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C3Conflict a Simulation Environment for Studying Teamwork in Command and Control

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ABSTRACT

This paper describes C3Conflict, a research and training environment developed to support research and training of co-ordination and collaborative work in C2 situations. C^3Conflict is a command, control and communication, simulation environment tailored to the peace-keeping military domain. The environment creates a situation where a group of people (3 to 12 persons) can tackle a variety of common problems in team work and C2. The tasks presented by C3Conflict are complex, dynamic and have opaque characteristics, similar to the cognitive tasks that people normally encounter in real-life C2 systems.

C3Conflict is based on the C3Fire microworld (www.c3fire.org) and are developed by the C3Fire team in collaboration with the Naval Postgraduate School, Monterey, USA. C3Fire is well established and has been used in a wide variety of research projects over the past ten years. In C3Conflict, unlike C3Fire, is a two-sided game where the adversaries can be willfully hostile. The presented situations have a military cover story and appearance.

One of the most important features of C3Conflict is that the system monitors the activities of all players. Monitoring is integrated into the simulation and all the information tools the players use. During a session, the system creates a log with all events and all computer mediated activities, such as communication and individual work.

The log enables analyses of quantitative measures of performance, communication, coordination and responsibility distribution. Analyses can be performed at both the individual and group levels.

The paper describes simulation usage and the functions that make it possible to use the environment to develop training exercises and to conduct research on C2 behavior, team work and collaboration.

INTRODUCTION

Computer based simulation and command and control training systems are relatively recent additions to the military research and training arsenal. They have proven to be valuable tools in both education and research. Scaled worlds and microworld systems, which have mainly been used for research, make it possible for researchers and trainers to select important characteristics of a real world system and to create a small and well-controlled simulated world with those characteristics. The simulated world provides an environment that captures both the complexity of the real world and the rigor of the experimental laboratory (Brehmer & Dörner, 1993). By importing the dynamics of real world situations into the laboratory, microworlds make it possible to conduct controlled studies of the performance of individuals and groups as they pursue real tasks. The data from the microworld sessions are amenable to standard methods of analysis.

The availability and interactive nature of microworld simulations provides a good medium for students to experience the complexity and dynamics of collaborative work. One important advantage in using computer-based simulation in C2 training is the possibility to monitor all computer-mediated collaboration. The monitored data can be processed and automatically analyzed by a monitoring tool. The monitoring tool can help the training manager or researchers to supervise the students so that specific goals can be achieved.

C3Conflict is a microworld that straddles the border between training and research systems. It can be used as a simulation environment for training or as a research system that can be used to elicit players' behavior in compellingly complex and dynamic situations. C3Conflict is a two-sided game-based simulation environment in a peace-keeping military environment containing both a friendly force and insurgents. Like all microworlds, C3Conflict is a human in-the-loop simulator in which participants are involved in and partially determine the simulation's operation (Sheridan, 2006). The ability to allow participants to shape the flow of events emulates and generalizes to human behavior a complex socio-technical system. C3Conflict supports computer mediated control and communication making it possible to collect data about a group's collaboration.

Low Fidelity simulations

Traditionally simulators have been considered better if they are as realistic as possible. However, high-fidelity simulators are not always the best. One example of that is apparent when they are used to train for adaptability rather than rote procedures (Gugerty et al. 2004; Naikar & Sanderson, 1999). Also, high-fidelity simulators can be difficult use for research. Their complexity means that experimental degrees of freedom remain high and confounding (Brehmer & Dörner, 1993). Brehmer describes the identical resemblance problem as the "Cat Problem", the most realistic simulation of a cat is another equally complex cat – which is just as difficult to understand (Brehmer et al. 2004). A complex simulation also makes it hard to find participants capable of operating them. In contrast, the strength of a low fidelity simulation, like C3Conflict, is that simplification allows experimental effects to be measured by reducing degrees of freedom. In training situations, a low-fidelity simulation captures a generic aspect of the environment or task that, in turn, makes it possible to focus on the training of individuals or teams. A simple simulation also makes scenario development, data collection, and metrics analysis simpler.

Microworlds

The C3Conflict environment can be classified as a microworld system. Microworlds are simulated environments that realistically capture important characteristics of a real system including the complex, dynamic and opaque characteristics of decision making problems (Granlund 2003; Woltjer, 2005). In the field of psychology, microworlds have, been viewed as tools to overcome the tension between laboratory research and the "deep blue sea" of field research (Brehmer & Dörner 1993). Laboratory research often lacks relevance or ecological validity. Much of field research is beset by a chronic lack of control and concomitant problems in finding causal interpretations of the results. The researcher who uses a microworld is able to investigate questions that cannot be addressed in either field studies or laboratory experiments (Gray, 2002). It has been shown that participants take well-designed microworlds seriously and become so engaged that their behavior becomes completely natural (Dörner and Schaub, 1994; Gray, 2002; Granlund, 2003).

When creating a microworld, the level of abstraction is an important design choice. (Jones, 2005, p. 184) describes abstraction in simulation design as the omission of “some feature of the modeled system without representing the system as lacking that feature”. To design a microworld the designer needs both to abstract and idealize. Abstraction such as by making no mention of the color of a driver’s simulated vehicle. Idealizing, on the other hand, involves distortion or approximation of a natural system’s properties, such as neglecting wind effects in a driving simulator (Hilliard 2007).

Tasks

An important property of micro-worlds is that they provide means to present participants with a number of different problems. The subjects’ task are good examples of what can be studied or trained (or trained to avoid) in a micro world. Typical tasks performed by the participants:

- The subjects must engage in goal analysis; identifying priorities among goals, identifying sub-goals, resolving conflicting goals.
- The subjects must understand their task and the environment, they needs to understand the properties of the resources and organization, they needs to understand behavior of the environment, make prognoses concerning the future development in the environment, and define action alternatives.
- The subjects needs to work as a team, they needs to understand their role and task in the team, understand the others needs, understand the importance of sharing information in a proper manner.
- The subject must make decisions, interact with the team and consider and evaluate their own strategies, over time.

Common Reasoning Errors

C3Conflict can be use to develop tactical reasoning by training participants to avoid common reasoning errors. Typical behaviors that the players can adopt in a micro-world are (Dörner 1987):

- They can adopt an *ad hoc* behavior.
- They can adopt a *thematic vagabonding* behavior. The error of thematic vagabonding occurs when attempts to control a system or situation have no structure. Participants jump from one topic to the next without analyzing the result.
- They can adopt an *attention tunneling* behavior. This refers to a single-minded focus on one approach to solve the problem to the exclusion of all others approaches. The narrowness of vision often precludes achievement of an overall view of the problem.
- They do not understand regularities in the time-course of events, e.g., non-linear growth is often seen as linear, oscillations are seen as chaotic.
- They do not understand the side effects of their actions
- They have problems with delayed feedback.

C3Fire

The C3Conflict is build based on ideas and experiences from the simulation system C3Fire. C3Fire is a microworld that allows controlled studies of collaborative decision making in a dynamic environment (Granlund et al 2001; Granlund 2002; www.c3fire.org). C3Fire was initially developed in the mid 90’s and has continuously been expanded and improved. It has been used in a wide variety of experiment-based research projects with a total of approximately 1000 participants. Typical research goals have been to test alternative designs for information tools or to elicit C2 behaviours from groups of people from different organisations or cultural backgrounds. The goal with C3Conflict is that it should be able to support the same type of research questions as C3Fire but with two-sided game with a military cover story.

The two most elaborated C3Fire projects are:

“The impact of GPS based GIS on professionals during a collaborative emergency response task” The goal of this project was to investigate the impact of a decision support system that presents global positioning system (GPS) information to the decision makers in crisis management organizations. A total of 304 persons participated (Granlund, 2009, 2010, Granlund et al., 2011a,b; Johansson 2010).

“Bridging Cultural Barriers to Collaborative Decision Making in On-Site Operations Coordination Centers” The goal of this project was to identify differences in norms for team work and collaboration between groups with different cultural backgrounds. A total of 114 persons participated. (Lindgren & Smith 2006; Smith 2008).

C3CONFLICT CAPABILITIES

The goal of the C3Conflict environment is to generate a research and training system that supports a two sided game with a peace-keeping military domain. The basic idée with the environment is to give a team the possibility to experience a team task in a C2 setting. In a training situation the environment support experience based learning including AAR support in the reflection and generalization phase. The environment is designed to support work tasks and learning goals that exist for decision makers that works on the tactical level. This means that the decision makers in the team hopefully will encounter problems that exist at the tactical level. To be able to support this kind of research and training the system is highly configurable and it monitors the players’ activities in the environment.

Experience based learning

The environment supports the four steps of experience-based learning. The recommended training procedure allows for repeated trials, with reflection phases in between. By using the session replay function the training manager and the players can perform a high-speed play-back of the whole session. The session replay used in an after-action review provides a good opportunity for the students to maximize group interaction to investigate their view of the situations and what they learned. The experience gained from using the session replay is an important step in the learning. When the players observe the session replay, they start to interact by presenting their views of what they thought had happened during the session and what to do in future engagements.

We believe that this function is one of the most important components in the C3Conflict environment and that the motivational appeal of the simulation increases dramatically when the students can see a replay and discuss their collaboration.

Kolb has expressed a generally accepted model of experiential learning (Kolb, 1998). The model can be adapted for research and team training performed with computer-based simulations (Granlund, 2008). The main component of the model is the learning cycle in the four steps (Figure 1).

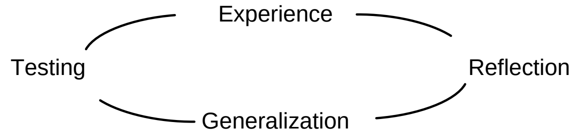

Figure 1. Kolb’s basic model of experiential learning.

According to Granlund (2008) having an experience is the first step in the experiential learning model. For team training with computer-based simulations, the instructor tries to direct the participant's experience against the objectives of the education. This is difficult. Although the participants face the same simulation, they will have different experiences during the training depending on their initial knowledge and experience.

Reflection on the experience is the next step in the learning model. It is important that all participants communicate what they experienced during simulation. Equally important is that the participants learn about the other participants' experiences. (Granlund, 2008).

The generalization links thoughts from the experience and from the reflection to the participant's initial knowledge. This linking is performed within the participant. The participants will not do the same generalization, as their knowledge and experience differs, but their shared reflection increases the ability to generalize in the same direction.

Testing is the last step of the experiential learning cycle where the ideas from the generalization are validated. If the ideas hold they might be included in the participant's knowledge.

Tactical Reasoning, Work Processes and Learning Goals

The learning goals in C3Conflict are focused around collaboration and tactical reasoning in the domain. The participants should be able to experience team work. The commander's task is to command and control the organization. This means that they should collect information from their subordinates and other sources of intelligence to develop an understating of the situation and its risks. Based on that they should define the task, plan and transmit orders to their subordinates, in order to direct and co-ordinate actions between the units. The process of sizing-up the situation can be described in three states, the current state, the evolution possibilities, and risk assessment. A goal with a training session can be to let the participants experience how it is to command and control the organization. The commanders should have knowledge so that they can collect proper information and co-ordinate the subordinate units so that they can regulate the target system. This means that the commanders need to know the characteristics of the organization, what resources exist and how they are related to different tasks that can be performed in the organization. Examples of training goals are:

Resources: How the resources behave when they are performing their tasks, in normal and critical situations.

Distributed Decision: Understand the decision process in the organization, how to exchange information with other persons in the organization, to understand the others persons needs and goals, and to understand the importance of shared frameworks and shared goals.

Communication: The communication in an organization is often critical. It is important to know the communication standards as map co-ordinates system, global positioning standards, etc. A training task can be to let the staff train using the terminology that exists in the domain.

Reconnaissance: One important task is to collect information about the situation. The commanders have the responsibility to collect and distribute information about the current situation. They should learn to use their resources for appropriate intelligence search.

Information Service: The commanders have the responsibility of having an overall view of the situation. They can learn to present this view to their subordinates.

Current State: The current state consists of environment information such as geography and city plans, where are the friendly units are and their status, the state of the citizens in different areas, information about the insurgents, etc. C3Conflict can be used to train commanders in the task of collecting data about the current state of the target system and organization so that they have enough information to make a proper situation assessment.

Evolution possibilities describe what can happen in the future.

Risks Analysis: It is important for the commanders to have the ability to analyze a situation and identify its risks. Some risks exist in the current state. Others may occur in the near future. Risk analysis is the connection between the evolution possibilities and task goals.

System Requirements

The main system environment requirements are:

Configurability: The environment can be highly configurative which makes it possible for the researcher to configure the system to meet the research goal. The players' organization and communication structures can be set up as wanted depending on that goal. The user interfaces and communication tools can also be individually set-up for all players. When the collaboration is mediated via the integrating communication systems, the session design will also be able to control some aspects the collaborative process.

Tractability: The tractability in the environment is high. The session designer can configure the environment so that relation and constraints are visible for the researcher. The data collected in the environment give the researcher a possibility to do performance analysis of the participants' individual and collaborative work.

Computer mediated activities: The control of the simulation, the usage of information tools and the communication can be done with the integrated systems that monitors and collects data about the participants' activity.

Engagement: The level of engagement for the participants is high. The simulation encourages participants to expend effort in the pursuit of their tasks**.**

Easy to learn: The operation of the environment is easy to learn. The players learn to operate the system so quickly that the researcher is able to train them and acquire good performance data in one three-hour session.

Dynamic Context: Decision making is carried out in a dynamic context in which an organization of participants work together to exercise control over a target system (e.g., an insurgent cell). Both the target system and the organization are complex and dynamic which change both autonomously and as a consequence of actions performed on them.

Distributed Decision Making: The decision task in the organization can be distributed over a number of participants, e.g., commanders and their subordinates. The decision making can be classified as team decision making where the members have different roles, tasks, and items of information in their decision-making process.

Time Scales: The participants' task can be defined so that the decision makers need to work at different time scales. A commander can work on tasks with a relatively long time frame such as strategic thinking and the co-ordination subordinates. The subordinates can be responsible for local, time-critical operations, such as conducting a cordon and assault mission.

THE ENVIRONMENT

The C3Conflict environment and the behaviors of the simulated objects are controlled by configuration files. The main parts in the C3Conflict environment that can be configured to fit the session goals are, the organization of the players, the communication possibilities, the resources, and the players' user interfaces. The goal for the session designer is to select the important characteristics of the real world and to create a small and well-controlled simulation that retains these characteristics. If the session is a training session, then some aspects of the created system can be made sufficiently realistic at some level of abstraction so that the players' experience can be transfer to the real world. If the session is a research session, then the range of actions performed by the players can be made to be similar to those they take in corresponding situations in the real world.

Player Organization

Players can be members of the same organization, e.g., the staff of a division-level C2 headquarters, or of different organizations, e.g., a friendly force or insurgents. The organization(s) can be hierarchic, flat (network based), or a mix. Figure 2 shows an example of a player organization in which one person plays the platoon leader, three play squad leaders, and another plays the leader of insurgents. The size of an organization can be freely configured with one to approximately 12 players depending on the speed of the computers being used. Every player can assume more than one role. The organization viewed in figure 2 are from a experiment performed at Fort Benning 2010, by NPS .

In addition to the players, a session manager and several session observers can join the session. The session manager can play external roles that direct training in the wanted directions. The session manager can also activate scripted messages that establish or modify goals, impose constraints, or issue directives during the session. The observers can follow the players' activities of the players and their communication but cannot intervene in the session.

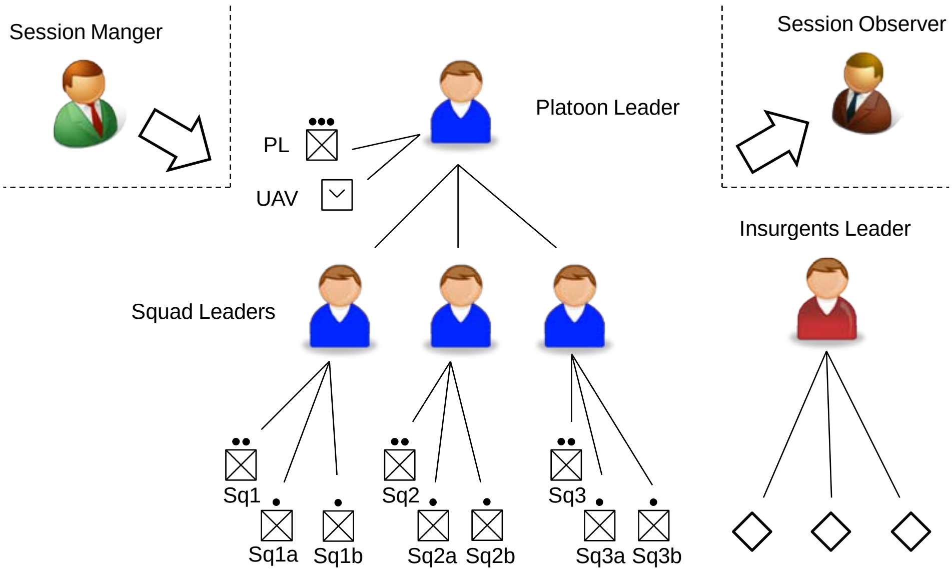

Figure 2: Example of player organizations.

Communication

In C3Conflict the players can communicate with e-mail, chat, with a distributed diary system and with symbols in the distributed map system. The communication tools are configurable to be able to support the session goals. The configuration defines who can communicate with whom including communication groups. For example, the platoon leader can be given access to a platoon net (for communication with superior officers) and a separate squad net (for communication with team leaders). Restricting team leaders to the squad net emulates standard squad- and platoon-level communications.

Mail, Chat: The mail and chat tools are the standard communication tools embedded it the environment. All information sent via these tools is logged and is subsequently available for protocol or content analysis. The session observer can follow all the messages exchanged in the mail and chat during a session.

Diary: The diary is a distributed tool that makes it possible to write diary notes in a shared diary. All players who have access to the diary can add and view the information. The inserted notes are sorted chronologically and marked to indicate who inserted the note. The players can be instructed to make notes about important decisions to designate critical incidents for subsequent review and or to flag events for the session observers and manager.

Map Symbols: C3Conflict presents a map of the area of operations. The images on the map can be road maps, satellite photographs, cartoons, and a maze. The distributed server-client architecture enables all players in a session have access to the same map, but not necessarily to the same information. The configuration can impose different limits on the availability of map-based information to different players. Players can also insert and delete symbols on the distributed map to communicate routes, designate way stations, or mark the suspected locations of insurgents to the other players that are in the same map information group.

Resources

The resources used by the players are defined in the configuration file. Resources can be mobile or fixed. Mobile resources are called ‘units’. A unit can represent a rifleman, a rifle team, a squad, a platoon, or a vehicle (in any combination) that can move around in the world shown on the map. Examples of fixed resources include ammunition dumps and fueling stations. The session designer can tailor every unit’s abilities and characteristics. Examples of basic abilities include ground locomotion, flying, recognizing information, creating trust, agitating the local population, providing aid, evacuating civilians, and destroying other units. Some activities are automatically triggered during the simulation. Others need to be activated by the player who controls the unit. A unit can be controlled by only one or by many players.

Tasks

Tasks that can be performed by the friendly force:

Reconnaisance: The friendly force can patrol the area.

Create Trust: The friendly force develop a relationship of trust between the civilians and the friendly force. When the civilians have trust in the friendly force, the insurgents can no longer create the mistrust that makes the civilians hostile to the friendly force.

Give Aid: The friendly force can give aid to the civilians. The aid can turn angry civilians into neutral bystanders or develop trust between neutral civilians and the friendly force.

Evacuation: The friendly force can transport civilians from one location to another. A common mission in our experiments is to achieve the goal of transporting ill or wounded (hostile, neutral, and/or trusting) civilians to a health center.

Find and destroy: The friendly force can destroy the insurgents.

Transport: Units or convoys that transport resources such as aid, fuel, or ammunition.

Tasks that can be performed by the insurgents:

Agitate: The insurgents can make the civilians angry and lead them to mistrust the friendly force.

Find and destroy: The insurgents can kill the friendly forces.

Simulation dynamics

When designing a session it is important to test the system to understand its behavior. Due to the opaque nature of the interactions between units, a small change in a few of the parameters that control a unit’s behavior can result in a large change in the dynamics of the whole system. The opacity of feedback loops emulates the dynamics of most C2 situations. Often, the only way to verify the dynamic behavior of the system is to have a group of people play a session.

Scenario

To create a proper session, the designer needs to define events that are activated during the session, either automatically at prescribed times or by the session manager when events dictate. The scenario file lists those events that will affect the session at a specified time. Typically, these events are text messages sent by ‘headquarters’, ‘intelligence officers’, or some other external actor outside the players’ organization. Another type of scheduled event can be the agitation of a particular group of civilians that produces anger or mistrust in the friendly force.

USER INTERFACE

The user interface in the C3Conflict system is composed of three main parts: 1) The map, object and symbol palettes, 2) unit information and control panels and 3) communication panels, (Figure 3). All user interface parts can be individually set-up for every player.

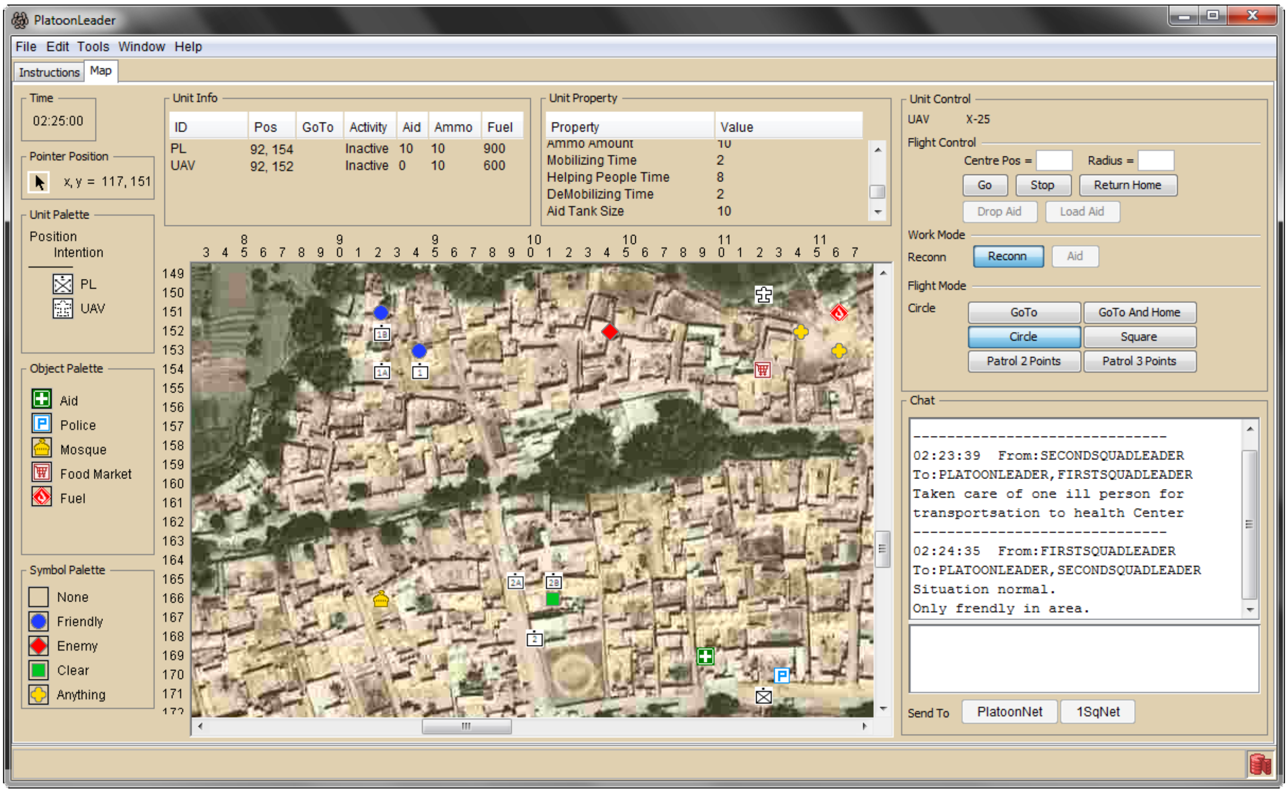

Figure 3. Example of a players user interface.

Map and Map Objects

The map system consists of a 2 dimensional matrix of cells, normally with a size 250x250. The physical dimensions represented by the cells are determined by the image shown on the map. In previous experiments, they have been as small as 5 meters or as large as several kilometers on a side. The map consists of a background image selected by the session designer. Based on that image the session designer can assign different rates of movement to different cells. For example, in the image of Figure 2, travel can be made significantly slower in cells containing buildings and faster in cells the cover roads. The map system has object and unit layers that show objects and units on top of the map image (Figure 4). The session designer can define where the objects should be located on the map and which of them should be visible and invisible at the beginning of the session. Objects that are invisible at start-up become visible only if they get in the visual field for some unit, team or UAV.

Communication with Map Symbols

The map system in C3Conflict supports symbol communication between the players. The session designer can define which players can share information. Players who have a shared map can drop and drag symbols that become visible for all players with the shared map. The session designer assigns palettes of symbols that the players can use in their communication. Figure 5 shows sample objects and affiliation symbols that the players can use to mark the threat status of the civilians in the area.

Figure 4. Example of objects.

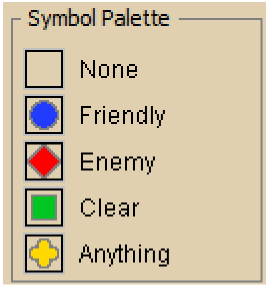

Figure 5. Example of map symbols.

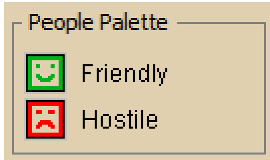

Figure 6. Example of civilian people

Civilians

The friendly force can develop a relationship of trust between the civilians and the friendly force. Figure 6 shows an example on the state of the civilians. The friendly force can give aid to the civilians (Figure 12). The aid can turn angry civilians into neutral bystanders or develop trust between neutral civilians and the friendly force. Insurgents can create the mistrust that makes the civilians hostile (Figure 11). When the civilians have trust in the friendly force, the insurgents can no longer create the mistrust that makes the civilians hostile to the friendly force. The friendly force can also evacuate civilians (Figure 9).

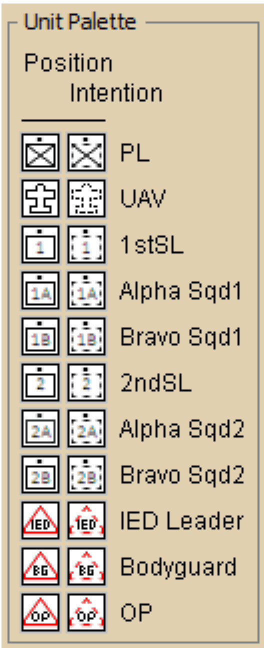

Figure 7. Example of units.

Figure 8. Example of a unit aiming.

Units

Units are mobile resources such as a vehicle, a group of people, a helicopter or an UAV etc. The session designer defines the number and type of units, their abilities, and properties. The designer also assigns units to the players who are to be able to control them and specifies who should receive the information that the unit observes. More than one player can control the same unit and the information by a unit can be send to more than one player. The units' designations and icon can be freely selected. Figure 7 shows example of resources and their icons. The units- movement, aiming, and shooting are controlled by mouse commands (Figure 8).

Players can observe their units' current state and activity in the unit information and unit property panels. Some of the activities are automatically controlled by the simulation. Others need to be activated by the player who controls the unit. Example unit control panels are shown in Figures 9 to 12.

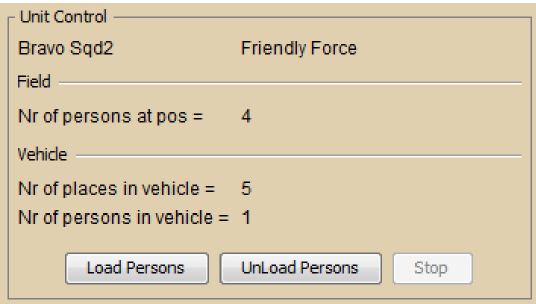

Figure 9. Person transportation control.

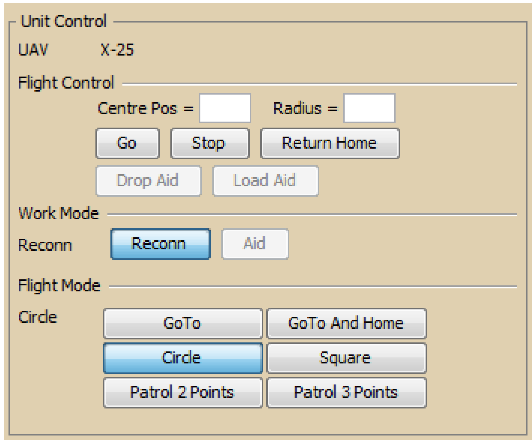

Figure 10. UAV control.

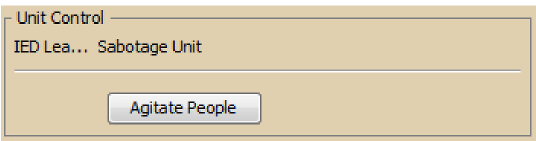

Figure 11. Agitate people control.

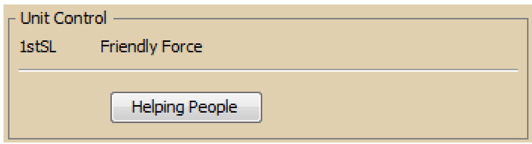

Figure 12. Helping people control.

MONITORING

To be able to analyze the collaborative work in the C3Conflict environment computer-based monitoring are used. The monitoring is integrated in the simulation and all the information tools used by the players. During a session, the C3Conflict system creates a log with all events in the simulation and all computer mediated activities. Figure 13 shows a view of the log process. The monitoring system logs information from the simulation about the current activities in the simulated world. It also logs information about individual work, in terms of marks in the personal map, and on the collaborative work in terms of information about the email and chat communication and the use of the distributed diary.

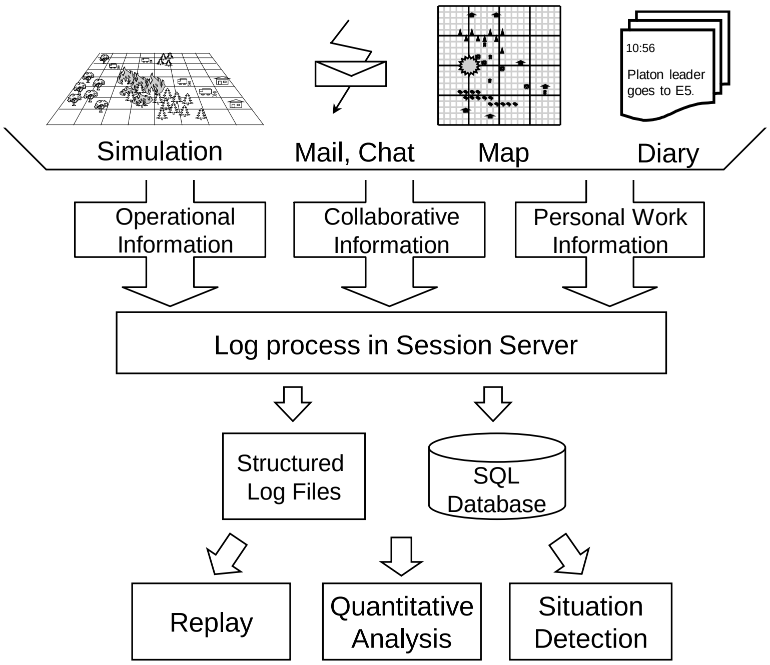

Figure 13. The log process in C3Conflict.

At the conclusion of a session, the log is centralised on the session server. It can then be used in three main ways: quantitative analysis, situation detection and session replay. The session replay function and some quantitative analysis are integrated in the C3Conflict environment while situation detection and advanced quantitative analysis are supported by the generated log information. The log information is stored in structured log files and SQL database which make it possible for the researchers to process the session information in a rigorous manner.

Session Replay

Using the replay function, the training manager and the students can perform a play-back of the whole session. The main reason for having a session replay function is that research on simulation-based and collaborative training shows that the reflection stages after a session increase the transfer effects and are an important step in a training process (Rankin et al. 1995; Reigeluth et al. 1987). The replay used in an 'after-action review' provides a good opportunity for the players to discuss their view of the situation and compare their views with that shown in the replay.

Quantitative Analysis

C3Conflict enables quantitative analysis of both process and outcome data pertaining to the players' performance and collaborative work. Both the simulation and the information tools are sources for these analyses. Examples of simulation data include the positions and activities of units, the usage of resources, and the civilians' reactions. These data are commonly use to assess players' performance against some standard. The information tools in the C3Conflict system are the map system, the email, the chat and the diary. Examples of data from these tools include the type and time for all communications, the locations and types of symbols displayed on the map, the time and content and sender and receiver(s) of every email and chat message and the time, creator and content of every inserted diary note.

Situation Detection

The goal of situation detection is to enable the detection of predefined micro- or macro-situations in the simulation. A situation can be a pattern describing a set of states and time relations. The situation detection can be used if the session designer can define the set of situations to be observed in a session. Such detection can be a useful tool in supporting educational strategies. A typical detectable situation is unit separation in critical areas. The system can detect and record whenever the distance between specified units becomes too great.

CONCLUDING EXPERIENSES AND ANALYSIS EXAMPLES

C3Conflict is a new environment and has recently started to be used. Some experiences from the first experiments exist but large set of experience exist from the C3Fire environment, which is the same type of environment. Examples on analysis goals that can be performed on the log information generated by the C3Conflict system are: the effectiveness of the teams, the information distribution in the team, and the teams work and collaboration methods.

Effectiveness of the Teams

One way to evaluate the sessions and see if the team has performed well is to use some kind of scoring system. A scoring system should change depending on the goal and the task given to the players. A typical scoring in the C3Fire system is to count the burned down area and destroyed objects. The weakness of this type of scoring system is that it may not capture other requirements on the team than fighting the fire. In real life a command team has other responsibilities, having backup resources, not putting the resources in to big danger, creating an activity diary, responding to incoming information from outside the organisation, etc.

In the research project "The impact of GPS based GIS on professionals during a collaborative emergency response task", (Granlund et al. 2011a), a phenomenon of measuring the effectiveness of teams was detected clearly. In this study the effects of a decision support tool was studied. Both university students and professionals were used as subjects. The environment was C3Fire with a forest fire domain. The simple measure of the success and performance of the team is a measure of the total amount of burned down area at the end of each simulation. A small amount on BurnedOutArea is preferable to a large (Figure 14).

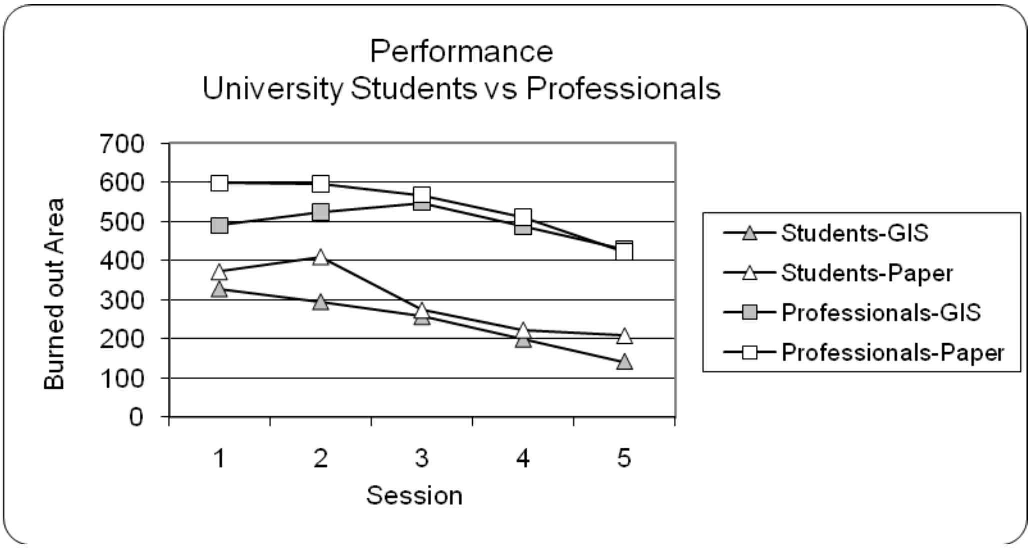

Figure 14. Students vs Professionals as subjects.

An observation when comparing the performance measure in results is that the students do perform better in terms of BurnedOutArea than the professionals.

The performance situation here is slightly different for the two groups. Students have none or a very limited experience of crisis management, paper maps or GPS. The students appreciated the game, appreciated to beat the game and found satisfaction in their group performance.

The professionals have a solid experience base to use when managing these kinds of efforts, especially when the means are paper maps. Their experience, skills and methods for crisis management make them connect the game to command and control aspects as well as crisis management in general. Situations that occur during simulations are close enough to their rough everyday responsibilities during response. They use the time for team and individual training. They appreciate the game as a means to find winning concepts from a response perspective.

Three possible explanations for the students over all better performance are computer game, professional experience and team composition. 1) **Computer game**: The students have more experience from playing computer games than the professionals. A larger set of students did see the problem as a computer game task that they should solve. Win the game was often the goal. 2) **Professional experience**: The professionals did behave as professionals when solving the task. They knew that their behaviour was observed and analyzed in a research project. They used the strategies that they were use to do in real life, like not using all the resources directly, discuss before acting, etc. They did see the simulated task's similarities to a real situation. They did not try to win the game as a game; they tried to do what they should have done in a real situation. They could relate the events in the simulation to their profession. Hence they practiced and reflected on strategies that they utilize in real life.

Information Distribution

One way to analyse the players is to observe how they collaborate. This can be done by analysing the communication between the players. Examples of analysing the communication and co-operation are to perform flow analysis and message classification of the email. When using message classes as commands, reports, questions, etc. it is possible get an indication of the collaboration process used by the players.

Typical mail classification are (1) Questions about the environment, (2) Questions about others activity, (3) Information about environment, (4) Information about own activity, (5) Information About other persons activity, (6) Mission order, (7) Direct order, (8) Request for help, (9) Request for clari-fication, (10) Acknowledgment on info or order, (11) Misc-ellaneous. (Figure 15).

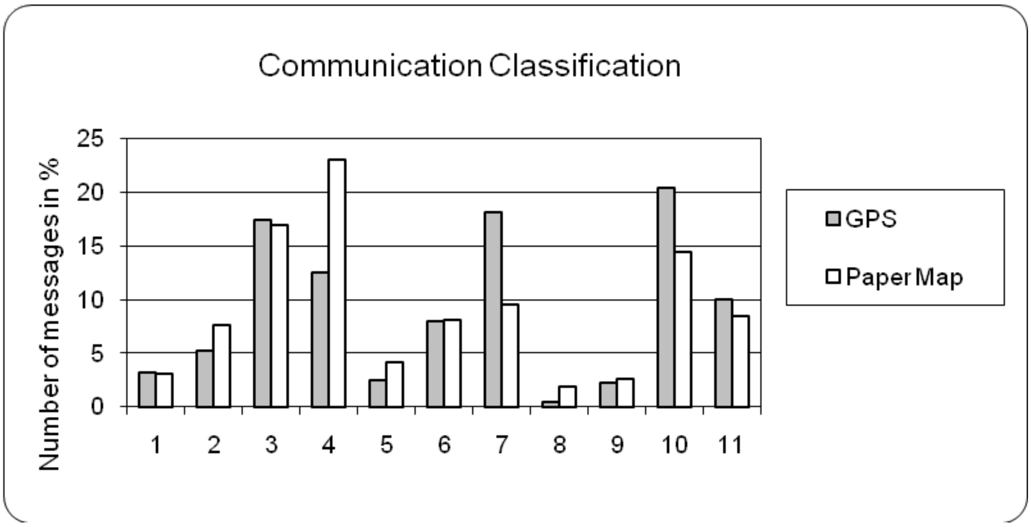

Figure 15. Message clssification.

Work and Collaboration Methods

If message classification methods are used it can be possible to detect the players work and collaboration methods. An example is to analyse the distributed decision making and detect who is doing what decision when. In the research project "The impact of GPS based GIS on professionals during a collaborative emergency response task" the response time was measured (Granlund et al. 2011b). When comparing the response time for teams that has advanced support tool compared with teams that did not, it did show that in some settings the team with the support tool did perform less good than them with no support tool.

The response time measurement was the time from alarm to that the first response activities has started and it indicates the behaviour learned by the ground chiefs (Figure 16). The results show that the ground chiefs in the two different conditions have adapted a routine on how to respond and that the routine differ depending on condition. The ground chiefs in the Paper Map (No support tool) condition have learned to "detect fire – inform the command post – act". The effectiveness of the first response depends on the actions of the ground chiefs. The ground chiefs in the GPS condition did not initiate first response and did have a longer response time. They did await orders from the commander "detect fire - inform the command post – await order - act". This indicates that the proposed decision support tool can in some situations chance the behaviour in the organisation that is not wanted.

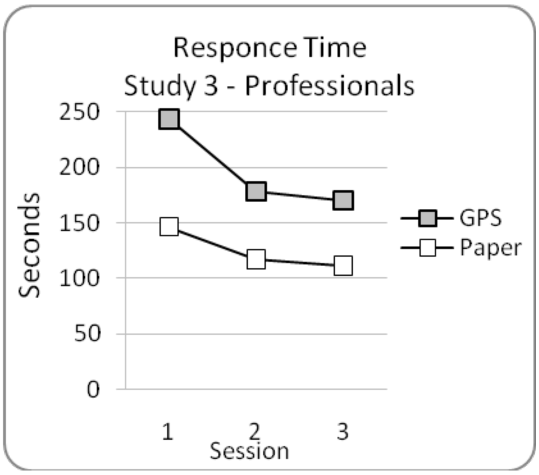

Figure 16. Response time.

Experiences from C3Conflict

The C3Conflict environment has been used by Naval Postgraduate School, Monterey USA (Smith 2011; Smith & Evangelista 2011) and in a recent experiment conducted by NPS at Fort Benning USA. Analyses of these data have included classifying events into nominal categories, e.g., into categories of verbal directives delivered using the chat tool, content analyses of the purpose of those directives, statistical analyses that contrast outcomes across experimental conditions, frequency analysis of specific maneuvers, time-series analysis of the lag in response to directives, and other quantitative measurements.

A single C3Conflict experiment can address a multitude of research hypotheses. For example, we used C3Conflict to assess whether and how the distribution to rifle teams of emergent wireless technology would benefit six types of mission-relevant C2 actions: coordinating unit navigation, emplacing and adjusting tactical positions, conducting precise operations, reinforcing an engaged unit, communicating during movement, and promoting team leader autonomy. To this end we developed an interface that emulated the information available to a soldier enabled by the technology and an interface that emulated the legacy system. In a between-groups experiment, we tested 18 hypotheses and were able to confirm 10. The effect sizes for the supported hypotheses were sufficiently large with only 5 groups of soldiers in each condition to obviate the need for additional data collection. In contrast, the effect sizes for the rejected hypotheses were so small that they precluded additional data collection. In sum, C3Conflict made it possible to test multiple hypotheses simultaneously and to discern which of the hypothesized benefits are likely to be observed in the field and which are not. The identification of the benefits enjoyed by soldiers who received the emergent technology is a valuable contribution to decisions regarding system development, acquisition, and the basis of issue.

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