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8) ABSTRACT

This report presents the results from an exploratory experiment conducted during the NATO exercise Battle Griffin in February/March 2005. The experiment was a part of the Norwegian Armed Forces Concept Development & Experimentation (CD&E) program.

The experiment explored ad hoc organisation of information flow applied to the distributed compilation of a common operational picture (COP). The main operational idea is that the new technological solutions will increase the ability to establish a COP in situations where dynamic configuration of forces is necessary. This will increase shared situation awareness. The idea is also that the processes of picture compilation should be tailored to get the most operational value out of the new technological possibilities. An additional aim was to explore new ways of collaboration (horizontal collaboration) between military units on the tactical command and control level, given the availability of new technological solutions.

We evaluated how selected components of the technology demonstrator and the new ways of collaboration affected situation awareness both on individual and team level. The main conclusion is that the results confirm our operational idea as a promising approach.

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EXECUTIVE SUMMARY

An exploratory experiment on ad hoc organisation of distributed picture compilation was successfully conducted by FFI during the Battle Griffin 2005 exercise in February/March 2005. The experiment aimed to explore the operational value of selected technological solutions for flexible information sharing in Network Based Defence (NBD). This comprised “ad hoc organisation of information flow” applied to the distributed compilation of a common operational picture (COP) together with new ways of collaboration between military units on tactical command and control level. We wanted to explore how this affected situation awareness (SA) both on individual and team level.

The experiment was designed according to essential NBD-ideas: Resources belong to the network rather than the platform, post & pull (i.e. from push to pull-oriented supply chain), flat organisation (peer-to-peer), horizontal collaboration and focus on the tactical level. An operational and technical setting was developed together with a military conflict scenario designed especially for this experiment. Central in the experiment was the use of a command and control technology demonstrator developed at FFI. The demonstrator supported the participants in their tasks and problem solving activities. 18 intelligence officers participated and were divided into groups by six. Each group consisted of three teams that collaborated in building a COP. Each group was organised in a flat (peer-to-peer) decentralised organisation at a tactical level. All elements in the situation were simulated and the experiment scenario was repeated three times, one for each group.

Our main conclusion is that the experiment has confirmed our operational idea as a promising approach. The results show that the participants appreciated the technology demonstrator. Overall SA correlated with perceived technology support, i.e. good SA is related to positive experiences with the demonstrator. However, the participants had some overconfidence in their individual SA. The participants were in average only aware of 12 % of the elements in the situation. Despite the low awareness of elements, the participants were able to understand the situation correctly and select right projections to a larger extent. Due to small samples it was difficult to conduct an elaborated analysis on team SA and shared SA. However, we found that team SA seemed higher than individual SA. When comparing the individual SA, team SA and the teamwork scores, a pattern emerged: A tendency towards a positive relation between collaboration (facilitated by the demonstrator) and good SA. We could not decide upon the significance of this result. However, we regard this as an interesting observation.

Obviously, the experiment did not provide clear answers on how command and control (C2) should be conducted in future NBD. However, the experiment is a small but important contribution in gaining experience and identifying new questions for exploration. The results of the experiment support our assumption that the human and organisational aspects - together with technology - must be included in the NBD transformation efforts in order to explore and learn more about this complex interplay. This is essential in order to better understand which organisations, cultures and technologies that are best able to leverage shared situation awareness.

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EXPERIMENT REPORT: "AD HOC ORGANISATION OF PICTURE COMPILATION AND SITUATION AWARENESS IN NBD" - BATTLE GRIFFIN 2005

1 INTRODUCTION

This report gives the main results from the exploratory experiment “Ad hoc Organisation of Picture Compilation and Situation Awareness in Network Based Defence (NBD)” conducted during the NATO exercise Battle Griffin in February/March 2005. The experiment was part of the Norwegian Armed Forces Concept Development & Experimentation (CD&E) program.

The overall aim of the experiment was to:

- Explore ad hoc organisation of information flow (flexible information sharing) applied to the distributed compilation of a common operational picture (COP).
- Explore new ways of collaboration (peer-to-peer horizontal collaboration) between military units on the tactical command and control (C2)-level.
- Evaluate how selected components of the technology demonstrator and the new ways of collaboration affect situation awareness (SA) both on individual and team level.

Our main operational idea is that the new technological solutions will increase the ability to establish a COP in situations where dynamic configuration of forces is necessary. This will increase shared SA. The idea is also that the processes of picture compilation should be tailored to get the most operational value out of the new technological possibilities. Further, we aim to explore new ways of collaboration (horizontal collaboration) between military units, given that new technological solutions for this are available.

The concept of “Ad hoc organisation of information flow” is an idea based on a picture compilation concept, developed at FFI (1) that we believe will increase information access and sharing in a more flexible and timely manner than existing systems provide today. The experiment made use of a command and control information system (C2IS) demonstrator developed at FFI (2) that utilizes Web Services and peer-to-peer technologies, among others.

The experiment described here was conducted as a part of FFI-project 898 “NBF Beslutningsstøtte” (NBD Decision Support). The project is working in the areas of architecture, middleware, data fusion, cognitive psychology and organisational informatics to help build better decision-support systems for military commanders in the future NBD.

1.1 Background

The point of departure of the experiment is the assumption that a dynamic model for organizing the information exchange, i.e. ad hoc organisation of information flow, is needed to enable network-based operations. This model for information exchange management allows dynamic linking of resources in the network. This is a move towards a “post and pull” direction in C2 (i.e. from push to pull-oriented supply chain).

In the spring of 2004 we conducted, as a part of the military exercise Blue Game 2004, an exploratory experiment in concerning ad hoc organisation of picture compilation. This effort confirmed (3) (4) that the concept of ad hoc organisation is complex, involving organisational (e.g. how things are done) as well as technological aspects. In order to realize the potential of ad hoc organisation, it is not enough to experiment with technology alone. Especially because the practice of today most likely need to change, or at least be adjusted, in order to realize the full potential of the ad hoc organisation on the tactical and operational command and control level. One of our main conclusions was that the human and organisational aspects - in interplay with technology - must be included in our transformation efforts. This required a multidisciplinary research approach. This constitutes the backdrop of the experiment conducted in 2005.

1.2 Other Projects Involved

The experiment “Negotiation Based Resource Allocation”, developed by FFI-project 879 “NBF i Operasjoner” (NBD in Operations), was conducted as an integrated part of our experiment. This experiment used our technical infrastructure and operational setting, and explored a new possible solution for dynamic and decentralized allocation of resources. This solution applies to resources that are considered strategic (in this case an Unmanned Aerial Vehicle (UAV)), but also resources where limited capacity and/or time constraints underline a possible conflict of interest between potential users.

The overall aim was to investigate a resource allocation solution where the decision process is dynamic and decentralized and based on negotiations reaching for consensus among users needing a given resource, rather than having resources allocated by a pre-defined hierarchy. The objectives were to:

- Gain a better understanding of resource allocation in a decentralised organisation.
- Test processes designed for the negotiation based resource allocation concept.
- Learn about technology support needs for the negotiation based resource allocation concept.

This was also an exploratory experiment. The evaluation and results from this experiment are given in (5).

FFI-project 869 "NBF Grid" (NBD Grid) also participated in Battle Griffin 2005. They conducted experiments on technologies for ad hoc communication systems. During the final days of the exercise, after both projects had finished experimentation, there was a technology demonstration held at our test site. The NBD-Grid presentation included a live demonstration of Blue Force Tracking and video transfer from vehicles operating in the surroundings of their test site, using tactical wireless Local Area Network (LAN) and gateways via Internet.

1.3 Outline of this Report

The structure of this report is as follows: Chapter 2 describes the implementation of the experiment and how these implementations deviated from the original plans. Chapter 3 gives a short overview of the main technological elements of the technology demonstrator. Chapter 4 outlines the theoretical approach to studying situation awareness and teamwork. Chapter 5 describes the experimental methodology (participants and procedure, measures and measurements). Chapter 6 gives a discussion of the main results. Chapter 7 presents some further observations and lessons learned. Finally, main conclusions are given in chapter 8.

2 EXPERIMENT IMPLEMENTATION

The main building blocks in the implementation of this experiment, were:

- A technology demonstrator for picture compilation, equipping the users with the tools necessary for the execution of their tasks within the experiment.
- A pre-planned course of action, which in this case was built into the overall context of the official scenario for Battle Griffin 2005.
- Methods and tools for the situation awareness measurements.

The experiment included three four-hour sessions where the participants interacted with the technology demonstrator. Six military officers participated in each session, 18 in total for the experiment. Each session was carefully timed into periods of introduction, self-studies and users performing actual “work” (picture compilation and resource allocation) according to experiment rules and system-generated events. At random chosen points in time, the action was frozen and the participants were presented queries concerning the ongoing situation to assess their situation awareness. The sessions were terminated by debrief and feedback from the participants.

2.1 Experimental Set-up

The technology demonstrator for this experiment was deployed to a Local Area Network (LAN) consisting of 17 laptop computers. Six of the computers were allocated to the user interaction.

The test site was divided into four separate rooms (figure 2.1). Three rooms were used by the user teams (two officers per team). In this way we set no limits to the cooperation between the two officers in each team, but cooperation between teams was regulated by the system.

A simulation environment stimulating the system with the pre-planned course of action was set up in the Main Room. All communication on the LAN was unclassified.

The main room was used for plenary presentations at the beginning of each session and debrief in the end of each session.

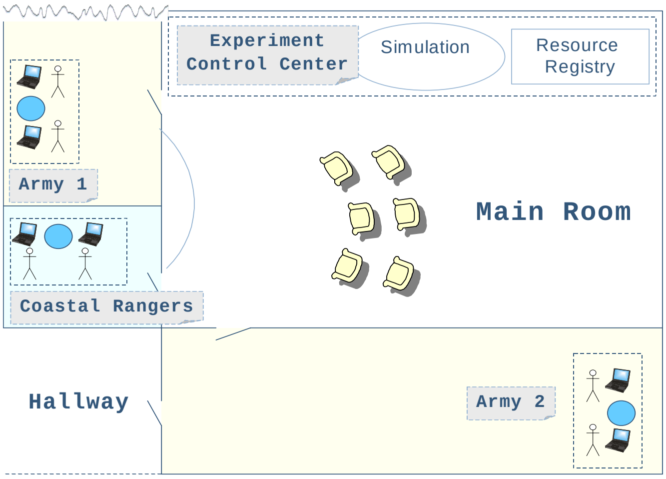

Figure 2.1 Test site setting

Figure 2.2 Short break in the main room

Figure 2.3 Dress rehearsal on site ("Army 2")

Figure 2.4 Snapshot from the control centre

2.2 Execution Timeline

An experimentation that has to make efficient use of the limited time available from professional users needs careful preparations. In addition to the time-consuming development of the demonstrator and the course of action, it was necessary to rehearse the four-hour session to make sure everything was set up to facilitate quality results from the experiment. The following list may illustrate the timescale of the main planning and execution events:

- Technology demonstrator and operational scenario development started August 2004.
- Inspection and room-planning at the selected test site: November 16-17, 2004.
- Testing the technology and experimental set-up:
  - Internal user testing started in January 2005.
  - Production test performed mid February 2005.

- Network installations at the test site: February 21-22, 2005.
- System installation and verification: February 28, 2005.
- Experiment execution: March 3 – 5, 2005.
- Technology demonstrations: March 6 – 7, 2005.
- “Clean –up” and return of leased equipment: March 8 – 18, 2005.
- Evaluation and reporting during March to May 2005.

2.3 Deviations from the Experiment Specification

In the Experiment Specification (17) we had originally planned for 30 participants (military personnel). This was essential in order to have a good sample base when performing this type of experiment. We had also planned for three-hour experiment sessions and five iterations of the sessions on site. As the design of the experiment matured, we realized that we needed more time for each experiment session. We wanted to extend each experiment session to last four hours. In order to succeed in our request for more time we accepted a reduction in the number of participants. This resulted in the number of 18 participants, four-hour sessions and that the experiment sessions were repeated three times (instead of five).

3 THE TECHNOLOGY DEMONSTRATOR – MAIN ELEMENTS

In this chapter we give a brief presentation of the main elements of the demonstrator used during the experiment. Further and more technically detailed descriptions are given in (13) and (16).

Our C2IS-demonstrator has been developed over several years, and supports distributed production of a situation picture. It consists of autonomous Picture Compilation Nodes (PCN) and supports peer-to-peer collaboration, made possible by an experimental mixture of technologies (Web Services and peer-to-peer technologies, among others). The PCNs are accessed through a Graphical User Interface (GUI), i.e. GeoViewer and NetViewer (see figure 3.1).

In an NBD the possibility for the user to dynamically select information sources will be critical. Information services will be published in the information infrastructure, ready to be utilized by anyone interested. To enable dynamic user-selected information flow based on service lookup, we needed a registry functionality that would allow the dynamic announcement and lookup of services in the information infrastructure. Therefore, two new components were developed for the Battle Griffin 2005 experiment: A Resource Registry (a type of look-up service providing flexible access to information and services) and a NetViewer (GUI for the Registry) that makes resources in the network available for decision makers.

This effort gave increased functionality for user interaction, and enabled user collaboration within and between the contexts of a PCN. This also allowed the introduction of unstructured information (e.g. pictures, documents, video. etc) as supplements to ordinary tracks.

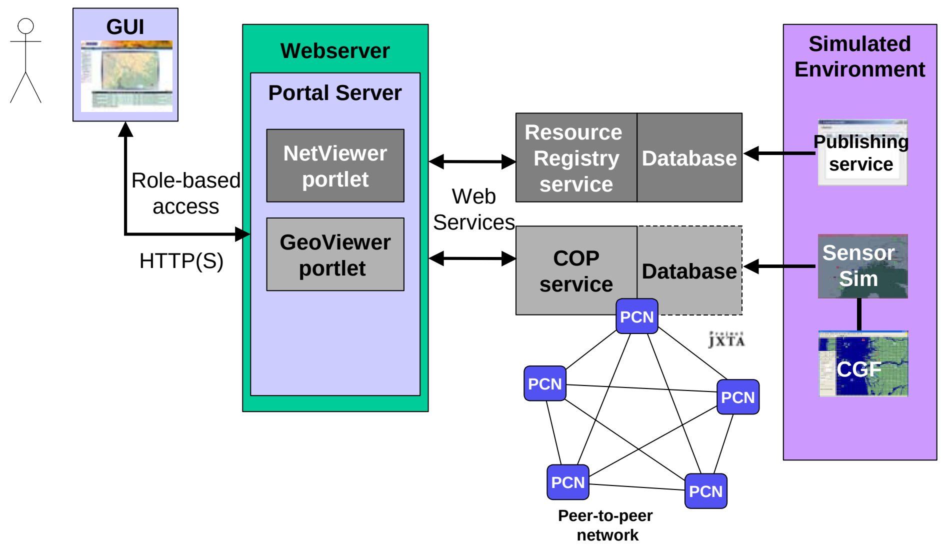

Figure 3.1 Main elements of the demonstrator used in the experiment

3.1 Distributed Picture Compilation

The technology demonstrator is being developed to support the different tasks involved in distributed picture compilation. The main idea is that autonomous PCNs receive sensor information, which is compiled into a COP. That is done as a distributed process, with each PCN independent of the other. Each PCN may also connect to other PCNs, thus receiving the contents of the other PCN's COP, adding this to the contents of its own COP. This may be maximized by an everyone-to-everyone connection pattern, resulting in a shared COP between all the PCNs.

The effects of the user-controlled ability to connect to the other groups and thereby share information, was one of the issues that were to be explored in the experiment.

3.2 Resource Registry and NetViewer

Central in an NBD is the sharing of information and resources to gain information superiority. Resources belong to the network rather than the platform. The concept "resources" includes services of different types (e.g. COP-service) and unstructured information. A challenge in an NBD is to keep track of resources, find and select relevant resources, and utilize them in an efficient and effective manner.

As an attempt to meet these challenges we developed a resource registry and an adherent graphical user interface, NetViewer (see figure 5.1). By including operative military personnel in the design process, we identified three basic needs. We needed to be able to:

- Keep an overview of available resources.
- Find and select resources to utilize.
- Make your own resources available in the network.

Functions for this were implemented and supported in the resource registry, while the NetViewer supported only the two first of the abovementioned needs in this experiment.

The resource registry was implemented as a web service (13), and contained metadata about the resources available in the information infrastructure. These metadata were made accessible through an *inquiry* interface, and to publish, update or delete such metadata a *publishing* interface was provided. The metadata were displayed in the NetViewer, which was implemented as a portlet (16), providing the participants with sufficient information to select which resources to utilize and which not to utilize. The content and the structure of the NetViewer interface were a result of an iterative process including experienced intelligence officers.

In this experiment we chose to include selected resources relevant for picture compilation and the achievement of information superiority (i.e. selected sensor- and decision components). The services were five PCNs, which it was possible to connect to and receive tracks from. Three of these nodes represented respectively the picture compilation process in three predefined areas in the scenario. The last two nodes represented tracks from a frigate and a UAV. As information, we fabricated intelligence reports, observation reports and other types of reports, which were made available to the participants of the NetViewer at different points in time during the scenario.

3.3 Simulated Environment

A simulated environment simulating a scenario made for this experiment (14) stimulated the PCNs in the demonstrator with data. The simulated environment consisted of two parts: A publishing service providing unstructured information (documents/files), and a simulator part providing structured information (track information) (see the right side of figure 3.1). The simulation part in its turn consisted of two applications: A commercial off the shelf (COTS) computer generated forces package simulating the movements of the scenario entities, and SensorSim, an FFI made simulator (18) (2) simulating sensors observing these entities.

4 SITUATION AWARENESS AND TEAMWORK: THEORETICAL FOUNDATION

The point of departure for measuring SA is Mica Endsley's (6) model of situation awareness in dynamic decision-making. Endsley's definition is a useful concept that places emphasis on spatial and temporal awareness as a result of attention towards critical aspects of the environment. Endsley's operational definition of SA includes both cognitive and context variables. I.e., SA is conceptualised as a relation between subjective awareness (cognition) and objective situation variables (context). Endsley refers to three levels of SA:

Perception	Level 1:	Perception of relevant elements in the situation
Understanding	Level 2:	Comprehension of the meaning of elements of the situation
	Level 3:	Projection of the status of elements in the immediate future

These levels form a hierarchy with level 1 as the lowest level and level 3 as the highest (expert/most skilled) level.

The definition is mainly addressing individual SA, but also includes aspects of shared SA in terms of overlap in individual tasks and the sum of individual SA (i.e. team SA). This formed the main approach in our effort in assessing SA in this experiment.

However, SA becomes especially complex when we consider teams (7), and we wanted to include more process-oriented measures in order to capture some of the dynamics of teams regarding interpersonal relations and team related variables in the situation (e.g. what to be aware of, the coordinated distribution of the situation knowledge within and between teams, and so on)[1]. In this experiment we used a team definition based on the Dickinson & McIntyre (8) teamwork model. This model consists of seven identified teamwork elements and their mutual relations. Three of these elements, i.e. communication, monitoring and coordination, relates to measuring team SA (7). *Monitoring* in this context relates to observation and awareness of other team members' tasks and performance. *Coordination* refers to the team members adjusting to each other. *Communication* is the component that links the other components. Communication is the link between monitoring the performance of other team members' and providing feedback about that performance. We therefore included a teamwork assessment measure (9) regarding teamwork awareness and mutual awareness of tasks performed, in order to capture some of these team related aspects in our analysis. A more thorough description of SA and teamwork is given in 0.

5 METHODOLOGY

We constructed a scenario within the overall Battle Griffin 2005 scenario, that focused on protection of an ethnic minority from attacks by paramilitary forces. The scenario was especially designed to require attention and coordination within and between teams. The task involved collaborating to build a COP involving land and sea forces, in a simplified simulated escalating military conflict situation. To guide their work, a prioritised list for intelligence collection was available to the participants. The aim for the teams was to construct an overall picture, a situation awareness, of the development of the whole operational area. The teams were to develop this SA, supported by our demonstrator. The scenario and the operational setting in this experiment were all developed by the project (14).

5.1 Participants and Procedure

18 intelligence officers participated and were divided into groups by six. Each group consisted of three teams that collaborated in a decentralized organisation (non layered) at tactical level. I.e. there was no chief in command (no hierarchy) in the organisation. In each team one officer was primarily responsible for situation assessment while the other organised the information collection and negotiated on the allocation of resources. However, there was a floating border between these two functions in each team. The three teams (representing two army units and

[1] These are aspects that Endsley's definition of team SA does not address sufficiently.

one coastal ranger unit) were distributed (not co-located). The premise for this setting was not only to monitor and collect information for each team's area of intelligence responsibility (AOIR), but also to collaborate in the fusion process of information collected under the collection plan for the whole operational area, thus contributing to a shared SA. At the end the group of three teams were to provide one agreed common picture and an agreed course of action.

All intelligence sources were simulated and delivered information both as structured information (track information that was directly visualized on the screen (in GeoViewer, see figure 5.1)) and unstructured information (typically human intelligence and other observations) posted on the net and directly available for the user in the NetViewer. All teams were initially given the same information. By linking into the other teams' picture compilation nodes they also shared each other's information streams. Also, the NetViewer gave all the participants access to all other information (e.g. maps, images, historical data, non-structured dynamical data) from sensors (see figure 5.1).

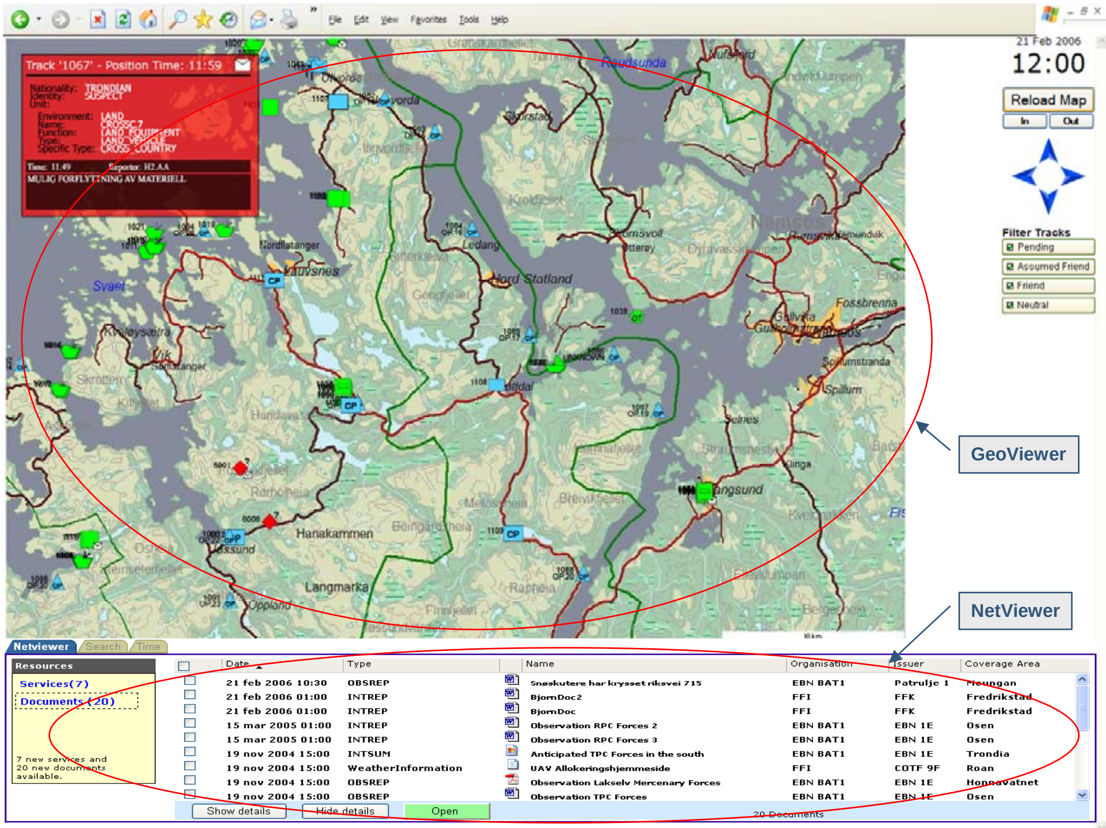

Figure 5.1 User view: GeoViewer and NetViewer of the Battle Griffin 2005 technology demonstrator

Chat (mIRC/JoinMe) was the main communication channel between the distributed teams. Chat was essential to all teams in order to pass information about the understanding of the situation development to each other. In addition, the demonstrator supported communication between the teams in allowing team members to add comments to tracks in the situation picture displayed on the screen (the red square in figure 5.1).

The experiment was run three times, each time with three new teams. Thus, we analysed three sextets, i.e. a total of 18 subjects (military personnel) by both observations and questionnaires. Each session lasted four hours including introduction, on site training and SA measurements. The simulation was played at a speed of four times real time.

5.2 Measures and Measurements

We used a combination of techniques to measure individual SA, shared SA and team SA. The Situation Awareness Global Assessment Technique (SAGAT) (10) covers all three levels of SA. Participants respond to task relevant queries during randomly chosen stops in the simulations. The responses were then compared to the actual state of the environment, providing an objective measure of SA. In the present study, the simulation was stopped three times and the participants had five minutes to respond to the queries. We also used SAGAT to measure aspects of team SA and shared SA.

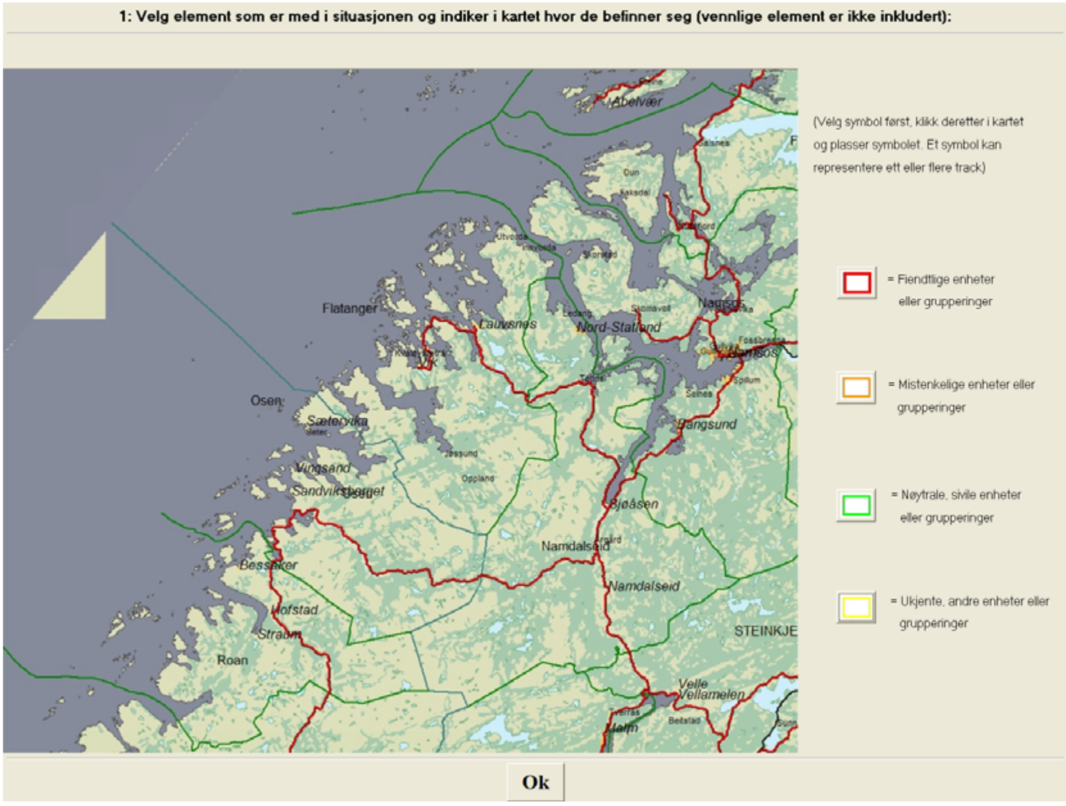

Figure 5.2 Example of SAGAT interface used in the experiment – measuring SA level 1

The Situational Awareness Rating Technique (SART) (11) is a subjective measure of SA. The participants rated their SA on ten different scales. The items are combined into three factors, i.e. *Demand*, *Supply* and *Understanding*, in addition to an overall SA factor that is a composite of the three factors.

- *The Demand factor* concerns the demand on cognitive resources from the context, i.e. the instability, complexity and variability of the situation.

- *The Supply factor* concerns the supply of cognitive recourses, i.e. arousal, concentration of attention, division of attention and spare mental capacity.
- *The Understanding factor* concerns the quality and quantity of information, as well as the degree of familiarity with the situation.

We supplemented our approach to team SA with a teamwork assessment measure regarding teamwork awareness and mutual awareness of tasks performed to capture the dynamics of teams. We used the teamwork assessment measure as a way of assessing the team members' mutual assessment of their teamwork processes. This is also a subjective method that makes the participants rate the teams in three teamwork behaviours (dimensions) (9):

- *Communication*: The ability to provide relevant information to others (between teams).
- *Backup (part of Monitoring)*: Ability to be aware of each other's workload build-up and react to adjust division of task responsibilities to redistribute workload (within team).
- *Coordination/Information exchange*: The ability to pass critical information to others, thereby enabling them to accomplish their tasks (between teams).

This was also given the subjects after the simulation had stopped.

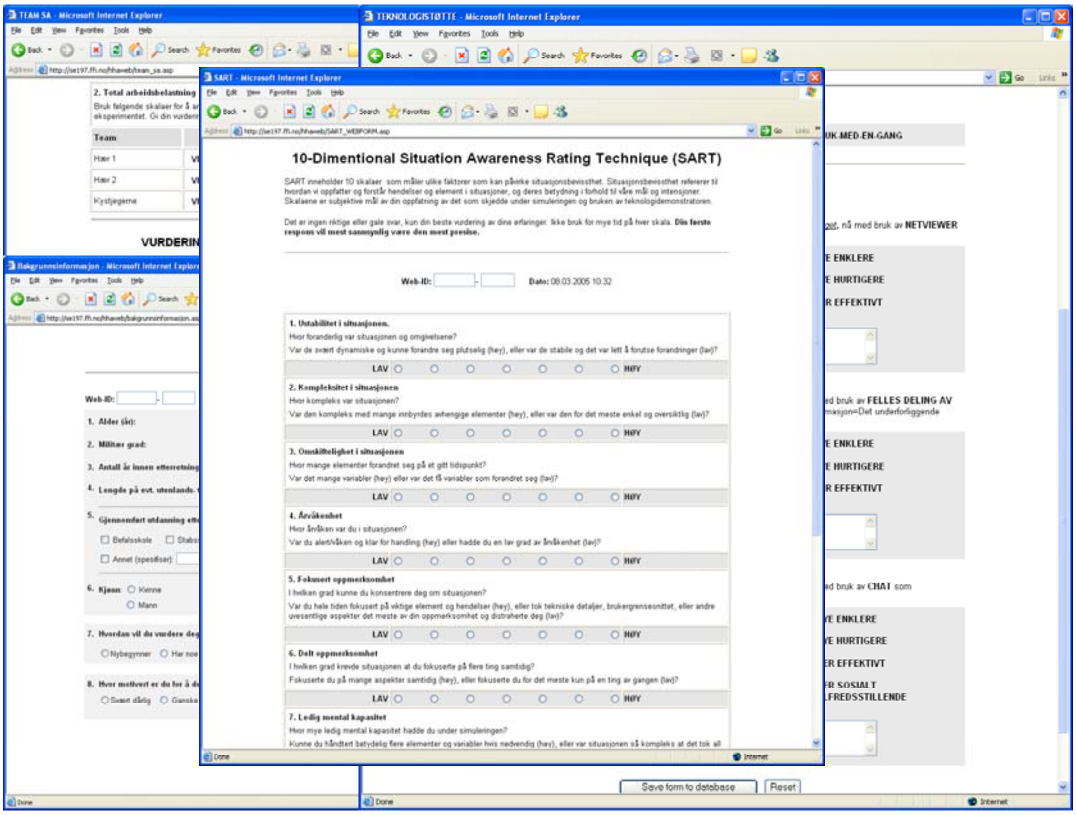

Figure 5.3 Examples of questionnaires used (e.g. SART, teamwork, etc)

In addition, we observed and took notes on team processes during the simulation. We measured the achieved team SA in relation to a simulated military conflict event that required teamwork within and between teams. This was to ensure the relevance of the team SA measures. We also monitored the subjects' ability to use the technology in a collaborative fashion. In addition, the participants evaluated different components of the technology demonstrator (Technology Support) by rating to what extent the NetViewer and the collective sharing of situation picture information (COP visualized through GeoViewer) supported their tasks and problem solving activities in the simulation. These measures were then compared to the SA measures. A more detailed description of methods and measurements is given in 0.

6 RESULTS AND DISCUSSION

In this section we present a discussion of the main results. A more thorough description of the results is given in (12) and (15).

6.1 Individual SA

The purpose of including the SA measures was to evaluate the distributed picture compilation and the support of the technology demonstrator. On the individual SA level the scores on the SART factors were average or close to average. This indicates that the tasks and work were neither too hard nor too easy and they felt that they had the resources to handle the situation. When looking at the individual items in SART, the quality of the information the participants acquired could have been better and the situation aroused them clearly above average, which might be a reflection of the intensity and complexity of the situation the participants experienced.

There is a mismatch between the scores on SART and SAGAT. This might be a reflection of the differences between the methodologies. E.g. SART uses self-evaluation reflecting participant confidence and trust in own SA, whereas SAGAT being a more objective, reflecting “actual” SA.

In general, the participants’ understanding (level 2 SA) and projections (level 3 SA) were better than their awareness of elements in the situation (level 1 SA). In average they were only aware of 12% of the elements. Again, this might be a reflection of the complexity of the situation they experienced, but also of a lacking ability of the technology demonstrator to support the participants in acquiring information and awareness of elements in the situation. However it did not prevent them from understanding the intension of the non-compliant forces (100% and 62% correct) and select the correct predicted course of action of these forces (63% correct), although picking the right place of attack was more difficult (27% correct).

6.2 Team SA and Teamwork

Our intention in this experiment was to explore how new technologies and new ways of collaboration affect the SA, both at individual and team level. *Team SA* is the degree of which team members have the SA to perform their tasks. Team SA is the sum of individual SA. *Shared SA* on the other hand is the degree of which each team member has the consistent understanding of what is going on.

We analysed team SA by combining the scores on the SAGAT queries into a total SA score on queries common for the participants in each group. *Total team SA score* represents the sum of the SA of the group. In addition, we used the mean SA scores of the participants in each group to create team SA score. *Team SA score* is thereby the mean of the team members' individual SA. Starting with the awareness of the elements (query #1, figure 5.3), i.e. level 1 SA, the scores differed between the groups. Group A had a total team SA score on 40% correct across the stops. Group B had a total of 37%, whereas Group C had the lowest total score with 25% correct. The team SA scores were 13%, 14% and 9% respectively (see figure 6.1).

Unfortunately, the number of responses did not allow a thorough analysis of shared SA. The small number of responses also affected the analysis of the higher levels of team SA. Only analysis of team SA level 1 (team awareness of elements in the situation) was feasible.

In general, the teams differed in their assessment of teamwork behaviours. We found that group C differed significantly from the other groups and came out with a significantly lower Teamwork Score (Group A 58%, Group B 68%, Group C 35%). Group C differed from the other groups by performing less coordination and communication activities.

These results are supported by our observation of how the teams interacted with each other during the simulation. Group B had a high frequency of interaction between the teams while group C had almost nothing. This reflects that the self-rating teamwork results varied from "Moderately Good" (group C), "Good" (group A) to "Very Good" (group B). Team SA score level 1 follows the same pattern. Group A and B have a higher level 1 team SA than group C.

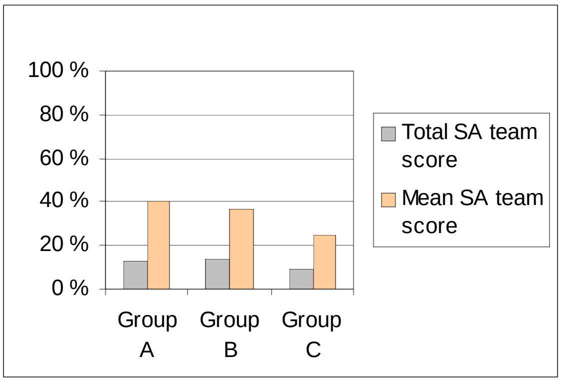

Figure 6.1 Comparison of total SA team score and team SA score

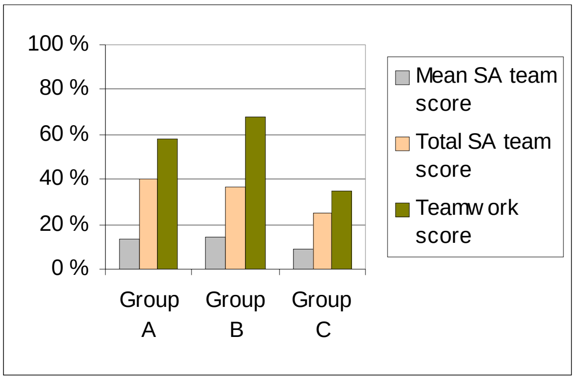

Figure 6.2 Comparison of team SA and teamwork

When comparing the team SA level 1 and the teamwork a pattern clearly emerged (figure 6.2). These results show a tendency towards a positive relation between teamwork and good SA. We could not decide upon the significance of this result. However, we regard this as an interesting observation in our further efforts to study team collaboration and team SA.

We have not yet studied the quality of the communication in detail (i.e. the substance of what the groups actually communicated). Such a "quality-check" would probably further illuminate these results.

It is worth mentioning that the participants themselves addressed the crucial aspect of "the importance of exercising new work practices". In addition, they found that using the technology demonstrator and chat (as the main communication tool) was unfamiliar. The flat organisation, the technology and the way of collaboration differed from what they were used to. Obviously, this affects the teamwork and to which degree they were able to utilize the new technology to efficiently support the team performance. Adopting new work practices utilizing new technology in a collaborative fashion and having personnel skilled in using it is a long and complex learning process. In our experiment the participants had little time to learn these things. However, the experiment was conducted in a simplified setting in order to highlight certain aspects of importance in the further transformation towards NBD.

6.3 Perceived Technology Support

In short, the appraisals of the participants were overall positive to the "GeoViewer"[2] and NetViewer components of the technology demonstrator. These components made it somewhat easier, efficient and effective to perform their tasks and problem solving activities. Positive evaluations of "GeoViewer" correlated with most of the SART factors. This could be interpreted that the participants who experienced support from GeoViewer also achieved a higher level of SA.

Positive evaluations of NetViewer also correlated with the Understanding factor and Overall SA, but not the Supply factor and Demand factor. The purpose of NetViewer is to provide increased access to resources. Increased access to information would also lead to increased cognitive load and the participants might assess the situation as more complex compared to situations where they have access to less information.

The assessment of chat as a means of communication was more neutral. Chat did not make a difference in terms of making problem solving easier and had no impact on the perceived effectiveness compared to existing systems. However, chat might represent a modest improvement of problem solving efficiency. There were also interesting connections between the assessment of chat and SA.

Overall SA in SART correlated positively on all support variables (Ease of use, Efficiency, and Effectiveness), i.e. good SA is related to positive appraisals with chat. More specific, evaluations of chat in terms of ease of use and effectiveness correlated positively with available cognitive resources and negative with demand on contextual demand of cognitive resources. This could mean that the participants with more positive appraisals of chat also had more cognitive resources available and experienced the situation as less demanding compared to other participants. In addition, participants that experienced the situation as familiar and had the information they needed also perceived the use of chat as more efficient than the technologies they use today. This could be interpreted that when they have relevant experience and relevant information with high quality, the use of chat improves the efficiency. In unfamiliar situations with little information available, chat may not be the technology to use in military tactical and operational command and control.

Unfortunately, these results could not be compared to the SAGAT results. However, the SAGAT results revealed that positive evaluations of technology support were not related to

[2] With "GeoViewer" we mean the collective sharing of situation picture information (i.e. sharing the underlying information content, not only the visual image that is presented on the screen to the user). This refers to the distributed picture compilation concept described in chapter 3.1.

awareness of elements in the situation (SA level 1). Unfortunately, we could not analyse the connection between experienced support of technology and level 2 and 3 SA by using SAGAT. Further efforts should focus on this to clarify this issue.

6.4 Summary

The results discussed above can be summed up as follows:

Situation Awareness (SA):

- The participants had overconfidence to own SA.
- Despite poor SA level 1, the participants were able to understand the situation correctly and chose the right projections to a larger extent (SA level 2 and 3).
- The demonstrator gave insufficient support to SA level 1 (e.g. poor map- and search functionality).
- The perceived complexity and the degree of recognition in the situation relates to experience.

Teamwork and SA:

- Significant differences in communication and coordination/information exchange between the groups
- A tendency towards a positive relation between collaboration (facilitated by technology) and SA.
- Problems with analysing higher levels of team SA and shared SA due to limited number of responses.

Technology demonstrator:

- SA correlated with technology support variables, i.e. good SA is related to positive evaluation of the technology demonstrator.
- “GeoViewer” (collective sharing of situation picture information) represents a moderate improvement in problem solving (easier, faster and more effective).
- NetViewer:
  - Represent a moderate improvement in problem solving (easier, faster and more effective).
  - Contributes to increased perceived complexity due to increased information quantity.
- Chat: Good SA relates to positive perception of the use of chat.

These results are not conclusive but give some direction for improvements and development of the technology demonstrator and coming studies of ad hoc organisation of picture compilation in NBD.

First, high utilization of the technology demonstrator lead to increased communication, collaboration and improved the participants' SA. Second, the support of level 1 SA may be improved by including better map functionalities. Third, the search functionality may be improved by including the possibility for decision makers to set priority to certain type of resources according to their needs. This may involve the possibility to subscribe to resources and automated selection of resources according to criteria set by the decision maker. Forth, ad hoc organisation might lead to increased access to information and thereby information overload. This may be improved by a more explicit focus on collaboration and the sharing of cognitive resources (e.g. in analysis).

7 OTHER OBSERVATIONS AND LESSONS LEARNED

During the experiment preparations and the experiment runs at the test site, we experienced some surprises and gained some new insight. Some relates to the research methods we used, others to the technology demonstrator and the experiment in large. Selected observations and lessons learned are elaborated in the following.

7.1 On Methodology

The experiment presented in this paper was explorative and we managed to gain insight into the relevancy of the ad hoc concept and the use of our technology demonstrator in operative settings. In that sense, the experiment was a success. However there were some methodological aspects that must be taken into consideration.

First, we had the ambition to study SA including team SA and shared SA. We assessed team SA to a certain degree but this was not satisfactory. One cause of this was the lack of responses on SAGAT queries concerning SA level 2 and 3. The respondents had a maximum of 5 minutes to respond to the queries. All queries, except for the query concerning the elements in the situation, were administered randomly to make sure that we got responses on all queries. Unfortunately, the number of responses was lower than we expected and we could not conduct all the analyses we planned for.

Second, the SAGAT stops are supposed not to have an impact on the tasks of the participants, at least not to a significant extent. However, we observed that the stops did have a moderate impact on some of the participants and their work. Instead of continuing where they left, many took on other activities, sometimes not returning to what they were doing before the stop. Thus, we need to learn more of how the SAGAT stops seem to influences cognitive activities like tactical and operational command and control.

Third, we used a beta software version of SAGAT to design and administer the SAGAT queries and ran into some problems when collecting the data due to errors in the software. The errors will be corrected in the final version of the software.

Forth, the use of the SAGAT methodology demands much effort. To use SAGAT one needs to conduct a goal-directed task analysis (GDTA) for the domain of interest. We based the GDTA on documents, other studies and interviews with intelligence officers. This is time consuming and must be considered when deciding to use the methodology. However, conducting a GDTA is a good way of acquiring an understanding of work and information requirements in the domain of interest.

Also, Endsley's definition of team SA is insufficient, especially in studies of collaboration and team SA. It does not fully capture the dynamic aspect of SA. We put some efforts in countering this by including more process-oriented measurements regarding teamwork awareness; in order to capture some of the team related aspects in our analysis. In hindsight, we should have placed more emphasize on those aspects in the experiment.

For our purpose it might have been enough to focus on the self-assessment SA measures, e.g. SART, and observation, perhaps in combination with interviews. Performance measures could also be included. On the other hand, the SAGAT methodology may very well serve the purposes of larger experiments with more time and a higher number of participants available, or in studies that compare two or more conditions.

7.2 The technology Demonstrator

Implementing the demonstrator and the course of action for the experiment took substantial efforts up front. New features were the web-portal based GeoViewer and NetViewer, and extended use of the Resource Registry. NetViewer enabled the users to select track input from any available PCN by establishing a connection, and made shared documents available to the users.

The experiment relied on the participants interacting with the system. From the very beginning the development team was determined to limit the efforts on developing user interfaces. ”*We should not have to stand comparison with actual K2IS products*” it was said. The ambition was to keep it simple, but good enough to achieve the goals of the experiment. In hindsight, the trade off between efforts and resulting quality was quite good.

From a technical perspective, there was another new feature in the demonstrator for this experiment: The first web services had been implemented as an internal interface between components. We believe the future will see more web services, and have nothing but positive experiences from the work we have done in that area so far.

The demonstrator was deployed using laptops in a LAN, making the whole system easily ”portable” to a new location. The system as a whole behaved in a stable and predictable manner during experiment sessions. Although we did have occasional but expected breakdowns in some of the weak components (i.e. SensorSim), the problems were kept well out of the users’ attention by carefully developed handling instructions and skilled system operators. For future use, there is a possibility in maximizing portability and minimizing the need for system operators, enabling low cost user-centric ”experimentation-in-a-box”, on locations suitable to the users.

We believe we met the challenge, and have achieved valuable experience in future technology areas like portal development and web services.

7.3 The Experiment in Large

The experiment in large was a success according to its premises. Most goals were met, and the experiment sessions were executed as planned without any technical or procedural problems. However, we acknowledge that we may have embraced too much into this experiment. It was too many things going on at the same time. The execution timeframe was also too short. We realize that studying complex phenomena, such as problems within the area of information sharing and collaboration, probably would require multiple experiments that collect a common set of data so that the contributions of each individual factor can be isolated (19). Then, over time – moving to other experiments – the factors can be brought together in increasingly larger combinations so that their independent and interactive effects are highlighted.

The selection of the participants (operational personnel) was not ideal. They differed very much in background and skills. E.g. some of them had not relevant background and experience in intelligence work. This had of course implications for how well the teams performed together during the experimentation runs.

8 CONCLUSIONS

Explorative experiments are designed to generate new ideas or ways of doing things ("thinking outside the box"). As an exploratory experiment the experiment presented in this report has provided few clear answers, yet they are in accordance with our expectations. Our main conclusion is that the results support our view as promising:

- New technological solutions *can* increase the ability to establish a COP in situations where dynamic configuration of forces is necessary. This can increase shared situation awareness.
- The processes of picture compilation should be tailored to get the most operational value out of the new technological possibilities.

Generally, the participants had some overconfidence in their individual SA. Due to the complex scenario, the participants were in average only aware of 12 % of the elements in the situation (SA level 1). Despite the low awareness of elements, the participants were able to understand the situation correctly (SA level 2) and select right projections (SA level 3) to a larger extent.

Due to small number of responses the analysis of team SA and shared SA were limited to analysis of team SA level 1. There were differences on level 1 SA, however. It also seemed that there were variations in the level of teamworking between the groups. There was no significant correlation between the level of teamworking and the three SA levels. Yet, when comparing the team SA level 1 and the teamwork, a pattern emerged: A tendency towards a positive relation between teamwork and good SA. We could not decide upon the significance of this result. However, we regard this as an interesting observation in our further effort to study collaboration in teams and team SA.

In the experiment the organisation, technology and the way of collaboration was different from what the participants were used to. This had implications on how well the teamwork was performed and to which degree they were able to utilize the new technology to efficiently support the team performance.

The results show that the participants appreciated the technology demonstrator, both the GeoViewer and the NetViewer. These components made it somewhat easier, efficient and effective to perform their tasks and problem solving activities. The experience of support from chat was more neutral. However, chat might represent a small improvement of problem solving efficiency. There were also interesting connections between the assessment of chat and SA. Overall SA in SART correlated positively on all support variables, i.e. good SA is related to positive evaluations of the demonstrator and chat.

The results of the experiment were in accordance with many of our expectations. Much has been learned about the possibilities and problems of measuring situation awareness. We also have gained more insight into the complex interplay between the involving organisational, procedural, human- and technological elements that constitute technology-supported collaboration in military operations. Several positively interesting observations and questions for further studies have been identified.

Altogether we consider the experiment a success, especially when considering the fact that this experiment was the first of its kind in the NBD-program at FFI (sosio-technical type of experiment that besides technology also embraced the cognitive and social domain) and one of the firsts and very few experiments in the area of the Decision-support Component (regarding the structural model in the Norwegian NBD) in the Norwegian CD&E program.

The results support our assumption that the human and organisational aspects - together with technology - must be included in the NBD transformation efforts in order to explore and learn more about this complex interplay.

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APPENDIX

A ACRONYMS AND ABBREVIATIONS

AOIR	Area of Intelligence Responsibility
C2	Command and Control
C2IS	Command and Control Information System
CD&E	Concept Development and Experimentation
COP	Common Operational Picture
COTS	Commercial Off The Shelf
GDTA	Goal-directed Task Analysis
GUI	Graphical User Interface
LAN	Local Area Network
NBD	Network Based Defence
PCN	Picture Compilation Node
SA	Situation Awareness
SAGAT	Situation Awareness Global Assessment Technique
SART	Situational Awareness Rating Technique
UAV	Unmanned Aerial Vehicle