowledge workers. They are technically well skilled at a very young age, IT aware, comfortable in the global village and are true idealists [5]. Generation Y is on average better educated and even more individualistic than Generation X, hence they are very easy to recruit and extremely hard to retain in an organization.



It is evident that due to the changing nature of the work itself, as well as the changing nature of subordinate characteristics, leadership styles have to change. In fact, it had to change some time ago in order to have accommodated the ever changing working environment. The oldest members of Generation X are fast approaching 35 years of age. They are suddenly starting to find themselves being included in the influential forums inside their workplaces and now some companies have been caught off-guard. The emerging Generation X was supposed to grow-up and adopt the values and world views of their seniors (the more experienced Baby Boomers) in the work-place, but this is apparently not going to happen.

Generational theorists have been proclaiming it for years now – people do not grow up and out of their value systems and world views [8]. Baby Boomers never turned into their senior Silent Generation parents and bosses, and Generation X is not going to either. If the required change was a continuous process of development and upgrading, the Silent Generation would have understood the Baby Boomers better, and they in turn would have understood Generation X



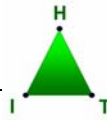
better. This relates to the research question when asking how the Baby Boomer manager is going to attract, recruit, retain, reward and motivate the younger generations, because if they have learned anything, it is that these younger generations do not do things the way the current older staff do things.

2.2.2 THE FUTURE PICTURE

Continuous improvement on whatever level is desperately needed. More specifically – it will be the responsibility of Generation X to facilitate the movement towards new managerial and motivational styles, since they are the future leaders of the workforce. They therefore have the necessary experience to guide the process, in order to be well adapted to the new styles by the time they reach 45 or 50 years of age, because it is by that age that they will be in the top managerial positions, and they will then have to manage Generation Y. In future, leaders should recognize the different work characteristics between generational groups and apply appropriate leadership styles. This in itself is a very difficult concept, but one that will contribute positively to the motivation of the employee.

The managerial challenge will be based on the clash of generations: a collision of values, expectations, ambitions and attitudes. In addition, the human factor will be increasingly important for maintaining a competitive advantage in business [9]. The change in the contract between company and employee will be the biggest generational shift of all in the workplace. The old contract was simple – employees came into an organization and accepted the values, vision and mission of the company. They sold the company's products to the set customers, using all the available systems of the company – vocabulary, methods and processes. Employees worked like slaves in order to climb the ladder up the company structure as fast as possible. In return, the company guaranteed that there would be a managerial position available in a few years. In this way, employees made themselves virtually unmarketable anywhere else, because they based their entire skills set on the paradigm of one company.

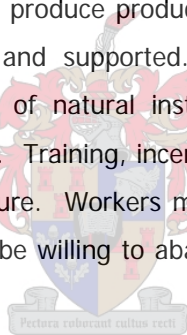
The new world contract is one in which companies cannot guarantee such stability, and if they cannot provide security, how can they demand loyalty? Loyalty to a company is still available, but today it is purchased with another currency: This includes helping employees develop a set of generic skills that will keep them marketable, creating an environment that is flexible and a feedback structure that gives constant, timely and honest feedback on everything they do. Unfortunately, there are no quick fixes to solve this problem. Simply adjusting the current human resources policy of the company, will not help. To adjust to the new generation requires



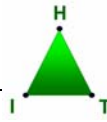
a change of attitude, a mindset shift and universal changes in organizational structures. If these shifts can be accomplished, the company will open itself up to such a forward leap in competitive advantage that the slight transitional difficulties will be well worth it.

The key in all of this is the people. Jeff Immelt [9], CEO of General Electric, said that *HR is not on the agenda – HR is the agenda*. He continued, saying that the clichéd phrase, *our people are our most important asset*, needs to come out of the chairman's annual report and become a reality in the company and world – companies cannot afford losing bright young personnel any longer (i.e. Generation X and Y). According to Coats [10], the war for talent is beginning to become a familiar refrain amongst the more credible strategic managers worldwide. In an emerging knowledge economy it makes perfect sense that this shift is where the new strategic battleground will be found.

Charles Latino [11], President of the Reliability Centre Inc. confirms this, when he says that it is the people who operate the plants and produce products, who are the most precious assets – they must be nurtured, encouraged, and supported. Managers must create cultures and environments that unleash the power of natural instincts and they must understand what workers need to perform and provide it. Training, incentives, rewards, and recognition are only a few of the ways to promote this culture. Workers must also be given the freedom to think, and the time to do it. Managers must be willing to abandon rigid traditions that hinder worker creativity, initiative and productivity.



Generation Y is currently in one of the best strategic positions that has ever existed. Technology is booming, information is readily available, knowledge is their strength, opportunities are rising and the workforce is experiencing a revolution with regards to managerial techniques. It is therefore vital that a company knows its workforce, and whereto the trend is. For Generation X and Y, the opportunities are endless and they are now in the position to build the future that they want.



2.3 THE INFORMATION COMPONENT

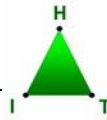
When studying the trend in Information management, it is evident that with new technologies come new ways of gathering, processing and representing information – all of which are to the benefit of the company implementing it. For the first time, top managers and line personnel alike, will be able to monitor the exact information that they require to make their day-to-day decisions, in real time. This section looks at the need for real time information and the philosophies that will be the driving forces behind information management in the future.

2.3.1 THE NEED FOR REAL TIME INFORMATION

In order to create a sustainable competitive advantage through information management, the enterprise must also value information in a new way. Gartner [12] says that the future sources of competitive advantage will lie in intimacy with customers – knowing exactly what they want and how to supply it to them. By retrieving real time operational feedback from frontline processes, extensive knowledge of processes can be obtained. With a dedication to customers and expert process know-how, comes foresight into the future with which a company gains the ability to establish trends and patterns through core knowledge. Enterprise management teams that value information and systematically use it to their competitive advantage, create a service that customers will value and competitors cannot match.

In order to create competitive value, appropriate information is required. Different approaches are used to create an agile information management environment that enables pro-active actions and decisions. Gartner [12] specifically mentions that the correct orientation of information correlates with business performance, and that information is the centre point of the three main drivers of business performance, namely people, information and technology.

For global business leaders, the last three years have been marked by a seemingly endless round of corporate revenue shortfalls, missed earnings expectations, bankruptcies, corporate fraud and failed mergers and acquisitions due to so called unforeseen circumstances [13]. After these events executives were forced to admit that they actually could have seen it coming. During this economic confusion, one unifying trend has emerged – the economic pace of the world is increasing. Jobs can switch to India overnight, contracts go to China, currency strength moves to Europe and whole systems are outsourced, only to return in-house within a few months.



To illustrate the volatility of the world of today, consider the speed with which the Severe Acute Respiratory Syndrome (SARS) appeared in 2003. It shook global business, stock markets and consumer confidence in a matter of weeks. Major airlines were barely surviving as business travellers stopped flying. The fear of the disease moved much faster across global news information networks, than air transportation could have spread the virus itself, yet the SARS problem was contained within weeks. Best-practice lessons on containment and treatment were replicated worldwide amongst medical teams using those same information networks and a medical epidemic was averted. The whole episode now seems like a distant memory to most people.

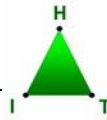
The economy is extremely unpredictable at the moment – the same can be said for the manufacturing industry. Fundamental changes in the manufacturing industry are observed. One reason for this is the effect of inexpensive, powerful telecommunications – everything from the World Wide Web and e-mail to mobile phones and satellite television. These technologies shrink the globe and accelerate forces such as transparency. In such an environment, decision makers must be given the earliest warning of events the moment they occur – information delays cost companies precious reaction time. What a CEO, director or line manager needs, is a system or a tool that at the touch of a button gives the exact positioning of the business with respect to what can or cannot be delivered, where, when and if expansion is possible.

2.3.2 FUSING PROCESSES IN A REAL TIME INFRASTRUCTURE



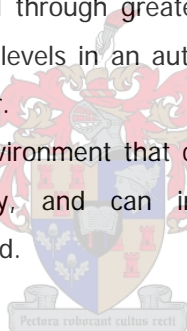
In order to achieve better information management, companies will need to establish infrastructures that support real time information management. In most cases, companies are drowning in data, not information – they need to take a step back and fundamentally review what can and should be tracked in order to have effective management decision making in the current business conditions.

A Real Time Infrastructure (RTI) is an infrastructure shared across customers, business units or applications where business policies and service level agreements drive dynamic and automatic optimization of the IT infrastructure, thus reducing costs while increasing agility and quality of service [14]. RTI is one of the main requirements for the Real Time Enterprise (RTE) in order to sense opportunities and problems faster and respond faster and more precisely. A RTE has flexible business processes and can establish relationships opportunistically and quickly. The RTE competes by progressively removing slack in executing critical business processes.



An inflexible IT infrastructure is not able to adapt and respond to rapidly changing requirements. In the future, IT must be seen as one of many investments that can improve business speed and business opportunity. In other words, a RTI does not just make the business processes faster, it also enables business growth. The change in philosophy of business information management is the key in the change required to become a RTE. Rapidly adjusting ways of managing information requires an IT infrastructure to be as rapidly adjustable. IT will become the focus point of the business – not just a development area, but a process with service delivery focus. Thus the shift occurs from simply gathering and representing information from processes, to the management of information as a critical step in business efficiency. The evolution towards RTI will have certain effects [14]:

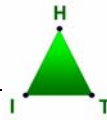
- Capital and labour costs will be reduced through more efficient use of information resources.
- The IT cost structure will be shifted from fixed to variable, in order to establish an adjustable cost structure that can adapt to business demand.
- Service levels will be improved through greater underlying IT service and component intelligence to manage service levels in an automated way, as well as providing faster response when failures do occur.
- The RTI provides a flexible environment that can absorb new services and changes in business requirements quickly, and can integrate better with completely new technologies that may be needed.



Gartner [15] defines Business Process Fusion (BPF) as the transformation of business activities that is achieved by integrating previously autonomous business processes to create a new scope of management capabilities. A key driver for BPF is the competitive pressure to build a real time enterprise. This is not simply a matter of running the enterprise faster, but also of sensing the environment more intelligently and predicting and correcting problems before they surface. It requires a new level of IT-enabled responsiveness, agility and adaptability. BPF is made achievable through a combination of two factors:

- Enterprises have invested in operational systems that are connected on a 24/7 basis, and that can continuously capture core transactional data.
- Software platforms and architectures have emerged, that span the traditional application silos and processing styles.

By fusing business processes, costs will decline and profitability will increase because of greater efficiencies, visibility and control [15]. It combines activities that previously required independent



systems and improves visibility and control of combined functions – this is achieved at the operational level but is extremely useful for management purposes as well. Gartner [15] predicts that by 2007, BPF will be a key driver for IT investment in a majority of global enterprises and that it will be the next stage in how business applications are developed, delivered and deployed to achieve business value.

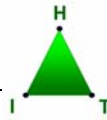
In this context, the Real Time Infrastructure and Business Process Fusion should be viewed as two philosophies, rather than practical solutions. They are discussed in such a way that the trend of information management is made clear, without coupling either one to a specific solution that is currently available. The industry of information management is moving along with technology and enterprise development, towards the real time paradigm, and will certainly require an infrastructure that adheres to these philosophies. It is on these philosophies that concepts such as Business Process Management and Business Activity Monitoring are based – concepts that are packaged and marketed by companies, ready to implement and use and that specifically aim at fusing business processes and establishing the real time infrastructure through real time information management.

2.3.3 REAL TIME INFORMATION IN REALITY

When a company has developed a real time infrastructure and is optimizing business processes by business process fusion, real time information becomes a reality. In the day to day operation of a company, technical asset information is crucial in order to sustain or improve profit levels – especially in companies where 24/7 uptime, production efficiency and safety precautions are mandatory.

Over the last decade, companies have implemented Asset Management solutions to get control over the routine maintenance of production assets. However, Asset Management cannot reach its full potential without the proper management of asset related technical documentation [16]. Technical asset information is of critical importance to resume production as quickly as possible in case of unplanned process downtime.

Honeywell's KPI Manager [17] allows multiple target values to be configured for each key performance indicator (KPI), which means calculation of industry benchmarks or best-in-class plants in a company can be done instantaneously – the management of complex, integrated performance targets is now achievable in order to:



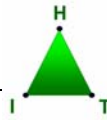
- Automate the collection of both target and actual values from a wide variety of production and business systems.
- Calculate and report the actual performance throughout the business, via intranet on an ongoing basis – even before the official measurement period is complete.
- Create a performance-driven enterprise through up-to-date tracking and analysis of business and production results.

By managing critical information in real time, certain benefits can be expected, including:

- Consistent, timely analysis of business performance.
- Faster and more effective decision making.
- Improved visibility of the organization's performance.
- Consistent reporting allowing evaluation of performance using industry (or corporate) benchmarks.

The benefits of having accurate performance indicators at hand are endless to any company. Giving personnel the freedom to customize the information display according to their specific needs will empower them to make correct decisions at any given time. Real time information becomes an every day reality the moment the correct technology is implemented – thus any company investing in new technologies should seriously consider developing a RTI strategy as soon as possible, in order to be more agile in the near future.





2.4 THE TECHNOLOGY COMPONENT

By simply looking at the current state of the world, it is evident that technological advances are made continuously. Processing speed and storage space is increasing, technological applications are ever more powerful and quality of components ensures a stable working environment. Even more astounding is the fact that the demand for technology seems to grow constantly. People want to be technologically enabled – connected to the information superhighway to get whatever they want, when they want, at a competitive price. Without going into the details of hardware specifications, this section looks at the kind of technologies that will drive the future real time Asset Management environment.

2.4.1 APPLICATIONS DRIVEN BY NEW TECHNOLOGY

The Gartner Hype Cycle (as explained in par. 2.1) for Business Application Technologies [18] shows a few indicative trends that confirm towards where the broad span technology trend leans (interpretation tables available in Appendix A).

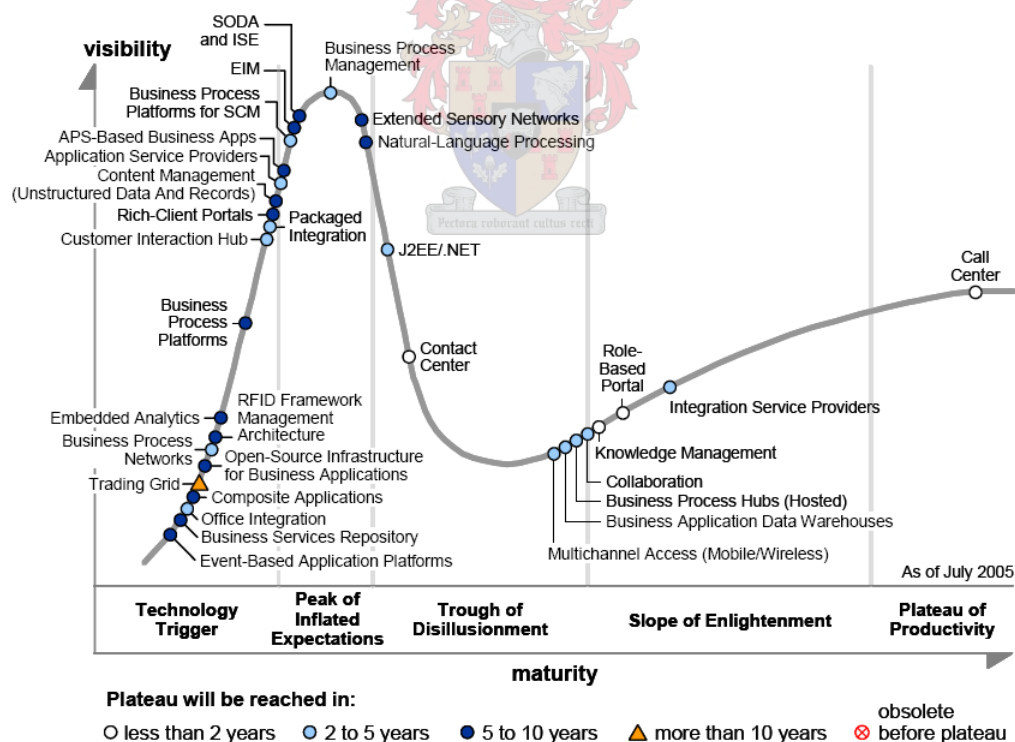
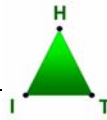


Figure 5 Gartner Hype Cycle for business application technologies

Gartner [18]

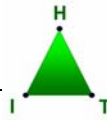


Gartner defines the following two concepts [18]:

- Knowledge management (in this context) is defined as the accumulation and management of consolidated information (companywide) from a central place. Adding, categorizing and continuously maintaining information and data, with a central repository to access it.
- Collaboration features are integrated directly into business applications, such as product team collaboration in product life cycle management, collaborative planning in supply chain management, and workforce management tools in customer relationship management.

Knowledge management and *Collaboration* is on the *Slope of Enlightenment*. This means that focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Both concepts have gone through all the paces and are now in a state where they can be marketed in the real world. These two are indicated with a white and a light blue circle respectively, which means that the *Plateau of Productivity* will be reached within the following two to five years. The plateau means that the real-world benefits of the technology are demonstrated and it is accepted as a comprehensive solution, thus these two concepts should be readily available solutions within the next few years.

The *Business Process Platform* (BPP) design provides business process flexibility and adaptability. BPP uses service-oriented architecture design principles, and is metadata and model-driven. A BPP consists of integrated content (residing in a service repository), and design time and runtime infrastructure components [18]. BPP is on the *Technology Trigger* phase of the hype cycle, which means that it is a breakthrough in technology which, with its launch, will generate significant press and industry interest. According to Gartner, the BPP will enable Business Process Fusion and move innovation from business application vendors to BPP ecosystems. It will replace customized business applications and custom development by extending core application platforms with composite applications. Due to these facts, BPP is rated as *transformational*, indicating that it enables new ways of doing business across industries and it will result in major shifts in industry dynamics. Unfortunately, the development stage is still classified as *embryonic*, meaning that it is still in development and will only reach a productivity level within five to ten years (indicated by the dark blue circle).



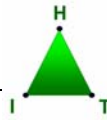
Business Process Management is a set of related technologies that help optimize business processes and flows, especially across traditional organizational and system boundaries [18]. It is a crucial component for building the BPP infrastructure. BPM integrated in a business application context is far less mature than stand-alone BPM applications. The benefit of BPM technologies is rated *high*, indicating that it enables new ways of performing horizontal or vertical applications that will result in significantly increased revenue or cost savings for an enterprise. The maturity level is rated as *emerging*, which means that first generation, highly customized applications are available, also at quite a high price. On the hype cycle, BPM is indicated by a light blue circle, meaning that it will be on the *plateau of productivity* within the next two to five years.

The hype cycle indicates these four technology applications within a scope of two to ten years – the most significant ones being Business Process Management, Collaboration and Knowledge Management, having a scope of two to five years. This is in line with the timeframe in which real time physical Asset Management will reach its full potential. The technology applications needed to successfully drive real time physical Asset Management, will thus also be available within this time frame.

2.4.2 TECHNOLOGY ADVANCES ENABLING THE REAL TIME ENTERPRISE

In companies all over the world, real time technologies are used. Real time connectivity is helping companies boost sales and increase productivity in the field [19] – for instance, a salesperson can access a company database at any time to place orders or check inventory levels. As the popularity of wireless handheld terminals rises, the question is asked if batch data collection will become extinct. Batch collection is the process where handheld devices are placed in a cradle to download and receive data. According to Charles Phyle [19], vice president of Universal Data, Inc. (a manufacturer of handheld computers), the days are near when batch systems will be thought of in the same way as companies presently think of DOS and floppy disks.

The trend is towards 24/7 connectivity – no more batching, no more queues, no more lag time – but will all companies benefit from a Wireless Wide Area Network (WWAN)? Companies need to determine how much benefit will be obtained through real time data collection, and should invest in such a system if time sensitivity is a critical factor. This could include anything from on time delivery of a product to monitoring critical performance indicators in real time. Phyle says that with real time data at the fingertips of service personnel, employees are able to respond quickly



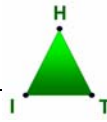
and accurately to any event. In cases like these, the return on investment may justify investing in wireless terminals.

There are, however some drawbacks to bear in mind when considering wireless data collection. The two main factors being the extra costs associated with wireless technology and inconsistent signal coverage. Real time systems tend to cost about 50% more than batch devices [19] and network coverage is not as consistent as for instance the coverage in first world countries of Europe. Europe has built up a network based upon the GSM (global system for mobile communications) standard that provides dependable coverage, while there is mixed technology in other countries that leads to gaps in signal availability. Since WWAN coverage can be inconsistent, businesses should maintain batch systems as a backup to real time connectivity in case of network failure – adding to the operational cost of the business, since two systems have to be kept up to date. Durability, ergonomics and the robustness of devices also plays a significant role and companies are increasingly seeking rugged handheld computes.

Due to the significant expense, unlike business-oriented handheld computers, rugged handheld computers are designed to serve more specialized functions [20]. Durability is a principal concern because these devices are taken through extremely demanding environments every day. Handheld computers share most of the features of the standard PDA form factors, such as a touch screen and stylus or keyboard input, however to ensure durability and high availability, these industrial units normally have reinforced displays, shock-resistant cases, high-capacity fast-recharge batteries and non-slip grips. Designs are increasingly modular to ensure that functionality can be added as the need arises. Modular products can include bar code scanners, imagers, sensors or connectors that allow various types of measurements or data inputs. Rugged handheld vendors are locked in a highly competitive race in which the barriers to entry are high enough to discourage other vendors from considering an entry into this market.



Figure 6 Handheld devices that will be used in the real time environment



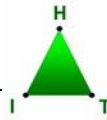
2.4.3 THE SHIFT IN FOCUS: NEXT GENERATION SOLUTIONS

Enormous technology advances have been observed in the past ten years and currently technology is at a level where even the late adopters are able to afford and implement technology that was very expensive and untested a few years ago [21].

Since the large scale commercialization of the internet in the early 1990's, its dominant applications have been the World Wide Web (WWW) and e-mail. The WWW has however remained essentially either static, pull or intermittent technologies where a user requests a web page or e-mail message, a web or mail server provides the relevant files and a browser or e-mail client presents the results to the user. A major shift in thinking on the WWW is underway. Traditionally the focus of the WWW was on making content available to users. The shift, described as Web Services, broadens this perspective and enables programs to share information without predefined application specific protocols using a web paradigm [23]. The emerging breed of applications are however driven by more dynamic, push or real time technologies such as Voice over IP (VoIP), Video Conferencing and Instant Messaging (IM) like Skype and MSN Messenger. These technologies are now readily available at minimal cost or even in some cases free of charge and it can have a drastic impact on the financial figures of the company – lowering operational cost and telephone bills.

Adoption of second-generation Internet technologies such as VoIP and IM has been intense, especially among the younger Generation Y that is coming of age in the era of the commercial Internet. Although the World Wide Web and e-mail will not disappear anytime soon, the new technologies will rapidly expand to fill niches that the Web and e-mail cannot address [21]. IM has an always-on presence and therefore it has become strategic technologies for service providers, financial institutions, healthcare providers, governments and other large organizations. Interoperability is no longer just nice to have, it is absolutely necessary for driving productivity and optimizing business processes [24].

The trends of these applications are quite clear – they centre on relatively rapid, continuous, high-attention activities between individuals or groups (voice, video, application sharing, IM), as well as timely delivery of content that individuals or applications want to learn about in as close to real time as possible (news, sports, weather, market information, emergency notifications). Usage of such applications is commonly driven by a special kind of data called *presence*, which is dynamic information about an entity's availability for communication over the network. Thus, the



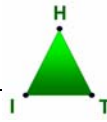
second generation internet mainly consists of a wide variety of real time applications in which structured or unstructured data is exchanged in the context of sessions that are negotiated between two or more users or applications, all driven by availability information in the form of *presence*.

2.5 SUMMARIZING THE TO-BE SCENARIO

It is always difficult to visualize a future perspective and the only way of doing this, is to study the trends of the drivers of change in a specific industry. In the Asset Management scenario, the change is towards the real time paradigm (see par. 2.1) and after careful consideration, the drivers of this change was established as human factors, information management and technology. Although it is still relatively impossible to clearly define what is to be within the next five to ten years, a very good indication can be gathered by studying the trends of these three drivers – an indication on which solid strategic visions can be built and the necessary preparations can be made.

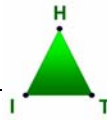
Within the next five to ten years, the lower part of the workforce will be made up of Generation Y personnel. These people know change – in fact, they welcome it. They will be managed by Generation X personnel – also drivers of change and relatively easy adapters to new environments. With a workforce that constantly seeks new potential and ways to improve, the organization will automatically have to have the internal structures to accommodate its personnel and facilitate a working environment that can sustain this constant adaptation. Generation Y tends to be loyal to their profession, and not necessarily to the company. Companies will have to be able to adapt to fast changeover in personnel on the bottom level, but they must also focus on identifying and (almost at all cost) keeping the best and brightest people within the company in order to build the top structure for the future.

Technology advances to a state where it exactly suits the user – anytime, anywhere availability supporting the loose structure of the future workplace. Instant Messaging, Voice over IP and Video Conferencing (as we know it now) will support the change towards the always online real time internet – enabling personnel to work from where ever they are comfortable, and still always be in contact with the core company. Information management moves with technology to a new level of Business Activity Monitoring where any person in the company can structure and customize the information they need and that supports their decision structure.



The only drawback this picture holds is the financial factor – most of these technologies and applications are currently quite expensive and costly to implement. Fortunately as the life cycle of technology progresses, so decreases the price thereof since more and more people and companies adopt it. Real time technologies are the future – all indicators lean towards this and it brings hope to the smaller companies. As soon as these technologies are adopted by the larger firms, it will become more affordable to the smaller companies, leading to a fully functional real time business infrastructure in the future.





3. LITERATURE REVIEW

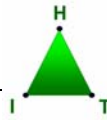
With the knowledge of where the industry is heading in terms of the three main components in the HIT model (human, information and technology), the literature can be consulted for solutions that would fit these trends the best. Different concepts were studied including those that might at the moment not be feasible, but will be fully developed within the next five to ten years (i.e. *Gartner Hype Cycles*, Chapter 2). These concepts include the following:

- The Maintenance Function: Introduction to the need for Asset Management and sketching the basis for the problem from which this research originated.
- Theory of Asset Management: Total Productive Management is used as theoretical model in order to not be company specific with a customized Asset Management model.
- Business Activity Monitoring: This is the basis for real time Asset Performance Management.
- The concept of Agility and a conceptual framework: The proposed HIT model is based on the concept of Agility, which supports continuous improvement and organizational adaptability.

3.1 THE MAINTENANCE FUNCTION

Maintenance is any activity carried out on an asset in order to ensure that the asset continues to perform its intended functions, or to repair the equipment [25]. Any modifications that are made to assets do not count as maintenance, even though they may be carried out by maintenance personnel. Maintenance ensures that the asset is kept in good working order and usually includes regular inspection, overhaul, repair and replacement of parts.

In his paper on Best Maintenance Repair Practices, Smith [26] discusses the deteriorating maintenance management situation in companies. He states that a number of surveys conducted in industries throughout the United States have found that 70% of equipment failures are self-induced. This is caused by maintenance personnel who are not educated in best maintenance repair practices and who do not see the bigger implications of a well thought through maintenance strategy. The existence of this problem has been validated through a skill assessment process performed in companies throughout the State of Georgia. This program evaluated the knowledge of basic maintenance fundamentals through a combination of written, identification and performance assessments of thousands of maintenance personnel from a wide variety of industries. The results indicated that over 90% lacked complete basic fundamentals of



mechanical maintenance. The most common reasons why a company does not follow best maintenance repair practices include the following:

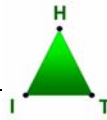
- Maintenance is viewed as a reactive process and does not follow the definition of maintenance.
- Maintenance workforce does not necessarily have the required skills and lacks discipline in best practices.
- Management is either not supportive or do not understand the consequences of not following these best practices.

Palarchio [2] did a study on a cross section of managers and employees from various industries within manufacturing and maintenance, asking them what the first thought is that comes to mind when the word *maintenance* is mentioned. The most common responses included: *fix it, high cost, under utilized, not highly valued, bottom of organizational structure* and *untapped frontier of competitive advantage*.

From these responses, there seems to be a fundamental problem within the word maintenance and the historical context that it brings. The limitations within the maintenance function can be further substantiated by the following points [2]:

- Rarely has an individual from the maintenance function of an organization risen to the rank of chief executive officer. Maintenance expenditure for the most part is viewed as a tolerated cost as opposed to a desirable investment.
- Many of the world's major physical asset disasters and associated fatalities have occurred from the root cause of inadequate maintenance.
- Most academic colleges and universities do not offer programs toward a maintenance profession diploma or degree.
- Most maintenance management personnel come from trade and engineering backgrounds with little business management experience.

From the research of Smith and Palarchio, it is evident that in most cases, maintenance is viewed as a service function rather than a critical business process. The service function view creates *customer-supplier* behaviour, whereas the critical business process view creates *comprehensive ownership* behaviour – one that is clearly more supportive of the elevation of the maintenance function.



There is a definite need for improvement in the maintenance function, but why would a company want to plan its maintenance, and what would be the goal thereof? According to the Plant Maintenance Resource Centre [27] the goal of planned maintenance is to achieve zero equipment breakdowns by implementing systems of parts replacement before failure through Time Based Maintenance (TBM) and Condition Based Maintenance (CBM) (see par. 3.2.1). The six main places where there are losses on equipment are in breakdowns, speed, setup, defect, start-up or yield and minor stoppages. The objective of planned maintenance is to systematically achieve breakthroughs in these losses and to establish standards for basic machine conditions – objectives that the Asset Management concept complies with.

3.2 THEORY OF ASSET MANAGEMENT

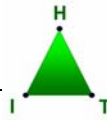
Dunn [25] defines Asset Management as the systematic planning and control of a physical resource throughout its life. This may include the specification, design and construction of the asset, its operation, maintenance and modification while in use and its disposal when no longer required.

3.2.1 TOTAL PRODUCTIVE MANAGEMENT

Effectively, Asset Management is the strategy of planned maintenance and it is built on the theory of Total Productive Management (TPM). Venkatesh [28] extensively explains the concept of TPM, of which only a concise description is given here.

TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to noticeably increase production while also increasing employee morale and job satisfaction. TPM brings maintenance into focus as a necessary and vitally important part of the business and ensures that it is no longer regarded as a non-profit activity. Down time for maintenance is purposely scheduled as a part of the regular manufacturing planning and in some cases even considered as an integral part of the manufacturing process. The goal is to keep emergency and unscheduled maintenance to a minimum.

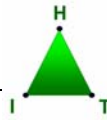
TPM is a Japanese concept which originated in 1951 when preventive maintenance (a United States concept) was introduced. Preventive maintenance is the concept wherein operators produced goods using machines and a maintenance group was dedicated to maintaining those machines. NIPPONDENSO (Toyota group) was the first company to implement plant-wide



preventive maintenance in 1960, but when it started automating its processes, maintenance became a problem as more maintenance personnel were required. Management decided that routine maintenance would be carried out by operators and the maintenance group only did the essential maintenance tasks – this became known as Autonomous Maintenance, one of the features of TPM. The maintenance crew then started modifying equipment for improving reliability and all modifications were incorporated in new equipment – hereby the maintenance team was preventing the need for maintenance. Maintenance prevention as well as the already implemented Preventive Maintenance, coupled with Maintainability Improvement, gave birth to Productive Maintenance. The aim of Productive Maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment. By then NIPPONDENSO had formed quality circles and was ensuring employee participation by involving them in implementing Productive Maintenance. Based on these developments NIPPONDENSO was awarded the distinguished plant prize for developing and implementing TPM, by the Japanese Institute of Plant Engineers (JIPE), whereby they became the first company to obtain the TPM certification.

From the brief TPM history, it is evident that there are several types of maintenance within TPM. A short description of each will be given to formalize the definitions:

1. Breakdown Maintenance: It means that the maintenance team waits until equipment fails and then repairs it. This concept can be used when the equipment failure does not significantly affect the operation or production or if it does not generate any significant loss other than repair cost.
2. Preventive Maintenance (1951): This is daily maintenance (e.g. cleaning, inspection, oiling and re-tightening), designed to keep the equipment in healthy condition and prevent failure by preventing deterioration. Deterioration is measured by periodic inspection or equipment condition diagnosis. It is further divided into Periodic Maintenance and Predictive Maintenance.
 - a. Periodic Maintenance (Time Based Maintenance – TBM): TBM consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.
 - b. Predictive Maintenance: In this method the service life of an important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to Periodic Maintenance, Predictive Maintenance is condition based maintenance – It manages trend values by measuring and



analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

3. Corrective Maintenance (1957): It improves the equipment and its components so that Preventive Maintenance can be carried out reliably. Design weaknesses must be redesigned to improve reliability or improve maintainability.
4. Maintenance Prevention (1960): It indicates the design of new equipment. Weaknesses of current machines are studied and improvements are incorporated before commissioning new equipment. This is achieved with on-site information, leading to failure prevention, easier maintenance and prevention of defects, safety and ease of manufacturing.

The major difference between TPM and other concepts is that the operators are also involved in the maintenance process, which creates a company-wide team spirit by eliminating the so called *I operate – You fix* conflict between operators and maintenance teams. The motives of the TPM program include:

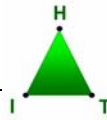
- Adoption of life cycle approach for improving the overall performance of production equipment.
- Improving productivity by highly motivated workers which is achieved by job enlargement.
- The use of voluntary small group activities for identifying the cause of failure and possible plant and equipment modifications.



To achieve these motives, TPM strives to achieve the following main objectives:

- Involve people at all levels within the organization.
- Achieve zero defects, zero breakdown and zero accidents in all functional areas of the organization.
- Avoid all types of waste in a quickly changing economic environment.
- Produce goods without reducing product quality, reduce cost and produce a low batch quantity at the earliest possible time.

The TPM program closely resembles the popular Total Quality Management (TQM) program and many of the tools such as employee empowerment and benchmarking used in TQM are used to implement and optimize TPM. Table 3 compares the two programs:



	TQM	TPM
Objective	Quality (Output and effects).	Equipment (Input and cause).
Means of attaining goal	Organize management and it is software oriented.	Employee participation and it is hardware oriented.
Target	Quality for parts per million.	Elimination of losses and wastes.

Table 3 Comparison of TQM and TPM*Venkatesh [28]*

Within Asset Management there are a few critical indicators, of which Overall Equipment Effectiveness (OEE) and Asset Utilization (AU) are two of the most important indicators.

$$\text{OEE} = A \times PE \times Q$$

Where **A** – Availability of the machine. This is the proportion of time that the machine is *actually available* divided by the time it *should be available*.

$$A = (\text{MTBF} - \text{MTTR}) / \text{MTBF}$$

$$\begin{aligned} \text{MTBF} &= \text{Mean Time Between Failures} \\ &= (\text{Total Running Time}) / (\text{Number of Failures}) \end{aligned}$$

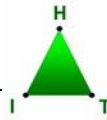
$$\text{MTTR} = \text{Mean Time To Repair}$$

PE – Performance Efficiency, given by:

$$PE = RE \times SE$$

RE = Rate efficiency – Actual average cycle time is slower than design cycle time because of jams, etc. Output is reduced because of jams.

SE = Speed efficiency – Actual cycle time is slower than design cycle time. Machine output is reduced because it is running at reduced speed.



Q – Refers to the quality rate, which is the percentage of good parts out of total produced (sometimes called yield).

In his paper on Asset Utilization, Ellis [29] says that in today's cost cutting, globally competitive market, AU is probably the most critical area in terms of plant profitability. AU is a tool focused on uncovering a plant's opportunity gap by measuring the difference between what assets are capable of producing and what they actually produce.

Formally defined, AU is the ratio of actual output to the output that could be achieved if a plant ran at its maximum capacity for 365 days per year while producing 100% quality product. From this definition, it can be seen that at the most basic level, implementing an AU program requires capturing only two pieces of data – *Actual output* and *Maximum capacity*.

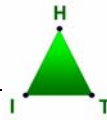
$$\text{Asset Utilization} = (\text{Actual output} / \text{Maximum capacity}) \times 100$$

$$\text{Opportunity Gap} = \text{Maximum capacity} - \text{Actual output}$$

For an AU program to be effective, it has to do more than just measure the opportunity gap. An effective AU program must include a process for documenting the levels at which losses occur as well as the causes of the losses. Once documented, these causes can be charted based on the impact to the business and reliability efforts can be focused on eliminating the causes. At that point the program moves from a measurement that gives a relative indication, to a measurement that provides direction. The causes of losses represent the starting point for focusing reliability improvement efforts because they provide the means to help define the problem, which is the first step involved in effective problem solving. Not all lost production incidents are caused by, or are within the control of the plant. For this reason, every AU model must include categories to which the losses caused by external sources can be allocated. The following are some examples of the types of losses that can occur:

- Planned Shutdown or Equipment Failure.
- Raw Material Shortage and Product Quality.
- Sales Demand.
- Acts of Nature.

Most reliability improvement efforts fail to demonstrate financial results because they are focused on activities and not on the business cost of unreliability. While no single measure can provide a



clear performance target or focus attention on all critical areas of plant performance, AU and OEE are two indicators that should be used to focus reliability improvement efforts because they focus on eliminating the cause of business opportunity gaps. Focusing reliability efforts on the systematic elimination of the cause of utilization losses is one of the most cost effective methods for increasing plant profitability.

TPM has targets outlined by PQCDSM measurement, which stands for Productivity, Quality, Cost, Delivery, Safety and Morale. The following targets should be met when operating in a TPM environment.

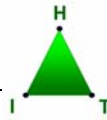
- **P** Maintain a minimum of 80% Overall Plant Efficiency (OPE) and minimum of 90% Overall Equipment Effectiveness (OEE). Machines should be run even during lunch – Machines do not need to eat; only operators do.
- **Q** Operate in a manner, so that there are no customer complaints.
- **C** Reduce manufacturing costs by 30%.
- **D** Achieve 100% success rate in delivering goods exactly as required by the customer.
- **S** Maintain an accident free environment.
- **M** Develop Multi-skilled and flexible workers.

In theory, when a company implements TPM correctly, there are a few direct benefits that should be observed [28]:

- Increased productivity and OPE by 1.5 or 2 times.
- Reduced manufacturing cost by up to 30%.
- 100% Satisfied customer needs by delivering the right quantity at the right time, with the required quality.
- Reduced accidents and following of established pollution control measures.

Even more rewarding when implementing TPM, are the indirect benefits which are more focused on the workforce:

- Higher confidence levels among the employees and a favorable change in the attitude of the operators. The workers will get a feeling of ownership and pride.
- Team spirit will be motivated and the workplace will be kept clean, neat and attractive.
- Horizontal deployment of a new concept in all areas of the organization with shared knowledge and experience.



3.2.2 THE INNER WORKING OF TPM

TPM is a very detailed process, but only a brief overview of the working of TPM will be discussed here in order to understand the basis for the Asset Management concept. TPM is made up of eight pillars. The first pillar forms the foundation of all that TPM is built on, and is thus indicated as a horizontal pillar, forming the base of the TPM house. Each of these pillars will be explained shortly at the hand of the publication by Venkatesh [28].

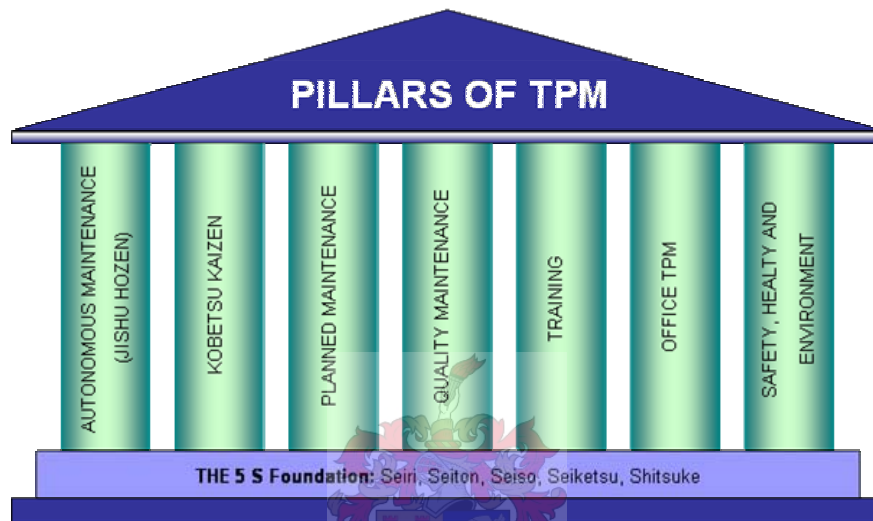


Figure 7 The pillars of TPM

Venkatesh [28]

PILLAR 1: 5S Foundation

Problems cannot be clearly seen when the work place is unorganized. The first step of improvement is cleaning and organizing the workplace, which makes problems visible to the team. This is done according to the 5S program:

1. SEIRI – Organization

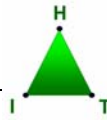
This means sorting and organizing the items as critical, important, frequently used items, useless, or items that are not needed as of now. For this step, the worth of the item should be decided based on utility and not cost.

2. SEITON – Tidiness

Keep the workplace tidy at all times. The concept here is that *each item has a place, and only one place*. To identify items easily, name plates and coloured tags have to be used.

3. SEISO – Cleaning

This involves removing all grease, oil, waste and loosely hanging wires from machines.



4. SEIKETSU - Standardization

Employees have to come together and decide on standards for keeping the work place neat and clean. These standards are implemented for the whole organization and are inspected regularly.

5. SHITSUKE - Self discipline

This means considering 5S as a way of life that brings about self discipline among the employees. It includes wearing badges, following work procedures, punctuality and dedication.

PILLAR 2: JISHU HOZEN (Autonomous maintenance)

This pillar is focused on developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance personnel to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating.

PILLAR 3: KOBETSU KAIZEN

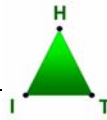
Kai means change, and *Zen* means good (or for the better). *Kaizen* stands for small improvements and is carried out on a continual basis, involving all people in the organization. Kaizen is opposed to spectacular innovations and requires no or very little investment. The principle behind it is that a very large number of small improvements are more effective in an organizational environment than a few improvements of large value. This pillar is aimed at reducing losses in the workplace that affect efficiencies. By using a detailed and thorough procedure losses are eliminated in a systematic way using various Kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

PILLAR 4: PLANNED MAINTENANCE

This pillar is aimed at having trouble free machines and equipment, producing defect free products for total customer satisfaction. This breaks maintenance down into 4 groups (as defined earlier):

- Preventive Maintenance.
- Breakdown Maintenance.
- Corrective Maintenance.
- Maintenance Prevention.

With Planned Maintenance efforts are evolved from a reactive to a proactive method and it uses trained maintenance staff to help train operators, in order to better maintain their equipment.



PILLAR 5: QUALITY MAINTENANCE

The aim here is towards customer delight, ensuring highest quality through defect free manufacturing. The focus is on eliminating non-conformances in a systematic manner. An understanding is gained of what parts of the equipment affect product quality in order to eliminate current quality concerns. From here potential quality concerns can be addressed. Thus the transition is from reactive to pro-active (Quality Control to Quality Assurance).

PILLAR 6: TRAINING

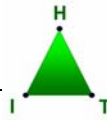
The focus here is to train multi-skilled employees whose morale is high and who have the drive to perform all required functions effectively and independently. Education is given to operators to upgrade their skills. It is not sufficient to only know how to fix problems – they should also learn why the problem occurred and the implications thereof. Through experience, operators know how to solve a problem, but they do this without knowing the root cause of the problem and why they are doing so. The goal is to create a factory full of experts and the employees should be trained to progress through the four phases of skill:

- Phase 1: Do not know.
- Phase 2: Know the theory but cannot do.
- Phase 3: Can do but cannot teach.
- Phase 4: Can do and can also teach.

PILLAR 7: OFFICE TPM

Office TPM should only be started after activating four other pillars of TPM – Autonomous Maintenance (Jishu Hozen), Kobetsu Kaizen, Planned Maintenance and Quality Maintenance. Office TPM must be followed to improve productivity and efficiency in the administrative functions as well as to identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM addresses twelve major losses, which are:

1. Processing loss.
2. Cost loss – also in areas such as procurement, marketing and sales leading to high inventories.
3. Communication loss.
4. Idle loss.
5. Setup loss.
6. Accuracy loss.
7. Office equipment breakdown.
8. Communication channel breakdown (telephone, fax, internet and network).

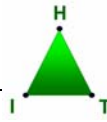


9. Time spent on retrieval of information.
10. Unavailability of correct on line stock status.
11. Customer complaints due to logistics.
12. Expenses on emergency dispatches/purchases.

PILLAR 8: SAFETY, HEALTH AND ENVIRONMENT

The target here is zero accidents, zero health damages and zero fires. In this pillar the focus is to create a safe workplace and surrounding area that is not damaged by processes or procedures. This pillar will play an active role in each of the other pillars on a regular basis. Usually a committee is constituted for this pillar which comprises of representatives of management as well as the work force and is headed by the senior technical director. Utmost importance to safety is given in the plant. To create awareness among employees various competitions like safety slogans, quizzes and posters which are related to safety can be organized at regular intervals.

Today, with competition in industry at an all time high, TPM may be a solution that stands between success and total failure for some companies. It has been proven to be a program that works and it can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other situations. Employees must be educated and convinced that TPM is not just another *program of the month* and that management is totally committed to the program and the extended time frame necessary for full implementation. If everyone involved in a TPM program does their part, an unusually high rate of return compared to resources invested may be expected.



3.3 BUSINESS ACTIVITY MONITORING

Business Activity Monitoring (BAM) is the most recent technology based application of the well known Business Process Management (BPM) concept. BPM is the design, execution and optimization of automated processes – everything from line-of-business processes such as work orders, customer interactions, payroll processing, order processing and regulatory compliance initiatives to core mission-critical processes such as payment remittance, billing, product development and logistics [30].

BAM will be specifically applicable within real time physical Asset Management – effectively, a new opportunity in which to apply BPM. The key is to implement a solution that is powerful enough to accommodate complex processes, flexible enough to handle ongoing change, easy enough for users to embrace, and simple enough to be implemented on time and within budget. This can be a challenging prospect for any organization.

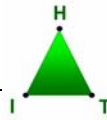
3.3.1 BAM OVERVIEW

Most companies are made up of complex technological environments, accompanied by a fragmented approach to managing the sub-components of this environment. Web-empowered customers, supply chain networks, partner business processes and the global internet economy all make it difficult to gain visibility into how business processes actually perform from end-to-end in real time.

According to Fujitsu Consulting [31], what is required is a way to monitor the current behaviour of an entire business process while it is in progress, so that key stakeholders in the process can:

- Pro-actively identify and contain anomalies instead of recovering reactively from failures after the damage is done.
- Substitute an integrated global process view for competing silo perspectives (e.g., how IT sees the process, how end-users see the process, how various organizations see the process).
- Provide IT and other organizations with a sensible view of business processes, enabling them to respond immediately and appropriately to changes in the business environment.

In 1999, Fujitsu Consulting pioneered BAM, which Gartner defined as the concept of providing real time access to critical business performance indicators to improve the speed and



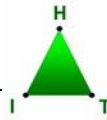
effectiveness of business operations. BAM is a key combination of technology and process that must be deployed by enterprises seeking to operate their businesses as Real Time Enterprises (RTEs) [32]. In a RTE, decisions and actions are triggered by alerts, which are events with context. The BAM system is responsible for generating alerts that represent predefined conditions that warrant attention.

Fujitsu Consulting [31] describes the necessity of BAM when a company wants to:

- Automate manual processes, resulting in lower operational costs or risks and improved efficiency.
- Transform current monitoring practices to a real time monitoring capability that allows pro-active responsiveness to anomalies before the customer is affected.
- Extract real time operational metrics, cross integration of specific components within the existing infrastructure and applications that enable a critical business operation, process or activity to enable an end-to-end view.
- Implement real time dashboards that distribute critical process information to the right people at the right time, empowering them to make the right business decisions.
- Monitor business processes and activities in terms of the business commitments or customer expectations.
- Maximize existing monitoring capabilities by incorporating them as event generators in the BAM solution.
- Validate the effectiveness of a process redesign and to provide a fact-based foundation for continuous improvement.
- Drive the effective implementation and support of an enterprise application from a user's perspective.

BAM is an effective way of bridging business and technology to drive real benefits:

- Process automation – Allows the company to improve business processes end-to-end and free up people for more productive tasks.
- Real time monitoring – Enable companies to detect problems before they affect customers, business partners, or employees. Improved customer satisfaction and enhanced company image is achieved through consistent service delivery and proactive customer management.
- Proactive operational control – Real time monitoring enables identification of critical breakdown points and bottlenecks as well as containing operating costs through crisis avoidance and minimizing rework.



- End-to-end process visibility – With an end-to-end view of the process while it is running, the current state of every critical point in the process is known. Graphical dashboards capable of information drill-down present the information about the business process for different users and it provides effective metrics to manage service levels delivered by internal and external service providers.
- User interaction – When new applications and processes are introduced, time-to-productivity can be measured in real time and actions taken to accelerate acceptance and proficiency. Cost efficiencies are realized by optimizing the capabilities of previous investments in discrete infrastructure technology and other monitoring tools.

The BAM software leverages existing applications and systems management tools as business process event generators and employs data filtering, rules-based impact correlation and alert triggers. Graphical user interfaces or dashboards display the health of business activities across the whole enterprise in a hierarchical series.

3.3.2 BAM ARCHITECTURE

The BAM architecture is explained at the hand of Figure 8. At the bottom of the figure are the running processes from which data is extracted and analyzed, indicated by the middle part of the figure. To the right is a data repository, coupled to a 3rd party reporting tool and a user interface. The user interface delivers real time information on the media shown at the top of the figure. When the application runs, it processes the information received from existing tools and correlates it in real time against the business activity rules and KPI requirements.

Based upon the thresholds that have been established for that particular KPI, the application calculates the business impact and initiates the appropriate notifications, alerts and alarms to the right people at the right time. The real time business activity performance data is displayed on customized user dashboards. Each user can interact with the data, drill down, initiate further queries to extract critical process information in Real-time and pro-actively manage their own element of the business' activities.

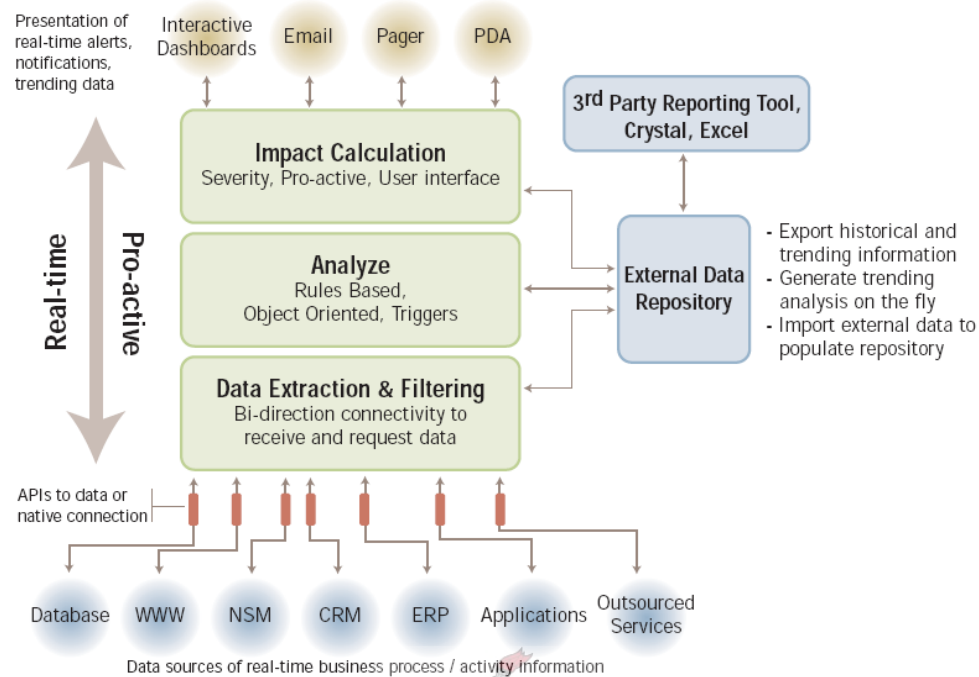
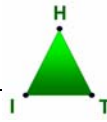


Figure 8 BAM Architecture

Fujitsu Consulting [31]

With BAM a company will gain real time visibility into the end-to-end execution of strategic processes to ensure the best possible customer experience and predictable quality of service and better fulfil business commitments and meet customer expectations by monitoring critical business activities and communicating changing requirements in real time.

In order to get a more comprehensive look at the inner working of the BAM architecture, the different parts will be discussed at the hand of the Fujitsu Consulting model, as detailed by Gassman [32].

There are many ways to build a BAM system, however there is a layered architecture that describes the basic structure of all approaches.

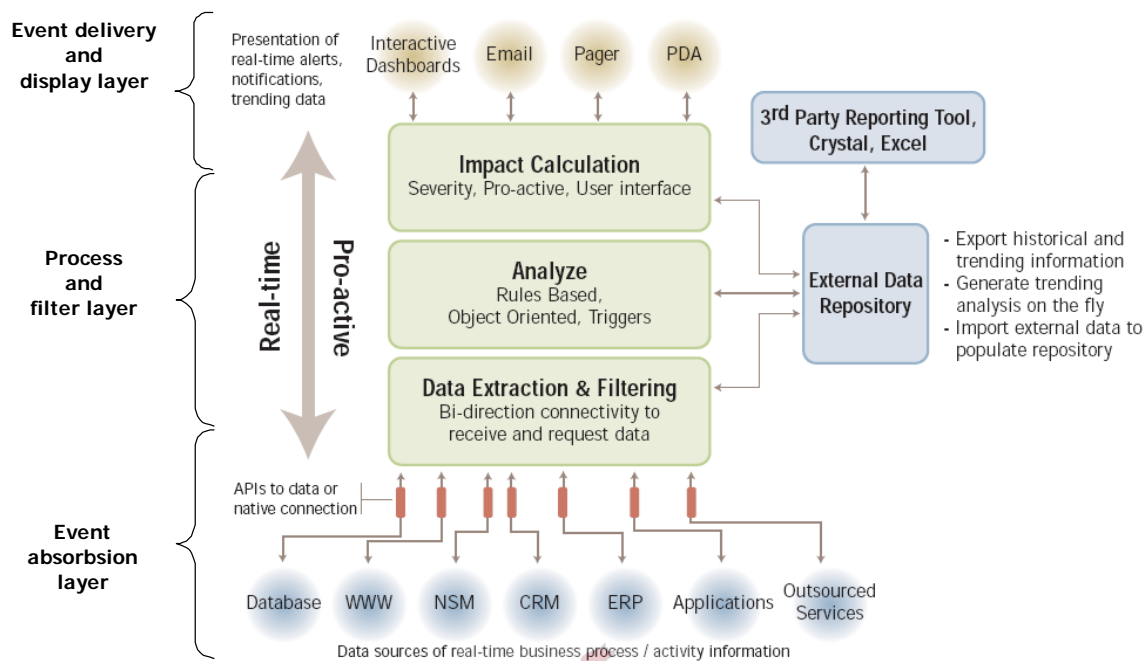
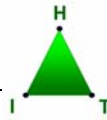


Figure 9 Layered architecture in a BAM system

Adapted from [31]

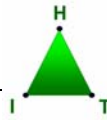
Event Absorption Layer

The event absorption layer is responsible for collecting events, filtering out irrelevant ones and transforming events into a format that is usable by the event-processing layer. The transformation validates messages and maps event attributes to a predefined data scheme. Context may be added to the event at this layer, using keys within the raw event as part of a database query. The source of event messages for BAM will most often be business- or process related, however technical events that occur during the operations of the IT infrastructure may also be collected. The collection of events can be through active or passive means.

- Passive collection happens when event messages are sent to the BAM system by various sources when they are available. Applications that create event messages can be configured to deliver them to the BAM system.
- Active collection occurs when agents that are part of the BAM system actively gather events, including accessing web pages, conducting database queries and gathering application logs.

Process and Filter Layer

The process and filter layer analyzes the stream of incoming events against a set of rules to determine if an alarm should be issued. Because a BAM system works in real time, it may need



to analyze thousands of events per second. The types of rules and the ability to string rules together also determine the system's degree of capability. The architecture of the event-processing layer has two primary components:

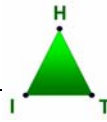
- The foreground piece handles the real time operational analytics.
- The background piece addresses configuration, optimization, alarm validation and short term storage.

The foreground is a real time process that operates on each new event as it arrives from the absorption layer. Simple systems may accumulate the attributes of the new event into a set of counters, located in an operational data store and perform simple threshold tests against the results. For example, an event counter for orders worth more than a certain amount may be incremented; if the counter is more than a predetermined value, e.g. 10, then an alarm is generated. Some BAM systems will have more complicated analysis abilities. They will combine attributes from new events with previous events, associate with the context of a multi-step process and analyze all of the events for trends, duration, delta changes, temporal occurrences and pattern matching. The most sophisticated BAM event processing layers will integrate with best-of-breed rule engines.

The background of the event-processing layer allows for real time and batch tools. Real time functions include a process engine to orchestrate tasks. For example, an out of stock event may invoke a workflow that performs an inquiry into the inventory system to verify the condition before an alarm is issued. The BAM system may also include modelling functions to test the rules with simulated or historical streams of events and an audit facility to allow subsequent analysis of rule accuracy. Each of these components can be integrated into a product or run as a stand-alone function.

Event Delivery and Display Layer

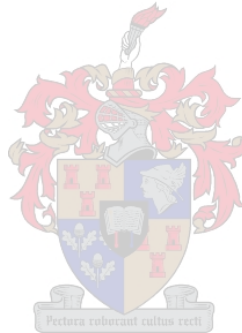
Once events are processed, the results are delivered through the event delivery and display layer in two primary ways — through alert messages or a real-time dashboard. Alerts can be delivered directly by the BAM system or integrated into a business's messaging and message delivery system, free from dependence on the BAM system that produced it. E-mail messages accomplish most simple alerts to users and other techniques include the use of e-mail, portals, taskbar icons, paging, and mobile phone and instant-message services. With a notification delivery system, users can control the type of alarms they receive as well as when and how they are distributed. It is common for a BAM alert to contain a Web link that directs the user to a dashboard or other

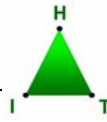


application that has drill-down information. Alerts may also be delivered to applications, such as BPM systems to trigger an automated action.

Real time dashboards provide a visualization of KPIs through the use of gauges, graphs and indicator lights. The dashboard updates as new data becomes available, thus it represents aggregated metrics as well as individual events. Dashboards are useful in a business operation centre and they also serve as drill-down tools for business managers who have been alerted to a significant event.

BAM systems do not require an integrated dashboard. Instead, many enterprises will use the alerting abilities of a BAM system and then switch to other tools to accomplish their drill-down analysis, or integrate the alerts into automated processes. BAM forms a part of the organization and practices of a RTE. Detection of a significant event simply begins another chain of events. Decisions are made by appointed personnel about how to react to an event and execute on the decisions.





3.4 THE CONCEPT OF AGILITY

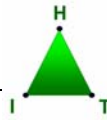
Gartner has been researching the concept of agility for several years and has taken a broad view of the topic. Agility is defined as the ability of an organization to sense environmental change and respond efficiently and effectively to that change. Sensing the need for change also includes the proactive initiation of change [33].

3.4.1 AGILITY OVERVIEW

Agility is a concept that was developed in the IT context, but the principles thereof are applicable to more business functions. Agility cannot be separated from its impact on the enterprise's bottom line. If methodologically sound measurement shows that an enterprise has increased its agility (i.e. obtaining a better agility measurement) compared with its past performance, there should be tangible results to show the impact of being more agile. If not, agility is a worthless measure. Organizational resistance is one of the main obstructions on the road to agile change, but by applying Agility in the right manner, a substantial internal change will be created.

Agility supports BAM, and in turn by effectively applying BAM, Agility is improved. Thus these concepts are in constant interaction. Gartner observes [34] that outdated management practices, especially in manufacturing drag out the cycle time for line management to act quickly. Management practices have to be up to date to effectively apply good business processes such as BPM, BAM and Agility. BPM also requires business managers to learn real time management skills by achieving greater business agility through improved collaboration within the organization. Strict governance and procedures must be in place for business rule management and approval of process flow changes. This implies that business processes and principles have to be followed at all times, without exception.

Perhaps most notable is the complexity of optimizing work that relies on a tangled web of people and computing systems. When the business challenge can be solved by redirecting people's activities, business managers are generally decisive and will move quickly to create plans to adjust responsibilities. Agility can be related to an athlete's agility [34] – it requires the ability to maintain organizational equilibrium while changing speeds and direction (an athlete's balance), the ability to move the organization rapidly (an athlete's speed), the ability to overcome resistance (an athlete's strength) and the ability to control the actions and movements of the



organization in conjunction with inputs from various sensory function, i.e. from BAM processes (an athlete's coordination).

In order to be agile the organization has to change its vision, goals and objectives, drivers for change (agility, cost, consistency) and current process models (internal behaviour). The key is to clearly define the context in which the change will happen, the processes that will be followed, the rollout and communications plan as well as the incentives that will accompany the change process.

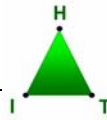
Fundamentally, business managers lack skills and experience in managing technological change. However, because business is conducted from a process foundation that includes people and computers working together, a more common set of management practices is needed that reflects the importance of people, computers and information as equal contributors to successful work. The BPM discipline treats people, computer systems and information as equally important resources and it encourages more formal management of the organization's business processes. A BPM driven organization implements governance and structured methods, policies, metrics, practices and tools that ensure that it defines, manages and continually optimizes its business processes in a holistic, unified way [34].

3.4.2 AGILITY OUTCOMES

With the more holistic approach of BPM, three key outcomes emerge that directly support business agility [34]:

- The availability of real time information delivered in context, which increases the business manager's level of confidence to make accurate and faster decisions.
- Shortening the time to revise a business process through an explicit understanding of shared responsibility across the business.
- Fast adoption of process changes by due to visibility, collaboration and consensus building.

One of the greatest values derived from BPM is gaining near real time information at the right moment to support decisions over business transactions while they are still in progress. The discipline requires practitioners to graphically model processes that explicitly identify *who* needs *what* information, for *what* purpose and *when* the information is needed. With the context clearly defined by business, the IT staff has a more manageable task of providing such information, because it knows where the information resides and how best to collect and present

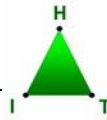


it. In the past, when extracting information from processes, not only did it take the information out of the context in which it was created, but it also did it selectively, choosing only completed business transactions. The resulting perspectives over business operations prevented managers from altering the course of business transactions before they were completed, removing their opportunity to potentially improve business outcomes.

Newer BAM technology found in a BPM suite equips personnel with alternative techniques to capture real time business event data and present it to business users in a graphic format – all in the context of the real time running process. In this way it is more intuitive for the business professional to use. Armed with real time data and graphical tools, business managers can apply familiar and new analytical functions (such as simulation and optimization) to this data to support faster decision making over transactions with a higher degree of confidence than before. If a process change is needed, the context of the supporting information is explicit, and the change can be tested before it is acted on. Not only does placing context around information accelerate the decision, but the simulation capability also verifies that the decision is the correct one, before it is executed.

Change management, as related to changing the way people work, has been the focus of a growing discipline within organizations for quite some time. Best practices in all change management solutions highlight the importance of communication – making sure people understand the goals and objectives driving the change and communicating that workers are valued, what they are expected to do and how they will be measured. An explicit representation of what people are expected to do is accomplished with models that deliver visibility to all stakeholders and participants about how the process works, and visibility into the status of work as it moves through the process. This degree of visibility drives a feeling of ownership and control over the process and participants. Visibility, combined with new shared performance objectives, requires new approaches to governance over the end-to-end process. This new governance approach must be implemented to replace functional-unit-level authority. The process change then becomes consensus-based, created by using the new tools to experiment with different alternatives and the ability for all stakeholders to see and understand the effects of those changes.

The transparency of the decision making within the process and the visibility across the organization empowers personnel to get involved and feel valued as the change is implemented. This shared perspective drives participants to work together toward shared performance



objectives rather than cross-purposes which are created by conflicting performance objectives – typically exhibited at a functional level. Incentives should be designed to drive these behavioural changes to support the new shared performance goals and objectives.

3.4.3 AGILITY CONCEPTUAL FRAMEWORK

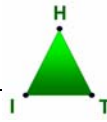
The Agility conceptual framework is discussed at the hand of the Gartner model, as detailed by Plummer & McCoy [35] and McCoy & Sinur [36].

Any framework for agility must address issues that go well beyond selection of the latest technologies. An enterprise's willingness to be agile, an understanding of its own enablers of agility, and the adherence to an agility cycle are just as important as the sensible use of agility influencing technologies. Rapid business change is driving a need for agility to respond more effectively to change.

An extensive set of questions must be asked of representatives of an enterprise whose agility performance is being assessed. The assessment is most relevant for the top management, but a credible assessment must also include one or more line-of-business managers who can provide insight into the agility performance and requirements of the business. There are several steps that need to be finalized for any agility measurement to be credible. Questions to be asked during a survey of any company should include questions about the enterprise building blocks and about the technologies. Through these questions, formulas can be built that relate cause to effect. Based on the issues that are revealed throughout the agility assessment, business managers can make prescriptive recommendations about the technologies and best practices that the enterprise should consider to achieve greater agility.

Enterprises that aspire to respond in real time must have the ability to be agile when needed. The requirement for agility is not new, but structured agility is an emerging best practice. One way of addressing this complex demand for agility is to employ a technology strategy that seeks to achieve:

- Greater efficiency of operation (productivity).
- Greater availability of information (awareness).
- Increased options for handling known changes (flexibility).
- More effective reaction to unanticipated changes (adaptability).



These four enablers of agility provide a framework for examining an enterprise's agility and a structure through which technology solutions can be delivered to improve agility. Each of the following key concepts behind the Agility Methodology Framework will be discussed in turn:

- The Agility cycle.
- Enterprise building blocks.
- Agility enablers.
- Willingness factors.
- Key technology areas.

3.4.3.1 THE AGILITY CYCLE

The agility cycle is a series of five intuitive acts that are required to be agile (Figure 10):

- Sense.
- Strategize.
- Decide.
- Communicate.
- Act.

By sensing the need for change, developing alternative reaction strategies, deciding on the most appropriate reaction, communicating the planned reaction and executing the plan (acting), an enterprise fulfils the definition of agility. The agility cycle is a continuous loop and in addition, each step should ideally incorporate information from each of the other steps. For example, Sensing depends on processing information from the previous loop through the cycle and incorporating that previous sensing information into the current cycle.

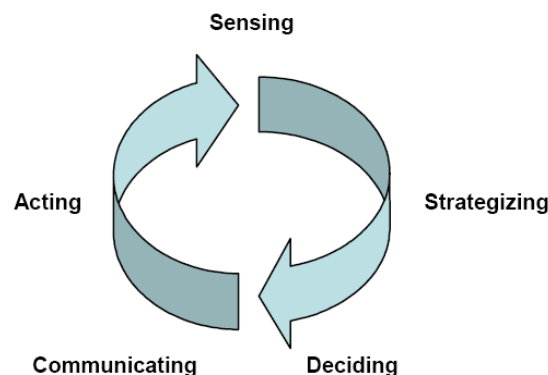
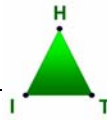


Figure 10 The Agility cycle

McCoy & Sinur [36]

**SENSE**

The first stage in the agility cycle is sensing a change in the business environment that may call for a modification to the strategic or tactical direction of the enterprise. The question to be answered is: "How aware is the organization of significant changes in the business environment?"

STRATEGIZE

Once an organization has sensed a change in the business environment, it must identify ideas, strategies and courses of action to respond to this change. The question to be answered is: "What is the ability of the organization to respond to the change?" The objective is to take advantage of the opportunity or lessen the potential damage of an issue, depending on the specifics of the change in the business environment. During this step, organizations must formulate alternatives and come up with several feasible scenarios to address the situation.

DECIDE

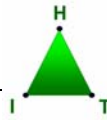
After developing potential alternatives, the organization must decide on the best course of action and execute it. The question to be answered is: "How well does the organization commit to a new strategy?" A comprehensive plan must be developed and the organization must commit to executing this plan in full consideration of resource and time constraints.

COMMUNICATE

Once the most feasible alternative has been selected and a detailed plan has been developed, the benefits, impact and details of the plan must be communicated throughout the organization. The question to be answered is: "How certain can the organization be, that the strategy and corresponding plans were communicated effectively to all necessary parties?" Requirements, costs, benefits, time frames, resource requirements and all other relevant factors must be communicated to the organization.

ACT

Once the plan has been communicated, the organization must act on the plan. The question to be asked from an agility perspective is: "How efficient is the organization in carrying out the new directives?" The ability to successfully act on a plan depends on many factors, including financial constraints, organizational structure, contractual obligations and internal skill sets. Organizations may be stronger in some steps of the agility cycle and weaker in others. For example, a major corporation may be strong in its ability to *sense* changes to the business, because it has an



internationally dispersed workforce. However, the same organization may be weak in its ability to act, based on distribution of skills and a complex and rigid infrastructure.

The steps of the cycle are the major areas in which agility measurements should be collected. Each measurement of technology uses, management initiatives, organizational characteristics or strategic directions is included in the finalization of each of these cycle steps. The principle here is that the agility cycle is used to determine where agility must be measured and then the measurements are done in the context of continuous improvement.

3.4.3.2 ENTERPRISE BUILDING BLOCKS

The enterprise building blocks are:

- Human capital.
- Business activities.
- Business relationships.
- Enterprise information.

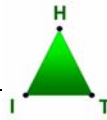
HUMAN CAPITAL

Human capital includes infrastructure that is required to support the work of the employees of the organization. Ensuring that the organization has the proper infrastructure is essential, because without the proper human capital infrastructure, numerous operational and organizational problems can arise that can prevent an enterprise from acting on opportunities or challenges as they emerge. Examples of the components of human capital include:

- Access time: Flexibility, allowing workers the ability to access the right resource at the right time.
- Skills: The facilitation of training and skills development to perform jobs in an agile fashion.
- Collaboration: The facilitation of collaborative processes and shared-work efforts to promote agility.
- Communication: The facilitation of effective communication and information mechanisms.

BUSINESS ACTIVITIES

Business activities are all the internal processes and activities that must be undertaken to run a business. Some of these processes are virtually universal and employed by all organizations, e.g. cost calculations. In contrast, many other activities are unique to the market, the industry and



the individual characteristics of the organization itself, e.g. regulations when handling food products. Examples of components of business activities include:

- Process integration: The degree to which key business processes create a seamless flow.
- Change management: The ability to anticipate, track and manage changes.

BUSINESS RELATIONSHIPS

In contrast to business activities, business relationships are defined as processes and activities that involve external stakeholders, such as customers, business partners and regulatory bodies. All processes that interface with entities outside the organization fall into this category. Examples of components of business relationships include:

- Diversity of types or quantity of partners: The ability to support any number of varying types of partner relationships managed by the enterprise.
- Technology standardization with partner infrastructure: The degree of similarity or compatibility established with a partner's IT infrastructure or systems environment.

ENTERPRISE INFORMATION

Enterprise information is a critical asset to the organization. It includes any information an organization uses to function and to base decisions on. Examples of components of enterprise information include:

- Information formats: The degree of information automation and format standardization.
- Collaborative environment: The facilitation of a collaborative and information sharing work environment.
- Quality and accuracy: The degree to which information supports quality assurance.

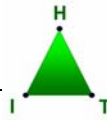
3.4.3.3 AGILITY ENABLERS

The following four capabilities enable an organization to increase agile performance across the agility cycle (more details available in Appendix C):

- Awareness.
- Flexibility.
- Adaptability.
- Productivity.

AWARENESS

Awareness is the knowledge that significant change is occurring in business conditions. Proactively identifying changes can provide an organization with more time to gather data and



react accordingly to the problem or opportunity that presents itself. Determination of awareness levels poses questions such as:

- Do end users see the right information at the right time?
- Does the organization suffer from any internal or external barriers to awareness?
- Is this information easily accessible by the right people?

FLEXIBILITY AND ADAPTABILITY

Flexibility is the ability to respond appropriately to expected changes in business conditions. Adaptability requires increasing flexibility through adding options to handle unexpected change. Financial viability, human capital and technical infrastructure are just a few examples of factors that will affect the flexibility and adaptability of an organization. Key questions include:

- Is the enterprise able to respond to expected (flexibility) or unexpected (adaptability) changes?
- If not, can the enterprise identify some of the problems that impede its flexibility and adaptability?
- Does the organizational structure of the enterprise promote or prevent flexibility and adaptability?

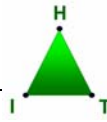
PRODUCTIVITY

Productivity is the ability to operate effectively and efficiently. Organizations that can execute efficiently and cost-effectively can have a significant agility advantage over competitors. Determining productivity's impact on agility includes questions such as:

- How efficient are the enterprise's operations?
- Is the enterprise effective from day to day?
- Can the enterprise identify any internal or external barriers that impede its productivity?

3.4.3.4 WILLINGNESS FACTORS

Willingness is a means of assessing how well an organization invests in people and financial support, along with how well it is performing as an organization to maximize technology potential and minimize the risks associated with deploying that technology. Willingness is essential to any positive movement on agility. Without proper commitment, leverage and controlled risk, an organization is more likely to scatter its resources and any agility achieved in this unwilling scenario is purely accidental. A definition of each of the willingness factors that help or hinder agility is provided below (more details available in Appendix C).

**COMMITMENT**

Commitment is defined as the degree to which an organization is willing to be agile in terms of people, money and time. Determination of commitment includes questions such as:

- Does the enterprise have the right people with appropriate skills and experience?
- Has the enterprise spent enough resources on being committed?
- Does the enterprise set appropriate and reasonable time schedules?

RISK

Risk refers to the degree of risk associated with implementing and managing changes to technology and it measures best practices and policies an organization uses to alleviate risk. Determination of risk includes questions such as:

- How well does the enterprise implement new technologies?
- Does the enterprise have a governance board or project management office to coordinate multiple technology projects?
- How risky are those changes to make?

LEVERAGE

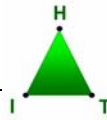
Leverage is the degree to which an organization fully utilizes technology in the manner intended or even beyond the manner intended to maximize the positive impact on the organization's effectiveness. The use of industry standards and development methodologies are examples of technology components that can be leveraged by an organization. Determination of the degree of leverage includes questions such as:

- How well are technologies used for purposes other than what they were purchased for?
- Is the enterprise's technology widely used in critical business situations?
- Does the enterprise have standards for integration and intersystem communication?

3.4.3.5 KEY TECHNOLOGY AREAS

To measure and analyze agility, it is critical to understand key technologies that can enable an organization to optimize its agility. Since each organization will have a different business and technology footprint, each organization may require different technology solutions. An agility measurement should provide answers to the question: "What key technologies will help the organization improve its level of agility?" Some key technology families and related topics to be examined include:

- Process: BPM, BAM, change management, metadata management, asynchronous operation and rule-based processing.

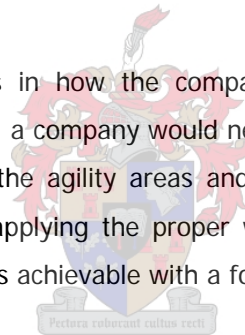


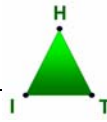
- Access: Portals, wireless connections, web browser support, authentication and authorization, e-mail integration and personalization.
- Data — XML, data warehousing, business intelligence and enterprise information management.
- Mobility — Synchronization, mobile application development and wireless PDA access.
- Connectivity — Internet, intranet, wireless support, WAN, DSL, VPN and asynchronous dial-up.
- Platforms — Interoperability, multiplatform and integrated platforms.
- Standards — Network, data format and access, electronic data interchange and Internet.

3.4.3.6 CONCLUDING THE CONCEPTUAL FRAMEWORK

This conceptual framework describes a detailed decomposition of agility. However, a company is often left with the questions of what needs to be done to become more agile, how agility is measured and how it is improved?

The answer to these questions lies in how the company chooses to apply the conceptual framework. In a more general sense, a company would need to create a company-specific series of questions that relate to each of the agility areas and tie those questions back to a list of technologies. The difficulty lies in applying the proper weights to each of the questions, the answers and the technologies, but it is achievable with a focused specialist team.





3.5 CLASSIFICATION OF SERVICE DELIVERY

This section addresses tools that will be used to classify the kind of organization and the nature of the service that they offer, as well as the mindset of the sales team. The underlying question is how the service and the knowledge obtained from driving a process in real time can be marketed to clients within the real time physical Asset Management Scenario.

3.5.1 CUSTOMER SATISFACTION WITH REAL TIME RESPONSES

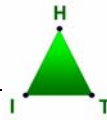
Customer service requirements vary between businesses, and customers need service in a variety of locations. The type of service (i.e. electronic or human) depends on the customer and the situation. For some companies it can be expensive to offer a manned customer service on a full time basis, so only electronic service may be available at certain times. The principles of the RTE can be applied in all of the channels shown in Table 4 [37].

		PLACE OF SERVICE		
		IN A SHOP	AT HOME OR OFFICE	ON THE MOVE
NATURE OF SERVICE	HUMAN INTERACTION	Shop Assistant	Field service	Mobile phone or Call Centre
	ELECTRONIC	Kiosk	Web via PC	Mobile phone or Web Site

Table 4 Service delivery types classified according to *place* and *nature* of service

Flint & Raskino [37]

For example, within the RTE there are two types of client demands. One is the workforce, who needs the information in real time, and the other is management, who needs rolled-up information reporting on certain key performance indicators. When mapping these two clients on the model above, the *Nature of Service* will be electronic and the *Place of Service* will be the office (workforce) or on the move (managers). The means of service delivery will be *Web via PC* and *Mobile Phone or Web Site* respectively. If human interaction is required, it will be done by the shop assistant.



Flint and Raskino [37], also discuss the importance of comprehensive, real time information. Comprehensive information must be available to customers and customer service staff via appropriate channels. The type of information depends on the business, for example:

- All businesses: Status of orders and transactions and detailed product information.
- Software vendor: Lists of bugs and fixes.
- Retailer: Stock levels and goods in transit.
- Manufacturer: Production plans.

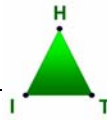
Information about products, services and the resources needed to deliver them should be maintained in real time, otherwise customers may be misled, causing embarrassment and possibly financial loss to the enterprise. Keeping information current requires changes that extend well beyond the customer-facing processes to the processes for supply, sales, delivery, scheduling and resource allocation, which makes the term RTE especially appropriate. In many cases, real time tracking is the key to real time information:

- Information on the arrival times of buses at bus stops requires real time bus tracking.
- Manufacturers can assess the completion dates for orders by monitoring production processes and the inbound supply chain in real time.
- Retailers need to monitor the inbound supply chain to update information on the availability of products.

The information gathered from monitoring processes is not enough to meet customer needs. In every case, the RTE must be able to use it to forecast the event that concerns the customer. For example, to estimate the likely completion time of an order, the enterprise needs to know how each order is progressing, how fast the production line is moving and whether there are any possible breaks in production (e.g. breakdowns). To ensure that these forecasts are reliable, the business process must be actively managed to guarantee that it behaves consistently.

3.5.2 SALES CULTURE AND TECHNOLOGY INVESTMENTS

The information demands and process maturity of an organization need to be mapped against the capability of a technology prior to investing in a sales technology strategy [38]. Gartner's Sales Culture Technology Alignment Decision Framework provides a point of emphasis for technology deployment, and is used to determine which sales culture warrants investments in which technologies. This is not an exclusive set of selection criteria, but gives appropriate direction.



Information Needs range on the vertical axis from low to high and *Complexity of Sales Process* range on the horizontal axis from *informal* to *defined*. Each quadrant as well as the appropriate technology focus will be discussed in turn.

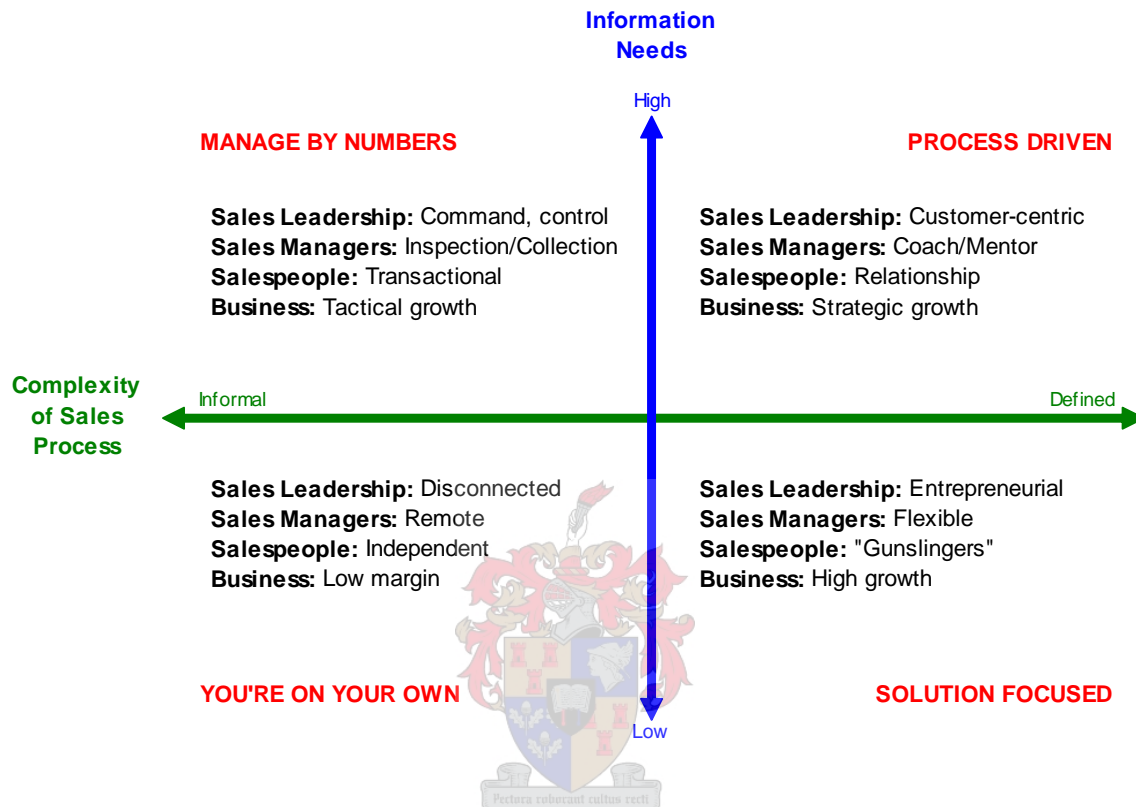


Figure 11 Sales culture and technology alignment matrix

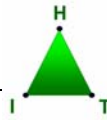
Gartner [38]

YOU'RE ON YOUR OWN

Sales managers who do not ask a lot of questions to inspect personnel performance often have few informational needs. In a sense, they are disconnected from the day-to-day operations of the sales organization and are only concerned with aggregate performance. This disconnected management style promotes a culture of independence and is most often seen in low margin commodity selling situations.

Technology Emphasis

Other than e-mail, cell phones and laptops for basic communication and information processing, investing in any sales automation technology will not provide value.



MANAGE BY NUMBERS

Organizations with a manage by numbers culture are focused on achieving performance targets, having little regard to how they are achieved. Technologies that manage and present performance data at both an aggregate and a detailed level are highly valued. The ability to access and analyze this data from a current, year-to-date or historical perspective is important. Forecast data is compiled and adjusted based on the credibility of the individual who is creating the forecast, rather than the facts behind each opportunity.

Technology Emphasis

The focus should be on the accuracy of the data presented and the format and flexibility of access to minimize data collection and management efforts by selling resources. Internal data should be used, that is readily available in read-only formats. Reporting flexibility through Web centric sales information portals enables easy access to the data that drives the sales organization. Key technologies include:

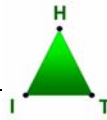
- Excel reporting.
- Sales analytics, forecast systems and informational Web portals.
- Incentive compensation management systems.

SOLUTION FOCUSED

A solution focused culture, focus on the productivity of the salesperson during sales execution. Typically, sales cycles are longer and require more information to convince customers to buy. The need for management reporting data is secondary to the needs of the salesperson selling to the customers. The solution focused culture puts the salesperson first and foremost. Sales management promotes an entrepreneurial style with less command and control of salespeople.

Technology Emphasis

Applying technology to the execution steps of selling requires an understanding of how people sell. Activities vary by sales tier (i.e. strategic, major, mass and inside) or vertical market, but they involve accepting qualified leads, access to content (brochures, competitive knowledge and case studies), sales configuration and quoting capabilities, proposal generation and order submission. This class of activities and its supporting technologies are designed to improve individual productivity through the automation of these sales events. The business process may be very well defined, such as that required for order management, or extremely flexible as with content management, but the focus is to make more information more readily available so that



salespeople can spend more quality time with prospects and close deals more effectively. Key technologies include:

- Sales content management.
- Sales configuration and quote management.
- Price management and proposal generation.
- Order management.

PROCESS DRIVEN

Organizations with a process-focused culture must have fully defined and institutionalized sales processes for managing opportunities through the sales cycle. As with the solution-focused culture, sales cycles are typically longer than for the other quartiles mentioned. Customer centricity or a more elaborate Customer Relations Management (CRM) strategy is also typical. Collaborative access to customer knowledge among sales teams and customer service is critical to promote long-lasting customer relationships.

Technology Emphasis

The optimal technology for this type of sales culture would include complete process enablement, which can be customized to the organization's specific methodology. Opportunity, account and contact management are combined with sophisticated, but flexible, reporting capabilities. Fully developed opportunity management systems will be adopted readily by this culture and will provide a foundation for sales participation in an organization's CRM initiative. Unfortunately, inadequate technology deployed into this environment will only frustrate users. Incomplete technology will reduce sales effectiveness in a process-driven sales team. Key technologies:

- CRM application suites.
- Opportunity, account or contact management.
- Collaborative client or sales portals.
- Customer data integration to obtain a 360-degree view of the customer.

When looking at the basic requirements of the RTE, information needs are inevitably high. In order to add enough value and effectively sell real time information, the sales process is also fairly complex and defined. If a company knows the effect that real time information has on business performance growth, it can align its sales strategy accordingly and thus progress to a better state in business performance.

4. HISTORY OF MODEL DEVELOPMENT

This chapter discusses the history of the HIT model and the factors that had an influencing role on its development. It also shows that there is just cause for the existence of each of the components, as well as the chosen interactions between the component pairs. The interactions have been chosen in such a way, that a definite solution can be coupled to each, giving the company a structured way to address this interaction. The components and interactions were developed over a period of six months, during which detailed literature studies as well as practical industry exposure were undertaken to validate the concepts.

4.1 DEVELOPMENT PROCESS

As described in the problem statement, the study originated in an environment in which a new opportunity for improvement has been found. Initially there were two aspects that had to be investigated: How ready a company is to implement a real time application solution and what kind of information will be needed in order to successfully run the solution. The best way to look at this type of problem is to investigate what the current state (AS-IS) of the business is and where it would be over time, as these solutions were implemented (TO-BE). This can be indicated by Figure 12, where the three axes indicate a mapping of the company's *readiness for real time applications* against the *types of information packages* needed. This would be investigated over time (3rd axis), from and AS-IS to a TO-BE state.

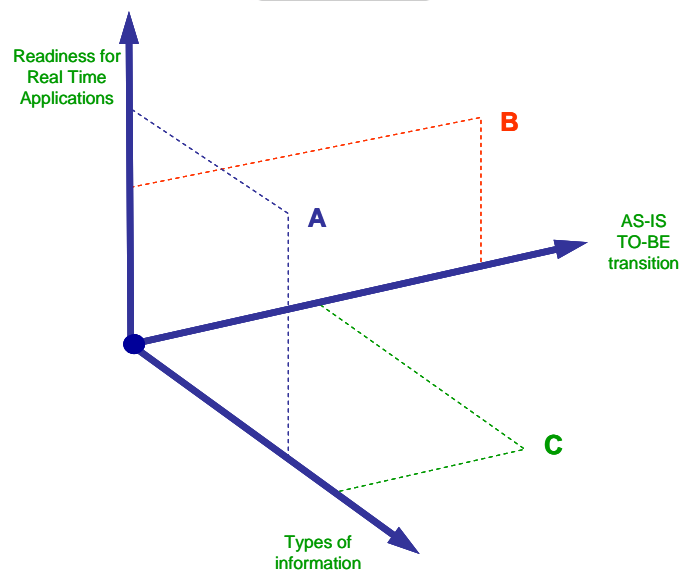
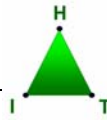


Figure 12 Model development: Phase I



Information packages and a company's readiness seemed to be sufficient for the real time asset management scenario, but throughout the literature study on this topic, three components that have to be managed kept emerging. Although almost never discussed or compared with each other, *Human factors* (i.e. People Management, Organizational management, etc.), *Advances in Technology* and *Information Management* seemed to have a certain interaction with each other. As technology improved, new ways of managing information was developed. More energetic and younger generations entered the workforce, developing new kinds of technology to suit their needs and finding improved ways of managing information. Whatever the component was, there was always an interaction that could be related to either of the other two. This interaction can be represented as follows:

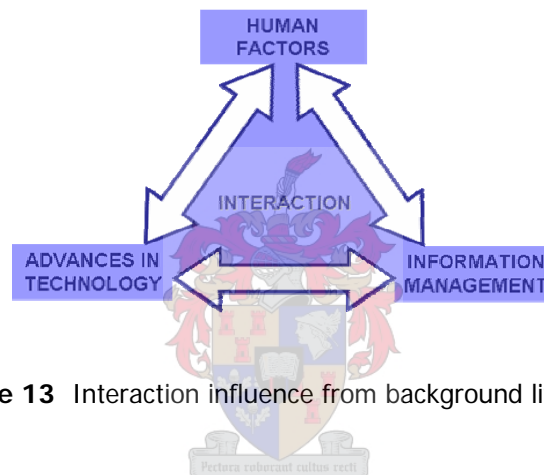


Figure 13 Interaction influence from background literature

The next logical step was to incorporate this knowledge into the model. *Types of Information* was changed to *Information Management* and the *Readiness* and *AS-IS, TO-BE* axes were combined, resulting in a diagram that evaluates the interaction of the three mentioned components from an AS-IS to a TO-BE state, through the steps of *Readiness for real time applications*. The AS-IS state is where a company is 0% ready and the TO-BE state is when the company is 100% ready – both being somewhat unobtainable, since a company will always have a certain degree of processes in place (thus not being 0% ready for any changes), but will neither have fully optimized real time capable processes (thus making 100% readiness only a theoretical state). This can be represented as follows:

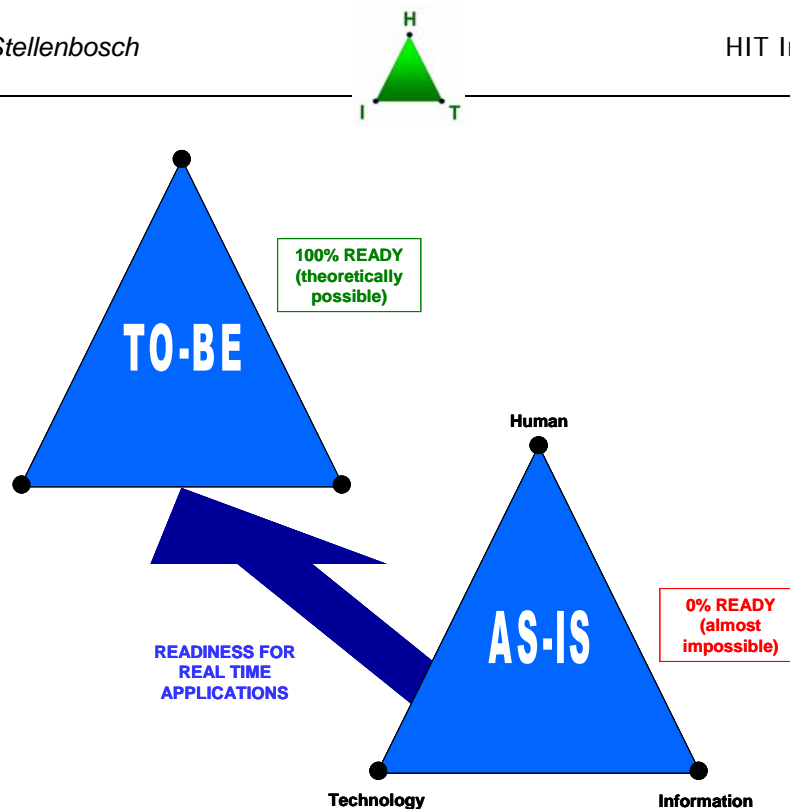


Figure 14 Model development: Phase II

The initial objective was to describe how to manage each of the three components over time, within the given environment, but since there is such a close relationship between the components, each one could not be dealt with in a solitary way. Since there are such obvious interactions throughout the literature, the best possible way to describe the management of each component is to couple it to an interaction. By addressing a certain interaction, the company would inherently address two of the components. The problem here is to find the right interaction that will lead to at least two focus areas - i.e. Human-Information, Human-Technology or Technology-Information.

In order to establish what three interactions suit the model best, it had to be established where the individual components are moving in the future. By knowing what people will be like in the future, a solution can be found that can be implemented over the next five years, to suit the frame of mind of the people that will be working with it. The same can be said for technology and information – by knowing the future states of each, the best potential solution can be found now, that would address the situation in the future. Thus, the trend analysis was added to the model (indicated by the dashed lines in the picture). All studies are done within the real time Environment (RTE), as indicated on the first triangle.

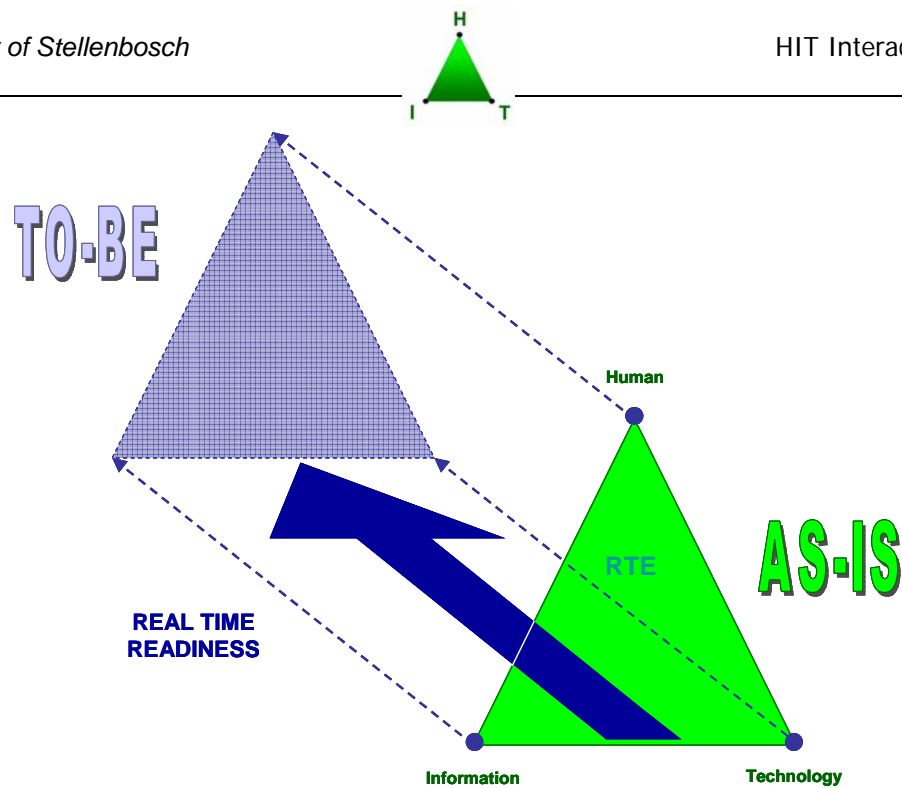


Figure 15 Final Model: Part 1

The final model sufficiently described the real time Asset Performance Management scenario, and is used as graphic explanation of the research study. The final model consists of two parts - Figure 15 indicates the trend analysis and Figure 16 indicates the description of the interactions. The same *Human-Information-Technology* (HIT) triangle is used, with its sides indicating the interactions.

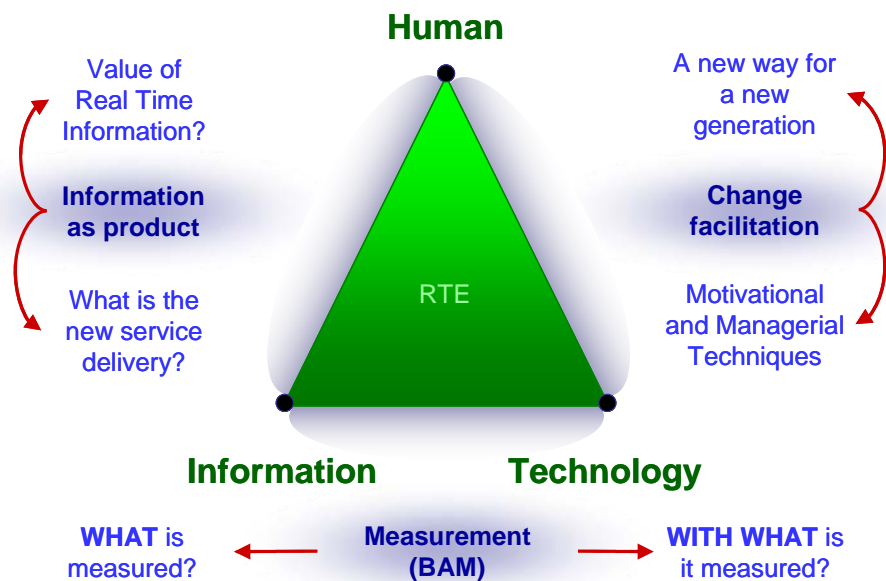
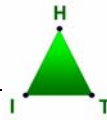


Figure 16 Final Model: Part 2



4.2 JUSTIFICATION OF COMPONENTS AND INTERACTIONS

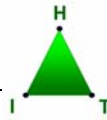
There are possibly many other interactions that could have been chosen, that would also describe the Human, Information and Technology interactions within a company. These three were chosen in such a way that best describes a general approach that will be feasible within the specific Real Time Asset Performance Management environment.

For each interaction, the following justification can be given:

- **INFORMATION-TECHNOLOGY:** *Measurement.* More specifically, measurement through Business Activity Monitoring. BAM is a solution that encompasses the whole information and technology question, describing within a framework exactly what kind of indicators have to be managed in order to get suitable information that will enable personnel to effectively manage the company. It also indicates what kind of technology will be needed to drive this information management.
- **HUMAN-INFORMATION:** *Information as product.* This interaction will describe what the service to the clients will look like and what the value of real time information is to them. By addressing these two components, the people in the organization will know how to use the information from their processes to their advantage and how it will enable them to better satisfy their clients. Information management is directly addressed and the people in the organization know exactly what their role is, and how to use the tools given to them.
- **HUMAN-TECHNOLOGY:** *Change facilitation.* In contrast to traditional change management, change facilitation enables the organization to understand what the profiles of the younger generations are, what motivates them and what they need in order to be successful. By coupling this with advances in technology, an organization will know what new developments there are to empower their highly motivated and adaptable workforce.

It now becomes evident that the HIT interaction is essential to real time business science. Each interaction satisfies the condition that it has to address two components, therefore justifying the choice of each. Even more, is that if these three interactions were to be implemented in a company, the separate components will be managed satisfactory by achieving the following results:

- **HUMAN:** Personnel will be empowered and motivated by enabling them to be the best they can. They will have access to the right information to make the appropriate



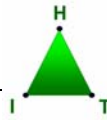
decisions and they will have sufficient technology to do their jobs. By successfully managing the changes, personnel will be involved and feel part of the organization – boosting morale and loyalty to the company.

- **INFORMATION:** Effective information management will be achieved by sourcing it with the appropriate technology and having personnel with a skill set to use this information to their advantage as well as to the advantage of the organization.
- **TECHNOLOGY:** Companies will always keep up to date with the most applicable technology by coupling technology needs with information needs. This outcome is strengthened by employing personnel that can effectively use technology to their advantage and suggest improvements where needed.

By successfully managing and allowing the HIT interaction to develop, the company will adhere to the basic requirements of Agility (see Chapter 3) – the ability of a company to sense environmental change and respond efficiently and effectively to that change. Agility is a concept that played a large motivational role in the development of the model – giving guidance and inspiration to build a model that describes what the company focus will be and the factors that will drive it, but also having these factors interacting with each other, allowing the company to adjust, improve and adapt as soon as any changes occur. Agility thus became the foundation on which the model is built.

As stated previously, a lot of reference is found in the literature to the management of these individual components, or combinations thereof. It has been that the components are essential to successful management in the real time Asset Management environment, but almost never is an explicit discussion found on all three components and their interactions, as proposed by this model. By looking closer at some of the strategies and real time concepts proposed by larger corporations, justification for this model can be found.

It is reasonable that only large corporations show trends towards the management of all three components within the real time paradigm, since it involves methods and technologies that are currently in developmental stages. Solutions like this will be widely available within the next five years, but currently it takes quite a large capital investment to fully realize the RTE. Two of these corporations are Sun Microsystems and Gartner – the former is currently running its processes on full-functional real time architecture, and the latter doing a lot of research within the real time environment, but focusing more on Information Technology as the central driver.



Gartner [12] says that by aligning their three drivers (Figure 17) of the RTE correctly, a company can expect financial and market share growth, as well as build a superior reputation. While this proposal gives an indication as to what components have to be addressed to obtain business performance, it does not specify what kind of interaction there is between them and neither is it applied in the Asset Performance Management scenario. It is however evident that Gartner sees these three components as critical drivers of their real time infrastructure, and thus the principles thereof can be used to justify the components within the HIT interaction model. The figure shows these three components and the aspects that control each, in order to create business performance.

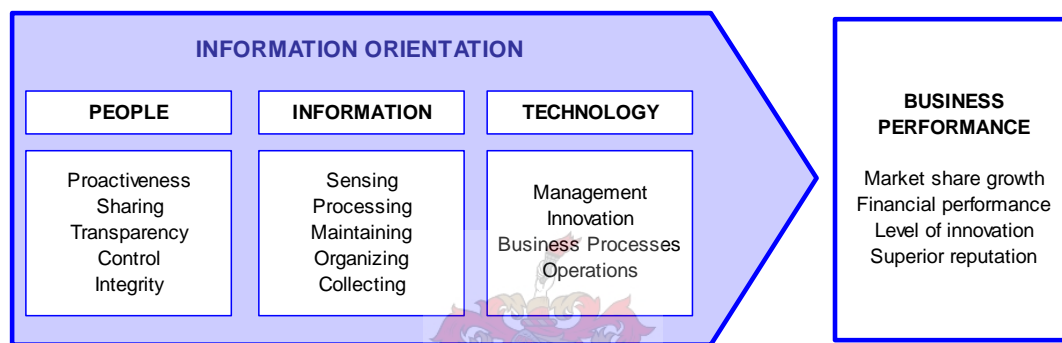


Figure 17 Gartner's information oriented components to drive business performance

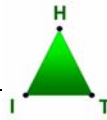
Gartner [12]

Not only does this figure validate information management as key component in the HIT Interaction, but it also validates the research as a whole, by showing that the three components (Human, Information and Technology) were chosen correctly and are in fact essential in creating a competitive advantage and substantial business performance.

Another example is that of Sun Microsystems. Since announcing N1 as its real time infrastructure strategy in September 2002, Sun Microsystems has incrementally progressed toward realizing its vision. The goal of N1 is to establish more efficient and effective data centre operations by building the system out of the network, rather than out of a single server [39].

When taking a closer look at the architecture of N1, the basic HIT components can be found by studying the description of each part of the architecture (Figure 18):

- Consulting services can be described as a human interaction with clients and the management of people, in order to sell the company and their solutions (green block).
- Telemetry refers to the information that is retrieved from processes (yellow block).



- The four subsections (policy and automation, provisioning, virtualization and resources) refer to technology that is needed in order to successfully run the architecture (blue block).
- From the description of partner solutions, it can be argued that it is partly technology based and partly a consulting service from partners. This section can thus be incorporated in the human interaction and technology sections as illustrated in Figure 18.

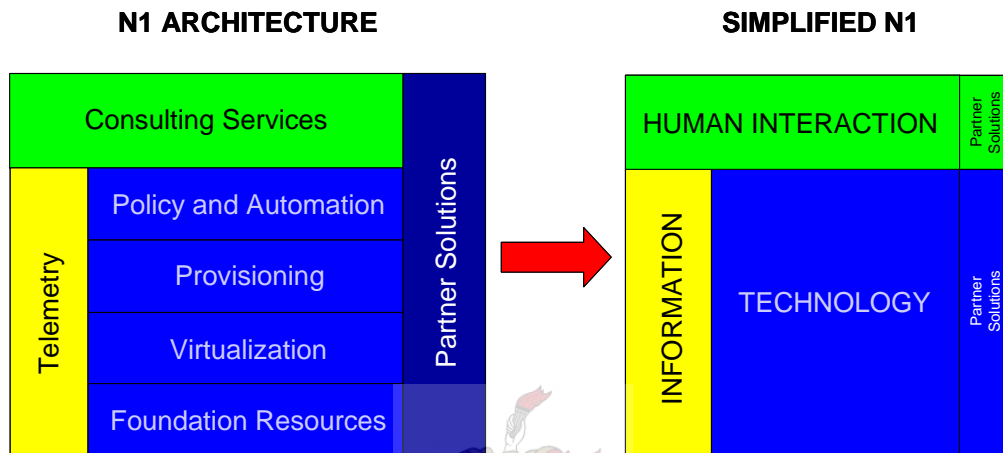
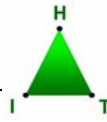


Figure 18 Simplification of Sun Microsystems's N1 Real Time Architecture

Adapted from [39]

It is clear that the HIT interaction (human, information and technology components) cannot be fully mapped on the N1 architecture, but it serves the purpose by showing that in an actual real time infrastructure, the basic HIT components can be found – thus also justifying the existence of the three components. The N1 vision is consistent with other suppliers' visions, as well as with Gartner's architectural blueprint – the path to RTI is a long-term journey and it is expected that enterprises will complete this journey between 2006 and 2010 [39].



5. HIT INTERACTION DESCRIPTION

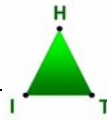
This chapter takes a closer look at each of the interactions between the component pairs, in order to better describe how they will be managed in the future. By only implementing the most recent technology, a company will only observe minor improvements since the people will not necessarily embrace the change it brings. In turn, only employing well trained and motivated people does not necessarily put the company in a higher performance bracket, since the people need the appropriate technology and the correct information at the right time in order to make the right decisions. A company cannot simply push advances in one component – the key is in a structured approach that will keep the improvements in all three components balanced. Attending to all three interactions will result in the company adhering to the trends and aligning their strategic vision with the TO-BE scenario (see par. 2.5) in real time Asset Performance Management.

5.1 INTRODUCTION TO THE INTERACTIONS

One of the paradoxes of today's business world is that one of the only constants is the need for change. Technology advances, what used to be enormous distances are shrunk to insignificance, national borders diminish in importance, global marketplaces are increasingly competitive and the pressures to strive for constant improvement in what is done and the way it is done are increasing in intensity.

When applying this to the Asset Performance Management scenario, it is even more relevant. It is in this subsection of the manufacturing world that that a new way of thinking arises – real time Asset Performance Management. Not only is this a revolutionary way of managing assets, but there is very little practical experience and references to go by. The whole Real Time paradigm is only just emerging as an application of rapidly advancing technology. In order to successfully build the HIT interaction model, there can only be referred to other applications that are running in real time, or near real time – these include a lot of examples from the service and information-technology industry where information has to be up to date at all times. These same principles from industries that have already obtained a certain degree of real time functionality can be applied to the Asset Management environment – clearly with some minor adjustments.

The discussion will cover an explanation as to how the interaction addresses the research questions (see Chapter 1) as well as how the current state (AS-IS) will be improved by managing



the specified interaction. The interactions specifically apply to the real time Asset Performance management scenario, not disregarding the fact that there may be other applicable solutions and interactions. The interactions have been chosen in such a way that they explain the management of the three components in a generic way that can be coupled to solutions that will be commercially available and affordable for smaller firms within the next five to ten years.

5.2 INFORMATION-TECHNOLOGY

The basis of the model is formed by the information-technology interaction. Without either of these components, the RTE will not exist and therefore neither will real time Asset Performance Management. This is a very basic interaction, founded on the principles of well known engineering techniques. The difference is in the way that the relationship is applied – new technologies and new ways of managing information have emerged, creating an interaction that suits the RTE perfectly.

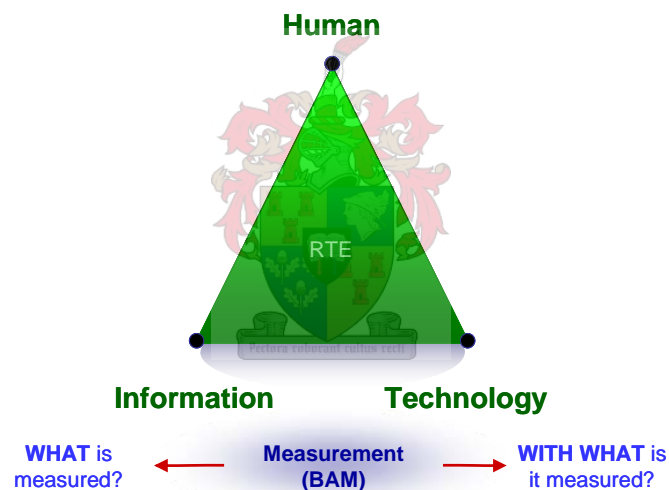
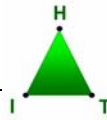


Figure 19 The Information-Technology interaction

5.2.1 ADDRESSING THE RESEARCH QUESTION

The research question of this section looks at *what is measured* and *with what is it measured?* This interaction shows how information is retrieved from a process and how is it represented in the real time scenario. It also involves how this interaction can be formally described, how it will be managed and what kind of technology the industry is looking at when managing information in the real time Asset Performance Management scenario.



One of the best ways to address this interaction is by applying BPM and more specifically, BAM (see Chapter 3) – two concepts that revolutionise the way in which information and technology is managed. This includes the design, execution and optimization of automated processes – everything from basic business processes such as work orders, payroll processing and order processing to critical processes such as payment, billing, product development and logistics. BAM provides real time access to critical business performance indicators that enables personnel to make informed decisions that will improve the speed of business operations. BAM literally creates the RTE wherein all decisions and actions are triggered by alerts from the system. The alerts are based on predefined conditions and customized according to the company's needs. Similar to the architecture discussed in the literature (see par. 3.3.2), a generic form would look as follows:

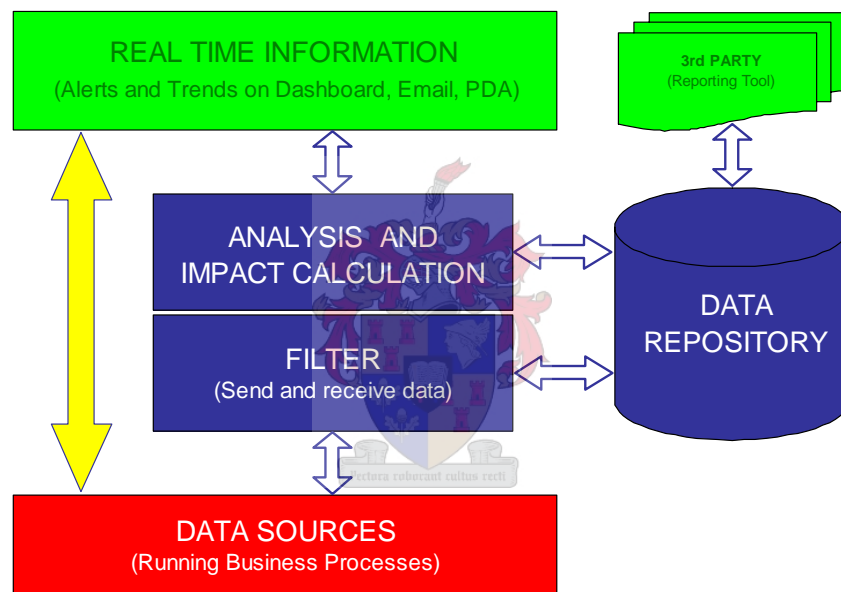
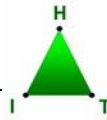


Figure 20 Generic form of the BAM architecture

By generalizing the architecture of BAM (i.e. not coupling it to the solution frame of a specific company), generic operation and outcomes of such a system can be established. The main transformation in the figure is that of data (from running processes) to information that can be displayed in real time (yellow arrow). It is up to the company in which BAM is implemented, to customize and configure these data sources (red block) according to the predefined key performance indicators. Typically in a manufacturing process, electronic sensors will be placed on critical parts in the process that will measure certain indicators and generate alerts as defined, but alerts can also be generated from sensors coupled to the enterprise resource planning system, customer relations management systems or other applications. Effectively, the BAM

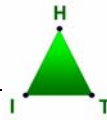


software uses existing applications and systems management tools as business process alert generators. Graphical user interfaces or dashboards are the most common ways of displaying information on the health of business activities across the whole enterprise in a hierarchical series – allowing for users to customize their view and drill down into the data when needed.

The BAM solution is responsible for data processing (blue parts) which includes filtering, analysis and impact calculations (to establish the severity of the alert) with the external data repository that is used for continuous generation of trending analysis, importing of external data and exporting of historical trending information. The processed data has now been placed in context and is usable information that is sent to the specified receiver in a format that is customized according to the company's needs (green block) – this can include anything from fixed station interactive dashboard applications and emails to mobile devices such as cell phone and PDA messages. Coupled to the external data repository, is usually also a 3rd party reporting tool that is used to analyze and compile reports of the data independently from the real time running analysis and reporting.

With BAM, monitoring capabilities of the company are increased by incorporating existing structures as event generators to the BAM system. It is not a simple process of sensors that detects and alerts anymore - full real time monitoring on all aspects of the business is now possible, allowing for the extraction of real time operational metrics and integration of information over different parts of the company into an end-to-end view. This information is sent to the right people at the right time, empowering them to make the right business decisions by monitoring critical business processes and activities in terms of commitments and customer expectations.

BAM is an effective way of bridging business and technology to drive real benefits. With process automation, more personnel are freed up for more productive tasks. Customer satisfaction is almost guaranteed since problems will be detected before the customer is affected, allowing for consistent service delivery and proactive customer relations management. Not only does the BAM solution cover external satisfaction, but it also increases efficiency within the company by identifying critical breakdown points and bottlenecks. The state of every one of these points is known continuously in real time, and with the 3rd party tools attached to the BAM solution, trending analysis and inter-industry benchmarking becomes an achievable everyday reality.



BAM is a concept that is being developed and will become commercially affordable within the next five to ten years. By applying it in a generic form to the HIT model, scope is left for improvement and changes thereto. The same can unfortunately not be said for technology. Although there are currently excellent suitable and affordable solutions on the market, they will probably be outdated by the time BAM is adopted in the market. Cingular [40] compares devices in their whitepaper on wireless technologies that creates business value. It compares solutions that are widely available with some that are only entering the market, over a range of functionality (Figure 21).

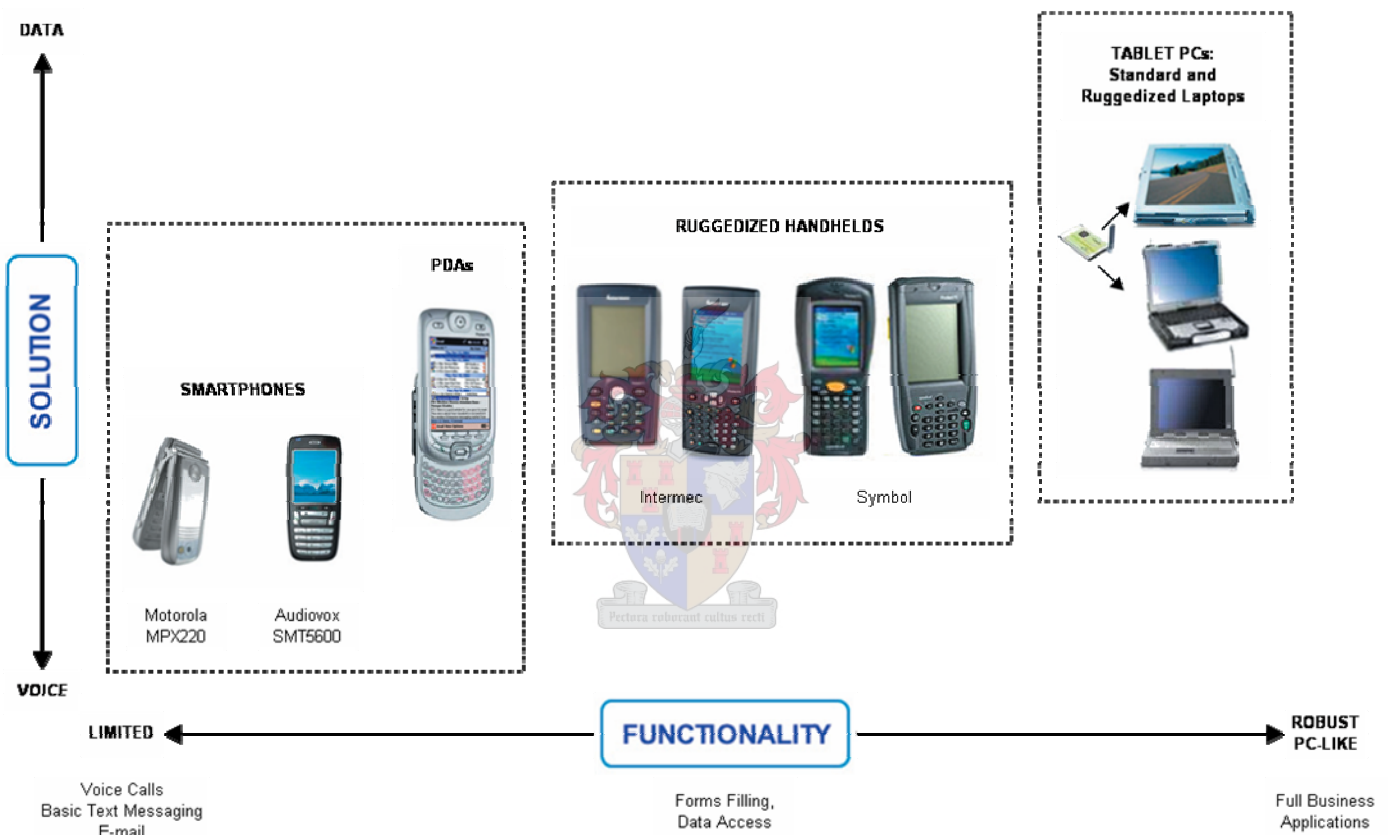
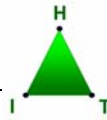


Figure 21 Comparison of wireless devices over a functionality range

Cingular [40]

Functionalities range from limited voice calls and text messaging in devices like smart cellular phones and PDAs, to robust pc-like solutions that have full business capabilities (i.e. like a regular laptop). Devices such as rugged tablet computers, that are only just being introduced, are still quite expensive. Ultimately similar types of devices will be used in the RTEs of the future. The most feasible solution for the smaller firms (and maybe even sufficient for use in today's business world) is the middle section of the graph, displaying rugged handheld terminals. These are



capable of the basic data access, filling in of forms and continuous monitoring of systems. They are also mid-range on the solution axis, with sufficient data capabilities, and some even having voice transfer (calling) capabilities.

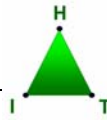
To take all the above to a practical example that is done in industry today, Fujitsu Consulting delivers a BAM system, employing a top-down approach that begins with understanding the relevant business activities [31]. Consultants employ proven applications, methodologies and tools to deliver business results. Everything is done in collaboration with the executive team, business units and IT organization to identify critical breakpoints, bottlenecks and failure points along the business activity path. The BAM application is then customized to the specific environment so that business activities are associated with business commitments. Business rules are defined and KPIs are established to govern the nominal operational parameters of a business activity. Thresholds are set for each KPI and the real time access to the critical data is established through the implementation of sufficient technologies.

5.2.2 IMPROVING THE CURRENT STATE BY MANAGING THE INTERACTION

The current state in this interaction is made up of the information and technology components in the HIT interaction. By managing the BAM solution within the company, it will have a direct impact on these two components by addressing core problems in each.

Information management in the Asset Performance Management field is a very slow process – especially in the consulting industry, where this research is based. The process is extremely lengthy, with data that has to be captured on a paper based system and sent to the outsourced consulting firm to be analyzed, before a detailed report is received. The total time is on average three to four weeks from the time that data has been captured, until a report is received. However efficient the consulting service is, the delay is still caused by the process before data analysis, usually brought on by mistakes made while capturing data, writing errors and in some cases companies not being motivated enough to enforce a best practice data capturing process.

The only answer is the realization of a true real time company. At any moment, unforeseen events in the running of the business are unfolding, that will have a great effect on suppliers, customers and stakeholders. These events offer opportunities to uncover underlying threats in the company that have to be overcome at all cost. To avoid business disasters, the only information that needs to be monitored in real time is *material* information [41]. This is information that, on receiving it will cause a change in judgment on the course of action to be



taken. The difficulty lies in finding this critical information in a world that is flooded by useless data. The company should therefore invest in determining what this material information should be and should be focused on managing these critical parts in the system. Fenn, et al. [41] proposes actions to bring about instant detection and faster response to events that offer potential disasters:

- The last three business disasters that have taken place in the company should be reviewed to see if relevant information existed somewhere prior to the event. If the information already existed, the source thereof and the reason why it was not acted upon or why it did not create sufficient notification should be established. Measures should be installed that will ensure the monitoring and reporting of critical events in these processes.
- The competitors in the company's industry segment should be identified that will most likely embrace instant detection. By knowing how competitors react, similar or even better measures can be put in place that will give the competitive edge. Similarly, when the industry does not offer sufficient competitors, the company should revert to benchmarking where comparisons are made on processes between best in class companies. It will then be required that the process (i.e. identification of and reaction to critical events) be identified in order to sufficiently compare it to the company that is the best in managing that specific process.

In a lot of manufacturing companies, apart from essential machinery, technology that will enable the RTE is at a minimum. The situation is even worse in the smaller companies where management does not see the practical benefits of technology. One of the biggest causes of this tendency is that regular operators become line managers or even division managers after being at the company for a number of years. They have enormous experience in the processes, but they have little managerial skills and in most cases lack the ability to visualize sustainable improvements [2].

It is however not necessary to immediately implement a full-on real time infrastructure and expect these people to cope with it – in fact, that would be business suicide. The bright side is that without incorporating handheld wireless computers and BAM dashboards with customizable views and information drill down capabilities, a certain level of technology can be implemented that will still be sufficient to result in business and operational growth. With standard views and features, management and personnel will become accustomed to using the technology and additional functionality can rather be added later.

Assuming that technology will continuously improve and will become a critical part of the day to day operation of a company, management will more and more be convinced that the competitive edge in Asset Performance Management lies in managing it with real time technologies. Emerging technologies and trends will transform the ability of businesses and people to control their work and personal environments. Enterprises must successfully face the business, information and technology challenges that will arise in the always-on, always-connected network world through 2010.

In the management of the information-technology interaction, there are a few aspects [35] that a company needs to ask itself on a continuous basis. These aspects are based on Gartner's Agility concept (see Chapter 3) and are used here in order to establish a continuous improvement cycle wherein a company will never stagnate. This involves sensing what the business environment is doing; strategizing on new improvements and coming to a definite decision (Figure 22). After these steps, the plan is carried out by communicating it to the company and all personnel and acting on decisions. A TO-BE state is thus continuously created, achieved and reset to a new TO-BE (i.e. TO-BE 2) state.

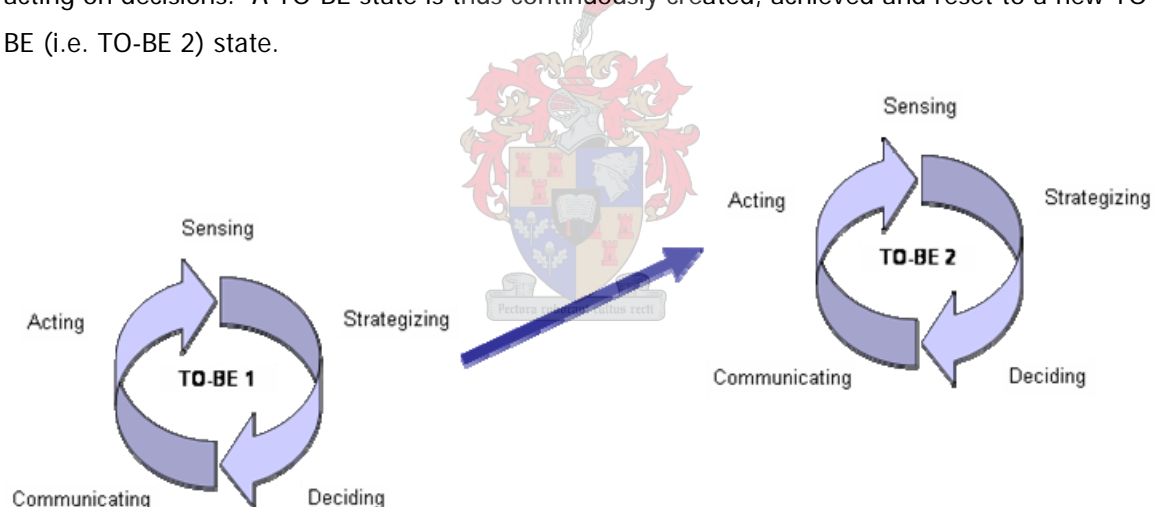
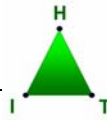


Figure 22 Continuous resetting of the TO-BE state

As established through the literature and the above discussions, enterprise information is a critical asset to the organization. This includes any information an organization uses to function and to base decisions on. When managing enterprise information, the following points should be continuously managed as well [35]:

- **Information formats.** This refers to the degree of information automation and format standardization. Automating is covered by the BAM solution, as discussed previously and standardization is a key component when working with enormous amounts of data. For

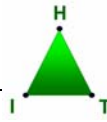


example, when constructing a database of the different types of assets within a company, best practice would include naming conventions for all similar types. This means that if a milling machine is listed, the naming convention in all databases should be the same, e.g. *mill* and not *milling*, *mill_machine* or other variations that would create confusion and also eliminate the possibility of successful benchmarking exercises.

- **Access and dissemination.** This refers to the degree to which raw data and foundational information are made available to facilitate greater business intelligence. Access to information should be regulated in such a way that the right people are supplied with the right information at the appropriate time, enabling them to make informed decisions on accurate real time data.
- **Quality and accuracy.** The degree to which information supports quality assurance. Information is useless if the data that it is created from is not from a trusted source. Distinct quality assurance procedures should be in place in order to ensure data accuracy.
- **Collaborative environment.** The facilitation of a collaborative and information-sharing work environment. This would typically include benchmarking reports that is used between companies with best in class processes for improvement purposes.

Business activities are all the internal processes and activities that must be undertaken to run a business. Some of these processes are virtually universal and employed by all organizations. In contrast, many other activities are unique to the market, the industry and the individual characteristics of the organization itself. In the management of the technology component, the following business activities should be looked at:

- **Process automation.** The degree to which key business processes are automated in order to save time and money by freeing up more personnel that could be used in other critical parts of the company.
- **Process integration.** The degree to which key business processes create a seamless flow. This indicates how well processes are put together, without unnecessary time delays and waiting times for other processes.
- **Cost management.** Every company should have the ability to monitor and manage costs while maintaining a productive and agile environment.
- **Change management.** The ability to anticipate, track and manage changes on a continuous basis.



The key in information and technology management is to implement a solution that is powerful enough to accommodate complex processes, flexible enough to handle ongoing change, easy enough for users to embrace, and simple enough to be implemented on time and within budget. This can be a challenging prospect for any organization, but by adhering to the above discussed principles and methods this becomes an achievable goal.

5.3 HUMAN-INFORMATION

There exist numerous interactions between Humans and Information, covering different aspects on how people should manage information, what kind of information is needed to run a business, the process of managing key performance indicators and a lot more. To narrow this enormous scope, the aspects were weighed up against the requirements and constraints of the real time Physical Asset Management scenario. Currently, the biggest question is that when the real time enterprise is achieved, what would be the value of this information, how will it be managed and, especially in the consulting industry, why would a client still pay for a service that is now almost fully automated – what value does a consultant add in the real time environment. All of this is described by looking at real time information as product and how people will use and sell it to satisfy their clients in a better way.

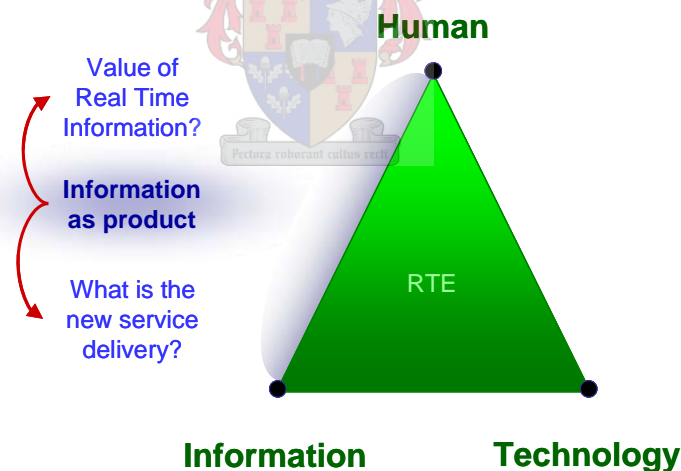
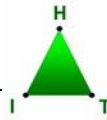


Figure 23 The Human-Information interaction

5.3.1 ADDRESSING THE RESEARCH QUESTION

This section addresses a specific research question that asks *what the value of real time information is*. Even if the critical processes are automated with technology and the BAM solution effectively retrieves real time information from running processes, how valuable is this



information? From practical experience it has been observed that currently, it takes a full day's work to compile an extensive report on the process performance of a facility, not counting the hours it takes to gather the data on paper based systems and to manually enter it into a system that will analyze the data. When the RTE is realized, information is readily available and such a report could be generated within a few minutes. Client concerns are obviously raised, since the reports will cost the same or even more than what is currently charged. The main difference is the value that is added within the real time paradigm and this will be the driving force behind the new marketing scheme.

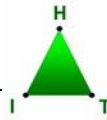
The premise here is that information is retrieved from a process with a certain type of technology. This information is mostly in the form of a KPI or other indicator. People use this information on two levels:

- Internal – to improve a process: In this case the information is used to either improve the process from which it was retrieved, or to help improve another part of the business.
- External – as marketable product. Processed data is used for benchmarking reports, to market the company and to gain competitive advantage in the industry.

As is the case with the BAM solution, KPIs, dashboards and other graphical data retrieval and display functions have already been researched extensively, thus the focus here is on how this information can be used to benefit the company internally, as well as externally.

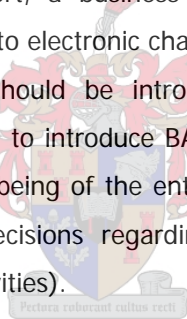
McGee [42] says that in Gartner's RTE research project, it was found that a large number of CEOs were immediately able to say exactly what kind of information they needed in real time to help run the company better and to improve processes. This is a good indicator that there is a definite need for better internal information – a fact that is also justified and addressed in the Information-Technology interaction.

On external level, customers are increasingly becoming more impatient and are demand the RTE. Equally, to fully become a RTE, a company will have to satisfy the needs of customers. Advances in technology have made it possible for customers to obtain products and services faster than ever before, resulting in a satisfaction guaranteed trend. This means that customers will get services or products whenever and wherever they want, according to the specifications they want. Customers get frustrated when companies cannot deliver fast enough, so they simply move to the competitor that can.



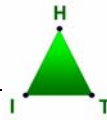
Essentially, companies that cannot operate in real time will be left behind. Gartner [43] summarizes it best when saying *customers want things yesterday*, and proceeds in giving directions on improving the order fulfilment process. These internal guidelines should be followed to better meet customer standards externally:

- The need for each process should be confirmed and critical processes should be streamlined. It should be established whether the process is actually making a contribution or if it is simply causing delays. If the process is indeed critical, it has to be streamlined to minimize delays and serve the customer better.
- Processes should be virtualized and the system extended to customers. In order to further lessen delays, improve control over the process as a whole, eliminate paperwork and work on integration between applications. Most problems can be removed by introducing unified electronic channels which are faster and allow instant detection and sometimes correction of defects. Furthermore, customers should be allowed regulated access to internal systems, i.e. order fulfilment and data acquisition processes. Without totally removing human support, a business that aspires to become a RTE should encourage customers to switch to electronic channels.
- Business activity monitoring should be introduced. To maintain consistently high performance, the RTE will need to introduce BAM systems. By having all the necessary information regarding the well-being of the enterprise all on one system, managers are enabled to make informed decisions regarding customer satisfaction (e.g. on time delivery or other influential activities).



The greatest advantage is that all of the processes and technologies involved in the service channels of the RTE only have to be understood by the personnel within the company. No matter the extent of process automation or activity monitoring, the clients need to know nothing of the underlying data structures and application logic to be able to actively use the sales process. They only used the information that had already gone through all the systems, processes and analyses to make informed decisions about the company or the product. Effectively, the company does not sell their real time technology or extensively monitored processes – they sell the product of that technology, which is information. Having up to date, always online information thus puts them at the front end competitive section of their market.

The RTE will have to move beyond regular customer relationship management in order to understand customer intentions. By analyzing the data that comes from sources such as sales transactions and business activity monitoring tools, winning enterprises will find patterns that will



enable them to know the intent of their customers [41]. In today's economy where time tolerance of customers diminishes, businesses will retain customers only if the customer's intent is known by detecting it earlier than competitors. To capitalize on the opportunities arising from connected customers and connected associates, the company will have to find new ways to understand customer intent from the digital trends. With this privileged information, the company will also become the trusted custodian of a customer's interaction trail – i.e. safekeeping of the history built up through different transactions.

It can be concluded, that having real time information with the push of a button, is one of the most valuable assets that any company can obtain. Not only is this investment excellent for internal benefit, but also for better customer relations management. Effectively, happy clients return to the company for more business, which results in business growth, epitomizing the main goal of every business.

5.3.2 IMPROVING THE CURRENT STATE BY MANAGING THE INTERACTION

The current state in this interaction is made up of the Human and Information components in the HIT interaction. By managing the *Information as product* throughout the company, a direct impact will be made on these two components by addressing core problems in each.

Information management, specifically in the Asset Performance Management field, is a very slow process especially if a company cannot afford to do it and has to outsource the service. The whole process of capturing data in the company, sending it to be analyzed and then receiving a report with usable information, can take up to four weeks – this is mainly due to the fact that the whole system is paper based and a lot of errors and unclear data slip into the capturing process.

This is extremely detrimental to internal, as well as external information usage. With very slow information feedback, a company can hardly act on alerts that arise from the information and can thus only improve processes incrementally when enough information has been gathered. By the time reports are received, they are so out-dated that they are of no use, apart from building trends. The result is that with such lengthy information feedback cycles, business performance is very slow and processes are only improved minimally over long periods of time (Figure 24).

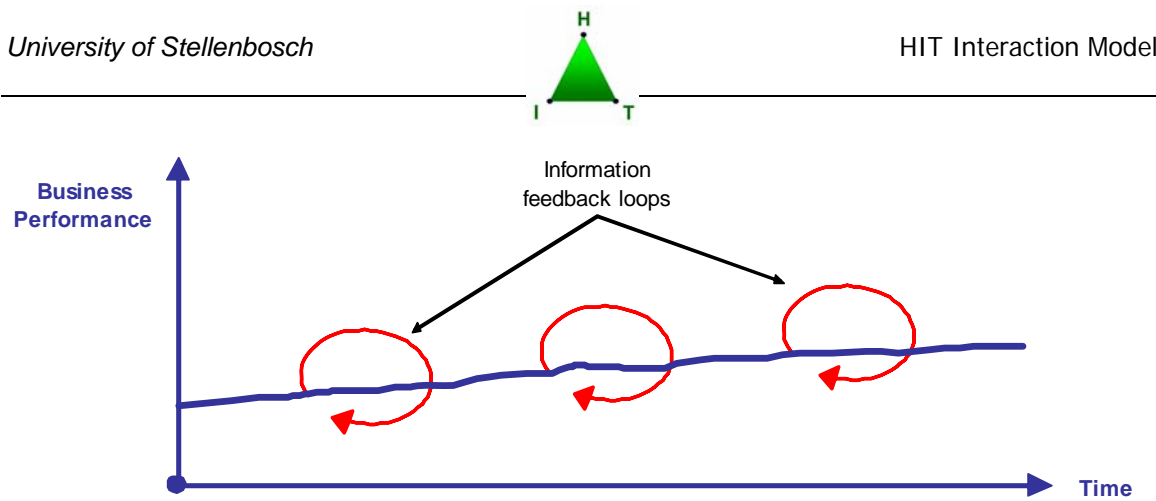


Figure 24 Lengthy information feedback loops result in minimal business performance growth

When information is received in real time, pro-active steps can be taken to improve processes, as alerts arise from a BAM system. When a process alert is generated, personnel can immediately act and correct the error. The effect of internal errors on customers is also dramatically decreased, since lengthy delays from personnel trying to find the right information and data to correct the error are eliminated. With all relevant information at hand, internal as well as external information usage will improve, resulting in higher business performance growth (Figure 25).

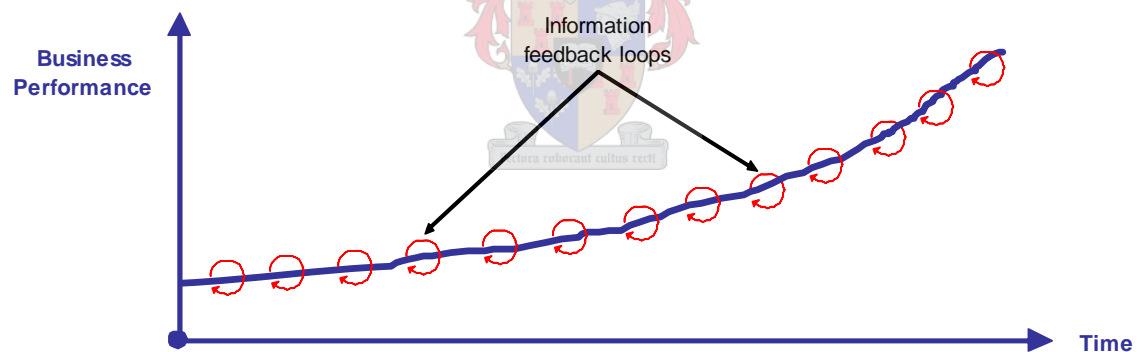
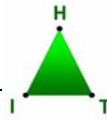
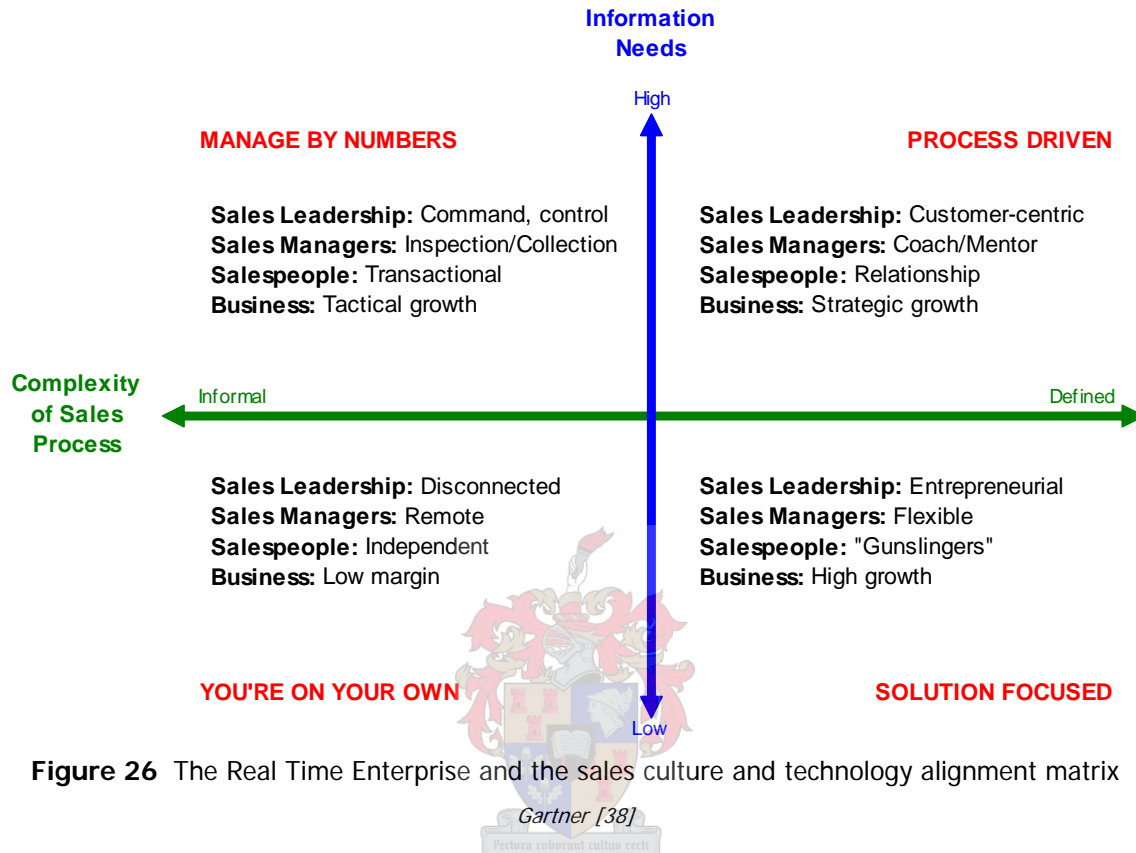


Figure 25 Shorter information feedback loops result in higher business performance growth

By knowing the effect that real time information has on business performance growth and by aligning this with an effective strategy to manage personnel, business performance will increase even more since personnel will exactly know how they need to behave to satisfy client needs (external information usage) as well as give feedback to improve processes (internal information usage).

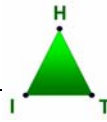


In the following model [38] (see Chapter 3) the RTE can be sufficiently mapped, in order to establish the kind of work environment that has to be created to sustain better information usage.



The AS-IS situation of most companies (within the Asset Performance Management environment) falls in the *Manage by Numbers* and *You're on Your Own* categories. In manage by numbers, the focus is on achieving performance targets, having little regard to how they are achieved. Processes and continuous improvement do not necessarily play a critical role and typically *quick fixes* are used to create the illusion of better productivity. In you're on your own, managers are not very involved and do not require a lot of information. In a sense, they are disconnected from the day-to-day operations of the company and are only interested in high level figures and performance. Both of these categories contribute to the low business performance that is observed in the industry today.

When looking at the basic requirements of the RTE, information needs are inevitably high. In order to add enough value and effectively sell real time information, the sales process is fairly complex and defined. The typical RTE will start in the *Solution Focused* category, moving towards the *Process Driven* category as the company matures. This is mainly due to the fact that



information needs grow as the company grows and as more functionality of a BAM system is implemented. Organizations with a process driven culture must have fully defined and institutionalized sales processes for managing opportunities through the sales cycle. As with the solution-focused culture, sales cycles are typically longer than for the other categories and customer centricity or a grander Customer Relations Management (CRM) strategy is also typical. Collaborative access to customer knowledge among sales teams and customer service is critical to promote long-lasting customer relationships.

In the management of the human-information interaction, there are a few aspects that a company needs to manage on a continuous basis. These aspects are based on Gartner's Agility concept (as discussed in par. 5.2.2). After these steps, the plan is carried out by communicating it to the company and all personnel and acting on decisions. A TO-BE state is thus continuously created, achieved and reset to a new TO-BE (i.e. TO-BE 2) state (Figure 27).

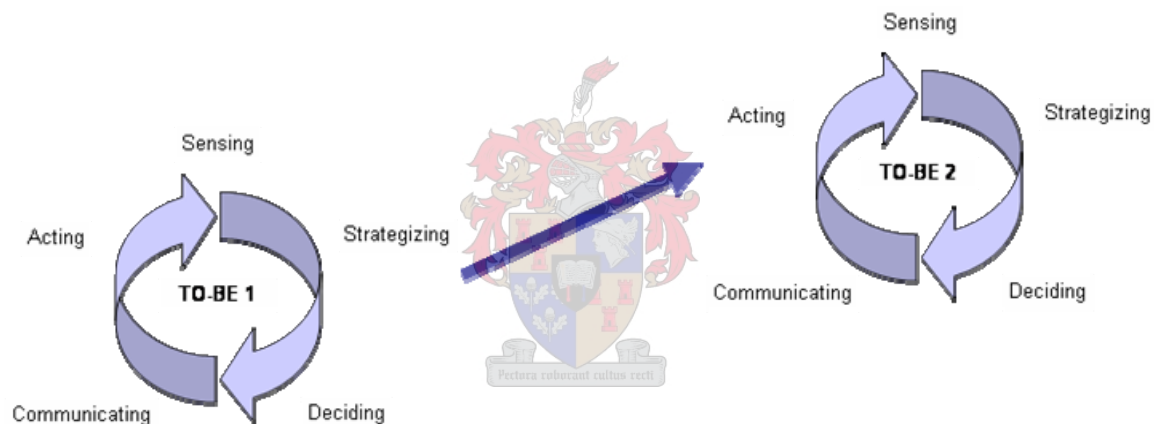
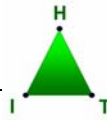


Figure 27 Continuous resetting of the TO-BE state

The dictionary defines service as a useful product of labour that does not produce a tangible commodity [44]. In fact, the benefits of offering excellent service and support are very real – service and support increases revenue, helps sell more products and keeps a strong connection with customers which are all tangible results [45]. The problem lies in generating these results. By selling service and support with the product, an opportunity is created to generate revenue throughout the life cycle of the product. It is exactly this service that, when added to real time information, makes the whole external use of real time information an excellent product. In order to realize the benefits of service and support, Kodak Service and Support [45] underlines two important processes which are very much applicable in the RTE as well:

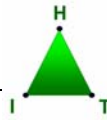
1. Some key issues to incorporate when determining how service and support is going to be delivered to customers, include:



- **Responsiveness.** Because downtime can happen anytime, service availability and response times are critical to the bottom line. The active use of the BAM system will increase responsiveness and minimize the effect of downtime on customers.
 - **Continuous training.** Because it is common for customers' systems to be built with equipment and applications from several different manufacturers, cross-training becomes an important element of service providers.
 - **Advanced feedback mechanisms.** No remark or comment from a customer should be left unattended. Feedback should be effective from the origin (customer) through to the level on which it is applicable and personnel should have an active response attitude.
2. Customers should fully understand the value of their service contracts. Time should be spent to sketch out the details of what their agreements buy them and exactly what they will benefit. Admittedly, it can be difficult for a customer to envision efficiency and an increased bottom line within the body of a maintenance agreement, that is why it is vital clearly define the tangible benefits of service to customers, such as:
- **Maximized uptime and increased productivity.** No equipment is infallible, and problems never occur at a convenient time. Through pro-active use of reports from the BAM system and delivering the right information at the right time to the right people, uptime will be maximized and as a result, productivity will increase.
 - **Cost control.** There is a saying that *it takes money to make money*, but in reality it a lot of money needs to be spent, in order to save money. A solid maintenance agreement will control costs resulting from lost productivity due to equipment downtime.
 - **Minimized business risk.** With real time data collection, the state of the business is known at all times and with advanced data mining, trends can be established in order to minimize future risks.

Gartner [46] discusses fundamental hurdles to success that have to be managed in order to fully achieve real time customer relationship management. Some key points include:

1. **Ensuring management buy-in.** It is advised that the commitment and total buy-in of management is always secured and to ensure that senior managers follow through with their endorsements. Senior management involvement also helps to ensure corporate alignment behind the initiative. Even limited commitment has an impact on the customer relationship that affects the overall company, for example inconsistent offers across the real time marketing channels give a poor impression of the business.



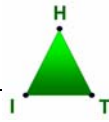
2. **Overcoming technology issues.** Typical technology issues involve application selection, integration with established systems, and data quality and availability. These issues should be sorted out so that technology enables the business to perform better (see par. 5.2), not obstruct progress.
3. **Identifying the right metrics.** Identifying the appropriate metrics depends on addressing several issues:
 - Do the metrics reflect the changing intent of the customer interaction?
 - Can the selected metrics help manage and refine the program over time?
 - Is there a need for additional metrics in order to accurately measure success?
4. **Ensuring user adoption through adequate change management.** This involves a realization that most aspects of real-time projects can be launched and improved incrementally, rather than through upfront investments in best-of-breed solutions. The organization is provided with more time to experiment and customize the solution (see par. 5.4).

In order to realize a process whereby customer feedback is gathered (external level) and actively used to increase business performance (internal level), an effective customer satisfaction management program has to be constructed. As is the case throughout the HIT model, timing, the right people and the right information plays a crucial role. Most organizations that have implemented customer feedback systems or programs have failed in one of three areas: distributing the questions too late, using the wrong questions or not acting appropriately on the feedback [47]. Implementing a three-layer customer feedback system will help organizations bypass these problems:

- Layer 1: Point-of-Delivery Survey.
- Layer 2: Customer Satisfaction Survey.
- Layer 3: Planning Survey.

Layer 1: Point-of-Delivery Survey

The most-important aspect of feedback is timing. Gartner has determined that feedback collected immediately after an event is 40 percent more accurate than feedback collected 24 hours after the event. In addition, response rates increase 10 percent to 12 percent simply by requesting feedback as soon as the event is completed [47]. Although it is ideal to conduct real time feedback collection, it is virtually impossible to do so in all situations due to extremely high costs. Point-of-delivery surveys are short (two to three questions maximum) and require only simple *yes* or *no* answers. Organizations must have an escalation process to address negative



feedback and it should be determined by established business processes. When no such process exists, one should be created prior to implementing the customer feedback system. Sample questions would include:

- Was the issue resolved and was the question completely answered?
- Was the consultant courteous/knowledgeable during delivery?
- Are there any follow-up items, issues or recommendations that would contribute to improvements?

Layer 2: Customer Satisfaction Survey

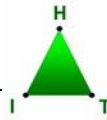
The questions get more complicated, more detailed and more specific in this section. It is no longer sufficient to know how the delivery was, because the company wants to ensure that the customer has no outstanding issues beyond delivery. Questions will typically use numeric scales and the survey should consist of no more than seven questions. There should be probed further into the actual relationship between the organization and the customer by using the following guidelines:

- What is the customer's satisfaction with overall delivery of service? *(e.g. on a scale from one to five)*
- What projects/solutions should be implemented to improve satisfaction? *(a multiple choice answer)*
- Was the response time acceptable? *(yes-no question)*
- Satisfaction with the total time it takes to solve a problem? *(e.g. on a scale from one to five)*
- Any other comments that would contribute to the improvement in service delivery?

Layer 3: Planning Survey

Here, customers get to contribute to the evolution of service. The planning survey should be prepared at least once a year. The purpose is neither to ensure proper delivery nor to measure customer satisfaction, but rather to determine the best way to improve the service and grow it over time, by using the following guidelines:

- From the following technologies, which is most important? *(List as many as are in consideration or evaluation to be implemented over the next year.)*
- Rate the overall performance of this service during the past year? *(on a scale of one to five)* Also give an indication where it should be in a year's time? *(scale of one to five)*
- From the following improvements to the customer service process, which one would you deem critical? *(List as many as possible while considering what your plans are for next*



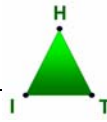
year.) Allow single or multiple selections based on future plans not related to technology implementations (that is another question).

- Different questions related to specific initiatives and projects that benefit the customer can be included here, as long as the benefits of the project and the information can be conveyed to customers.

When implementing such a customer feedback system, it is always advisable to remember a few key points:

1. Integrate feedback down to business processes level. This means that all customer feedback should be actively used to improve processes, in order to better fulfil customer needs. Collecting feedback and not using it in business processes will yield no results for the organization.
2. Centralize the deployment of all actions related to the customer feedback system by standardizing everything within an enterprise wide feedback management system. This functionality would typically be included in the BAM system that monitors enterprise wide activities and alerts.
3. Properly train employees on how to embrace a culture where changes are driven by feedback, and where acting on feedback makes a change for the client as well as the employees. If this culture is achieved, then the employees will be willing to encourage clients to provide true feedback, and this same feedback will be pushed to upper management.
4. Gartner research indicates that customers embrace and respond to surveys when they believe responses will promote change. Closing the loop on feedback (i.e. notifying the customer what was done with their comments) is the essential component in increasing response rates to such a program.

By addressing this interaction, key problems in the human and information components will be addressed. A better understanding of what clients expect, backed up by real time information from internal processes will enable the Real Time Enterprise to continuously improve processes on internal, as well as external level – not only ensuring customer satisfaction, but supporting a internal working culture that embraces change and renewal on a continuous basis.



5.4 HUMAN-TECHNOLOGY

One of the key factors in every project is the management of the changes it requires. For a number of years the phrase *Change Management* has been prophesized by change agents to such an extent that it has become a cliché to which little attention is given when mentioned.

With the evolution of the generations into the technology enabled world, the conventional ways of addressing change is becoming somewhat outdated since it focuses mainly on getting older members of the organization to see things in a new light, come out of comfort zones and start embracing change and what it brings. In recent years, technology and change as such, has become such an integral part of business that a shift in change management has occurred. This section addresses this shift and explains the management thereof.

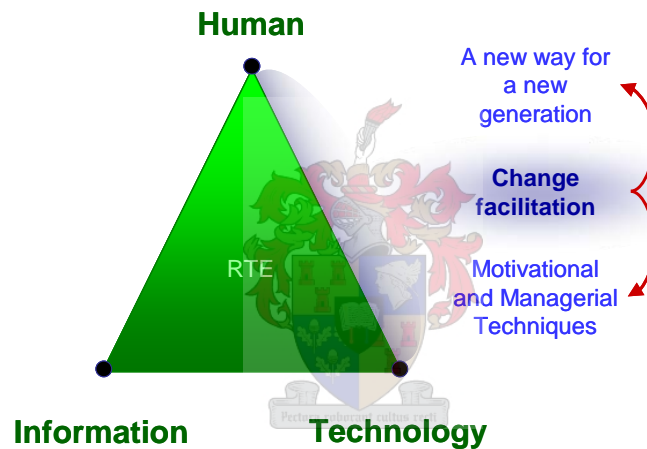
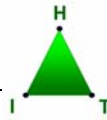


Figure 28 The Human-Technology interaction

5.4.1 ADDRESSING THE RESEARCH QUESTION

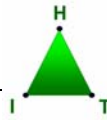
The first part of the research question is about *motivational and managerial techniques*. Although there should be some adaptations, the basic principles of change management are still required to keep people motivated and on the lookout for opportunities to adapt and change – the focus however, should not be on getting people out of comfort zones, but rather on the evolved format: *Change Facilitation*. This concept looks at how people are managed in the new world where change is actually embraced by the younger generations, and without going into a conventional change management solution, the answer will be found as to how change is facilitated in the new world, i.e. the real time Asset Performance Management scenario. Thus the focus shifts to what a company has to do to facilitate change, understand it and make transitions smooth for the company and personnel alike.



One-dimensional change typically generates either modest improvement in the bottom line, or outright failure [48]. Better change is always multi-dimensional. If personnel are expected to improve work performance, work processes have to be improved, they have to be given access to the right tools and information, authority to make decisions and their performance measurement and rewards will have to be in new ways and on new scales. It is here where the other two interactions link the whole HIT model together – motivated personnel that are technologically enabled and that have the right information at the right time at their fingertips to make informed decisions in real time.

In a maintenance environment and because the personnel therein come from a technical background, the focus is often on how to change and adapt technologies or processes. Often the importance is underestimated of ensuring that the changes made in these dimensions must be balanced with corresponding changes in the people that run these processes and use the technologies. In turn, these people often resist changes, since it was not managed appropriately. Professors Nieder and Zimmerman (University of Bremen, Germany) developed the resistance pyramid [57] which identifies and addresses people's resistance at three levels: resistance caused by *not knowing*, resistance caused by *not being able* and resistance caused by *not being willing*. The pyramid is depicted in tabular format in Appendix B and is shortly described here. It can be used as-is for the identification of the type of resistance and what the reactions thereto have to be.

- **Not knowing.** Resistance emerges when people know something is happening, but have no information about what is coming. Management should focus on information, accountability and timelines. This level is characterized by lots of whispering, sudden silences when managers enter a room or passive-aggressive e-mails. In the absence of thorough and honest communication, they make up information and half truths spread like wildfire.
- **Not able.** Resistance reflects people's fear that they lack skills or knowledge for the future. Management should focus on education, training, new roles and professional development. This level is characterized by people that stop interacting with others, when anger emerges in an entire group or when people do not communicate. They are afraid of what might happen to them, they try to stay invisible, or they vocally belittle the current plans and leaders.
- **Not willing.** Resistance emerges when the old way of doing things is rewarded. Management should focus on metrics, rewards and cultural behaviours of the new world, rather than that of what has been (a new way for a new generation). This level is



characterized by people deliberately adopting or sustaining behaviours contrary to agreements and policies. In rare cases, people simply have bad attitudes but it is more likely that they experience a culture that rewards past behaviour. If no one else is changing, then why should they?

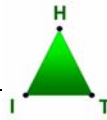
The other part of the research question asks about *a new way for the new generation*. From the above, it is evident that change has to be multi-dimensional. There are however definite changes that the RTE will demand, but in order to get to this new way, there are a few false principles on which the maintenance environment is currently built. Idhammar [49] discusses a few people management legends that have been believed for a number of years within the maintenance environment. A company should focus on revealing the truth about these legends before attempting to migrate towards the real time environment.

- **LEGEND 1: People do not like change**

From experience, Idhammar says that people love change – they just do not want to be changed by someone else. People tend to be very receptive to change as long as they are part of the change process. The problems arise when a project improvement plan goes through the usual number-crunching and other bureaucracy while the involvement of people is often forgotten. Production and operations changes are often 80% to 90% dependent on technical solutions (including process automation). An equipment reliability and maintenance change initiative is 95% dependent on changing peoples' behaviour. Management must address the issues of involvement and acceptance while encouraging the enthusiastic people in a project. Generating acceptable results is the product of quality actions, an acceptance of change and enthusiasm for that change.

- **LEGEND 2: People are a company's biggest asset**

People are not a company's biggest asset - the right people are a company's biggest asset, and the wrong people are liabilities. Idhammar confirmed this opinion during a recent seminar for a group of supervisors and craftspeople. The discussions started with the question, "Isn't it true that if any given crew in this plant would lose its poorest performing people (bottom 10% to 20%), the loss would hardly be noticed?" Several people confirmed that there were always a number of people in any given crew who had never accomplished an honest day's work, and that this statement was true.



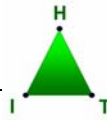
These findings correlate with the A-B-C (20-70-10) classification of the workforce by Jack Welch (CEO, General Electric, 1981 – 2001) [22]. Personnel are constantly evaluated and classified into groups A, B and C. The A's are the top 20% performers, having high *energy* levels, the ability to *energize* others around common goals, the *edge* to make tough decisions and the ability to consistently *execute* and deliver on promises (also known as the four E's of GE leadership). These people should be kept in the company at all costs. The B's are the vital 70% of the workforce – performing well and delivering what is expected of them. They are the heart of the company and should be developed to achieve the A status. The C's, however are the bottom 10% performers – they typically cannot get the job done and should be deployed elsewhere where they would (hopefully) be of better use to the company.

- **LEGEND 3a: Having more maintenance people on shift reduces downtime**

In fact, more maintenance people cause more confusion and just run up costs. If a company has many problems, operations typically requests more people on shift to fix the breakdowns. This is a sufficient solution in the short run, but over time it becomes a nightmare. The company needs to find out why these problems occur and fix the source rather than appoint more people to repair the problem. This legend is specifically addressed by better management, i.e. having the right information at the right time in order to direct maintenance work teams in better ways. This also ties in with the BAM solution when, if implemented fully, a company will at all times know the state of the operations and can sense where maintenance is needed and when it is needed.

- **LEGEND 3b: Maintenance personnel cannot be motivated to improve reliability, because breakdowns generate income for them**

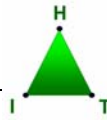
Maintenance people typically do make more money when there are breakdowns. A *catch 22* situation is perceived by maintenance management because crews cannot be motivated to improve reliability and maintenance because higher equipment reliability will reduce the amount of overtime. The answer to the question goes back to Legend 3a. Only a minor percentage of people do not contribute as well as others; the rest want to be good performers. The key word is pride: pride matters more than overtime pay. Pride drives maintenance personnel to spend an extra hour or two to do adjustments and perfect their work even though few will notice.



Management can instil pride in an organization by developing clear expectations for reliability and maintenance and by training and supporting people over the long term in achieving these expectations. For example, a clear definition should be developed of preventive maintenance as well as an action plan and training initiatives on how to improve inspection routes, lubrication, cleaning practices, operating procedures, alignment, and other preventive maintenance practices. In his book, Dr. Goldratt [50] summarizes it best when he says, *Tell me how you measure me, and I'll tell you how I'll behave*. Measuring the performance of maintenance personnel on how many repairs they make, creates a twisted sense of performance. Since financial rewards are also a motivator, provide incentive pay for equipment reliability rather than breakdowns repaired – this will be to the benefit of both personnel and company.

By knowing these legends and pro-actively managing or eliminating them, a company is set up to move towards a RTE in terms of people management. New management processes are required to operate in this way, but new processes are not enough for work that depends on the judgment and values of those involved. Enterprises need to adopt a management culture that embodies the attitudes and values that are required to make real-time management work. To achieve this, enterprises will need to overcome five challenges [51]:

1. **Executive arrogance.** To avoid business crises, executives need to be willing to accept that things may have gone wrong, despite their best efforts and track record for success. Real time managers are decisive, but aware that they can make mistakes. They seek the facts needed to track the consequences of their decisions and are willing to change their minds if necessary.
2. **Indifference to time.** Real time managers set time-reduction targets for processes and projects. They expect staff to meet their targets by process improvement rather than heroic efforts. They reserve heroic efforts for real times of crises where it will be much needed.
3. **Consensus.** The insistence on consensus prevents executives from acting quickly. Somebody always has to be consulted before a concise decision can be reached and valuable time is wasted on meetings, liaison and navigating complex bureaucracy. Empowering managers to act will not create real time management unless they feel that decisiveness will be rewarded and that if they make a poor decision, it will not be subject to condemnation by fellow employees. Real time managers know what they are accountable for and use their authority.



4. **Bureaucracy.** Bureaucracy takes the form of excessively complex processes, too many handoffs and over detailed forms – steps that only provide a false sense of security for the inexperienced worker. In reality it is an inhibitor for those that are experienced and self confident in their abilities and work. Processes are necessary and good processes can be a competitive advantage, but bureaucracies have processes for the sake of processes rather than results. Bureaucratic processes create delays because of their need for multiple approvals and useless data. This is contradictory to the goal of the RTE, which is effective data management, with the correct information available at the touch of a button.
5. **Technical purism.** When implementing systems that provide executives with warnings (i.e. BAM), the IT department should recognize that a warning is worthless if it is not used. Warning systems need to be accessible via devices that are easy to use and that a manager uses frequently. This includes devices such as wireless personal digital assistants (PDAs) or mobile phones, rather than PCs. In addition, IT will need to pay more attention to human factors and eliminate similarly IT-related bureaucratic behaviour such as redundant password checks and transfers between applications.

By watching out for the legends and overcoming the obstacles listed above, the High Performance Workplace (HPW) becomes a reality. Gartner [52] defines the HPW as a physical or virtual environment designed to make workers as effective as possible in supporting business goals and providing value. A HPW results from continually balancing investment in people, process, physical environment and technology, to measurably enhance the ability of workers to learn, discover, innovate, team and lead, and to achieve efficiency and financial benefit.

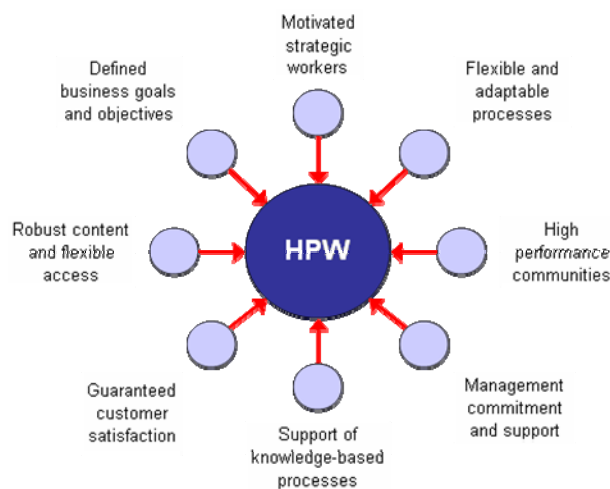
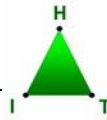


Figure 29 Graphical representation of the High Performance Workplace

Adapted from [52]



The HPW typically has motivated workers that are always thinking on a strategically competitive level and a great degree of flexibility and process adaptability. High performance communities are created from the company's customer relationship program. Management is committed and actively give support to workers. Processes are knowledge based with advanced customer feedback loops that ensures satisfaction. Data management is extremely good with the implementation of a business activity monitoring system. The RTE is also able to better define business goals, objectives and strategic plans and observes a generally better state of the company as a whole.

5.4.2 IMPROVING THE CURRENT STATE BY MANAGING THE INTERACTION

The current state in this interaction is made up of the Human and Technology components in the HIT interaction. By successfully facilitating change throughout the company, a direct impact will be made on these two components by addressing core problems in each.

In smaller companies within the Asset Performance Management environment, technology levels are minimal or non-existing. Typically the larger companies have larger budgets and an investment in expensive technology does not have such a big impact. The smaller companies however see early adoption of new technologies as a major risk, since it has not yet proven itself and stand the risk of failing – leaving the company at a financial loss. The problem is, that as the years have gone by, several small in-house solutions have been developed to cope with the surroundings, and technology levels have thus been left unattended. With the dawning of the real time age, these companies are in a very daunting position, since they have not kept up with technology advances, which have since become the benchmark for doing business.

The AS-IS situation of the Human-Technology interaction is best described by Figure 30 [1], comparing the *Rate of Change* (red curve) and *Rate of Learning* (green curve) over *Time*:

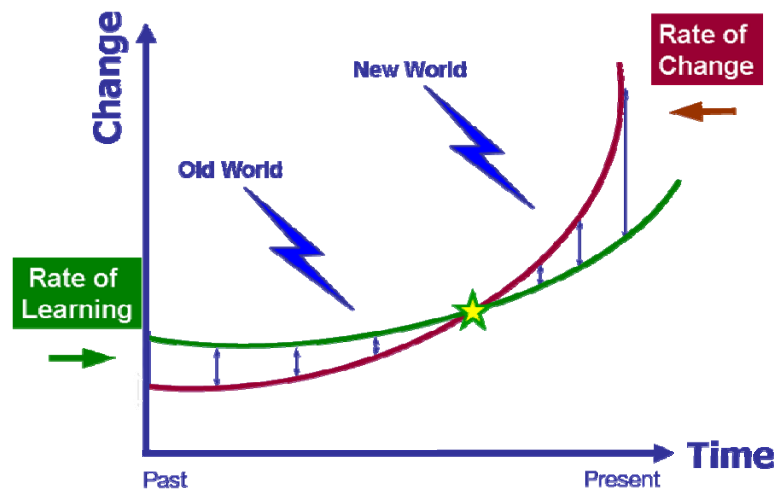


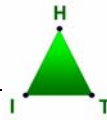
Figure 30 *Rate of change vs. Rate of learning over time*

Obeng [1]

In the past (Old World), the *rate of change* in technology and processes was very small and people had the time to adjust to the change at their own pace – resulting in an equally low *rate of learning*. In recent years (New World) changes in the business environment have come about almost yearly and even monthly in some cases, and people simply did not have the same chance to adapt to the new technology levels and ways of operating as they have had in the past. The *rate of change* has thus far surpassed the *rate of learning*, leaving a workforce behind that is confused and mostly resisting every new idea that comes about – all in a futile effort to cling to the old ways of doing things. The aim here is to decrease this gap by better managing the Human-Technology interaction through the facilitation of change.

According to Gartner [53], gaps between technology-induced acceleration of business processes and human beings' finite capacity for absorption and response can derail real time process plans. Management must ensure alignment between people and processes. Although applications and systems can be modified to accelerate information flow and response time, people reach a wall in responsiveness and absorption. The workforce implications of the RTE mean that the company must provide the context, information, tools and skills to help employees respond correctly, and at an ever-faster pace.

The problem is that no matter how effectively technology removes information latency, the nature of real-time decisions (complex, dynamic, knowledge-intensive) demand ever-higher levels of human judgment, decision-making authority and analytical capabilities. What is more, as enterprises move toward the global delivery of information, services and innovation, sustainable



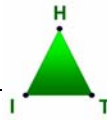
competitive advantage will emerge – not necessarily from the application of up to date technology, but rather from the quality, preparation and capacity of the workforce. Enterprises that anticipate and understand the impact of real time processes on the workforce will be prepared for success in the real time business world.

This confirms the phenomenon (as depicted in Figure 30) that people cannot change as fast as technology. Even though the technology can cope with the evolving situation in business, the fundamental analysis, decisions, and judgments are still left to the human. Thus technology advances should be only implemented to such an extent that it enables the human to better cope with the changing environment and to move towards faster and more effective decision making. It is here that the facilitation of change occurs. If a company (including the people therein) embraces change as one of the key drivers to success and improvement, it will be successful.

The facilitation of change must be powerful enough to produce images of things to come that are so positive they excite people to action. The essence being, that the driving force must have a dimension of practicality. It must also be designed so that people do not have to defend their prior actions (i.e. decisions made in the *old world*) and it should recognize previous work as a stepping stone to a new future. According to Latino [54] people will be motivated and the urgency for change will be created if it is evident that there is something to strive for that has been impossible to reach in the past and that by remaining in the current position (without changing) things will not necessarily get worse, but it will certainly not get any better – thus implying that by not changing, severe damage can be done to the company as well as the employees.

Manufacturing operations often have a unique culture that makes any improvement initiative involving changing people's behaviour a challenge. The unfortunate fact is that most initiatives fail in this environment because the chasm between current behaviour (some form of reactive approach to equipment reliability) and desired behaviour (proactive behaviour through effective leadership, planning, supervision, execution, and failure elimination) is so difficult to bridge [55].

The core challenge is motivating members of an organization (production, maintenance, and management) to change their collective behaviour in support of sustaining positive change and realizing a return on investment. When attempting to change an organizational culture, there are certain aspects to incorporate within the new culture:



- **Trust.** This is the most important factor to ensure the success of any new project. This is an essential prerequisite before attempting to make major decisions or implement major projects.
- **Commitment.** No significant project can be achieved without overcoming serious challenges. The importance of a proposed change and the rationale for the particular strategy that has been chosen must be acknowledged by all participants from the top of the organization to the bottom.
- **Communications.** Clear two-way communication is vital. Many change decisions affect virtually everyone in the organization. There must be a mechanism so that everyone who will be affected knows what decisions are being made, why they are necessary and what channels are available to provide input into the decision-making process.
- **Clarity of Purpose.** As a result of the common understanding of an institution's strategic goals and the open communication that informs all involved participants, each person in the organization understands what changes are being made and why those changes have been chosen.
- **Agility.** Successful cultures are agile [56]. They can respond rapidly and accurately to new factors that require a change in how they operate and the ability to support effective change management is a defining characteristic of these organizations.

Another factor that has to be managed is the skills requirement of personnel within the RTE. Gartner [55] lists some core competencies within their Business Intelligence Competency Centre (BICC). These are also applicable to the RTE and are discussed at the hand of Figure 31, depicting *Business*, *Analytical* and *IT skills* that are required within the RTE.

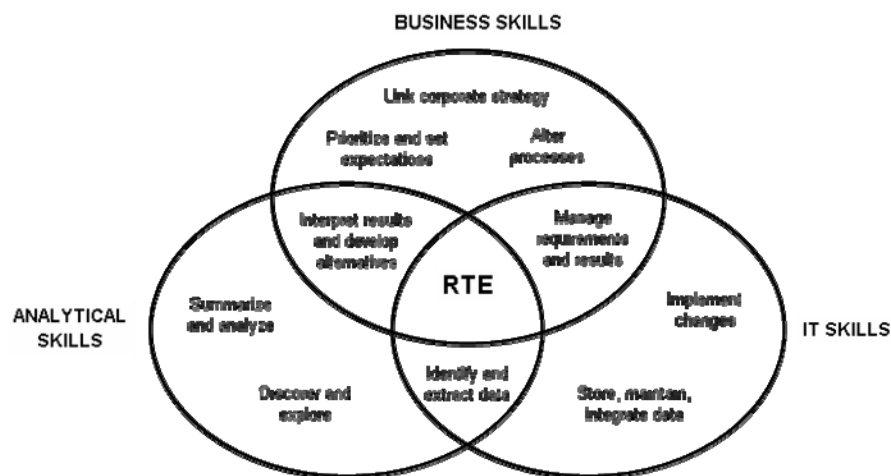
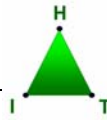


Figure 31 Skills requirements in the Real Time Enterprise

Burton, et al. [55]



Business skills required include the following:

- Understanding of line-of-business needs, such as finance, sales and marketing, human resources and the supply chain.
- Having the ability to communicate at executive level and link information from the BAM system with the enterprise's strategic goals.
- Helping business managers set and balance priorities by analyzing consequences of choices.
- Understanding the organization's strategic business objectives and the role that material information plays in achieving the corporate objectives.
- General experience-based skills to drive standardization of official hierarchies, business vocabularies and terminology.

Analytical skills required include the following:

- Fluency with key analytic applications using various techniques, ranging from simple data aggregation via statistical analysis to complex data mining.
- Researching business problems and creating models that help analyze these business problems.
- Exploring the data and discovering patterns, meaningful relationships, anomalies and trends.
- Producing sound recommendations, based on the right set of metrics.
- Training skills to teach users how to transform data into usable material information and how to use this information.

IT skills required include the following:

- Having the ability to understand the business intelligence infrastructure implications (e.g. design changes that may be required to accommodate new data sources).
- A deeper understanding of how to access and manage data required to support business and analysis requirements.
- A deeper understanding of diverse business intelligence and performance management tools and technologies, such as analytic applications, corporate performance management or data mining.
- Data governance, architecture and management skills.
- Data administration and data management skills to support transparency in order to verify business intelligence results.

It is necessary for a company to expect some form of resistance as people try to figure out how they will fit into the future and how the changes required for workforce reconfiguration will affect outcomes. If a company knows the challenges and techniques involved in changing an organisational culture, as well as understand what kind of skills the RTE requires from personnel, they have already moved a lot ahead in achieving the agile workforce.

In the management of the human-technology interaction, there are a few aspects [35] that a company needs to ask itself on a continuous basis. These aspects are based on Gartner's Agility concept (as discussed in par. 5.2.2). A TO-BE state is thus continuously created, achieved and reset to a new TO-BE (i.e. TO-BE 2) state (Figure 32).

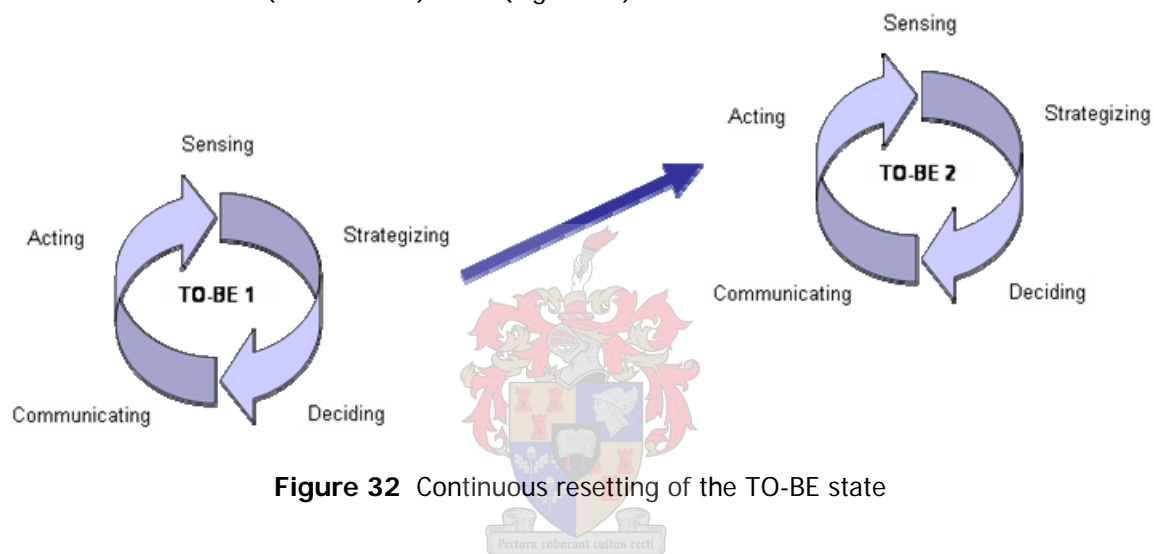
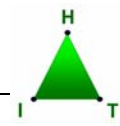


Figure 32 Continuous resetting of the TO-BE state

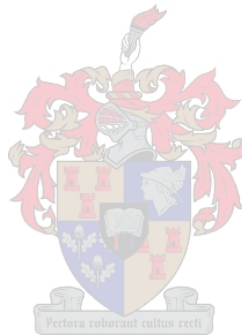
Organizational agility requires a deep and coordinated commitment to changing the competencies, processes and procedures of the organization. People who sense opportunity or threats and then respond effectively with speed, nimbleness and grace are considered agile [57]. It is these people that an organization needs to attract, reward and keep at all cost. There are a few people-agility principles that apply:

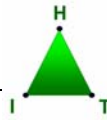
- The greater the versatility and adaptability of the workforce, the greater the success of workforce reconfiguration.
- By reassigning people to new activities, roles and projects they learn many of the functions of the business and thus enhance the ability of the company to reconfigure the workforce when sudden changes are required.
- Multifunctional projects improve people's breadth, understanding and skills.

By addressing this interaction, key problems in the human and technology components will be addressed. A better understanding of how to facilitate change, the skills requirements and the



management of resistance, will lead to a more agile working environment – all contributing to the creation of the fully operational RTE that adheres to the HIT model.





6. RESEARCH METHODOLOGY AND VALIDATION

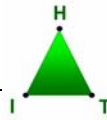
This chapter discusses the research methodology that was followed from conceptualization through development to closure. The research as a whole is then critically looked at to evaluate the validity of the process followed, as well as the proposed model itself. Detail will be given on the validation method that was followed as well as an interpretation of the results.

6.1 RESEARCH METHODOLOGY

This research maps a theoretical solution on practical observations. The concept has been tested in practice, to evaluate whether the statements and descriptions will hold – thus making it a sound theoretical description that is practically applicable.

It has to be kept in mind that this is a descriptive model of a situation that will evolve through the next five to ten years. Real time Asset Performance Management will come into its own by 2010 and companies that recognize the trend of the industry towards the real time paradigm, can use the proposed HIT model to re-engineer their processes accordingly. The research methodology that was followed went through the following steps (see graphical representation in Appendix D):

1. **BASIC PROBLEM.** After a substantial amount of background literature and conversations with practitioners in the field of Asset Performance Management, the basic problem could be derived. The essence was that there is an improvement opportunity within one of the existing pillars of Asset Management: overall machine performance has to be increased. Throughout the background study, Human Factors, Information Management and Technology Advances stood out as the three main components within the Asset Performance Management Field. This led to the formation of the research hypothesis that states: *Human, Information and Technology are the three most essential components in Real Time Asset Performance Management; the interaction between these components has to be in harmony for a company to stay competitive and adjust sufficiently in a constant changing world.*
2. **PRACTICE.** This step involved taking a closer look at the current evolution within the industry. By studying the industry, and looking at where it is heading (trends), one can better facilitate a solution that would suit this natural evolution of the industry. More specifically, trends were studied on Human, Information and Technology levels. The

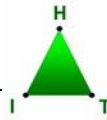


trend is found to be towards the Real Time Enterprise. Only in a few cases, combinations of the three components were addressed, but never all three together. This sparked a renewed interest to find the solution as to how humans, information and technology interact within this new improvement opportunity, namely real time Asset Performance Management. The study on trends helped form the two objectives of the theses:

- To confirm the hypothesis, as stated above.
- To describe the Human-Information-Technology Interaction (HIT Interaction) for real time Physical Asset Performance Management, so that it can be used by companies wanting to enter this environment as a descriptive guideline to improve overall machine performance by effectively managing personnel, information and technology.

3. LITERATURE. With the knowledge of the trends in the industry, as well as the two main objectives of the thesis, the literature was consulted for solutions that would fit the description of the interactions best. Different concepts were studied including those that might at the moment not be feasible, but which will be fully developed within the next five to ten years (see Chapter 2: *Gartner Hype Cycles*). By incorporating this into a single model, companies are enabled to obtain a view on whereto the industry is moving, as well as establish a strategic plan to be ready for the arrival of the RTE that supports real time Physical Asset Management. Concepts and solutions that were studied include Asset Management (general), Business Process Management, Business Activity Monitoring, Total Productive Management, Agility, Change Facilitation and Service Delivery.

4. SOLUTION. To guide companies through the transition towards the real time enterprise as well as improve overall machine performance (origin of research), the HIT Interaction model for real time Physical Asset Performance Management is proposed. Companies wanting to enter this environment can use this model as a descriptive guideline as well as to improve overall machine performance by effectively managing personnel, information and technology. The concept is based on Gartner's Agility, with BAM, Change Facilitation and Service Delivery as key interaction drivers. The HIT Interaction model also looks at the AS-IS situation of companies and describes where it should be in terms of Human, Information and Technology, within the RTE.



5. VALIDATION. The proposed model had to be validated in the industry, in order to establish whether or not the interactions were chosen and described correctly. Validation is done on two levels: Validating each component and validating the interactions between the components.

- **COMPONENTS:** This is validated through the study on the industry trends, as well as by the choice of interactions. The trends indicated that the specified components had to be addressed in order for the company to be successful. If the interactions were chosen correctly, the problems in each component will directly be addressed through managing the interaction.
- **INTERACTIONS:** As explained in Chapter 1, the company PRAGMA was used as basis for this research. PRAGMA has a diverse client base, ranging from small companies (focus of this model) that fall in the AS-IS state of the model to large companies that are already RTEs (TO-BE state). This was ideal to test whether or not the interactions accurately address the three components (Human, Information and Technology). The interactions are validated through a checklist that evaluates each company.

6. CONCLUSION

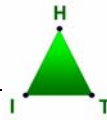
If the model has been validated and concepts and descriptions therein are accepted as correct:

- The hypothesis will be confirmed, meaning that no sufficient evidence exists at this moment to reject the model and that it does in fact accurately describe how to manage the real time Physical Asset Performance Management environment.
- The second objective of machine performance improvement will be reached.

By reaching the two main objectives, the research study will be successful. From here, certain conclusions can be drawn about the RTE, real time Asset Performance Management as well as the HIT model.

6.2 VALIDATION OF THE MODEL

A purely theoretical validation would not have been sufficient since it is believed that justification for almost any cause can be found through creative literature studies. A practical component was thus coupled to the validation process by validating the HIT model in the industry. This ensured that the theoretical principles that are proposed were put through practical scrutiny, in order to determine whether solid arguments were made. Since this is a descriptive model of a



rising opportunity for companies, it had to be established whether or not the interactions were chosen correctly and if the statements made would hold up in a practical situation.

The validation was conducted at PRAGMA – a leading Asset Performance Management company. This was the ideal environment, because by evaluating companies in terms of the criteria of the model (three components and the interactions) it could be established if the model described both the AS-IS and the TO-BE state of companies wanting to enter the Real Time Asset Performance Management environment.

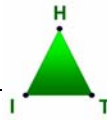
6.2.1 VALIDATION PROCESS

The validation process is based on a short checklist (framework shown in Table 5) that evaluates a company on a scale of 1 – 4 in each of the four criteria (ability to change, business interface, processes and automation and overall performance). The criteria of the checklist represent the three interactions of the HIT model, i.e. Ability to change (*Change Facilitation*), Business Interface (*Information as Product*) and Processes and Automation (*Business Activity Monitoring*) and it tests whether or not a company addresses these issues. Each section of the scale (1-4) describes a scenario. When rating a company, the scenario that best describes the current state in the company is chosen (see Appendix E for the scenarios). These scenarios are based on the trends in the industry (Chapter 2) and the literature review (Chapter 3).

Criteria \ Points		1	2	3	4
OVERALL PERFORMANCE	ABILITY TO CHANGE				
	BUSINESS INTERFACE				
	PROCESSES AND AUTOMATION				
	MACHINE PERFORMANCE				
	ASSET UTILIZATION				
	OEE				

Table 5 Validation checklist evaluation form

To eliminate the possible misconception that companies were specifically chosen to validate the model, machine performance rating were coupled to the checklist (sub-sections of overall performance). The overall performance is based on three measurements that are used within the Asset Performance Management field, namely *machine performance*, *asset utilization* and



overall equipment efficiency (OEE). The main reason for this choice is that it gives a good representation of how the company performs in terms of overall asset management. Companies that operate in real time should have better machine performance and companies that do not operate in real time should have very low overall performance. There should be a correlation between the score of the company and how well the machine performance is:

- If a company scores high, and its machine performance is high, the conclusion is reached that by addressing the specified components, a company will successfully improve machine performance.
- If a company scores low and its machine performance is also low, the conclusion is reached that if the specified components are not addressed, machine performance will remain low and uncompetitive. The objective is that if the HIT interactions are indeed addressed, the company will score high, and if the interactions are not addressed, the company will score low.

The model will be fully validated if the companies that are rated show the correlations as explained above. If however, a company scores low and has high machine performance levels or vice versa, then it is an indication that there could be a fundamental flaw in the model, the choice of interactions or the way that components are addressed.

The company's overall rating is then calculated by adding the scores of each criterion and dividing it by 16 (maximum possible score). This results in a percentage rating, that places the company in four different categories of real time readiness, i.e. *Basic*, *Standardized*, *Virtualized* and *Real Time Enterprise* (RTE) – categories that were derived through the literature review. Real time readiness shows on what level of readiness a company is for the real time environment (Figure 33). The figure shows a linear relationship, meaning that the higher the *Rating* (x-axis), the higher the *Real Time Business Performance* (y-axis) will be.

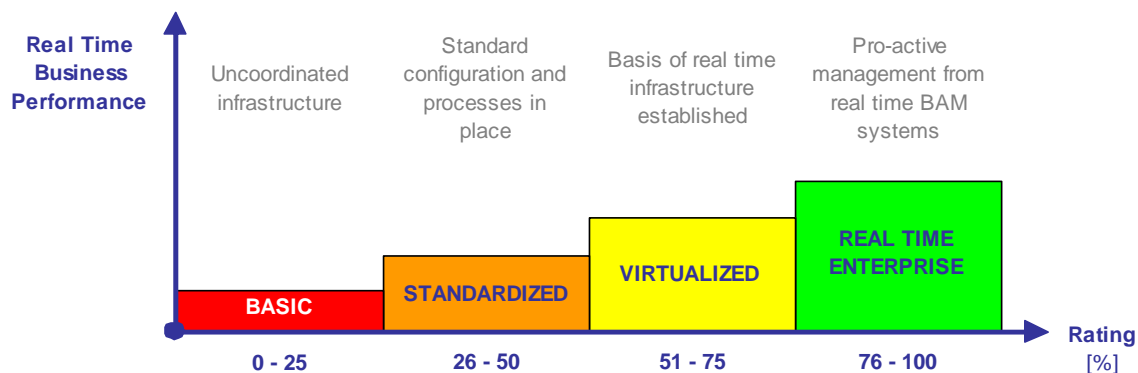
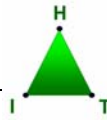
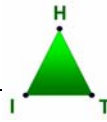


Figure 33 Categorization of real time readiness



Each category depicts the real time readiness state of the company and can be explained as follows:

- **BASIC.** Companies in this category have a totally uncoordinated infrastructure. They typically take very long to implement any suggestions or new concepts, management commitment tends to be very low and there is a total lack of collaboration. There are no sufficient client feedback loops installed, and if suggestions are received it will take months to years to reach shop-floor level to be implemented. This organization is characterized by very little process management (paper based if any) and no automation. All of this results in a very low overall performance.
- **STANDARDIZED.** Companies in this category have a few standard configurations and processes in place. They tend to take a few months to implement changes, personnel initiatives are not always recognized and their skill sets tend to be low because of a lack of commitment from management. There are some client feedback loops, but suggestions are not fed through the system to shop-floor level. If suggestions go through, changes take very long to be implemented. The standardized company has a paper-based process management system in place, but this is more to the detriment of the company since it delays actions and improvements due to inaccuracy and bureaucracy. Their overall performance tends to leave room for a lot of improvement.
- **VIRTUALIZED.** Companies in this category have established the basis of the real time infrastructure. There is a large degree of executive commitment, skill sets are improved by active training, and personnel initiatives are encouraged. Communication and client feedback channels are established, but tend to slow down improvement because of bureaucracy. These channels are not streamlined and information takes too long to go through the channels back to the shop floor, thus improvements are done, but over extended periods of time. These companies are characterized by a few in-house developed automating solutions which show the eagerness of personnel. This sets them up for real time operation, making the RTE and a full-on BAM solution the next logical step.
- **RTE.** Companies in this category are pro-actively managing all processes from a real time BAM system. Executive commitment is high, skill sets are actively broadened, communication is excellent and collaboration is high. Personnel are empowered to take initiative and make informed decisions. The BAM system is used effectively to be responsive to client needs and advanced feedback systems exist from clients to shop-floor level. Feedback loops are actively used to improve internal processes as soon as alerts arise. These companies are characterized by excellent process control and a large



degree of process automation. Real time data is retrieved continuously, which enables real time process management as well as the RTE.

The HIT model describes what and how to manage when moving towards the RTE and after a company has established its current position (according to the categories above) it can refer back to the model to establish a strategic plan to reach the next level.

6.2.2 ANALYSIS OF RESULTS

Ten companies were used in the validation process. The evaluation of the overall performance rating proved to be more difficult than originally expected. In three cases, the company showed a very high overall performance figure, which conflicted with the other criteria: *Ability to change*, *Business Interface* and *Processes and Automation* rated very low. At first, this indicated that there could be a fundamental problem with the HIT model, but further investigation showed that data was not collected for the whole plant, was constantly incorrect or was only based on a few machines that perform constantly well.

It was found that all three required machine performance measurements were only available in large companies that already operate in real time, and that have gathered quite a lot of historical data. This research focuses on the companies that wish to enter the real time environment, but in a few cases (as mentioned above) these companies either did not measure the required figures, or were so lost in their paper based systems that even though data is being captured, it is not representative of what is actually observed in the company. In these cases, the opinion of the consultant responsible for that client was sought, in order to establish the performance of the company.

A table of the results is shown in Appendix F. The table also shows the total scores, percentage ratings and the resulting categories. It should be noted that the percentage rating and the category have to be used together. This is due to the fact that two companies may score in a certain category and that there then needs to be a relative measure as to which one is better rated. For example, a *standardized* company with a percentage rating of 30% needs to put in more effort to achieve the *virtualized* status, than a company with a percentage rating of 50%. Figure 34 shows a summary of the final results.

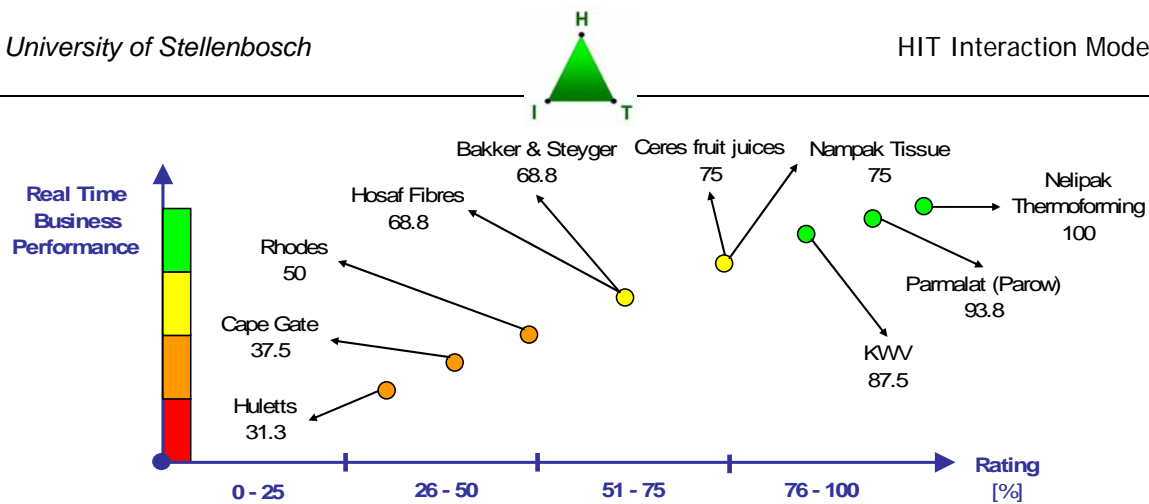
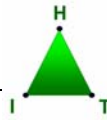


Figure 34 Summary of validation results

None of the companies rated as *basic*. The reason for this is that all companies are clients of PRAGMA, who deliver an outsourced Asset Performance Management system to them. This means that everyone has at least some form of process control, client feedback and machine performance improvement plan (although very minimal in a few instances). A *basic* company is typically one that scores lowest in all categories, and since it is the goal of PRAGMA to elevate such a company and improve machine performance, it is acceptable and understandable that none of the current clients would rate in that category.

Three companies rated *standardized*. According to the designated consultants, constant problems are experienced with these companies – this is reflected in their low score. They adhere to the specifications of the *standardized* company (as described in par. 6.2.1). It is these companies that, as explained earlier, tend to show high overall performance figures, but due to mismanagement and lack of control, these figures are not representative of the real life situation in the company. These companies prove that if the interactions are not successfully addressed, a low overall performance and general chaos can be expected.

Four companies rated as *virtualized*. These companies are experienced by the consultants to be highly motivated towards improvement, which is reflected in the high scores. They are typical *virtualized* companies (as described in par. 6.2.1). These companies prove the mid-range ratings - i.e. if there is enough commitment from management and a fair degree of process control, a company will perform well. They do however not perform on a world class level and there is much room for improvement. Their next step is to elevate their established paper-based systems and control measures, to a full-on real time system that adheres to the requirements of the Real Time Enterprise. These companies also prove that if the interactions are addressed to a fair degree, that a relatively good overall performance can be expected.



Three companies rated in the *RTE* category, one of which rated 100% RTE. These companies are proof that by sufficiently addressing the interactions of the HIT model, excellent performance will result. They operate in real time and actively use continuously gathered data from their systems to address alerts as soon as they occur. These companies adhere to the *RTE* classification (as described in par. 6.2.1) and are the role models for all other companies that are moving towards the real time environment.

6.3 CONCLUSIONS

The following conclusions can be made about the validation process and the model:

- The validation process as a whole proved to be successful. The checklist was sufficient as it addressed both key issues that are essential to the Real Time Enterprise within Asset Performance management, as well as the main components and interactions of the HIT model.
- The main objective of the validation was reached, since companies that address the HIT interactions score high, and the companies that do not address the HIT interactions score low.
- After careful evaluation of the companies (as explained earlier), it was proved that there is indeed a correlation between the degree to which the interactions are addressed (score) and overall machine performance.
 - Companies that scored high had high machine performance – thus by addressing the interactions, a company will successfully improve machine performance.
 - Companies that scored low also had low machine performance. In some cases, machine performance was not even calculated or it was a misrepresentative figure. By not even knowing a relatively accurate figure of performance, the companies confirmed the contributing factors to the low score – thus by not addressing the interactions, these companies will continue to observe low machine performance.
- The expectation of the linear relationship between *Percentage Rating* and *Real Time Business Performance* was confirmed, as can be seen from Figure 35. The data has however not been put through a formal statistical analysis. This however, was not necessary since the objective was only to find a general behaviour pattern, in order to validate the descriptions of the model.

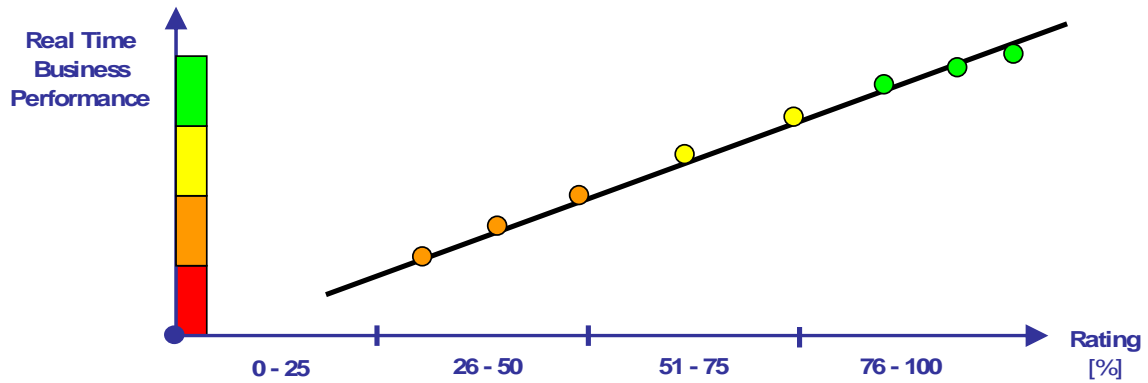
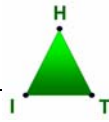
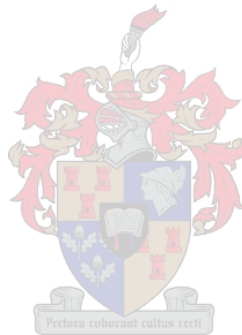
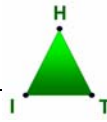


Figure 35 Linear relationship between *Percentage rating* and *Real Time Business Performance*

Consequently, there is no sufficient evidence to believe that the model is flawed or cannot be accepted as fully validated at the present time. The expected correlations were proved and none of the scores had contradicting behaviour.





7. RESEARCH CONCLUSION

This chapter serves as conclusion of the research project. Some general conclusions are drawn, where after the contributions of this research to theory and practice are discussed. A critical evaluation is done, along with some recommendations and a final concluding statement.

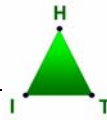
7.1 GENERAL CONCLUSIONS

This thesis was founded in an environment which, for several years, had not had any major improvements or breakthroughs. The maintenance management environment stagnated and was seen by companies as a necessity, rather than a critical improvement opportunity.

It is only in recent years, and in the largest part thanks to advances in technology, that companies have realized that there could still be some opportunities in what seemed like a dead function. The latest opportunity for improvement is to move the process of physical asset maintenance to a real time system – using advanced technological solutions and process management techniques, this function suddenly had the opportunity to be responsible for large increases in production output and financial performance. Along with this change, a generational shift is also occurring in the workplace. The new workforce will be exceptionally capable of handling the challenges set to them with minimal resistance to the constant change and adaptation it requires - it would thus not be sufficient to apply the traditional methods of managing change.

With the basis of the research being on the front-end improvement section of the market, a lot of theoretical research was done. The solution had to fit an environment that would only fully come into its own within the next five to ten years. New techniques, tools and solutions was sought in order to establish a sufficient solution. From background literature, practical experience and conversations with experts in the field, the three essential real time Asset Management components (Human, Information and Technology) were identified.

As a starting point, a review of the industry trend was done. Along with other sources, Gartner's *hype cycles* played a key role – they evaluate IT solutions in terms of feasibility over the next fifteen years, from those that are currently being developed, to those that are already established in the market. This gave a good indication as to what solutions would fit the future environment best. The trend was found to be towards the Real Time Enterprise.



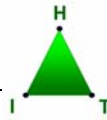
Only in a few cases, combinations of the three components were addressed, but never all three together. This sparked a renewed interest to find the solution as to how humans, information and technology interact within this new improvement opportunity, namely real time Asset Performance Management. The study on trends helped form the two objectives of the research.

The HIT Interaction model for real time physical Asset Performance Management was proposed and the final interactions (Information as Product, Change Facilitation and Business Activity Monitoring) were successfully established through an in-depth literature study on the components and possible interactions between them. They specifically apply to the real time Asset Performance Management scenario, not disregarding the fact that there may be other applicable solutions and interactions. The interactions have been chosen in such a way that they explain the management of the three components in a generic way that can be coupled to solutions that will be commercially available and affordable within the next five to ten years. The bottom line of the research problem was to understand these interactions within the specified environment. Certain research questions were asked, on which the study was based. In the description of the model, all of the research questions were sufficiently answered and the impact on the AS-IS situation was addressed by proposing focus areas that have to be managed.

The key is in having a balanced approach to the three interactions. By pushing only one of the components (as is typically observed in the industry), a company will have only minor improvements. When managing all three interactions, the three components are directly addressed and in turn the Real Time Enterprise is realized.

Since the HIT model is a descriptive model of a rising opportunity for companies, it had to be established whether or not the interactions were chosen correctly and if the statements made would hold up in a practical situation. PRAGMA was the ideal environment, because it could effectively be proved that the model indeed described both the AS-IS and the TO-BE state of companies wanting to enter the real time Asset Performance Management environment. Four levels of readiness for the real time environment were also established – thus by using the HIT model, companies are empowered to assess their current situation and establish a strategic development plan to achieve the next state of real time readiness, in terms of what is required by a fully operational Real Time Enterprise.

Consequently, there was no sufficient evidence to believe that, at the present time, the model is flawed or could not be accepted as sufficiently descriptive of the real time Asset Performance



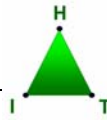
Management scenario. The expected correlations were proved and there was no contradicting behaviour.

As a whole, the research methodology proved to be successful. A thorough study was done on what is currently observed in industry as well as what experts and academics propose through theoretical literature. A fully validated model was proposed, which can be actively used in industry.

7.2 EXPECTED RESULTS

Companies that choose to follow the methodology of the HIT Interaction model can expect dramatic results. All the processes that are proposed are in support of the ever-more agile working environment and will guarantee a company improvement on internal process level, as well as external customer satisfaction level. By adhering to the requirements of the HIT model, a company will effectively realize the real time High Performance Workplace (HPW). Within this high performance environment, direct high level benefits are observed:

- Motivated workers that are always thinking on a strategically competitive level.
- A great degree of flexibility and process adaptability in reaction to a number of different unforeseen events that may occur.
- High performance communities are created since the company will ensure a well balanced customer relationship program.
- Management will be committed and actively give support, enforce good communication channels and welcome worker initiative.
- With real time information, comes real time responsibility – processes become knowledge based and with improved skill sets in workers, this knowledge environment will only be to the benefit of the company.
- On external level, advance customer feedback loops that relay initiatives back to shop floor, the customer will be ensured of higher satisfaction. Internal information is also actively used to notify the client as soon as any alerts arise which may delay the delivery of the product.
- Data management becomes extremely good with the implementation of a business activity monitoring system. Flexible, anytime, anywhere access allows users to at all times know the state of the company and enables them to make more informed decisions. With customizable user views and advance data mining capabilities, the exact required information is guaranteed.



- In a more global perspective, the Real Time Enterprise will be able to better define business goals, objectives and strategic plans, by having a better handle on information throughout the company.
- The state of the company as a whole will be much better than what is currently observed and the model will assist companies in entering the real time competitive section of their markets.

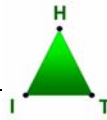
7.3 CONTRIBUTIONS TO THEORY AND PRACTICE

Although the research had a theoretical approach, the product was still a descriptive model of what has to be done in practice. This means that it describes a TO-BE situation and the best ways to manage that environment in terms of what is available today.

In practice, there are many different applications of Asset Management, ranging from the financial sector to human resources and, as is the focus of this study, the manufacturing environment. Consequently there are numerous employment opportunities for the Industrial Engineer, but apart from specialized courses, the subject of Asset Management is at times neglected. With the exception of a few focused research projects, it is possible that students pass through their course without even realizing that there exists such a field.

Not only does this thesis adhere to the academic requirements of delving deeper into a specified field, it also gives a comprehensive discussion on the practical side of the Asset Performance Management environment. Research is done on a front end improvement opportunity within Asset Performance Management – more specifically, understanding the complex interaction between three components that are key to real time Asset Performance Management. A new perspective is given by researching the interaction of the human component with two of the most fundamental components in this field, namely information and technology. A complete research perspective is formed, by looking at the current (AS-IS) as well as the future (TO-BE) situation and a method is facilitated to evaluate the movement between the two. Academics and students alike will be able to use this research as reference, since it uses only the latest (but still credible) sources.

In practice this research can be considered invaluable, even if it is only for its Research and Development (R&D) use. If a company does not have a R&D division, a comprehensive piece of research such as this, along with the progress made on the development of the model, eliminates numbers of man-hours that would have had to be spent to achieve the same result. If the



company does have an R&D division, they now have a solid base to work from, since a lot of the groundbreaking work has already been done as well as fully validated. They can simply develop customized solutions from there.

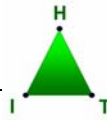
Apart from the R&D application, there are solid strategic planning uses for this research. The companies that have already entered the real time Asset Performance Management environment now have a sufficiently descriptive view of what can be expected within the next five to ten years. By using the evaluation of the model, they can assess their current state and put themselves in a better strategic position for the future – thus being more competitive, or even taking over their market segment.

7.4 RECOMMENDATIONS

As stated with the evaluation, it has to be kept in mind that this is a descriptive model of a situation that will evolve through the next five to ten years. There are a number of factors that could possibly change, most of the proposed ideas will evolve and adapt and in some cases a few will become irrelevant. It will be up to those that choose to use this model, to stay in contact with developments on Human, Information and Technology components, and the interactions that best describes the management thereof. When moving any company towards a new way of thinking and doing things, some complications could be expected. Apart from what has been discussed in the text, following recommendations can be considered:

1. The HIT model alone does not achieve anything – success is only achieved if the company as a whole is dedicated to change and adaptability, and then only if that change is done in a structured fashion.
2. Use the model to evaluate the AS-IS state, understand the complexity of the interactions and come up with a strategic plan to put the company in a more competitive section in the future.
3. Training is vital in all companies. Be sure that everyone involved fully understands the concepts of agility and what it requires of a company.
4. Even if the Real Time Enterprise is achieved and the company is in the top business performance level as described in the research, the agility cycle should still be kept running, by constantly evaluating AS-IS situations and determining the next step TO-BE.

This is a research project on a front end improvement opportunity, opening the way towards other research projects:



1. Directly applicable to this project, is an elaboration on the classification of real time readiness (i.e. final year student). The categories can be further expanded to classify a greater range of readiness. Add a stepwise description (or roadmap) for companies to see what has to be achieved in each category and adapt the scoring levels accordingly.
2. A benchmarking study would be tremendously supportive of the research. Consider evaluating what the best in class industries are doing in terms of retrieving and managing real time information. Industries to benchmark with would include Vehicle tracking and recovery (technology and management of information), Medical intensive care (reaction times on alerts) and companies that are rated by employees as best employers.
3. The model is described on a very high level with the intent that it would be used for strategic planning purposes. The topic as a whole is so broad, that a further research project could be undertaken in each component. The recommendation however, is to take the component pairs and elaborate on that with the current descriptions as basis - i.e. the interaction of Information and Technology within Asset Performance Management. On this level, other areas can be addressed, such as specific KPIs, dashboard representations, tools and techniques.

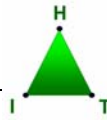
7.5 EVALUATION IN TERMS OF OBJECTIVES

It was stated in the first chapter, that if the model can be validated and the concepts and descriptions therein can be accepted as correct, then the two main objectives of the research study will have been confirmed.

The two main objectives of this research study were reached. It was proved that there is no sufficient evidence to reject the hypothesis at the present time. Human, Information and Technology are the three most essential components in real time physical Asset Performance Management; the interactions between the component pairs have to be in constant balance for a company to stay competitive and adjust sufficiently in a constant changing world. The second objective, which is in support of the hypothesis, was also reached by sufficiently describing the HIT Interactions for real time physical Asset Performance Management, so that it can be used by companies wanting to enter this environment as a descriptive guideline to improve overall machine performance by actively managing personnel, information and technology.

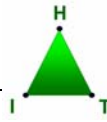
In order to achieve these two objectives, the following goals (as stated in Chapter 1) were accomplished:

- A comprehensive literature study was done.



- Sufficient background studies on Asset Management, the maintenance environment and the future perspective thereof were undertaken.
 - The focused study justified the existence of the three components and identified possible interactions between them.
- Research on what each component contributes to the industry was done, in order to understand the trend of each.
- A TO-BE scenario was defined and a relative point to which the industry is moving was established. The TO-BE state served as an acceptable basis from where model validation was done.
- Answers to the proposed research questions were studied, in order to better describe the interactions between the component pairs.
 - Information and Technology: *What is measured? and With what is it measured?*
The answer was found on how to manage this environment and what kind of technology the industry is looking at when managing information in the real time Asset Performance Management scenario.
 - Human and Technology: *How is the change facilitated?*
The answer explained how change is facilitated in the new world with younger generations. It describes what the workforce will look like in the future and also how change will be facilitated therein.
 - Human and Information: *What is the value of real time information?*
This answer explains what the value of real time information is and why a customer would pay for such information. It also describes what the client relationships will look like in the future, and how satisfaction can be guaranteed with effective information feedback loops.
- Within the validation process, a structure is facilitated by which companies can be evaluated in terms of the stages of readiness for real time operation. It groups companies in four categories of readiness, by answering a checklist. This enables them to establish where they currently are and what strategic steps to take in order to reach the next level. This is achieved by referring back to the interaction descriptions and looking at what still needs to be addressed.

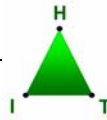
With the exponential growth in technology, it is almost impossible to think otherwise, but the situation could arise where another industry shift occurs. This situation however, is only possible in extreme cases where a revolutionary new innovation arises that make the Real Time Enterprise not feasible. If such an event occurs, the details of the described interactions will not be valid



anymore, but the main concepts will however still be applicable: Change is inevitable, technology will change exponentially and information will have to be monitored continuously in order to have an agile company with a competitive edge.

In whatever situation arises, the competitive edge will still be achieved by managing Human, Information and Technology factors by addressing the interactions between them. It is essential for any company wanting to leapfrog into the front end competitive section of their market, to understand this interaction and to embrace the change the future brings.

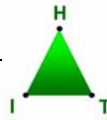




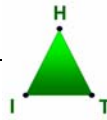
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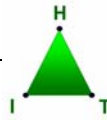
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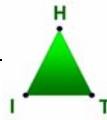
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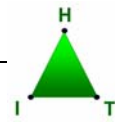


The following sources were consulted for background literature – these do not have specific reference in the text, but were useful for decision making and forming opinions.

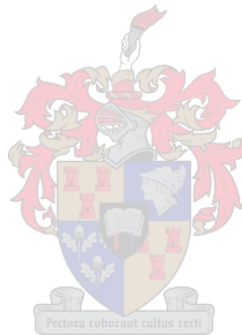
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Appendix A ***HYPE CYCLES:***
Interpretation
Tables



Interpretation tables of Gartner Hype Cycles [18].

Table 1. Hype Cycle Phases

Phase	Definition
<i>Technology Trigger</i>	A breakthrough, public demonstration, product launch or other event generates significant press and industry interest.
<i>Peak of Inflated Expectations</i>	During this phase of over enthusiasm and unrealistic projections, a flurry of well-publicized activity by leaders in technology result in some successes, but more failures, as the technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers.
<i>Trough of Disillusionment</i>	Because the technology does not live up to its over inflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
<i>Slope of Enlightenment</i>	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Commercial, off-the-shelf methodologies and tools ease the development process.
<i>Plateau of Productivity</i>	The real-world benefits of the technology are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. The final height of the plateau varies according to whether the technology is broadly applicable or benefits only a niche market. Approximately 30 percent of the technology's target audience has adopted or is adopting the technology as it enters the Plateau.
<i>Time to Plateau (Adoption Speed)</i>	The time required for the technology to reach the Plateau of Productivity.

Table 2. Benefit Ratings

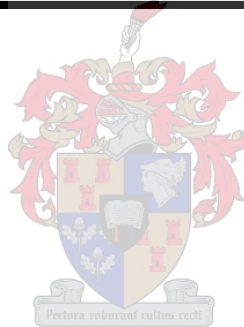
Benefit Rating	Definition
<i>Transformational</i>	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
<i>High</i>	Enables new ways of performing horizontal or vertical applications that will result in significantly increased revenue or cost savings for an enterprise

<i>Moderate</i>	Provides incremental, but significant, improvements to established processes that will result in increased revenue or cost savings for an enterprise
<i>Low</i>	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Table 3. Maturity Levels

Maturity Level	Status	Products/Vendors
<i>Embryonic</i>	In labs	None
<i>Emerging</i>	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
<i>Adolescent</i>	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
<i>Early mainstream</i>	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out of box Methodologies
<i>Mature mainstream</i>	Robust technology Not much evolution in vendors or technology	Several dominant vendors
<i>Legacy</i>	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
<i>Obsolete</i>	Rarely used	Used/resale market only

***Appendix B THE RESISTANCE
PYRAMID***



The resistance pyramid [57] must include tactics at all levels and along multiple timelines. Introducing tactics during the first month of an announced change and reinforcing those tactics during the subsequent months is equally important. Depending on groups, management practices and personal behaviours, timelines will vary. The framework should be filled in and the tactics used when resistance emerges.

RESISTANCE LEVELS	IMPROVEMENT APPROACH	TACTICS
LEVEL 1: Not knowing PRIMARY SYMPTOMS: Rumours, Loss of productivity, Missed deadlines	FOCUS: Personal and professional priorities and options. PRIMARY COUNTERBALANCE: Communicate, inform, describe options and set timelines, set accountability. STAND TAKEN: Skills, processes and attitudes clearly defined for the following three years.	<ul style="list-style-type: none"> • Provide examples of why change is required. • Amplify cost of failure. • Name people as champions and program managers. • Prepare people for initial assessment and analysis. • Create channels for people to offer suggestions.
LEVEL 2: Not able PRIMARY SYMPTOMS: Drop in personal performance, High stress levels, Failure to take action	FOCUS: Care and attention PRIMARY COUNTERBALANCE: Educate, prepare, develop and train people. STAND TAKEN: Education and learning programs defined for the next three years to increase opportunities and establish new career paths.	<ul style="list-style-type: none"> • Clarify changes in activities, processes and tasks. • Set strategic values for competencies. • Create development and learning objectives. • Build portfolio of classes, mentoring and books for learning. • Facilitate personal coaching.

<p>LEVEL 3: Not willing</p> <p>PRIMARY SYMPTOMS: Opposing actions to agreements, Unhealthy competition, Reward system supporting historical behaviour and not supporting change, Managers not adhering to objectives.</p>	<p>FOCUS: Do what was promised.</p> <p>PRIMARY COUNTERBALANCE: Motivate, reward, reinforce and change.</p> <p>STAND TAKEN: The development of people who are highly versatile and who can move smoothly among others. These people will be attracted, rewarded and developed.</p>	<ul style="list-style-type: none">• Announce new terms of recognition and reward.• Acknowledge role models.• Institute new goals and measures for performance.• Take action about people who do not fit in (see par. 5.4 <i>Legend 2</i>)
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Appendix C ***THE AGILITY
CONCEPTUAL
FRAMEWORK:
Detailed questions
for better
management***



In Gartner's Agility conceptual framework [35], numerous questions are provided to ensure that the framework is managed correctly. Here follow the detailed questions on *Agility enablers* and *Willingness factors*.

AGILITY ENABLERS

The following capabilities enable an organization to increase agile performance across the agility cycle:

1. Awareness

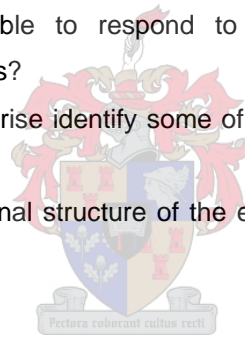
Determination of awareness levels poses questions such as:

- Do end users see the right information at the right time?
- Does the organization suffer from any internal or external barriers to awareness?
- Is this information easily accessible by the right people?

2. Flexibility & Adaptability

Flexibility & Adaptability key questions include:

- Is the enterprise able to respond to expected (flexibility) or unexpected (adaptability) changes?
- If not, can the enterprise identify some of the problems that impede its flexibility and adaptability?
- Does the organizational structure of the enterprise promote or prevent flexibility and adaptability?



3. Productivity

Determining productivity's impact on agility includes questions such as:

- How efficient are the enterprise's operations?
- Is the enterprise effective from day to day?
- Can the enterprise identify any internal or external barriers that impede its productivity?

WILLINGNESS FACTORS

A definition of each of the willingness factors that help or hinder agility is provided below.

1. **COMMITMENT** Determination of commitment includes questions such as:
 - Does the enterprise have the right people with appropriate skills and experience?
 - Has the enterprise spent enough or too much?
 - Does the enterprise set appropriate and reasonable time schedules?
2. **RISK** Determination of risk includes questions such as:
 - How well does the enterprise implement new technologies?
 - Does the enterprise have a governance board or project management office to coordinate multiple technology projects?
 - How risky are those changes to make?
 - The formal components of risk in Gartner's specific agility model include:
 - *Budget* — The ability of the IT organization to deliver within budget
 - *Workload* — An adequate staff for the workload
 - *Changes* — The ability of the IT organization to manage technology changes well
 - *New technologies* — The effective incorporation of new technology deployments into the business environment
 - *Scheduling* — Setting and sticking to proper deployment schedules
 - *Timely delivery* — The IT organization's ability to deliver on schedule
 - *Project sign-off* — The proper approvals and sign-offs for key IT technology projects delivered in a timely fashion
 - *Understanding requirements* — An understanding on the part of an IT organization of what users want and need
 - *Delivering on requirements* — Delivery of systems that meet the specified requirements
 - *Hiring and retention of key staff* — The hiring and retention of IT organization staff with skills that are exceptionally good or imperative to effective operations
 - The formal components of commitment in Gartner's specific agility model include:
 - *Scheduling or calendaring* — The use of a standardized scheduling or calendaring mechanism
 - *Timelines* — The use of delineated timelines for projects
 - *Strategic direction* — Policies that specify appropriate time frames for strategic projects
 - *Tactical direction* — Policies that specify appropriate time frames for tactical projects
 - *Project management* — controlling the progress of projects.

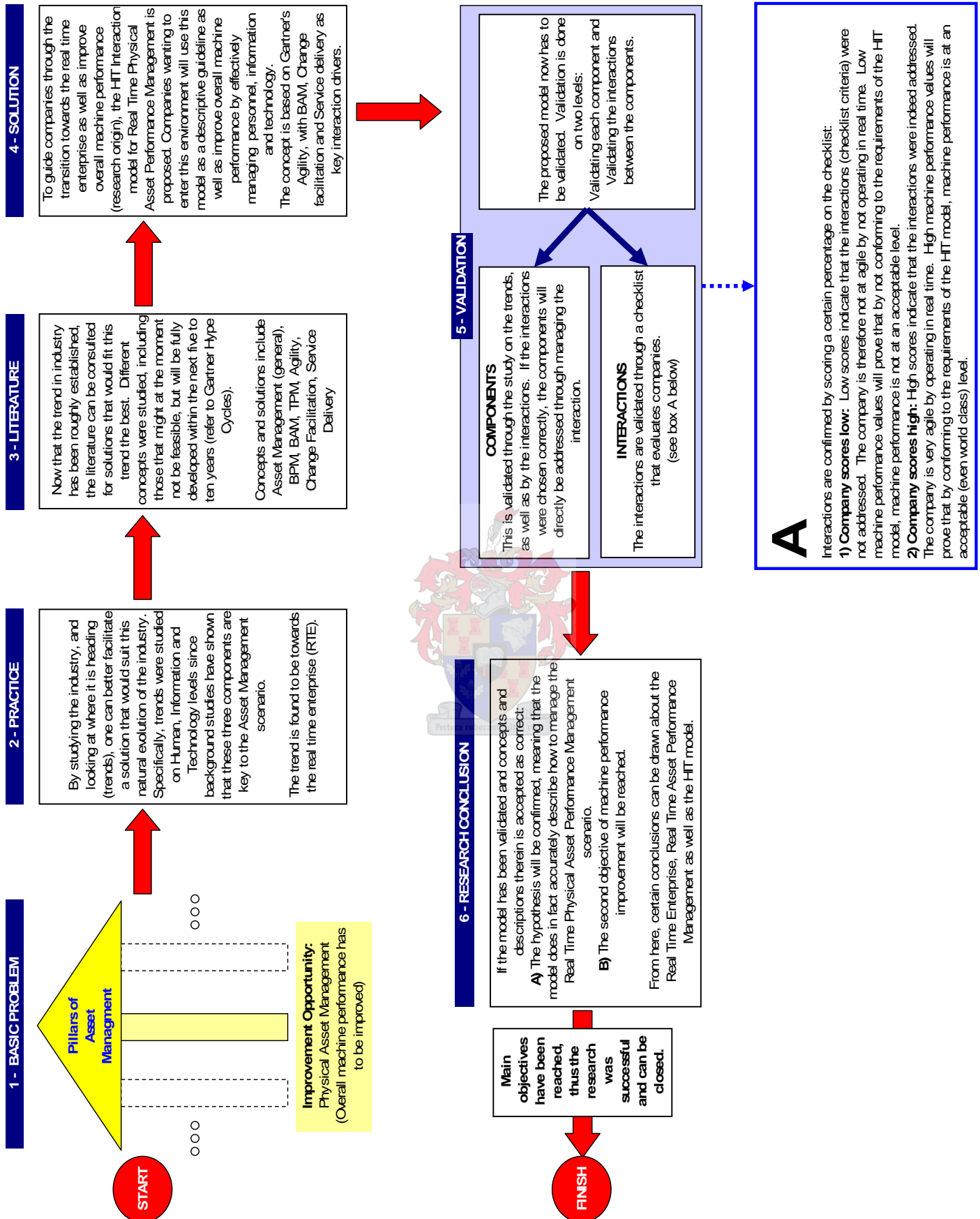
- *Work hours* — The appropriate allocation of work hours for individuals to achieve stated goals for any given project
- *Milestones* — Clear milestones that enable the organization to track project success
- *Deliverables* — The identification of deliverables for each milestone in a project
- *Planning* — The allocation of time and energy to plan projects effectively

3. **LEVERAGE** Determination of the degree of leverage includes questions such as:

- How well are technologies used for purposes other than what they were purchased for?
- Is the enterprise's technology widely used in critical business situations?
- Does the enterprise have standards for integration and intersystem communication?
- The formal components of leverage in Gartner's specific agility model include:
 - *System optimization* — Optimizing the established resources of the IT organization to perform better, faster and less expensively
 - *Legacy extension* — Ensuring that "legacy" systems can be used to supplement new systems
 - *In-house modification* — Modification of purchased systems and fine-tuning them to the IT organization's needs
 - *Outsourcing* — The use of outside sources to supplement enterprise IT staff and system assets
 - *Innovation* — The use of technologies in an innovative fashion beyond what they were originally purchased and deployed for
 - *Timely updates* — Keeping products up-to-date and ready to accommodate changing technology requirements
 - *Standards* — The use of policies that encourage the development and use of architectures, tools and products that complement one another and match the IT organization's skills
 - *Best practices (such as architecture, tools and products)* — The use of industry best practice models in the deployment and use of technology
 - *Reuse* — The reuse of software components or technology components to build new systems
 - *Collaborative organization* — The sharing of information or knowledge that helps the enterprise to use technology more-effectively

Appendix D ***GRAPHICAL
RESEARCH
METHODOLOGY***





Appendix E ***VALIDATION
CHECKLIST:***
Details



A company scores from 1 - 4 points on each criterion, according to the specifications.

Point Criteria	1	2	3	4
ABILITY TO CHANGE	<p>Months to years.</p> <p>No executive commitment and involvement is low - dictatorship style. Collaboration is low with decisions made by top management simply forced down through hierarchy.</p>	<p>Months.</p> <p>Management knows what goes on in the company, but is not committed to improvement or involvement. Management decisions are forced down with collaboration very minimal. Personnel initiative is not actively encouraged and skill sets tend to be low.</p>	<p>Weeks.</p> <p>Executive commitment is fair. Personnel have fairly good skill sets with collaboration being promoted (not always done). Communication channels are established but not regularly used. Some personnel initiatives are taken seriously.</p>	<p>Hours to days.</p> <p>Executive commitment is high. Broad skill sets in personnel. Communication is very good and collaboration is high. Personnel empowered to make decisions and take improvement initiative.</p>
BUSINESS INTERFACE	<p>EXTERNAL:</p> <p>Service/product is delivered with no client feedback.</p> <p>INTERNAL:</p> <p>No feedback loops installed.</p>	<p>EXTERNAL:</p> <p>Some form of client feedback exists, but is not used effectively for improvements in service. Little or no action is taken when suggestions is received.</p> <p>INTERNAL:</p> <p>Minimal feedback loops are installed - not effective due to slow information feedback.</p>	<p>EXTERNAL:</p> <p>Client feedback systems exist. Fair degree of usage. Client needs not always effectively addressed - information takes too long to go through processes (not streamlined or integrated).</p> <p>INTERNAL:</p> <p>Feedback to processes exist. Process improvement over long periods.</p>	<p>EXTERNAL:</p> <p>BAM system used effectively to be responsive to client needs. Advanced feedback systems from clients to company.</p> <p>INTERNAL:</p> <p>Feedback loops are installed and actively used to improve internal processes as soon as alerts arise.</p>
PROCESSES AND AUTOMATION	<p>No or very limited process management. No effective information management. Lack of information feedback result in general chaos (firefighting).</p>	<p>Limited process management - typically on paper based systems (no automation). Fair degree of process control, but information feedback is very slow (weeks).</p>	<p>Good process management. Fair degree of automation (i.e. in-house solutions like Excel). Still far from best in class - information feedback is slow (days). Foundation is ready, making a BAM solution the next logical step.</p>	<p>Excellent process control. Large degree of process automation. Real time data is retrieved from BAM or similar solution. Real time process management with use of alerts generated through BAM software.</p>
OVERALL PERFORMANCE	Based on either exact measurements from historical data OR a discussion with the consultant responsible for the client.			

Appendix F **VALIDATION
RESULTS**



Criteria	Company									
	Rhodes Foods Cannery	Bakker & Steyger (Steinhoff)	Ceres Fruit Juices	Hulets Hydro Extrusion	Hosaf Fibres	Cape Gate	Nelipak Thermoforming (Ireland)	Nampak Tissue	Parmalat (Parow)	KWV
ABILITY TO CHANGE	2	3	3	1	3	1	4	3	3	3
BUSINESS INTERFACE	2	3	3	1	3	1	4	3	4	4
PROCESSES AND AUTOMATION	1	2	3	1	3	2	4	3	4	4
OVERALL PERFORMANCE	3	3	3	2	2	2	4	3	4	3
TOTAL SCORE	8	11	12	5	11	6	16	12	15	14
PERCENTAGE	50.0	68.8	75.0	31.3	68.8	37.5	100.0	75.0	93.8	87.5
CATEGORY	Standardized	Virtualized	Virtualized	Standardized	Virtualized	Standardized	RTE	Virtualized	RTE	RTE

Rated value should be from 1 - 4