USABILITY WITHIN THE DIGITAL BATTLEFIELD

Usability Issues As Applied To The

Digitised Battlefield Within A Southern African

Military Context.

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Thesis presented in partial fulfilment of the requirements for the degree of

Master of Commerce at the University of Stellenbosch.

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MARCH 2002

DECLARATION

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

Signature:

Date:

ABSTRACT

USABILITY WITHIN THE DIGITAL BATTLEFIELD

Defence forces around the world are experiencing a period of dynamic change with new force structures being combined with new technologies in an effort to enhance effectiveness. Present day resources and technology available to the modern society, have facilitated the evolution of warfare as a technologically advanced enterprise, with the decided emphasis on the digitisation of the battlefield. With rapid development in the field of battlefield digitisation there is an increasing need to address the important issues and challenges facing the military. In order to meet strategic defence guidelines, it is necessary to integrate the capabilities of defence forces with modern technology. In this regard the South African Defence Force is striving towards the digitisation of the battlefield. This digitisation can potentially satisfy the many requirements set for the Defence Force, in a more timely and cost-effective manner than traditional methods of functioning and training would be able to achieve.

Effective situational awareness and command and control structures are essential for any military operation, especially with increasingly complex military demands. Key areas of importance are the collection, dissemination and management of information, which if executed skilfully, will result in forces capable of operating more effectively and with greater flexibility. Decision makers on the battlefield continually suffer from information overload due to the extremely rapid inflow of information. This is likely to worsen with the continued introduction of new information technologies. The technology level of any defence force should therefore be appropriate, driven by usefulness and cost-effectiveness.

The digitised battlefield allows for the execution of near realistic military exercises, while conserving material and reducing the detrimental impact on environment and personnel, as is the case with traditional exercises. A key issue of focus is the usability and integration of related technologies within the digital battlefield. Promoting optimal usability through continuous and comprehensive user-based evaluation is crucial and will result in increased human performance through interaction with technology. Optimal usability must be engineered into any product (defined as something produced by means of either human or mechanical work) from the inception of the product's life cycle.

Within today's technology orientated society, the digitisation of the battlefield and the usability thereof have become increasingly important issues. Most research has investigated the concepts of battlefield digitisation and usability in isolation, and little co-ordinated effort has been made to integrate digitisation and usability, even though the relation is important and necessary. A study of this nature has not hitherto been conducted within the South African military context. The purpose of this study is to provide a theoretical background of the issues of military digitisation and usability, in order to determine the significance of this relation. This research aims specifically to promote the viewpoint that usability is central to military digitisation, as well as to emphasise the importance of user-centred approaches to system development and utilization. The result will be enhanced human performance and satisfaction when interacting with digital battlefield applications.

The theoretical perspective is provided by way of a literature review of the relevant military and usability concepts. Military functioning is discussed, highlighting the importance of situational awareness and effective command and control capabilities. The digitisation in the military is examined with specific reference to Virtual Reality and simulation. An overview of usability (within a human-computer interaction and user-centred design context) and usability evaluation methods are provided.

This research was conducted during a military exercise conducted by the South African National Defence Force. A usability inquiry approach was followed with questionnaires distributed to participants involved with the Command and Control Digital Battlefield System. Information was obtained concerning participants' characteristics, likes, dislikes, needs, and understanding of the digital battlefield system. The analyses of the information consisted of descriptive statistics as the research aimed to illustrate the attitudes concerning usability and the digital battlefield. The results provide an understanding of the perceptions of the users regarding the digital battlefield system and its usability. Conclusions are drawn from results obtained and recommendations are made for future research.

OPSOMMING

"USABILITY WITHIN THE DIGITAL BATTLEFIELD"

Moderne weermagte deur die wêreld ervaar tans 'n periode van dinamiese verandering met nuwe magstrukture wat met nuwe tegnologieë gekombineer word ter bevordering van doeltreffendheid. Die hedendaagse hulpbronne en tegnologie tot die moderne samelewing se beskikking, het meegebring dat oorlogvoering ontwikkel het in 'n tegnologies gevorderde aksie met die klem op gevegsterrein-digitalisering. Die betreding van 'n era van tegnologies gevorderde oorlogvoering met die gepaardgaande snelle ontwikkelings in die veld van gevegsterrein digitalisering, het 'n toenemend groeiende behoefte laat ontstaan vir die indringende aanspreking van belangrike strydvrae en uitdagings wat 'n moderne weermag in die gesig staar. Dit is noodsaaklik dat die vermoëns van weermagte geintegreer word met moderne tegnologie ten einde aan strategiese verdedigingsvereistes te kan voldoen. Die Suid-Afrikaanse Nasionale Weermag het digitalisering van die gevegsterrein ten doel. Sodanige digitalisering kan potensieel die talle vereistes gestel aan 'n weermag op 'n meer tydige en koste-effektiewe wyse bevredig as wat met tradisionele metodes van funksionering en opleiding gedoen kan word.

Effektiewe situasionele bewustheid en bevel en beheer strukture, is onontbeerlik in enige militêre operasie, veral in die lig van toenemende komplekse eise gestel aan die moderne weermag. Sleutelareas van belang is die insameling, disseminasie en bestuur van inligting, wat as dit met die nodige insig en kundigheid uitgevoer word, aanleiding sal gee tot die verhoogde doeltreffendheid en buigsaamheid van 'n weermag. Die tegnologiese vlak van enige weermag behoort dus toepaslik en bruikbaar te wees, sowel as koste-effektief gedrewe.

Die gedigitaliseerde gevegsterrein maak voorsiening vir die uitvoering van bykans-realistiese militêre oefeninge met behoud van material en grootskaalse uitskakeling van die negatiewe invloede op die omgewing en personeel, meer so as wat andersins die geval sou wees met tradisionele oefeninge. 'n Sleutel-aspek is die bruikbaarheid en integrasie van verwante tegnologieë in 'n gedigitaliseerde gevegsterrein. Die bevordering van optimale bruikbaarheid deur aaneenlopende en omvattende gebruikersbaseerde evaluasies, is deurslaggewend en sal lei tot verhoogde gebruiker prestasie betreffende interaksie met tegnologie. Optimale bruikbaarheid moet reeds vanaf die aanvang van 'n produk se lewenssiklus, bewerkstellig word.

In die hedendaagse tegnologie-gebaseerde moderne samelewing, het digitalisering van die gevegsterrein en die bruikbaarheid daarvan, toenemend belangrik geword. In die meeste

navorsing word gevegsterrein digitalisering, asook bruikbaarheid, afsonderlik ondersoek, onafgesien van die belangrike verwantskap daartussen, en slegs geringe gekoördineerde pogings is van stapel gestuur om digitalisering en bruikbaarheid te integreer. In die Suid-Afrikaanse militêre konteks is so 'n studie nog nie uitgevoer nie en derhalwe het hierdie studie ten doel om 'n teoretiese agtergrond te voorsien van militêre digitalisering- en bruikbaarheidskwessies, asook die vasstelling van die verwantskap daartussen. Hierdie navorsing het spesifiek ten doel om die standpunt te bevorder dat bruikbaarheid sentraal staan tot militêre digitalisering sowel as om die gebruiker-gebaseerde benadering tot sisteem ontwikkeling en benutbaarheid, te bevorder. Die resultaat sal verhoogde gebruikerprestasie en tevredenheid wees wanneer interaksie met gedigitaliseerde gevegsterrein toepassings plaasvind.

Die teoretiese perspektief word voorsien deur 'n literatuur-oorsig van die relevante militêre- en bruikbaarheidskonsepte. Militêre funksionering word bespreek met beklemtoning van die belang van situasionele bewustheid en doeltreffende bevel en beheer vermoëns. Militêre digitalisering word ondersoek met spesifieke verwysing na virtuele realiteit en simulasie. 'n Oorsig van bruikbaarheid (binne die konteks van mens-rekenaar interaksie en gebruikersgeoriënteerde ontwerp) sowel as bruikbaarheidsevaluasie-metodes word voorsien.

Hierdie navorsing is uitgevoer tydens 'n militêre oefening van die Suid-Afrikaanse Nasionale Weermag. 'n Bruikbaarheidsondersoek-benadering is gevolg deur vraelyste uit te deel aan die deelnemers wat betrokke was by die gedigitaliseerde bevel en beheer stelsel. Informasie is ingewin betreffende die deelnemers se kenmerke, persepsies, voorkeure, afkeure, behoeftes en begrip van die gedigitaliseerde gevegsterrein-stelsel. Die analise van die informasie het beskrywende statistieke behels omdat die navorsing ten doel gehad het om ingesteldhede betreffende bruikbaarheid en die gedigitaliseerde gevegsterrein, uit te lig. Die resultate voorsien 'n begrip van die persepsies van die gebruikers rakende die gedigitaliseerde gevegsterrein, en die bruikbaarheid daarvan. Gevolgtrekkings word gemaak vanuit die resultate verkry en aanbevelings word voorsien vir verdere toekomstige navorsing.

ACKNOWLEDGEMENTS

I would like to thank the following people and institutions for their valuable contributions:

- My supervisor, Dr. Marna Cilliers-Hartslief, for her advice, encouragement and recommendations as well as for her enthusiasm for research and this subject in particular, which I admire and aspire to. I have never known a lecturer to work so hard for her students. The lessons I've learnt from her reach far beyond this thesis.
- Mr. CJ Calitz, who agreed to act as co-examiner.
- Mr. B Kleynhans, who agreed to act as external examiner.
- Coreli Cillie, who is always ready to help and assist with any request.
- The South African Army for the opportunity to do the research within their environment, in particular 43 and 46 SA Brigade. In particular I would like to thank Col. George van Rensburg, Mr. Anton Jordaan and Col. Theo Wilken.
- The National Research Foundation (NRF), for research funds. Opinions expressed in this thesis and conclusions arrived at, are those of the author and not to be attributed to the NRF.
- Raoul de Villiers, for his encouragement and love, good humour and understanding. Going through this process together made the load much more bearable.
- Finally, I thank my parents for their love, support, time, effort, especially for their guidance, and in particular my father for his expert technical help. Their praise and encouragement have made me believe that I can accomplish anything. Their investment in me is greatly appreciated.

> *If I believe I cannot do something, it makes me incapable of doing it. But when I believe I can, then I acquire the ability to do it even if I didn't have it in the beginning.*

- Mohandas K. Gandhi

KEYWORDS

Command and control (p. 15)	Bevel en beheer
Digital battlefield (p. 17)	Digitale gevegsterrein
Human-Computer Interaction (p. 26)	Mens-Rekenaar Interaksie
Information Management (p. 12)	Inligtingsbestuur
Simulation (p. 22)	Simulasie / Elektroniese Nabootsing
Situational Awareness (p. 9)	Situasionele Bewustheid
Synthetic Environment (p. 15)	Sintetiese (elektroniese) Omgewing
Usability Engineering (p. 34)	Bruikbaarheidsingenieurswese
Usability Evaluation (p. 36)	Bruikbaarheidsevaluering
Usability (p. 28)	Bruikbaarheid / Benutbaarheid
User-Centered Design (p. 26)	Gebruikersgeoriënteerde Ontwerp
Virtual Reality (p. 18)	Virtuele Realiteit

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CHAPTER 1: INTRODUCTION

BACKGROUND

The resource and technology base of advanced information-based societies has enabled warfare to evolve into a technologically advanced enterprise, involving a wide range of technologies with the emphasis on the digitisation of systems. Within a military context the focus is on issues concerning the use and usefulness of digitisation. With the rapid development in the field of battlefield digitisation, there is an increasing need to address the key issues and challenges facing the military, as we move towards an era of high technological warfare. Although the capabilities of less developed societies are more limited and certain high technology resources are excluded, the modern approach to warfare gravitates towards the more advanced end of the technology spectrum. Ultimately, the technology level of any defence force should be appropriate, driven by usefulness, affordability and cost-effectiveness.

The success of an organisation depends on its level of productivity, underpinned by three aspects, namely human and technical factors, as well as knowledge. The optimisation of the contribution of the workforce to the organisation, as well as the successful assimilation of relevant technical factors, depend largely on the quality of training provided. In military training and preparation, exercises must be realistic, yet safe – battles without bloodshed. Digital battlefields can provide unique training environments, especially suited to military training where the real environment is dangerous, equipment is expensive or where situations that are trained for may, or may never occur (for example war). Digital battlefield applications can be utilised as a concept development tool, a training tool, a procedures development tool and an integration tool.

Effective situational awareness, defined as the dissemination and appreciation of the aggregate of all the important information necessary to make an optimal decision, as well as sound command and control structures, being the exercise of authority and direction over a military force, are essential for any military operation, especially with increasing complex military demands. Key areas of concern are the dissemination and management of information, resulting in forces capable of operating at higher levels and with greater flexibility. In an effort to increase the effectiveness of defence force operation through increased situational awareness and superior command and control capabilities, the global tendency is towards the digitisation of the battlefield. The digitised battlefield allows for the performance of near realistic military exercises while conserving material and reducing the impact on the environment. Within the digital battlefield, a key issue of focus is the usability and integration of related technologies. Military Human Factors Engineering is a diverse and challenging area and has contributed significantly to Human Factors in general, especially in terms of research and development activities. Human Factors engineers support the acquisition, development and deployment of a wide variety of military systems. The crucial issue is the promotion of high levels of usability through continuous and comprehensive user-based evaluation, thereby ensuring that human performance is increased through interaction with technology.

The importance of usability is becoming increasingly obvious from the growing number of Human Factors professionals and firms specialising in usability, as well as an increasing amount of publications, meetings and conferences concerning the subject, concomitant with the realisation of national ergonomic standards in many countries. To ensure the usability of interactive computer products, usability concerns must be included in the system design process. The goal of the User-Centred Design process is to ensure that the system being designed, takes account of human capabilities, skills, limitations and needs. A high level of usability is not something that happens by accident; it should be engineered into a product from the beginning of the product's life cycle.

WORLD TRENDS

After events such as the end of the cold war and the fall of the Berlin wall, as well as increasing passivism, environmentalism, Human Rights activism and the shift toward social upliftment, there is a lack of threat perception resulting in the defence forces around the world going through a period of dynamic change. In order to meet strategic defence guidelines and enhance effectiveness, it is necessary to integrate defence forces' capabilities with modern technology. In an era of budgetary constraints, securing adequate funding to develop, implement and integrate new technologies, is becoming increasingly difficult. This is achieved by capability development activities involving a combination of command post exercises, field training exercises and advanced simulations (Unewisse, Gaertner, Grisogono, & Seymour, 1999).

Defence forces will be developed to cover the widest range of operational contingencies likely to be encountered in the future. These forces will share significantly enhanced situational awareness, through the introduction of advanced Command and Control systems, allowing for broader dispersion of forces with enhanced firepower. Much of the enhanced capability of the new forces will be derived from improvements in individual capabilities, by means of the application of enhanced Command, Control, Communication, Computing, information, Intelligence, Surveillance and Reconnaissance (C^4I^2SR) systems. It will increase the ability of commanders to shape the battle environment, and empower field personnel with unprecedented levels of information (Unewisse et al., 1999).

A key feature of the new trend in defence force application is that it will usually be operating as part of a joint force (Army, Navy and Air Force) and as a multi-national interagency (joint-combined) force. Thus C^4ISR systems will have to be able to convey situational awareness across the full range of participating forces and nationalities. Prime examples of countries around the world that endeavour to develop their forces to meet the unique challenges of future warfare include Australia, Britain and Germany, and in particular the Defence Force of the United States of America (Ripley, 1999 & 2001; Wilson, 1997).

THE SOUTH AFRICAN PERSPECTIVE

The White Paper on Defence (as approved by Parliament on 14 May 1996) provides that the primary role of the South African National Defence Force (SANDF) shall be to defend South Africa against external military aggression, as well as to maintain territorial integrity and political independence of state (Republic of South Africa, 1998). The SANDF has as its goal the provision of conditions in which individual citizens live in freedom, peace and safety; participate fully in the process of governance; enjoy the protection of fundamental rights; have access to resources and the basic necessities of life; and inhabit an environment that is not detrimental to their health and well being. The expectations of the SANDF are that the defence force should be equipped and ready to carry out tasks such as having an affordable and sustainable force, structured appropriate to its peacetime role and capable of expanding timeously to meet defence contingencies, which might arise in the future. The defensive policy is one of deterrence: the policy of discouraging enemy attack by maintaining sufficient military force to retaliate. The SANDF must maintain effective intelligence and early warning capabilities to enable it to respond timeously to changes in the strategic environment. The SANDF must maintain and develop the capabilities and skills required to contribute to national and regional security (Republic of South Africa, 1998).

The success of the SANDF depends on its level of productivity, based on its knowledge, human and technical factors. To succeed, the SANDF must integrate employees through training in order to enhance loyalty, and minimise regional, ethnic and personal interests. The optimisation of the contribution of the workforce to the organisation, as well as the successful integration of relevant technical factors, depend on the quality of training provided. Training is of critical importance to the SANDF in order to build and maintain the competency of soldiers. Special training programmes and environments are required to integrate forces and standardise procedures. The quality of the SANDF's training will be a major determinant of the SANDF's future effectiveness in executing its defence function. The near impossibility of duplicating actual combat situations for training purposes, the financial constraints and physical danger of conducting live field exercises, make simulation and war gaming, vital tools for preparing soldiers, both on a single service and a joint service basis (Andrews, Dineen & Bell, 1999). Simulation and war gaming are invaluable for teaching combat drills and procedures and are essential for the evaluation of doctrine, operational concepts and command and control concepts (Republic of South Africa, 1998).

Taking into account the list of requirements, environmental realities and resource limitations, choices have had to be made and as a result, several strategically essential technologies and capabilities have been identified. Relevant to this study, they include:

- Command, Control, Communication and Computing systems; and
- Simulation systems and war gaming.

Command, Control, Communication and Computing (C^4) systems are considered strategic to military functioning. Without these any battle, conflict or operation, (for example peacekeeping support or humanitarian operations) will be unsuccessful. It is vital to have control over the technology, supply and operation of the software and equipment, which must also conform to the unique SANDF organisational doctrine and tactical requirements. Success in countering the threats of the future security environment will require that C^4 systems must consist of durable, robust, reliable and secure communications equipment, networks, and supporting infrastructures (Republic of South Africa, 1998).

Simulations vary from simple mechanical or electronic aids, from teaching basic skills to soldiers, to highly sophisticated computer-driven systems, that enable the development of complex skills such as flying an aircraft, or air combat manoeuvres against an opponent in a linked simulator. War-gaming may range from board and sandbox games to sophisticated computer controlled systems that enable the simulation of combat between imaginary forces of opposing command cadres (Republic of South Africa, 1998).

The development of new doctrine and weapon systems, that exploit innovative technology in order to provide significant combat capabilities in future conflicts, is a complex, expensive and time-consuming task. Prior to the actual development of new systems, a specific military 'need' must be articulated based upon identified military threats. Given the time and expense associated with weapon systems testing and doctrinal development, the use of simulation environments and digitisation of the battlefield, may alleviate the risks in cost and time (Unewisse et al., 1999).

The digital battlefield can satisfy many requirements set for the defence force. One of the most important requirements set for commanders is to be in a position where awareness of enemy movement is greater, and reaction and decision-making is quicker. Being able to operate within the decision making cycle of the opposing commander is a distinct advantage. It is important to be able to issue orders and instructions to units at a rapid rate and in a comprehensible and executable format.

RELEVANCE OF THE STUDY

Within today's modern technologically based society, the digitisation of the battlefield and related usability issues have become increasingly important. Although the constructs have received a lot of attention, most research has investigated the constructs in isolation and little co-ordinated effort has been made to integrate digitisation and usability, even though an association seems quite logical and relevant.

Secondly, no study of this nature has been conducted in the Southern African military context, which is characterised by tremendous change and uncertainty. In an era of budgetary constraints, securing adequate funding to stage large and realistic training exercises, is becoming increasingly difficult. As a result, the SANDF is endeavouring to digitise the battlefield, which can potentially fulfil the many conditions set for training as well as command and control execution, in a more timely and cost-effective way than traditional methods would be able to do. The SANDF has agreed to participate in this study, because they recognise the importance of the constructs in question.

PURPOSE OF THE STUDY

The main purpose of this research is to attempt to provide a theoretical background of the issues of usability in military digitisation and to determine how they are related. To date no study of this nature has been undertaken. This research aims to provide an overview of the area of investigation and to set a precedent for further research.

The specific objectives of this research are as follows:

- To promote a better understanding of, and insight into usability in military digitisation, by providing a comprehensive description of the related concepts and issues;
- To support and advance the perspective that usability is central to military digitisation, and to instil in researchers, developers and users, the importance of user-centred approaches to system development and use. The key is constant and thorough user-based evaluation, to ensure that human performance and satisfaction are increased by interaction with digital battlefield applications;
- To design a study with both theoretical and practical relevance. The research should thus be of considerable interest to academics, Human Factors practitioners and military personnel;
- To make a contribution to theory building in the field of Human Factors. The relations between the constructs are complex and are indicative of many possible networks.

OUTLINE OF THE RESEARCH REPORT BY CHAPTER

The research chapters are organised as follows:

Chapter 1 comprises an introduction with a general overview providing the background for the study, with observations concerning the relevance and purpose of the study.

Chapter 2 consists of a literature review of military digitised battlefields and usability concepts relevant to this study, and thus provides the theoretical perspective. The chapter includes an overview of military functioning, highlighting the importance of situational awareness and command and control capabilities. The digitisation of the military is discussed with particular reference to Virtual Reality and simulation. Furthermore, an overview is provided of usability within a context of Human-Computer interaction and User-Centred Design. The chapter concludes with a discussion of usability evaluation methods.

Chapter 3 deals with the research strategy employed in this study. The research problem and objectives are elucidated. Within this chapter the hypotheses are stated, and an account is given of the sample, the measuring instrument, and the statistical analysis.

Chapter 4 comprises the presentation of the results and a discussion of the findings.

Chapter 5 provides the final conclusions as well as the proposals and recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 MILITARY CONCEPTS

2.1.1 INTRODUCTION

The rapid and ever increasing advances in the field of electronic science and the application thereof in information technology, are receiving increasing attention from scientific, business, academic and also military communities, due to its high potential for easier communication between humans and computers. Within a military context, the focus is on issues concerning the use and usefulness of digitisations of a military nature. With the soaring growth of investment in the field of battlefield digitisation, there is an increasing need to address the key issues and challenges facing the military's needs in the 21st century, as we move towards an era of ever advancing technological warfare.

As it is the purpose of this research is to provide a theoretical background of the issues of usability in military digitisation and to determine how they are related, a discussion will now following concerning military issues and topics relevant to this study.

2.1.2 DEFENCE FORCE OPERATION

There are several aspects of the future world that will impact on the armed forces of any country. Globalisation will continue to expand, fostering an increased awareness of and participation in international events. The advances in transportation, communication, information technology and extended economic ties further advance the internationalisation of the world. Concomitant herewith, potential enemies will also have access to the global commercial base and much of the same technology. No single force will be able to sustain a wide technological advantage over their adversaries. Therefore, the armed forces of the future must be prepared to confront a wide range of military challenges in various and unfamiliar parts of the world, operating with multinational forces and coordinating with the military, governmental agencies and international organisations. The advantage will thus come from equipment and training that will assist forces to take advantage of technology in order to achieve superior effectiveness (Joint Vision (JV) 2020, 2000).

Success in countering the threats of the future security environment will require the skilful integration of the competencies of separate forces into a joint force, tailored to specific situations and objectives. Thus command and control, communications and intelligence systems will have to be able to connect participants across a range of forces and nationalities (Unewisse et al., 1999). Interoperability will be the foundation of effective joint, multinational and interagency operations. Interoperability is defined as the ability of systems, units or forces to provide services to and accept services from other systems, units or forces and to use the services exchanged in this fashion, to enable them to operate together effectively (JV 2020, 2000).

The ultimate goal of a military force is to accomplish the objectives directed by their National Authorities. For a defence force of the future, this implies the ability to control any situation across a wide range of military operations. The wide range of operations include both combat and non-combat operations as shown in Figure 2-1:

MILITARY OPERATIONS		GOALS	EXAMPLES
COMBAT	War	*Fight & Win*	▪ Combat operations: Attack / Defend / Blockade
NON COMBAT	Military Operations Other Than War	*Deter War & Resolve Conflict*	▪ Peace enforcement ▪ Counter terrorism ▪ Show of force ▪ Nation assistance
		Promote Peace & Support Civil Authorities	▪ Humanitarian assistance ▪ Civil support

FIGURE 2-1: Schematic Representation of a Range of Military Operations

(Adapted from JV 2020, 2000, p. 7)

The complexity of future operations requires that forces must have the capability to participate effectively in unity. Operational concepts (as defined in JV 2020, 2000) that are central to the functioning of the joint (and combined) force of any country, include:

- *Dominant Manoeuvre* – This refers to the ability of a joint force to gain positional advantage with decisive speed and operational expediency in the achievement of military tasks. Widely dispersed joint air, land, sea and special forces will secure this advantage through the application of information, deception, engagement, mobility and counter-mobility capabilities;
- *Precision Engagement* – The ability of joint forces to locate, survey, discern and track objectives or targets; select, organise and use the correct systems; generate the desired

effects; and re-engage with decisive speed and operational expediency as required throughout the wide range of military operations;

- *Focussed Logistics* – Ensuring joint military capability by delivering the right equipment, supplies and personnel in the right quantities, to the right place, at the right time in order to support operational objectives;
- *Full Dimensional Protection* – Refers to the ability of the joint force to protect its personnel and other assets, especially in the presence of threats, in order to enable them to conduct operations decisively.

2.1.3 SITUATIONAL AWARENESS

INTRODUCTION

New technology, advanced weapon systems, sensors, and information systems will continually become more freely available. Prioritising the establishment and continuation of superior knowledge capabilities, is considered essential to maintaining an advantage, as modern military technology becomes progressively more available to potential adversaries (Unewisse et al., 1999). Thus, any edge over potential adversaries will result from better and more effective use of these systems, that is to say, through improved decision-making resulting from superior situational awareness.

The requirements and challenges relating to situational awareness are influenced by the many factors included within the modern battlefield. The modern battlefield is a fusion of components operating in the land, air, naval and information domains. Landscape, weather, vegetation, man-made elements amongst others, all contribute to the complexity of the environment, which in turn complicates all aspects of operations, for example communications, surveillance and mobility. The battle environment is further complicated by a large number of independent elements (individual soldiers or groups that must be integrated into operations and controlled), and increased dispersion of operations as a result of improved mobility, communication, command and control. In addition, the battle space is populated with own forces, enemy forces and neutral entities that must be located and identified within a multifaceted battle environment (Endsley, 1995; Unewisse et al., 1999).

Situational awareness is a cognitive process. The ability to understand the present state and visualise a successful future end state, demands people with excellent cognitive skills. The higher the organisational level, the more complex the task and the cognitive capacity required to accomplish the task. Cognitive processes consist of many types of mental processes such as learning, memory, concept formation, problem solving and decision-making. Cognitive complexity involves a broad range of skills that include integration of information, abstraction, independent thought and the use of complex frames of reference. Cognitive complexity is not a measure of what to think, but how to think. Higher cognitive complexity skills give commanders the ability to understand what information is important and thus to correctly see the present battlefield state and desired end state (Bloom, 1956; Reisweber, 1997).

Decision-making under stress is characterised by limited time available, high workload, and ambiguous information. The two main components of military decision making involve assessing the situation to establish what is happening and action selection (deciding what to do). Action selection is addressed by standard operating procedures drilled into soldiers via military training from an early stage. Situational awareness is more difficult to instil in a soldier. Effective situational awareness is fundamental to any operation (defence or humanitarian), especially in increasingly complex military environments, as well as constantly evolving technical environments. In order to achieve a better understanding of the battle environment and promote rapid and improved decision making, it is essential for soldiers to have a knowledge advantage whilst on the battlefield (Moroney & Bittner, 1995).

A key element in accomplishing the maximising of defence force success (within limitations such as budgetary constraints) is the effective collection, processing, management and dissemination of information in order to optimise situational awareness. An effective situational awareness system, will allow a force to dominate any potential adversary by enabling that force to deny or exploit the enemy's flow of information and optimise their own flow of information in order to facilitate the most advantageous decision making (Unewisse et al., 1999).

DEFINITION

Unewisse et al. (1999, p.1) characterises situational awareness as 'a superior understanding of all relevant elements of the battle space (e.g. status and location of own and enemy forces) relative to any potential adversary'. It involves battlefield visualisation, which refers to the process whereby a commander develops a clear understanding of the current state with relation to the enemy and environment, envisions a desired end state which represents mission accomplishment, and then subsequently visualises the sequence of activity that moves the commander's force from its current state to the end state (Corona, 2001; Training and Doctrine Command (TRADOC), 1995).

Situational awareness is defined as the dissemination and appreciation (by the decision maker) of the sum total of all the important information necessary to make an optimal decision (Ripley, 1999; Unewisse et al., 1999). Situational awareness is concerned with providing a decision maker, usually a commander, with the required information at the appropriate time, in a manner that is useful. The previously mentioned challenges within the battlefield environment, causes this to be a demanding requirement to meet. Battlefield situational awareness is recognised as a concept separate from decision-making and performance, although a discrepancy in one leads to inconsistency in another (Endsley, 1995). Inaccurate situational awareness often causes inadequate decision making, which results in poor performance.

Endsley (1995) defines situational awareness as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the future. In the model of situational awareness (see Figure 2-2) the first level of achieving situational awareness is to perceive the status, attributes and dynamics of relevant elements in the environment. A commander needs an accurate perception of the location, size, capabilities and dynamics of all own and enemy forces within a battlefield along with their relationship to other points of reference. Secondly, situational awareness involves an understanding of the significance of those elements. The commander forms a holistic picture of the battlefield, understanding the importance of certain elements and their relation to and influence on other elements. The ability to project the future actions of the elements in an environment forms the third and highest level of situational awareness. Knowing the status and dynamics of elements, it involves the ability to decide on the most favourable course of action to meet one's objectives.

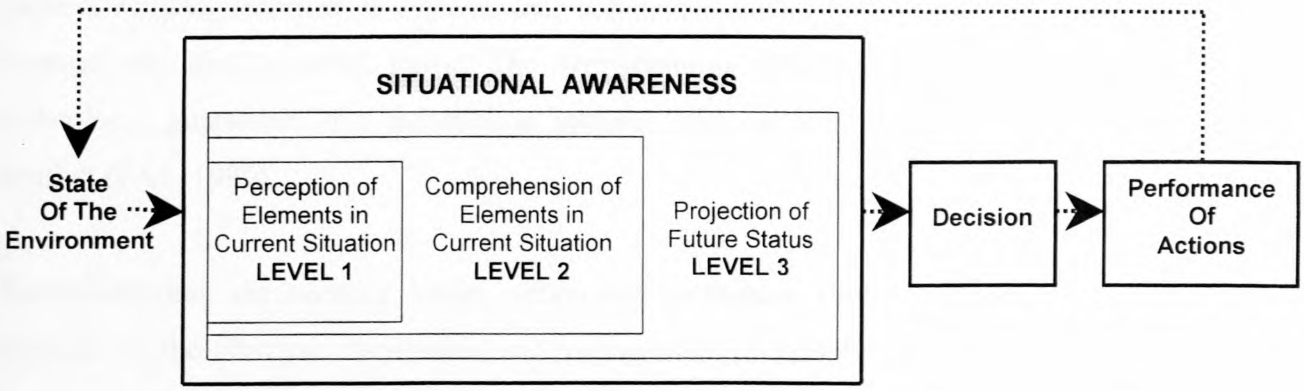


FIGURE 2-2: Model of Situational Awareness

(Adapted from Endsley, 1995, p. 35)

Situational awareness will influence the way in which information is assessed and used to make decisions. Situational awareness consequently impacts on performance. It is expected that good situational awareness can increase the probability of good performance, by influencing the quality of the decisions made (Endsley, 1995).

The main objective of situational awareness is the provision of intelligence in the form required and in a manner optimised for assimilation by the decision makers (Corona, 2001; Seymour, Kirby, Krieg, Reid & Unewisse, 2001). Battlefield situational awareness relies on superior abilities to plan, monitor and evaluate problem solving. It involves understanding what information is important, and perceiving the battlefield state. Situational awareness is ultimately the ability to define the essence of a situation and is dependant on the management of information.

THE MANAGEMENT OF INFORMATION

Information has always been a central component of warfare. Information, information processing and communications networks, are at the core of every military activity (JV 2020, 2000). Information about an enemy's intentions and actions will define one's response. Precise information about enemy forces and capabilities is essential for targeting and damage assessment. Detailed knowledge concerning one's own forces is also necessary for effective deployment of these forces. Wars can be lost due to insufficient or incorrect information, or due to too much information delivered too late or unintelligibly (Federation of American Scientists (FAS), 1995). Ultimately, the quality of the information influences the quality of the intelligence.

The centrality of information technology as a component of warfare has a potentially negative implication. As the development of information technology accelerates, new vulnerabilities are created. Military information systems face active threats and can become principal targets for enemies who aim to wreak havoc. The overwhelming dependence on advanced information technology, guarantees that information systems will become important targets in times of conflict (FAS, 1995).

Notwithstanding the security issues, situational awareness within a battlefield environment depends on the effective distribution and management of information (Unewisse et al., 1999). Information superiority is defined as the capability to collect, process and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same (JV 2020, 2000). The ongoing information revolution is creating quantitative and qualitative changes in the information environment that will result in profound changes in the conduct of military operations.

Currently the flow of information is achieved mainly through a manual process, involving a chain of command where information is passed up or down this structure. Different information systems have been implemented within specific roles such as logistics or artillery. These systems, although effective for their specific individual functions (see Figure 2-3 for a graphic representation), have often ended in the bottlenecking of information, due to an inability to share information with other systems and information overloading. Successful situational awareness can only be achieved if information systems are fully integrated and interoperable, with data being shared with other systems or units (see Figure 2-4 for a graphic representation).

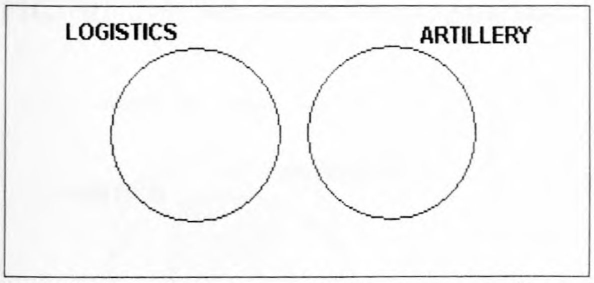


FIGURE 2-3: Schematic Representation of a Specific Information Space

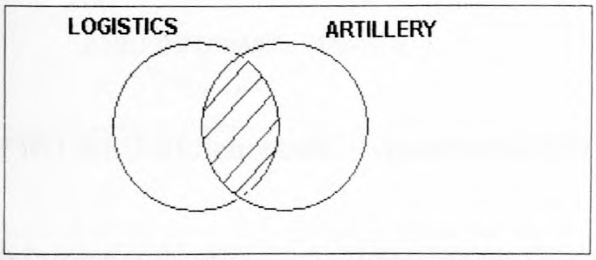


FIGURE 2-4: Schematic Representation of an Interoperable Information Space

The graphic representation, although simplistic, illustrates that new generations of information systems have to be inherently interoperable so that it is easy to share information with other systems, especially in the case of higher order systems such as task forces and headquarters (Seymour, et al., 2001). Unewisse et al. (1999) postulates that this concept will be extended into a network of systems able to tap into a pool of information within a virtual information space, which can be referred to as a Joint Information Space (Seymour, et al., 2001).

Elements such as logistics or artillery will continue to operate with their local command and control system in order to communicate with and direct their subordinates. However, a large proportion of the information flow will be routed through the joint information area (see Figure 2-5 for a graphic representation). Any unit will thus potentially have access to all of the information contained within the distributed information pool. Situational awareness of the complete battle picture can only be improved if information systems are interoperable and data is increasingly shared among systems (see Figure 2-6 for a graphic representation).

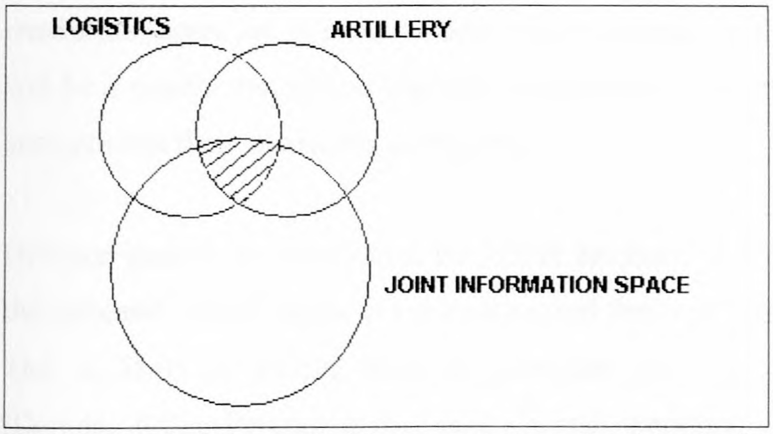


FIGURE 2-5: Schematic Representation of a Joint Information Space

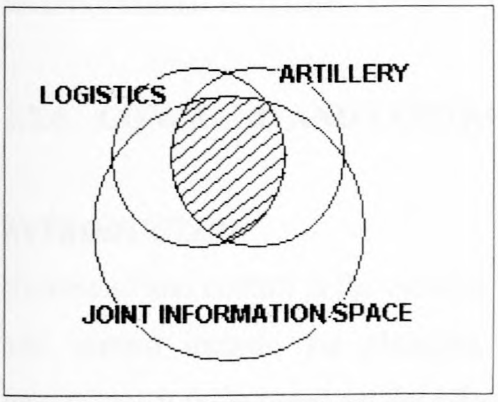


FIGURE 2-6: Schematic Representation of Improved Situational Awareness

Information dominance will provide the joint force with a competitive advantage only, when it is effectively translated into improved knowledge and decision-making. The joint force must be able to take advantage of superior information converted to superior knowledge in order to achieve decision superiority. Decision dominance does not automatically result from information superiority. Aspects such as organisational and doctrinal adaptation, training and experience, command skills, as well as command and control tools, are also necessary.

In order to achieve information superiority, it is necessary to sort and filter information since most users will only want the information needed to help them make a specific decision. Information filters must be implemented to customise the intelligence presented to the user, so that it is relevant to their current role (for example within an artillery unit) and within the context of the battle space. The information presented should ideally only include the information required by a decision maker to achieve the necessary situational awareness, in order to formulate the appropriate decision. Decision-making is significantly influenced by the order in which the information is received and decision makers often show a confirmatory bias (preferentially recalling information that is consistent with their final decision) (Moroney &

Bittner, 1995). Methods must therefore be implemented to manage the flow of information to ensure that users are not overloaded with unnecessary information. The ideal result, therefore, will be a system that allows the user to customise their interaction with the information system and optimise their situational awareness.

Decision makers on the tactical battlefield are burdened with a severe mental workload due to the extremely rapid inflow of information and they continually suffer from information overload. This is likely to worsen with the continued introduction of new information technologies (Corona, 2001). Psychologists explain mental workload in terms of task demands, imposing a load on cognitive processing mechanisms. Reduced situational awareness can be expected if high levels of mental workload and stress are present (Cilliers, 1992).

2.1.4 COMMAND AND CONTROL

INTRODUCTION

Command and control is the exercise of authority and direction over a military force. Command and control include the planning, directing, coordinating and controlling of forces and operations. It is focussed on the effective execution of the operational plan and accomplishment of a mission, with the central focus on decision-making. Command and control is most effective when decision superiority exists. Decision superiority results from superior information filtered through the commander's experience, knowledge, training and judgement; the expertise of supporting staff and the efficiency of associated systems (JV 2020, 2000).

Battle command remains a combination of art and science. It involves expertise in understanding the current state of the battlefield, visualising a desired future end state, communicating intent and making the desired end state a reality (Reisweber, 1997). It is the ability of commanders of defence forces to create a vision for success and see it applied on the battlefield by successfully communicating it to subordinates, constructing a plan that will achieve success and providing leadership, that will carry the operation to a successful end state. Although information technology remains a core part of the ability to visualise a battle situation, focussing on and training of the human element will be critical for success. There is no substitute for technical superiority in proficient battle command. However, technical proficiency alone is not a guarantee for success on the battlefield (Reisweber, 1997).

To operate successfully in a changing world, defence forces need an awareness of the battlefield that allows them to make and implement decisions faster than the enemy. This is the foundation of knowledge-based warfare, which is based on the principle that knowledge is not just a support function of military capabilities, but that it is the key to all military capabilities (Paige, 1996). The command and control function must be extended to include issues related to communication, computing, intelligence, surveillance and reconnaissance. The application of enhanced Command, Control, Communication, Computing, Information, Intelligence, Surveillance and Reconnaissance (C^4I^2SR) systems will increase the ability of commanders to shape the battle space and empower field personnel with superior levels of information (Unewisse et al., 1999).

Joint command and control is a connection point between humans and technology, and the evolving capabilities of both. Current command and control structures will continually be challenged by factors such as voluminous, ambiguous information and the increased non-hierarchical dissemination of information; dispersed joint force headquarters and decision makers; faster operational tempo; and increased choices among weapons and effects (JV 2020, 2000).

OBJECTIVES

According to Unewisse et al. (1999) there are certain goals that have to be met in order for a defence force to meet its evolving requirements. These goals are associated with the attainment of a better understanding of the current situation, influencing current actions within a dynamic and changing environment and influencing the environment for future actions. Situational awareness is critical in order to provide decision makers with information and the ability to understand, command and control the battle situation. These goals are:

- *Optimum Battle Space Awareness* (involving the collection, initial processing and presentation of required information);
- *Focussed Battle Space Visualisation* (where information is presented to and processed by users in order to achieve understanding of the current and future battle environment).
- *Dynamic Battle Space Planning* (creating plans within the context of the continually changing battle environment);
- *Timely Decision Making* (making the required decisions within the allocated time, more rapidly than the enemy);
- *Superior Command and Control* (the implementation of decisions and plans, as well as the effective control of own forces, more so than the enemy).

2.1.5 BATTLEFIELD DIGITISATION

INTRODUCTION

In an effort to increase the effectiveness of defence force operations through increased situational awareness and superior command and control capabilities, there is a global tendency towards the digitisation of the battlefield. While humans are better at discernment, machines are better at remote sensing and communications and can remove humans from combat danger as well as affording enhanced performance (Beal, 2000).

The concept of battlefield digitisation has been heavily influenced by American experiences and concepts, but can be extended to any defence force wanting to gain and maintain a competitive edge. At the core of digitisation is the harnessing of modern computer-based information technology, to achieve military advantage with the focus on information dominance and battle space awareness (Ripley, 1999).

The digitised battlefield is an instrument that allows for the performance of realistic military exercises, while conserving material and reducing the impact on the environment and can potentially satisfy the most rigorous requirements set for the training of military commanders and crews. These requirements are determined by the complexity of the technologies employed in modern warfare, operations within alliances (combined forces), the diversity of potential military enemies and the socio-political environment (Theile & Godau, 2001).

Battlefield digitisation is viewed as an essential enabler that will provide information superiority on the tactical battlefield. It is intended to support joint defence force concepts such as dominant manoeuvres, precision engagement, focussed logistics and full-dimensional protection via improved command and control (Director, Operational Test & Evaluation (DOT&E), 2000). The digitisation of the battlefield has already been implemented in countries such as America, Australia, Britain, Canada, China, France, Germany, Israel, the Netherlands, Russia and Sweden, producing important results relevant for the development of the armed forces such as force preparation, the formation of rules and regulations and mission doctrine, as well as equipment development, testing and procurements (Bourn, 1998; FAS, 1995; Lambert, 2000; MacMillan, 2000; Pettersson, 1995; Ripley, 1999, 2001; Theile & Godau, 2001; Unewisse, et al., 1999). Recently, South Africa joined the digitalisation movement with a force preparation exercise utilising prototype digital battlefield technologies (Beeld, 2001). A sophisticated digital warfare combat system tested electronic warfare capability and evaluated the potential of digitising the battlefield. Exercise HOUSE (Higher Order User System Exercise) forms the basis from which the sample was drawn for this study (Republic of South Africa, 2001).

Extreme pressures with regard to the time available and success achieved, govern military decision-making processes. Commercially available satellites are sources of immediate information. Hostile forces can utilise this information to their own advantage and thus absolute safety of action under pressure will only be possible through thorough preparations. The digitisation of the battlefield allows for comprehensive preparation and objective assessment and analysis of decision processes and actions. Battlefield simulations can result in more sophisticated military command, control, communication and computing (C^4) systems and decision-making (Theile & Godau, 2001).

Decisions and actions that are delayed are often rendered ineffective. According to the Observation-Orientation-Decision-Action (OODA) cycle each party to a conflict begins by observing themselves, the surroundings and their adversary (Good, 2001). Next they orientate themselves by making mental images of the situation, providing the perspective from which a decision is made. The decision takes into account all the factors present at the time of orientation. Lastly, the decision is implemented, requiring action. The adversary who continuously goes through the cycle faster than others, gains the advantage (Good, 2001).

The challenge set for the digitisation of the battlefield lies within the complexity of military command and control on the one hand, and the interoperability of different combat systems on the other. The basis for meeting this challenge lies in the use of digital information technology (FAS, 1995). Advanced digital technology will enable forces at all levels to receive orders rapidly, exchange intelligence, maintain focus on the enemy and friendly forces, and to synchronise targeting. The efficient and qualitative dissemination of information across the battle environment will maximise situational awareness. The efficacious implementation of new technologies will improve military training and enhance battle preparedness. Ultimately, the aim of digitising the battlefield is to unify the battlefield, and the resultant unity of effort and the enhanced battle command capability will allow the commander to control the battlefield, the operational pace and the environment (FAS, 1995).

VIRTUAL REALITY

Virtual Reality (VR) is a rapidly developing technology that alters the way in which individuals interact with computers. VR uses advanced computer systems to create the illusion that the user is an 'inhabitant' in the world generated by the computer (Baylis, 2000). The term Virtual

Reality (VR) has different meanings for different people. Other terms that have been used include Augmented Reality, Synthetic Reality, Cyberspace, Artificial Reality and Simulator Technology. There are those to whom VR is a specific collection of technologies, such as a Head Mounted Display or Glove input. Others stretch the term to include pure fantasy. The United States' National Science Foundation includes all the mentioned meanings but mainly refers to VR as computer mediated systems (Isdale, 1998). Though it is often associated with computer games and motion pictures, this technology is receiving increased attention as a tool for research, education and training (Baylis, 2000). The applications being developed for VR covers a wide spectrum, from games to architectural design, from business planning to military applications. It is the military application of Virtual Reality, in the form of the digital battlefield that forms the focus of this discussion.

Virtual Reality (VR) is defined as a cognitively valid computer-generated environment, in which a participant is able to sense and experience and is stimulated to think. Objects, attributes and relationships are positioned within this virtual context and users are able to create, manipulate and edit the objects and information (Roth, 1995). It can be described as a state produced in a person's mind, occupying their awareness, akin to that of a true environment (MacPherson & Keppel, 1998). The promise of VR technology is to enable the user to experience and interact with computer generated environments that are perceived to be real. Current VR applications lack full realism (Roth, 1995). Significant limitations include the time lag between a gesture and the updating of the display, the resolution and realism of the display, as well as providing realistic sensory impressions.

Virtual Reality (VR) is a way for humans to visualise, manipulate and interact with computers and complex data. When characterising VR it is important to expand on the most prominent aspects of VR, which include visualisation, interaction, immersion, navigation, manipulation and simulation (simulation will be discussed under a separate heading). These concepts are the keys to Virtual Reality.

In Virtual Reality (VR), visualisation represents information in an integrated visible, audible and indirectly touchable virtual scene such as a synthetic environment. It refers to the computer generating visual, auditory or other sensory outputs to the user (Isdale, 1998). The goal of visualisation is to present data in ways that eases the interpretation thereof for the user (Coomans & Timmermans, 1997). Information is thus experienced instead of simply being retrieved. Interpreting massive sensory input rather than purely relying on linguistic thinking powe,r achieves this enhanced perceptibility (Biocca & Levi, 1995).

Interaction is the result of the computer graphics and programs responding to the user (Baylis, 2000). Natural user interaction allows for an easy response to a simulation system. Interaction with the virtual world in real time is a critical test for VR. In order to appear natural, interactivity must present the following characteristics (Coomans & Timmermans, 1997):

- Sensitivity of the system to the natural actions of the user;
- Real-time feedback (immediate response from the system on a user's actions);
- Feedback in a way that appears natural to the user.

By virtue of its expectant natural interactivity, Virtual Reality (VR) produces the perception of immersion (in varying degrees). Immersion is the feeling of being deeply involved. In order to realise this illusion, VR systems imitate the natural environment using stimuli that resemble real-life. VR can establish a synthetic environment through a coherent visual, acoustic and haptic representation, responding to the user's actions in ways that seem 'natural' to the user. The synthetic environment is not only shown or described, it is possible to participate in it (Coomans & Timmermans, 1997).

VR systems are mainly differentiated based on the manner in which they interface with the user, their distinct display and feedback systems (Baylis, 2000; Isdale, 1998). Types of VR systems include:

- Desktop VR that utilises a conventional computer monitor to display the virtual world. This is ideal for individual professional use. It can be enlarged to the level of a VR theatre, which involves a curved screen ideal for large group presentations (Schmidt, 1998);
- Immersive systems are the ultimate in VR systems. The user's personal viewpoint is completely immersed inside the virtual world. These systems are often equipped with a Head Mounted Display incorporating visual and auditory displays (Isdale, 1998). Other immersive systems use multiple large projection displays to create a four-wall room in which the users stand. This is referred to as a 'CAVE' (Computer Assisted Virtual Environment) (Schmidt, 1998). These 'caves' are ideal for work groups and training.

One of the first areas where VR found practical application was in military training and operations. According to Baylis (2000); Merkle, Peterkin, Bowers, Chandler, Colella, Gibbs, Frese, Helles, Lileikis, Luginsland, McGrath, Sasser and Watrous (1998); and Wilson (1997) the military applications of Virtual Reality include:

- *Research and Development, as well as Test and Evaluation* - Researchers can implement and study virtual prototypes of new concepts. They can evaluate the military worth and usability of such designs in a virtual environment. Performance of weapons or components of a system can be evaluated by simulation of the complete system context, before the entire system is finished;

- *Maintenance* - Maintenance personnel can be trained on virtual models for improved fault diagnosis of defence systems and military hardware;
- *Training and Rehearsal* - Creating realistic virtual environments in which soldiers receive training can reduce the number of field exercises and the resultant financial expenditure;
- *Operational Employment* – Commanders from platoon to brigade level can verify their tactics to achieve a stated objective under specified circumstances. The effectiveness of various tactics and systems can be measured and compared in this way.

An example of Virtual Reality (VR) application within the military is the 'virtual battlefield'. The battlefield is a complex and dynamic information space involving geographic, abstract and temporal information. Appropriate algorithms, graphic workstations and virtual environment devices are designed to support visual simulation and interactive walkthrough (Baker & Stein, 1998). In an era of declining budgets, obtaining the funding to stage a large and realistic training exercise is becoming increasingly problematic. Armies around the world are looking into virtual battlefields as a cost-effective way of improving the skills and expertise of their soldiers and commanders. A virtual battlefield would not necessarily call for a room within which a virtual environment can be created with the effect of total immersion. Developments in desktop computers are resulting in real-time three-dimensional tabletop displays with unprecedented views of the battlefield (Wilson, 1997).

Typically a virtual battlefield would involve simulators representing all the dynamics of the battlefield. Weapon systems in a unit or battalion would be linked, so that operators view the same battlefield in a virtual format. Each operator looks at the same piece of virtual terrain from different perspectives and as the participants move, their view changes to reflect their new positions. A combination of the real world in the form of the terrain, weather and equipment with artificially generated events giving the soldier the impression of being faced with harsh reality allows exercises to be carried out with a degree of realism that is only possible within a virtual battlefield, since they would involve unavoidable risks in reality. The simulators can be networked by simulated radio communications allowing commanders and soldiers to conduct the fully interactive battle (Ripley, 2001). In this way a realistic exercise can be conducted without physical danger and bloodshed.

A key factor that would influence the decision about whether or not to utilise Virtual Reality (VR), is the cost of implementing the necessary technology versus the benefits gained. The main advantage of employing a VR system is that dangerous or rare situations can be simulated fairly accurately and repeatedly without risk to the user. Other advantages are that VR systems are flexible, offering a wide variety of applications, and promote intuitive interaction. VR encourages more efficient learning by doing, rather than reading, thus participation is increased through an enhanced sense of presence. Learning from mistakes within a safe environment is a key benefit (Baylis, 2000).

The main weakness influencing the implementation of VR technology, include the high cost of entry, which is increased by the pace of technological development (Landauer, 1995). Although high cost is a serious consideration, low cost systems may suffer from inferior quality interfaces and may fuel the perception of unreliability, characterized by continually crashing hardware and software full of viruses (Baylis, 2000). Another concern is technology acceptance and technological literacy, which could explain why users sometimes reject information systems (Davis, 1989). A reason often given for the rejection of technology is the level of computer illiteracy; too few people know how to use computers (Landauer, 1995).

SIMULATION AND TRAINING

From a military viewpoint, simulation is considered to be an extremely useful tool in joint education, training and military operations, as well as research and development, test and evaluation, production, and logistics. Simulation meets the goal of military training research by reducing training time and cost, and increasing training effectiveness (Moroney & Bittner, 1995).

The simulation system takes the user inputs, along with any tasks programmed into the virtual world, and determines the actions that will take place. Mathematical simulation processes deliver the realistic representations of the virtual environments (Coomans & Timmermans, 1997). It handles all the interactions, the scripted actions, the simulations of physical laws, as well as determining the virtual world's status (Isdale, 1998). The foundation of simulation is natural interaction that allows for an easier response to the computer (Biocca & Levi, 1995). The user can only experience realistic simulation if the output devices deliver the result of the simulation effectively.

A synthetic environment, of which simulation is an example, can be defined as an environment within which humans can interact through simulations and simulators, at multiple networked sites using compliant architecture, modelling, protocols, standards and databases (Defence Modelling and Simulation Office (DMSO), 1994). Depending on the requirements of the simulation, a synthetic environment can include representations of physical objects, as well as the attributes of, and relationship between these objects, as well as between the objects and the human. The objects within a synthetic environment typically include the terrain and topographical features, models of vehicles and personnel, as well as the climatological factors. Within the virtual environment, the user may change their vantage or observation point and this is referred to as navigation. By manipulating the environment, the user is able to interact with the synthetic environment and effect changes (Casa, Fialho & Maia, 1997).

As the scope of operations in which the modern military is involved grows more expansive, simulation becomes an increasingly important facet of the military structure. Simulation is the means by which military personnel can gain experience in operations, both wartime and peacetime, which would otherwise be too expensive or impossible to conduct in a live scenario (Baylis, 2001; Kelly & Phillips, 1998). The suitability of Virtual Reality (as a form of simulation) to military training and decision-making, is especially evident where the real location is dangerous and equipment expensive. Prime examples of such situations are the utilisation of live ammunition and reconnaissance. To perform either of these tasks well, is time consuming, with the soldier being exposed to real enemies and hostile fire.

The synthetic environment is a critical element in a simulation since it forms the playing field in which simulated operations and interactions take place. For the purposes of a virtual battlefield, the synthetic environment may represent various aspects of the full sphere of ground, air and maritime operations across an entire spectrum of both conflict operations and non-aggressive operations. In order to be successful, a synthetic environment must realistically represent the dynamic effects and interactions of weapons, vehicles, communication, individual soldiers and defence force units (Unewisse et al., 1999). In order to realise a common realistic synthetic environment it is up to distributed interactive simulation (DIS – now referred to as HLA or High Level Architecture) to combine simulators, constructive simulations, and simulated equipment of varying types into a simulation exercise (Braudaway, 1998). High Level Architecture (HLA) is the architecture, or structure, for the combination, integration and networking of different simulations. It offers the development engineer of a virtual world, the rules for designing and creating a simulation.

TECHNICAL ASPECTS

The digitisation of the battlefield will have a wide range of systems designed to optimise the flow of information (Gourly, 1997). Interactive simulation can control the behaviour and movement of hundreds or thousands of entities such as tanks, trucks, missiles, and so forth (Baylis, 2001). By consistently utilising information and communication technologies, the simulation system within such a battlefield can provide for practically every conceivable training scenario. Image generators use photographic data as the basis for synthetically generated high-quality visual presentations. Positional and directional data of persons and equipment can be determined at all times and laser and model computations represent the effects of weapons in action. The technical prerequisites for creating a virtual battlefield include essential action parameters, presentation of scenarios and networking. Networking techniques allow for the different processes in battlefields to be combined into one (Theile & Godau, 2001).

ELEMENTS

This research study examined the use of a digitised battlefield within a military exercise. It is thus necessary to understand the aspects and elements involved with battlefield digitisation. The essential elements of a digitised battlefield include the soldiers (who will participate in either a real, or a synthetic environment such as created by Virtual Reality), with equipment adapted to training purposes, the simulators, special communication and navigation devices, dispersed higher command structures, and finally a central command centre from where activities are controlled and all information is collected. The operations control centre will have information and analysis systems able to record and process all information. Various structures of the battlefields are possible, for example scenarios for the interaction of all armed forces even with the spatial separation of the participants (Theile & Godau, 2001).

The digitised simulated battlefield provides the facilities for the joint and joint-combined arms combat exercises of units and forces. Combat can be simulated and the effects thereof on the course of the battle can be registered for presentation in a digitised map in the operations control centre. To simulate all weapons and weapons effects, the participants are provided with equipment meeting the prerequisites for actively participating in the simulation. The communication system comprises the connection to the combat net radio, data net radio, the controller net radio, video communication and the communication network-training area (Theile & Godau, 2001).

The operations control centre is provided with the hardware and software components that typically include facilities such as work place consoles, audio and video units, software workstation, software server data unit, network, and mobile auditorium. These hardware and software components are used to control, assess, evaluate and record the training of units and forces in battlefield simulations. The actual operations in the battlefield can be stored with precision and processed to allow for After Action Review (AAR) operations (Theile & Godau, 2001).

2.2 USABILITY CONCEPTS

2.2.1 INTRODUCTION

The main purpose of this research is to provide a theoretical background of the issues of usability in military digitisation and to determine how they are related. It is therefore essential to have an understanding of what usability denotes and entails. Usability is one of the major technical areas within the field of Human-Computer Interaction (HCI), although it is certainly not confined to this field only. HCI deals with all aspects of the human use of computers, usually within the context of interactive information technology systems. HCI is in turn a major part of a larger subject termed Human-System Interaction (HSI), and HSI is a large part of the discipline known as Ergonomics or Human Factors, also known as Human Engineering, as shown in Figure 2-7 (Shackel & Richardson, 1991; Weimer, 1995).

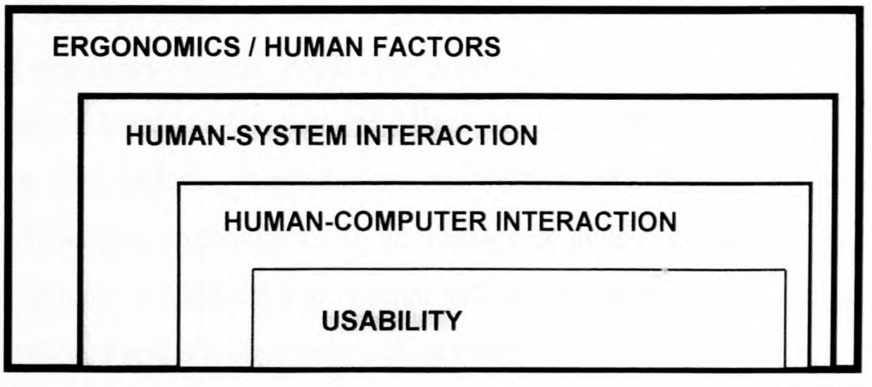


FIGURE 2-7: Usability In Context

(Adapted from Shackel & Richardson, 1991, p. 2)

Ergonomics has as its main focus the enhancement of the human approach to executing tasks and thus the improvement of productivity. It is the study of the relationship between the human and the work environment, encompassing research and practical application emanating from science and technology. The purpose is to examine and understand the situation of people at work and thus being able to optimise the situation. Ergonomics is user-centred, with the emphasis placed on efficiency in operation as well as, effectiveness, safety, comfort and satisfaction. Human-system interaction (HSI) is concerned with methods and mechanisms for enhancing cooperation between people and systems within an interactive organisational environment. HSI studies aspects of the human, the organisation, the job, tasks, machines and the environment, which directly influence the effectiveness and acceptability of systems for the user (Shackel & Richardson, 1991).

Human-Computer Interaction (HCI) is the process that takes place when a human user and a computer system are required to perform a task. HCI aims to establish how best to make this interaction work. The main goal is to provide the user with a high degree of usability. Usability is defined as the extent to which users can use a product or system to perform tasks and achieve goals with effectiveness, efficiency and satisfaction. Characteristics of usability include the degree to which a product or system is easy to use, easy to learn, and optimised from the end-user's perspective (Shackel & Richardson, 1991).

2.2.2 HUMAN-COMPUTER INTERACTION

DEFINITION

Human-Computer Interaction (HCI) is the process that takes place when a human user and a computer system are put together to perform a task. It is defined as the practice of designing products in order for users to perform required tasks with a minimum of stress and a maximum of efficiency (Rubin, 1994). The study of Human-Computer Interaction aims to find how best to make this interaction succeed (Hix & Hartson, 1993). In a Human-Computer Interaction process, the user and the computer possess information that has to be exchanged. This co-operative information exchange must go through a physical medium (in this case the computer). The computer is connected to receive and process information through input devices (for example a keyboard and a mouse) and output devices (for example a monitor for graphics and a speaker for sound). From a military viewpoint, Human-Computer Interaction is considered to be an integral part of education, training and military operations.

The field of HCI includes user-interface hardware and software, user and system modelling, as well as human factors. The International Organisation for Standardisation (ISO) (1998) defines a 'user' as anyone affected by the output from, provides input to, maintains or uses a system. A 'system' refers to a distinguishable physical entity, composed of integrated and interacting elements, and a defined purpose. A 'task' refers to an activity required to achieve an intended outcome of a work system. Tasks are sets of actions to be performed by the user in a goal-directed way, and their descriptions will influence the specification of the interface components. The 'user interface' is that part of an interactive system directly concerned with end-user interaction (Shackel & Richardson, 1993). It supports the two-way flow of information between the system and the user. The user-interface includes all aspects of the relationship between a product and an end-user (Opaluch & Tsao, 1993).

2.2.3 USER-CENTRED DESIGN

DEFINITION

User-Centred Design can be defined as designing interfaces for users' ease of use, by including end-users on a project design team (Opaluch & Tsao, 1993). Designers often perceive users only as 'end-users', betraying an attitude responsible for poor designs, where the 'end-user' is often the last person to be considered in the design of a system or product. Users must be seen as central to the design process, and not as a sideline issue (Shackel & Richardson, 1991). The purpose of the human-centred design process is to ensure that the system to be designed takes account of human capabilities, skills, limitations and needs (Preece, 1993). User-Centred Design has as its primary intention the consideration of the requirements of the user, individuals and groups, utilising the output from a system.

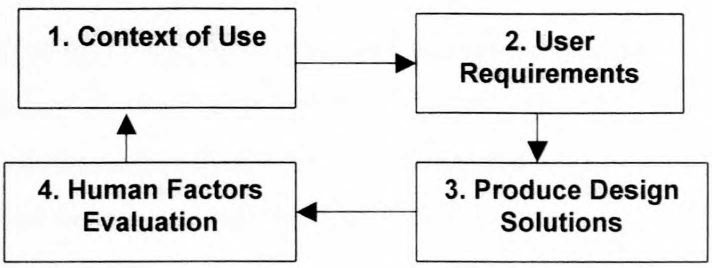


FIGURE 2-8: User-Centred Design

(ISO, 1998, p. vi)

In Figure 2-8 the purpose of the 'Context of Use' process is to inform system developers and owners of systems, of the characteristics of the users, their tasks and the technical, organisational and physical environment in which the system will operate. Within this study the context is of a military nature, involving soldiers as the users, having to command and control a simulated battle utilising digital battlefield technologies. The objective of the 'User Requirement' practice is to establish the requirements of the user (in this case the commander or soldier utilising the digital battlefield technologies). To 'Produce Design Solutions' attempts to incorporate human factors and human resources knowledge into potential design solutions, and the 'Human Factors Evaluation' aims to collect and report feedback on the evaluation of the developing system concerning aspects related to its use or users (ISO, 1998). This research is an example of a Human Factors Evaluation conducted in order to gather and report feedback related to the use of the digital battlefield system.

The main goal of User-Centred Design is to provide the user with a high degree of usability and the attainment of this goal rests on three principles, starting with an early, systematic focus on users and tasks. Secondly, emphasis should be placed on the empirical assessment of product usage, highlighting measurements of ease of learning and ease of use. The last principle of User-Centred Design is iterative design (illustrated by the continuous loop formed by the arrows in Figure 2-8). This allows a product to be shaped through a process of design, test, redesign and modification, and retesting resulting in a superior product (Rubin, 1994).

PROCEDURE

There are several steps involved in the user-interface design process. Depending on the complexity of the product, the budget allowed, time available, and many other factors, more detailed steps can be included. According to Nielsen and Molich (1990) the fundamental steps involved in the user-interface design process include the following:

- *Know the user*. It is essential for designers of products to understand the expectations, abilities and limitations of the users of the product;
- *Involve users during the design phase*. This will ensure that their needs are considered and engineered into the product from the beginning of the process;
- *Co-ordinate the total user interface*, ensuring that all the parties have been included and that all the issues involved have been addressed;
- *Empirical measurement* of the usability of the product will ensure that flaws are identified;
- *Iterative design* to remove usability problems. This involves continuous design, test, measure and redesign of the product (as a regular cycle) to identified flaws, taking corrective action, and thus enhancing end-user satisfaction with the product.

Many advantages follow the successful implementation of a user-design process. A main advantage is the exclusion of the possible adverse effects on human health, safety and performance stemming from the use of a poorly designed product. User effectiveness (and efficiency) is enhanced, and user satisfaction with, and acceptance of, the system is improved. An additional benefit is that training and support costs can be greatly reduced as a result of higher ease of use and satisfaction with the product (ISO, 1998).

2.2.4 USABILITY

If the user can't use it, it doesn't work. If the user can't find it, it doesn't exist.

(Dray, 2001, p.1).

INTRODUCTION

Usability refers to how well an individual can interact with a product or operate a piece of equipment. Usability is achieved when easy and effective use is made of a product's full potential (Scerbo, 1995). Usability is not functionality, but the two concepts are related. Functionality refers to what a product can do, whereas usability refers to how the functionality is implemented. When decisions have to be made about products or systems, they depend upon an assessment of various factors. Factors considered include how useful the system will be, whether it is suitable, will users like it and how much will it cost. Usability engineering is a process that allows you to assess the usability aspects of products (Scerbo, 1995).

In addition, Shackel and Richardson (1991) suggest that the acceptability of something depends upon whether it is considered sufficiently useful, usable and likeable in relation to its cost. Usability is placed in a balanced position with functionality, and as the use of computers and other digital systems become more regular, wide-spread and universal, usability issues become more dominant in the acceptability decisions made by designers, purchasers and users.

DEFINITION

Usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction within the specified context of use (ISO, 1998; Shackel & Richardson, 1991). Effectiveness denotes the accuracy and completeness with which users achieve specified goals; while efficiency indicates the amount of effort and resources expended in relation to the accuracy and completeness with which users accomplish goals. Satisfaction is demonstrated by the level of comfort the user feels when using the product as well as a positive attitude towards the use of the product or system (Jordan, 1998).

Usability refers to the degree to which a system is easy to use, easy to learn, and optimised from the end-user's perspective. High usability directly influences user satisfaction (Opaluch & Tsao, 1993). High usability is thus not only desirable, but also very important. People are increasingly unwilling to tolerate difficult to use products and thus it is becoming a factor in purchase decisions. Complicated and user-unfriendly products can be frustrating and the annoyance caused will lead to the discarding of the product (Scerbo, 1995). In the working environment difficult to use products negatively impact on productivity and can compromise the safety of the user (Jordan, 1998).

USABILITY ATTRIBUTES

Usability has many attributes by which it is defined. The first step in usability evaluation is to operationalise usability by establishing usability specifications. By establishing usability specifications early in the design and development process, as well as monitoring at each stage of development, it is possible to measure whether a design is converging to become a more usable design (Hix & Hartson, 1993; Scerbo, 1995). Usability attributes outline the features and characteristics of the product that influence the learnability, effectiveness, efficiency and satisfaction with which users can achieve specified goals in a particular environment (Hugo, 2001).

The most cited of usability attributes used in usability studies and research, include the following:

- *Effectiveness*: This refers to the extent to which the system allows a goal or task to be successfully achieved, consistent with a specified level of performance (ISO, 1990; Jordan, 1998; Rubin, 1994; Shackel & Richardson, 1991);
- *Efficiency*: The system should be efficient to use so that a high level of productivity is possible once the user has mastered the system (ISO, 1990; Landauer, 1995; Nielsen, 1993). Jordan (1998) adds that efficiency refers to the amount of effort required to complete a task. The less effort required, the higher the efficiency. Effort can be measured for example, in terms of the time taken to complete a task, or the number of errors made;
- *Satisfaction*: The system should be pleasant to use so that users are subjectively satisfied when using the system or product (ISO, 1990; Landauer, 1995; Nielsen, 1993). Satisfaction is also influenced by how acceptable the product is to users as a means of achieving their goals (Jordan, 1998) and the positive attitude engendered in users by the system (Preece, 1993; Shackel & Richardson, 1991);
- *Learnability*: High learnability is essential and refers to the time and effort needed to become skilful at using the system and reaching the specified level of user performance. If the method for performing the task proved easily mastered, the product would be highly learnable (Hix & Hartson, 1993; ISO, 1990; Jordan, 1998; Nielsen, 1993; Preece, 1993; Rubin, 1994; Scerbo, 1995; Shackel & Richardson, 1991).

Other usability characteristics are:

- *Reliability*, which refers to the dependability of the system and the repeatability without failure of tasks using the system (Landauer, 1995; Nielsen, 1993);
- *Accuracy* as indicated by the exactness and correctness of the system (ISO, 1990).
- *Compatibility*, which refers to the degree to which the system's method of operation conforms to the user's expectations (ISO, 1990; Nielsen, 1993);
- *Consistency and controllability*. The ability of the system to respond to user inputs in a consistent way and to perform similar tasks in similar ways (ISO, 1990; Jordan, 1998);
- *Ease of use* and operation refers to the effortlessness and user-friendliness of the system (Landauer, 1995; Rubin, 1994);

- The *suitability* of the system or product for use in the execution of the task (ISO, 1990);
- *Flexibility* or the capacity for individualisation. The extent to which users can adapt a system to new ways of interaction as they become more experienced (ISO, 1990; Preece, 1993; Scerbo, 1995; Shackel & Richardson, 1991);
- *Error tolerance* (Hix & Hartson, 1993; ISO, 1990). Systems should have low error rates and if errors are made recovery should be simple and quick (Nielsen, 1993).

And finally, two areas of great importance are:

- *Usefulness*, which refers to the value, worth and helpfulness of the system (Landauer, 1995; Nielsen, 1993; Rubin, 1994); and
- *Utility*, which refers to the functionality of the system to the user (Landauer, 1995; Nielsen, 1993; Shackel & Richardson, 1991).

USABILITY ISSUES

According to Gabbard, Swartz, Richey and Hix (1999) different usability issues exist when designing a product, namely:

- System issues, which reflect fundamental properties of the system and technology, such as latency and synchronisation, and must be addressed by system designers;
- Interaction issues, which arise due to the complexity of interacting with a system, for example to navigate in an immersive system (such as a computer assisted virtual environment - CAVE) may be difficult and is highly task dependent. The easier a product is to interact with, the more usable it is considered to be;
- Application issues involve problems that arise due to functionality and presentation. For example the tension caused between making objects realistic so that participants recognise them when the objects are presented in a virtual environment, and the limits of such objects. Within a military context, this is an important issue when utilising digital battlefield technologies, as exercises must be as realistic as possible without the danger of the actual experience

Even some of the best-designed systems and programs can have usability shortcomings that leave users in despair. Developers know that no amount of testing, or evaluation of any kind, will reveal as many issues as simply having a product or system on the market for a month (Randall, 1998). Usability issues should not necessarily be confused with technical issues. A specific feature might work well from a technical point of view but still be less user-friendly than it could be. Usability testing and evaluation is not necessarily about detecting missing features, but rather about discovering issues related to using existing features.

Rubin (1994) postulates that there are several reasons for difficult to use products and systems. Firstly, during product development the emphasis has often been on the machine or system, and not on the person who will be the ultimate end-user. Developers usually focus on the scientific and technical issues and not on the ambiguous issues associated with human beings. However, since the development of a system or machine is an attempt to improve human performance in some area, developers must consider the human being during their design process.

Secondly, as technology has penetrated the mainstream consumer market, the target audience is continually changing. The original users of computer-based products, such as VR systems, possessed expert knowledge of computers and technology (Rubin, 1994). Today, it is virtually impossible for the average person not to come into contact with a computer, either at work or at home. Such users often have little technical knowledge, and little patience with technologically challenging products.

Another reason for user-unfriendly products is that the issue of usability is trivialised. Although much has been written about usability and usability engineering, the concept remains elusive and is treated as though it were simply common sense. Gould and Lewis (1985) determined that designers had flawed concepts of a user-centred approach to developing systems. Rubin (1994) came to the same conclusion. When the time comes for usability to be evaluated, opinions on how to achieve it are not sufficient; it has to be operationally defined and requires precise measurement.

THE USER

Studying a product in isolation cannot assess usability. As is shown in Table 2-1 knowing the user is the most basic of all usability guidelines. Within a military application such as the digital battlefield 'users' should include everybody who is affected by the system or product. The attributes required for a product such as one involving digital battlefield technologies to be considered usable, is influenced by variables such as the nature of the user, the task it is to be used for, and the environment within which it will be used. Also, individual user characteristics, the user's current task and variability in task have a sizeable impact on usability. A product that is usable for one person may not be so for another. It is vital to gather as much information about the users as is possible prior to the design of a product or system and thus have an understanding of those for whom the product is intended. Information about users will help determine the usability attributes which are necessary, and will significantly reduce the number of iterations needed to meet usability objectives (Scerbo, 1995).

A number of user characteristics exist, which could predict a product's ease of use for a specific user. Previous experience with a product is likely to affect how easy or difficult it is to complete a task. Negative experiences with similar products can adversely affect users' attitudes toward new products (Jordan, 1998). Another important factor is the amount of knowledge the user possesses regarding the execution of the task. If a person understands what has to be done, they will perform better with the system or product, than someone who has no understanding of what they are supposed to accomplish. This is referred to as domain knowledge (Jordan, 1998). Enhancing the domain knowledge of its soldiers was one of the goals of the military exercise forming the basis of this study. The cultural background of the user can also influence how they react with products and should be taken into consideration when designing for particular markets. This includes differences in people's age, gender, physical characteristics, level of education, and exposure to technology. The South African National Defence Force has particular consideration and respect for cultural diversity (Republic of South Africa, 1995).

Davis (1989) proposed and tested the Technology Acceptance Model (TAM), which attempts to explain and predict why users sometimes reject information systems. Davis (1989) adapted Fishbein and Ajzen's (1975) Theory of Reasoned Action (TRA) to intentions to accept information technology. The TAM (see Figure 2-9) predicts that user acceptance of technology is based on two factors namely 'perceived usefulness' and 'perceived ease of use' These factors impact on behavioural intentions to use a system, as well as on the actual use thereof (Grossberg, Struwig & Tlabela, 1999).

The purpose of the TAM is to explain and predict user acceptance of technology. A person's acceptance of technology is determined by their intention to accept it. This intention is determined by the person's attitude toward the technology. Attitudes are formed from beliefs a person holds about the technology. The beliefs in the TAM consist of the person's perceptions of its usefulness and ease of use. External variables such as the task, user characteristics, resistance to change, political influence or organisational factors are expected to influence technology acceptance behaviour indirectly by affecting beliefs and attitudes.

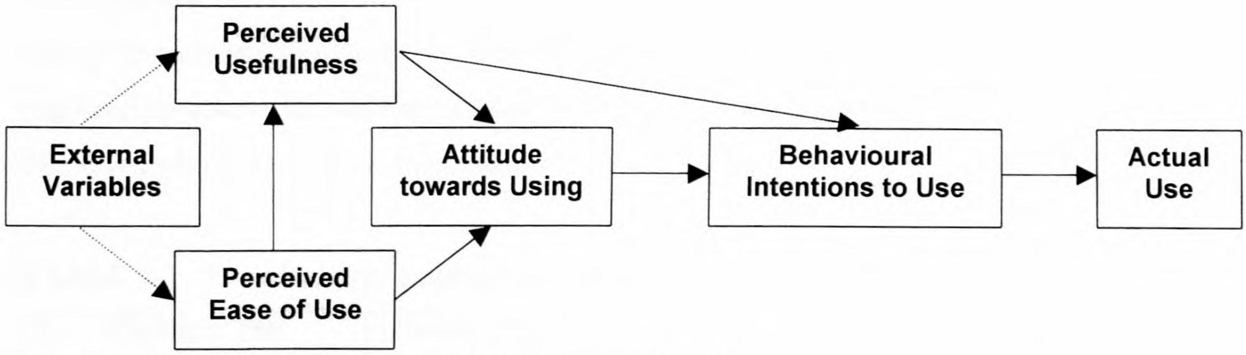


FIGURE 2-9: Davis' Technology Acceptance Model

(Grossberg, Struwig & Tlabela, 1999, p. 88)

Grossberg, Struwig and Tlabela (1999) found that a direct connection exists between 'ease of use' and 'usefulness'. The easier a technology is to use, the more useful it is perceived to be. The TAM has consistently shown statistical significance in predicting this link (Szajna, 1996). For this reason practitioners would find the Technology Acceptance Model useful in situations such as the evaluation and choice of military digital and virtual reality technologies. Ease of use and usefulness are strong indicators for such a choice. Therefore, by assessing the usability of a system and establishing its ease of use and usefulness, it would be possible to predict user acceptance of, and satisfaction with a technological system, such as a digital battlefield.

USABILITY ENGINEERING

Usability engineering is the overall procedural framework in which a series of specified forms of usability testing and evaluation is done (Ramey, 1991). It is defined as a process through which usability characteristics are specified, and measured throughout the process of product design and development (Hix & Hartson, 1993). Usability engineering aims to assure that user-interfaces are optimised from an end-user's perspective. The main objective of usability engineering is to provide principles, methods, and tools for supporting quality user interface and maximising usability (Opaluch & Tsao, 1993). To ensure the usability of products, usability concerns must be included in the design process. Only a systematic effort using established methods can qualify as usability engineering (Nielsen, 1992).

According to Nielsen (1993) usability engineering is a set of activities that take place throughout the life cycle of the product, with significant activities happening at the early stages before the user interfaces have even been designed. Usability designers and engineers can optimise customer satisfaction by early and consistent use of design processes that emphasise ease of use. The benefits of such an approach include reduced learning time, enhanced productivity and fewer operating errors (Opaluch & Tsao, 1993).

Although usability engineering can still be successful even if it does not include every possible step of the eleven stage-process, Gould and Lewis (1985) declared that the multiple usability engineering stages should supplement each other. They suggested the Usability Engineering Model, of which the main elements are:

TABLE 2-1: The Usability Engineering Model

1. Consider the larger context	Usability engineering is not a one-time event where the user interface is fixed up before the release of a product. Usability should be included within the broader corporate product development context and applied to entire product families to ensure compatibility.
2. Know the user	This is the most basic of all usability guidelines. 'Users' should include everybody whose work is affected by the system or product. Individual user characteristics, the user's current task and variability in task have the largest impact on usability.
3. Competitive analysis	An analysis of competing products will provide ideas for the new design and will provide a list of guidelines for approaches that work and those that should be avoided.
4. Setting usability goals	Usability comprises of several components. The different usability parameters can be operationalised and expressed in measurable ways.
5. Participatory design	Users should be involved and participate in the system design process.
6. Co-ordinated design of the total interface	Consistency should be applied to the whole usability engineering as well as the system design process.
7. Guidelines for heuristic analysis	A heuristic is a guideline or general principle or rule of thumb that can guide a design decision or be used to critique a decision that has already been made. The goal of heuristic evaluation is to find the usability problems in a user interface design so that they can be attended to as part of the iterative design process. Heuristics may include: ▪ User control and freedom ▪ Consistency ▪ Help users recognize, diagnose, and recover from or prevent errors.
8. Prototyping	Early usability evaluation should be based on prototypes of the final system that can be developed much faster and cheaper, and can be changed many times until a better user interface has been achieved.
9. Empirical testing	User-based evaluation with real users is the most fundamental usability method and provides direct information about the use of systems and products and what problems there are with the interface being tested.

10. Iterative design	This entails a cycle of continuous design, test, measure and redesign of the product based on the usability problems and opportunities disclosed by the empirical testing, taking corrective action and thus enhancing end-user satisfaction.
11. Collect feedback from field use	Follow-up studies of installed systems assess how actual users use the interface for tasks occurring naturally in the real working environment and can provide insights not always gained from laboratory studies.

(Adapted from Gould & Lewis, 1985)

Table 2-1 can easily be adapted to any situation involving a product and its users. Within a military context the larger context could include the National Defence policy and considering all its implications, knowing the commanders and soldiers who would be using the product (there requirements and abilities), analysing adversaries' capabilities, setting design goals, coordinating the design process, prototyping and evaluation of the product, as well as collecting feedback from a field study such as the exercise forming the basis on which this research is based.

Usability does not occur by chance; it must be engineered into a product from the beginning of the product's life cycle. The Usability Engineering Model (see Table 2-1) defines the Human Factors activities that must take place to ensure usability. The above-mentioned Human Factors activities should transpire throughout the Product Development Life Cycle, as is indicated in Figure 2-10.

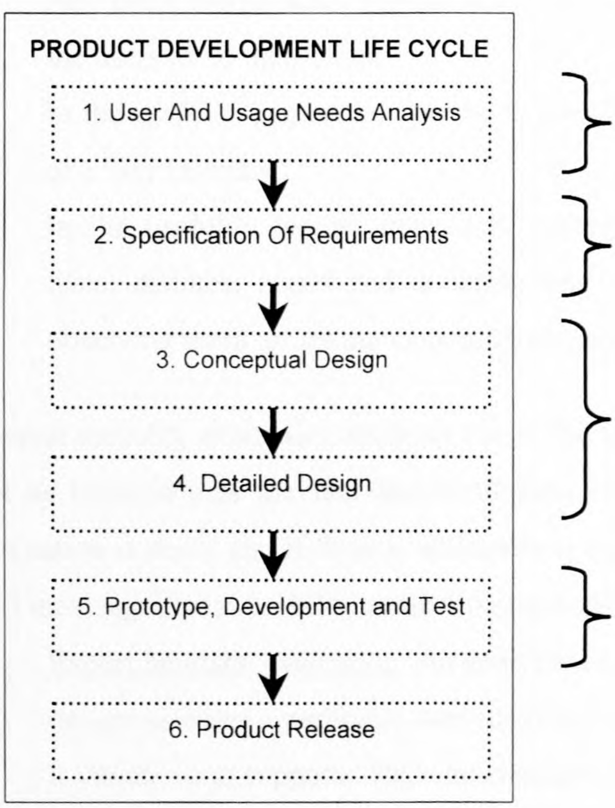


FIGURE 2-10: Product Development Life Cycle

(Adapted from Rubin, 1994, p. 14)

Human Factors activities during the Product Development Life Cycle:

1. *Consider the larger context*
2. *Know the user*
3. *Competitive analysis*
4. *Setting usability goals*
5. *Participatory design*
6. *Co-ordinated design of the total interface*
7. *Guidelines for heuristic analysis*
8. *Prototyping*
9. *Empirical testing*
10. *Iterative design*
11. *Collect feedback from field use*

User-based evaluation with actual users is an indispensable method of establishing usability providing direct information about the use of systems and the problems experienced. Within the context of the Usability Engineering Model (see Table 2-1), this research fits into stage nine, the Empirical Testing Stage. Such testing and evaluation is an essential component of developing any interactive application and is especially important for digital, Virtual Reality (VR) and simulation applications. Although this study is placed within the testing phase of the usability cycle it is important to note that human factors activities are necessary throughout the lifecycle of any product or system, to ensure the usability of the end product.

USABILITY EVALUATION

User-based evaluation with actual users is an indispensable method of establishing usability by providing direct information about the use of systems and the problems experienced. Evaluation should be utilised throughout the product life cycle. Evaluation is an essential component of developing any interactive application and is especially important for digital, Virtual Reality (VR) and simulation applications. Even a relatively small investment in usability evaluation methods can result in significant improvements in the usability of a system (Nielsen, 1990).

There are several approaches that can be taken when attempting to determine usability. Mayhew (1999) divided the approaches into the following groupings:

- In the *usability testing approach*, representative users work on typical tasks using the system/prototype and the evaluators use the results to see how the user interface supports the users to do their tasks;
- In the *usability inspection approach*, usability specialists examine usability-related aspects of a user interface;
- In the *usability inquiry approach*, usability evaluators obtain information about users' likes, dislikes, needs and understanding of the system by communicating with them, observing them, or letting them answer questions in written form.

Several usability evaluation methods exist. The issue of what evaluation method is employed is not as important as the fact that evaluation *must* take place. It is imperative that usability evaluation is done, and if done it will serve to significantly improve the usability of the system. The most significant usability evaluation methods include:

- <u>Expert heuristic evaluation</u>: An analytical evaluation in which an expert in user interaction design assesses a particular user interface by determining what usability design guidelines it violates and supports. Recommendations for improvement are made based especially on the violations (Gabbard, Swartz, Richey & Hix, 1999). Principles to consider for heuristic evaluation include natural dialogue, minimisation of user's memory load, consistency, provision of feedback, good error messages and prevention of errors (Gould & Lewis, 1985; Nielsen, 1993). In a study conducted by Nielsen & Molich (1990), it was found that different evaluators found different problems and that typically, a single evaluator found only a third of the problems;

- Formative evaluation: An empirical, observational assessment with users that begins in the earliest phases of user interaction design and continues through the life cycle. The purpose is to repeatedly and quantifiably assess and improve user interaction design. (Gabbard, Swartz, Richey & Hix, 1999; Hix, Swan, Gabbard, McGee, Durbin & King, 1999);
- Summative evaluation: An empirical assessment with users of an interaction design in comparison with other interaction designs for performing the same user tasks. The aim is to compare the user performance of different designs to determine which one is better (Hix, Swan, Gabbard, McGee, Durbin and King, 1999);
- Performance measurement: This technique is used to obtain quantitative data about participants' performance when they perform tasks during usability testing. Quantitative data is most useful in doing comparative testing, or testing against predefined benchmarks (Mayhew, 1999; Nielsen, 1993). According to Landauer (1995), the period of time that a user needs to accomplish a given amount of work, and the amount of errors made, are the main aspects of user task performance that can be observed and used in performance analysis;
- Thinking-aloud protocol: During the course of a usability test, the test users are asked to express their thoughts, feelings, and opinions while interacting with the system. It is very useful in capturing a wide range of cognitive activities (Mayhew, 1999; Nielsen, 1993; Scerbo, 1995);
- Cognitive walkthrough: Cognitive walkthroughs involve evaluators inspecting a user interface by going through a set of tasks and evaluating the understandability and ease of learning. The user interface is often presented in the form of a working prototype or a fully developed interface. The inputs to the walkthrough include the user profile, especially the users' knowledge of the task domain and of the interface (Mayhew, 1999);
- Field observation: Human Factors engineers visit representative users' workplace and observe them work, to understand how the users are using the system to accomplish their tasks and what kind of mental model the users have about the system (Jordan, 1998; Mayhew, 1999);
- Focus groups: This is a data collecting technique where users are brought together to discuss issues relating to the system. A human factors engineer plays the role of a

facilitator, who needs to prepare the list of issues to be discussed beforehand and seek to gather the needed information from the discussion. This can capture spontaneous user reactions and ideas that evolve in the dynamic group process (Mayhew, 1999; Nielsen, 1993);

- Interviews: In this technique, human factors engineers formulate questions about the product. Representative users are then asked questions in order to gather the desired information (Mayhew, 1999; Nielsen, 1993);
- Logging actual use: Logging involves having the computer automatically collect statistics about the detailed use of the system. Typically, an interface log will contain statistics about the frequency with which each user has used each feature and the frequency with which various events (such as error messages) have occurred (Mayhew, 1999; Nielsen, 1993);
- User survey questionnaires: A questionnaire is a method for the elicitation, collecting and recording of information. The main purpose is to gather information from participants in order to clarify understanding of the product's strengths and weaknesses. Answering a questionnaire focuses the respondent's mind on a particular topic. The advantage is that a usability questionnaire gives you feedback from the point of view of the user (Jordan, 1998; Mayhew, 1999; Nielsen, 1993; Rubin, 1994; Scerbo, 1995).

Due to budgetary and time constraints it was the researcher's decision to make use of user survey questionnaires as the method of determining the usability of a digital battlefield within the South African military context. Within the context of the Usability Engineering Model (see Table 2-1) this research fits into stage nine, the Empirical Testing Stage. Empirical testing often involves evaluations where a user or user group is asked to evaluate a system by, for example identifying problem areas, through the use of a questionnaire. Empirical testing has the advantage that the user is quite involved with the design and evaluation of the system (Woodward, 1998). The users are empowered to help develop the system by indicating their needs, likes and dislikes, as well as frustrations with the system. Although this study is placed within the testing phase of the usability cycle it is important to note that human factors activities are necessary throughout the lifecycle of any product or system, to ensure maximum usability of the end product.

2.3 CONCLUSION

Human Factors or Ergonomics studies the relationship between the human and the work environment and aims to enhance the human approach to executing tasks and thus the improvement of productivity. Military Human Factors is a diverse and challenging area aspiring to enhance the human approach to executing military tasks and thus leading to improvement of military productivity and performance. The current and future military context is characterised by dynamic change featuring more mobile joint-combined forces, limited opportunity for realistic combat training due to environmental and cost restraints, as well as technology integration and transference.

Employing technology in the military has become increasingly important. It has also become clear that technology must have high usability in order to increase user acceptance and effectiveness. Battlefield digitisation has been examined in many studies, but the focus has not always been on the effects that interaction with a digital battlefield system may have on the user. The main focus of this study is the promotion of the importance of ensuring the usability of military systems. If the system introduced into the battlefield, such as digital battlefield technologies, does not make the soldiers life easier or help make decisions faster and with greater accuracy it is not of much use.

It has been established in the literature that a connection exists between high usability of a system and user acceptance and satisfaction. Characteristics of usability include the degree to which a system is easy to use, easily learnable and optimised from the user's perspective. The literary review endeavours to explain what the utility of usability and usability evaluation is in order to achieve the full potential and optimal use of a technological system such as a digitised battlefield. The research focuses on establishing the importance of usability as applied to the digitised battlefield.

The force preparation exercise utilising prototype digital battlefield technologies recently held by the SANDF, was the first of its kind in the South African military context. This military exercise forms the basis from which the research sample was drawn for this study. The research aims to supply the SANDF with usability information that can be used in an iterative design process to optimise the prototype digital battlefield system tested in this exercise.

This chapter aimed to define and explain concepts of a military nature and the role of digitisation within the modern military, as well as concepts related to usability. An attempt was made to explain the necessary and important connection between usability and any technological system, especially within a military context where life and country could be at stake. This overview of the literature firstly provides a background and secondly, supports the contents of the next chapter. In Chapter 3 a description will be provided concerning the research strategy that has been followed.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This study investigates the usability issues as applied to the digital battlefield within a South African military context. This chapter provides an overview of the research problem and objectives of the study, as well as the descriptive existential hypotheses that were set for this study. Furthermore, the research design and methodology employed for the research, as well as type of research, are discussed. The chapter includes a description of the measuring instrument, the sample used in this study, the sampling method and the statistical approach applied to analyse the data obtained.

In September 2001, South Africa held a military exercise utilising digital battlefield technologies (Beeld, 2001; Republic of South Africa, 2001). Exercise HOUSE involved the simulation of a battle and the utilisation of prototype digital battlefield technologies in order to test command and control as well as force deployment. This is a new system within the South African military context. The system's capabilities include supporting the mobile forces of the SANDF during military operations by means of a joint tactical command and control digital user system with higher and lower tactical capabilities. The system was implemented in order to improve the decision making process, both in quality of decisions made, as well as increasing the tempo with which decisions are made.

3.2 BACKGROUND

3.2.1 DESCRIPTION OF MILITARY EXERCISE

The South African Army is required to confirm its capacity to perform its primary functions on an annual basis through force preparation exercises (SA Army Force Preparation, 2001). Exercises of this nature are traditionally of a much larger scale, but due to financial constraints, the military exercise that served as the base from which the sample for this research was drawn was confined to headquarter elements only. Although the exercise appeared relatively small in contrast to traditional full-scale exercises, all the representatives of the headquarter elements were represented and thus it is still possible to determine whether efficient command and control capabilities exist, and whether all participants were able to execute the standing operational procedures. Even though the scale of deployment was smaller than it traditionally would have been, it was correct in terms of routes, outlay and functions. The total personnel strength for this exercise was approximately 385. If the full complement of troops were included, this exercise would have comprised of more than 4200 personnel (SA Army Force Preparation, 2001).

All elements were deployed in or around a Brigade Administrative Area (BAA) from where they participated in the execution of the exercise. The Tactical Headquarters were in control of the exercise. From this location the commander conducted the battle. The Tactical Headquarters commanded the elements who executed the exercise. The groups involved in this exercise comprised headquarter elements from Air Defence Regiments, the Air Force, Armour Regiments, Artillery Regiments, Engineering Regiments, Infantry Regiments, Intelligence Regiments, Medical Services, Maintenance Units, Signal Regiments, Personnel and Special Services (SA Army Force Preparation, 2001).

All the elements involved in the exercise were equipped with normal radio communications and in strategic cases, with digitised computer systems through which to command and control their role in the exercise. These elements and the commanders were provided with a dynamic and realistic scenario, to determine whether they could assess the enemy correctly, fix them in a position for advantageous engagement and measure the effect that the destruction attempt has had (SA Army Force Preparation, 2001).

The digital battlefield command and control system allows lower echelon commanders to monitor progress, while the command headquarters can focus on planning. Eight digitised computer workstations, featuring digital connectivity to higher and lower echelon elements, were provided to key locations, through which elements were to command and control their role in the exercise (see Figure 3-1). Commanders from platoon to brigade level could thus verify their tactics in order to achieve the stated objectives under the specified circumstances. The effectiveness of various tactics and systems can thus be measured, evaluated and compared.

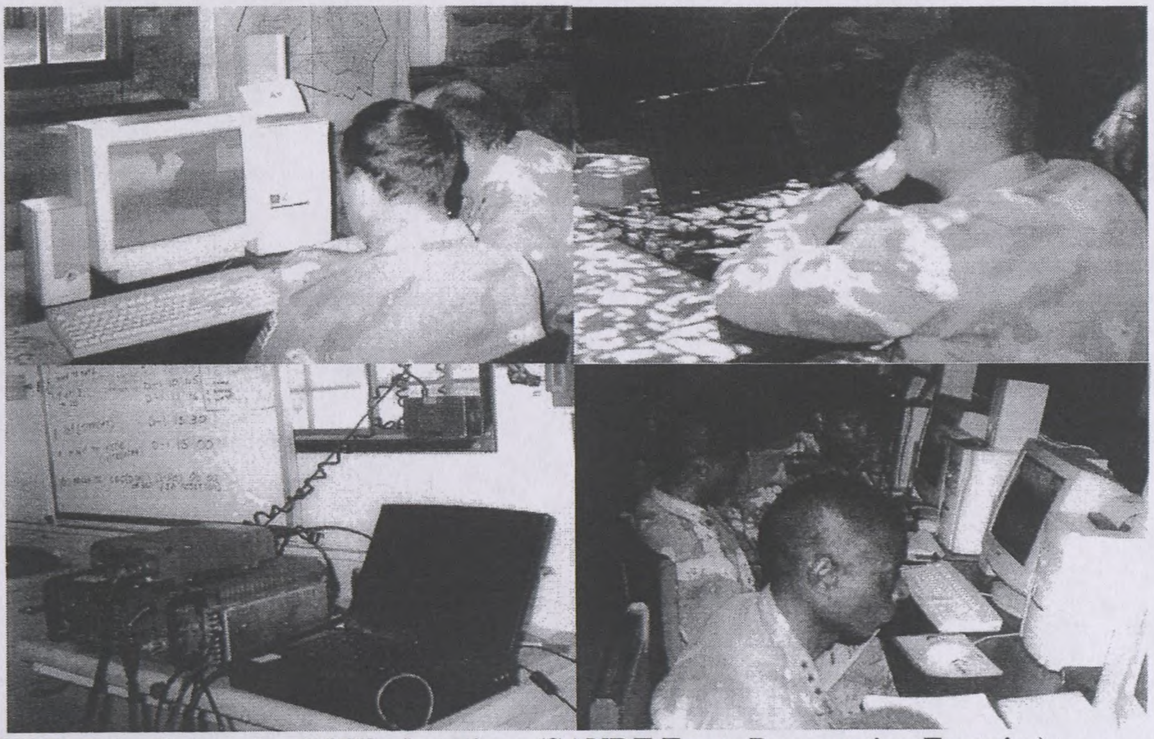


FIGURE 3-1 : Examples Of Workstations (SANDF Force Preparation Exercise)

3.2.2 OBJECTIVES OF MILITARY EXERCISE

The South African Defence force set a number of objectives for the exercise (SA Army Force Preparation, 2001). Objectives that are of direct importance to this study include:

- To test command and control capability;
- To test and evaluate standing operational procedures;
- To test and evaluate digitisation of the battlefield.

The digital battlefield command and control system tested in this exercise and evaluated in the research, was developed to focus integration of command and control and mission planning activities in order to strive towards the army's vision of a digitised force. For this exercise the Defence Force replaced financially exhaustive personnel and equipment resources with a computer simulated battlefield. The primary intention was the successful implementation and evaluation of a digitised battlefield system. A secondary intention was to reduce the cost and danger of live training. Although the exercise relied on a battle simulation, a dynamic and realistic scenario was provided where enemy and own forces were tested to react to each other's manoeuvres and decisions. Other aspects tested included command initiative and effective decision-making (SA Army Force Preparation, 2001).

3.3 THE RESEARCH PROBLEM

The purpose of this study is to research the usability issues as applied to the digital battlefield within a South African military context. The literary survey aims to explain what the utility of usability and usability evaluation is in order to achieve the full potential and optimal use of a digital battlefield. The research focuses on establishing the importance of usability (and related aspects) and the digital battlefield.

3.4 THE RESEARCH OBJECTIVES

The research problem creates a frame of reference within which the objectives of this study are formulated. The main objective of this study is to empirically investigate the usability issues (measured by the questionnaire designed by the researcher) as applied to the digital battlefield, within a South African military context.

To achieve the main objective of this study, the following resultant objectives are set:

1. To research and determine the important usability issues and dimensions relevant to a digitised battlefield;
2. To research the digital battlefield and related concepts;
3. To determine by means of a usability inquiry the perceptions of the usability of a digital battlefield system and possible causes for the variations in the perception of usability;
4. To determine by means of a usability inquiry the needs of members of military units with regard to the future use of a digital battlefield system;
5. To supply the SANDF with usability information that can be used in an iterative design process to optimise the prototype digital battlefield system tested in this military exercise.

3.5 THE RESEARCH HYPOTHESES

A hypothesis is a conjectural statement of the relation between two or more variables (Kerlinger, 1986). According to Mouton (1996) hypotheses can be categorized into two main groups, namely existential and relational hypotheses. An existential hypothesis is a provisional statement about a certain state of affairs. Such statements are claims that certain entities (for example a group of individuals) have certain properties (for example level of education or certain attitudes toward technology) and what the value is of those properties. A relational hypothesis proposes that a certain relationship exists between two or more variables. Depending on the type of relationship that is being postulated, relational hypotheses can be divided into correlation (or descriptive) hypotheses or causal (or explanatory) hypotheses (Mouton, 1996).

In view of the fact that descriptive research methods are used in this study, existential hypotheses have been utilised in this study. This type of methodology is suitable for data that is derived from observational situations (Behr, 1988). In descriptive research the emphasis is on the description of a specific individual, situation, group, organisation, culture, and so forth, or the frequency with which a specific variable is present in a sample (Mouton, 1996). Descriptive research focuses on the portrayal of variables in the problem. The hypotheses are of a general nature for example: x correlates with y (Lehmann, 1991).

The insight that has been gained from the literature review in chapter two will form the basis of the outlined hypotheses. The hypotheses have been formulated in accordance with the proposed statements about the usability concepts contained within the literature and research problem.

HYPOTHESIS ONE

A positive perception exists that the utilisation of the digital battlefield system will lead to improved effectiveness.

HYPOTHESIS TWO

A positive perception exists regarding the reliability of the digital battlefield system.

HYPOTHESIS THREE

A positive perception exists concerning the accuracy of the digital battlefield system.

HYPOTHESIS FOUR

A positive perception exists that use of the digital battlefield system will lead to improved efficiency.

HYPOTHESIS FIVE

A positive perception exists concerning the compatibility of the digital battlefield system.

HYPOTHESIS SIX

A positive perception exists concerning the consistency of the digital battlefield system.

HYPOTHESIS SEVEN

A high level of satisfaction exists regarding use of the digital battlefield system.

HYPOTHESIS EIGHT

A positive perception exists concerning the usefulness of the digital battlefield system.

HYPOTHESIS NINE

A positive perception exists concerning the utility of the digital battlefield system.

HYPOTHESIS TEN

A positive perception exists regarding the ease of use of the digital battlefield system.

HYPOTHESIS ELEVEN

A positive perception exists regarding the learnability of the digital battlefield system.

3.6 THE RESEARCH PROCESS AND DESIGN

3.6.1 BACKGROUND

Research is a procedure by which the researcher systematically attempts to find (with verifiable fact) the answer to a question or the resolution of a problem (Kerlinger, 1986; Leedy, 1993; Merriam & Simpson, 1984). In this study the researcher has attempted to consistently abide by the following principles.

- The research can be replicated;
- The data is generated in a standardised form;
- The data can be statistically managed;
- Defensible conclusions can be drawn;
- Improved understanding is attained as a result of these conclusions;
- Further possibilities for research are indicated.

Any research can be viewed as being circular in the sense that the researcher seeks data seemingly pertinent to the solution of the research problem, from within the environment that produced the researchable problem. Subsequently, the collected data is organised, analysed and interpreted in order to facilitate the solution of the research problem that originally gave rise to the research effort (Leedy, 1993). This process continues to spiral, as research often induces further unexplored problems, which require a repeat of the research cycle.

This concept of a continuous loop can be extended and is indeed central to one of the most important principles of usability evaluation and User-Centred Design namely iterative design. This entails a cycle of continuous design, test, measure, and redesign of a product based on the usability opportunities and problems disclosed by the empirical testing; and as a result taking corrective action, which thus enhances end-user satisfaction.

3.6.2 THE DESIGN

The research methodology can be viewed as the implementation of scientific methods in the study of reality, within the previously described research cycle. The research design creates the framework for the analysis of the variables by setting up the study in such a way that it will produce answers to specific questions. It refers to the basic strategy of the research and the logic behind it, which will make it possible and valid to draw conclusions from it. Research design therefore has two purposes namely to provide answers to research questions, as well as to control the experimental, extraneous and error variance (Mouton, 1996; Oppenheim, 1992).

This research was conducted during a military exercise held by the South African National Defence Force. After careful consideration of the methods available and the budgetary and time constraints it was the researcher's decision to follow a usability inquiry approach was involving the obtainment of information about users' characteristics, perceptions, likes, dislikes, needs and understanding of the system by letting them answer questions in written form. Questionnaires were distributed to participants directly involved with the command and control digital battlefield system to be evaluated. The questionnaires were distributed to the relevant participants upon conclusion of the exercise, immediately completed and returned.

Due to the nature of the exercise and security concerns, anonymity and confidentiality were guaranteed. Names and identities of individuals, products or military elements, may not be divulged. The sample questionnaire that appears in Annexure A is supplied without details that can identify any individual or product.

3.6.3 SURVEY RESEARCH

Survey research (as was employed in this study), studies both large and small populations by selecting and studying samples chosen from the populations to determine the relative incidence, distribution and interrelations of sociological and psychological variables (Kerlinger, 1986). The interest of the researcher with this study is the establishment of measurement of the subjective perceptions of the sample concerning the usability of the digital battlefield system. Survey research can be used to obtain factual information and also allows the study of attitudes. Since it cannot be assumed that people think in certain ways without asking them what they think, academic surveys play an important role when attitudes are of interest and emphasise the explanation of attitudes (Nachmias & Nachmias, 1981; Schnetler, Stoker, Dixon, Herbst & Geldenhuys, 1989).

Several methods exist by which survey research can be conducted. For the purposes of this study, the survey questionnaire was employed. The survey questionnaire is an example of a structured data collection instrument through which information is elicited, collected and recorded (Schnetler et al., 1989). Answering a questionnaire focuses the respondent's mind on a particular topic, which in the case of this study is the usability (and related usability issues) of the digital battlefield command and control system. The main advantage of usability questionnaires is that they provide feedback from the user's point of view (Jordan, 1998; Mayhew, 1999; Nielsen, 1993).

The decision to make use of the questionnaire survey method to find answers to the research problem as defined in this study, was motivated by the advantages of this method. It was felt that the advantages outweigh the potential disadvantages. Kerlinger (1986) and Schnetler et al, (1989) indicate that survey research (usually in the form of a questionnaire), has the following advantages:

- Questionnaires usually are the lowest-cost method of gathering data. Considerable amounts of time and money are saved;
- Anonymity is ensured since there is no interviewer present to identify the respondent. This was an important consideration as respondents are often more inclined to answer questions honestly when they remain anonymous;

- The questionnaire may be completed at the respondent's convenience, allowing them the opportunity to spend more time on their answers. In the case of this study, the questionnaires were distributed to the relevant participants upon conclusion of the military exercise, which formed the basis of this design. The questionnaires were completed and returned immediately;
- The standardised wording of a questionnaire means that the stimulus provided to the respondents, is identical in all cases, which assists in the comparison of different respondents' answers;
- Questionnaires are highly structured, and thus make for easier coding and capturing of data.

Bailey (1987), Emory and Cooper (1991), Huysamen (1994) and Schnetler et al, (1989) state that this method has the following shortcomings:

- The major disadvantage of the questionnaire survey method is the low response rate. Respondents who do not return questionnaires often have some definite opinions on the subject, thus bias might be introduced into the data because of the poor response rate. This problem was not encountered within this study, as all the possible respondents within the sample were tested;
- Due to the fact that questions in the questionnaire are set, there is a lack of flexibility by reason of the fact that respondents cannot qualify or justify their answers;
- Personal interpretation occurs due to the fact that questions are interpreted from the respondent's frame of reference often making it impossible for a researcher's to clarify the interpretations;
- Respondents may omit questions that they don't fully understand or do not care to answer.

3.7 DESCRIPTION OF THE SAMPLE

In order to test the stated hypotheses and make significant and valid inferences, a sample was secured consisting of 28 military personnel who have been exposed to the military exercise involving a digital battlefield system used to facilitate command and control. The qualifying condition set for respondents to be included in the sample was, that these individuals participated in the exercise by directly using the digitised battlefield system in order to execute command and control functions with regard to their respective forces.

The survey questionnaire was distributed to the sample population, in order to establish their attitude towards the usability and their acceptance of the digital battlefield. They varied in rank from sergeant to colonel, and hailed from units within the Army, Air Force as well as the SA Military Health Services. Tables 3-1 and 3-2 present a profile of the responding soldiers:

TABLE 3-1: Rank Profile Of Sample.

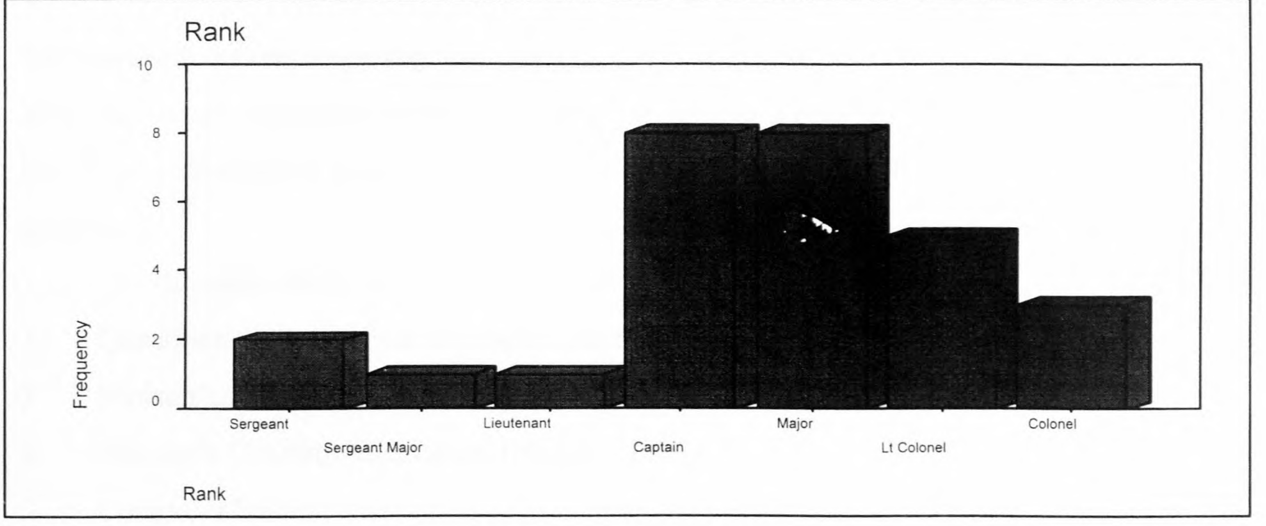
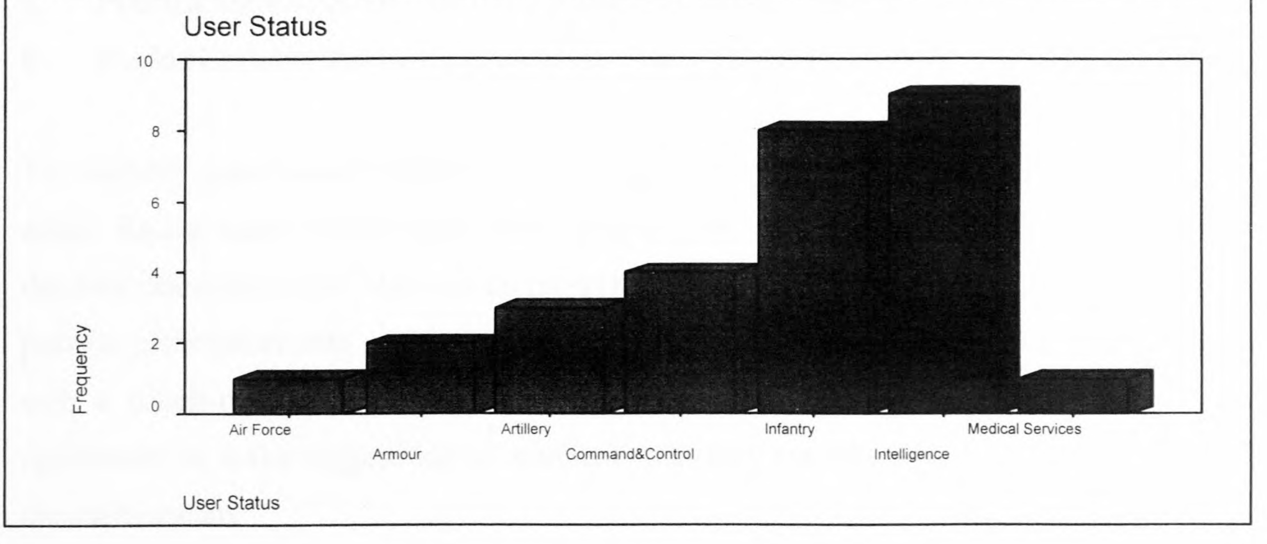


TABLE 3-2: User Status Profile Of Sample.



3.8 MEASURING INSTRUMENT

3.8.1 DEVELOPMENT OF THE QUESTIONNAIRE

Thus far, several usability questionnaires have been developed to assess users' perceptions of systems. Chin, Diehl and Norman (1988) has found several weaknesses in many of the subjective evaluation measurement tools. Problems range from a lack of validation, to low reliability. According to Chin et al (1988) several past studies have examined the types of questions that would be appropriate for questionnaires. It was found that checklist questionnaires are insufficient, and that open-ended questions should be added to allow for the indication of other necessary features to be added, or suggestions for improvement. It was also found that users prefer concrete adjectives for evaluations. In addition, specific evaluation questions appeared to be more accurate than general questions (Chin, Diehl & Norman, 1988).

This research utilises a questionnaire designed by the researcher, after careful investigation into all of the issues concerned, as well as examining several similar questionnaires. Specifically, the following collection of usability questionnaires were examined, before a final questionnaire was designed:

1. Questionnaire for User Interface Satisfaction (Chin et al., 1988);
2. Questionnaire for Perceived Usefulness and Ease of Use (Davis, 1989);
3. Nielsen's Attributes of Usability (Nielsen, 1993);
4. Nielsen's Heuristic Evaluation (Nielsen, 1993);
5. Computer System Usability Questionnaire (Lewis, 1995);
6. After-Scenario Questionnaire (Lewis, 1995);
7. Practical Heuristics for Usability Evaluation (Perlman, 1997);
8. Purdue Usability Testing Questionnaire (Lin & Salvendy, 1997).

The usability questionnaire designed for this study (see Annexure A) mainly makes use of rating scales. Rating scales present respondents with several categories from which they pick the one that best characterises the object being rated (Kerlinger, 1986; Scerbo, 1995). Rating scales items provide participants with concrete adjectives to facilitate evaluation, in the form of statements with a Likert-type response. Open-ended questions are included to afford participants the opportunity to make suggestions or comments that may not otherwise have been addressed by the questionnaire.

The questionnaire consists of four sections:

A: This section is composed of questions aimed at eliciting general biographical information and consisted of three broad sections. The first segment gave an indication of the general background of the participants. Questions here related to the candidates rank, the Defence Force group they originated from and their status within the group. The second portion consisted of questions relating to the respondents' level of education and technology-related knowledge and ability. The third part included questions relating to issues concerning the specific digital command and control system used in this military exercise, such as amount of training received and which functions were utilised.

B: This section consists of questions related to general usability issues. Specific questionnaire items were chosen from previous usability research (Chin et al., 1988; Davis, 1989; Lewis, 1995; Lin & Salvendy, 1997; Nielsen, 1993; Perlman, 1997). Only questions relating to the usability issues that were identified to be pertinent to this study were chosen.

The scales included in the questionnaire that are relevant to measuring usability (as was previously discussed in chapter two of this study) are:

- *Effectiveness* - the extent to which the system enables the tasks to be completed and the goals achieved;
- *Efficiency* - the degree to which the system enables the tasks to be completed in a timely, competent and economical fashion;
- *Satisfaction* - the user's level of comfort with the system, feelings towards, and acceptability of the system to the user;
- *Usefulness* - the value, worth and helpfulness of the system.
- *Utility* - the functionality of the system;
- *Ease of Use* - the effortlessness and user-friendliness of the system;
- *Learnability* - the time and effort required to reach a specified level of user performance.

The following subsets are also included in the questionnaire:

- *Reliability* - the dependability of the system and the repeatability without failure of tasks using the system;
- *Accuracy* - the exactness and correctness of the system;
- *Compatibility* - the degree to which the system's method of operation matches with the user's expectations;
- *Consistency* - the ability of the system to respond to user inputs in a consistent way and to perform similar tasks in similar ways;
- *Human-Computer Interaction* - concerned with computer systems that are functional, safe, easy and enjoyable to the user.

C: This section is comprised of questions aimed at determining how participants rated specific functions and settings within the digital command and control system, used in this military exercise.

D: The last section contains open-ended questions. The researcher has coded the open-ended questions in order to simplify statistical analysis. This has been done through content analysis, which allows responses to be reduced into categories. The frequency of occurrence of different categories of response can then be counted. Open-ended questions allow participants the chance to make suggestions or comments that may not otherwise have been addressed by the questionnaire.

Before a measuring instrument is developed and administered to a group of subjects, the issues concerning reliability and validity must be addressed. If the reliability and validity of the measuring instrument (and as a result, the data) is unknown, very little trust can be put in the results obtained and conclusions drawn.

3.8.2 RELIABILITY

Kerlinger (1986) states that reliability is the accuracy or precision of a measuring instrument. Synonyms for reliability include dependability, stability, consistency and predictability. It can be defined as the relative absence of errors of measurement in a measuring instrument. The measuring instrument is unreliable to the extent that errors of measurement are present in that instrument (Kerlinger, 1986). The amount of error of measurement can be ascertained by determining the variance. Systematic variance occurs when errors are constant or biased (all scores lean to one direction, they are either all high or all low). With random or error variance, the scores tend to lean in any direction. Errors are random, resulting from a condition (such as fatigue) at a particular time that temporarily affects the subject or the measuring instrument.

To be interpretable, a test must be reliable. Unreliable measurement is loaded with errors, making the interpretation of variables and the determination of relations between variables, a difficult task. High reliability is not necessarily a guarantee for good scientific results, but there can be no respectably scientific result without reliability. Kerlinger (1986) affirms that reliability is a necessary, but not always sufficient, condition of the value of research results and the interpretation thereof.

The reliability of a questionnaire is directly related to the number of items (the larger the number of items, the higher the reliability) (Nunnally, 1978). However, a questionnaire with a large number of questions often takes a longer time to complete. This was not a major concern within the confines of this study, as the sample to which the instrument was administered was bound to complete the whole questionnaire irrespective of the length of time required. Nevertheless, it is recommended that further reduction does take place. Chin et al (1988) suggests that the number of questionnaire items could be reduced across a series of administrations, while still maintaining a high degree of reliability.

Cronbach's Alpha, which is an estimation of reliability based on the average intercorrelation among question items, was used as the measure of reliability. The reliability measured by the alpha coefficients was found to be as follows:

- .8850 for 'Effectiveness';
- .0848 for 'Reliability';
- .7121 for 'Accuracy';
- .5550 for 'Efficiency';
- .8469 for 'Compatibility';
- .4253 for 'Consistency';
- .4481 for 'Satisfaction';
- .7791 for 'Usefulness';
- .8268 for 'Utility';
- .7593 for 'Ease of Use';
- .6922 for 'Learnability';
- .8531 for 'Human-Computer Interaction'.

Although the reliability measures for 'Efficiency', 'Consistency', 'Satisfaction' and in particular 'Reliability', could be increased by the exclusion of certain questions, after careful consideration by the researcher, it was decided no questions should be excluded from the total set of questions at this first implementation. However, it is possible and recommended that after a series of administrations of the questionnaire, the number of items be reduced, while still maintaining a high degree of reliability.

3.8.3 VALIDITY

Validity determines whether the measuring instrument in fact measures that which it is supposed to measure. Validity also refers to whether or not the experimental design answers the research question, and is threatened when uncontrolled factors confound the experiment (Weimer, 1995). Types of validity include content, criterion related, and construct validity. Content validity is the representativeness or sampling adequacy of the content of a measuring instrument (Kerlinger, 1986). It is virtually impossible to draw large collections of items from a universe of content. Thus content validity is often a matter of judgement. The items of a measuring instrument must be studied, each item being weighed for its presumed representativeness of the property being measured. Within this study, questions were chosen from previous research that specifically investigated similar usability issues.

To confirm criterion validity, it is important to determine whether the wording of the questions is understandable, or which elements need to be included or excluded to provide answers to specific aspects of the research. Validity is often assessed during the pilot testing of the questionnaire, however, due to the nature and frequency of military exercises such as the one during which the research was conducted, it was not possible to pre-test the questionnaire. However, the questionnaire was presented to several usability experts and non-experts alike to determine whether the questions were clearly worded and easily understood. This is especially important when measuring subjective concepts such as attitudes. Probing for attitudes usually requires a series of questions that are similar but not the same. The battery of questions should be answered consistently, and if this is the case the scale items will have high internal validity.

In terms of the validity of this research, as well as the measuring instrument designed for this study, several steps were taken to prevent factors that threatened validity. Rating scales (as were used in the questionnaire) have several weaknesses. The first is the tendency to rate an object in the constant direction of a general impression, referred to as the halo-effect (Kerlinger, 1986). To counter the halo-effect, the questionnaire items consisted of both positive and negative statements forcing respondents to read carefully and consider their responses. Another source of invalidity in ratings is the error of central tendency (Kerlinger, 1986). This is the tendency of respondents to avoid extreme judgements and rate down the middle of a rating scale. To contend with the problem of centrality the response, alternatives were presented in an even number format consisting of six-point scales with no alternatives such as 'unsure', for example:

Overall, I regard the system as:

1 VERY INEFFECTIVE	2 MOSTLY INEFFECTIVE	3 SOMEWHAT INEFFECTIVE	4 SOMEWHAT EFFECTIVE	5 MOSTLY EFFECTIVE	6 VERY EFFECTIVE

According to Kerlinger (1986) further threats to validity include the error of severity, which is the tendency to rate too low, and the error of leniency, which is the opposite general tendency to rate too high. Emotional variables such as those mentioned here cannot be controlled. Subjects may possibly have experienced pressure from military officials, or they may not have been motivated to participate. Other possible threats to validity could have resulted from the composition of the group. Individual differences such as technological optimism might have influenced the results or the resistance to change (even though change may lead to improvement). An additional factor possibly influencing validity, is a concept known as 'reactivity' (Campbell and Stanley, 1963; Weimer, 1995). Reactivity results when the group being studied acts differently simply because they know they are being studied. It is anticipated that the assurance of anonymity would counteract the mentioned negative factors. Although measures have been taken to control extrinsic and intrinsic factors, the validity of the research may still have been affected by and would be taken into account during the interpretation of the results.

Due to the nature of the military exercise during which the sample was administered, as well as the limited frequency with which such military exercises occur, it was not possible to pre-test the questionnaire. The questionnaire was, however, presented to members of the SANDF and related industry participants (some knowledgeable and others ignorant of usability issues, to determine whether the questions were clearly worded and easily understood. The researcher also reviewed several past usability studies to determine the types of questions considered appropriate for usability questionnaires. It was found that checklist questionnaires were insufficient and that open-ended questions had to be added to allow for the expansion on opinions and suggestions for improvement. It was also found that users preferred concrete adjectives for evaluations. In addition, specific evaluation questions appeared to be more accurate than general questions. The researcher designed the questionnaire after careful investigation into all of the issues mentioned above.

Concerning the sample itself, although it was relatively small, this was the full extent of the possible population that could have been tested, since only 28 subjects were exposed to the computer system and thus only their perception of the usability of the system could be assessed. Virzi (1992) conducted a series of experiments to determine how many subjects would be necessary to identify usability problems. It found that the first few subjects detected the majority of problems as well as the more severe problems. Virzi concluded that in most situations as few as five subjects would be able to detect 80% of the most important usability problems in a test session. It is therefore believed that the sample for this study is sufficient to establish the usability of the digital battlefield, as it represents the entire available population.

3.9 STATISTICAL ANALYSIS TECHNIQUE

The primary data obtained through the questionnaires, was analysed utilising the Statistical Package for Social Science (SPSS) program at the Stellenbosch University (SPSS, 1990). The analysis consisted of descriptive statistics, as this was deemed most important to the main objective of the research. The research aimed to illustrate perceptions of usability and the digital battlefield.

3.10 CONCLUSION

This study investigates the usability issues as applied to the digital battlefield within a South African military context. The military exercise utilising digital battlefield technologies held by the South African National Defence Force (SANDF) focussed on the integration of command and control and mission planning activities, as well as decision-making processes. In this chapter an attempt was made to explain the research design and methodology that was employed during this study, as well as during the usability evaluation of the military exercise. Although the exercise conducted by the SANDF was relatively small, it is considered to be representative of actual military functioning and operations. It is therefore believed that the usability of the digital battlefield (or lack thereof) can sufficiently be established.

This chapter provides an overview of the research problem and objectives of the study aiming to explain what the utility of usability and usability evaluation is in order to achieve optimal use of a digital battlefield. Due to the descriptive nature of this study existential hypotheses were set based on the insight that has been gained from the literature review in accordance with the proposed statements about the usability concepts.

This research utilises a questionnaire designed by the researcher, after careful investigation into all of the related issues. A concerted effort was made to ensure the reliability and validity of the measuring instrument in order to ensure that the research results obtained and discussed in the next chapter, is both extensive and valuable.

Chapter 4 consists of a discussion of the research findings. It details the results obtained from this research, using descriptive statistical methods.

CHAPTER 4: DISCUSSION OF FINDINGS

4.1. INTRODUCTION

In descriptive research the goal of the investigation is the careful mapping out of a situation, that is, to describe what is happening. The purpose of this study is to describe certain aspects of usability as they relate to a digital battlefield system within a South African military context. The purpose of this chapter is to report the results of the analyses described in the previous chapter.

The analysis of the data obtained through the questionnaires consisted of descriptive statistics, and was examined utilising the Statistical Package for Social Science (SPSS) program (SPSS, 1990). The research aimed to illustrate perceptions of usability and the digital battlefield. The findings will be discussed in accordance with the structure of the questionnaire (see Annexure A).

4.2 THE RESEARCH FINDINGS

4.2.1 DESCRIPTIVE STATISTICS CONCERNING THE BIOGRAPHICAL INFORMATION

BRIEF REVIEW OF THE BIOGRAPHICAL DIMENSIONS

The general biographical information segment of the questionnaire consists of three broad sections:

1. The first gives an indication of the general background of the participants. Questions here relate to the candidates' rank, the Defence Force group they originate from and their status within the group.
2. The second section relates to the respondents' level of education and their technology-related knowledge and ability.
3. The third section relates to issues concerning the specific digital battlefield command and control system used in the military exercise, which forms the basis of this study, such as the amount of training received and which functions were utilised.

BIOGRAPHICAL RESULTS

- The questionnaire was issued to 28 individuals ranging in rank from colonel to sergeant (see Table 4-1).
- Most of the respondents fell into the higher-ranking categories with 8 individuals ranked as Captain, 8 as Major, 5 as Lieutenant Colonel and 3 as Colonel.
- It is interesting to note that most of the higher-ranking respondents have an intelligence-user status (see Table 4-2) and all have graduate qualifications (see Table 4-3).
- It is apparent that all respondents are well educated with 67.9% having matriculated, 25% with a graduate qualification (diploma or degree), and 7.1% with a post-graduate qualification.

TABLE 4-1: Rank Profile Of Sample.

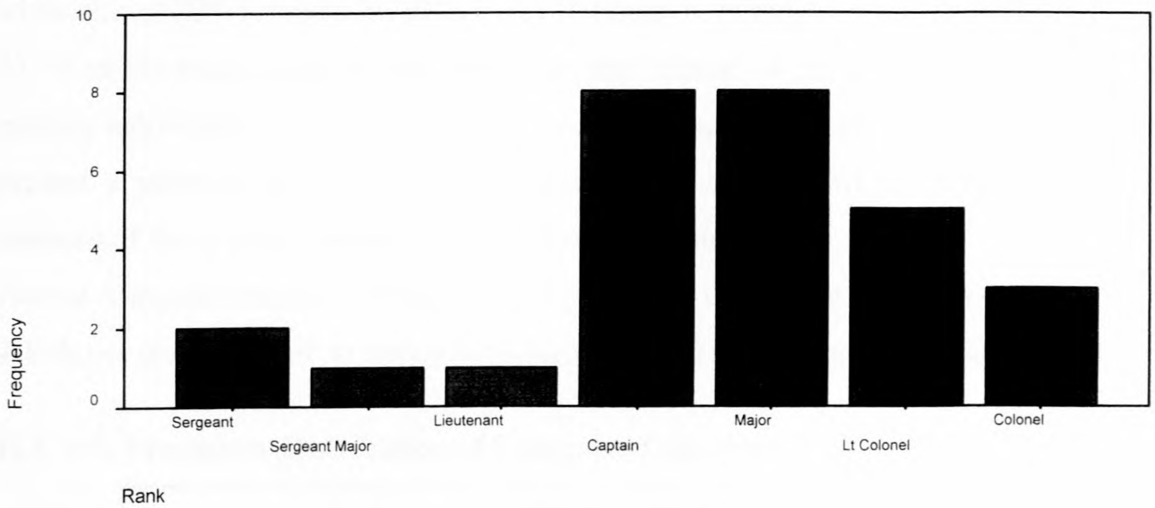


TABLE 4-2: Cross-tabulation of Sample Rank Profile and User Status.

Count

		User Status							
		Air Force	Armour	Artillery	Command &Control	Infantry	Intelligence	Medical Services	Total
Rank	Sergeant	1					1		2
	Sergeant Major					1			1
	Lieutenant						1		1
	Captain		1	1		3	3		8
	Major		1	1		3	2	1	8
	Lt Colonel			1	2	1	1		5
	Colonel				2		1		3
Total		1	2	3	4	8	9	1	28

TABLE 4-3: Cross-tabulation of Sample Rank Profile and Level of Education.

% of Total

		Level of education			
		Matric	Diploma/ Degree	Postgraduate	Total
Rank	Sergeant	7.1%			7.1%
	Sergeant Major	3.6%			3.6%
	Lieutenant	3.6%			3.6%
	Captain	21.4%	3.6%	3.6%	28.6%
	Major	25.0%	3.6%		28.6%
	Lt Colonel	3.6%	14.3%		17.9%
	Colonel	3.6%	3.6%	3.6%	10.7%
Total		67.9%	25.0%	7.1%	100.0%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

Of more interest within the boundaries of this study, are the qualifications and experience that individuals have in terms of computer usage, as this is expected to have an impact on their assessment of the digital battlefield system. Users with more experience may perceive the system as more usable than individuals with limited experience.

- Seen from Table 4-4, 42.9% of the respondents claim regular computer experience, 46.4% moderate and 10,7% little experience.
- The majority of respondents are exposed to computers on a regular basis; all have access to a computer at work while half have access to a computer at home (see Table 4-5 and 4-6).
- In terms of formal computer training received (see Table 4-7) approximately half of the respondents (46.4%) claim to have received 10 or more hours of formal computer training, while almost 20% received between 2 and 10 hours of training.
- 35.7% of the respondents have received less than 2 hours of training, all of whom are higher ranking individuals (3 captains, 3 majors and 3 lieutenant colonels and 1 colonel). This may present a problem, as the operation of this digital system will probably improve if the operator of the system is more experienced with computer use.
- Formal computer training is however not a guarantee of ensuring ease with computers. Table 4-8 shows that 78.6% of all respondents across all ranks use computers on a daily basis.

TABLE 4-4: Frequency Distribution of Computer Experience.

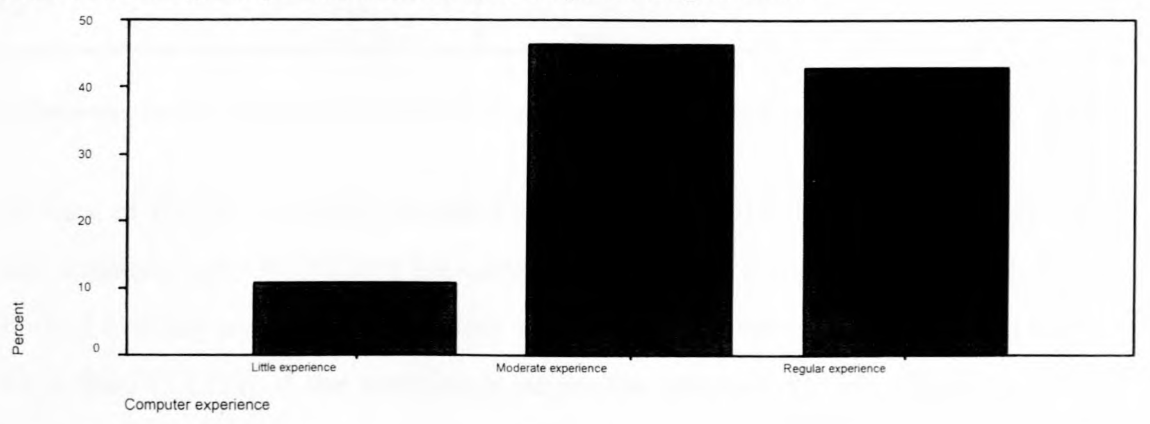


TABLE 4-5: Computer Exposure at Work.

		Frequency	Percent	Valid Percent
Valid	Access to a computer at work	28	100.0	100.0

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

TABLE 4-6: Computer Exposure at Home.

		Frequency	Percent	Valid Percent
Valid	Access to a computer at home	14	50.0	50.0

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

TABLE 4-7: Cross-tabulation of Sample Rank Profile and Formal Computer Training.

			Formal computer training				
			Less than 2 hrs training	2 to 4 hrs training	4 to 10 hrs training	10 hrs (or more) training	Total
Rank	Sergeant	Count		1		1	2
		% of Total		3.6%		3.6%	7.1%
	Sergeant Major	Count			1		1
		% of Total			3.6%		3.6%
	Lieutenant	Count		1			1
		% of Total		3.6%			3.6%
	Captain	Count	3	1		4	8
		% of Total	10.7%	3.6%		14.3%	28.6%
	Major	Count	3			5	8
		% of Total	10.7%			17.9%	28.6%
	Lt Colonel	Count	3			2	5
		% of Total	10.7%			7.1%	17.9%
	Colonel	Count	1	1		1	3
		% of Total	3.6%	3.6%		3.6%	10.7%
Total		Count	10	4	1	13	28
		% of Total	35.7%	14.3%	3.6%	46.4%	100.0%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

TABLE 4-8: Cross-tabulation of Sample Rank Profile and Computer Usage.

			Computer usage			
			Every day	A few times a week	A few times a month	Total
Rank	Sergeant	Count	2			2
		% of Total	7.1%			7.1%
	Sergeant Major	Count	1			1
		% of Total	3.6%			3.6%
	Lieutenant	Count	1			1
		% of Total	3.6%			3.6%
	Captain	Count	7	1		8
		% of Total	25.0%	3.6%		28.6%
	Major	Count	5	2	1	8
		% of Total	17.9%	7.1%	3.6%	28.6%
	Lt Colonel	Count	4		1	5
		% of Total	14.3%		3.6%	17.9%
	Colonel	Count	2	1		3
		% of Total	7.1%	3.6%		10.7%
Total		Count	22	4	2	28
		% of Total	78.6%	14.3%	7.1%	100.0%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

- In view of the fact that the Command and Control (C^2) Digital Battlefield System is a new development, only 39.3% have had previous exposure to the system (see Table 4-9).
- Formal training concerning the system was provided, however, as can be seen from Table 4-10, a third (32.1%) of the participants began the exercise utilising this system without any previous training with regard to this system.
- Although most of the participants feel that the amount of training received (see Table 4-11), as well as the adequacy of the training (see Table 4-12) is satisfactory, a third of the participants are not at all satisfied with either the amount or adequacy of training provided, and more than half (53.6%) indicate that they have further training needs (see Table 4-13).

TABLE 4-9: Previous Exposure to the C² Digital Battlefield System.

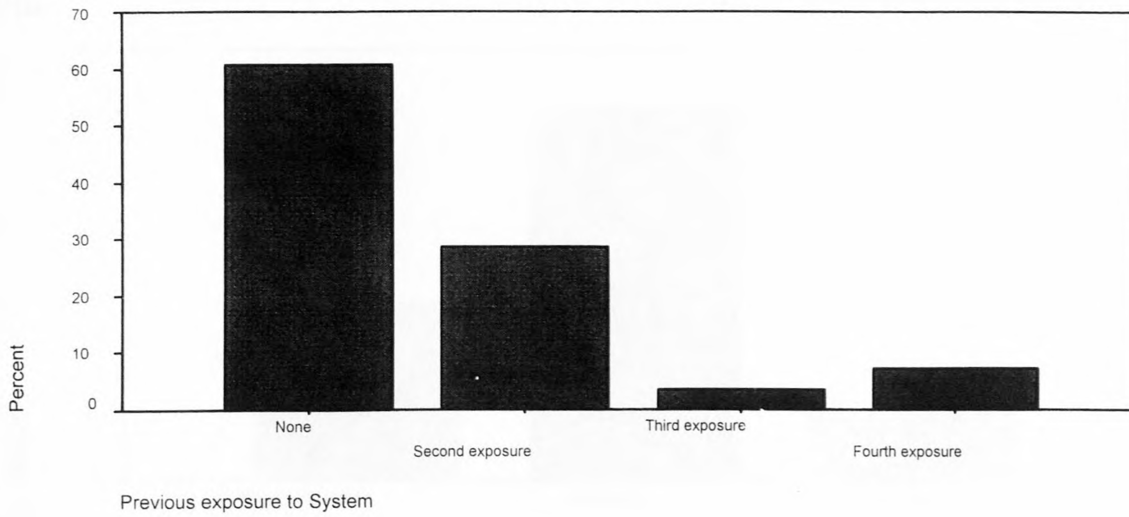


TABLE 4-10: Frequency Distribution of Training Received Concerning the C² Digital Battlefield System.

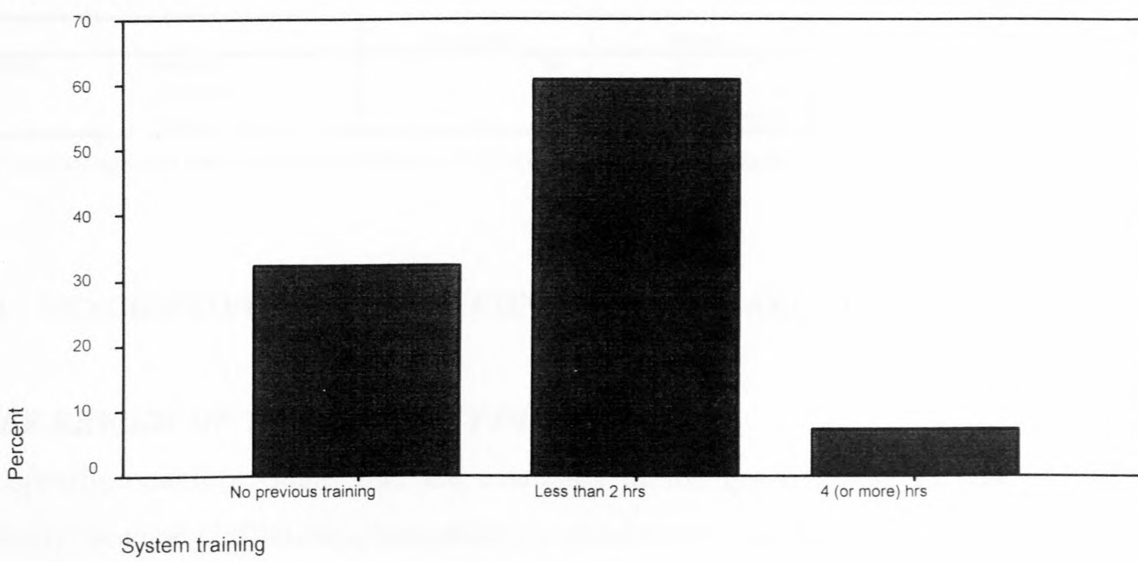


TABLE 4-11: Amount of Training Received Concerning the C² Digital Battlefield System.

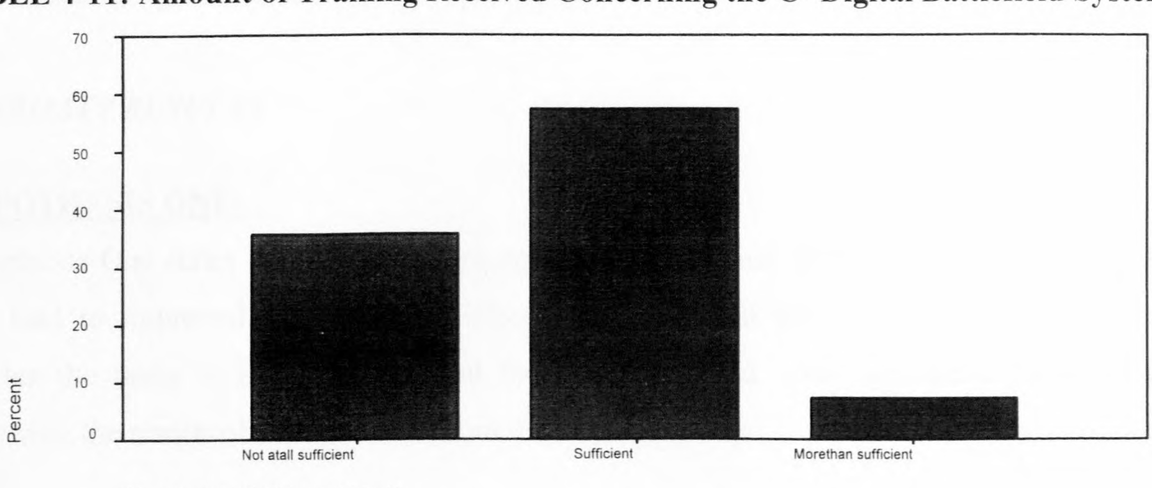


TABLE 4-12: Adequacy of Training Received Concerning the C^2 Digital Battlefield System.

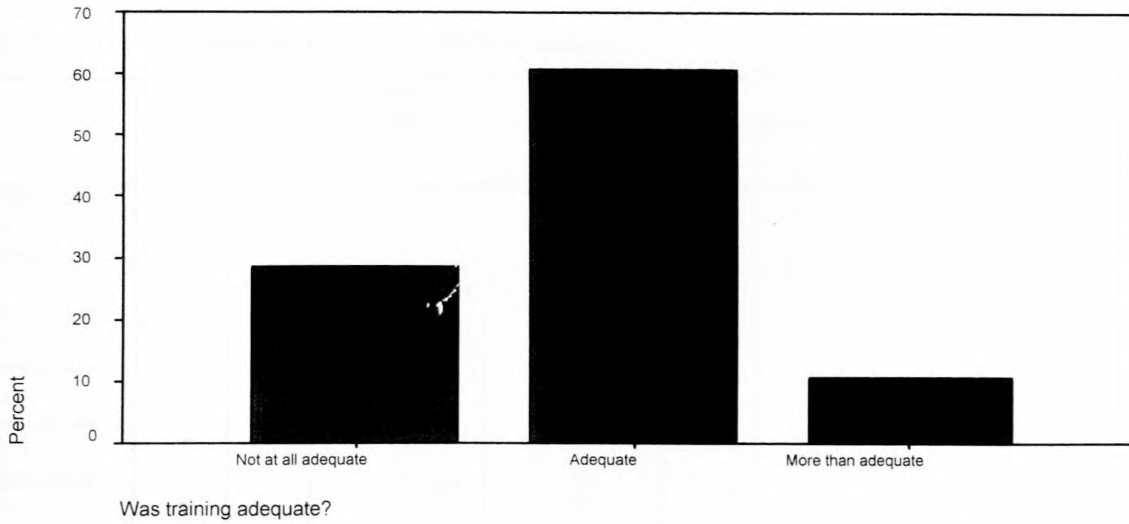


TABLE 4-13: Indication of Further Training Needs.

		Frequency	Percent
Valid	Negative	13	46.4
	Affirmative	15	53.6
	Total	28	100.0

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

4.2.2 DESCRIPTIVE STATISTICS CONCERNING USABILITY

BRIEF REVIEW OF THE USABILITY DIMENSIONS

The specific usability issues that are examined in the questionnaire include effectiveness, reliability, accuracy, efficiency, compatibility, consistency, satisfaction, usefulness, utility, ease of use and learnability. The findings and hypotheses will be discussed in accordance with the structure of the questionnaire.

USABILITY RESULTS

HYPOTHESIS ONE:

Hypothesis One states that a positive perception exists that use of the digital battlefield system will lead to improved effectiveness. Effectiveness refers to the extent to which the system enables the tasks to be completed and the goals achieved. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-14, the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-14: Frequency Table for 'Effectiveness'.

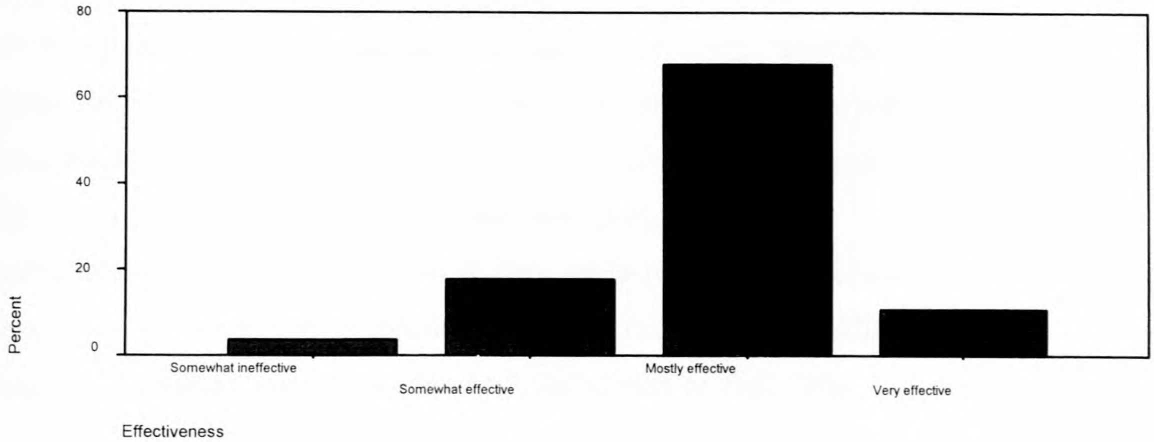
	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Effectiveness (18)	1	3.6%			6	21%	7	25%	12	43%	2	7.1%
Effectiveness (19)			2	7.1%	3	11%	1	3.6%	12	43%	10	36%
Effectiveness (20)					1	3.6%	6	21%	8	29%	13	46%
Effectiveness (21)					1	3.6%	2	7.1%	10	36%	15	54%
Effectiveness (22)	2	7.1%			3	11%	5	18%	7	25%	11	39%
Effectiveness (23)			1	3.6%			5	18%	10	36%	12	43%
Effectiveness (24)			1	3.6%	4	14%	4	14%	7	25%	12	43%
Effectiveness (25)							5	18%	10	36%	13	46%
Effectiveness (26)			1	3.6%	1	3.6%	5	18%	11	39%	10	36%
Effectiveness (27)	1	3.6%			4	14%	6	21%	13	46%	4	14%
Effectiveness (28)					1	3.6%	5	18%	19	68%	3	11%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

As can be seen from Table 4-14 the majority of responses are positive:

- 42.9% of the respondents mostly agree that they could effectively complete their work using the system and that using this system would save time.
- The majority of respondents (up to 53.6%) strongly agree that using this system would improve the time needed to make decisions, communicate information, process intelligence, and redistribute intelligence to lower level headquarters.
- 42.9% of the respondents strongly agree that they could effectively communicate information using this system.
- There is strong agreement (46.4%) that job performance would be improved. 39.3% of the respondents indicate that situational awareness is improved through the use of this system, this is echoed by the 46.4% of respondents who mostly agree that the digital battlefield system realistically represents the battlefield.

TABLE 4-15: Ratings of Overall Effectiveness of the Digital Battlefield C^2 System.



- Table 4-15 indicates that most of the respondents (more than 90%) regard the system as effective (17.9% of the respondents rate the system as somewhat effective, 67.9% rate the system as mostly effective and 10.7% rate the system as being very effective).

Hypothesis One, which states that a positive perception exists that use of the digital battlefield system will lead to improved effectiveness, is therefore accepted.

HYPOTHESIS TWO:

Hypothesis Two states that a positive perception exists regarding the reliability of the digital battlefield system. Reliability refers to the dependability of the system and the repeatability without failure of tasks using the system. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-16 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-16: Frequency Table for 'Reliability'.

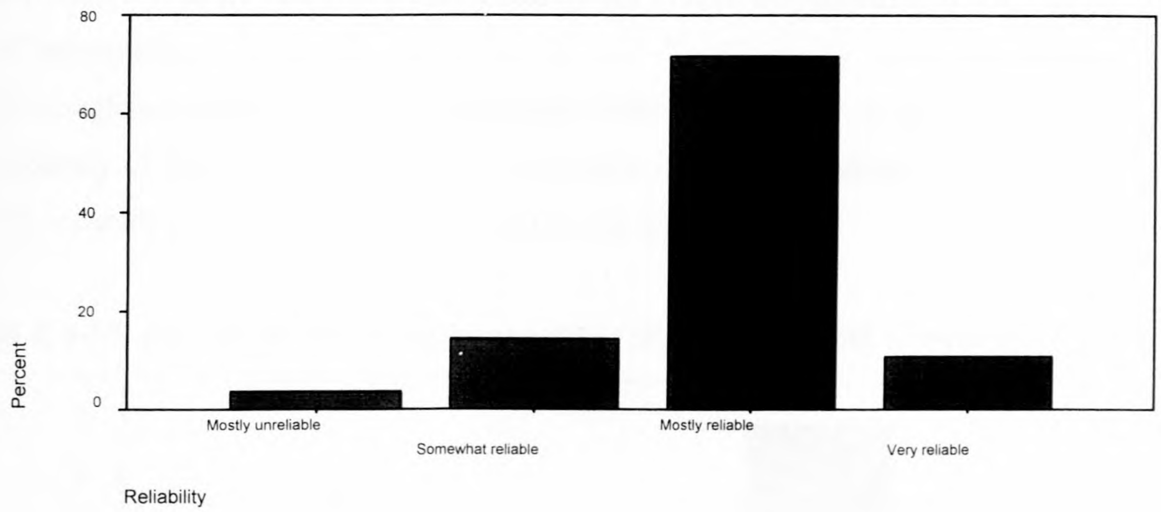
	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Reliability (29)			2	7.1%	3	10.7%	1	3.6%	17	60.7%	5	18%
Reliability (30)	3	10.7%	2	7.1%	2	7.1%	5	18%	8	28.6%	8	29%
Reliability (31)	4	14.3%	5	18%	3	10.7%	9	32%	4	14.3%	3	11%
Reliability (32)	7	25.0%	9	32%	8	28.6%	2	7.1%	2	7.1%		
Reliability (33)	2	7.1%	5	18%	4	14.3%	7	25%	7	25.0%	3	11%
Reliability (34)			1	3.6%			4	14%	20	71.4%	3	11%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

Table 4-16 indicates that the majority of responses are positive:

- Although 60.7% of the respondents mostly agree that they trust the information presented to them by the system, almost two thirds indicate that, when presented with conflicting information, they would rather trust verbal information from a colleague. This indicates that there is a resistance to placing complete trust in the system.
- Although 32% of the respondents slightly agree that the system often stops or hangs during execution of tasks, most respondents reported that it was not difficult to restart the system and feel confident that they could restart the system on their own.

TABLE 4-17: Ratings of Overall Reliability of the Digital Battlefield C^2 System.



- Table 4-17 indicates that overall more than 90% of the respondents regard the system as reliable (14% of the respondents rate the system as somewhat reliable, 71.4% rate the system as mostly reliable and 11% rate the system as being very reliable).

Hypothesis Two, which states that a positive perception exists regarding the reliability of the digital battlefield system, is therefore accepted.

<u>HYPOTHESIS THREE:</u>

Hypothesis Three states that a positive perception exists concerning the accuracy of the digital battlefield system. Accuracy refers to the exactness and correctness of the system. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-18 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

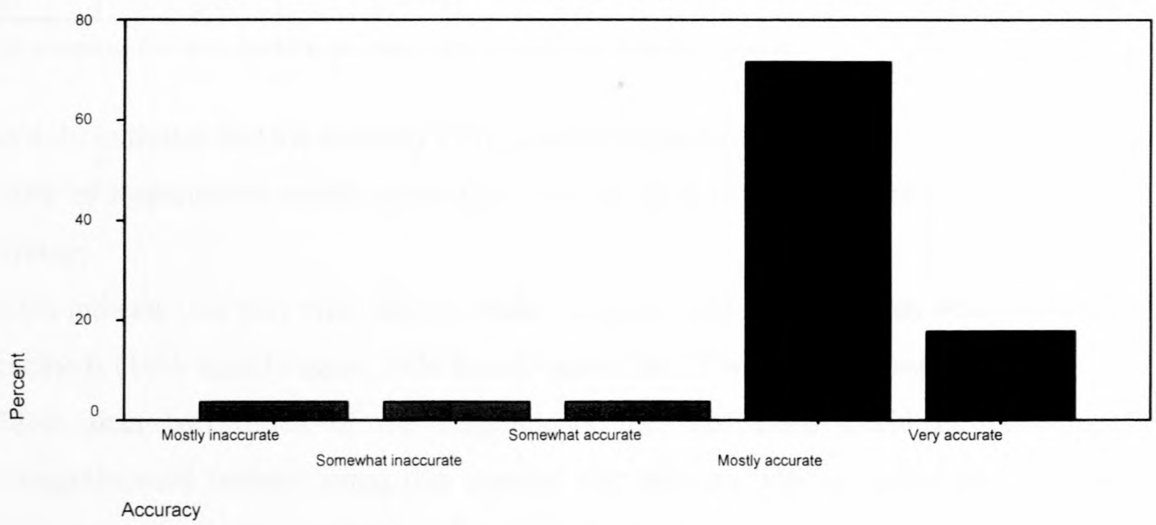
TABLE 4-18: Frequency Table for 'Accuracy'.

	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Accuracy (35)			1	4%	2	7.1%	9	32%	12	43%	4	14%
Accuracy (36)			1	4%	1	3.6%	4	14%	15	54%	7	25%
Accuracy (37)	1	4%	2	7%	3	11%	6	21%	14	50%	2	7.1%
Accuracy (38)					2	7.1%	4	14%	14	50%	8	29%
Accuracy (39)			1	4%	1	3.6%	1	3.6%	20	71%	5	18%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

- As is indicated by Table 4-18, 43% of the respondents mostly agree that they could verify the accuracy of the information presented by the system by comparing it with other sources of information.
- Although more than half of the respondents mostly agree that using this system improves the accuracy of decisions (54%) and communication (50%), they indicate that they often verify the accuracy of the information presented by the system.

TABLE 4-19: Ratings of Overall Accuracy of the Digital Battlefield C^2 System.



- Table 4-19 shows that, overall, most of the respondents regard the system as being accurate. 3.6% of the respondents rate the system as somewhat accurate, 71% rate the system as mostly accurate and 18% rate the system as being very accurate.

Hypothesis Three, which states that a positive perception exists concerning the accuracy of the digital battlefield system, is thus accepted.

HYPOTHESIS FOUR:

Hypothesis Four states that a positive perception exists that use of the digital battlefield system will lead to improved efficiency. Efficiency refers to the degree to which the system enables the tasks to be completed in a timely, competent and economical fashion. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-20 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-20: Frequency Table for 'Efficiency'.

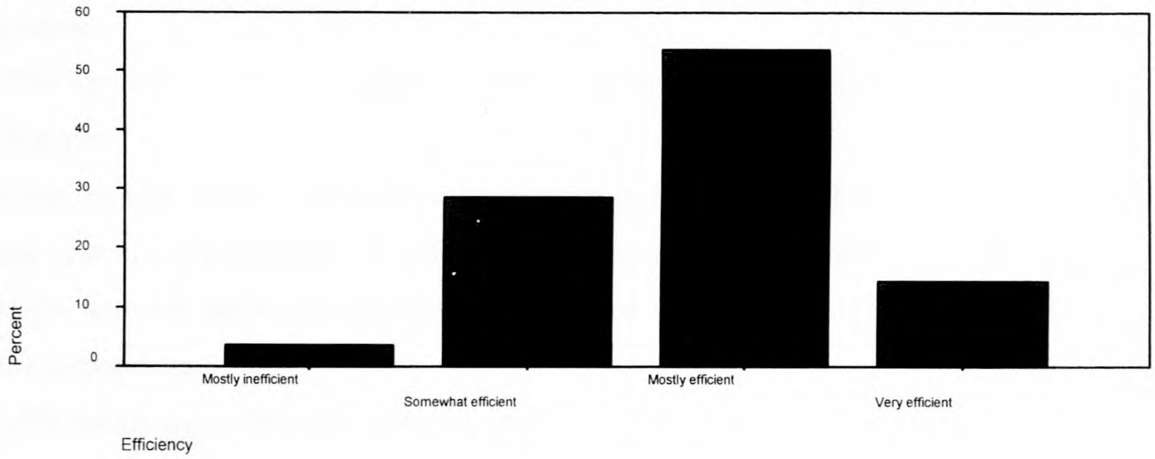
	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Efficiency (40)			1	3.6%	3	11%	2	7.1%	14	50%	8	29%
Efficiency (41)					2	7.1%	4	14%	15	54%	7	25%
Efficiency (42)	2	7.1%			1	3.6%	2	7.1%	14	50%	9	32%
Efficiency (43)	1	3.6%	1	3.6%	4	14%	2	7.1%	14	50%	6	21%
Efficiency (44)			1	3.6%	3	11%	4	14%	14	50%	6	21%
Efficiency (45)	3	11%	10	36%	5	18%	4	14%	4	14%	2	7.1%
Efficiency (46)			1	3.6%			8	29%	15	54%	4	14%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

Table 4-20 indicates that the majority of responses are positive:

- 50% of respondents mostly agree that they are able to make decisions quickly using this system.
- 93% indicate that they were able to make decisions more quickly than when using previous methods (14% slightly agree, 54% mostly agree and 25% strongly agree).
- More than two thirds of the respondents feel that tasks could be performed in a straightforward manner using this system; that they are able to efficiently complete their work using this system; and that information is organized in a straightforward manner.
- While two thirds of the respondents disagree that there are too many steps required to get something to work, a third (35.1%) did in fact report that there are too many steps to follow to execute a task.

TABLE 4-21: Ratings of Overall Efficiency of the Digital Battlefield C^2 System.



- Overall, as shown in Table 4-21, 29% of the respondents rate the system as somewhat efficient, 54% rate the system as mostly efficient and 14% rate the system as being very efficient. Most of the respondents (97%) regard the system as efficient.

Hypothesis Four, which states that a positive perception exists that use of the digital battlefield system will lead to improved efficiency, is accepted.

<u>HYPOTHESIS FIVE:</u>

Hypothesis Five states that a positive perception exists relating to the compatibility of the digital battlefield system. Compatibility refers to the degree to which the system's method of operation matches the user's expectations. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-22 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-22: Frequency Table for 'Compatibility'.

	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Compatibility (47)			2	7.1%	4	14%	6	21%	11	39%	5	18%
Compatibility (48)			2	7.1%	2	7.1%	3	11%	18	64%	3	11%
Compatibility (49)			2	7.1%	4	14%	1	3.6%	17	61%	4	14%
Compatibility (50)			2	7.1%	2	7.1%	3	11%	17	61%	4	14%
Compatibility (51)					4	14%	5	18%	15	54%	4	14%
Compatibility (52)			1	3.6%	1	3.6%	9	32%	14	50%	3	11%
Compatibility (53)	1	3.6%	1	3.6%	1	3.6%	9	32%	13	46%	3	11%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

As can be seen from Table 4-22, the majority of respondents positively rate the compatibility of the system:

- 78% agree that the system does what they require it to do, while the remaining percentage disagree.
- More than two thirds of the respondents agree that the results of the commands entered into the system are compatible with their expectations, that the control procedures match their skills, and that the system terminology is in line with standard terminology that is used by the respondents.
- 54% mostly agree that this system corresponds with their idea of the way things should be done. This statement is echoed by the 50% who also mostly agree that this system corresponds with traditional methods of operation.
- 46% of the respondents mostly regard and 11% strongly regard the system as compatible with the existing procedures.

Taken as a whole, most of the respondents regard the system as compatible with their expectations (see Table 4-22), and thus **Hypothesis Five**, which states that a positive perception exists relating to the compatibility of the digital battlefield system, is accepted.

HYPOTHESIS SIX:

Hypothesis Six states that a positive perception exists concerning the consistency of the digital battlefield system. Consistency refers to the ability of the system to respond to user inputs in a consistent way and to perform similar tasks in similar ways. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-23 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-23: Frequency Table for 'Consistency'.

	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Consistency (54)			4	14%	2	7.1%	9	32%	9	32%	4	14%
Consistency (55)			1	3.6%	5	18%	5	18%	12	43%	5	18%
Consistency (56)			2	7.1%	5	18%	3	11%	11	39%	7	25%
Consistency (57)	8	29%	9	32%	3	11%	5	18%	3	11%		

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

Table 4-23 shows that although the responses are mostly positive, it is more distributed than previous ratings:

- Most respondents agree that they feel more comfortable if they use only a few familiar commands or operations (32% slightly agree, 32% mostly agree and 14% strongly agree).
- 43% indicate that they mostly feel in control of the system when they are using it. 39% of the respondents mostly agree and 25% strongly agree that it is easy for them to make the system do what they want it to do.

Given that most of the respondents agree that the system is consistent (see Table 4-23), **Hypothesis Six**, which states that a positive perception exists concerning the consistency of the digital battlefield system, is accepted.

HYPOTHESIS SEVEN:

Hypothesis Seven states that a high level of satisfaction exists regarding use of the digital battlefield system. Satisfaction refers to the user's level of comfort with the system, feelings towards, and the acceptability of the system to the user. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-24 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-24: Frequency Table for 'Satisfaction'.

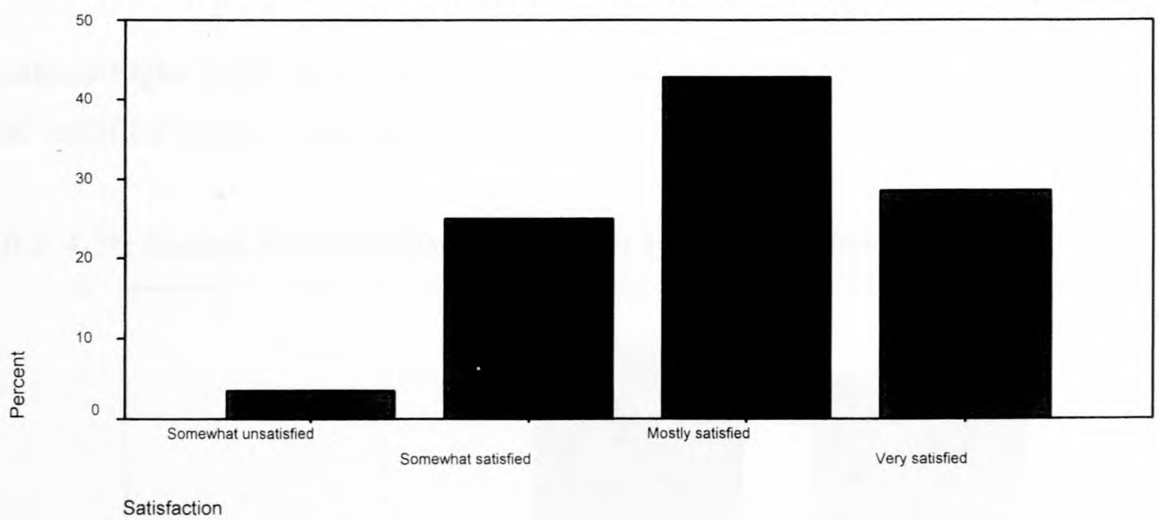
	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Satisfaction (58)	1	3.6%					5	18%	15	54%	7	25%
Satisfaction (59)	1	3.6%			2	7.1%	1	3.6%	17	61%	7	25%
Satisfaction (60)	9	32%	7	25%			2	7.1%	7	25%	3	11%
Satisfaction (61)	10	36%	9	32%	4	14%	2	7.1%	1	3.6%	2	7.1%
Satisfaction (62)	10	36%	8	29%	2	7.1%	7	25%	1	3.6%		
Satisfaction (63)	12	43%	6	21%	1	3.6%	8	29%	1	3.6%		
Satisfaction (64)	9	32%	11	39%	1	3.6%	5	18%	1	3.6%	1	3.6%
Satisfaction (65)			1	3.6%	2	7.1%	7	25%	11	39%	7	25%
Satisfaction (66)					2	7.1%	6	21%	11	39%	9	32%
Satisfaction (67)			2	7.1%	1	3.6%	6	21%	11	39%	8	29%
Satisfaction (68)			1	3.6%	2	7.1%	2	7.1%	12	43%	11	39%
Satisfaction (69)			1	3.6%	3	11%	6	21%	8	29%	10	36%
Satisfaction (70)					1	3.6%	7	25%	12	43%	8	29%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

As can be seen from Table 4-24 the majority of responses were positive:

- 54% of the respondents mostly agree that they benefit from using this system and almost 90% agree that they found it satisfying to work with the system.
- 32% of the respondents feel strongly and 25% mostly feel that they would like to use this system everyday, 25% mostly feel that they would not like to use this system every day.
- 36% strongly disagree and 32% mostly disagree with the statement that they would not like to use this system for this type of mission execution.
- 36% of the respondents strongly disagree that they found the system frustrating, 25% did however indicate that they found the system slightly frustrating.
- Although 43% of the respondents state that they did not feel awkward using this system, 29% indicate that they did feel slightly awkward using this system.
- Over two thirds of the participants did not feel uncertain about whether they were using the system in the correct way. 89% agree (in varying degrees) that interfacing with this system is pleasant and 92% like (in varying degrees) using the interface of this system.
- The vast majority of the respondents (almost 90%) are satisfied with how easy to use the system is, the amount of time it took to complete tasks using the system and the support information available when using the system.

TABLE 4-25: Ratings of Overall Satisfaction with the Digital Battlefield C^2 System.



- 97% of the respondents indicate overall satisfaction with the system (see Table 4-25). Only one respondent is somewhat unsatisfied.

Hypothesis Seven, which states that a high level of satisfaction exists regarding use of the digital battlefield system, is therefore accepted.

HYPOTHESIS EIGHT:

Hypothesis Eight states that a positive perception exists concerning the usefulness of the digital battlefield system. Usefulness refers to the value, worth and helpfulness of the system. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-26 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-26: Frequency Table for 'Usefulness'.

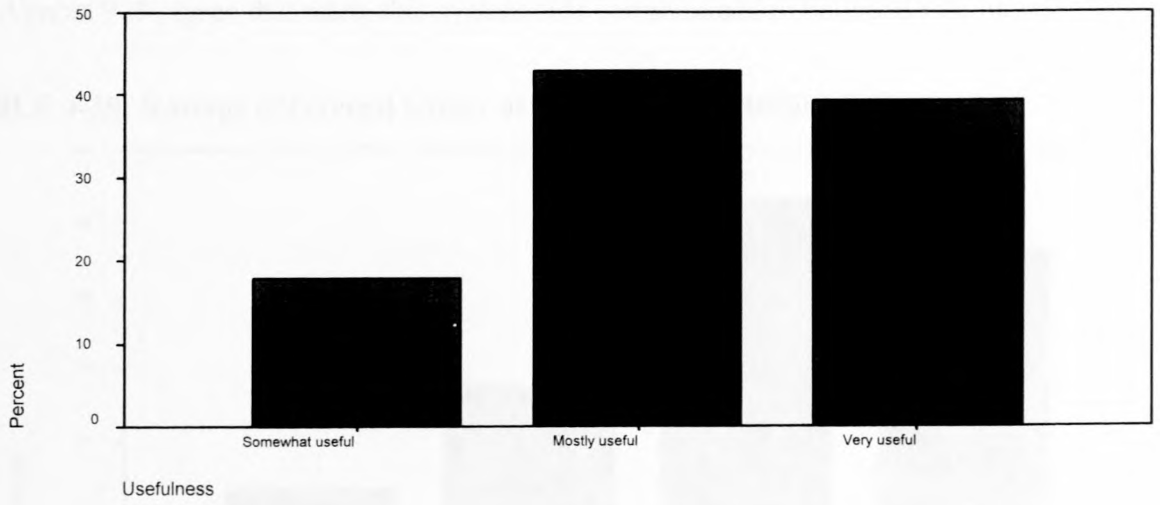
	Strongly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
Usefulness (71)	1	4%	1	3.6%	4	14%	13	46%	9	32%
Usefulness (72)					5	18%	12	43%	11	39%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

- As can be seen from Table 4-26, 14% of the respondents slightly agree, 46% mostly agree, and 32% strongly agree that they find the system useful in the execution of their job.
- As can be seen from Table 4-27 all of the respondents regard the system as useful. 18% regard the system as somewhat useful, 43% regard the system as mostly useful, and 39% regard the system as very useful.

Hypothesis Eight, which states that a positive perception exists concerning the usefulness of the digital battlefield system, is therefore accepted.

TABLE 4-27: Ratings of Overall Usefulness of the Digital Battlefield C^2 System.



HYPOTHESIS NINE:

Hypothesis Nine states that a positive perception exists concerning the utility of the digital battlefield system. Utility refers to the functionality of the system. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-28 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-28: Frequency Table for 'Utility'.

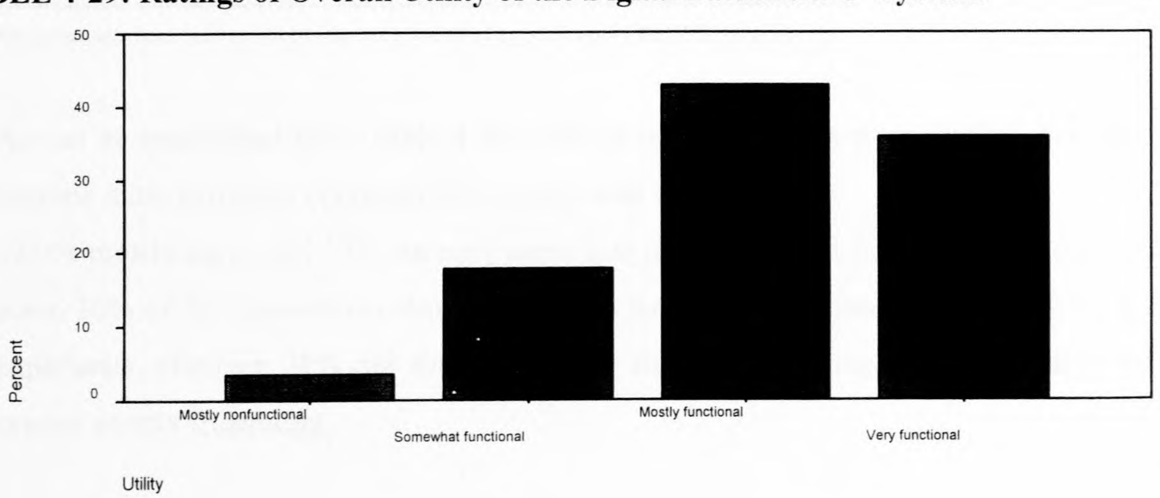
	Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
Utility (73)			2	7.1%	3	11%	17	61%	6	21%
Utility (74)	2	7.1%	2	7.1%	1	3.6%	13	46%	10	36%
Utility (75)	2	7.1%	2	7.1%	1	3.6%	13	46%	10	36%
Utility (76)	1	3.6%	2	7.1%	1	3.6%	13	46%	11	39%
Utility (77)	1	3.6%	2	7.1%	1	3.6%	11	39%	13	46%
Utility (78)	1	3.6%			5	18%	12	43%	10	36%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

Table 4-28 indicates that the majority of responses to the rating of the system's utility are positive:

- Two thirds of the respondents mostly agree that the system enables them to accomplish specific command and control tasks.
- 46% of respondents mostly agree and a 36% strongly agree that this system aids their decision making, that it would increase the productivity of themselves and their groups, and that using this system would make it easier to do their job.
- Almost 90% agree that using this system aids communication between role players.

TABLE 4-29: Ratings of Overall Utility of the Digital Battlefield C^2 System.



- Overall (see Table 4-29), most of the respondents (more than 95%) regard the system as having a high utility. 17.9% of the respondents rate the system as somewhat functional, 43% rate the system as mostly functional and 36% rate the system as being very functional).

Therefore, **Hypothesis Nine**, which states that a positive perception exists concerning the utility of the digital battlefield system, is accepted.

HYPOTHESIS TEN:

Hypothesis Ten states that a positive perception exists relating to the ease of use of the digital battlefield system. Ease of Use refers to the effortlessness and user-friendliness of the system. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-30 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-30: Frequency Table for 'Ease of Use'.

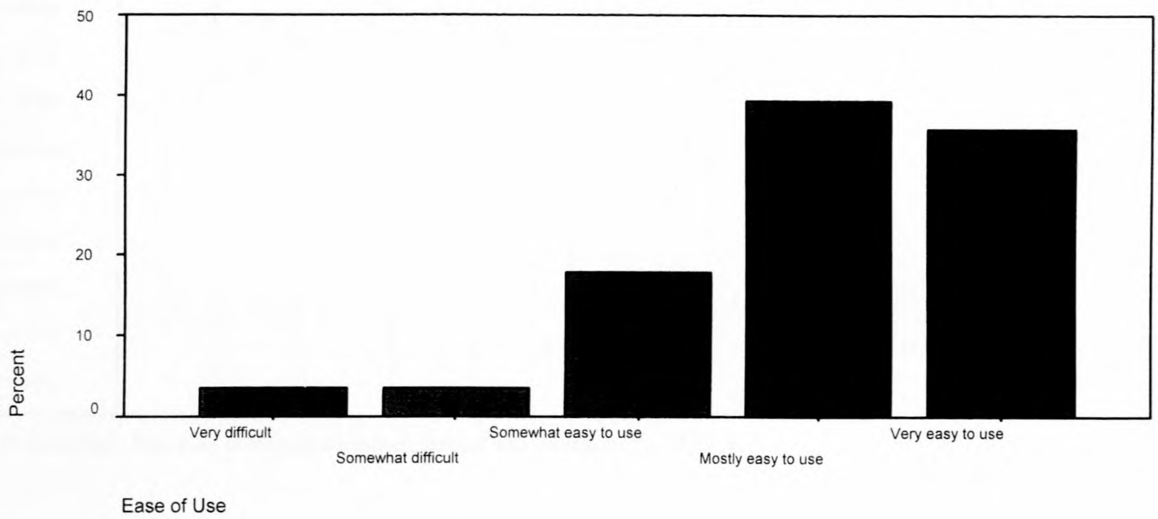
	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Ease of Use (79)									10	36%	18	64%
Ease of Use (80)					2	7.1%	3	11%	12	43%	11	39%
Ease of Use (81)	10	36%	7	25%	2	7.1%	6	21%	3	11%		
Ease of Use (82)							1	3.6%	13	46%	14	50%
Ease of Use (83)	1	3.6%	1	3.6%			3	11%	13	46%	10	36%
Ease of Use (84)			2	7.1%	3	11%	4	14%	10	36%	9	32%
Ease of Use (85)			1	3.6%	2	7.1%	5	18%	10	36%	10	36%
Ease of Use (86)			1	3.6%	4	14%	5	18%	9	32%	9	32%
Ease of Use (87)	1	3.6%			1	3.6%	5	18%	11	39%	10	36%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

- As can be established from Table 4-30, 64% of the respondents strongly feel that they will become more skilled at operating this system with continued use.
- 42.9% mostly agree and 39% strongly agree that it is easy to get the system to do what they want. 36% of the respondents strongly disagree that using this system was a very frustrating experience, although 21% did find the system slightly frustrating and 10.7% did find the system mostly frustrating.

- All of the respondents feel that it would be easy to become skilful at using the system. 46.4% mostly agree and 36% strongly agree that they find the system easy to use.
- Over 80% of the respondents are comfortable with using the system, pleased with how easy it is to use this system, and find the system simple to use.

TABLE 4-31: Ratings of Overall Ease of Use of the Digital Battlefield C^2 System.



- 18% of the respondents rate the system as somewhat easy to use, 39.3% rated the system as mostly easy to use and 36% rated the system as being very easy to use.

Given that most of the respondents (more than 90%) regard the system as easy to use (see Table 4-31), **Hypothesis Ten**, which states that a positive perception exists relating to the ease of use of the digital battlefield system, is therefore accepted.

<u>HYPOTHESIS ELEVEN:</u>

Hypothesis Eleven states that a positive perception exists pertaining to the learnability of the digital battlefield system. Learnability refers to the time and effort required to reach a specified level of user performance. This hypothesis was tested by reviewing the results obtained from the questionnaire.

In Table 4-32 the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-32: Frequency Table for 'Learnability'.

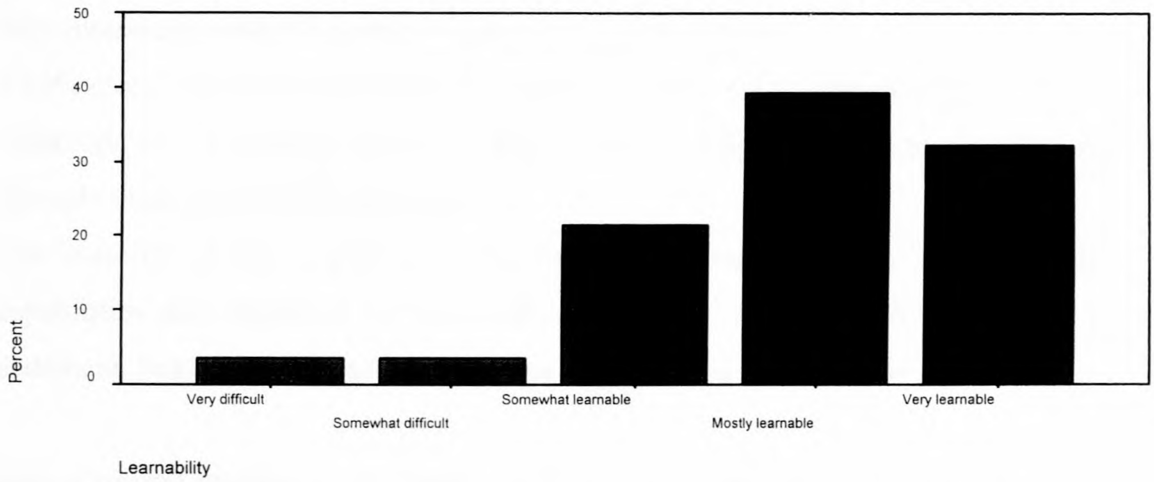
	Strongly disagree		Mostly disagree		Slightly disagree		Slightly agree		Mostly agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Learnability (88)	4	14%	4	14%	4	14%	7	25%	9	32%		
Learnability (89)	1	3.6%	3	11%	2	7.1%	5	18%	14	50%	3	11%
Learnability (90)	2	7.1%	1	3.6%	2	7.1%	9	32%	12	43%	2	7.1%
Learnability (91)	3	11%	6	21%	4	14%	3	11%	8	29%	4	14%
Learnability (92)	6	21%	10	36%	2	7.1%	2	7.1%	6	21%	2	7.1%
Learnability (93)	1	3.6%	1	3.6%	3	11%	8	29%	7	25%	8	29%
Learnability (94)					7	25%	5	18%	13	46%	3	11%
Learnability (95)	1	3.6%			3	11%	10	36%	8	29%	6	21%
Learnability (96)					3	11%	11	39%	7	25%	7	25%
Learnability (97)					2	7.1%	11	39%	7	25%	8	29%
Learnability (98)					2	7.1%	9	32%	11	39%	6	21%
Learnability (99)					5	18%	7	25%	12	43%	4	14%
Learnability (100)	1	3.6%			1	3.6%	6	21%	11	39%	9	32%

Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

Table 4-32 shows that although the responses are mostly positive, it is more distributed than previous ratings:

- 43% of the respondents disagree that the system provides error messages that tell them how to fix problems. Although half of the respondents mostly agree that they recover quickly whenever they make a mistake, more than 80% indicate that they require help from someone else.
- 54% indicate (to varying degrees) that they prefer to stick to facilities and functions they know best. 36% mostly disagree with the statement that there is never enough information on screen, when it's needed. The majority of respondents agree somewhat that it is easy to explore other functions.
- 46% of the respondents found that correcting mistakes is mostly easy.
- 36% found that learning to operate the system is somewhat easy, 39% found remembering the names and uses of commands, as well as performing tasks in a straightforward manner also somewhat easy.
- The majority of the respondents found the help messages on screen helpful. 43% mostly agree that it is easy to find help on the screen.

TABLE 4-33: Ratings of Overall Learnability of the Digital Battlefield C^2 System.



- Table 4-33 shows that the majority found the system to be learnable (21% somewhat learnable, 39% mostly learnable, and 32% very learnable.

Hypothesis Eleven, which states that a positive perception exists regarding the learnability of the digital battlefield system, is accepted.

4.2.3 DESCRIPTIVE STATISTICS CONCERNING USER-SYSTEM INTERACTION

BRIEF REVIEW OF THE USER-SYSTEM INTERACTION DIMENSIONS

The user-system interaction dimensions are aimed at determining how participants rate specific functions and settings. Specifically the Human-Computer Interaction (HCI) with regard to the particular C^2 digital battlefield system used in this military exercise is examined, as well as the overall reaction to the system. Human-Computer Interaction is concerned with the design of computer systems that are functional, safe, easy and enjoyable to the user.

USER-SYSTEM INTERACTION RESULTS

In the tables listed below the number within the parentheses indicates the question number in the questionnaire to which that item refers and should be read in conjunction with the questionnaire.

TABLE 4-34: Frequency Table for Human-Computer Interaction.

		Strongly disagree	Mostly disagree	Slightly disagree	Slightly agree	Mostly agree	Strongly agree
Human-Computer Interaction (101)	Count	1		1	10	9	7
	%	3.6%		3.6%	35.7%	32.1%	25.0%
Human-Computer Interaction (102)	Count	1		1	5	15	6
	%	3.6%		3.6%	17.9%	53.6%	21.4%
Human-Computer Interaction (103)	Count	4		2	4	6	12
	%	14.3%		7.1%	14.3%	21.4%	42.9%
Human-Computer Interaction (104)	Count	2	3	1	10	8	4
	%	7.1%	10.7%	3.6%	35.7%	28.6%	14.3%

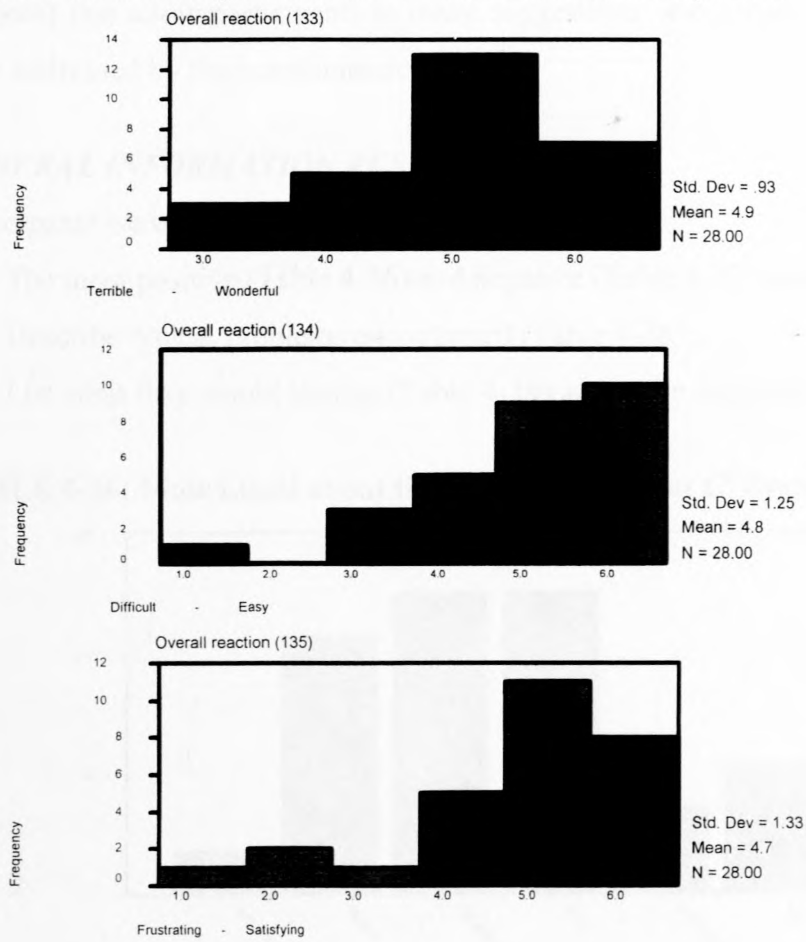
Note: All percentages have been rounded to the nearest tenth of a percentage by the SPSS program.

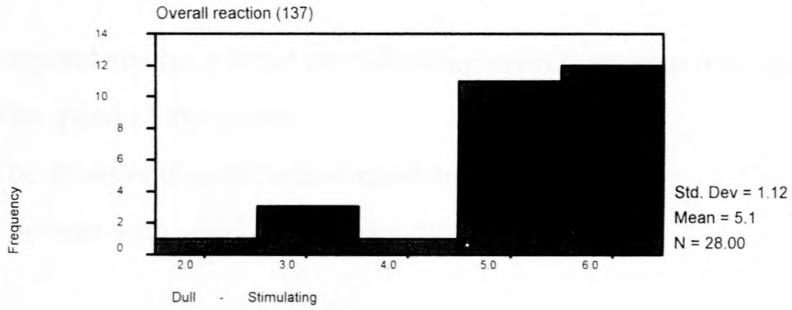
- In terms of the HCI, Table 4-34 indicates that more than 90% of the respondents agree that their interaction with the system is clear and understandable.
- 53.6% mostly agree that they find the system to be flexible to interact with.
- Although 42.9% strongly agree that the system is designed for all levels of users, 14,3% strongly disagree with this statement.
- The majority of the respondents feel that the system does have all the functions and capabilities they expect it to have, although slightly more than 20% disagree with this statement. Suggestions for added functions are discussed in Table 4-40.

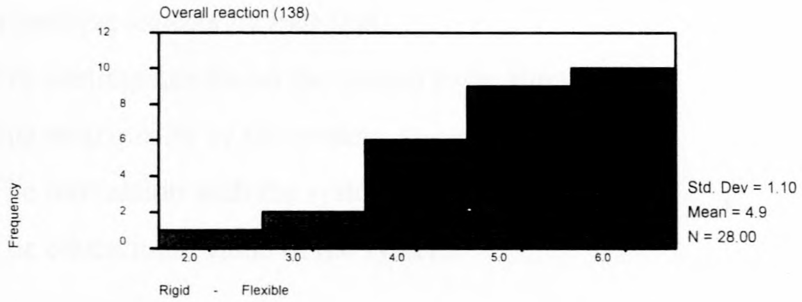
In terms of overall reaction to the system, Table 4-35 (below) indicate that respondents rated the system positively:

- The respondents' overall reaction to the system is toward the system being wonderful, easy, satisfying, with adequate power, stimulating and flexible.
- The mean ratings (on a scale of 1 to 6) fell between 4.6 and 5.1 and the standard deviation fell between .93 and 1.33.

TABLE 4-35: Histogram for Overall Reaction to the System.







4.2.4 DESCRIPTIVE STATISTICS CONCERNING GENERAL INFORMATION

BRIEF REVIEW OF THE GENERAL INFORMATION DIMENSIONS

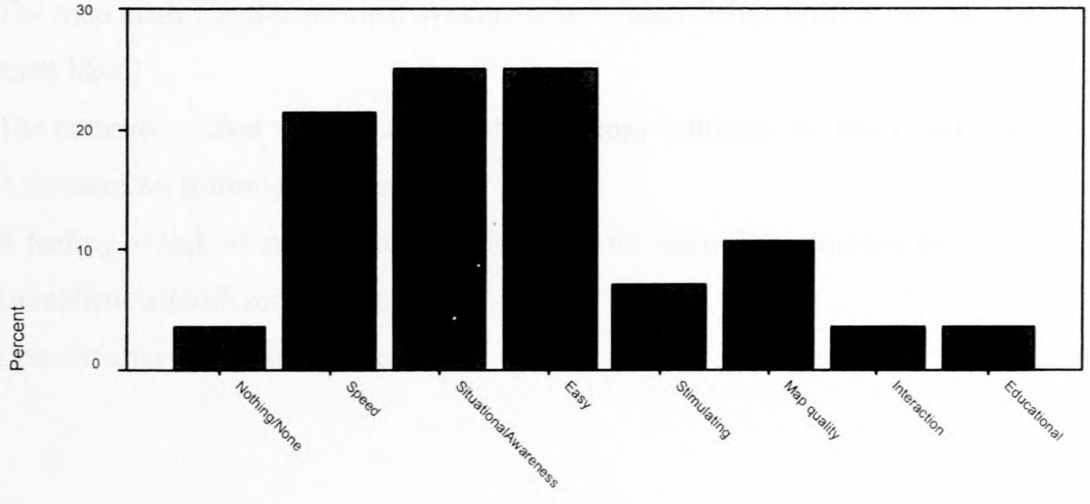
General information dimensions are measured by open-ended questions (coded through content analysis) that allow participants to make suggestions or comments that may not otherwise have been addressed by the questionnaire.

GENERAL INFORMATION RESULTS

Participants were asked to comment on the following:

- The most positive (Table 4-36) and negative (Table 4-37) aspects concerning the system;
- Describe typical problems encountered (Table 4-38);
- List what they would change (Table 4-39) and make suggestions (Table 4-40).

TABLE 4-36: Most Liked about the Digital Battlefield C^2 System.



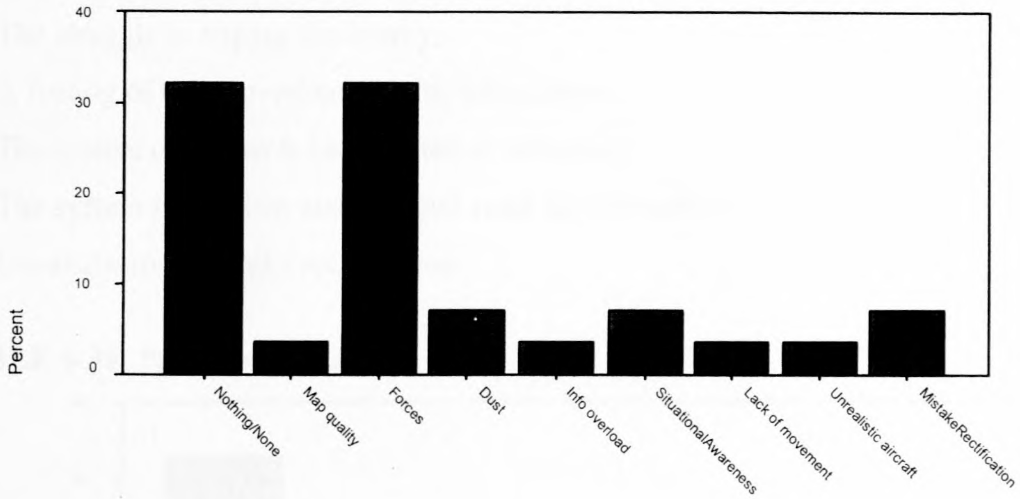
The respondents have listed the following aspects as what they most like about the system:

- The speed of the system;
- The situational awareness created by the system;
- The ease with which the system can be operated.

Other positive aspects include that:

- The participants found the system to be stimulating;
- The map quality of the system;
- The interaction with the system;
- The educational value of the system.

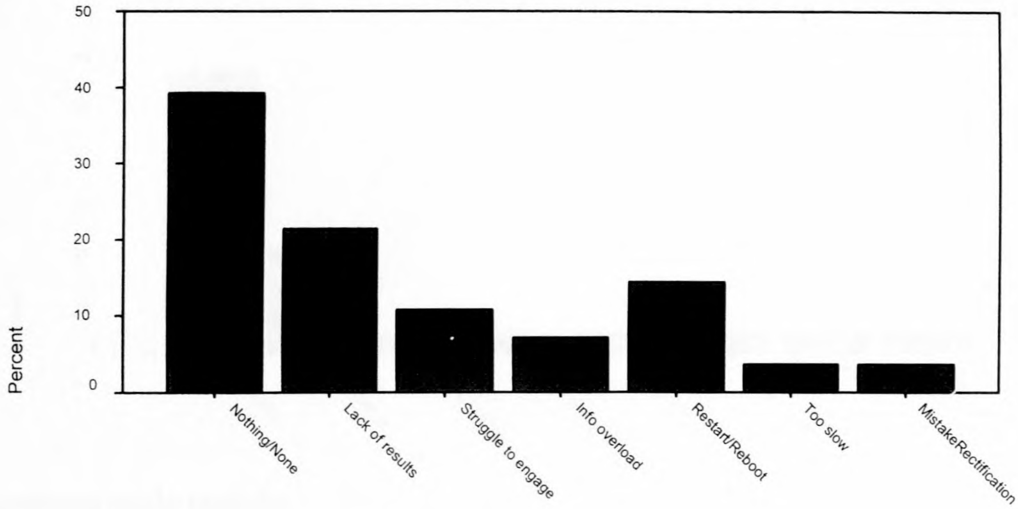
TABLE 4-37: Most Disliked about the Digital Battlefield C^2 System.



The respondents have listed the following aspects as what they most dislike about the system:

- The inability to place and deploy forces, also that forces can not attack or be manoeuvred while in formation;
- The map quality and situational awareness were also disliked (these are also listed as aspects most liked)
- The presence of dust and the concern that this may influence the functioning of the system;
- A concern for information overload;
- A feeling of lack of movement associated with the inability to position forces;
- Unrealistic aircraft movement;
- Unsatisfactory mistake rectification.

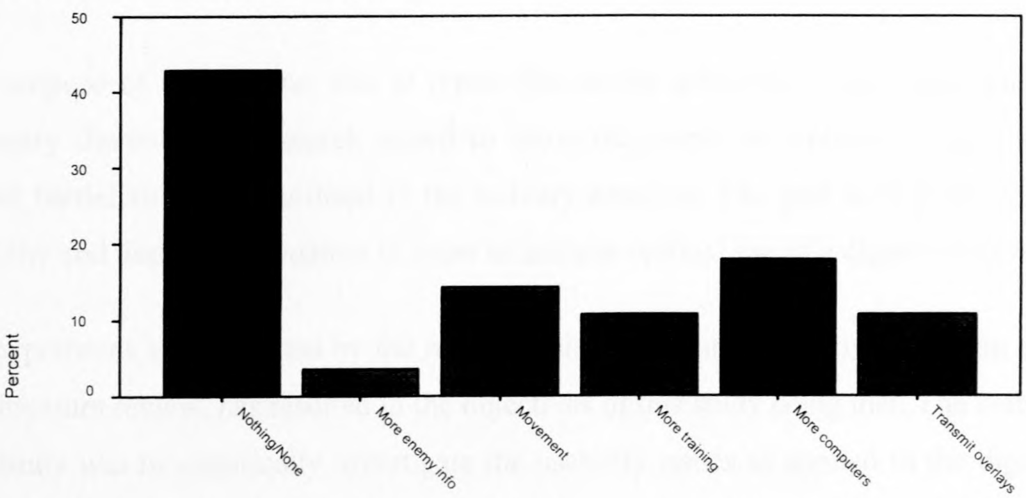
TABLE 4-38: Typical Problems experienced with the Digital Battlefield C^2 System.



Typical problems encountered by the respondents include:

- A lack of updated results primarily related to what the results of engagement were;
- The struggle to engage the enemy;
- A feeling of being overloaded with information;
- The system often has to be restarted or rebooted;
- The system is too slow and does not react fast enough to their commands;
- Unsatisfactory mistake rectification.

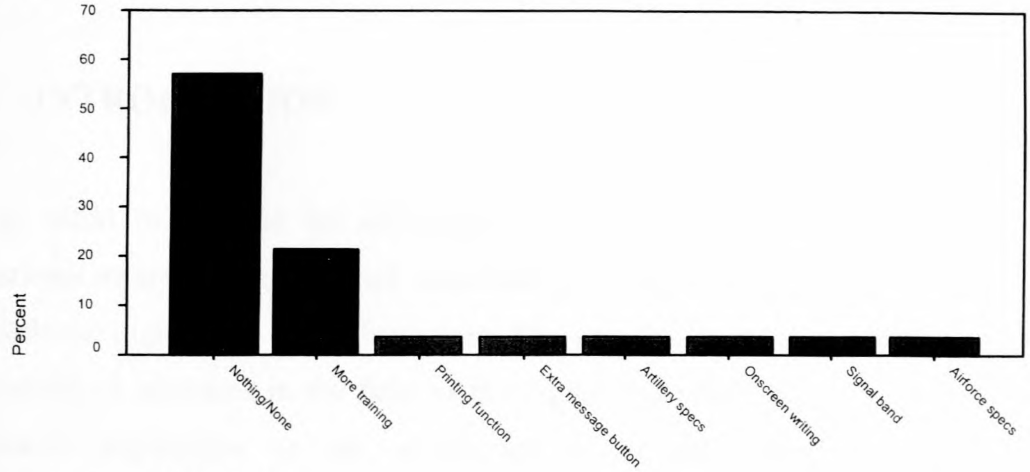
TABLE 4-39: Proposed Changes.



The majority of respondents did not specifically recommend any changes, although this may be due to a lack of technical expertise. Changes proposed included:

- More information should be available concerning enemy forces;
- Increased ability to move and see forces;
- More formal training should be provided;
- More stations (computers) should be provided;
- The ability for users to transmit overlays should be added.

TABLE 4-40: Suggestions.



Suggestions made include:

- The majority of respondents suggest that more formal training concerning the system should be provided;
- A printing function might be added;
- A request for extra message buttons;
- The development of artillery and air force specific techniques and procedures;
- The facility to write onscreen;
- The provision of the signal band.

4.3 CONCLUSION

The purpose of this chapter was to report the results achieved in this study and to provide a summary thereof. The research aimed to show the users' perceptions of the usability of the digital battlefield system utilised in the military exercise. The goal is to promote the utility of usability and usability evaluation in order to achieve optimal use of a digital battlefield.

All hypotheses are supported by the results. This, in conjunction with the insight gathered from the literature review, has resulted in the objectives of this study being met. The main objective of this study was to empirically investigate the usability issues as applied to the digital battlefield within a South African military context. Extensive and valuable research results have been obtained supplying the SANDF with usability information that can be used in an iterative design process to optimise the digital battlefield system tested in this military exercise, as well as contributing to the body of knowledge concerning Human Factors and military digitisation.

The next chapter consists of the general conclusion, and will offer recommendations for future research on this topic.

CHAPTER 5: CONCLUDING REMARKS

5.1 INTRODUCTION

In an effort to increase the effectiveness of Defence Force Operations through increased situational awareness and superior command and control capabilities, there is a global tendency towards the digitisation of the battlefield. The past few years have been characterised by rapid technological advances in the field of the digital battlefield. Many countries have either fully embraced digitisation or are considering it for their defence forces. The efficacious implementation of new battlefield digitisation technologies, can improve military training and enhance battle preparedness.

The most important aspect of any digitisation being introduced to the battlefield is whether it has utility. If it does not make the soldier's life easier or does not enhance decision-making, then it is of little use. Whatever the digital system, in order for it to be useful on the battlefield, it must provide an increase in operational effectiveness to ensure that a defence force has an edge over potential adversaries. An edge will result from better and more effective use of these systems, resulting in improved command and control, which is most effective when decision superiority exists. Decision superiority results from superior information gained from greater situational awareness.

The SANDF is striving towards battlefield digitisation in an effort to satisfy the requirements set for the defence force in terms of training and command and control execution, in a more timely and cost-effective way than traditional methods would be able to do. The recent force preparation exercise held by the SANDF was the first of its kind in the South African military context utilising digital battlefield technologies. The South African Defence force set a number of objectives for the exercise, including the testing of command and control capability, the evaluation of standing operational procedures and the evaluation of the digitisation of the battlefield. It involved the simulation of a battle as well as the utilisation of prototype digital technologies in order to test command and control as well as force deployment. The system is capable of supporting military forces during operations, by means of a joint tactical command and control digital user and was implemented in order to improve and accelerate the decision-making cycle.

Due to the established relation between the usability of a system and user acceptance, or rejection, of the system, it is important to determine what the utility and usability of a system is, in order to achieve the full potential and optimal use of a digital battlefield system. Even the best-designed systems may have usability shortcomings and no amount of product testing will reveal as many issues, as simply having a system used by actual users. This research outlines a preliminary empirical enquiry into the usability issues, as applied to the prototype digital battlefield system within a South African military context.

Although this study is placed within the testing phase of the usability cycle, it is important to note that human factors activities are necessary throughout the lifecycle of any product or system, to guarantee the usability of the end product. By involving the user in the design and evaluation of the system, users are empowered to help develop the system by indicating their needs, likes and dislikes, as well as frustrations with the system.

This chapter will discuss the conclusions drawn from the results obtained in the research, following which the shortcomings of the study will be discussed. Lastly, recommendations for future research will be made.

5.2 PURPOSE OF RESEARCH

Although much has been written about usability and usability engineering, the issue of usability is often trivialised and is treated as though it were simply common sense. The main purpose of this research was to provide a theoretical foundation of the usability issues involved in military digitisation and to determine how they are related. Specifically this research endeavoured to advance a better understanding of the centrality of usability to a digital battlefield. The aim is to instil in researchers, developers and users, the importance of user-centred approaches to system development and use with the focus on continuous and methodical user-based evaluation in order to ensure that performance, productivity and satisfaction are increased.

5.3 RESEARCH FINDINGS AND RECOMMENDATIONS

In order to achieve the objective of this study, important usability issues and dimensions relevant to a digitised battlefield were researched. The perceptions of the usability of the digital battlefield system were determined by way of a usability inquiry, in order to supply the SANDF with usability information that can be used in an iterative design process to optimise the prototype digital battlefield system.

USER CHARACTERISTICS

The usability enquiry involved mostly higher-ranking participants. The majority of higher-ranking individuals have an intelligence-user status and all of these have graduate qualifications. Of more interest is the qualifications and experience that individuals have in terms of computer usage, which may impact on their perceptions concerning the usability of the digital battlefield system.

Most individuals who participated in this study are exposed to computers on a daily basis either at work or at home. This impacts favourably as technology acceptance, and optimism related thereto, is often influenced by exposure to technology. Users with more computer experience often perceive a technological system as more usable than individuals with limited experience.

PERCEPTION OF USABILITY

The specific usability issues that were examined in order to establish users' perception of usability include effectiveness, reliability, accuracy, efficiency, compatibility, consistency, satisfaction, usefulness, utility, ease of use and learnability.

- Effectiveness refers to the extent to which the system enables the tasks to be completed and the goals achieved. More than 90% of the participants deemed the system to be effective, agreeing that they could effectively complete their work using the system and that this system enhances job performance. It was also agreed that this system saves time by accelerating the decision-making cycle, as well as the time needed to process, disseminate and communicate intelligence.

- Reliability refers to the dependability of the system and the repeatability without failure of tasks using the system. More than 90% of the participants regard the system as generally reliable. A third of the participants, however, felt that the system often stops or suspends action during execution of tasks. With enhanced hardware facilities and 'ruggedisation' of the hardware and software facilities, this problem could be overcome. Given the requirements for deployment, it is assumed that appropriate hardware will be utilized.

- Accuracy refers to the exactness and correctness of the system. More than three quarters of the participants regarded the system as being accurate. Many participants agreed that they verify the accuracy of the information presented by the system, by comparing it with other sources of information, although using this system improves the accuracy of decisions and communication. This may be indicative of a lack of trust in the system and can be influenced by the participants' resistance to technology and their reduced level of technological optimism. The lower their level of optimism, the higher their resistance will be to trusting the system. It can also be an indication of the fact that the ability to verify information is a necessity in the military context, since relying on unverifiable information can result in decisions that are subject to higher levels of risk. It may also indicate that participants are not knowledgeable about the system and feel that they have to verify the accuracy in order to assure that they have proceeded correctly. Participants may experience uncertainty due to a lack of training.

- Efficiency refers to the degree to which the system enables the tasks to be completed in a timely, competent and economical fashion. Most of the participants considered the system to be efficient. The participants agreed that they were able to make decisions quicker using this system, and the majority indicated that they were able to make decisions more quickly than with the aid of previous methods. More than two thirds of the participants felt that tasks could be performed in a straightforward manner using this system; that they were able to efficiently complete their work using this system; and that information was organized in a straightforward manner. A third of the participants felt that there are too many steps to follow, possibly indicating a need for training. It could also have a design implication, indicating that designers will have to reassess the steps required to get the system to do something, and finding ways of reducing the number of steps required, thereby increasing user-friendliness.

- Compatibility refers to the degree to which the system's method of operation matches with the user's expectations. Most of the participants regarded the system as compatible with their expectations. A fifth of the participants agreed that the system does not do what they require it to do. This may indicate a lack of adequate prior training concerning the system, and would probably improve with additional training and continued exposure to the system. It can also be indicative of the need for more help information to be made available to users of the system. It can possibly reflect a paradigm shift that needs to be facilitated, as users may not be willing to accept that the system can do what they need it to do due to a lack of technology optimism and acceptance.

- Consistency refers to the ability of the system to respond to user inputs in a consistent way and to perform similar tasks in similar ways. Although most of the participants agreed that the system is consistent, the majority only felt comfortable using a few familiar commands or operations. This may indicate a need for additional training in order to familiarize the users with all the commands allowing optimised functionality. Continued use of and exposure to the system should enhance the level of comfort with all the system's commands and functions. When taken in conjunction with the statements of the majority of participants who reported that they only felt comfortable using a few familiar commands or operations, this may indicate that the system may have too many commands and functions and possibilities for simplification can be considered in order to increase user-friendliness.

- Satisfaction refers to the user's level of comfort with the system, feelings towards, and the acceptability of the system to the user. 97% of the participants indicated overall satisfaction with the system. The majority agreed that they benefited from using this system and found working with the system satisfying. Although the majority felt that they would like to use this system daily, a quarter felt that they would not like to use this system every day and that they found the system frustrating. A third indicated that they did feel slightly awkward using this system. This may be a result of a lack of training or a low level of comfort with technology. With further training and continued exposure it is expected that users would feel less frustrated and awkward. The findings can also indicate that an effort must be made by designers to enhance the interface, making it more acceptable to users.

- Usefulness refers to the value, worth and helpfulness of the system. All of the participants regard the system as useful, thus perceiving it as having value and worth. They all found the system to be useful in the execution of their job.

- Utility refers to the functionality of the system. Overall the participants regarded the system as having a high utility and being very functional. The participants agreed that the system enables them to accomplish specific command and control tasks, aids their decision making and communication, increases the productivity of themselves and their groups, and that using this system would make it easier to do their job.

- Ease of Use refers to the effortlessness and user-friendliness of the system. Most of the participants (more than 90%) regarded the system as easy to use and feel that they will become more skilled at operating this system with continued use. Although the majority of participants agree that it is easy to get the system to do what they require, a third found the system frustrating. Although all of participants feel that it would be easy to become skilful at using the system, this frustration must be addressed to find out exactly what it was that frustrated the users. It can indicate a need for additional training, or possibly the redesign of the interface in order to make it even easier for users to work with the system.

- Learnability refers to the time and effort required to reach a specified level of user performance. The majority of the participants found the system to be learnable. However, a significant number of participants indicated that they do require help from someone else whenever they make a mistake, that they prefer to stick to facilities and functions they know best, and that there is never enough information on screen, when it's needed. In order to enhance learnability and the overall usability, additional error messages and help functions may prove very useful to users. Additional training and exposure to the system may school users on how to overcome problems they may encounter.

COMPUTER LITERACY

Since operation of a computer system will probably improve if the operator of the system is more at ease with the computer, it is recommended that computer literacy within the SANDF receive continued attention. The level of comfort with, and acceptance of, any new technology will be enhanced, if users are already comfortable with and accepting of the basic technologies.

In this study the majority of participants had an intelligence user status. It could be expected that these individuals would have extensive computer experience and high computer literacy, but this was not so in most cases. More than a third of the participants have received less than 2 hours of computer training. This may present a problem, as the operation of this digital system will probably improve if the operator of the system is more experienced with computer use. Although formal computer training is not always indicative of being at ease with computers (as the majority of the participants use computers on a daily basis), higher levels of computer literacy will accelerate acceptance of new technology. Users with more training may perceive any system as more usable than individuals with limited training.

TRAINING

It is recommended that the issue of training with regard to the prototype digital battlefield system employed in this military exercise, be addressed. In view of the fact that the system is a new development, only a very limited number of participants have had previous exposure to the system (in some form or another). Although formal training concerning the system was provided, a third of the participants began the exercise without any previous training regarding the system. It is recommended that concerted effort be made to ensure that all participants receive applicable training.

More than half of participants indicated that they have further training needs. Most participants agreed that they felt more comfortable only using a few familiar commands or operations, and a third of the participants felt slightly awkward using this system. With further training and continued exposure, users should begin to feel less frustrated and more at ease with the system. Users with more training perceive a system as more useful and easier to use, than individuals with limited or no training. With further training and continued exposure, users should begin to feel less frustrated and more at ease with the system. The results from the usability evaluation should be used to determine where more intense training might be needed with regard to improving user productivity, effectiveness and efficiency.

Almost half of the participants felt the need for the system to provide detailed error messages that tell them how to solve problems. The majority indicated that they require help from someone else whenever they make a mistake. Within a training exercise there are instructors and aides available to help and guide the participants, however, within an operational situation the participant must be certain of how to use this system, as there is no help at hand in the form of an instructor. In order to enhance learnability and the overall usability, improvement of error messages may prove very useful to users. Additional training specifically with regard to mistake rectification will school users on how to fix problems they may encounter. The provision of tutorials, error messages, and a help function will also alleviate this situation and is likely to manifest in a significant reduction of frustration levels.

TRUST

Although the majority of the participants agreed that they trust the information presented to them by the system, almost two thirds indicated that, when presented with conflicting information, they would rather trust verbal information from a colleague. This indicates that there is a resistance to complete trust of the system. Continued exposure to and use of the system may break down this resistance and enhance trust.

More than half of the participants agreed that using this system improves the accuracy of decisions, yet they indicated that they often verify the accuracy of the information presented by the system, by comparing it with other sources of information. This is not necessarily indicative of a lack of trust in the system, but rather an indication of the fact that the ability to verify information is a necessity in the military context, since relying on unverifiable information can lead to decisions that might result in fatalities and defeat.

ACCEPTANCE

Most participants felt that they benefited from using this system and the vast majority indicated overall satisfaction with the system. All of the participants regarded the system as useful. The majority felt that it aids their decision-making; that it would increase their productivity as well as group productivity, and that using this system would make it easier to perform their tasks. Most were pleased with how easy it is to use this system. This is extremely important, as it will facilitate acceptance of the new technology and faster integration of the system.

SYSTEM INTERACTION

Human-Computer Interaction (HCI) is concerned with the design of computer systems that are functional, safe, easy and enjoyable to the user. In terms of overall reaction toward the system, the participants found it to be wonderful, easy, satisfying, with adequate power, stimulating and flexible.

The participants listed the speed of the system, the situational awareness created by the system and how easy it is to operate the system as factors that they most liked about the system. Other aspects included the fact that they found it to be stimulating, as well as the positive educational value of the system.

The participants highlighted the inability to place and deploy forces, as well as the fact that forces cannot attack or be manoeuvred while in formation, as factors that they most disliked about the system. This inability could possibly indicate a need for complimentary training. It may also indicate a need for an iterative design process to improve software and system functioning. Also disliked were the map quality and situational awareness. Participants indicated that they became lost when they zoomed in and thus lost all situational awareness. These factors are also listed as 'aspects most liked' which could simply be indicative of personal preference, or they can possibly indicate that a need exists for map reading training, as well as training in order to improve individual capabilities on how to use the system so as to optimise situational awareness.

Participants indicated that they were concerned with potential information overload and sometimes felt overloaded with excessive information. This problem may point toward a need for better information filtering or the addition of improved selective decluttering facilities within the system's functions. In order to achieve information superiority it is necessary to sort and filter information. The information presented should ideally only include the information required by a decision maker to achieve the necessary situational awareness, in order to formulate the appropriate decision. Information filters must be implemented to customise the intelligence presented to the user, so that it is relevant to their current role and battle context. Information will only provide a competitive advantage if it can be effectively disseminated and translated into improved decisions.

Typical problems encountered by the participants included a lack of timeously updated results primarily related to what the results of engagement were. Further highlighted areas of concern include apprehension about the lack of control and movement associated with the inability to position forces, as well as unrealistic aircraft movement. Participants reported that they struggled to engage the enemy, and that the system often had to be restarted and did not react fast enough to their commands. These problems highlight areas of the system that may require more development within an iterative design process, in order to enhance and optimise the functioning of the prototype digital battlefield system.

Unsatisfactory mistake rectification was also listed as a problem area, indicating a need for additional training in order to familiarise participants with correct mistake rectification procedures. It can also be indicative of a need to redesign the system's help functions to some extent with the addition of for example error messages and a comprehensive help-information function. However, a help-function which is too extensive may slow down the learning process, as users may become too reliant on the help-function, and as a result do not become confident users of the system. Through a User-Centred Design process, an agreement must be reached to ensure optimal usability of the system without compromising the learnability of the system in any way.

The majority of participants did not specifically recommend any additions or changes, although this may simply be due to a lack of technical expertise. However, an often-made suggestion was that more formal training concerning the system should be provided and that more computer workstations be made available.

5.4 SHORTCOMINGS OF THIS STUDY

In this study a non-experimental descriptive method of research was followed. This type of methodology is suitable for data that is derived from observational situations where the purpose is to discover, classify, and measure phenomena. It is considered appropriate for the purposes of this study, although it is not without inadequacies. The main inadequacy involves the lack of control over variables that may influence the results. Measures were taken to control as far as is possible, factors that may influence the validity of the research. Future research will have to include intensive statistical analysis in order to take the conclusions arrived at here one step further.

It is also apparent that more research must be done on the details included in the evaluation questionnaire. The questionnaire information is not adequate in itself. In subsequent studies it will be necessary to gather additional information through behavioural observations, including timing and durations of specific activities to ensure that a function rated as 'easy to use' is not simply a subjective perception. These aspects should be measured against predefined performance criteria. Questions should be closely tailored to the individual systems being evaluated, encompassing current capabilities while leaving room for suggested improvements. When multiple functions are evaluated by a single questionnaire a compromise must be reached regarding the level of detail included.

Although this study attempts to denote usability and digital battlefield technology issues, it is by no means exhaustive. New innovations and the fast-paced development of technology such as that utilised in virtual battlefields and other synthetic environments may render elements of this study incorrect or irrelevant.

A shortcoming of this study is that it does not report explicitly how to implement a given usability treatment. No single document can extensively detail all the information but a concerted effort was made to include all the pertinent facts.

A further shortcoming is the small sample, as well as the non-randomness thereof, however, based on research by Virzi (1992), which found that as few as five subjects detected the majority (80%) of problems, as well as the more severe problems. It is therefore believed that the sample for this study is sufficient to establish the usability of the digital battlefield, as it represents the entire available population.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

This research aimed to report on all the usability dimensions in order to present a full picture of what would be involved in a usability evaluation. However, a critical problem for the advancement of usability and usability evaluation, is the lack of consensus in research in general, regarding the metrics used for measuring usability dimensions. Further research into developing reliable and valid scales for measuring products on the dimensions of usability within a South African context will prove very useful. The dimensions should be defined from the user's perspective. The goal should be the creation of an instrument that can become a formal standard (with variations depending on the application thereof). This would add structure to research on user interface methodologies and new design techniques. It would allow research to be integrated into practice more effectively.

This study aimed to provide an overview of military functioning. One of the main aspects involved is situational awareness. The future use of usability evaluation methodology within a military context should be conducted concurrently with evaluations of situational awareness and workload (both individual and shared, as well as inter- and intra-team operations). This is necessary in order to produce a more complete picture of the impact of the digitisation of the battlefield on the operations they are designed to enhance. The focus should be on the impact of digitised systems on the situational awareness of teams as a whole, especially in military settings where groups or teams rely on the system for enhanced information processing abilities within for example joint forces or joint-combined forces. Enhancing an individual's situational awareness does not automatically enhance the situational awareness of a team. Evaluation must be carried out to ensure that shared situational awareness is not diminished by the introduction of digital technologies.

It is also recommended that the influence of other variables on technology acceptance (such as technological optimism) should be tested within the South African military context. The Defence Force might consider applying the Technology Acceptance Model (TAM) to the digital battlefield system (as described in chapter two of this research). The purpose of the TAM is to explain and predict user acceptance of technology. The research done within this study will serve as a basis from whence to conduct such an evaluation, as the TAM predicts user acceptance of technology based on the perceived usefulness and the perceived ease of use. These factors impact on intentions to use a system, as well as the actual use thereof. Consequently, by assessing the usability of a system and ascertaining its ease of use and usefulness, it would be possible to predict user acceptance of, and satisfaction with a digital battlefield system.

The technology level of any defence force should be appropriate, driven by effectiveness, and in an era of declining budgets, affordability. Defence forces worldwide are considering more cost-effective ways of improving the skills and expertise of their soldiers and commanders. The value of this study will be manifested when calculations are made to provide estimates of cost-effectiveness and benefit in terms of timeous inputs made during the design phase, as well as consideration of the improved overall system effectiveness given the adoption of a User-Centred Design approach.

5.6 CONCLUSION

This study investigated usability within the digital battlefield, by researching usability issues as applied to the digitised battlefield within a Southern African military context. Although all the research hypotheses were accepted and all research objectives have been met, this study is only the first step in the investigation of usability within this context. Further investigation is strongly recommended.

This research aimed to advance a better understanding of the usability issues involved within the digitisation of military systems. It is believed that a valuable contribution has been made to theory building within the fields of Human Factors as well as military digitisation and that the research will be of considerable interest to acquisition institutions, system developers, users of digitised battlefield systems, establishments responsible for training, academics and Human Factors practitioners.

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ANNEXURE A

Questionnaire Number **(For office use only)**

USABILITY EVALUATION

INSTRUCTIONS

This is a questionnaire to provide a description of the usability of a C^2 DIGITAL BATTLEFIELD system. Please describe your experience by answering **all** the questions.

PLEASE NOTE:

The information you provide here is kept completely **CONFIDENTIAL** and no information is stored that could identify you as a person. The questionnaires will be handled and used by the researcher only. **ANONYMITY** is assured.

For the research to yield valid results, it is important that you answer **ALL** the questions as **HONESTLY** as possible. Please react to each individual question or statement as honestly as possible. The answers must reflect your own opinion and perception, and not that of the group within which you operate.

For example: If you agree slightly with a question mark the box with the number 4:

1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

The questionnaire consists out of 4 sections (Section A to Section D). **Please, read each question carefully and answer all questions and statements**.

Thank you for your participation - it is greatly appreciated.

SECTION A: BIOGRAPHICAL INFORMATION

1. RANK (*Mark the appropriate option*):

No Rank	1	Sergeant Major	6	Lt Colonel	11
Lance Corporal	2	2nd Lieutenant	7	Colonel	12
Corporal	3	Lieutenant	8	Brig General	13
Sergeant	4	Captain	9		
Staff Sergeant	5	Major	10		

2. USER GROUP (*Mark the appropriate option*):

Army	1
Air Force	2
Navy	3
Medical & Health Services	4
Special Force	5

3. USER STATUS (*Mark the appropriate option*):

Air Defence	1	Engineering	6	Naval	11
Air Force	2	Infantry	7	Personnel	12
Armour	3	Intelligence	8	Signals	13
Artillery	4	Logistics	9		
Command & Control	5	Medical Service	10		

4. HIGHEST LEVEL OF EDUCATION (*Mark the appropriate option*):

Less than matric	1
Matric	2
Diploma/Degree	3
Postgraduate Degree	4

5. COMPUTER EXPERIENCE (*Mark the appropriate option*):

Little experience	1
Moderate experience	2
Regular experience	3

6. COMPUTER EXPOSURE: Do you have...? (*Mark the appropriate options*):

Access to a computer at work	1
Access to a computer at home	2

7. EMAIL ACCESS: Do you use...? (*Mark the appropriate options*):

I don't use email	1
MS Outlook	2
Internet Email (for example Hotmail, Yahoo, Webmail, ABSA-freemail, etcetera)	3
Lotus	4
Groupwise	5

8. HAVE YOU PREVIOUSLY RECEIVED ANY FORMAL COMPUTER TRAINING (*Mark the appropriate option*):

Less than 2 hours of training	1
2 to 4 hours of training	2
4 – 10 hours of training	3
10 or more hours of training	4

9. HOW OFTEN DO YOU USE A COMPUTER? (*Mark the appropriate option*):

Every day	1
A few times a week	2
A few times a month	3
I don't need to use a computer	4

11. AMOUNT OF PREVIOUS EXPOSURE TO THE C² DIGITAL BATTLEFIELD SYSTEM (*Mark the appropriate option*):

No previous exposure	1
Second exposure	2
Third exposure	3
Fourth (or more) exposure	4

12. AMOUNT OF TRAINING RECEIVED CONCERNING THE C² DIGITAL BATTLEFIELD SYSTEM (*Mark the appropriate option*):

No previous training	1
Less than 2 hours of training	2
2 to 4 hours of training	3
4 or more hours of training	4

13. WAS THE AMOUNT OF TRAINING RECEIVED SUFFICIENT?

1	2	3
Not at all sufficient	Sufficient	More than sufficient

14. WAS THE LEVEL AND INTENSITY OF TRAINING RECEIVED ADEQUATE?

1	2	3
Not at all adequate	Adequate	More than adequate

15. DO YOU HAVE ANY OTHER TRAINING NEEDS OR SUGGESTIONS FOR FUTURE TRAINING?

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....

END SECTION A: Please start Section B

SECTION B: USABILITY

EFFECTIVENESS:

Effectiveness refers to the extent to which the system enables the tasks to be completed and the goals achieved. Please rate the effectiveness of the system by responding to all of the statements below…

18. I can effectively complete my work using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
19. I can save time using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
20. Using this system would speed up decision-making time.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
21. Using this system would improve time needed to communicate information.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
22. Using this system would improve time needed to process intelligence.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
23. Using this system would improve time needed to redistribute intelligence to lower level HQ's.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
24. I can effectively communicate information using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
25. Using the system would improve my job performance.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
26. Situational awareness is improved using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
27. This system realistically represents the battlefield environment.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

28.	1 VERY INEFFECTIVE	2 MOSTLY INEFFECTIVE	3 SOMEWHAT INEFFECTIVE	4 SOMEWHAT EFFECTIVE	5 MOSTLY EFFECTIVE	6 VERY EFFECTIVE

RELIABILITY:

Reliability refers to the dependability of the system and the repeatability without failure of tasks using the system. Please rate the system's reliability by responding to the statement below…

29. I trust the information presented to me by the system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
30. When presented with conflicting information I will rather trust verbal information from a colleague.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

31. The system often stops or hangs during execution of my tasks.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
32. If this system stops, it is not easy to restart it.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
33. If this system stops, it is easy for me to restart it on my own.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

34.	1 VERY UNRELIABLE	2 MOSTLY UNRELIABLE	3 SOMEWHAT UNRELIABLE	4 SOMEWHAT RELIABLE	5 MOSTLY RELIABLE	6 VERY RELIABLE

ACCURACY:

Accuracy refers to the exactness and correctness of the system. Please rate the system's accuracy by responding to the statement below...

35. I can verify the accuracy of information presented in this system (through comparison with other sources).	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
36. Using this system improves the accuracy of decisions.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
37. I often verify the accuracy of information presented by this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
38. Using this system improves the accuracy of communication.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

39.	1 VERY INACCURATE	2 MOSTLY INACCURATE	3 SOMEWHAT INACCURATE	4 SOMEWHAT ACCURATE	5 MOSTLY ACCURATE	6 VERY ACCURATE

EFFICIENCY:

Leave out

Efficiency refers to the degree to which the system enables the tasks to be completed in a timely, competent and economical fashion. Please rate the efficiency of the system by responding to all of the statements below...

40. I am able to make my decision quickly using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
41. I am able to make my decision more quickly using this system than when using previous methods.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
42. Tasks can be performed in a straightforward manner using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

43. I am able to efficiently complete my work using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
44. Information is organised in a straightforward manner.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
45. There are too many steps required to get something to work.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

46.	1 VERY INEFFICIENT	2 MOSTLY INEFFICIENT	3 SOMEWHAT INEFFICIENT	4 SOMEWHAT EFFICIENT	5 MOSTLY EFFICIENT	6 VERY EFFICIENT

COMPATIBILITY:

Compatibility refers to the degree to which the system's method of operation matches with the user's expectations. Please rate the system's compatibility by responding to all of the statements below...

47. The system does what I want it to.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
48. The results of commands entered into this system are compatible with my expectations.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
49. The control procedures are matched to my skills.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
50. The system terminology is in line with standard terminology that I use.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
51. This system corresponds with my idea of the way things should be done.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
52. This system corresponds with the traditional methods of operation.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
53. I regard this system as compatible with the hand/existing procedure.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

CONSISTENCY:

Leave out

Consistency refers to the ability of the system to respond to user inputs in a consistent way and to perform similar tasks in similar ways. Please rate the system's consistency by responding to all of the statements below...

54. I feel more comfortable if I use only a few familiar commands or operations.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
55. I feel in control of this system when I am using it.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
56. It is easy to make the system do exactly what I want.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

57. The system is inconsistent.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

SATISFACTION:

Satisfaction refers to the user's level of comfort with the system, feelings towards, and acceptability of the system to the user. Please rate your satisfaction with the system by responding to all of the statements below...

58. I benefit from using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
59. Working with this system is satisfying.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
60. I would not like to use this system every day.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
61. I would not like to use this system for this type of mission execution.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
62. Using this system is frustrating.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
63. I feel awkward using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
64. I feel uncertain whether I am using this system in the correct way.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
65. Interfacing with this system is pleasant.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
66. I like using the interface of this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
67. I am satisfied with how easy it is to use this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
68. I am satisfied with the amount of time it took to complete tasks using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
69. I am satisfied with the support information available when using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall satisfaction with the system is:

70.	1 VERY UNSATISFIED	2 MOSTLY UNSATISFIED	3 SOMEWHAT UNSATISFIED	4 SOMEWHAT SATISFIED	5 MOSTLY SATISFIED	6 VERY SATISFIED

USEFULNESS:

Usefulness refers to the value, worth and helpfulness of the system. Please rate the usefulness of the system by responding to all of the statements below...

71. I find the system useful in the execution of my job.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

72.	1 VERY USELESS	2 MOSTLY USELESS	3 SOMEWHAT USELESS	4 SOMEWHAT USEFUL	5 MOSTLY USEFUL	6 VERY USEFUL

UTILITY:

leave out

Utility refers to the functionality of the system. Please rate the system's utility by responding to all of the statements below…

73. The system enables me to accomplish specific command & control tasks.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
74. This system aids my decision-making.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
75. This system would increase the productivity of myself and my group.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
76. Using the system would make it easier to do my job.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
77. This system aids communication between role players.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

78.	1 VERY NONFUNCTIONAL	2 MOSTLY NONFUNCTIONAL	3 SOMEWHAT NONFUNCTIONAL	4 SOMEWHAT FUNCTIONAL	5 MOSTLY FUNCTIONAL	6 VERY FUNCTIONAL

EASE OF USE:

Ease of use refers to the effortlessness and user-friendliness of the system. Please rate the system's ease of use by responding to all of the statements below…

79. I will become more skilled at using this system with continued use.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
80. I find it easy to get the system to do what I want it to do.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
81. Using this system was a very frustrating experience.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
82. It would be easy for me to become skilful at using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
83. I find the system easy to use.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
84. I am comfortable using this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
85. I am pleased with how easy it is to use this system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
86. It was simple to use the system.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the system as:

87.	1 VERY DIFFICULT TO USE	2 MOSTLY DIFFICULT TO USE	3 SOMEWHAT DIFFICULT TO USE	4 SOMEWHAT EASY TO USE	5 MOSTLY EASY TO USE	6 VERY EASY TO USE

LEARNABILITY:

Learnability refers to the time and effort required to reach a specified level of user performance. Please rate the system's learnability by responding to all of the statements below…

88. The system provides error messages that tell how to fix problems.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
89. Whenever I make a mistake using the system I recover quickly.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
90. I require help from someone else to fix problems I encounter.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
91. I prefer to stick to facilities and functions I know best.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
92. There is never enough information on the screen when it's needed.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
93. In this exercise it was easy to explore other functions.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
94. Correcting mistakes is…	1 VERY DIFFICULT	2 MOSTLY DIFFICULT	3 SOMEWHAT DIFFICULT	4 SOMEWHAT EASY	5 MOSTLY EASY	6 VERY EASY
95. Learning to operate the system is…	1 VERY DIFFICULT	2 MOSTLY DIFFICULT	3 SOMEWHAT DIFFICULT	4 SOMEWHAT EASY	5 MOSTLY EASY	6 VERY EASY
96. Remembering names and use of commands is…	1 VERY DIFFICULT	2 MOSTLY DIFFICULT	3 SOMEWHAT DIFFICULT	4 SOMEWHAT EASY	5 MOSTLY EASY	6 VERY EASY
97. Performing tasks in a straightforward manner is…	1 VERY DIFFICULT	2 MOSTLY DIFFICULT	3 SOMEWHAT DIFFICULT	4 SOMEWHAT EASY	5 MOSTLY EASY	6 VERY EASY
98. Help messages on screen are…	1 VERY UNHELPFUL	2 MOSTLY UNHELPFUL	3 SOMEWHAT UNHELPFUL	4 SOMEWHAT HELPFUL	5 MOSTLY HELPFUL	6 VERY HELPFUL
99. It is easy to find help on the screen.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall, I regard the learnability of the system as:

100.	1 VERY DIFFICULT TO LEARN	2 MOSTLY DIFFICULT TO LEARN	3 SOMEWHAT DIFFICULT TO LEARN	4 SOMEWHAT LEARNABLE	5 MOSTLY LEARNABLE	6 VERY LEARNABLE

END SECTION B: Please start Section C

SECTION C: USER-SYSTEM INTERACTION

HUMAN-COMPUTER INTERACTION:

Human-computer interaction (HCI) is concerned with the design of computer systems that are functional, safe, easy and enjoyable to the user. Please rate the system by responding to all of the statements below...

101. My interaction with the system is clear and understandable.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
102. I find the system to be flexible to interact with.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
103. The system is designed for all levels of users.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE
104. The system has all the functions and capabilities I expect it to have.	1 STRONGLY DISAGREE	2 MOSTLY DISAGREE	3 SLIGHTLY DISAGREE	4 SLIGHTLY AGREE	5 MOSTLY AGREE	6 STRONGLY AGREE

Overall reaction to the system *(mark the appropriate options)*:

133.	TERRIBLE	1	2	3	4	5	6	WONDERFUL
134.	DIFFICULT	1	2	3	4	5	6	EASY
135.	FRUSTRATING	1	2	3	4	5	6	SATISFYING
136.	INADEQUATE POWER	1	2	3	4	5	6	ADEQUATE POWER
137.	DULL	1	2	3	4	5	6	STIMULATING
138.	RIGID	1	2	3	4	5	6	FLEXIBLE

END SECTION C: Please start Section D

SECTION D: GENERAL INFORMATION

What do you like about the system? List the most positive aspects:

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What do you dislike about the system? List the most negative aspects:

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Describe typical problems that have been experienced when using this system:

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What would you change?

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Your suggestions for extra commands and functions:

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....

....

END SECTION D: End of Questionnaire

THANK YOU FOR YOUR CO-OPERATION