Developing a Spatial Data Infrastructure for use in the military, how to assess progress?

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A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science in GIS

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Declaration of originality

This is to certify that the work is entirely my own and not of any other person, unless explicitly acknowledged (including citation of published and unpublished sources). The work has not previously been submitted in any form to the Manchester Metropolitan University or to any other institution for assessment for any other purpose.

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Date 15th April 2011

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Abstract

The future operations of the Dutch military will be characterized by uncertainty. Because the *"where, why, with whom, against whom* and *how"* questions cannot be answered, flexibility, interoperability and operational readiness are key terms for the Armed Forces. The quality and timeliness of information is of great importance to reach a state of information superiority that is in turn necessary to achieve decision superiority and thus competitive advantage over the adversary. The vision on future war reflects the belief that information superiority will be lifeblood of a post-modern military and the key to success. Network Enabled Capabilities (NEC) is the enabling concept to achieve this and the Network Information Infrastructure (NII) serves as the envisioned set of facilities to support NEC.

Geospatial information continues to be a critical force multiplier for the military and its operations. A Spatial Data Infrastructure (SDI) has the potential to distribute, share and to collaborate on geospatial data with large numbers of relevant stakeholders and communities. An SDI supports the decision making process and the role of geospatial information is rapidly changing and gaining importance. The Defence SDI (DSDI) is an integrated part of the NII as overarching infrastructure.

This dissertation aims at the construction of a conceptual roadmap for a DSDI that is supposed to improve the geospatial information position within the military. Alignment and integration with the overarching NEC concept and the Strategic Vision on NII is necessary. A framework with methods to assess the DSDI is included. The organisational perspectives and the user's perspectives were investigated and relationships with afore mentioned NEC and NII are highlighted where appropriate.

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Glossary

C2	Command and Control
C2CoE	Command and Control Centre of Excellence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CCS	Command and Control System
CNAD	Conference of National Armaments Directors
(J)COP	(Joint) Common Operational Picture
CTEF	Military Command Team Effectiveness
DSDI	Defence Spatial Data Infrastructure
DGIWG	Defence Geospatial Information Working Group
EBO	Effect Based Operations
GeoINT	Geospatial Intelligence
GIS	Geographic Information System
GII	Geographic Information Infrastructure
GSDI	Global Spatial Data Infrastructures
IAF	Integrated Architecture Framework
IAW	Information Age Warfare
ISO	International Standardization Organisation
LoD	Lines of Development
METOC	Meteorological and Oceanographic
NCO	Network Centric Operations
NCW	Network Centric Warfare
NEC	Network Enabled Capability
NGO	Non-Governmental Organisation
NII	Network and Information Infrastructure
NML	NEC Maturity Level
NSA	NATO Standardization Agency
NSDI	National Spatial Data Infrastructure
MoD	Ministry of Defence
OGC	Open Geospatial Consortium (geospatial related)
OGC	Office of Government Commerce (management of risk related)
OOTW	Operations Other Than War
PfP	Partnership for Peace
RNLAGA	Royal Netherlands Army Geographic Agency (in Dutch: DGKL)
SDI	Spatial Data Infrastructure
SOA	Service Oriented Architecture
(S)SA	(Shared) Situational Awareness
STANAGS	Standardization Agreements
SU	Shared Understanding
W3C	World Wide Web Consortium

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1. INTRODUCTION

1.1 Background

Since the 1990s the Dutch Ministry of Defence (MoD) has a growing demand for digital mapping, satellite imagery, geospatial analysis, location aware devices, and GPS. Geographic information is indispensable for the preparation and execution of military operations and the supporting intelligence processes.

Nowadays military operations are conducted in a dynamic and unpredictable environment. Soldiers on the modern battlefield face a complex spectrum of challenges. The Three Block War concept aims at full-scale military action, peacekeeping operations and humanitarian aid within the space of three contiguous city blocks (Krulak, 1999). The Comprehensive Approach aims at collaboration and sharing of information between all actors in complex situations. For instance the Afghanistan operation area includes besides all military forces, governmental institutions, non-governmental-organisations (NGOs) and industry. These parties have the greatest impact on the daily lives of the Afghan population whose support is needed to succeed.

During recent military operations it became clear that not all Defence partners (Joint[1] and Combined[2]) did use the same accurate and current geographical information in their weapon-, command and control-, intelligence-, and logistic systems. In most cases a complex conversion was needed to make the data fit for purpose. Besides the lack of using standards, the insight of *what* information and data are available, is still not commonly shared. The (Joint) Common Operational Picture ((J)COP) and (Shared) Situational Awareness ((S)SA) were therefore not up to date and lacked consistency, which can lead to collateral damage and fratricide (Kuipers, 2009).

The Strategic Vision on Network Information Infrastructure (NII) (MoD, 2011) points towards one information infrastructure centrally managed and capable of handling secure data transmissions and exchange, (secure) collaboration with military and non-military partners under all circumstances. The Internet infrastructure should be used when possible and as far as security and continuity of services allows.

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[1] Joint operations are operations between Defence forces of one Nation (Navy, Air force, Army).
[2] Combined operations are operations between Defence forces of more than one Nation.

1.2 Aim and objectives

The general *aim* of this research is to provide insight in the development and assessment of an SDI in a military environment. The Strategic Vision on NII (MOD, 2011) addresses problems as interoperability, availability, sensor data analysis and storage, affordability and information security issues in close relationship with the ambitions of the Dutch Armed Forces. A DSDI is part of this NII and it fuels the Network Enabled Capabilities (NEC) concept with geospatial information, these concepts need to be developed in coherence.

By investigating ways to assess or evaluate progress of the development of a DSDI, this research may contribute to the improvement of the overarching NII and NEC framework. A conceptual roadmap for the DSDI can be used to harmonize this process.

Furthermore the DSDI creates possibilities for making new connections and comparisons by crosscutting existing boundaries between different disciplines, time periods and geographical areas. In this way this research aims to contribute to new trends and innovations in the MoD. This is necessary for maintaining the high quality of the existing level of GIS expertise and knowledge within the MoD and it is of vital importance for keeping in touch with the frontline developments in the international arena of the military applications of GIS.

Both the concepts of NEC and SDI are complex and comprehensive. Therefore the research has a relatively large theoretical body. The main *objectives* for this research are formulated as follows:

- Review of relevant literature on NEC and SDI;
- Create an inventory of best practices for realising a DSDI by using recent insights and developments in computer science;
- Develop and evaluate a method for the assessment of the DSDI;
- Assess how a DSDI contributes to the improvement of NEC;
- Construct a conceptual roadmap for the development of the DSDI;
- Formulate recommendations for sustaining the DSDI for the long-term.

1.3 Research Problem

When developing SDI's it is important to assess their outcomes in order to justify the resources spent on those infrastructures. This task is difficult due to the dynamic and constantly evolving nature of SDI (Grus et al., 2007). Besides the long period of time it may take to develop and complete an SDI, it is also difficult to measure its value and benefits.

The performance of an SDI cannot be measured in terms of profitability of generic viability (Rajabifard et al., 2002). This is because SDI's are in nature complex and therefore will have complex performances (Rajabifard et al., 2002).

SDI assessment methods and criteria are mostly based on technical, financial and governance aspects (Crompvoets, 2006; Grus et al., 2007). Organisational aspects may be overlooked or underestimated, but they are considered important although it may be difficult to conceptualise it (Crompvoets, 2006). The SDI assessment will therefore play a crucial role in managing the SDI initiative (Rajabifard, 2008). The performance, efficiency and productivity of a system can only be improved if it is measurable or assessable (Kaplan and Norton, 1996).

Due to the dynamic character of warfare, the military business model is assumed to be different than the environment most civil SDI's serve in.

The main research problem is two folded:

1. Why is it important to have a DSDI and to keep it aligned with the NEC concept?

2. How can the development and maturity be assessed of an SDI within a military setting and in context with the military business model?

Sub-questions related to the main research problem are:

- What is the military business model (NEC) and what are the current trends?
- What exactly is an SDI and what are the current trends and developments?
- Which appropriate measurement frameworks and methods are available to evaluate progress and maturity of an SDI within a dynamic environment?
- What is the current status of geographic information handling within the military?
- What are the current and expected user needs?
- Which components are critical for the DSDI?

1.4 Relevance

Scientific relevance:

The transition of the Armed Forces from the old massive collective to stop the enemy coming from the East, to an expeditionary flexible military force that can operate all around the globe changed the dynamics of geospatial information handling dramatically.

The comprehensive approach forces the military to be more interoperable with non-governmental organisations and industry. The impact on SDI development and performance will be subject of this study.

Assessments of Information Technology (IT) systems and SDI's have been studied extensively, although the methodologies and the ability to generalize from the assessment frameworks, and the contextual factors in future SDI assessments are still unclear (JRC, 2006). Georgiadou and Stoter (2008) conclude in their research on SDI for public governance that a more integrative approach of assessing SDI's is needed to better understand the social context, the actual use of Geo-ICT and how they relate to each other

This research aims to contribute by combining the organisational and user's perspectives and best practice into an assessment framework applicable in a dynamic military environment.

Managerial relevance:

This research aims to develop a method to assess an SDI initiative in the context of the military business model. It may be used to justify resources spent on this development. It may also complement the already existing NEC maturity assessment framework that is not yet well enough equipped to assess geospatial information management. In the study on NEC within the Dutch Armed Forces, Krijgsman (2005) asserts that research is needed on the availability and assessment of new technologies. An assessment method to evaluate the aspects of a DSDI may therefore contribute to the NEC implementation and progress.

1.5 Methodology

The research questions cannot be answered easily within one single method, therefore a mixed-method approach is chosen. The organisational perspectives will be investigated by desk-research and interviews with senior management and experts. The user's perspectives will be covered partly by a survey and partly by interviewing experts in the field of geospatial information management. This mixed-method research will be discussed in detail in chapter three.

1.6 Dissertation Structure

The first chapter starts with a background of the problem and introduction to the research. Chapter two presents the review of relevant literature, journals and other sources of information on the military business model Network Centric Warfare (NCW), NEC and Information Age Warfare (IAW). Next the SDI theories and models will be discussed. Finally chapter two synthesises all information in a section that links the geospatial aspects to the military business model. Chapter 3 starts with describing the theories behind assessment of SDI and it presents the framework for this research, including the approach, models and instruments used including their coherence. Chapter 4 presents the results and analysis. Chapter 5 outlines the conclusions of the research including recommendations and a conceptual roadmap. Chapter 6 is used to reflect on the models, instruments, methods and approach including a brief discussion on general aspects. Figure 1.1 depicts the structure of the research conducted for this dissertation.

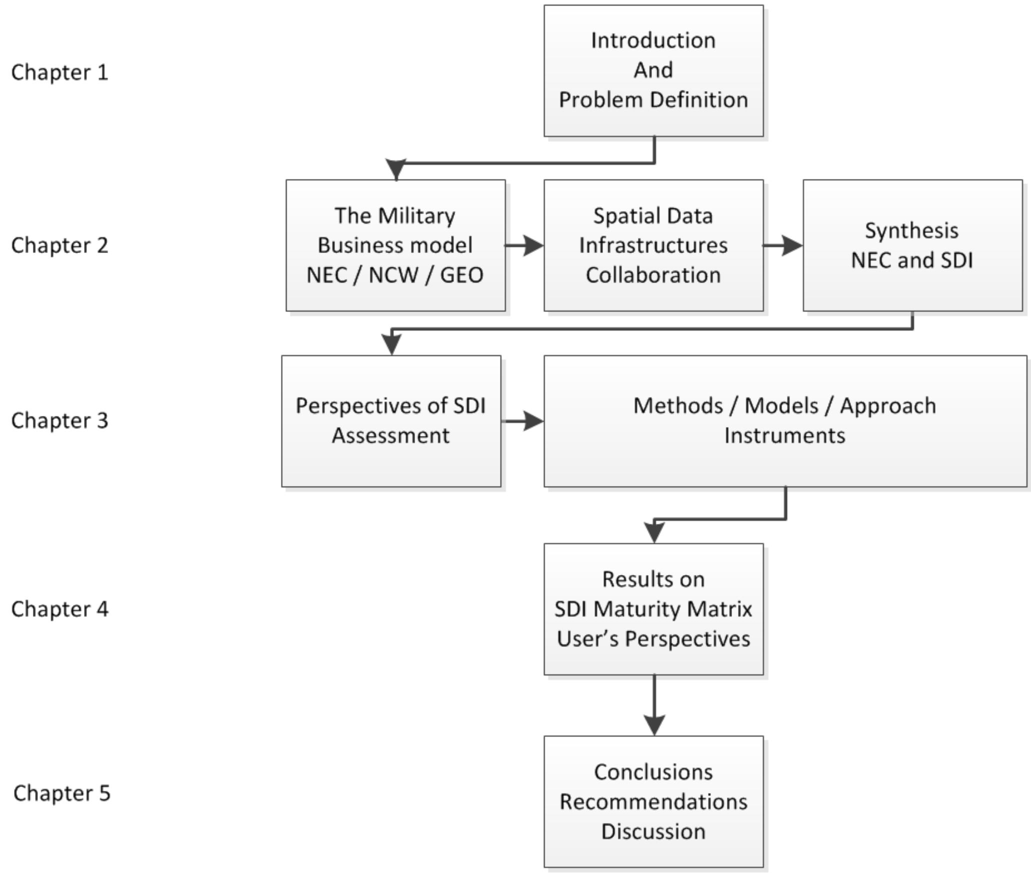

Figure 1.1: Research and dissertation structure.

2. LITERATURE REVIEW

This chapter reviews the concepts of NCW, NEC and SDI and it outlines the context in which geospatial information plays a role within the military and its dynamic environment and behaviour. The chapter starts with a review of the key theories and concepts of the military business model. Secondly the concept and theories of SDI development will be subject of reflection. The models and components used will be discussed and this section is used as fundament of the SDI assessment theory and approach in chapter three. The literature review concludes with a synthesis that outlines the connection of the body of knowledge related to the research problem and questions.

2.1 The Military Business Model

2.1.1 Introduction

This section describes the key theories behind the concept of the military business model, more specific the elements of NCW, NEC and Information Age Warfare (IAW). This background information is necessary to understand the differences between the civil business models and the military equivalent if it may be called a business model. It may also define a basis to understand the position of geospatial information and the SDI initiatives within the military within the right context.

2.1.2 What is Network Centric Warfare?

The concept of NCW is closely related to the vision of the United States of America (USA) Department of Defence (DoD) and its new way of looking at military operations. The concept can be considered as a new way of handling military situations in the future.

During the mid-nineties the concepts of NCW and IAW were introduced (Alberts et al., 2000; Alberts et al., 2001; Alberts, 2002).

The term NCW was *publicly* introduced in the Defence community by Vice Admiral Arthur K. Cebrowski and John J. Garstka in 1998 when they published the article *"Network Centric Warfare: Its Origins and Future"*. When writing the article, they were inspired by the tremendous interest of the commercial sector in the Internet and the new possible approaches for warfare in the Information Age. The concept of NCW closely relates to the term systems-of-systems, which can be defined as a collection of connected systems that process a result that no single system could achieve in isolation. NCW is more based on the modus operandi and the term systems-of-systems is more based on the systems needed to achieve NCW (Alberts et al., 2000).

There is no single and profound definition on NCW. The USA Department of Defence (USA DoD, 2004, p8.) describes NCW as follows:

"An information superiority enabled concept of operations that generates increased combat power by networking sensors, decision makers and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability and a degree of self-synchronization. In essence, NCW translates information superiority into combat power by effectively linking knowledgeable entities in the battle space".

From this definition we learn that NCW is a concept based on warfare; linking networks of sensors, weapon systems and decision makers can optimize the operational process. With this concept the operational effectiveness improves; right information, by the right people, at the right place, at the right time.

NCW is not a system, nor a capacity or capability. The NCW concept improves a force's ability to quickly, efficiently and effectively bring to bare all of its available assets to accomplish assigned missions. These capabilities result in part from the ability of a force to achieve a high degree of integration across a number of dimensions, the ability to move *information* instead of people and material. NCW allows forces to adapt more quickly to a dynamic environment (Alberts, 2000).

NCW is a force-enabling concept; it is conditional for other concepts like Effect Based Operations (EBO) that focuses on effective and integrated exploitation of military and non-military instruments to achieve strategic political goals.

But NCW is also important for precision engagement and focused logistics. All these concepts assume the integration (coordination and collaboration) of military and non-military allies involved in operations. The integration of these units is a central goal of the NCW concept. If the concept is used in the civil domain it may be called Network Centric Operations (NCO), another term used in the commercial sector with generally spoken the same objectives is Network Centric Enterprise (NCE).

The development of NCW is an evolutionary (cyclic) change process that may take a long time to transform the organisation (Alberts et al.2000). The start and end are not easy to define clearly. NCW may also be a buzzword that is used in several documents to highlight importance of activities, systems and plans.

2.1.3 Why NCW?

2.1.3.1 Transformation into Information Age

Most of the existing doctrines and practise of command and control were developed during the Industrial Age. This not only applies to military matters, it also counts for economies and civil corporations. These principles are mainly based on decomposition, specialization, hierarchy, centralized planning and decentralized execution (Alberts and Hayes, 2005).

The 21st century security environment differs qualitatively from the security environment faced during the Industrial Age. Military now need to respond to a wider range of potential threats, many that are difficult to assess and many cannot be responded to with conventional military tactics and capabilities. Many operations require that militaries work together with a variety of civil and nongovernmental partners (Alberts and Hayes, 2005). This change needs a comprehensive approach aiming at collaboration and sharing of information between governmental, NGO's and industry in complex situations because these parties have the greatest impact on the daily lives of the Afghan population whose support is needed to succeed. The cooperation in the light of national security and Public Order and Safety also forces the military to be more interoperable.

The information technology (IT) changed fundamentally from *platform* centric to *network* centric computing. The platform centric computing emerged with the widespread proliferation of PC's in business and home environment. Large investments in R&D and product development led to innovative technologies that created the conditions for emergence of network-centric computing (Cebrowski and Garstka, 1998). Information "content" now can be created, distributed, and easily exploited across the extremely heterogeneous global computing environment (Cebrowski and Garstka, 1998). Past decennia extended networks emerged and information could be transferred faster and cheaper between organisations and units than ever before. To illustrate the potential of information networks, the laws of Moore, Metcalf and Gilder are important as guidance (Alberts et al., 2000; Alberts and Hayes, 2005)

- The Law of Gordon Moore asserts that the capacity of computer chips doubles every 18 months by an equal price. This law is expected to be relevant until 2020.
- The Law of Gilder states that the bandwidth and speed of communication systems triples every 12 months and that for at least 25 years.
- Metcalfe's Law, which asserts that the number of nodes in a network increases linearly, governs network-centric computing; the potential value or effectiveness of the network increases exponentially as the square number of nodes in the network.

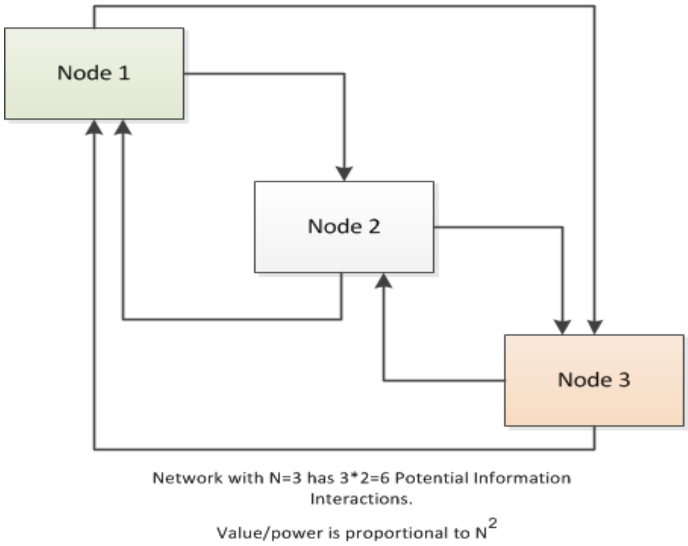

Figure 2.1: Visual presentation of Metcalfe's Law.

As the number of people in a network grows, the connectivity increases and if people can link to each other's content, the value grows exponential (Alberts et al., 2000). If a network exists, it enables the interaction between nodes.

NCW does not focus on network centric computing and communications alone. It primarily focuses on information flows, the nature and characteristics of the battle space entities and how they need to interact. It derives combat power from distributed interacting entities with significantly improved access to information.

2.1.3.2 Shared Situational Awareness (SSA)

SSA describes the awareness of a shared situation that exists in part or all of the battlespace or in the area of operations at a particular point in time. The information preceding the event or current situation may be of interest, as well as how the situation developed (Nofi, 2000). SSA develops in the cognitive domain; therefore education, training and doctrine are important factors that influence the SSA (Alberts et al., 2000). SSA is dynamic, a continuous cycle of perception, projection, comprehension and prediction.

According to Alberts et al. (2001) SSA consists of the components: Time and Space, Mission and Constraints, Opportunities and Risks, Capabilities and Intentions (blue forces vs. red forces and others) and Environment.

For this research the components Environment and Capabilities and Intentions are essential because of their geospatial content. Alberts (2001) states that relevant elements of the environment include: terrain, weather, social, political and economic elements.

Capabilities and Intentions are strongly related to Environment but have a more dynamic spatial character.

SSA is necessary to collaborate and to synchronise activity. A Joint Common Operational Picture (JCOP) is therefore of great importance, otherwise there will be no SSA which may lead to unsuccessful collaboration and synchronisation.

An important characteristic of warfare is called "fog of war", which addresses uncertainty. A commander needs to know where everyone is, what their capabilities are, and what the nature of their intentions is (Alberts, 2001). Another important characteristic is called "friction", which means that when carrying out plans things can go wrong due to poor communication and sometimes lack of shared knowledge (Alberts, 2001). However a significant residual fog will persist and it may have implications for military operations and for organisations. JCOP and SSA are therefore of great importance for a commander, without them the commander has to deal with too much fog of war and friction.

Although IT advances increase the capability to collect, process, disseminate and utilise information, the technology is still not that far and rapid enough to keep pace with the increases in collection. Humans are still required to make sense of what is collected.

2.1.3.3 Information Superiority

Alberts (2000) states that information has the dimensions of *relevance*, *accuracy* and *timeliness* and to obtain the maximum limit these dimensions should be nearby 100%. It may be obvious that these values are difficult to achieve. Consequently the objective is to approach the upper bounds faster than the competitor and thus gain competitive advantage. By exploiting IT, restructuring organisations and processes, customers could be provided with more value and thus the competitive position of the organisation improves by Information Superiority. This principle is used as the fundament for the NCW concept and is defined by Alberts (2001, p53) as follows:

"A state of imbalance in one's favour (relative advantage) in the information domain that is achieved by being able to get the right information to the right people at the right time and in the right form while denying an adversary the ability to do the same".

Kaufman (2004) has an interesting theory of NCW and argues that the NCW concept does not lead to information superiority by itself. This is based on two claims; first it overestimates man's capacity to deal with contradictory information and secondly it underestimates the enemy's ability for deadly mischief.

Information superiority and NCW are concepts that enable the military to create value from information and thus create information superiority that may lead to a state of competitive advantage. This state may be reached by achieving decision superiority and the ability to execute operations and deny the adversary to do the same.

The fundamental hypothesis of NCW asserts that a military force with these components and capabilities will be able to generate increased combat power by better synchronising effects in battle space, achieving greater speed of command and increase lethality, survivability and responsiveness or agility (Alberts et al., 2000).

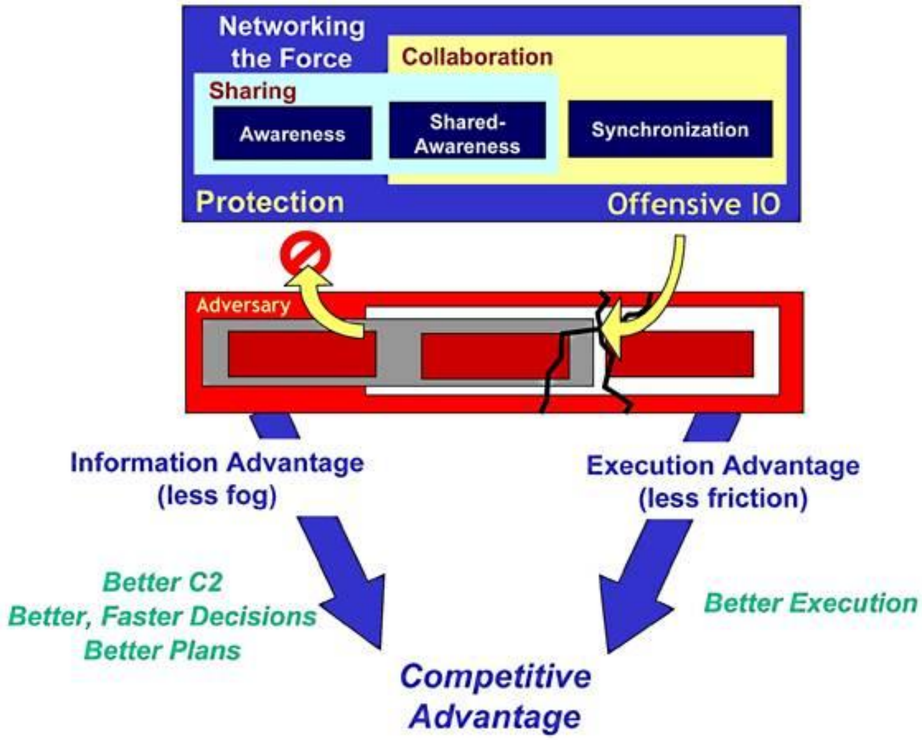

Figure 2.2: Competitive Advantage of NCW (Alberts et al., 2000).

2.1.4 NCW related to NEC

The concept of NCW has several forms and military allies use different terms. In this research the term Network Enabled Capabilities is used. The UK MoD introduced this latter and recently NATO adopted it as well (NATO Network Enabled Capabilities (NNEC)). The principles and basics of the UK NEC concept are almost the same as those of the NCW concept introduced by the US.

The MoD definition can be best formulated as follows (Krijgsman, 2005, p22):

"NEC improves the coherence of a multinational coalition force's operation, in order to gain decision superiority over the adversary. This will be achieved by optimal use of information and a complete as possible integrated and coordinated utilization of all available sources".

Compared to the definition of NCW may be concluded that the concept of NCW emphasises on the vision and the way to execute operations, where NEC concentrates on the capabilities needed to achieve it. Within NEC, the ‘network’ is not the centre of gravity; it is the *enabler to effective military operations*. The network is only of value within an operational context where effective and efficient use of scarce military recourses is needed. NEC may be seen as a translation of conceptual visions and doctrines into tangible military capacity. NEC also offers a framework to expand (further) development of doctrines (Krijgsman, 2005). Boyd et al. (2005) describes the main differences as follows:

- NCW is considered to be resource driven, while NEC is resource limited;
- NCW considers the network to be the primary driver, while NEC views the network as an enabler only;
- NCW is considered a doctrine, while NEC is considered part of a gradual improvement in force effectiveness;
- NCW is a planned and structured development of technology rollout, while NEC is expected to evolve through networking battlefield entities;
- NCW is limited, by definition, to warfare, while NEC is to be applied more widely to Operations Other Than War (OOTW).

The NII includes all managed services and facilities to support NEC on communication, the processing of data, integration and the sharing of information in a secure environment. The public Internet serves as important source for information and as information highway. NEC and SDI as well are fully dependent on network infrastructures and that leads to more threats such as cyber attacks (cyber warfare). The complete set of defensive countermeasures against cyber warfare is called cyber defence. The effectiveness of cyber defence increases if the number of networks decreases; on the contrary the network becomes more vulnerable then. Diversity and a balanced mix of military and civil capacities are envisioned to reduce this risk (MoD, 2011).

2.1.5 NATO Network Enabled Capabilities

The Dutch Armed Forces adopt the NEC concept that resides under the NATO Enabled Capabilities (NNEC) framework that will be discussed briefly in next sections. The NATO defines NNEC as the alliance’s cognitive and technical ability to federate the various components of the operational environment from the strategic level (including NATO HQ) down to the tactical level, through a networking and information infrastructure” (C2CoE, 2009).

NNEC includes the development of technical and operational interoperability standards and targets for adaptation. NNEC also aims to align national NEC related programs and not only technical interoperability but also operational interoperability, like training, doctrine etcetera (C2CoE, 2009).

For this research the NATO maturity levels and methodology will be used to create a context of the current situation where the DSDI has to find its place in.

NNEC Command and Control (C2) Maturity Model (NML) provides a framework to assess C2 approaches and capabilities. NML is rooted in the Capability Maturity Model (CMM) developed by the Carnegie Mellon University (C2CoE, 2009). The model consists of five C2 maturity levels that are related to the degree that an entity is able to effectively conduct network centric operations (Alberts et al., 2010). It is not only based on the ability to select of appropriate C2 approaches in divers situations, but it is also understanding (shared) situations and shifting between approaches if necessary; in preparation but also during the operation.

There are eight variables, or Lines of Development (LoDs) that are used to measure progress. The following table briefly describes the LoDs.

Doctrine	Fundamental principles that guide the employment of military forces in coordinated action towards a common goal.
Organisation	A cooperation unit or elements with a common mission that directly provides or supports war-fighting capabilities.
Training and Education	Training based on doctrine and tactics, techniques and procedures to prepare forces and staffs to respond to strategic and operational requirements.
Material	All items necessary to equip, operate, maintain and support military activities without distinction as to its application for administrative or combat purposes.
Leadership	The ability to influence, motivate and enable others to contribute towards the success of the organisation and inspire to change in order to improve effectiveness.
Personnel	The human capital of a force serving as part of an organisation tasked to accomplish a mission.
Facilities	A building, place or infrastructure that provides a specific kind of operating assistance to the military.
Interoperability	The ability to operate in synergy in the execution of an assigned task.

Table 2.1: NNEC Lines of Development (C2COE, 2009).

NML is developed on basis of the earlier mentioned NML and refined to fulfil the NATO forces requirements. Table 2.2 shows the defined NMLs including a brief description (Alberts et al., 2010; C2CoE, 2009).

Stand-alone	Closed to external interactions. Information is not shared; isolation is the common word. Decision-making is build up based on own information.
De-conflict	Planning conducted to prevent interference but with a distinct lack of harmonisation. Interoperability is pre-planned and restrictive. CIS does not support interaction across national and between NATO security domains. Extensive use of swivel chair interfaces (human interaction) is required. It is characterised by stand-alone applications and communication networks running with some "functional stovepipes" in place. Little Shared Situational Awareness due to limited interoperability.
Coordinate	Planning is coordinated horizontally and vertically but execution is mainly by component. Interoperability is pre-planned but not restrictive. CIS supports interaction across national and NATO security domains. The implementation of interfaces and gateways eliminates air gaps between separate systems. Some human interaction is still required. This phase aims to break the information barrier through "communication and information".
Collaborate	Planning and execution are coordinated horizontally and vertically. Interoperability is ad-hoc as needed. CIS is advanced semantic integrated registry and discovery services and all user services are accessible through generic portals or workspaces. Advanced semantic interoperability exists. By exploiting the Shared Situational Awareness in a better way, decisions can be made towards better actions in the field. "Advanced collaboration and planning capabilities" are introduced. Improved data sharing allows full collaboration.
Coherent effects	One homogeneous force. Complete situational awareness is possible through a proliferation of sensors and there is extensive information sharing and continuous interaction between elements. Seamless and transparent collaboration of all parties involved leads to unprecedented mission effectiveness. Interoperability including technical and operational is improved to the maximum extent.

Table 2.2: The 5 NMLs and brief description (C2CoE, 2009).

NNEC is about networking; NATO defines a network as a group of interconnected entities, such as a network of universities, people or a network of computers. The connection of entities and elements makes it a network (C2CoE, 2009; Alberts et al., 2002). Three networks can be identified (Alberts et al., 2010; C2CoE, 2009): First a technical Network, the physical infrastructure to enable acquisition, generation, manipulation, distribution and utilisation of information. Secondly a social network, all people with similar interests or concerns who are interactively involved to support a mutual goal. And thirdly the knowledge network that takes place in the minds of people, this is where perception, awareness, understanding and expertise reside and decisions are made (C2CoE, 2009).

2.1.6 Impact of NEC on the Organisation

By implementing the NEC concept, the armed forces will be enabled for operations in the Information Age. NEC is an innovative concept for operations, which means that changes in processes, personnel, organisation and culture are aspects to deal with. The concept is an evolutional and cyclic process without a clear start or end. The impact of NEC on the organisation will not be discussed in detail; this change process is worth a dissertation at its own. This section only highlights the aspects important for this study.

NEC has commonalities with change processes within the information management departments of other organisations. The automation and digitalization of operational decision-making processes can be marked as a first step within military organisations towards NCW. As long as systems operate in an autonomic environment and are focused on specific tasks, the first stage of NCW is not yet reached (Krijgsman, 2005).

NEC will also have an impact on the availability and nature of assets. The military effectiveness is no longer depending on more physical presence of soldiers, tanks, frigates or fighter planes. The precision and timely information to support target acquisition and actions based on this information will be of decisive importance. The "*how*, *when*, *what* and with *whom*" military recourses are operationally used, will be a much more dynamic process (Alberts, 2002). The quality of supporting systems such as sensor- and communication networks is at least equally important as the quality of weapon systems (Krijgsman, 2005).

Finding (sensor) data, transforming it into information and sharing it securely and fast with our own forces and allies to get a shared understanding of the area and to make better and faster decisions will be a challenge and asks for more efficiency within the departments.

Regarding spatial information processes need to be reshaped and structured to fulfil the requirements necessary for NEC. More specific, if a (J)COP is needed, the basic geospatial information should be current, accurate and coherent. To achieve this the geospatial information management has to be improved, standards and interoperability are needed and sharing of information should have priority (Kuipers, 2009). Capacity to process, to evaluate, to interpret and to analyse sensor data will be a challenge for the near future.

C2CoE (2009) concludes that the social and knowledge skills are as important as technical aspects in contemporary C2 organisations. Many underestimate the human factor and important improvements can be achieved on this aspect.

2.1.7 The role of Geospatial Information in NEC

Decision makers at lower levels of command require shared understanding of both the big picture and the local situation. This changed C2 principles demand timely, current, qualitatively and complete geospatial information over the area of responsibility, operations or battlefield. To reach higher levels of information superiority, the relevance, accuracy and timeliness of information have to increase. To support the units with this geospatial information, new and specialist applications will be required.

(S)SA includes the component environment which could encompass geodetic, geomagnetic, imagery, gravimetric, aeronautical, topographic, hydrographical, littoral, cultural, political and toponomic data that are accurately referenced to a precise location on the surface of the earth. At a basic level, geospatial information provides a map that can be used to indicate location.

Sensors are playing an important role within the military; for intelligence gathering, monitoring the operations area, situational awareness, tracking & tracing and many more applications. From this perspective, Heidemann and Bulusu (2001) concluded in their research on using geospatial information in sensor networks that these networks are depending on spatial information. Current sensor networks too often depend on ad-hoc or non-existing models of localization, logical location, and communication costs. Better models are required in each of these areas to achieve better operation. Better integration between spatial and sensor information is necessary for sensor networks to move from simply tracking to counting and monitoring areas.

Sensor mining suggests a role for (ad-hoc) sensor networks in long-term data analysis and problem detection; drawing conclusions based on distributed information gathering over time. (Geospatial) information quality is crucial for the entire Command, Control Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) chain and underlying processes that depend on correctly perceiving the military situation and in creating a common perception across all actors. Credibility of this information is also an important aspect on which the commander can act, if the commander perceives major uncertainties, he can act cautiously and execute plans to improve or develop better awareness. Sensors are extremely important to visualize and monitor the area of operations. Millions of sensors are in the field already and the data flows grow rapidly. As Lt. General Deptula, USAF deputy chief of staff ISR said recently in a Defense Industry Daily article: *"We are going to find ourselves in the not too distant future swimming in sensors and drowning in data."*

Next chapter discusses the concept of Spatial Data Infrastructures in detail.

2.2 Spatial Data Infrastructures

2.2.1 Introduction

The use of geographic information (GI) has increased considerably over the last decades and it has been acknowledged that it is a key factor in governmental decisions and private businesses (Williamson et al. 2003, Longley et al. 2005). To gain a better understanding of the existing model of SDI and how it evolved to its current forms, the theory behind SDI's is studied and presented. This may also help to determine which type of assessment model is needed (Hansen, 2005). There are many varying definitions for SDI, the following sections identify and compare most common elements.

2.2.2 SDI Definition

In general it can be said that the conceptual objective of an SDI is to create an environment in which all involved stakeholders can collaborate with each other and interact with the use of technology, to better achieve their objectives. There are many definitions created to describe an SDI, Chan (2001) collected eleven popular SDI definitions that were used around the world. Every definition differs slightly, but not one describes the SDI completely. A uniform definition of the objectives of SDI to allow worldwide benchmarking will be impossible to find due to different views and opinions (Grus et al., 2007). The following table presents three definitions that may cover most important aspects.

First definition by US and published in the Federal Register on April 13, 1994:
"National Spatial Data Infrastructure (NSDI) means the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilisation of geospatial data".
In 2005, Masser reworked the GDI definition extensively with following result:
"A spatial data infrastructure that supports ready access to geographic information. This is achieved through the coordinated actions of nations and organisations that promote the awareness and implementation of complementary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the (national) and regional scale are not impeded in meeting their objectives"
The GSDI Cookbook (2009) defines the SDI comprehensive:
"Spatial Data Infrastructure is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of, and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, and academia and by citizens in general".

Table 2.3: Three important definitions of SDI.

From these definitions we can learn that SDI evolved in time to a state that covers technology (hardware, software and networks), data, standards, policy, processes, organisation and people. As noted an SDI has to serve large communities. Collaboration should be possible and it should improve utilisation of geospatial information. The interaction of the geospatial information users, data end-users, suppliers and other value adding resources drive the development of an SDI. So, an SDI aims to improve the decision making process. Budhathoki et al. (2008) recognise three main areas that underpin all SDI's:

- Policy and organisation, the creation and maintenance of SDI's involves organisational, institutional, management, financial, political and cultural aspects;
- Interoperability and sharing forms the backbone of an SDI;
- Discovery, access and use of spatial data. The main purpose of SDI's.

2.2.3 SDI Evolution

The origin of SDI can be found in the need to standardize the storage of, and access to geospatial data and information. In the late 1970's national surveying and mapping agencies already recognised this needs but were merely focussing on the technical aspects. In time the institutional and organisational aspects were taken into account as well (Groot and McLaughlin, 2000). In the past decade more case studies and papers that value the development and implementation of an SDI were published. Burrough and Masser (1998) discuss the development of (multi) national databases and the need to access these sources of geospatial data. Nations started to establish National Spatial Data Infrastructures during the mid-1990's to fulfil this need.

But it remains hard to tell when exactly the SDI was invented. In most situations it takes a long breath to create an SDI and in some cases it even takes decades before they are fully operational. This process is likely to be an evolving one and organisations involved reinvent themselves over time. Rogers (1995) defines reinvention as the degree to which an innovation is changed or modified by a user, in the process of its adoption and implementation. Rogers also asserts that some innovations are difficult or impossible to reinvent and others are more flexible in nature and adopted and implemented in different ways. After studying the degree of reinvention involved in GIS implementation within the British local government, Campbell and Masser (1995) conclude that the meaning of technology such as GIS was constantly being reinvented at both the organisational and individual scales.

2.2.4 SDI Components

Rajabifard et al. (2002) developed a product based SDI model that covers three following core components: *access network*, *technical components*, *people* & *data* as depicted in Figure 2.4.

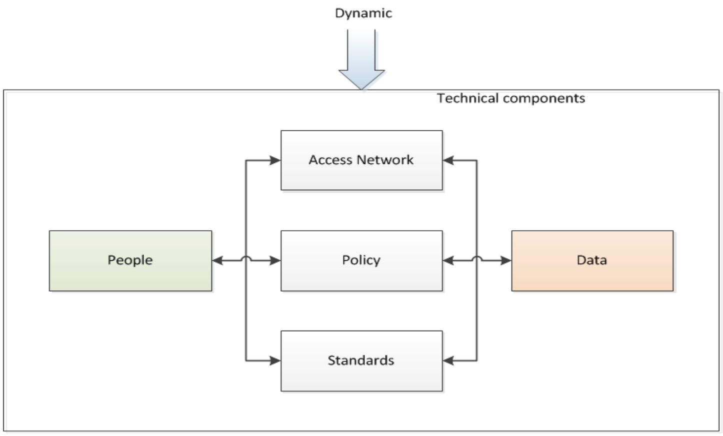

Figure 2.3: Nature and relations between SDI components (Rajabifard et al., 2002).

The components can be categorized based on interaction with the SDI framework. Because of the important and fundamental role between people and data this could be considered as a one group.

The second group is formed by the main technical components: access network, policy and standards. This second group of components is dynamic due to rapidly changing technologies and changing restrictions, responsibilities and user interaction that always has to find its way through the technology components.

<u>1. People:</u>

People are marked as important element of SDI; they are, or can be aggregated into groups with or on basis of other elements of SDI. Including cooperation between organisations, social and technical factors and geospatial information flows. Partnerships, social systems and stakeholders' different views influence the dynamic nature and characteristics of SDI. People are the key to transaction processing and decisions-making (Williamson et al., 2003; Rajabifard et al., 2002; Alberts et al., 2002).

Users are important to make a success of information systems. Crompvoets et al. (2004) assert that user-unfriendly interfaces and discipline-specific nature of metadata and clearinghouses are among the primary reasons for declining trend in clearinghouse use. Exploring intended users and the use of geospatial information before the actual system building may lead to more useful systems.

To affect users in the design process, they become more involved with the systems on the one hand and on the other hand, system designers are more affected in the actual use of the systems and this may lead to more useful systems as well (Nedovic-Budic et al., 2008). From the perspective of providing spatial data, people are getting more important as well. Initiatives of Voluntary Geospatial Information (VGI) such as Wikimapia and OpenStreetMap are becoming more popular and according to Goodchild (2007) the model of VGI clearly fits the model of SDI. A collection of individuals acting independently, and responding to the needs of local communities can together create a patchwork coverage (Goodchild, 2007).

2. Data:

Data provide content for an SDI, including the management and delivery of high quality metadata in on-line directories and portals. Data may consist of cadastral, topographical, administrative, hydrological, aeronautical, thematic layers and so on.

The discovery of spatial data is facilitated through metadata catalogues and portals that depend and rely on metadata standards (Craglia and Masser, 2002; Craig, 2005; Smith et al., 2004). This implies that good data management and quality management are mandatory, otherwise metadata may not be up-to-date, data cannot be discovered and the objectives of an SDI cannot be achieved (Crompvoets et al., 2006).

The up going trend that more sensors fly around than ever before, increases the importance of metadata as well. So, metadata is needed to organise geospatial data so that it can be found, accessed, stored, assessed and used appropriately. This metadata process is often overlooked because it requires time and recourses. But without metadata the value of geospatial data is less.

3. Standards:

Standards are defined as collective agreements on technical aspects, data and organisation with as goal interoperability and optimisation of the SDI. Standards ensure interoperability of data, datasets, technology, access mechanisms, processes and workflows (Smith and Kealy, 2003). Standards can be applied at many different levels within an SDI. In terms of data standards are required for quality, reference systems, models, data dictionaries, metadata, formats (Crompvoets et al., 2004). Bishr (1998) recognises six levels of technical interoperability: network protocols, hardware and operating systems, spatial data, database management systems (DBMS) data models and semantics.

The non-technical interoperability is identified as more problematic by Nedovic-Budic et al. (2004) and Craig (2005), the impediments of sharing are know but the solutions to solve the impediments are not always easy to implement. Trust is identified as the most mutual feature of sharing organisations (Harvey, 2003).

Four important standardisation organisations are providing standards that are important in the process of geospatial information disclosure. The Open Geospatial Consortium (OGC), the ISO TC-211, INSPIRE and the World Wide Web Consortium (W3C). These are all organisations with a different focus, but with the common goal of reaching a state of harmonisation and standardisation to support the interoperability.

For the military the NATO Standardization Agreements (STANAGs) and the Defence Geospatial Information Working Group (DGIWG) are additional sources with a role in standardisation. DGIWIG is an international body that develops military geospatial standards; it provides guidance and technical expertise to NATO and PfP countries and EU nations. The NATO Standardization Agency (NSA) and the Conference of National Armaments Directors (CNAD) provide the STANAGs. STANAGs are understood and supported by the industry.

4. Access Network:

The access network component is critical from a technical perspective; it facilitates the use of data by people via distribution networks such as the Internet, intranets or extranets. This may be depending on corporate policy or security issues. Vandenbroucke et al. (2009) suggest that the component network may also be considered as a collection of nodes that exchange geospatial information. Each producer and user is a potential node in the network. They can be more or less intense and nodes can even be isolated. This could be an organisation that use geospatial data in their organisation but have no sharing mechanism in place with any other node(s).

Links can be weakened due to the existing technological and/or non-technological barriers. The barriers can act as a kind of impedance; if the impedance is becoming too high, the link does not function. In contrast, the link will become stronger or the organisations (nodes) will become almost (virtually) one when measures are in place to enhance sharing and exchange of data (Vandenbroucke et al., 2009). This is a situation the SDI is envisioning: the SDI is a network of single entities, but they behave as if they are one continuum. This way of describing the sub-national (or national) SDI allows characterising the stakeholders and their behaviour. It will make us better understand them individually, as well as the impact of their behaviour on the whole network or parts thereof (Vandenbroucke et al., 2009).

5. Policy:

The component policy is critical for SDI development, for the production, maintenance, access and application of standards and datasets in the SDI. Examples of policy aspects are licensing, funding, privacy, security, metadata and custodianship. Policy is important to guide change and to control authorisation and access

Stakeholders will only actively participate if there are certain benefits or advantages to win for their organisations. Another aspect may be that there should not be a threatening situation by implementing an infrastructure (GSDI, 2009). Stakeholders should be involved closely in developing supportive policy. Some relevant considerations regarding development of supportive policy are presented in Table 2.4 (GSDI, 2009 (1-4); MoD, 2011 (5)):

The management of the data should be done as close as possible to source; this ensures the accuracy and quality of the data.
Stakeholders need to feel comfortable as active participants in the infrastructure. They should not feel threatened by infrastructure business models or policies.
Sustainable long-term business models and contracts.
Multiple levels of "buy-in"; low barrier to entry the access component of the infrastructure that allows the suppliers to choose a level meets the requirements and operational objectives. Especially important in the early operation of SDI.
Security issues caused by the broad availability of geospatial information might cause risk to national security, abroad as well as homeland security. The combination of maps, satellite imagery and other sources of data can easily lead to more classified information. Policy needs to be in place to cover these aspects properly.

Table 2.4: Supportive SDI policy.

2.2.5 Product-based vs. Process-based Approach

The model developed by Rajabifard as mentioned in the previous section is mainly product-based. Its main aim is to link existing and new databases and information that may result in added value. The shift of information systems towards the Information Age changes the focus from *product quality* to *decision quality* that may or should ultimately lead to decision superiority over the adversary (Watson, 1996; Alberts et al., 2000). Therefore the process-based approach as described by Rajabifard et al. (2002) will be discussed in this section.

The process-based model aims at facilitating the management of information assets, something NEC also claims to achieve. The objective is to provide better communication channels for the community for sharing and using data assets instead of linking databases and information (Rajabifard et al., 2002).

Figure 2.5 presents the process-based model for SDI development.

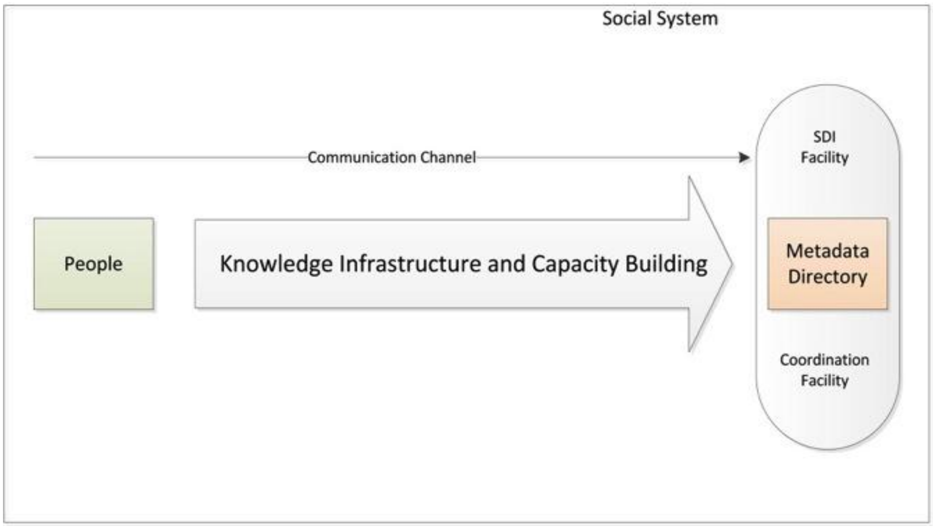

Figure 2.4: Conceptual process based model (Rajabifard et al., 2002).

Both models are focusing on decision quality in business processes as a final goal, but Masser (2005) asserts that the trend in development of SDI's is shifting from products-based to process-based approaches.

SDI's are considered to support business processes that make use of, or produce geospatial data and information and therefore it seems to make sense that both models can be applied in the development of SDI's. Van Loenen (2006) uses INSPIRE as an example of a mixed-approach of both. Van Loenen also relates the stages of development as discussed in section 2.2.7 to the use of the models. In his theory the first stages are more data centric, and thus product-based. In the third stage the hybrid-approach is applicable.

According to Grus et al. (2007) SDI's are complex structures because of the dynamic and non-linear transactions between the components. The functionality becomes more complex in time as new applications of the SDI emerge and are adopted by the users. The SDI model changes from a product-based structure to a service-centric structure that makes assessment even more complex.

Rajabifard (2007) relates the product- and process-based approaches to the generations of SDI Development. This theory can be linked to the development of NEC, because this development continuum also changes from product-based approaches through a process-oriented environment towards the ultimate form of user-centric operations. Figure 2.6 presents the continuum of SDI development.

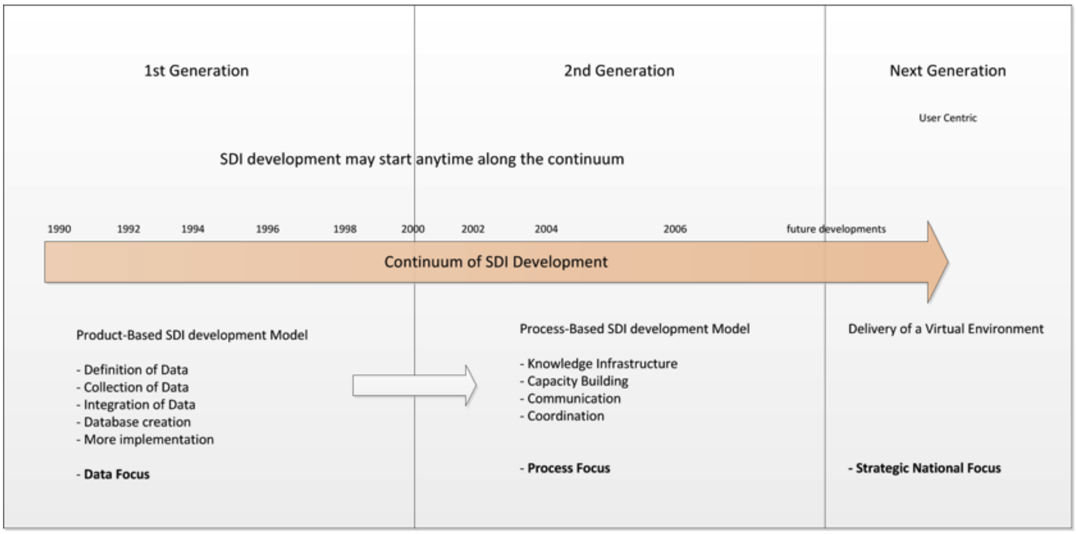

Figure 2.5: The continuum of SDI development related to generations (Rajabifard, 2007).

For the first generation of SDI's the data was the primary driving force and a technology push was evident. The value of SDI's was measured in terms of productivity and output. By sharing geospatial data and information efficiency is achieved.

The second generation focuses on the actual use of the geospatial data and information or its application(s); pulled by demand. User needs are central and the driving force behind the SDI development. Better understanding of geospatial decision-making, the complete system and the financial and cultural benefits of SDI development will arise (Rajabifard et al., 2003).

The Next generation is user-centric and aims at a virtual environment with a strong strategic national focus. The up-coming cloud services and VGI are premature (part) examples of the next generation SDI's.

2.2.6 SDI Hierarchy

Many countries are developing SDI's at different levels ranging from local to state, from national to regional levels and some countries participate in the global spatial data infrastructure (GSDI). These initiatives facilitate better management and utilisation of spatial data assets (Williamson et al. 2000).

According to Burrough and Masser (1998) the most important objectives of these initiatives are to promote economic development, to stimulate better government and to foster environmental sustainability.

As a result of developing SDI's at different levels, a model of SDI hierarchy that includes SDI's developed at different political-administrative levels was developed and introduced (Chan and Williamson, 1999, Williamson et al. 2000). Figure 2.2 illustrates the SDI hierarchy where inter-connected SDI's at corporate, local, state, national, regional and global levels.

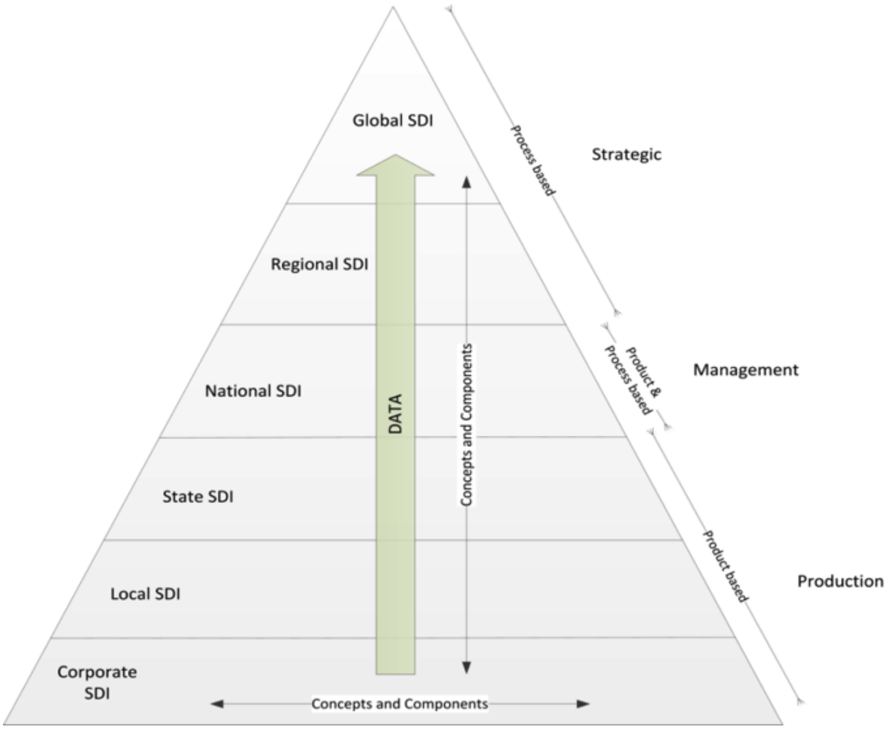

Figure 2.6: SDI Hierarchy Model adopted from Chan (2000) modified by Rajabifard (2002).

Each SDI at the local level or above is primarily formed by the integration of spatial datasets originally developed for use in corporations operating at that level and below. The vertical relationships are both way interactions, the SDI's at all levels under the global level look up and down at component level and conceptual level. There are also complex horizontal relationships between SDI's within its own jurisdictional level (Williamson et al. 2000). Rajabifard et al. (2002) extended the model by implementing the management levels. Relevance for this dissertation is that each layer of the organisational level has its distinctive information needs and requirements. Rajabifard et al. (2002) suggests that the strategic level (Global and Regional SDI) should follow the process-based development strategy. Main reason is the voluntary nature of SDI partition within these levels of SDI hierarchy.

2.2.7 The SDI Stages of Development

The MoD is combining, improving and integrating geographic services in several projects throughout the organisation. In the light of these developments, the SDI Stages of Development as outlined by Van Loenen and Van Rij (2008) are interesting and will be discussed in this section.

Stage 1. Stand-alone:

Different departments build their own infrastructures, data, models and standards. There is a lack of leadership and no need to invest in common interests. At individual level this may be adequate but at the general level this is not effective and more expensive (Bemelmans and Matthijsse, 1995). In this stage only a few have insight in the concept of SDI but there is no support at senior management level, nor there is any mechanism to convince them (Van Loenen and Van Rij, 2008).

SDI is not a priority of the individual organisations, but more another development that is perceived as not relevant for the organisation (Van Loenen and Van Rij, 2008). Organisations are not dependent on each other for their performance and there is and there is no need for a corporate vision. Financial sustainability is limited to projects, no long-term investments.

Boonstra (2004) describes this stage as cynical, in that individual organisations that are potentially going to participate in the SDI are not experience any problems or bottlenecks in their own organisation.

Change is considered to be unnecessary, focus is on own interest, no willingness to change exists and communication between organisations is not open (Boonstra, 2004).

Stage 2. Exchange and standardization on technical level:

External developments drive the change of organisations to operate efficiently and new technologies emerge. Organisations may become aware of the benefit of sharing and using information of other departments and organisations. It may be a way to address the increasing pressure on budgets, especially in an economic climate of recession.

In this second stage a common goal and the recognition of a (potential) win-win situation are critical (Rezgui et al., 2005). The development of the SDI is gains momentum but is still fragile. At the end of this stage, a first vision is created and priorities are set (Watson et al., 2001). The dominant role of the information producers results in the primary focus on standardization, digitization, information integration and reducing duplication; product based strategies (Williamson et al., 2003).

From an organisational perspective, this stage is described as “sceptical stage”. There is sufficient dissatisfaction about the current situation and/or organisations desire a new situation (Boonstra, 2004).

Stage 3. Intermediary:

This stage is between the problem identification and the envisioned situation. Central in this stage is implementing the vision developed in previous stages. In this stage the islands of organisations are becoming a network of organisations. The focus is more at coordination and meeting user-needs as described in the process-based SDI as discussed in 2.2.5. An accepted non-threatening leader, for example an independent coordination body, may lead this network. The potential of new technology gains awareness and new applications emerge. The availability of information that can be used makes participants in the SDI start to realise the potential of the network (Watson et al., 2001). The data perspective focuses on fulfilling the initial vision and starts with the process of institutionalize the SDI framework datasets. The responsibilities and roles of organisations within the SDI are formalised and information management and system management are implemented (Bemelmans and Matthijsse, 1995).

In this stage the distribution of tasks and the requirement of organisations to focus on core tasks result in interdependencies between organisations. A critical factor in this stage is the extent of willingness of organisations to cooperate with other (Van Loenen, 2006).

Stage 4. Network:

The SDI has become a network organisation with a clear vision and pro-active operations (Van Kerkhoff et al., 1999). The SDI has become a "multi-purpose" system with clear distribution of responsibilities and shared leadership. It includes well-integrated information from multiple systems and sources (Watson et al., 2001).

Data or information is maintained at the source and comprehensive metadata documentation has to be available (Watson et al., 2001) and duplication of effort is minimized. Standardization has shifted from supplier- or product specific to adherence, and then to international standards with a supplier independent nature (Bemelmans and Matthijsse, 1995). According to Boonstra (2004) this stage only a few bottlenecks exist and the change process is process driven by innovative motives.

2.2.8 Collaboration and Sharing of Geospatial Information

From the network perspective, the SDI has potential to distribute, share and to collaborate geospatial data with large numbers of relevant stakeholders and communities (Crompvoets et al., 2008). Collaboration efforts such as Open Street Map demonstrate that this concept works, although much research is not yet available. Goodchild (2007) concludes in his study on Voluntary Geographic Information (VGI) that this concept fits in the model of NSDI.

A group of individuals acting independently creating maps that suite the needs of local communities. Budhathoki et al. (2008) argues that SDI is still needed as fundament for agreements, policy, standards, organisation and interoperability.

For a VGI these aspects may be useful and an SDI might be reconceptualised to support the VGI. The collections of non-professional users produce and share geospatial information and thus participate in the production process. Craglia (2007) focuses more on the evolution of VGI that may cause challenges when the audience of the reconceptualised SDI grows. The validation and quality assurance process will be different and more real time data need to be included. Goodchild (2007) argues the importance of sensor networks. Three types of sensor networks are identified: static, carried sensors and human sensors. According to Goodchild (2007) VGI makes effective use of this network, enabled by Web 2.0 and the technology of broadband communication.

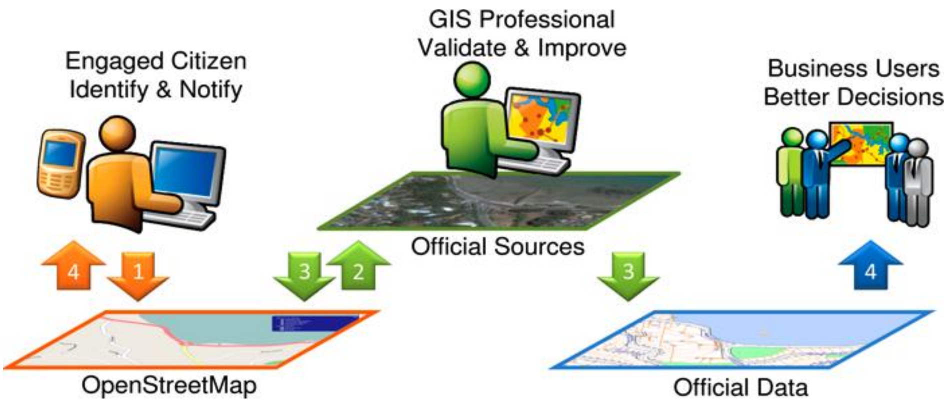

Figure 2.7: Volunteered Geographic Information (VGI) as proposed by Swann (2010).

In the current operating environment there is abundant information to be gathered among the civilian population on the street and in the villages, and that is where the individual Soldier has the edge over technical means. The Army gave this concept a name: “Every Soldier is a Sensor.” (CALL, 2008).

McDougall et al. (2006) defined collaboration as a process to reach goals that cannot be achieved by one single agent. The three components are:

- Jointly developing and agreeing on a set of common goals and directions;
- Sharing responsibility for obtaining those goals;
- Working together to achieve those goals, using the expertise and recourses of each collaborator.

2.3 Synthesis of the Military Business Model and SDI

Between the NEC concept including its NII and the SDI concept similarities and differences can be observed. When the components of SDI are taken as reference, the following comparison can be made.

First of all people, they are one of the most important elements of SDI and NEC. If there is no trust between parties, cooperation, sharing of information or collaboration will not happen and the concepts will both fail in reaching its goals. People as a sensor in combination with SDI and NEC seems a powerful concept that needs more research. Secondly, geospatial content in a DSDI is used for analysis; basic background maps and serves as important input for the NEC processes and finally decision-making and better synchronisation of resources. Difference between both concepts may be that NEC has a more dynamic content and an SDI may serve more as a static content environment. Sensor networks and VGI may in time be incorporated into SDI as well; which might make an SDI also more dynamic in content. Geospatial content is part of the NII and the complete information management process. NII has to provide the technology, agreements and people to facilitate the activities and tasks necessary in a networked force. Thirdly the access network, without this component both the concepts will not function properly and benefits or common goals will not be achieved. The network glues all nodes together. The networked perspective of Vandenbroucke et al. (2009) and the VGI concept as proposed by Goodchild are interesting if compared with the NEC concept, both highlight the value of the Law of Metcalfe and both see people as important sensors of geospatial information.

The Achilles' heel of a networked force is the network itself. Therefore information security and physical security of the network components are important. For an SDI in a civil environment this might be less urgent and besides of commercial restrictions and limitations no other constraints are hampering exchange of geospatial information. In the military environment practically all information in theatre has some kind of classification. When these classifications differ, exchange is difficult due to information security restrictions. Another related effect that needs more research is the collection of geospatial information that at its own does not have a security classification (or only a low grade), but that may have as a pile of layers a higher grade of security classification. Security policies need to be in place and people should be aware and trained to work in line with these policies. Trade-offs may be necessary to enable the sharing of information between the military domain and the SDI domain.

3. DATA, METHODS AND INSTRUMENTS

3.1 Introduction

This chapter emphasises on the theories and perspectives of assessing SDI's, the methods, approaches and instruments. First the aspects of SDI assessment will be discussed; next the models, methods and approach of this research are explained and finally the setup of the instruments used will be outlined.

3.2 Assessment of SDI

3.2.1 Introduction

The development of a DSDI may take a long time and substantial budgets and resources are needed. To justify these investments spent on such infrastructures the outcomes should be measurable. Because SDI's are complex, dynamic and constantly evolving infrastructures with sometimes vaguely defined objectives, it is difficult to assess SDI's from one perspective (Grus et al., 2007). Besides this theory, external influences put pressure on budgets and thus priorities need to be set accordingly.

3.2.2 Perspectives of Assessment

Assessment of SDI is closely related to the evaluation of IS/IT. Doherty and King (2004) describe evaluation as a process of establishing by quantitative and/or qualitative techniques the value of IS/IT projects to the organisation. The need to evaluate or assess IS/IT is commonly agreed, the way *how* to evaluate differs and can be subject of discussion. Crompvoets et al (2008) conclude in their publication with the suggestion that three important questions should be addressed before starting the assessment of SDI.

First the user of SDI assessment; A policymaker has different demands than a manager or politician. A distinction can be made in hierarchy with three levels: strategic (policy), management or operational. Secondly SDI's can be evaluated with different perspectives in mind and with different objectives as required results. The perspectives can for instance be organisational, technical, financial and performance. The required results can vary as well, in relation with the perspectives but also in level of detail and scale. Third important assessment perspective is *what* is to be assessed; it may be an assessment of performance between SDI's or it may be an evaluation of internal processes or even an assessment of the concept of SDI.

For this research the SDI internal processes of development were evaluated from the <u>organisational</u> and the <u>user's perspective</u>.

Georgiadou et al. (2006) add timing as important factor in selecting the right approach. Timing is explained in terms of moments to perform assessment. Three moments can be distinguished:

- *"A priori"* needed to decide whether to implement the project and to justify it;
- *"During"* when systems are developed or implemented to measure progress;
- *"A posteriori"* to evaluate the outcomes related to the expected results.

The development of a roadmap for DSDI mainly consists of organisational aspects at the management level. The user's perspectives and desk-research cover the operational aspects. This research can be used for *"A priori"* and *"during"* moments because the development of the DSDI is not one programme but more a collection of smaller projects that are not yet linked clearly to each other. Some projects are already further in progress phases and some other are still in planning phases or at the drawing board.

When looking at the evolution of SDI's it is not unexpected to see that the emphasis in assessment was until recently on the access to geospatial information and not on the use and the users (Askew et al., 2005). When working towards the next generation of SDI's that is mainly user-centric, it becomes even more important to pay attention to user's perspectives. The NEC concept is also user-centric, and the strategic vision on NII promotes the perspectives of the user as well. As depicted in Figure 2.6 this evolution from product-based to user-centric is a journey that cannot be accomplished in a short time frame and comes in phases. To establish a roadmap the current position of the envisioned DSDI has to be determined and assessment methods need to be tailored to the right needs.

3.2.3 Multi-View SDI Assessment Framework

Due to the increased research on and the development of SDI assessment methods, the approaches to evaluate SDI's in all its facets have matured (Crompvoets et al., 2004). The multi-view framework as proposed by Grus et al. (2007) is intended to facilitate the assessment of SDI's. This framework consists of a number of approaches that may be applied simultaneously. The framework can be tailored to fit and support the user's assessment purpose and goal (Grus et al. 2007). The multi-view framework is equipped to assess the multi-faceted character of SDI's; each approach evaluates the SDI from a different perspective with specific objectives.

The advantage of this framework lies in its flexibility, the wider scope and multi-disciplinary perspectives (Crompvoets et al., 2008). Figure 3.1 presents the conceptual model of the multi-view framework used for this research with in green the chosen approaches.

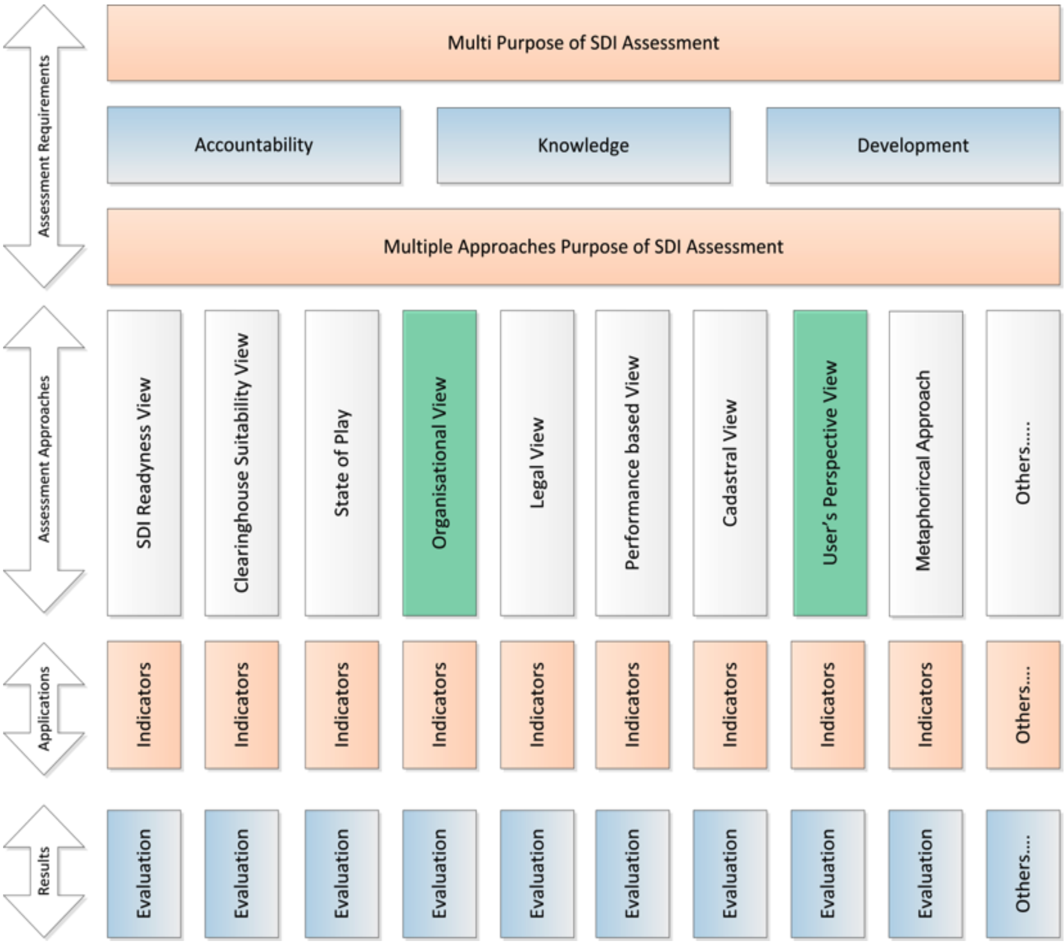

Figure 3.1: Conceptual model of Multi-View SDI Assessment Framework (Grus et al., 2007).

Chelimsky (1997) recognises three main purposes of SDI assessment: *Accountability*, *Knowledge* and *Developmental*. Developmental assessment has the purpose to measure and recommend changes in organisational activities and to monitor how projects are being implemented, there may be some correlation to the *"A priori"* moment as discussed in previous section.

Performance indicators or key aspects to measure are important ingredients. Because the DSDI has to be developed, the focus lies on the requirements development and knowledge. From the policy and management level the assessment perspective will be on organisation; fed with the user's perspective and best practices and theories.

The multi-view framework as presented by Grus et al. (2007) contains several methods that not only focuses on the evaluation of performance of SDI's, but also investigate the more functional aspects that might help to improve the development of DSDI. Figure 3.2 presents the approaches that Grus et al. (2007) examined and that were implemented in the multi-view framework. The figure also briefly describes the goal, method, applicability and purpose.

Assessment Approach	Goal / Description	Method	Applicability	Assessment purpose
SDI Readyness View	To assess if the country is ready to embrace the SDI development	Survey	Implementation	Developmental Knowledge
Cadastral View	To measure five evaluation areas of LAS	Survey	Needs Approvement	Knowledge Accountability
Organisational View	To measure the SDI development from the institutional perspective	Case Study, In-depth Interview	Applicable	Developmental
Performance based View	To measure SDI effectiveness, efficiency and reliability	Not available	Needs improvement	Accountability
Clearinghouse suitability View	To measure the development and impact of SDI clearinghouses worldwide	Survey, key informants	Applicable	Developmental Knowledge
State of Play View	To measure the status and development of SDI's	Document study, survey, key informants	Applicable	Developmental Accountability
User's perspective	To measure the status and development of SDI's	Document study, survey, key informants	Applicable	Developmental Knowledge
Metaphorical	To analyse organisational and management aspects of the SDI	Literature review	Needs development	Knowledge
Legal	To measure complicance, coherence and quality of the SDI legal framework	Case studies	Needs improvement	Knowledge

Figure 3.2: Assessment approaches summarised, including purposes (Grus et al., 2007).

For this research the approached in green are chosen, next sections explain why these approaches fit this research best.

3.2.4 The Organisational Perspective

The SDI maturity matrix can be used to assess the coherence of the geospatial community within the Dutch armed forces. A better coherence may lead to a more successful DSDI. Successful implies a multipurpose system with clear distribution of responsibilities and share leadership (Kok and Van Loenen, 2005). The SDI maturity matrix is part of the organisational perspective approach and may help to determine the starting point of the DSDI development and it may draw the outlines of the conceptual roadmap for the DSDI. The SDI maturity matrix is used on a corporate scale, to measure the internal processes of the DSDI and it may serve as a fundament for the conceptual roadmap.

The SDI maturity matrix is a pattern to assist in the development of SDI strategies; it roughly identifies the status of organisational aspects (Crompvoets et al., 2008). So it may be that too much detail is missing to distinguish differences in maturity between departments within Defence.

Another weakness of the method might be the limited view on the economical aspects that influence the SDI. The theory suggests that the ultimate stage to strive for is the networked stage including a major network that connects all nodes. The development of such an infrastructure might be economical not always be preferable or it might be too difficult to integrate with other existing networks.

The SDI maturity matrix consists of the four stages of SDI development discussed in section 2.2.7 in correlation to six key aspects: vision, leadership, communication, self-organizing ability, awareness for GII and financial sustainability.

For this research the model has been extended with the aspect of information security, which will be explained in next section.

3.2.5 Extending the SDI Maturity Matrix

A network that may consist of computers, servers or even persons connects nodes in a networked force. Information security is identified as a potential weakness of such infrastructures (MoD, 2011). The Wikileaks affaire might be a good example to address the importance of this weakness. Security regulations and measures for an SDI in a civil proposition may not be as strict as in a military setting.

The Strategic Vision on NII emphasises on the organisational aspects of information security. For that reason the aspect of information security has been added to the SDI maturity matrix as presented in Figure 3.3 on next page.

Aspect \ Stage	Stand-alone Initiation	Exchange Standardization	Intermediary	Networked
Vision	Focus on individual organization	Developed with all stakeholders	Implementation of vision	Commonly shared and frequently reviewed
Leadership	Focus on individual organization	Questioned	Accepted	Respected by all stakeholders; "champion"
Communication	Focus on individual organization	Open between (public) parties	Open between all stakeholders	Open en interactive to all
Self-organizing ability	Passive problem recognition	Neutral problem recognition	Actively helping to solve identified problems	Actively working on innovation
Awareness for GII	Professionals in one organization: Organizational SDI	Professionals of organizations together: SDI	Awareness at many levels including Decision Making	Commitment at all levels/ continuous support in politics and management
Financial Sustainability	Limited to projects	Neutral	Guaranteed for certain period	Sustainable but frequently reviewed
Information Security	Strict, focus internally. No structural sharing and collaboration	Strict but focus on corporate. Development of risk management	Implementation of risk management. Multi-level security	Flexible information security, object-based security

Figure 3.3: SDI Maturity Matrix adopted from Van Loenen et al. (2006).

The best way to secure systems is to forbid any kind of connection and to encipher or encrypt all information in such a way that information is only available for some insiders. This hampers interoperability and it will be hard to collaborate in ad-hoc situations (MoD, 2011).

Information security may be seen in relation to risk management that identifies, assesses and prioritises risks. It may be followed by a coordinated and efficient use of recourses to minimise, monitor and control the probability and/or impact of events or to make use of opportunities (OGC, 2007). Risk management adds value to the decision-making process. Four stages can be derived from best practices. In the first stage the information security is strict and focused on internal department regulations and restrictions. This stage is dominant by avoidance of any risk. No framework for risk management is implemented and there is no need to be more flexible. This situation might work well for an isolated unit but in situations of cooperation within coalitions this could frustrate operations.

The second stage is marked by a strict security policy based on corporate regulations and thus restrictions; exchange is already better arranged within the corporate. The nodes of the network are connected with all kinds of security countermeasures in place. There is a better understanding of information security issues and there is a need to be more flexible because of external influences such as ad-hoc collaboration. The fundaments of a corporate management of risk framework are built; some departments already may have their own management of risk framework or set of rules. In stage three a management of risk framework is implemented and all departments agree and adhere to the utilisation of the framework, tools and mechanisms. The fourth and last stage is the ultimate network with a fully operational risk management framework in place. All members understand the policies and benefits; the framework is subject of review. Risks can be shared and transferred between stakeholders, shared responsibility.

3.2.6 User's Perspective

A 'good' information system that is perceived by its users as a 'poor' system is a poor system. This statement served as a fundament for the theory that user satisfaction is a key aspect for information systems development and in the support of decision-making (Ives et al., 1983). There are several models that could be used to measure the users acceptance. The following table briefly lists commonly used models.

Model	Use
TRA Theory of Reasoned Action (Fishbein and Ajzen, 1975)	Predicts and explains the people's behaviour in a specific situation. In the model, behaviour is strongly influenced by intention. TRA served as fundament for TAM.
TPB Theory of Planned Behaviour (Ajzen, 1981)	Explains social behaviour and the use of IT. According to Ajzen (1981) intention is a predictor of behaviour. Ajzen (1981) defines PBC as the perceived easy or difficulty of performing behaviour.
IDT Innovation Diffusion Theory (Rogers, 1983)	IDT provides a framework that supports predictions for the time period it takes to accept a technology (Rogers, 1983). Constructs are characteristics, communication networks and characters of the adopters.
TAM Technology Acceptance Model (Davis, 1986)	Davis (1986) developed TAM to explain the use and acceptance of information technology.
TAM2 Technology Acceptance Model 2 (Venkatesh and Davis, 2000)	Extension of the original TAM, it includes social influence processes.
UTAUT Unified Theory of Acceptance and Use (Venkatesh et al., 2003)	The composition of eight models (TRA, TAM, MM, TPB, Combined TAM-TPB, PC Utilization, IDT and Social Cognitive Theory. It aims at explaining the users behaviour and intentions to use an IS. Four critical constructs are direct determinants of usage intention and behaviour (Venkatesh et al., 2003)

Table 3.1: Models commonly used for evaluation or assessment user acceptance.

On-going evaluation research is still focussing on the access to geospatial information instead of the use and utility of the infrastructure and user aspects are neglected (Masser, 2005; Askew et al., 2005). For this study the user's perspectives were investigated with two approaches, a survey to measure the GIS end user's acceptance in general and interviews with experts in the field of geospatial information management within Defence to determine the experts view.

These experts are also interviewed as part of the SDI maturity matrix because of their vision and in-depth knowledge of the organisational aspects. The opinions of experts were used to formulate statements and to validate the model by cross-referencing the results.

The Technology Acceptance Model (TAM) as introduced by Davis in 1986 has proved to be effective as measurement model for the implementation, the acceptation and use of ICT systems. It is also a broadly used, robust and validated model that predicts and explains the behaviour of users. TAM is rooted in social psychology and the model is an extension of the theory of reasoned action (TRA) (Fishbein and Ajzen, 1975). The model addresses the issue *how* users come to accept and use a technology. Two specific variables are the basis of the theory: *perceived usefulness* and *perceived ease of use*. Both variables are important constructs for the user acceptance (Davis et al., 1989). The model evolved during the years it was used, for this research the final version as proposed by Venkatesh and Davis (1996) was used. The following figure shows the conceptual model.

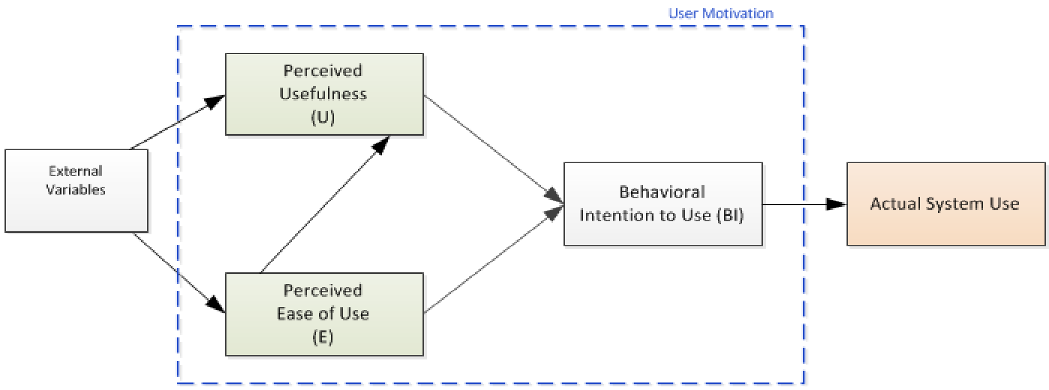

Figure 3.4: Final version of Technology Acceptance Model by Venkatesh and Davis (1996).

Perceived usefulness is defined as the degree to which a person believes that using a particular technology or system will improve job performance (Davis et al., 1989). Perceived ease of use refers to the degree to which a person believes that using a particular technology or system will be free of effort.

So the performance benefits of usage are out weighted by the effort it takes to use it. The perceived usefulness is influenced by the perceived ease of use (Davis et al., 1989). The two specific variables of TAM are also the basis of the greatest weakness of the model and it led to more comprehensive models. TAM2 and TAM3 (under construction) are the more comprehensive versions of TAM including social aspects and influences such as subject norm, voluntariness, job relevance and computer anxiety.

For this research the original TAM is comprehensive enough. It will be used to find the intention to use the DSDI in its current form. That is important to know and together with the gaps in the current situation priorities can be set in the conceptual roadmap. The targeted personnel are professionals and trained to use computers and willing to use them. As a GIS specialist or analyst appointed to a position, job relevance may not be applicable as well as the aspects voluntariness, perceived enjoyment, and computer play fullness etcetera.

3.2.7 Roadmap

Defence uses several definitions and methods to develop roadmaps. For this study the roadmap is defined as a tool to enable the evolution of markets, products and technologies to be explored, together with the linkages between the various perspectives (MoD, R&D, 2005).

It is necessary to develop a common agreed vision on a particular subject and to establish a timeline. Roadmapping is supposed to be a process with stakeholders.

A roadmap is also a way of communication and it is useful to create plans to achieve objectives and it links business strategy and market data with product and technology decisions. Roadmaps prioritize investments based on drivers and to more competitive and realistic. Within Defence roadmaps exist at four levels (MoD R&D, 2005):

Level	Objective
Strategic	Corporate objectives, large investments
Realization	Technology and product development, non-recurring.
Development	Technology and product development, non-recurring.
Research	Knowledge building, science, in support of decisions.

Table 3.2: Roadmap levels MoD (MoD R&D, 2005).

The proposed conceptual roadmap in this study fits mostly within the research level.

3.3 Approach and Instruments

The research (sub) questions as mentioned in the first chapter cannot be answered easily within one single method; therefore a mixed-method approach is chosen. Mixed-method research is not new, but it is a corollary of the current re-examinations and studies of new practices. Mixed-method research can incorporate techniques from both the qualitative- and the quantitative research approaches in a unique composition to answer research questions that cannot be answered in another way (Tashakkori and Teddlie, 1998). They identified three reasons that may provide a sound basis for the justification for the application of this method for the research in this dissertation:

- *Mixed-method research can answer questions other methodologies cannot;*
- *Mixed-method research provides better (stronger) inferences;*
- *Mixed-methods provide the opportunity for presenting a greater diversity of views.*

Table 3.3 presents an overview of the research questions correlated to the approach.

Question	Approach	Method
1. What is the military business model and what are the current trends? 2. What exactly is an SDI and what are current trends and developments? 3. Which appropriate measurement frameworks and methods are available to evaluate progress and maturity of an SDI within a dynamic environment?	Desk-research	Literature Best Practice
4. Which components are critical for the DSDI?	Desk-research Interviews	Model of Rajabifard as well as the Best Practice serves as reference
5. What is the current status of geospatial information handling (DSDI) within the military?	Interviews Survey	Organisational Perspective, SDI Development Matrix
6. What are the current and expected SDI user needs?	Interviews Survey	User's Perspective View TAM + SDI Development Matrix

Table 3.3: Relationship questions – approach – methods.

The first three questions have a more qualitative nature and seek to *explain* the nature of SDI, its interactions and processes. Question four, five and six are more quantitative in nature and seek for identifying *factors* and issues. These questions might require a mix of the qualitative and quantitative approach. Figure 3.5 on next page presents the mixed-method research approach and coherence of models as proposed. The conceptual model is adapted from MCDougall et al. (2006) and extended; interaction between the qualitative and quantitative research is added. This could be beneficial for equal weight mixed-method.

The questions *"Why is it important to have a DSDI and to keep it aligned with the NEC concept?"* and *"How can the development and maturity be assessed of an SDI within a military setting and in context with the military business model?"* cover a variety of sub questions in a wide spectrum. To answer these questions more models are to be applied. The desk research and literature review include best practice cases that can be used as background information to determine key indicators for the SDI maturity matrix. It also helps to avoid situations that might hamper the construction of the DSDI. Finally the desk research delivers information to develop the survey instrument to investigate the user's perspective.

Validity of Mixed-methods by Triangulation

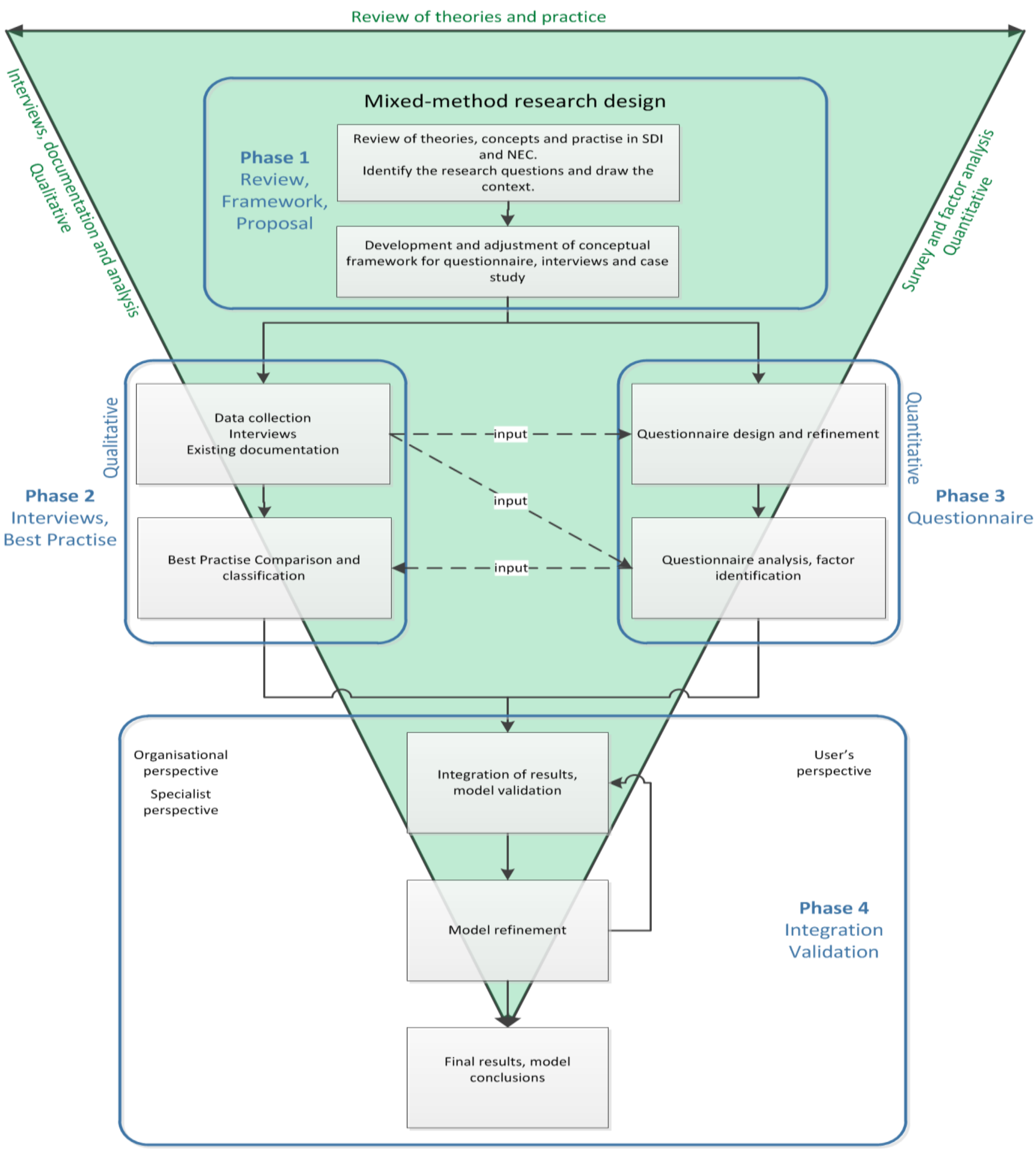

Figure 3.5: Mixed-Method research approach including the triangulation validation.

The SDI maturity matrix will be used to measure the current situation from an organisational perspective. Large part of the SDI roadmap is related to organisational change and new technologies such as Service Oriented Architectures, geo-portals and webservices have to be ready for use within the organisation to support and to fuel this change. The lack of user acceptance influences the success of new information systems negatively (Davis et al., 1989) and therefore the user acceptance is important and a central factor in this research. The TAM is used to investigate the understanding of SDI and the willingness to use these technologies from the user's perspective. This may help in the process of developing the users needs and expectations.

Next sections describe the development of instruments used to support the Mixed-Method schema in Figure 3.5.

3.3.1 In-Depth Interview Instrument

In-depth interviews are one of the main methods of data collection used in qualitative research. It is important to have conversations with people to grasp their point of view (Burgess, 1984). A better understanding of the situation can be achieved with in-depth interviews. But, there are also some limitations when using the in-depth interview instrument. It may be more time consuming and more intensive because of the preparation, the interview itself and the analysis of transcripted data. Another challenge might be the control in direction and pace of the conversation. Finally the analysis of the unstructured data may be more challenging than finding patterns in the structured data that could be collected by a survey (Patton, 2002).

NEC and SDI are both complex concepts with numerous variables and linkages to other fields of study. The military business model is quite different than the commercial approaches. In that the military may be more focused on effectiveness while the SDI concept is focussing on efficiency. To get a clear understanding of what organisational and political aspects are currently of influence on the military environment and the development of NEC and SDI, in-depth interviews with six (senior) management and six experts in the field of geospatial information management were organised. The in-depth interview supports the SDI maturity matrix as discussed in section 3.2.6, it can be used assesses the coherence of the geospatial community.

Analysis of the data is divided into two parts. The SDI maturity matrix will be filled with a maturity percentage for each aspect, any other data will be analysed and used for the conclusions and recommendations.

3.3.2 The Survey Instrument

A survey can be used to describe a population; it may count and describe how people perceive things or situations. A survey in this sense is a detailed and quantified description, a precise map and/or a precise measurement of potential (Sapsford, 1999).

Survey research consists of three parts (Sapsford, 1999): quantification, sampling and comparison. Quantification: systematic observation or interviewing, asking the questions the researcher wants to be answered. Consistent answers to consistent questions, standardisation of the questionnaire as a measuring instrument. Sampling: a representative sample of the whole population to reduce cost, time, coverage and training. Comparison: to monitor changes over time, before and after, with or without.

Sapsford (1999) defines four processes in survey research: problem definition, sample selection, design/selection of measurements and concern for respondents (ethics). From these four main processes, a workflow has been developed for the creation of the survey for this research (Figure 3.6).

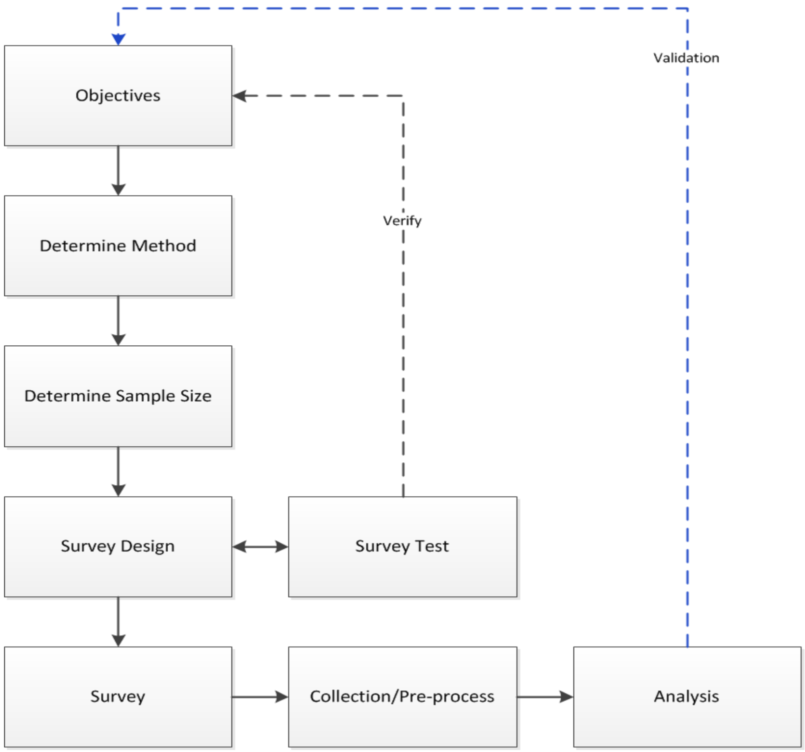

Figure 3.6: Workflow development of survey instrument.

The technology acceptance model will be fuelled with data derived from the survey instrument. The process to create the survey will be described in this section; the results of the process can be consulted in Appendix D.

The first step in the process is to describe the objectives of the survey: what questions need to be answered? As already stated in Table 3.3 question six may be (partly) answered with the survey. TAM can be used with the original set of questions but for this research the questions were slightly rephrased to fit the subject and the objectives.

Perceived usefulness is covered by the aspects find, collaborate, standards, efficiency and effectiveness. The perceived ease of use focuses on these aspects as well.

Secondly the method has been determined. Due to geographical dispersion, exercises and leave, it was found not efficient to visit the expected sample of people. Therefore a survey by mail was expected to work best and two short introduction meetings with some of the respondents were held.

The third process was the determination of the sample size; the calculation for this process is included in Appendix B.

The design was created, by formulating five statements for each of the perceived aspects. The first concept version was sent to two test respondents, three issues were identified. The statements missed some context and more explanation on the research was needed. The first scales (five-point) were found too general and finally a brief explanation for each statement was found useful to inform the respondents about each subject's context. All issues were taken into consideration and led to the final survey design (Appendix C).

The statements were held against the original objectives in order to verify the expected outcomes. This verification led to some rephrasing of the statements to be complete in covering the subject.

The research model was designed to be flexible and adjustable. In that, *if* there were any aspects emerging in the interviews with experts or senior management, they could be included in the survey. Four aspects were defined: *information security*, *communications*, *standards* and *maintenance (support/sustainability)*. These aspects were added to the survey with a more harsh method of scaling. The respondents could answer with agree, disagree or not applicable with as main reason to prevent (expected) biased or 'safe' answers.

The survey was sent by email to 35 respondents that cover a balanced reflection of the Defence geospatial community. Approximately 50% of the respondents are working in an operational setting, the other 50% in the more supportive roles such as real estate management, asset management, the hydrographical office and the IT department.

Standard MS Excel software was used to collect and pre-process the data, mainly a manual process but because of the low number of respondents feasible. The results are presented in percentages to be interoperable between the methods.

4. RESULTS

4.1 Introduction

This chapter presents the results of the SDI maturity matrix and the results of the TAM related survey including additional statements.

4.2 Results SDI Maturity Matrix

The SDI maturity matrix helps to establish the starting point for development of the DSDI initiative and it serves as the backbone for the conceptual roadmap. The key aspects vision, leadership, communication, awareness for GI, self-sustaining ability, financial sustainability and information security were subject of discussion. The data of the in-depth interviews were analysed and Figure 4.1 represents the overall generalized scores on the SDI maturity matrix in percentages by stage for each aspect. These results include the additional aspect of Information Security. The higher the scores in the first stage (Stand-alone) the lower the maturity of the DSDI.

Three important trends can be distinguished. First the lack of leadership and vision, which may fuel the second trend that the self-organising ability is more developed. Third trend is the awareness for GII, which is necessary to convince the senior management of the benefits.

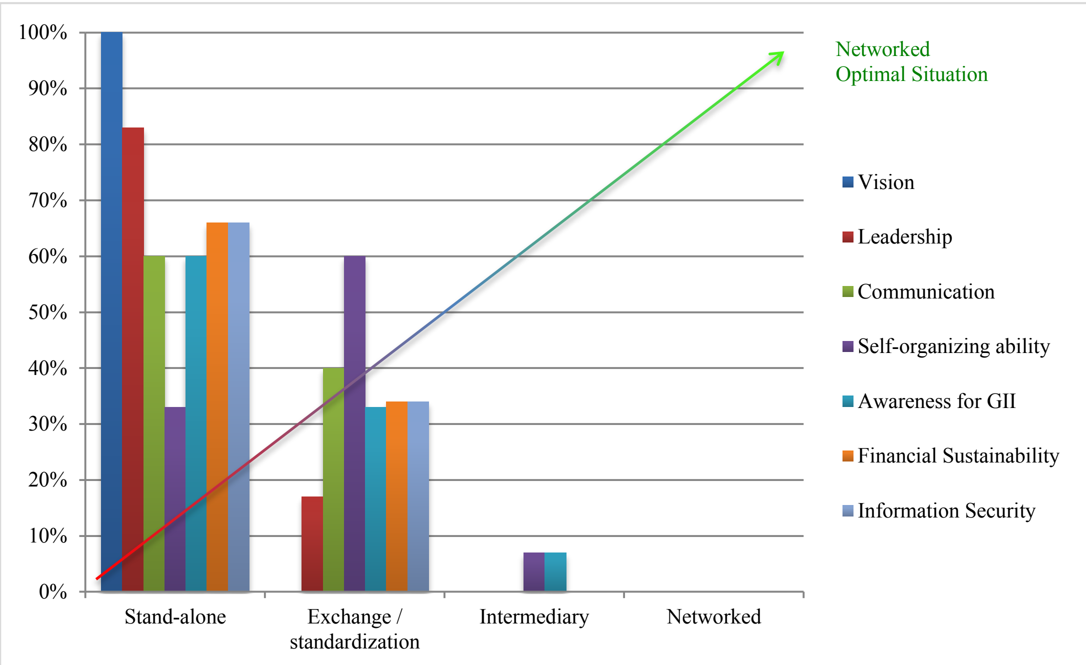

Figure 4.1: Generalised scores on the SDI maturity matrix.

Next pages discuss the aspects one by one and in more detail.

Vision:

The results on the aspect Vision did not differ a lot between interviewees. Generally spoken, it can be said that the corporate vision of IS and IT is well know to all staff employees within the geospatial branch. There is no *corporate* vision for geospatial information management, it is intended to be (sub) part of the corporate vision on IS and IT. From senior management to lower level management the existence of sub-visions (department or unit bound) on geospatial information and systems was recognised and the need to transform these sub-visions into the corporate vision was expressed. The sub-visions are not completely in line with the corporate vision of on IS/IT and they are not aligned in relation to each other.

One of the key determinants on this stage is the isolation of organisations and their independence of each other on performance. The current situation within Defence is that some organisations are already depending on each other. For example *if* the DGKL cannot provide the basic layers for an operation, it has immediately consequences for the demanding organisation and the products that are supposed to be constructed.

It seems that although there is not yet a corporate vision, organisations are already seeking cooperation and are aware of the benefits of collaboration. There are initiatives planned to develop a corporate vision on geospatial information.

Leadership:

In a military organisation one should think leadership is arranged well. In the context of the geospatial community, the local lines of command are in place and functioning well. One challenge may be the scattered structure of the geospatial community along all departments and units.

There is no overarching formal organisation that guides the geospatial information management and community. Geospatial information is not, or not completely embedded in the C2 architecture. All interviewees expressed this lack of leadership and they were aware of the initiative to set up a centralised management body. This formal body advice the senior management on decisions related to geospatial information management and it should bring coherence in the geospatial-working environment. It is not yet formal, but it is clearly a step into the second stage. It is expected that this body will achieve a better understanding of the problems faced by the geospatial community, although most of the experts have some reservations about the effectiveness of the body.

There is no “Champion” for the geospatial community and if leadership clearly exists at lower management levels, it may be questioned. Several initiatives were started but they did not lead to a structural changed situation.

Communication:

The aspect of communication led to some discussion and different views. Informal communication is arranged well and specialists and general users find each other and information exchange takes place on several levels.

Communication between multi-level management structures is recognised as difficult and challenging. The gap between unit management, which is often specialism driven, and the senior management is experienced as large.

The translation of technical or specialist issues into relevant business and management information seems to be hampering decisions occasionally. Interviewees identified as reason that personnel is not following a certain development path in the field of geospatial information management throughout their career, e.g. from (non-commissioned) officer to staff and senior staff or from specialist to staff. Most of the times the military personnel changes every three years of position and most of the times in another field of duty.

This is differently arranged by the armed forces of allied countries, the geospatial community is represented on all levels of management and it is recognised as branch and field of work. This may help in translating technical and specialist issues into management information and it might help to get support on the important level of senior management.

Open communication throughout the organisation is identified as difficult; a common goal is not always the number one priority. The aspect communication is changing into the second stage.

Self-sustaining Ability:

The self-sustaining ability led to some discussions as well. Generally spoken the problem solving ability is neutral. It seems that at unit level the ability to get involved in the process of problem solving is not always easy. Most of the times the pressure of day-to-day business is too high to be actively involved in problem solving. Besides the day-to-day business the lines of communication are quite long and not always as fast as necessary.

Some organisations already have an active posture in problem solving. This might be due to legal obligations e.g. production of data/information used for navigation. Another reason might be in correlation with the aspect of leadership and vision. If both are lacking, the nature of the military is to improvise and survive which may explain the relative high scores for this aspect.

Awareness of GII:

At all levels of the Defence organisation the awareness of the geospatial information infrastructure exists. Different opinions about *what* this GII should include and how to organise it were clearly expressed during the interviews. Generally spoken it can be argued that at higher management levels the focus is user-centric and based on the general IS/IT corporate vision. At the lower levels the awareness is strongly based on products in support of the operation(s) or civil tasks as ordered mandatory by INSPIRE or other legislations and regulations. There is a difference between the management view and the expert view; first group was more positive and the experts complained about the disconnected stovepipes that still exist. The experts clearly expressed the need to improve exchange of geospatial information and knowledge in order to achieve a common goal and to be more efficient.

Financial Sustainability:

The government knows a rigid system of financial control. All interviewees agreed on this point. The senior management identified the problem of project-based budgets that might hamper long-term sustainability of the geospatial infrastructure. Due to external pressure on budgets it becomes more and more important to better justify and explain the value of geospatial information for the operational decision-making.

Information Security:

Not all networks can be connected due to information security regulations. There is a strongly expressed need to be more flexible in (ad-hoc) network propositions. The information security is focussing on the corporate policy and is based on avoiding risk instead of managing risk. No corporate risk management framework is in place, but some interviewees express the need. The awareness of risk management is not widespread.

4.3 Conclusion SDI Maturity Matrix

The results show that the initiatives on DSDI are in transition from the first stage into the second stage. Leadership is lacking and vision is focussed on internal processes; this might be the reason that other aspects are not developing as well. Standardisation for instance is depending on agreements, decisions, structure and architecture. If decisions are left to units and no formal agreement can be reached, standardisation and exchange may fail. The explanation that self-sustaining ability scores relatively high, is therefore not a surprise because when leadership is lacking the willingness and creativity to survive is high. Awareness for GII may be used to convince the senior management of the benefits of GII, which in turn is necessary to obtain a sustainable financial situation with long-term investments.

4.4 Results User’s Perspectives

The questionnaire was completed by 80% (28) of 35 employees that were asked to participate. 50% of the respondents are operating in an operational environment, or closely related to the operational processes. 50% of the respondents are working in an office environment in a supportive role like housing, logistics and IT. The high commitment was not completely unexpected due to active communication prior sending the questionnaire that informed most of the respondents of the importance of the research. All respondents filled in the questionnaire correctly.

The results of the survey are presented in this section grouped by the Perceived Usefulness and the Perceived Ease of Use. The four additional statements that not belong to the TAM will be analysed and presented separately at the end of the section. The section concludes with a brief wrap-up of the results. The survey itself is included in appendix C and the detailed results are included in appendix D. The respondents were asked to give their opinion on five statements that cover the user’s perspective on the <u>usefulness</u> of the DSDI initiative(s).

1. *A corporate SDI supports the faster achievement of our team and/or department goals.*
2. *Collaboration in a corporate SDI improves the quality of geospatial products and services that are delivered by my unit or department.*
3. *Collaboration in a corporate SDI speeds up the production process within my unit.*
4. *Our unit or department does not benefit of the use of standards in a corporate SDI.*
5. *A corporate SDI improves the efficiency of my or our geospatial activities.*

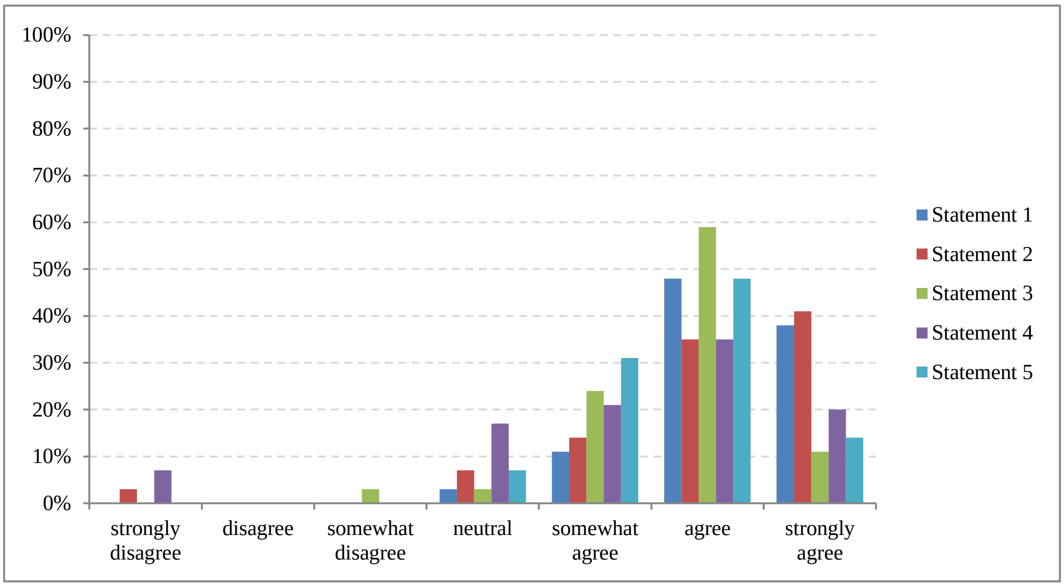

Figure 4.2: Generalised score on Perceived Usefulness.

The generalised view of the Perceived Usefulness in Figure 4.2 shows that most respondents agree that the DSDI concept improves the quality of geospatial information. The efficiency improves, and the perception exists that 'more with less' can be achieved. Work can be done faster; which is in a dynamic environment as the military business model a requirement. The usefulness of standards is qualified more neutral, which might be due to unfamiliarity or unawareness. Collaboration is also understood more neutral and this might be due to unawareness of the benefits and the understanding of the concept.

To determine the perceived ease of use of the current initiatives and the envisioned DSDI, the respondents were asked to give their opinion on following five statements. This user's perspective can be different from the IT or IS perspective that might be more technical and focused on performance. For the users a full scale DSDI may include extra tasks or activities to support for instance metadata or (exchange) standards. The results of the perceived ease of use are presented in Figure 4.3.

6. *A corporate SDI metadata portal is easy to use.*
7. *The implementation of metadata standards in my current position is easily to achieve.*
8. *The application of (exchange) standards is complicated.*
9. *The use of webservices (WMS/WFS) is relatively easy to learn and toe practice in my current GIS projects.*
10. *In general, I think that the components of a corporate SDI are easy in use.*

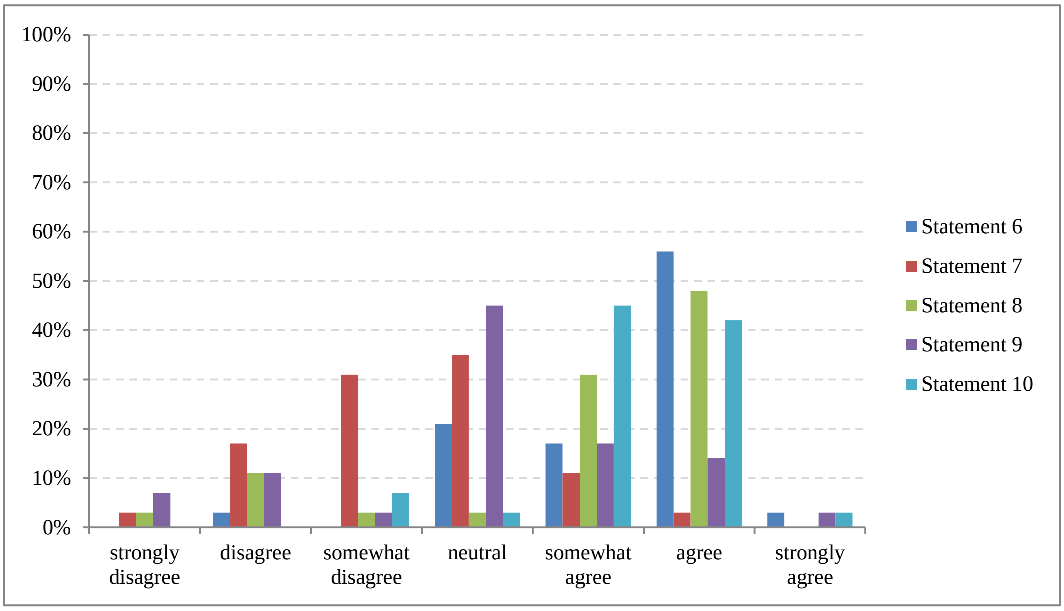

Figure 4.3: Generalised score on Perceived Ease of Use.

4.5 Additional statements included in the survey

Not all research questions could be answered with the survey designed for TAM. For the following aspects additional statements were included in the survey: *Information Security, Connectivity, Geographic Models* and *System Management*. The following statements could be answered with ‘agree’, ‘no opinion/not applicable’ and ‘not agree’.

Statement 11:

‘Security aspects often provide barriers related to the exchange of geographic information’.

All respondents agreed on this statement, the experts also expressed this issue during their interviews.

Statement 12:

‘Connectivity aspects often provide barriers related to the exchange of geographic information and knowledge’.

86% of the respondents agree that connectivity is often hampering their work. Different security levels might cause this connectivity issues so that networks cannot connect due to regulations. 7% has no problems with connectivity; these group belongs to a department that uses the less dynamic Defence intranet in a regular office environment. Another 7% has no opinion or the statement was not applicable.

Statement 13:

‘For our work we often use our own geographic data models that are partially or not standardized’.

Interesting detail in the results of this statement are the differences in opinions of the experts and user’s working in the same department. Some of the ‘disagree’ answers were in contradiction with the experts working in that same department that did agree. Probably this has to do with the perception of what standards are and how these standards need to be implemented. 17% uses standards, 59% is using their own data models and 24% don’t know or it the statement was not applicable.

Statement 14:

‘The functional, technical, and application management of our geographic information systems is formally organized and well calibrated’.

83% agrees that the systems management is not properly addressed; the experts also expressed the need to improve this issue. 17% of the respondents reacted positive on the systems management; these respondents work in a controlled and stable office environment, which is usually managed and maintained well.

4.6 Conclusions Users' Perspectives

The 28 respondents represent approximately 23% of the geospatial population of Defence. The following graph presents the roles of respondents divided in three groups: operational, supporting and office personnel. The representation is a good reflection of the real situation, although it remains difficult to define concrete numbers.

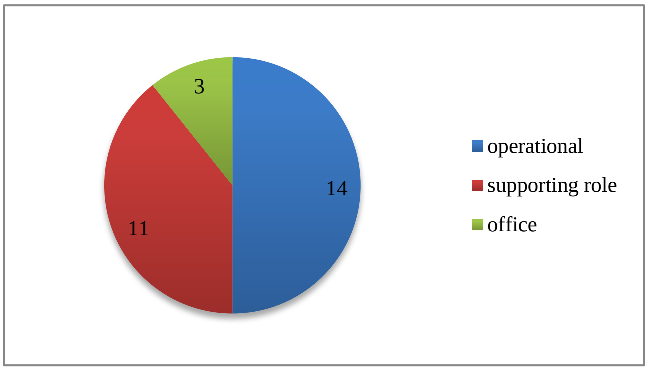

Figure 4.4: Partitioning of respondents.

When looking at the average scores on perceived usefulness and perceived ease of use the following conclusions can be drawn.

- 80% of the sample size perceives the *usefulness* of the DSDI initiatives as positive for achieving their work related goals. The other 20% is less positive or neutral.

- 66% of the sample size perceives the *ease of use* of the DSDI initiatives as positive, which may be translated in not to difficult to learn and to work with. 34% of respondents reacted with more care and restrictions; this might be due to the fact that they foresee technical related challenges and limitations and extra responsibilities or tasks. The experts confirmed this assumption.

When comparing the two main groups, operational and supportive (including office), the clear trend can be observed that the operational user is less positive. Statement 4 is phrased in a negative sense, which might explain the only deviation.

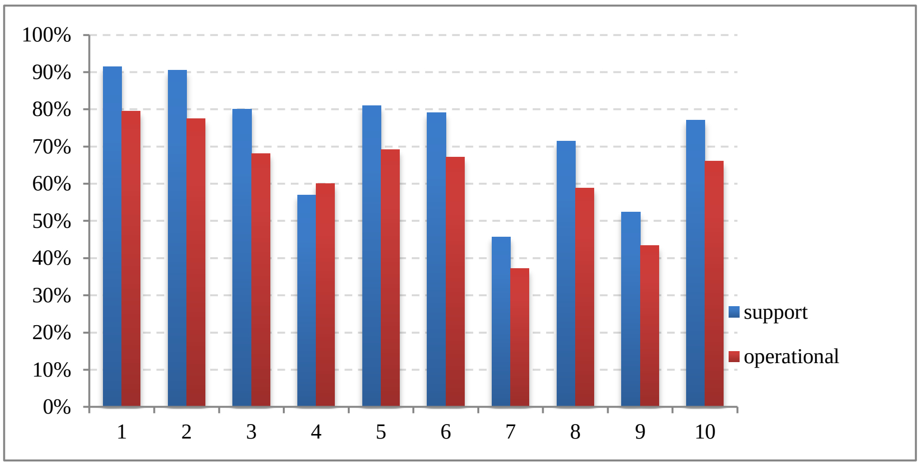

Figure 4.5: Comparison of operational and supporting respondents.

The four additional statements in general conclude that users perceive security aspects and connectivity as bottlenecks in the exchange of geospatial information and knowledge. Formal systems management of geospatial information systems is perceived as not arranged well enough by the operational users. On standardisation of geospatial data models discussion exists, but in the users perception only 17% uses standard data models and 59% is using their own models.

When comparing the operational users with the supportive users, the following observations can be made. Statement 12 concerns connectivity that may hamper the exchange of information, not surprisingly that some of the respondent in the supportive role (including office) disagree or answer with not applicable. But connectivity issues apparently hinder the operational users. Statement 13 also shows some differences; the operational users disagree for 17% more on not using own data models but more standardised ones. Statement 14 clearly shows the result that formal systems management is not arranged well enough, the operational users perceive it as more problematic than users in the supportive roles. The agree answers were of units that are already in control due to finished small scale projects with the objective to support GIS environments in the near future. Figure 4.6 shows the generalised scores of the four additional statements of both groups, the operational users versus the supportive users.

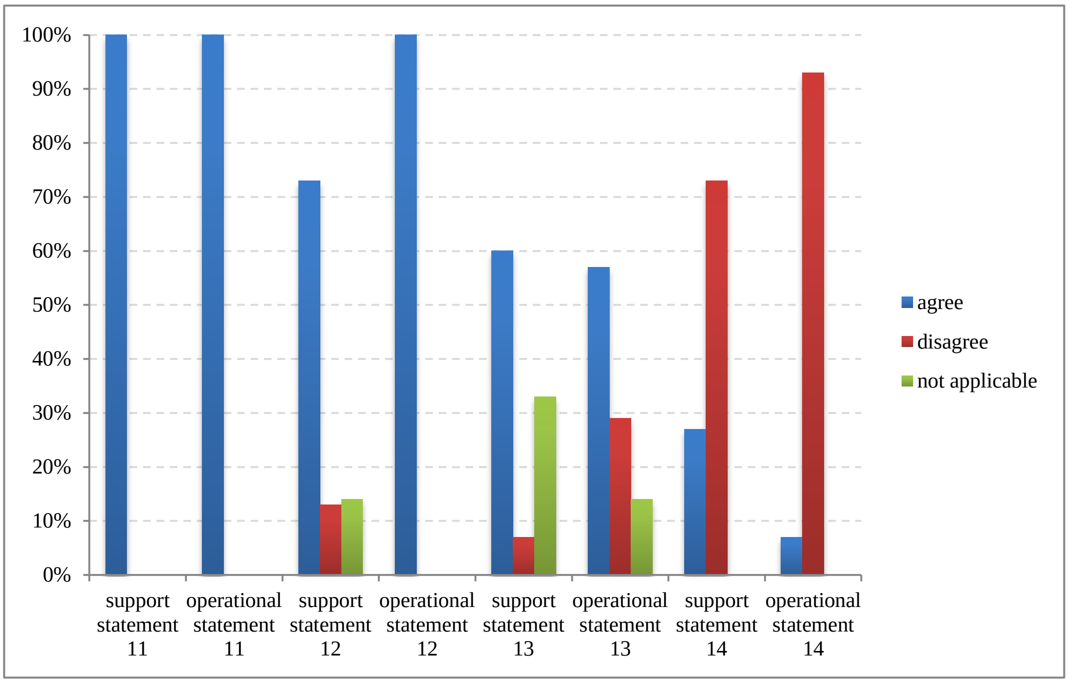

Figure 4.6: Comparison of operational and supporting respondents for extra statements.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 General

NEC is about gaining information superiority that leads to better en faster decisions over the adversary, which ultimately leads to decision superiority and advantage. From best practices and literature we can learn that geospatial information continues to be a critical force multiplier for the military and its operations. The NEC concept can only be successful if geospatial information is timely, accurate, precise and fit for purpose.

The experts in the field of geospatial information management unanimously support this statement. At the management level the support was also unanimously, only the *how to* achieve the envisioned benefits differed somewhat. The general perspective was more focused on efficiency and thus ‘more with less’, which might be emerging due to forecasted severe budget cuts.

The networked perspective of Vandenbroucke et al. (2009) and the VGI concept as proposed by Goodchild are interesting if compared with the NEC concept, both highlight the value of the Law of Metcalfe and both see people as important sensors of geospatial information. But sharing and collaboration also needs an organisational change and a different mind-set. Sharing benefits normally is not the problem, but sharing the burden of failures often leads to discussion. This organisational change and the way it is communicated and orchestrated are the key to successful implementation of the DSDI. This orchestration needs leadership and vision, which both are in the first stage of development when looking at the SDI maturity matrix. With the in 2.1.3 mentioned Comprehensive Approach in mind; collaboration and thus interoperability are critical aspects to manage. Security issues may arise when systems of civil and military assets need to connect; information security is identified as a crucial aspect and the Achilles’ heel of NEC and NII. If an assessment method of the DSDI is implemented, information security should therefore be part of it. The sharing of risks and thus sharing the burden if things go wrong, may improve collaboration efforts.

The military business model is much more dynamic in character than the civil equivalent. There where a civil SDI may have a more static posture and accommodates well-known data and models about a well-known area of interest, the military has to cope with rapidly changing environments and datasets. Sensors are getting more and more important and therefore the role they play within the DSDI needs more attention.

The community needs or requirements may change as result of the new developments and technologies, and so may change the perceptions of what the DSDI was planned to improve also. The organisational conditions are relevant to develop a mature and sustainable DSDI and therefore they need to change with the changing requirements for the DSDI. This is an on-going process that needs long-term budgets and long-term policy, which in turn can only be managed with clear leadership and vision.

Communication is one aspect of maturity that scored relatively high in the second stage. This may be a positive fact, but on the contrary all interviewees expressed the lack of a career path with as result that the long chains of command are lacking the appropriate skills and knowledge at some important positions. This sometimes hampers the translation of practice in the field into business information used by the senior management.

The users' perspective on the statement that the DSDI supports NEC needs explanation. An average of 80% of the users, and thus part of NEC, agreed that the use of a DSDI improved the quality of products, the timeliness, interoperability and collaboration. It may be concluded that in the users' perception the DSDI improves NEC, the interviews with senior management and experts confirm or validate this conclusion. It may also be concluded that 66% of the users perceive the use of the DSDI as relatively ease. The other 34% has somewhat more reservations and perceive the ease of use as more difficult.

Because NEC and the DSDI are closely connected, the next section will describe the combination of both concepts.

5.2 Conceptual Roadmap

Knowing where you are is not sufficient for the journey at hand. A roadmap that shows how to get to the next step is necessary. The SDI maturity matrix helped to position the DSDI and it helped to identify the needs to move the organisation to the next level of SDI maturity. Figure 5.1 on next page presents the journey as proposed by Van Loenen (2009), but then translated to the military business model and in combination with the SDI development continuum as proposed by Rajabifard et al. (2007). The continuum goes from *products-based* to *process-based* and finally the *user-centric* stage as ultimate goal. This ultimate goal has large similarities with the concept of NEC, which is supposed to be user-centric in character as well. The information security aspect that has been added to the maturity matrix has been incorporated in the conceptual roadmap too.

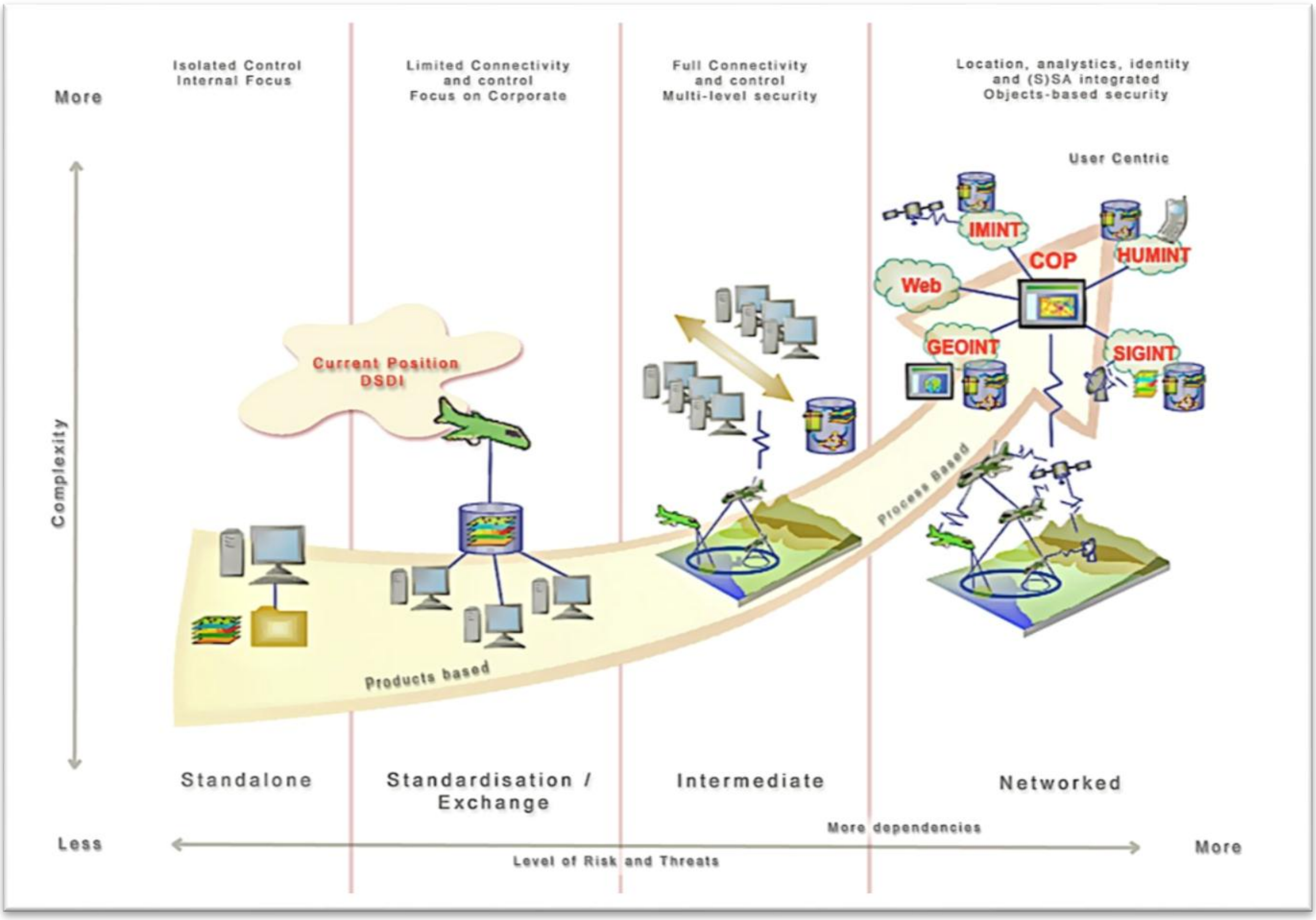

Figure 5.1: Conceptual roadmap DSDI.

In next section recommendations will be proposed that might be necessary when transforming to next stages is envisioned and part of the organisations' ambition.

5.3 Recommendations

1. Arrange clear and accepted leadership, find a 'Champion' (GIO) or make it a part of existing position. For the Dutch Armed Forces this could be the CIO advised by the DOGEO (Decentralised Formal Geospatial Coordination Body).
2. Develop a Corporate Geospatial Vision, Strategy and Planning.
3. Arrange long-term budgets and investments for the development of DSDI.
4. Investigate and define GIS user requirements and communicate strategy and planning.
5. Arrange formal geospatial data and information management roles.
6. Agree on standards, implement standards and adhere to standards.
7. Arrange formal systems management (including licensing).
8. Organise GIS Staff – Recruiting, Training & Retaining.
9. Develop and implement a Risk & Information Security Management Framework.

5.4 Discussion on approach

The Mixed-Method approach worked well, although it experienced to be difficult to write up the complete detailed approach in advance of the process. This might be due to variables that changed because of the interactions between the models. For example: the interviews emphasised on aspects that were not part of TAM, but were found important in answering the research questions. Therefore the survey needed to be expanded with additional questions. At the end it seems to deliver a more complete insight and completeness of the answers and the approach has proved to be flexible enough to deal with dynamics of assessing SDI's.

The approach includes some overlap at certain areas by measuring the same aspects; e.g. asking an expert what his opinion is about the benefits of metadata portals will certainly overlap with questions regarding the user's perspectives. On the other hand, this overlap may be utilized to crosscheck information and to validate the models.

5.5 Discussion on framework

The multi-view SDI assessment framework has proved to be flexible and useable for the assessment of the DSDI. The ingredients of the framework can be tailor-made, which seems to be necessary because the development of a DSDI is not a standard product that can be found in a catalogue. Therefore a careful selection has to be made that supports the different views. This selection of ingredients was part of this research and it proved to be difficult and time consuming to find the right, the most efficient and reliable ones.

5.6 Discussion on methods – models

The SDI maturity matrix may be a more general method to define an overall status. For the development of a conceptual roadmap this might be a good assessment tool. To create a more detailed roadmap that covers more aspects, extensions on the model can be made easily. One limitation of the model may be the assumption that the networked stage is the most ultimate status to achieve by fulfilling the key aspects in the earlier stages. But this might be a to limited perspective because there are other aspects that may hamper or influence the construction. This may be technical or social aspects, security issues and economic influences.

The TAM and the additional statements did give an impression of the users' perspectives, which was found sufficient enough for the purpose of this study.

5.7 Recommendations of further research

Further research on the dynamic geospatial content in SDI's may lead to better understanding of the integration of sensors within the network. Decision-making is heavily relying on this network and its sensors; this may be people working together or flying sensors that provide live streams of data.

Although it was not the goal of this dissertation and the evidence has a more epistemological character, the correlation between the lack of leadership and the higher maturity of the self-sustaining ability was noticed. More research on the correlation between aspects could improve the understanding of the process of developing an SDI.

Risk management / Information Security in relation to SDI's is not investigated extensively yet. As mentioned before, the network is important. When an SDI operates and connects with other organisations or agencies (the nodes) it is necessary to have a risk management framework in place or aligned with the other nodes. Only then risk can be shared, which may improve collaboration and thus value.

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Appendix A - SDI Maturity Matrix Interview Guide

The SDI Stages of Development (Van Loenen, 2006) were used as fundament for the SDI maturity matrix. The key aspects served as an agenda or *aide de memoire* to be used as a flexible guide throughout the organised interviews (Burgess, 1984). For each stage these key aspects were determined by reviewing literature and by assessing best practices.

Stage 1. Stand-alone
- Different organizations
- Own infrastructure
- Bad connectivity
- Security issues
- Own data models
- Own standards
- Own source systems, filling
- Leadership lacking
- No common interest
- No common vision

Stage 2. Exchange
- External drives for change, e.g. budget cuts
- Awareness of 'external' information, experimental exchange
- New technologies, more requirements
- Outsourcing, concentration core business
- Need for system and process integration
- Development of common goal
- Start of coordination activities (informal)
- Need to reduce duplication of effort
- Definition of architecture, security framework
- Significant investments/budgets scheduled

Stage 3. Intermediary
- Vision starts to be implemented
- Islands becoming networks, start to realize the potential of networks
- Formal leader, coordination body
- Explicit roles, information management
- Formal system management
- Capacity building
- Distribution of tasks
- New applications emerge
- Multilevel security aspects
- Meeting user needs and coordination

Stage 4. Networked
- Networked organization
- Clear vision and strategy
- Organizations act pro-active
- Organisations are dependent on each other
- Shared responsibilities and risks
- Shared and accepted leadership
- Multi-purpose system, security on objects (labelling)
- Virtual organization (units), one goal
- New applications by stimulated innovation
- SDI not challenged but exploited

Appendix B – Survey Sample Size Calculation

Source: http://www.surveysystem.com/sample-size-formula.htm

$S = N/[1 + \left(\frac{N}{population}\right)]$ In which $N = Z * Z[\frac{P(1-P)}{D*D}]$

Expected frequency of factors under study is 95% and worst case = 88%.

S= Sample Size; P= Expected Frequency Value =95%;

D= (Expected Frequency - Worst acceptable frequency) = 7%.

Population Value = 120; Z=1.960 with a Confidence Level of 95%

First the value *N* is calculated:

$N = 1.960 * 1.960\ [\frac{0.05(1-0.07)}{0.07*0.07}]$ *N*= 36,456

$\mathrm{S} = 36{,}456/[1 + \left(\frac{36{,}456}{120}\right)]$ Sample Size $= 28$ (Confidence interval of 16.28)

Because it concerns a finite population, a correction on the sample size is necessary. The following formula may be used.

$$Corrected\ Sample\ Size = \frac{Sample\ Size}{\frac{Sample\ Size - 1}{pop} + 1}$$

$$\frac{28}{\frac{28-1}{120} + 1} = Corrected\ Sample\ Size = \mathbf{27}$$

Appendix C – Survey

Questionnaire to determine the current
Defence SDI status
from the users' perspective.

(Translated, the original survey is in Dutch)

January 2011

This survey has been executed in support of the dissertation *'Developing a Spatial Data Infrastructure for use in the military, how to assess progress'*. This dissertation is submitted in partial fulfilment of the requirements for the degree of Master of Science in GIS. The research is supported and coordinated by the Free University of Amsterdam and the Manchester Metropolitan University.

1. Introduction

This survey serves as part of an investigation carried out to determine how a Spatial Data Infrastructure (SDI) for Defence (DSDI) would be set up and how it could be developed and assessed. In order to enter such a process, it is necessary to examine a number of factors. This study does not encompass all factors that could play a role in this process; the research focuses on organizational and user perspectives. For the latter, the Technology Acceptance Model (TAM) was used which mainly focuses on the operational level. It is used in order to see whether the organization would be able to process such a radical change.

2. Fundamental Concept of SDI:

The use of geographic information has increased significantly in recent years and it is impossible to imagine the business without it. For both commercial parties and the government, geographic information is used for aspects as decision-making, planning, education and so on. The result of the recognition that geographic information is crucial in decision-making, has contributed to the development of the SDI concept. National Spatial Data Infrastructures (NSDI) are now used worldwide and serve as a fundament for the Global Spatial Data Infrastructure; the Dutch NSDI initiative is developed by Geonovum (www.geonovum.nl).

The organizations that provide data for such NSDI's are often called Corporate SDI's, there is a clear hierarchy in the design of SDI's. Other names such as Enterprise GIS, Corporate GIS and Geographic Information Infrastructure (GII) are also used where appropriate. A comprehensive definition of an SDI that covers the load is as follows:

"A spatial data infrastructure that supports ready access to geographic information. This is achieved through the coordinated actions of nations and organisations that promote the awareness and implementation of complementary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the (national) and regional scale are not impeded in meeting their objectives" (Masser, 2005).

A corporate SDI provides a small piece of the functions mentioned above, information is produced/offered, and through search portals information can be found. An SDI is particularly necessary as a framework in which an organization can work efficiently and effectively. One of the objectives of SDI is to avoid duplication of effort, in other words, no duplication in data storage (except for backup), products, organizations, etc. and thus efficiency.

As part of DSDI development, the proposed project "Standardization and Improvement GI Services" will serve geographical information via standard webservices and portals. For the (end) user it is maybe not that interesting to know where information on the server(s) is located; the end user wants central access and search tools. In addition, the end user wants to know, for example, what can be done with the data, to whom it may be distributed and what the quality, precision and accuracy are. The Royal Netherlands Army Geographic Agency (RNLAGA) serves a metadata portal including webservice, which may be seen as a good example of what a SDI has to offer.

The development of such a DSDI is complex and it may take a long time to accomplish. In difficult financial times and severe budget cuts, priorities must be set and motivated extensively. This study contributes to this process, by identifying critical components of a SDI and by identifying bottlenecks in the current organisation. In addition, this study shows how to assess the progress of the development of a DSDI.

3. The survey:

This survey is sent to a group of 35 operational users of GIS. This sample size is spread over the different domains in order to provide full coverage and therefore it is important that as many users as possible complete the survey to create an overall picture of users' perspectives.

- The survey consists of 10 statements that can be answered in a series of seven figures, ranging from *'completely disagree'* = 1 to *'completely agree'* = 7.

- Four statements that cover the additional aspects of the users' perspectives follow the previous ten statements of the Technology Acceptance Model. These additional statements can be replied to with *'agree', 'disagree'* or *'not applicable'*

- Each of the statements will be explained and examples are given.

- If support is needed to complete the survey please call +31653402793 or sent an email to: wm.steenis@mindef.nl.

- The survey can be completed via email, to be returned to wm.steenis@mindef.nl

- The information collected is confidential and anonymously included in reporting.

- The results of all research will be published mid-2011.

- The deadline for submitting this survey is February 15, 2011.

- Two professional books will be raffled among participants!!

Thank you for your valuable cooperation and success with filling in the questionnaire!

Willem Steenis

Student Free University of Amsterdam and Manchester Metropolitan University

M: +31 6 53402793

E: wm.steenis@mindef.nl

4. Registration:

- Name:
- Function:
- Part:
- Organization:
- Email:

5. Statements Part A:

The first part of the statements correlates to the **perception** of users about the *usefulness* of the DSDI. It is important here to consider what a DSDI can offer. Some example SDI components are given, they can – along with your own perception and experience – be used to fill in the answers.

- Search Portal for all key geographic data and information for Defence (RNLAGA Portal).
- Metadata catalogue geographic information (quality, accuracy, constraints, costs, size, etc.).
- Standardization of data, resources, procedures and methods.
- Cooperation on technical, organizational, and professional levels.
- Technical resources to promote exchange (WMS, WFS, GML, etc.).
- A network (or links) that enable collaboration.

Example:

Statement:

Do you think that a DSDI will enable your teams', departments' or divisions' goals to be achieved more rapidly?

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7
					X	

Statement explanation

Here you will find an explanation of the statement including some examples if appropriate.

On next page you will find the statements, good luck!

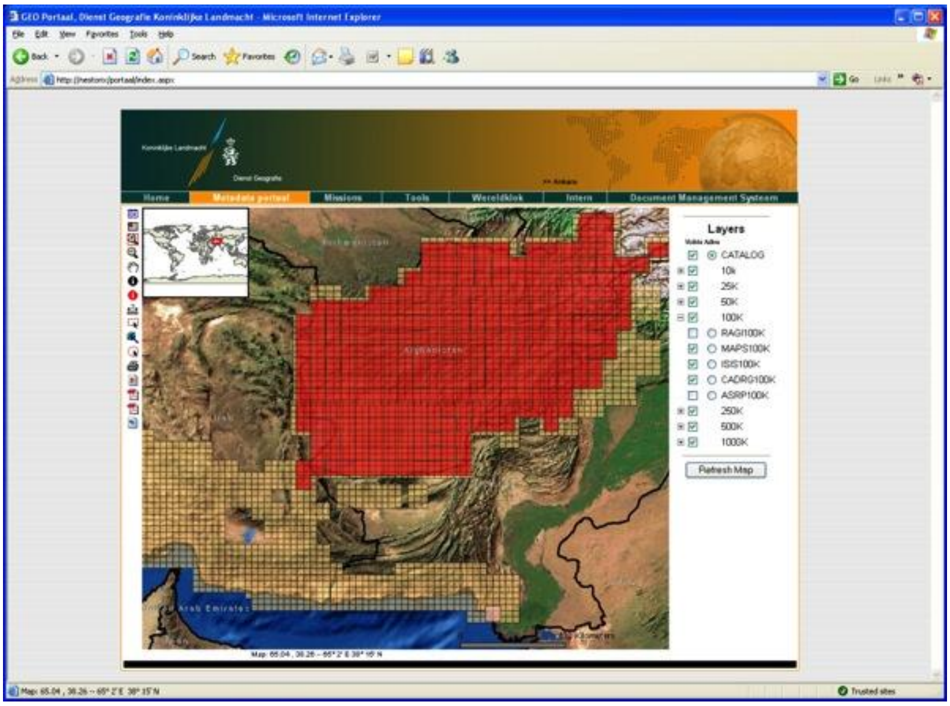
Statement 1:

The DSDI contributes to the more rapid achievement of our team and / or department goals.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

<u>Statement explanation</u>

Crucial in performing a geo job under pressure of time is to quickly find the appropriate geospatial information. The RNLAGA metadata portal (see illustration) is a good example, but www.nationaalgeoregister.nl is a good example of a portal where geospatial information can be found. Currently it is not possible to find available geospatial information within Defence, so main question is to ask yourself whether this is really necessary to perform your work faster.



Furthermore, it is obviously important that databases are accessible or linked; this could quickly complete a picture of the environment without requiring any media to be sent around.

Another good example is the search for products within Defence, in other words, does another unit or department already have a (geospatial) product of a particular area and is it (partly) usable?

Statement 2:

Cooperation within the DSDI concept improves the quality of geospatial products and services that I (or my unit) deliver.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

<u>Statement explanation:</u>

A DSDI facilitates cooperation between units, for example by linking databases so that more information becomes available. But it also shares knowledge about methods, techniques, standards and many more aspects.

An example of this is the Engineers Corps who are measuring objects in the field, taking pictures and inserting this information into the DSDI. If this is a continuous process, the products are becoming more accurate and complete. But even if products are apparently independent processed, they could be in coherence of each other improving other products. An example are the measured ground control points that can be used for the ortho-rectification process of satellite imagery. Another example is the sharing of knowledge related to the sharing of methods, techniques and workflows, which may lead to quality improvement of products.

Statement 3:

Cooperation in a DSDI concept accelerates our (my) production process of geospatial products and services.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

<u>Statement explanation:</u>

According to statement 2, only the focus is now more on the increased speed of processing orders when operating a DSDI. In this statement you may ask yourself the following questions:

- Would you benefit if databases are linked?
- Would the search for information for a complete product then be shorter?
- When is the product finished, if all relevant and timely information is processed and verified?
- How would you then know if the latest and most accurate information or data is used?
- Where can I find workflows and methods that I can use if I need help?

These are aspects that should be taken care of in a well-equipped SDI.

Statement 4:

The use of standards in a DSDI offers me (us) **no** benefits.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

Statement explanation:

A DSDI is based on the appropriate application of standards, so that exchange of geospatial data and information is easier to organise and faster to implement.

It is not yet feasible to use (geospatial) standards within Defence in all situations. For example, the C2 system ISIS still uses the Tensing Raster format which is propriety but has a very small footprint and for the purpose a very high performance grade. Another example is the use of base maps for PFPS, are these maps compatible with ISIS?

This argument is about whether you are affected by this aspect in your current job or not. But also whether the users of your products and data are suffering from it.

Statement 5:

A DSDI improves the efficiency of my (our) geo work.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

Statement explanation:

In this case, efficiency means fewer people (staff), cost, space and effort in providing services with at least the same performances.

A DSDI offers a framework that includes management of geospatial information. This implies that the included geospatial information is maintained at the source and that appropriate contracts are centrally managed. RNLAGA and the Hydrographical Service are playing a central role herein. This means that theoretically there are no possible duplications in data (purchases), apart from the backups. But also the technical exchange of knowledge, acquiring and managing licenses and maintenance of the (GIS) software (e.g. Enterprise License Agreement) may contribute to efficiency.

These were the statements concerning the perception of the usefulness of a corporate SDI. On the next page, Part B follows with five propositions relating to the perception of ease of use of a corporate SDI.

6. Statements Part B:

The following brief series of statements relate to the expected ease of use of the DSDI. Here will be discussed how people think about learning to use the DSDI, its complexity, the clarity and its interfaces.

Statement 6:

A DSDI metadata search portal is easy to use.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

Statement explanation:

Metadata tells something about the data or information; for example the quality, projection system, legal constraints, price etc. To quickly search terabytes of geospatial information, this metadata is very important. Not everyone within Defence can already make use of the metadata portal of RNLAGA. As of today it is not uncommon to use out-dated paper catalogues.

For this statement it is therefore important to look at the ability to search for information using the metadata RNLAGA portal or via other portals (e.g. NATO core GIS). It is also possible to look at the Internet portal of the Dutch NSDI: www.nationaalgeoregister.nl.

Statement 7:

The implementation of metadata standards in my current work is easy to perform.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

Statement explanation:

In order to quickly and thoroughly search the metadata, arrangements are necessary regarding the storage of metadata, what metadata should look like and what metadata should include. For this, standards have been developed. But how hard is it to apply those standards? Are they used at all? Or are they being used partially?

Statement 8:

The application of exchange standards is complicated.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

Statement explanation:

You can think of the current method of sharing existing standards such as GML and SHP. Sometimes even a conversion is required, how complicated is this?

Statement 9:

The use of web services (WMS / WFS) is easy to learn in my current GIS projects.

Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

Statement explanation:

After finding geographic information, it is also possible to offer geospatial information via standard web services. For example the level 2 VMAP database of certain areas that, like WFS, is read into the GIS application. This requires a different way of working and may also have implications for the work processes.

Statement 10:

Overall I think the elements of a corporate SDI are easy to use.

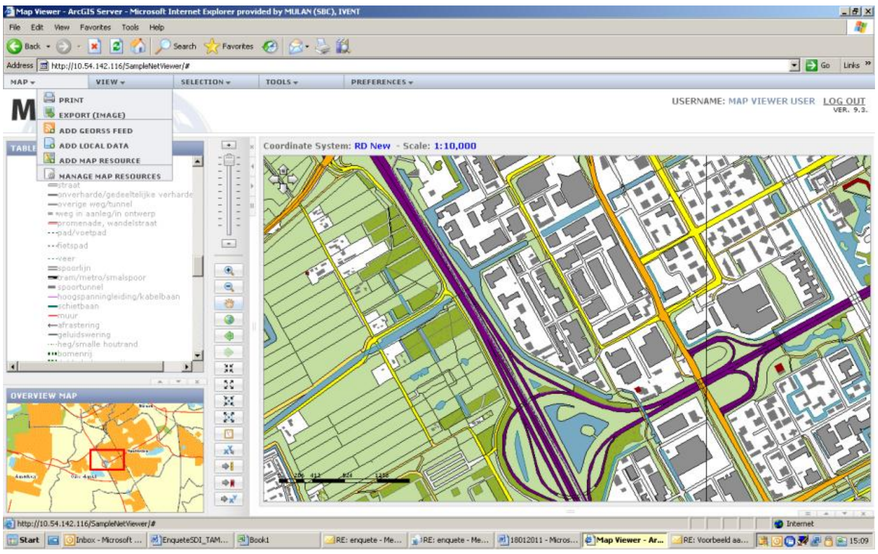
Fully disagree			Neutral			Fully agree
1	2	3	4	5	6	7

<u>Statement explanation:</u>

Some components of a DSDI, which are visible for the end-user, could include:

- Metadata portal in which it is possible to navigate through all geographic information.
- Geo webservices offering basic geospatial information such as VMAP, DTED, imagery, etc.
- Knowledge portal with procedures, methods, workflows and events.

Not all of these parts are currently available as a whole. The knowledge portal, for example, can be found in parts at: http://wiki.mindef.nl/kennisweb_geo_info/index.php?title=Hoofdpagina or http://iventportaal.mindef.nl/operations/aena/gis/default.aspx (Intranet and sometimes registration is required). An example of Web services can be found at: http://10.54.142.116/SampleNetViewer/# (Intranet only). This is a proof of concept (no guarantees for performance) in which all the available layers of the Netherlands as web services are displayed. Including some other features, see Fig.



On the next page you will find four propositions that can be answered with **agree**, **disagree** or **not applicable**.

Statement 11:

Security aspects often provide barriers related to the exchange of geospatial information.

Fully disagree	Not applicable	Fully agree

Statement 12:

Connectivity aspects often provide barriers related to the exchange of geospatial information.

Fully disagree	Not applicable	Fully agree

Statement 13:

For our work we often use our own geospatial data models that are not standardised or just partially standardised.

Fully disagree	Not applicable	Fully agree

Statement 14:

The functional, technical, and application management of our geographic information systems is formally organized and well managed.

Fully disagree	Not applicable	Fully agree

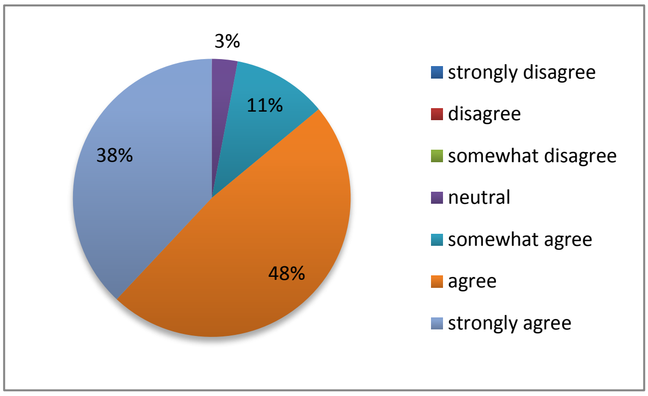
This is the end of the survey, thanks again for your time, effort and opinion!

If you have any questions please let me know.

Appendix D – Survey Results

<u>Perceived Usefulness, statement 1:</u>

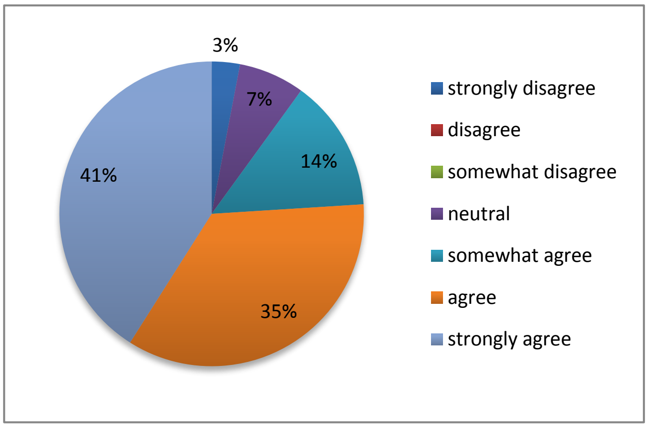
"A DSDI supports the faster achievement of our team and/or department goals"



Most respondents (97%) agree with this statement. One respondent replied with *neutral*, this response came from unit level, acting in isolated situations. The bandwidth is between 4 and 7, which means between *Neural – Strongly Agree*.

<u>Perceived Usefulness, statement 2:</u>

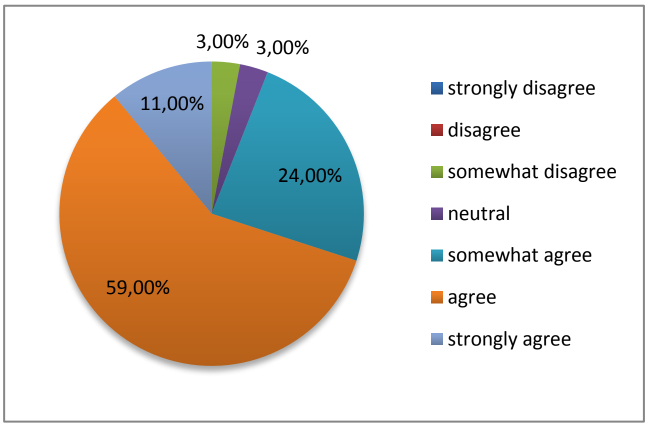
"Collaboration in a DSDI improves the quality of geospatial products and services that are delivered by my unit or department".



90% of the respondents agree with this statement. One respondent replied with *Strongly Disagree*, this came from a unit acting in isolated situations. Two respondents reacted neutral, both from an operational point of view. Bandwidth is between 1 and 7, which means *Strongly Disagree – Strongly Agree*.

<u>Perceived Usefulness, statement 3:</u>

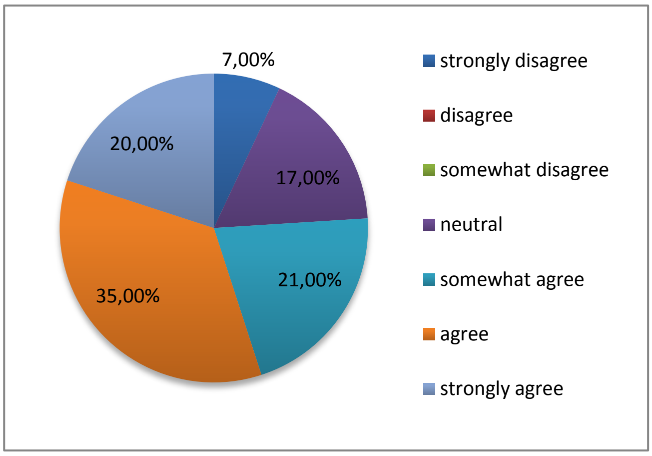
"*Collaboration in a DSDI speeds up the production process within my unit".*



94% of the respondents agree with this statement. One respondent replied with *somewhat disagree;* this response came from unit level acting in isolated situations. One respondent reacted neutral. The bandwidth is between 3 and 7, which means *Somewhat Disagree – Strongly Agree*.

Perceived Usefulness, statement 4:

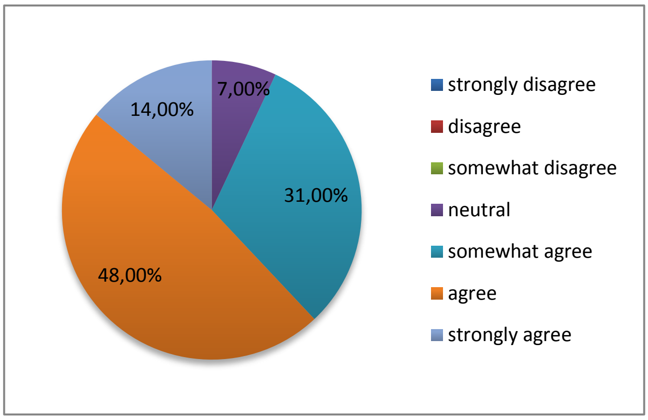
“Our unit or department does not benefit of the use of standards in a DSDI”.



93% of the respondents agree with this statement. One respondent replied with *Strongly Disagree;* this response came from unit level acting in the simulation branch. Another *Strongly Disagree* reaction came from a unit that should benefit. This was probably a mistake due to inversed statement. Bandwidth is between 1 and 7, which means *Strongly Disagree – Strongly Agree*.

Perceived Usefulness, statement 5:

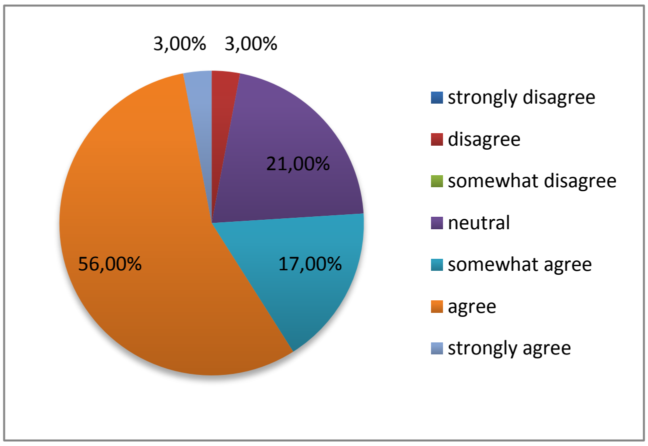
”A DSDI improves the efficiency of my or our geospatial activities”.



93% of the respondents agree with this statement. Two respondents replied with Neutral. Bandwidth is between 4 and 7, which means *Neutral – Strongly Agree.*

Perceived Ease of Use, statement 6:

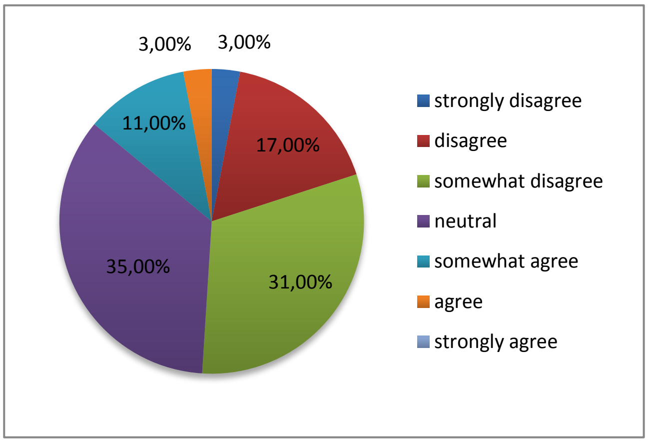
"A DSDI metadata portal is easy to use".



76% of the respondents agree with this statement. One respondent replied with Disagree, this respondent reacted from an often-disconnected situation and therefore has not always the ability to use a portal. 21% of the respondents reacted Neutral. Bandwidth is between 2 and 7, which means *Disagree – Strongly Agree*.

Perceived Ease of Use, statement 7:

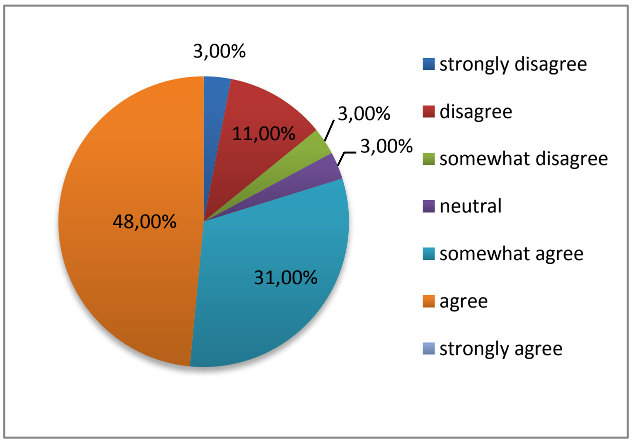
"The implementation of metadata standards in my current position is easily to achieve".



50% of the respondents disagree in some kind of form. The other half of the respondents answered neutral or with somewhat agrees. Only 1 respondent agreed. Bandwidth is between *Agree - Strongly Disagree*.

Perceived Ease of Use, statement 8:

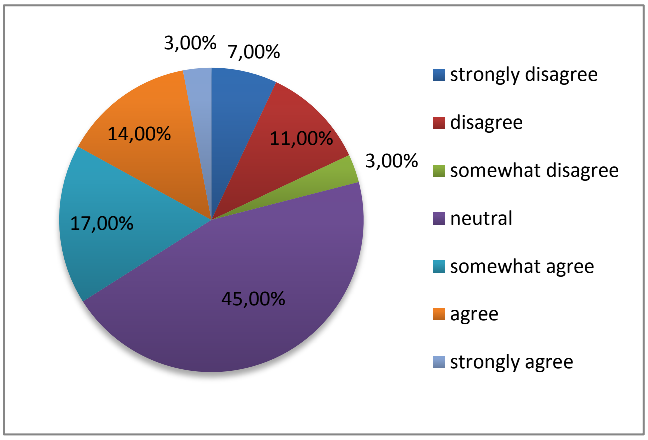
"The application of (exchange) standards is complicated".



79% of the respondents agree or somewhat agree on this statement. 21% disagree or answered neutral. The 'disagree' reactions are spread amongst operational and supportive roles. Bandwidth is between *Strongly Disagree – Agree*.

Perceived Ease of Use, statement 9:

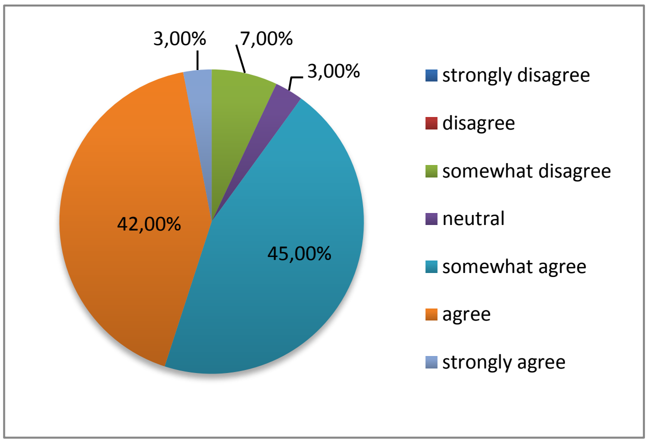
"The use of webservices (WMS/WFS) is relatively easy to learn and to practice in my current GIS projects".



21% of the respondents perceive the use of webservices as relatively difficult to learn and use in their current projects. 45% is neutral and the 34% perceive the ease of use more positive. Bandwidth is between Strongly *Disagree* and *Strongly Agree.*

Perceived Ease of Use, statement 10:

"In general, I think that the components of a DSDI are easy in use".



87% of the respondents somewhat agree or agree on the perception that the DSDI is easy to use. Only 7% somewhat disagrees. Bandwidth is between *Strongly Disagree* and *Strongly Agree.*