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EXPERIMENT REPORT: "NEGOTIATION BASED RESOURCE ALLOCATION" - BATTLE GRIFFIN 2005

REITAN Bård K, ENEMO Geir, BJØRNSTAD Anne Lise, HAFNOR Hilde

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FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
P O Box 25, NO-2027 Kjeller, Norway

FORSVARETS FORSKNINGSINSTITUTT (FFI)
Norwegian Defence Research Establishment

P O BOX 25
N0-2027 KJELLER, NORWAY

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REITAN Bård K, ENEMO Geir, BJØRNSTAD Anne Lise, HAFNOR Hilde

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8) ABSTRACT

This document contains an overall description of the exploratory experiment “Negotiation based resource allocation”, conducted by FFI-project 879 “NBF i operasjoner” in the period March 1-6 2005 during the military exercise Battle Griffin 2005. The experiment was conducted as an integrated part of another FFI experiment: "Ad hoc organization of picture compilation and situation awareness in NBD".

The aim of the experiment was to test a new resource allocation concept where the decision process is dynamic and decentralized and based on negotiations reaching for consensus among users needing a given resource. The concept is a mix of ideas based on electronic marketplaces and online collaborative tools. In the experiment, a simulated UAV was selected as the resource in question. The collection of data from the chat-log, a questionnaire and observations will result in further reports with more in-depth analysis.

The main conclusion from the project is that the concept “Negotiation based resource allocation” looks promising. However, there is a need for training and familiarizing into new processes and a completely new organizational setting.

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EXECUTIVE SUMMARY

This document contains an overall description of the exploratory experiment “Negotiation based resource allocation”, conducted by FFI-project 879 “NBF i operasjoner” during the military exercise Battle Griffin 2005. The experiment was conducted as an integrated part of the "Ad hoc organization of picture compilation and situation awareness in NBD" experiment of FFI-project 898 "NBF beslutningsstøtte".

The aim of the experiment was to test a new resource allocation concept 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 through a pre-defined hierarchy. With *network-organized forces*, if no changes are made to the current resource allocation processes, one is likely to experience improper time-consuming resource conflicts. What we suggest is a more efficient concept for resource-allocation: *negotiation based resource allocation*. The concept is a mix of ideas based on electronic marketplaces and online collaborative tools.

The objectives of the experiment were:

- To gain a better understanding of resource allocation in a decentralized organization.
- Test processes designed for the negotiation based resource allocation concept.
- Learn about technology support needs for the negotiation based resource allocation concept.

Three simulation runs were conducted. For each simulation run, three groups of two officers were equal peers in the decentralized organization.

In the experiment, a simulated UAV was the resource in question. The availability of the UAV was presented in a UAV homepage. The negotiations were conducted in a dedicated chat-room.

The collection of data from the chat-log, a questionnaire and observations will result in further reports with in-depth analysis.

The main conclusion from the project is that the concept “Negotiation based resource allocation” looks promising. However, there is a need for training and familiarizing into a completely new organizational setting.

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1 INTRODUCTION

This report contains an overall description of the exploratory experiment “Negotiation based resource allocation”, conducted by FFI-project 879 “NBF i operasjoner” in the period March 1-6 2005 during the military exercise Battle Griffin 2005. The experiment was conducted as an integrated part of the "Ad hoc organization of picture compilation and situation awareness in NBD" experiment of FFI-project 898 "NBF beslutningsstøtte". Supplementary information regarding the FFI-project 898 experiment may be found in their Experiment Report (1).

1.1 Experiment Aims and Objectives

The aim of the experiment was to test a resource allocation concept where the decision process is dynamic and decentralized and based on negotiations reaching for consensus among users, or "customers", needing a given resource, rather than having resources allocated through a pre-defined hierarchy.

The objectives of the experiment were:

- To gain a better understanding of resource allocation in a decentralized organization.
- Test processes designed for the negotiation based resource allocation concept.
- Learn about technology support needs for the negotiation based resource allocation concept.

1.2 Experiment Concept

Negotiation based resource allocation is a new concept for decentralized allocation of resources. This concept is mainly suited for resources that, in most cases today, are considered strategic resources, e.g. Unmanned Aerial Vehicles (UAVs), but the concept is also suited for resources where limited capacity and/or time constraints underlines a possible conflict of interest between multiple interested parties.

The users in need of a given resource will "meet" through an "arena of negotiation", similar to an electronic marketplace, to discuss and negotiate how the resource is best put at use. Supported by the "arena of negotiation" and the accompanying processes, the parties involved should strive to reach a common understanding and converge at a common decision. Sudden changes in the current situation that necessitate a dynamic re-allocation of the resource may also be handled through the same channels.

Although this experiment, for practical purposes, simulated the use of a physical component/platform (an UAV) as a resource, a more real life approach could be having users not asking for specific platforms, but rather flagging , through an "arena of negotiation", a need for a certain service (i.e. sensor coverage for a certain area, information about certain objects, ground fire, etc) without worrying too much about how the service provider chooses to use the available, “netted” assets.

2 BACKGROUND

2.1 Challenges in resource allocation

Network organized forces are discussed, amongst others, in *Forsvarets konsept for nettverkssentrisk krigføring* (2) and *NCW – Developing and Leveraging Information Superiority* (3). Network organized forces are hypothesized to give better *efficiency* and *robustness* through more *efficient utilization* of resources (4). A central idea in the concept of network-organized forces is to consider a larger fraction of the military resources as *common resources* within the organization. That is, more resources are meant to be shared, and not to be owned and utilized by a pre-selected few. However, a serious showstopper may be that when sharing resources of limited availability, resource conflicts are inevitable.

If resource conflicts occur, the preferred solution is that resources are put to use where they may contribute the most to the organization reaching its goals or solving its tasks. To decide where a resource is needed the most, or will contribute the most, is no simple task. First of all, knowledge about all relevant aspects of the current situation is necessary. Further, knowledge of all future plans that may have some influence on the decision is also needed. In a hierarchy, the commander-in-chief is trusted to possess or collect such knowledge for all situations. When the commander himself does not have sufficient knowledge, he will rely on his staff and his subordinates to provide it.

With an increasing number of resource conflicts, and conflicts involving different branches of the hierarchy, even trifling conflicts may involve several levels in the hierarchy and finally be de-conflicted at a high level in the hierarchy. If one still trusts the traditional hierarchy to solve resource conflicts with network organized forces, one may experience improper time-consuming resource conflicts.

Limited resources of common interest, or strategic resources, are often put in one central pool. Air- and artillery support, UAVs, and transportation are examples of such resources or services that are often pooled. With pooling, some of the hierarchy's problem is omitted by putting the resources at the very top of the organization. The problem with pooling is that when requesting a pooled resource, the request still has to be filtered as it is passed on upwards in the hierarchy – Such processes may be time consuming and the reason for the resource being requested may be poorly communicated as it reaches the final decision makers.

If one wants to succeed with network-organized forces, a more suitable resource allocation process may be necessary. Such a process should make sure that conflicts are solved at a suitable level, involve relevant parties, and are not too time consuming.

2.2 A new concept for resource allocation

What FFI-project 879 has suggested is a new concept for resource-allocation: *Negotiation Based Resource Allocation*. The suggested concept is founded on decentralization and is suitable for a more dynamic organization. Most importantly, conflicts are solved at a suitable level and the concept facilitates decisions of high quality as the process seeks to reach consensus among decision-makers with stakes in the decision being made. The concept also facilitates flexible decision-making as it makes re-allocation quite easy.

The concept is inspired by the ideas of electronic marketplaces as well as the ideas of online collaborative tools. Negotiations reaching for consensus between relevant experts and decision-makers are central to the concept. Central is also the idea of offering relevant resources as *services* to all relevant decision-makers.

At an electronic marketplace, objects for sale, or services to be performed are announced. Different tools are available for potential buyers to search through, or to be notified when an object or service of interest is available. Driven by the developments of e-commerce, these systems will only get more sophisticated. Military components or military resources could be offered as services in a similar way. An offer should include aspects as: how and when the component can contribute, is it limited, how may it be reserved, who may reserve the component etc.

Announcing or offering the service is half the job. If the resource is limited, conflicts may occur and allocating it may be challenging. With multiple interested parties, the military way is to let the commanding officer decide, the economists way is to hold an auction and let the one who pays the most get priority, the democratic way is to let everybody be heard and let the majority decide. It is not necessarily one best way; different situations call for different approaches.

Auctions can assure quick decisions, but decision quality may be poor since auctions are competitive in nature. In an auction, everybody is optimizing based on his or her local view of the world. The participants of an auction have no interest in why the other interested parties should need the resource. The non-cooperation is not a desired property of a new system. Decision makers should cooperate to reach an overall well coordinated decision. For this last goal, the democratic model may be a better template.

What if all interested parties could agree on one decision? Consensus is obviously not possible at every incident, and especially not in extreme situations with human lives at stake. However, for the occasions where the parties with an interest in a resource could agree on a decision,

there is little need for involving higher command levels. In these situations, good decisions may be reached quickly without wasting higher officers' limited time.

Facilitated discussions or facilitated negotiations can bring forward issues important for allocating the resource of consideration. The idea is to set up an electronic meeting place where parties with stakes in the resource of current interest may meet for discussions and negotiations. Negotiations should be open and the history of the negotiations should be available. With the history available, the setting for the current decisions are available and the importance of arising demands can easily be compared to the arguments of the current allocation: Re-allocation is made easy. Furthermore, if the commanding officers wish to monitor the decisions, it is simply done by browsing the log of the negotiations.

As mentioned, the concept includes two major tools that must be provided to support the allocation processes:

- A site for presenting the availability of the resource or the service.
- A site for discussions or negotiations.

Figure 2.1 illustrates some aspects of the negotiation based resource allocation concept.

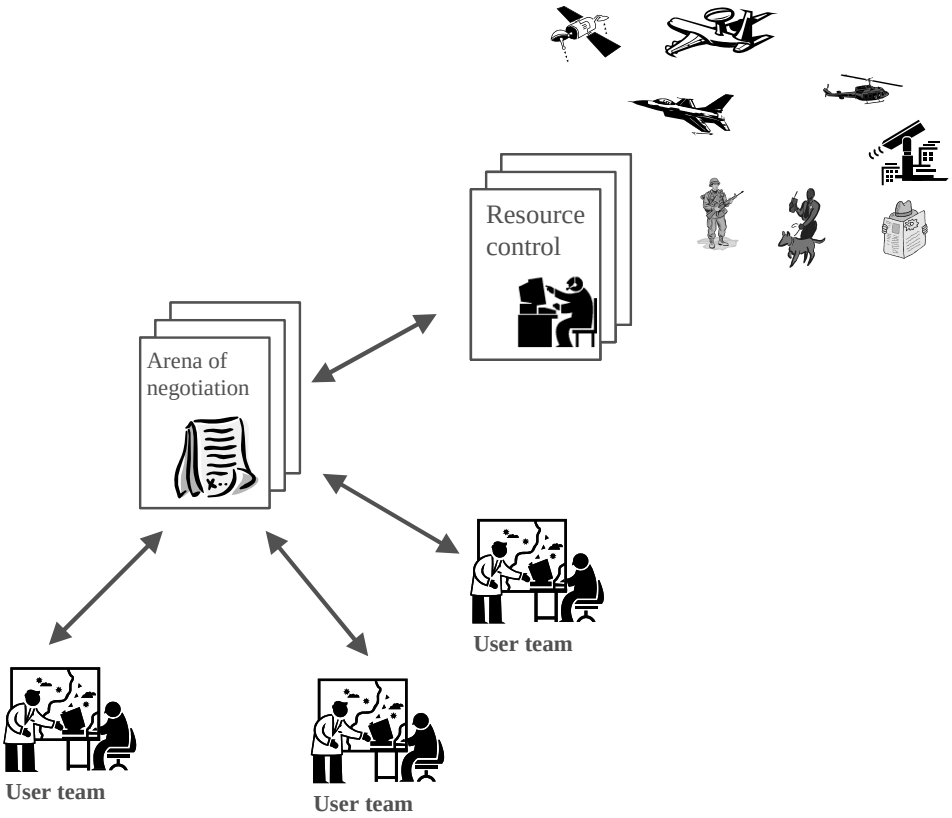

Figure 2.1 General illustration of negotiation based resource allocation

A common resource, e.g. UAV, air support, some sensor capacity, is offered as a service. A resource operator is the “salesperson” and represents the resource. The resource operator announces the availability of the resource. Interested parties can make public their views on

how the resource is best put to use. The interested parties can front their views of *how* and *why* through the “arena of negotiation”. With an adequate holistic view among the interested parties, one decision may stand out as the best decision and consensus is reached among the interested parties.

In the experiment we tested the democratic approach as outlined. We tested the concept with very little intervention in order to better be able to learn about the pros and cons of the concept.

3 THE EXPERIMENT

The experiment was run as an integrated part of the “NBF beslutningsstøtte” experiment, which provided the infrastructure, the synthetic environment and the scenario. The two experiments were run in parallel. The Experiment Report from “NBF beslutningsstøtte” (1) provides additional details about the experiment setup.

The experiment was of an exploratory character. The concept of *negotiation based resource allocation* is in its infancy and qualitative results from the experiment are more than sufficient to assure progress in the development of the concept.

A simulated UAV was selected as the resource in question. Tracks from a UAV were simulated in the synthetic environment and so were the entities the UAV identified on its flights. The UAV was the only resource put out for negotiations. However, the simulated UAV was one of many resources made available to the test persons.

3.1 Preparations

As an “add-on” to the FFI-project 898 experiment, the preparations were mainly limited to developing negotiation based resource allocation specific features. Most of the preparations concerned the simulated UAV and were put together in cooperation with “NBF beslutningsstøtte”. As part of the preparations were:

- Adding a simulated UAV for negotiations to the scenario.
- Developing a UAV-homepage to publish the availability of the UAV.
- Setting up an extra chat-room for UAV-negotiations.
- Preparing a questionnaire for the participants.

3.2 Setup

3.2.1 Organization

During the experiment, three experiment sessions were conducted. Six intelligence officers participated in each session. The six officers were split into three teams/task-groups of two officers. The three teams were seated in separate rooms, sufficiently apart not to see or hear the

other teams. Between the teams, chat was used as the only means of communication. Each officer was seated at a PC-terminal.

In the experiment organization, the officers were at the same organizational level, but belonging to different task-groups within the organization. No commanding officers were available, and the participants were equal peers in a flat distributed organization.

The participants' main task was to build and maintain a common operating picture (COP). Based on the information made available to them, and through horizontal cooperation, they were instructed to build and maintain the COP. To guide their work, a prioritized list for intelligence collection was available to the officers. After the simulation, the officers were given a final task of describing the situation, and what they expected would happen next.

A project member played the UAV resource operator. The UAV resource operator would inform the teams about the availability of the UAV, but not take an active part in the negotiations.

3.2.2 Infrastructure and applications

The infrastructure and the synthetic environment were provided by the “NBF Beslutningsstøtte”-experiment. The main applications at the PC-terminals were:

- *NetViewer*: a front end for their Resource Registry service. The Resource Registry service contained references to unstructured information (e.g. intelligence reports and the UAV-homepage). During an experiment run, new intelligence reports were made available in the resource registry by a publishing service. The UAV homepage was accessible through NetViewer.
- *GeoViewer*: a front end for their COP service. Battlefield entities and their sensors were simulated and fed into the database of the COP service. The UAV and entities it discovered through its flights were available through GeoViewer.
- *mIRC*: chat software. Chat was the only channel for communication between the teams. In addition to the chat-room set up for general communication between the teams, a separate chat-room was set up for the UAV negotiations.
- In addition: Internet Explorer and MS Word were used to present documents.

Figure 3.1 illustrates how some of the applications were used. Through these tools, the same information was made available to all teams. The feedback through GeoViewer is not included in the figure.

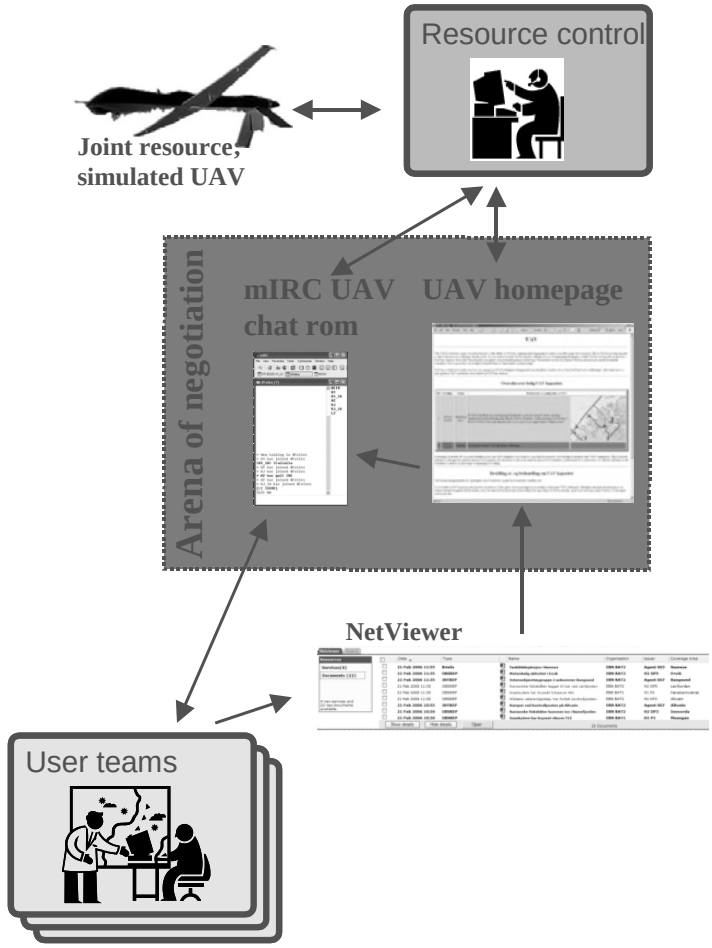

Figure 3.1 Illustration of the setup.

3.3 The simulation

An experiment session, including the introduction, the simulation, the questionnaires and the final discussions, took almost four hours. However, the simulation itself took only about one hour. Simulation time equaled four times real-time. During a simulation run, the UAV was made available two times. That is, there were two negotiations per session.

The deadline for the negotiation was 30 simulated minutes after the UAV was announced. In real-time, this meant only a little more than 7 minutes.

3.4 Presentation of available resources

The availability of the UAV was presented at a UAV homepage. A snapshot of the UAV page is shown in figure 3.2. The UAV-homepage consists of three parts: a static part containing general information about the UAV and its services, a dynamic part describing the availability of the UAV and finally there was a static part suggesting how to "order" the UAV, or claim a need for the UAV to get involved in the negotiations. The resource operator manually updated the dynamic part of the UAV homepage.

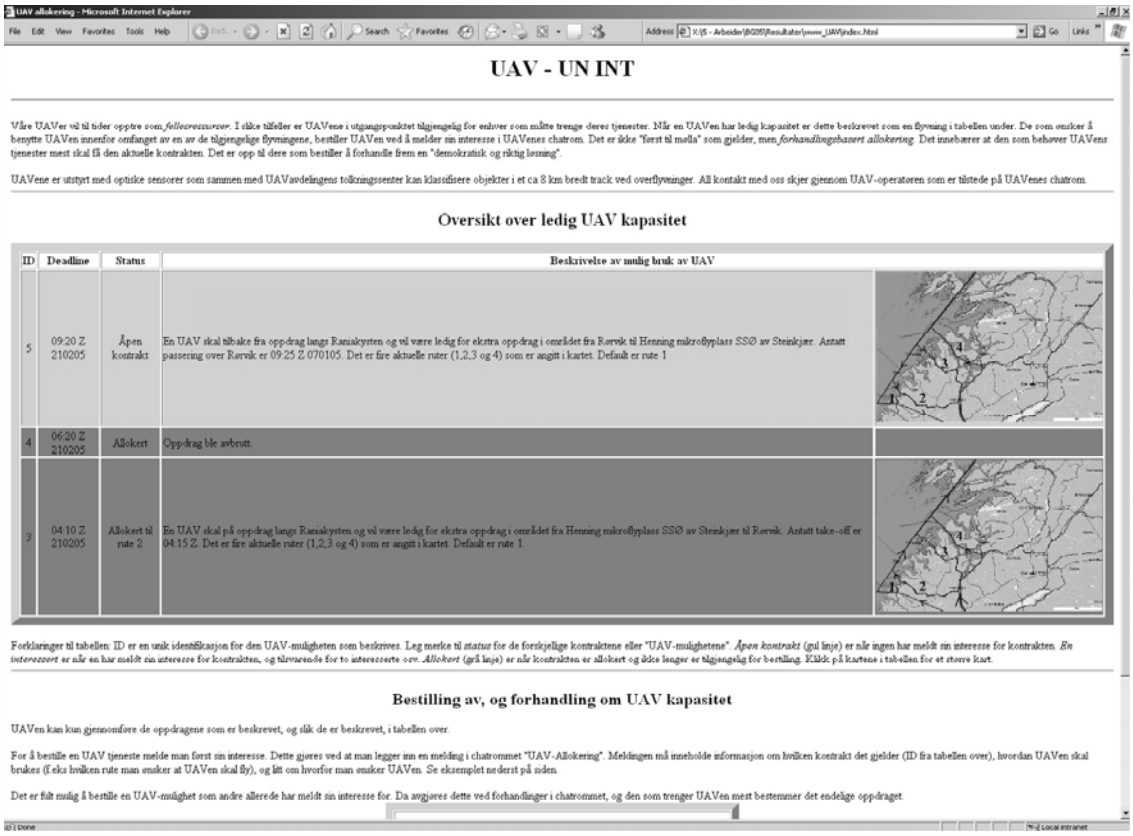

Figure 3.2 The UAV-homepage

In the scenario, the availability of the UAV was limited to when the UAV was on its way to and from other tasks of higher priority. The idea was that the participants would take advantage of leftover UAV capacity. Its availability was also fixed to a limited number of predefined routes to make the negotiations simpler.

To make conflicts more likely, the routes were constructed such that they would pass the teams' areas of interest in different ways. The UAV would identify different objects for the different routes. The teams had access to the same information, but since they had different areas of interest, they had different expectations of how the UAV could contribute.

3.5 The negotiations

As mentioned earlier, the UAV was allocated twice during the simulation in an experiment session. The UAV operator would announce on the chat-room when the UAV was available and also update the UAV-homepage with the new possible UAV-flights.

From the UAV-homepage it was suggested to start negotiations with a semi-formatted message containing *where* one wanted the UAV to fly, and *why*. The resource operator would ask *why* the UAV should fly a suggested route if that was missing from the message. The other teams would then "place their orders" as suited and supplement their earlier arguments if necessary.

At deadline, if the teams did not agree, the UAV would fly a pre-announced default route. As a worst case, none of the desired routes would be flown. The resource operator did remind the teams of the deadline and the consequences of not reaching an agreement a few minutes before the deadline.

3.6 Methods and data

Being an exploratory experiment, focus was put on gaining experience with the concept of negotiation based resource allocation and its related issues. Only preliminary results are reported in this document. More in-depth analysis will be provided in later reports.

Three sources of data are available for further analysis:

- *Chat*: Both chat-rooms were logged, and the negotiations may be replayed using these logs.
- *Questionnaires*: The participants answered questions from a web-based questionnaire.
- *Observations*: Four project members took part and/or observed the experiment, taking notes of interesting moments or issues. The experiment was also concluded with a plenary discussion with the participants giving feedback.

The data collected will provide feedback for improvements and design criteria for the processes and necessary technology support for the concept of negotiation based resource allocation.

4 PRELIMINARY RESULTS

In this chapter we will first give an evaluation of the experiment as a whole, and then continue discussing some issues in more detail.

4.1 Overall evaluation of the experiment

Prior to the experiment, many viewed it as “doomed to fail”. They claimed that it was impossible to use the UAV in a sensible fashion without having any predefined procedures or rules, e.g. having the UAV allocated to a specific unit under a given commander. The actual results from the experiment are more mixed:

Negotiations succeeded in reaching a good solution about 50% of the time. The remaining 50 % of the negotiations failed in that no agreement had been reached within the time limit and consequently the UAV flew the default route. Although the failure rate was 50%, the results still surpassed the original expectations.

The reasons for not being able to reach a good solution are many and complex. Probably no single factor was responsible for the failure to reach a conclusion in the negotiations. More likely, a combination of the factors caused the breakdown. In the following sections some probable causes/issues are discussed.

4.2 A lack of common understanding

A crucial issue in the experiment setting was the ability to obtain situational awareness (SA) regarding the whole ongoing operation, in other words, the ability of the participants to obtain SA outside own Area Of Responsibility (AOR). Some of the participants were too focused on own AOR, with almost no communication with the other nodes. This made it less likely for the participants to obtain an understanding of the broader picture which in turn made a fruitful discussion about the best use of the UAV much more difficult.

4.3 Too short a time frame for the negotiations

Each negotiation was to take place within a simulated timeframe of 30 minutes. However, this constituted just 7 minutes (real time)[1]. As the UAV negotiations was just one part (albeit an important one) of the whole operation, in some of the cases the participants simply failed to cope with all the information available to them through the system and totally forgot about the UAV or reacted too slowly.

4.4 Unfamiliarity with chat

A chat-solution was chosen as the only means of communication between the nodes. Several of the participants felt hampered by this way of communicating, especially compared to ordinary voice. In some cases the problem seemed more to originate from the fact that chat was a relatively new experience, rather than an intrinsic limitation in the tool itself. However, the use of chat also seemed to make it more difficult to join a discussion at a later stage.

[1] The simulation was played at a speed of four times real time.

4.5 No “eye-popping” effects

The simulation used no “eye-popping” effects (live video etc) from the UAV. The UAV was visible only as an ordinary track on the screen. It called no attention to itself when finding items previously not detected by the sensors already deployed. This was not a flaw in the experiment setup, but, for practical reasons, was a deliberate choice. The lack of feedback felt by some participants may have made people downplay the significance of the UAV, hence also the interest in the negotiations.

4.6 Unfamiliarity with the processes and the organization

The feedbacks from the personnel involved in the experiments are, as the actual results, mixed. Some felt that this could be the future way of doing things and thought the idea of discussing with other users about what is best for the operation as a whole, “the greater good”, was satisfying and put the operation in the right perspective. Others argued that in real life, under pressure, the process either wouldn’t work or take too long, due to man’s inability to think outside his or her immediate needs.

Furthermore, the role of a neutral, “hands-off” resource operator for the UAV resource allocation is unfamiliar thinking. Some groups waited for the operator to facilitate and cut through the discussions and automatically assumed the operator decided in the end. This is most probably due to them being accustomed to working in a hierarchic organization, where there always is a person higher in authority who will make the final decision.

It is definitely not enough just to tell people to change their behavior and do things in a different way. The behavior of individuals is based on their established understandings and expectations (i.e. mental models) of the organizational processes. Trough years of education and experience they have learned to work in a less flexible hierarchic organization, where decisions are made on the basis of authority. Changing this engraved understanding will necessarily take time and practice. Not until this has been done, will we be able to fully understand the potential of the concept.

When it came to the overall objective of working together, building up situation awareness for the entire operation, there were several examples of falling back into old habits, focusing only on one’s own pre-defined area of responsibility.

5 CONCLUSION

The questions one has to ask about the concept “Negotiation based resource allocation” is: Is it a viable solution? Is it possible this way of doing resource allocation will result in a more flexible and efficient use of resources?

The main conclusion from the project is that the concept *Negotiation Based Resource Allocation* looks promising. However, it could be that totally unstructured negotiations without any rules or fixed procedures are a bit too naïve. One may need some form of explicit mechanisms to reach convergence, especially when rapid response is a priority. What this mechanism could look like, apart from today's hierarchy and resource owners, is still unclear. A recommendation for further work would therefore be to look into such new possible mechanisms.

Also, regardless of whether the allocation concept will work in real life or not, a conclusion on a different level may be reached: there is a need for training and familiarization with a completely new organizational setting.

6 FURTHER REPORTING FROM THE EXPERIMENT

This report only describes the main features of the problem complex and the conclusions from the experiment. There is in our project significant work still in progress that will try to delve more into details and into how different variables are connected. For example: Why some groups failed to reach an agreement while others had very good discussions where they tried to see the greater good and reached a good solution, makes an interesting study. What characterized the groups who failed from the groups who succeeded?

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