A SYSTEMS ENGINEERING APPROACH TO TELEMEDICINE SYSTEM IMPLEMENTATION IN SOUTH AFRICA

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ABSTRACT

The South African National Department of Health (DoH) is recognizing, for more than a decade already, the potential benefit of information and communication technology (ICT) to deliver healthcare to rural areas. However, despite generous funding and proven technology, not many of telemedicine systems sustained after pilot phase. The purpose of this paper is to develop a maturity model that can be used to measure and manage the capability of a health system to sustain health care delivery after the pilot phase of a telemedicine project.

Four existing frameworks are used as input to this maturity model, namely the ISO 15288 Systems Engineering Life Cycle Standards, the ISO/IEC 15504 Software Process Improvement and Capability Determination (SPICE), eHealth Readiness Instrument for developing countries and the Layered Telemedicine Implementation Model. The validity of this maturity model is tested by means of a focus group discussion, during a workshop of provincial representatives from a provincial department of health (DoH). In conclusion, follow-up work is proposed for the development and validation of future versions of this framework towards a maturity model for telemedicine projects.

1 INTRODUCTION

The South African government published their first telemedicine strategy in 1998, in which telemedicine is recognized as a strategic tool to overcome unequal distribution of healthcare resources. Since then, many telemedicine projects have been launched into the public health sector by the national Department of Health (DoH), of which most passed the pilot-phase. However, many of these projects were not implemented successfully or were not sustained after implementation.

Apart from the obvious waste of equipment and human resources, Yellowlees [1] considers the damage to the reputation of telemedicine as an even greater cost. The South African public health sector is already paying this price: in 2010, the Department of Health placed a moratorium on the launching of any new telemedicine projects, until a strategy is in place to raise the success rate of telemedicine projects.

It is proposed that the low success rate of sustainable telemedicine systems implemented in the public health sector of South Africa can be attributed to a lack of systems engineering. A successful pilot project focuses on the technological capability of a telemedicine solution [2]. However, if a systems-of-systems design approach is followed, the health system in which this solution is to function, should also be considered. Implementation planning is needed to ensure that the users, organizational work processes, policies and protocols in which this technology system finds itself will contribute to sustained implementation.

The purpose of this paper is to develop a maturity model that can be used to measure, manage and optimize all the components of a telemedicine system as well as the health system within which it is implemented. With a maturity model the capability maturity of a specific domain is measured and an improvement process is facilitated that will best suit the enterprise and that is in accordance with the prescribed best practices of the domain [3].

The following methodology was used to accomplish this purpose and this paper is therefore, structured as follows: Firstly, telemedicine is defined within the context of initial telemedicine projects deployed by the South African Department of Health.

This is followed by respective discussions of the ISO 15288 Systems Engineering Life Cycle Standards, the ISO/IEC 15504 Software Process Improvement and Capability Determination (SPICE) [4] and[5] eHealth Readiness Instrument for developing countries [6], and the Layered Telemedicine Implementation Model(6). The strengths and weaknesses of each of these are considered, as well as the contribution that each can make towards a maturity model for telemedicine.

These frameworks are then integrated to propose a maturity model for telemedicine. The validity of this framework is tested by means of a focus group discussion, during a workshop of provincial representatives from a provincial department of health (DoH). In conclusion, follow-up work is proposed for the development and validation of future versions of this framework towards a maturity model for telemedicine projects.

2 TELEMEDICINE AND EHEALTH

By definition telemedicine refer to the delivery of healthcare services (“medicine”) were distance (“tele”) is an issue. Although, the use of information and communication and technology (ICT) is not required per this definition, the development of telemedicine is so much intertwined with the development of ICT that reference to ICT is found in almost all definitions for telemedicine.

The term telemedicine was coined in 1971[7]. This definition was clearly influenced by the prevailing technology of the time (interactive audio-video communication systems). Many authors that followed, limited their scope to the technology within their frames of reference, for example, the Internet, transmitted images, voice as well as other data [8] and video [9].

Sood et al. [7] worked through 104 peer-reviewed articles, after which a further definition for telemedicine was provided:

> *"Telemedicine being a **subset of telehealth**, uses communications networks for delivery of healthcare services and medical education from one geographical location to another, primarily to address challenges like uneven distribution and shortage of infrastructural and human resources."*

Telehealth – in turn – is a subset of eHealth, which in the widest sense of the term, refers to the use of ICT in the delivery of healthcare. For the purposes of this article, we will be employing Sood *et al.*'s definition, which – like the DoH – recognizes the role of telemedicine as a means to address the uneven distribution of health resources. Background, concerning the history of telemedicine initiatives in South Africa, is provided in the following section.

In 1998, the first phase of telemedicine implementation began in South Africa. The implementation was guided by the National Strategy for Telemedicine. The objectives of the strategy focused on providing high-quality and cost-effective health care and education; improved recruitment and retention of health professionals; the delivering of health care at a distance, and improving the accessibility of specialist health care.

Significant progress in telemedicine has been made since 1998. This is largely due to the constantly evolving nature of technology, which has made technology more affordable and available, simultaneously increasing its capacity. An extensive dedicated communication infrastructure is no longer a necessity for transmitting data, as the transmission can now be achieved with the use of existing mobile phone networks and similar wireless connectivity options (10). Another driving factor which has contributed to the success of telemedicine is the participation of champions in the process (1). A champion is a person inside an organization who is responsible for driving telemedicine initiatives within that organization.

In 1999, the DoH initiated 28 pilot telemedicine projects in six different provinces. The initial focus of the projects was on teleradiology, together with tele-ultrasound, telepathology and teleophthalmology.

These initial projects were launched in several provinces: in the Free State, teleradiology was implemented at the following hospitals: Harrismith; Zastron; Senekal, and Universitas Academic. In addition, an early link was established for telepathology in the Eastern Cape, with the service being driven by a professor who was based at Walter Sisulu University. Collaborative links were also forged with the University of Basel and the Armed Forces Institute of Pathology, Washington, DC, USA.

A telemedicine project was started in the Western Cape for tele-education and telepsychology. The latter was an ambitious project, which was enthusiastically inaugurated by the then Minister of Health. The project served a region where the inhabitants suffer particularly from alcoholism and violence, and its focus was to aid nurses at the local clinic, who often had to deal with severely agitated clients. Over the weekends, these clients were confined to police cells until a local state doctor – not a psychiatrist – could see them. The Department of Psychology at the University of the Western Cape, which was 450 kms away, provided a consultation service, and also used related material for teaching purposes. The same link allowed access to tele-education for two groups of counselors. One group consisted of local professionals, teachers and social workers, the other comprised senior high school students, who acted as peer counselors. However, the project ended prematurely when the relevant equipment was stolen.

In KwaZulu-Natal, a tele-ophthalmology service was set up. The service was provided at six different hospitals, and was administered by various specialist clinician champions, together with the University of KwaZulu-Natal.

Sadly, as pointed out by Mars[11], the volume of telemedicine in South Africa's public health sector is still very low and most telemedicine projects are still in pilot phase. In many cases, telemedicine workstations are locked up in storerooms or awaiting maintenance. Contributing to this implementation failure is the lackof support from health professionals and a lack of technical support, training and site-coordinators. The absence of effective financial models for the public sector and little appreciation for the complexity of change management can also be seen as negative factors[11].

3 LIFE CYCLE STANDARDS, E-HEALTH READINESS INSTRUMENTS AND THE LAYERED IMPLEMENTATION MODEL

The purpose of this paper is to develop a maturity model that can be used to measure, manage and optimize all the components of a telemedicine system as well as the health system within which it is implemented. There are many frameworks, models, checklists, taxonomies, *et cetera*, that can be useful as input in such a model – all with their own strengths and weaknesses. However, from these, four frameworks were identified as having the most to contribute towards such a maturity model. They are as follows:

- eHealth Readiness Instruments for Development Countries [6]
- ISO 15288 Systems Engineering Life Cycle Processes (5)
- ISO/IEC 15504 Software Process Improvement and Capability Determination (4)
- The Layered Telemedicine Implementation Model[2]

This section is devoted to a description of each of the above, as well as a discussion concerning their strengths, weaknesses and relevance with respect to the purpose of this article.

3.1 eHealth readiness intruments

eHealth readiness is defined as the "degree to which users, healthcare institutions and the healthcare system itself, are prepared to participate and succeed with implementation." [6]. Jennett *et al.* [12] specifically refer to eHealth readiness when arguing that time, money and energy can be saved if the *status quo* of an eHealth/telemedicine system context is determined before implementation.

In 2010, Legare *et al.* [13]identified six different assessment tools, which can be used to measure e-readiness within a health context. However, information concerning internal validity and reliability is available for only two of these tools. From these, Khoja's [14]*E-health Readiness Assessment Tool* was selected for the purposes of this paper, because it is specifically directed towards developing countries.

This instrument covers five categories, each containing a number of statements, to which a respondent is asked to agree/disagree according to a 5-point Likert scale:

1. Core readiness (21 statements) deals with aspects of planning and integration.
2. Technological readiness (10 statements) considers the availability, reliability, affordability and ICT, and related infrastructure.
3. Learning readiness (6 statements) addresses issues related to the programs and resources to provide training using the technology.
4. Societal readiness (11 statements) considers the interaction between the institution and other institutions in the region and beyond. Socio-cultural factors are also included.
5. Policy readiness (12 statements) deals with policies at government and institutional level to address common issues such as licensing, liability and reimbursement.[6]

Essmann [3] explains that a maturity model's first objective is to establish the capability maturity of an organisation in terms of a specific domain of practice. The strength of this eHealth Readiness instrument lies in the fact that it provides us with a set of statements, which can be used as a yardstick to measure the eHealth Readiness of an organization. The validity and reliability of this measuring instrument is validated through various studies [13] and can thus provide us with a set of statements which can be used with confidence to establish, to a certain extent, the capability maturity.

The drawback of eHealth readiness tools lies in the fact that they do not accommodate the second purpose of a maturity model, namely to describe the best practices of the domain and then facilitate the process of moving that enterprise towards those best practices [3]. Molla and Licker [15]identified a similar drawback in developing a model and instrument for eCommerce adoption in South Africa and consequently developed a maturity model for e-commerce.

3.2 Systems engineering life cycle standards (ISO 15288)

The ISO 15288 Systems Engineering Life Cycle Processes Standard provides a common framework to improve communication, co-operation and integration among all parties who create, utilize and manage complex systems [5]. This standard provides a set of desired processes and best practices and claims to provide for the assessment and improvement of the life cycle processes, and hence may be able to address the second purpose of a maturity model [3].

In these standards, a number of life cycle processes are defined in terms of the activities and outcomes associated with each of these processes. Four categories of processes are defined, namely (1) agreement processes, (2) enterprise processes (3) project processes and (4) technical processes.

3.2.1 Agreement processes

The purpose of the two processes in this category, namely (1) acquisition process and (2) supply process, is to establish agreements with international and external organizational entities.

3.2.2 Enterprise processes

The enterprise processes manage the organization's capability and infrastructure to acquire and supply products or services. Five processes are included in this category, namely (1) enterprise environment management, (2) investment management, (3) system life cycle management, (4) resource management and (5) quality management.

3.2.3 Project processes

The project processes are used to establish and evolve project plans, to assess actual achievement and progress against the plans and to control execution of the project up until fulfilment. This category includes the (1) project planning process, (2) project assessment process, (3) project control process, (4) decision-making process, (5) risk management process, (6) configuration management process and the (7) information management process.

3.2.4 Technical processes

These processes are used to define the requirements for a system and to transform the requirements into an effective product. They optimize the benefits and reduce the risks that arise from technical decisions and actions [5]. The first process within this category is the (1) stakeholder definition process, followed by (2) requirement analysis, (3) architectural design, (4) implementation, (5) integration, (6) verification, (7) transition, (8) validation, (9) operation, (10) maintenance and (11) disposal.

3.3 Software Process Improvement and Capability Determination (SPICE)

The process assessment model for the ISO/IEC 15504 Software Process Improvement and Capability Determination (SPICE) is often used in conjunction with the ISO/IEC 15288 System Life Cycle Standards[5]. The capability levels, as described in ISO/IEC 15504, are listed in Table 1.

Capability Level	ISO/IEC 15504 Capability Level Description
Level 0 Incomplete	There is a general failure to attain the purpose of the process. There are little, or no, easily identifiable work products or outputs of the process.
Level 1 Performed	The purpose of the process is generally achieved even though the achievement may not be rigorously planned and tracked. There are identifiable work products for the process, and these testify to the achievement of the process.
Level 2 Managed	The process delivers work products according to specified procedures and is planned and tracked. Work products conform to specified standards and requirements.
Level 3 Established	The process is performed and managed using a defined process. Individual implementations of the process use approved, tailored versions of standard, documented processes to achieve the process outcomes.
Level 4 Predictable	The defined process is performed consistently in practice, within defined control limits, to achieve its defined process goals.
Level 5 Optimizing	Performance of the process is optimized to meet current and future business needs, and the process is consistent in meeting the defined business goals.

Table 1: The Capability Levels of ISO/IEC 15504 [16]

3.4 Layered telemedicine implementation model

It is not only in South Africa that telemedicine projects have a significantly high failure rate. An international study by Broens et al. [2] confirmed that telemedicine projects are more likely to fail, than prove sustainable, after the prototype phase. They conducted a systematic literature review to answer the question "why is it so difficult [to implement telemedicine] and what goes wrong?" In this study, the theoretical model of Tanriverdi and Iacono [17] was used as a point of departure in the identification of the so-called *determinants for the successful implementation of telemedicine*.

Broens et al. [2] postulated that different *determinants* become applicable as telemedicine implementation maturity is gained and their *Layered Implementation Model* was developed accordingly. The four implementation layers are shown in this figure, with the corresponding categories of *determinants*, indicated in brackets. The relation between each *implementation layer* and their associated *determinants* are described below.

3.4.1 Prototype

This evaluation deals mainly with technological feasibility such as the availability, quality and support of the technology in use. Within the scope of the *technology* category, the following are included: support, training, usability and quality.

3.4.2 Small-scale pilot

In the small-scale pilot phase, users need to work with the system, which shifts the focus to acceptance, including attitude and usability, as well as evidence-based medicine, diffusion and dissemination.

3.4.3 Large-scale pilot

Financing and organization become increasingly important at this stage. Aspects such as provider and structure, intramural work practices and extramural work practices now become relevant.

3.4.4 Operational product

When the systems become an operational product, policy issues, like legislation, policy, standardization and security need attention.

4 TOWARD A MATURITY MODEL FOR TELEMEDICINE IMPLEMENTATION

The Systems Engineering Life Cycle Processes [5], Software Process Improvement and Capability Determination (SPICE) standard, eHealth Readiness Instruments [6] and the Layered Implementation Model [2] can each be used as individual frameworks to support telemedicine implementation. However, neither of these are a comprehensive maturity model which is applicable in the telemedicine and eHealth domain.

In the following section, these four frameworks have been combined to develop a three dimensional model (Figure 1) that can be used to measure, manage and optimize all the components of a telemedicine system, as well as the health system within which it is implemented. Each of the three dimensions is discussed in this section.

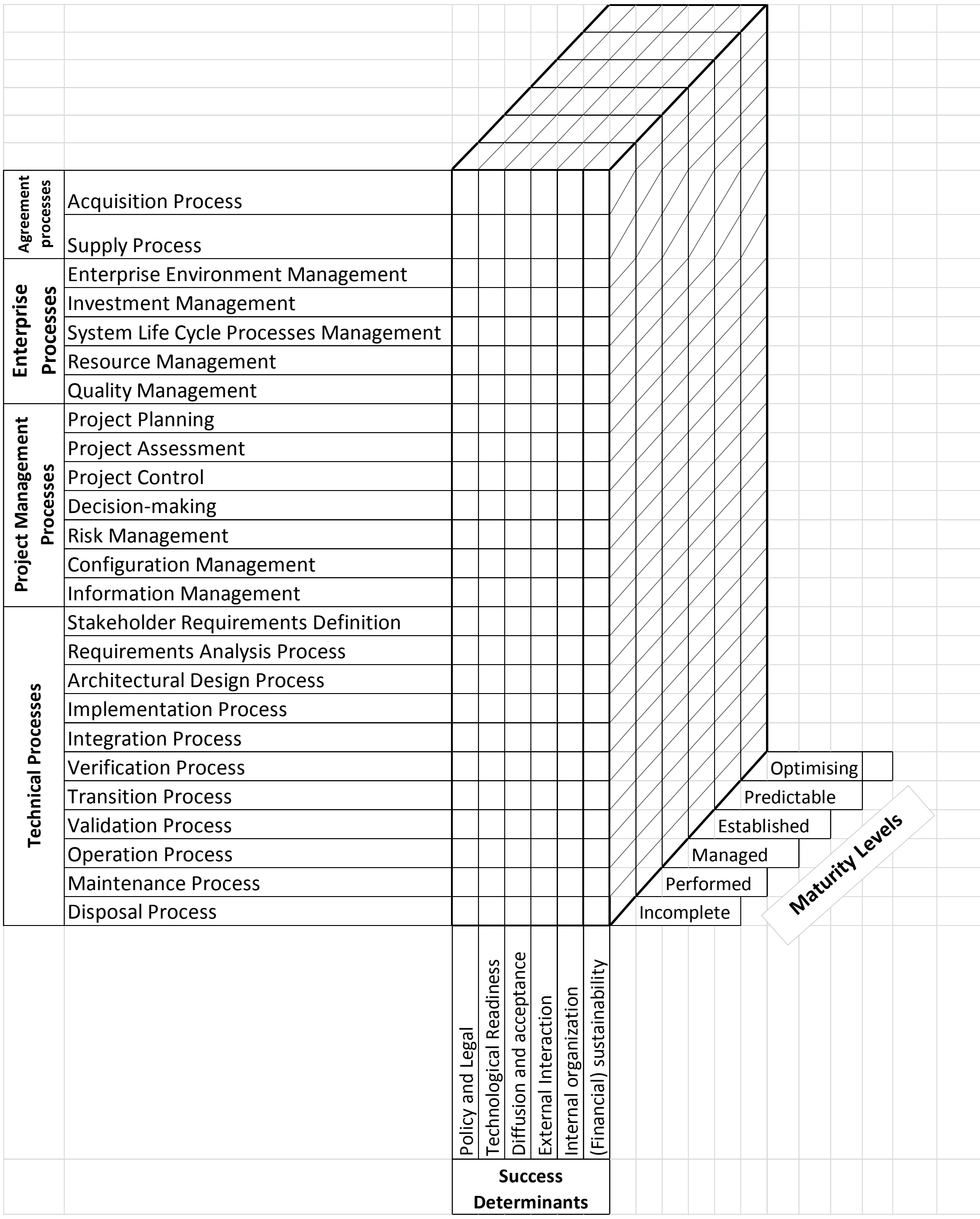

Figure 1: Toward a maturity model for telemedicine Success determinants

4.1. Success determinants

Khoja's [6] eHealth readiness categories are aligned with the determinants for the successful implementation of telemedicine by Broens *et al.*[2]. Both Khoja and Broens *et al.* recognize *technology* and *policy* as determinants for the successful implementation of telemedicine. *Core readiness*, *learning readiness* and *societal readiness* are additional eHealth readiness categories, whilst Broens *et al.* added *user acceptance*, *finance* and *organization (internal and external)* to their determinants.

For the purposes of the framework presented in this paper, the success determinants are organized as follows:

- Policy and legislation: Governmental and institutional policies and procedures, standardization and security
- Technology: ICT availability, reliability, training, usability
- Diffusion and acceptance: Trust and willingness of users and decision makers, producing evidence, change in way of doing
- External interaction: Interaction with society and other institutions
- Internal organization: Decision making processes, work procedures
- (Financial) sustainability: Business models which will ensure continuation of the telemedicine endeavour

4.2. Maturity levels

Essmann [3] defines a maturity level as "a well-defined evolutionary plateau of domain of practice capability maturity." The maturity levels from the ISO/IEC 15504 standards are used, as previously shown in Table 1, since these standards are often used in conjunction with ISO 15288.

Broens *et al*.[2] explain that *maturity is gained* as one moves from one implementation layer to another. The ISO/IEC 15504 maturity levels and the maturity gained through Broens' implementation layers can be aligned as follows:

- For a *prototype*, identifiable work products are expected, although not necessarily rigorously planned and tracked (maturity level 1[16]).
- A *small scale pilot* would require that work products conform to specified standards and requirements and that they are planned and tracked (maturity level 2[16]).
- In a *large scale pilot*, previous pilots are repeated, hence the necessity that individual implementations of the process use approved, tailored versions of standard, documented processes (maturity level 3 [16]).
- An operational system, as it is defined by Broens, would require that the performance of the process is optimized to meet current and future business needs, and that the process achieves repeatability in meeting the defined business goals (maturity levels 4 and 5 [16]).

4.3. Life cycle processes

On this dimension all the ISO/IEC 15288 system life cycle processes are included.

5 VALIDATION

In the previous section a maturity model was proposed that can be used to measure, manage and optimize all telemedicine systems as well as the health systems within which they are implemented. The following research questions are set accordingly.

5.1 Research questions

- Q1: Can this framework be used to ***measure*** the implementation of a telemedicine system and the health system within which it is implemented?
- Q2: Can this framework be used to ***manage and optimize*** a telemedicine system and the health system within which it is implemented?

5.2 Validation workshop

On 14 June 2011, a telemedicine training workshop was held at one of the nine provincial Departments of Health. Of the 9 people who attended this workshop, 5 were medical practitioners and 4 were ICT system managers. The 9 attendees were briefed about the frameworks presented in this paper, after which the following assignments were given.

1. Map Khoja's eHealth readiness statements on the two-dimensional "Determinants-Maturity-Level"-plane (refer to Figure 2).
2. Map Khoja's statements on eHealth readiness on the two-dimensional "LifeCycleProcesses-Maturity-Level"-plane (refer to Figure 3).
3. Based on your experience from telemedicine implementation in the public health sector of South Africa, do you think there is a correlation between the average maturity level and the level of success?
4. Do you think such a maturity model can be instrumental in the achievement of sustainable telemedicine systems?

For assignments 1 and 2, attendees were provided with an A3-version of Figure 2 and Figure 3 as well as strips of paper, each containing one statement from the eHealth readiness questionnaire. Assignments 3 and 4 were executed as a focus group discussion.

Maturity Levels		Success Determinants: Policy and Legal	Technological Readiness	Diffusion and acceptance	External Interaction	Internal organization	(Financial) sustainability
Maturity Levels	Optimising						
	Predictable						
	Established						
	Managed						
	Performed						
	Incomplete						

Figure 2: Determinants-MaturityLevel-Plane

		Success Determinants: Policy and Legal	Technological Readiness	Diffusion and acceptance	External Interaction	Internal organization	(Financial) sustainability
Agreement	Acquisition Process						
	Supply Process						
Enterprise Processes	Enterprise Environment Management						
	Investment Management						
	System Life Cycle Processes Management						
	Resource Management						
	Quality Management						
Project Management	Project Planning						
	Project Assessment						
	Project Control						
	Decision-making						
	Risk Management						
	Configuration Management						
	Information Management						
Technical Processes	Stakeholder Requirements Definition						
	Requirements Analysis Process						
	Architectural Design Process						
	Implementation Process						
	Integration Process						
	Verification Process						
	Transition Process						
	Validation Process						
	Operation Process						
	Maintenance Process						
	Disposal Process						

Figure 3: LifeCycleProcesses-MaturityLevel-plane

5.3 Feedback

The minutes taken during the discussion session, addresses the research questions as follows:

5.3.1 Q1: Can this framework be used to measure?

The workgroup found it easier to relate to the *Determinants for successful telemedicine implementation* than to the *Life Cycle Processes*. Some of the terms used in a systems engineering context may have a different meaning within a health system context, for example *acquisition process, risk management, quality management* and *verification process*. Other concepts, such as *architectural design* and *validation* was foreign the delegates – especially those with clinical – rather that technical – background. The quantity of processes was also found to be overwhelming. In future versions of this maturity model, members from this community should be included in the process or (re)defining this axis.

The statements of the eHealth Readiness Instrument was easily understood and mapped on the *Determinants-Maturity-Level-plane*. As anticipated, the statements were mostly mapped towards the lower maturity levels. Future work will included the identification of statements which relates the all maturity levels. The workgroup, furthermore, suggested that *Technological Readiness* be split into two categories, namely *Infrastructure* and *Devices/Equipment*.

5.3.2 Q2: Can this framework be used to manage and optimize?

The second purpose of a maturity model is to facilitate an optimization process according to the best practices set for the specific domain. This is done in accordance with the defined maturity levels. The workgroup found the ISO15504 level descriptors to be useful, but not completely appropriate. However, the progression facilitated by the maturity levels, is appreciated.

One delegate commented a public health sector health practitioner do feel comfortable with the notion of measuring (diagnose) and putting measures in place to improve (treat), but that this process is seldom followed through until all levels of best practices are reached.

6 CONCLUSION

Change management was identified, in the literature [1], [11], [18]as well as by the DoH representatives, as the key to the successful implementation of telemedicine. A maturity model for telemedicine implementation could thus be instrumental in managing this change.

eHealth readiness instruments assist in measuring the extent to which an organization is ready for change, but it does not facilitate the change process. The ISO/IEC 15288 and ISO/IEC 15504 standards are useful for managing change caused by systems development, but need to be adapted for the telemedicine domain. The layered telemedicine implementation model helps to recognise the effect of maturity on telemedicine implementation, but it does not provide means to measure the maturity of a system.

The purpose of this paper was to develop a framework that can be used to encourage a systems engineering approach to telemedicine implementation throughout the product and project life cycle. The proposed framework has much room for improvement, as was identified in the previous section. However, it will indeed be worthwhile to address these issues so as to move towards a maturity model which would facilitate effective telemedicine implementation in South Africa.

7 REFERENCES

[1] **Yellowlees PM.** Successfully developing a telemedicine system. J Telemed Telecare 2005;11(7):331.

[2] **Broens THF**. Determinants of successful telemedicine implementations: a literature study. J Telemed Telecare 2007;13(6):303.

[3] **Essmann HE**. Toward innovation capability maturity. 2009.

[4] **ISO12207**. ISO/IEC/IEEE Standard for Systems and Software Engineering - Software Life Cycle Processes. IEEE STD 12207-2008 2008:c1-138.

[5] **ISO15288.** Adoption of ISO/IEC 15288:2002 Systems Engineering-System Life Cycle Processes. IEEE Std 15288-2004 (Adoption of ISO/IEC Std 15288:2002) 2005:0_1-67.

[6] **Khoja S, Scott RE, Casebeer AL, Mohsin M, Ishaq A, Gilani S.** E-health readiness assessment tools for healthcare institutions in developing countries. Telemedicine and e-Health 2007;13(4):425-432.

[7] Sood **S, Mbarika V, Jugoo S, Dookhy R, Doarn CR, Prakash N, et al.** What is telemedicine? A collection of 104 peer-reviewed perspectives and theoretical underpinnings. Telemedicine and e-Health 2007;13(5):573-590.

[8] **Grigsby J, Rigby M, Hiemstra A, House M, Olsson S, Whitten P.** Chapter 7: The Diffusion of Telemedicine. Telemedicine Journal and e-Health 2002;8(1):79-94.

[9] **Whitten P.** The diffusion of telemedicine - Communicating an innovation. SCIENCE COMMUNICATION 1997;19(1):21-40.

[10] **Doarn CR, Merrell RC.** Change, Discovery, Innovation--Where Does It Lead? Telemedicine Journal & E-Health 2009;15(3):209-210.

(11) **Mars M.** Telemedicine in South Africa. Telehealth in the Developing World 2009:222.

[12] **Jennett P,** Gagnon M, Brandstadt H. Preparing for success: Readiness models for rural telehealth. J Postgrad Med 2010;51(4):279.

[13] **Legare E,** Vincent C, Lehoux P, Anderson D, Kairy D, Gagnon MP, et al. Telehealth readiness assessment tools. J Telemed Telecare 2010;16(3):107.

[14] **Khoja S, Casebeer A, Scott R, Gilani S.** Validating e-Health readiness assessment tools by using qualitative research methods. eHealth International Journal 2007;3(1).

[15] **Molla A, Licker PS.** eCommerce adoption in developing countries: a model and instrument. Information & Management 2005;42(6):877-899.

[16] **Hwang SM, Kim HM.** A study on metrics for supporting the software process improvement based on SPICE. Software Engineering Research and Applications 2006:71-80.

[17] **Knowledge barriers to diffusion of telemedicine.** Proceedings of the international conference on Information systems: Association for Information Systems Atlanta, GA, USA; 1998.

[18] **Bashshur R, Shannon G, Sapci H.** Telemedicine evaluation. Telemedicine Journal & e-Health 2005;11(3):296-316.