INTEGRATING COMPLEMENTARY VIEWS ON AN EXERCISE INTO AN OBJECTIVES-BASED TRAINING SUPPORT TOOLSET

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ABSTRACT

A significant trend in the use of synthetic environments for military unit training is to move away from using generic scenarios that cover a multitude of training objectives. Instead, dedicated scenarios are designed that cover a smaller set of specific training objectives. A few tools exist that support the development of scenarios tailored to these objectives and the collection of data for an after-action review based on the objectives. For real-time monitoring of the exercise however, most environments use a standard set of tools, e.g. plan view display, 3D stealth and ORBAT (ORder of BATtle) Browser. These tools only provide a generic view on the exercise. Specific information necessary for evaluation of the training objectives is often not present or only available after time-consuming manual adjustment of the tools.

This paper reports on the definition of a training support toolset that uses training objectives as a framework. The toolset enables the instructional staff to focus on training objectives during all stages of the lifecycle of an exercise: definition, preparation, execution and review. The current emphasis is on the execution and the review stages.

The paradigm for the approach described in this paper is to regard the training support toolset as a set of complementary views on the synthetic environment. Each view is optimised to display certain types of entity information, e.g. position in the battlefield, force hierarchy or vehicle status. To support the evaluation of a particular training objective or group of objectives during an exercise, the toolset is configured for the instructional staff as a dedicated set of views, enabling them to retrieve the necessary information.

Two other guidelines used for the construction of the toolset are the presentation of additional information as overlays over the views, and the use of system-wide controls that influence all relevant views in the toolset. The paper gives examples that show how the toolset allows the members of the instructional staff to retrieve information on entities in an effective and efficient way.

The instructional staff uses the information obtained to build a common mental picture of the performance of the trainees by evaluating the training objectives during the execution stage. They can provide on-line feedback, or store the information for use in an objectives-based after-action review.

The approach is applied in co-operation with the Royal Netherlands Army to prototype training support tools for tactical training environments. One of their main interests in this approach is to conduct high-quality training exercises with a relatively small instructional staff.

Biographies

Jan van Geest is a scientific researcher in the Training and Education Group of the TNO Physics and Electronics Laboratory (TNO-FEL) in The Hague, The Netherlands. His responsibility is the functional definition of training support tools for virtual and live exercises. He is interested in merging instructional requirements and technical opportunities into effective, user-friendly software. Jan van Geest is a graduate of the Delft University of Technology.

Rudi Gouweleeuw graduated in Artificial Intelligence at the Free University, Amsterdam. Since 1990 he works as a scientific researcher in the division "Command & Control and Simulation" of the TNO Physics and Electronics Laboratory. His work is concentrated on research and specification of training simulators, with special interest in instruction support and Computer Generated Forces. He is consultant to the Materiel Command for the Tactical Indoor Simulation (TACTIS) project.

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INTRODUCTION

Tactical Team Training

Tactical team training with the aid of simulation, live, virtual and constructive, is a rapidly developing area. Much effort is directed to the construction of simulations, data exchange architectures and protocols, etc. However, a simulation can be as realistic as technically possible, an important factor in the effectiveness of the training is the quality of the scenario, and of the feedback that the instructional staff is able to provide to the trainees. This paper focuses on tools that support the instructional staff in a tactical team training exercise using virtual simulators. Compared to traditional ways of tactical team training the instructor of a virtual simulation exercise is in an advantageous position. Information about almost anything that happens on the battlefield is available in some form. However, this ocean of data easily leads to an information overload of the instructor. This may force the instructor to limit his attention to the rough outlines, missing vital information. Therefore, a framework for structuring the information is needed. The toolset presented in this paper uses training objectives as a framework during all stages of the exercise life cycle.

Exercise Life Cycle

The life cycle of a tactical team training exercise is defined for this research effort in four stages:

- Definition
- Preparation
- Execution
- Review

The tasks of the instructional staff of an exercise in these stages are envisioned as follows: based on a set of training objectives obtained from a curriculum or from the unit to be trained, a scenario and a Training Support Package (TSP) for the exercise are developed. The events, terrain, weather etc. in the scenario are all related to the training objectives. In particular, each event that is defined should be related to one or more training objectives. Based on the objectives and on the data needed for their evaluation, a toolset for the instructor is composed that will be used during the next stages. During the preparation stage, the scenario and TSP may be tailored to specific training requirements of the unit to be trained. In this stage, the instructors may also brief the training objectives to the trainees. In the execution stage the instructors have the training objectives at hand and make observations in relation to these objectives. Alerts are generated to notify the instructor of events that are important in the context of the objectives. The observations that the instructor enters during the execution stage, together with the pre-defined events form the basis for a structured After Action Review (AAR). Since observations and events are stored in relation to the applicable training objective, an AAR and/or Take Home Package (THP) that is structured by these objectives can be generated shortly after execution. In this way, the instructional staff can provide effective feedback to the trainees.

Training Support Toolsets

As a training support toolset we define the collection of tools that support the instructional staff during one or more stages of the exercise life cycle. The tools are primarily software applications that have a Graphical User Interface (GUI) that is displayed on an instructor console, often referred to as Instructor Operator Station (IOS). In currently operational simulations, the toolset is often a mix of several applications that have a separate goal and GUI. Examples of these applications are a 3D stealth view, statistics, a Computer Generated Forces (CGF) generation application with a plan view display, etc. The functionality of these applications is often based on technical drivers and often not co-ordinated between the applications.

To execute the educational process correctly, it is essential that exercises are tailored to the selected training objectives and that the achieved results are presented to the trainees. The training support toolset supports the training staff in these tasks and thus, to a larger extent, determine the effectiveness of a training simulator. A training support toolset does not replace the operational and didactical qualities of the training staff. The instructors will remain domain experts who perform their tasks in areas where the training support tools are (still) inadequate.

The Goals

The main goal of the research this paper reports on is to define a training support toolset that supports the training staff effectively and efficiently in all stages of the exercise life cycle.

One of the main interests of the Royal Netherlands Army (RNLA), as the major sponsor of this project, is to conduct high-quality training exercises with a relatively small instructional staff. The better the toolset supports the staff in its tasks, the fewer instructors are needed for an exercise to achieve the same training value. The needed quantity of the training staff is inversely proportional to the quality of the training support tools, thus determining the efficiency of a training system.

The foremost challenge of the research area is to present the right information, in the right format, at the right time, to the right person (in the event of a training staff consisting of multiple persons). To assess the performance of the trainees, it is essential that the tools provide information that is geared to the training objectives, in terms of operational variables and quantities. Furthermore, the provided information must be presented conveniently, using suitable (combinations of) media such as graphics, overlays, audio, video, text etc. To avoid overwhelming the training staff with information or having them continuously search for information themselves, the toolset should interpret the information to some extent and provide it only at relevant moments.

In the current practice, every training system has its own training support tools, with their own characteristic properties and interfaces. This research strives to standardise the support tools for the different training systems. Through standardised training support tools, the training staff can easily be employed on different training systems. In addition, the trainees benefit since the training process and feedback can be conducted in a similar way.

Special attention is paid to the user friendliness and accessibility of the toolset, because the military instructors are not often computer and simulation experts and they have a limited posting of three years (in the RNLA). These reasons argue for tools that require minimum training effort before maximum results can be achieved.

The research effort is conducted in two parallel tracks. One track defines a concept for the definition of instructor support toolsets, the other track implements a toolset based on the concept. This is done in an iterative way, so that each track profits from the knowledge and experience acquired in the other track. Currently, a prototype toolset has been built for a mixed cavalry and infantry training system on the platoon and company level.

The present focus of the research is on the use of the toolset during the execution and review stage of the exercise, which are extensively supported. The definition and preparation stages are supported partially.

Although the concept is currently applied to virtual simulations for the army domain, the use of the concept and of the toolset being discussed is certainly not restricted to this domain and/or this form of simulation.

Contents

The remainder of the paper is structured as follows: initially, the concept that was developed is described. In particular the four guidelines for the development of training support toolsets are elaborated, followed by the implementation of the concept in a prototype toolset for a virtual simulation. Finally, the set-up and results of user evaluations of the toolset are discussed.

THE CONCEPT

Guidelines

To achieve the required effectiveness and efficiency mentioned above, a new concept for training support toolsets has been formulated. In order to guarantee effectiveness, training objectives are the framework for the toolset. In essence, all effort of the instructional staff and of the trainees has to be related to the training objectives for the exercise, and the toolset should support this.

To achieve efficiency of use a new paradigm for the toolset has been chosen: the toolset is composed as a set of complementary views on the exercise, each view with its distinct way of displaying the elements of the synthetic environment. Each view presents particular types of information that are inherent to that view, such as entity position, terrain features, hierarchy, vehicle status information etc.

Information about the battlefield that is not inherent to a particular view is displayed as an overlay over the views of the toolset. With the use of these views and overlays, the user can retrieve information about the exercise in rapid and consistent fashion.

Another guideline for efficiency is that the user has a compact set of controls that influence the entire toolset. In this way, the toolset is controlled as a system, as opposed to a set of independent applications. This significantly decreases the time it takes to retrieve information.

Summarising, the concept that is defined for the development of training support toolsets consists of four guiding principles:

- the toolset supports the use of training objectives;
- the toolset consists of complementary views on the exercise;
- additional information is presented to the user as overlays over the applicable views of the toolset;
- the toolset is controlled by a compact set of system-wide controls.

Each of the guiding principles is discussed in more detail in the following paragraphs.
The toolset can be configured to the training objectives for a particular exercise, and to the role of a specific member of the instructional staff (e.g. observer/trainer for a cavalry platoon). For large, complex exercises, it may also be configured for each phase of the exercise. The user has easy access to the elements of the toolset that he needs for that exercise or phase. All other elements remain available but require more actions of the user. In this way, the toolset is focussed on the objectives, and all functions that the user needs for the execution of his tasks are directly at hand.

Training Objectives

Training objectives are used as a framework for the definition and use of the toolset. For this research effort training objectives are defined as tasks that a person or team should be able to execute under given circumstances. The task lists could be defined for example in the Army Training and Evaluation Plans (ARTEP), that are present in the TRaining Exercise Development System (TREDS). The circumstances for the execution of the tasks are defined by the scenario, and by the mission that is given to the crew in the scenario as described in a Training Support Package (TSP).
Methods such as those based on Instructional Systems Design (ISD) or as described in the Handbook of Simulator-Based Training emphasise the importance of these objectives both for the acquisition and definition of simulation environments and for the development of exercises and scenarios. The training support toolset described in this paper joins in these methods by using their output products such as a task analysis.
A trend in the use of synthetic environments for military unit training is to move away from using generic scenarios that cover a multitude of training objectives. Instead, dedicated scenarios are designed that cover a smaller set of specific training objectives. In this way the training can be built up step-by-step, and better tailored to the experience level of the audience.
The use of training objectives is supported explicitly by several views, and implicitly by the entire toolset by providing that information that the instructor needs to evaluate the training objectives in a direct way.

Views

The toolset is composed as a set of views on the exercise. Each view displays what is going on in the exercise from a different perspective, and has different types of information that are inherent to that view. For example, one view is based on a 2D map, the other on the hierarchy of the participating forces etc.
The views are designed to be complementary; i.e. the overlap of information that is inherent to the view is kept to a minimum. This facilitates that the user becomes easily acquainted with the system, and rapidly knows where to look for certain information. It also prevents the views from becoming overloaded with redundant information. The views that are presented to the user for a particular (phase of the) exercise depend on the training objectives, and on the role of the user.
The views can be displayed on a console consisting of multiple monitors. The configuration of the views depends on their number and their size, and on the number of available monitors. The views can all be operated by the same mouse and the same keyboard.

Overlays

The views mentioned above form the basis for the toolset. They display basic information that is inherent to the different views. Information that is not inherent to one of the views, but is necessary in the context of the training objectives, is presented to the user in the form of overlays over the views. That is, it is displayed in one or more views that are capable of representing the information. For example, lines-of-sight between entities may be displayed in both the 2D and the 3D stealth view. Unlike the inherent information presented in a view, the overlays are only displayed when needed by the user. One option to do this is via the system-wide controls described below. Alternatives are also studied. For example, an overlay presenting the sectors that are covered by the sensors of the vehicles in the battlefield could be displayed as soon as this is necessary to evaluate the training objectives of a particular phase in an exercise. This would provide an even easier interface to the user. However, for complex exercises a danger is that the views become overloaded with information, or that the conditions for the automatic display of overlays are difficult to define.

Controls

The fourth guideline concerns the way the system is operated by the user. Where in current systems each tool has its own user interface, the toolset described in this paper has a user interface that controls it as a system. This means that a -relatively small- set of controls is available for the user. Each control influences all relevant views that are present in the system. For example, when an entity or group of entities is selected in any of the views (by clicking the mouse pointer on it), this is a system-wide selection. This implies that the entity is displayed as selected in all views.

Once a selection is made, the user can give one of the system-wide commands to be applied to the selection, for example focus on the entity, follow the unit, or display the details (vehicle status, sensor views) of the selection. In addition, commands to display the different overlays are available. Another category of commands consists of those that allow the user to handle events, for example by focussing the different views on the entities that were involved in the event.

THE TOOLSET

Implementation

The concept described above has been applied during the implementation of a prototype toolset for a platoon and company level tactical virtual simulation for the army. As indicated above, the toolset consists of views, overlays and system-wide commands. Each of these elements is elaborated in the paragraphs below. The toolset can be configured to the training objectives for a particular exercise or phase.

Views

The concept described above is currently implemented in a prototype toolset for a company-sized tactical army trainer. The next paragraphs describe the views, overlays and commands that are part of the toolset.

Training Objectives View: allows the user to define the training objectives for each phase of the exercise during the definition stage. The objectives can be defined as a list of tasks that have to be executed under given conditions. The task list can be based on a master task list for the unit to be trained. The tasks can be structured in levels. For each phase of the exercise, a different set of tasks can be assigned. The conditions in which the tasks have to be executed, for example pertaining to the terrain or the opposing forces, are also defined per phase. Finally, for each objective it is possible to define performance measures that apply to the training objectives. A differentiation can be made between standard performance measures for a task and performance measures based on specific conditions.

The view is used to brief the trainees as well as the instructional staff in the preparation stage. If necessary, the objectives can be tailored to the specific needs of the unit to be trained. During the execution stage, the instructors keep the objectives for each phase at hand to ensure a systematic evaluation. The view is used during the review stage to conduct an after-action review structured according to the training objectives that were briefed prior to the exercise.

Events View: this view allows the user to handle events in the exercise. Two kinds of events are discriminated: events that are automatically detected by the simulation, and events that are inserted on the initiative of an instructor. In the definition stage the user can choose from a list of events that may be automatically detected, for example the crossing of phase lines, or the first time an enemy is within the field of view of a vehicle sensor. Events on the initiative of the instructor can be inserted at any time. All events should be explicitly related to one or more of the previously defined training objectives. Further attributes that are stored with an event are: the vehicle(s) or unit(s) that is (are) involved, the time and, if necessary, position.

The instructor is alerted during the execution stage as soon as a pre-defined event takes place. He then has the option to view the event, to store it for the review stage or to discard it. Viewing an event implies that the set-up of the views and overlays is optimised to view the event. In the review stage the events/observations can be sorted on each of the attributes, e.g. chronologically or by training objective. Especially the latter way of sorting is useful for a structured AAR. In this stage the instructor may also view the event, implying that the logger is forwarded to that point in time, and the other views are set up as would be done in the execution stage. This may be used to show particular events in the AAR.

2D Map View: displays to the user the battlefield in two dimensions on a map. This view has earned its merits, and is one of the classical views in simulation environments. The view is suitable for displaying many information types, as defined in the overlays.

3D Stealth View: the other classical view in simulation environments. Provides view of the battlespace as from a video camera. Like the plan view display, this view offers many opportunities for the display of information in overlays.

Order of Battle View: displays the hierarchy of the entities participating in the exercise. Since training objectives for tactical exercises often apply to a unit that consists of multiple entities, this view offers a good insight in the exercise to the instructional staff. It is also used extensively to select entities and units in order to provide control commands to the other views (see controls).

Entity Sensors View: displays the battlefield as from one of the sensors of a particular entity. The user can select one of the available sensors or visual sights of a vehicle.

Status View: provides details about the status of an entity or unit. For example, the operational status (alive, mobility-kill etc.) is displayed, and can be changed by the user. If applicable, status information of the various controls (switches etc.) of an entity is displayed.

Chronological View: this view displays a chronological overview of events that happened in the exercise. All events can be displayed, or only a selection of events (filtered on training objective, vehicle etc.). This view is suitable for analysing the co-ordination of actions in the exercise, and for selecting events for replay in the after-action review.

Overlays

Overlays that can be presented over the different views are described below.

Communication Overlay: displays which entity sends a radio message, and which entities are able to receive.

Lines of Sight Overlay: shows what part of the terrain could possibly be seen by a selected entity or unit if their sensors were looking into the right direction, and what entities are within that terrain.

Lines of Observation Overlay: shows what part of the terrain is actually covered by the sensors of an entity or unit. The overlay also displays which entities are visible in the sensors.

Observation History Overlay: displays the sectors that an entity or unit has covered during a time span.

Position History Overlay: displays the route that entities or units have travelled during a time span.

Controls

The user has several controls to influence the toolset. They influence each view if applicable, so the user only has to give one command, instead of giving a separate command to each application. Possible commands are:

Select: selections can be made in any view. A selection that is made in one view applies to the entire toolset. This implies that the selection is highlighted in every view. Apart from the highlight, nothing happens upon selection. Selections can be made on entities, units and on geographic positions.

Figures 1, 2 and 3 illustrate the system-wide selection. In these figures one main battle tank (designated as 600A12) has been selected. As a result a yellow rectangle highlights this vehicle in the Order of Battle View, in the 2D Map View and in the 3D Stealth View. The selection could be the result of a mouseclick on the representation of the vehicle in any of these views.

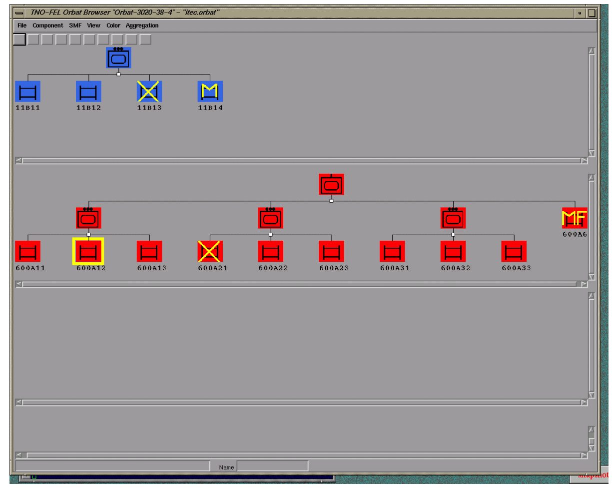

Figure 1. Vehicle 600A12 in the Order of Battle View.

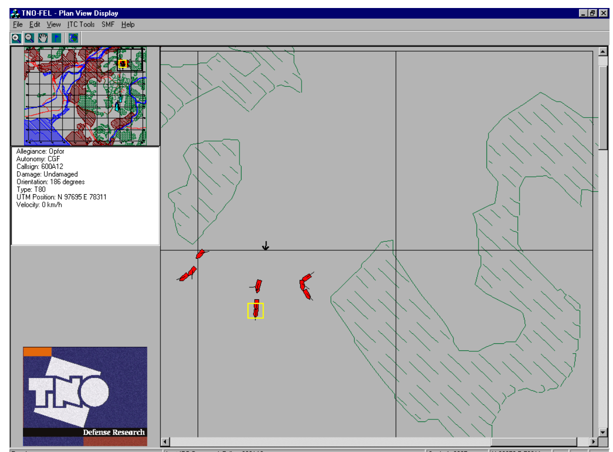

Figure 2. Vehicle 600A12 in the 2D Map View.

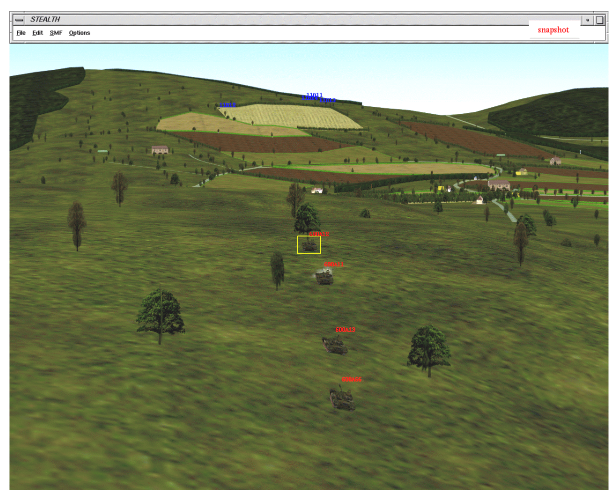

Figure 3. Vehicle 600A12 in the 3D Stealth View.

Once a selection is made, one of the following commands can be given.

Focus Selection Command: all applicable views in the toolset are set-up in a way that the selected entity, unit or position is visible. This is a one-time change.

Follow Selection Command: the same command as the focus command, but the selection is kept in focus continuously.

Show Details of Entity Command: this command allows the instructor to virtually jump into the selected entity. He has the opportunity to see the battlefield as from one of the sensors of that entity via the entity sensor view. In addition, the status view of the entity is displayed. This command is used for example by an instructor whose primary task is to monitor a platoon, but in some cases wants to see what is going on in a vehicle.

Figures 4 and 5 illustrate the Show Details of Entity Command applied to a main battle tank designated as 11B12. As a result of the command some operator panels are displayed, as well as visual sight of the vehicle commander.

Figure 4. Operator panels of vehicle 11B12.

Figure 5. Visual sight of the commander of vehicle 11B12.

Handle Event Commands: allows the user to respond to an automatically detected event alert (store, view, edit or discard it), or to enter an event/observation on his own initiative.

Switch Overlay On/Off Commands: enables the user to switch an overlay on and off.

USER EVALUATION

Exercises

In order to get feedback from potential users, exercises and demonstrations are organised with the objective to evaluate the toolset. More exercises are planned in the near future. For the definition and preparation of the exercises, the toolset was frequently used together with the user to set up and test the exercise scenarios.

In the exercises a mix of virtual simulators and computer generated forces (CGF) was used.

The toolset was evaluated for its use by platoon observer/trainers during both platoon-sized and company sized exercises, and for an observer/trainer at the company level.

Lessons Learned

The exercises have yielded a large deal of lessons learned with respect to the concept, the toolset and its use. The main lessons learned are:

- *The system-wide commands offer great improvement in the ease of control of the toolset.* The system-wide selections make it easy to recognise entities in the different views. The follow command ensures that an entity or unit that falls within the responsibility of an instructor is visible in all the views. It also provides the flexibility to jump instantly to another unit or entity for a moment, and back. The entity details command was used frequently to gain insight in problems that occurred at the vehicle level.

- *Training objectives are a good basis for the definition, monitoring and evaluation of an exercise*. By relating the elements of the scenario to the training objectives the training was effectively focussed. During the execution stage, the objectives were systematically checked, and many observations were made related to the evaluation of the objectives. In this way, the evaluation of the trainees was clearly related to the objectives. They were based on traceable facts in the scenario and not only on what happened to meet the eye of the instructor. Another benefit of the use of training objectives is the common picture that all members of the instructional staff gain about the performance of the trainees. However, the construction of a well-defined set of training objectives is a substantial effort that has to be done by subject matter experts.
- *The evaluation of training objectives was well supported by the toolset*. The training objectives view supported the systematic evaluation of the training objectives, and was used extensively during the execution stage. The observations were entered in the events view, and almost all observations were actually related to a training objective. In the review stage the observations, sorted by training objective, by vehicle and/or chronologically, helped to gain good insight in what actually happened. In general, the configuration of views and system-wide commands supported the instructors in retrieving the information necessary for the evaluation of the training objectives in rapid fashion.
- *The workload for monitoring a platoon is still high for a single instructor*. In the ideal situation, all players in a platoon exercise are well-trained in their tasks at the individual and vehicle level. However, many things can go wrong at these levels, and it remains a point of attention to find a proper balance between the monitoring of platoon (or team) training objectives and issues that happen at a lower level.
- *The user needs to be supported more in the handling of events and observations*. One of the lessons learned from the exercises is that many events that are interesting in the context of the training objectives could be detected automatically. This would reduce the workload of the instructor in two senses: he is alerted to interesting events and can focus on them instantly, and he can store them for later use in the AAR with one mouseclick instead of typing observations via the keyboard. Another option mentioned by the users was to store the observations as voice recordings.

CONCLUSION

The paper describes a concept for the definition of instructor support toolsets. The concept features four guidelines, related to the use of training objectives, complementary views, information overlays and system-wide commands. The concept has been used in the definition of a prototype toolset for a virtual simulation for army tactical training. This toolset has been implemented to a large extent and was successfully evaluated by potential military users of the toolset. These evaluations yielded an enthusiastic audience as well as a large deal of lessons learned.
The evaluations point out that the concept works. Effectiveness of the training is enhanced by the focus on training objectives supported by the toolset. Efficiency in the use of the toolset is facilitated by the configuration of a dedicated set of views, overlays and commands depending on the training objectives and on the role of the user within the instructional staff.

FUTURE EFFORTS

On the way ahead, the concept and the functionality of the toolset will be enhanced. Looking deeper into the future, an application of the concept for other types of simulation (live, constructive) and other domains (Air Force, Navy) is envisioned. In addition, the application to simulation objectives other than training (simulation based acquisition, development of doctrines) is a subject of investigation.

REFERENCES

TREDS. Http://www.stricom.army.mil/PRODUCTS/TREDS/ (July 31, 2000)

Farmer, E., Jorna, P., Riemersma, J., Van Rooij, J., & Moraal, J. (Eds.). (1999). Handbook of Simulator-Based Training. Aldershot, UK: Ashgate.