Joint Scenarios and Simulation for High Level Information Fusion Development

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ABSTRACT

The need for situation and threat assessment (STA) tools with modern command and control systems is commonly acknowledged. STA tools help in managing the enormous information load in the command and control task by enhancing situation awareness. However, the development process of STA systems and tools can be difficult when suitable test environments and input data are not available. The main purpose of our research project was to develop and evaluate STA algorithms for joint command and control systems through a wide range of real-time sensor and knowledge-based information.

With the Finnish Air Force Headquarters co-operating in the project we designed a testbed to assist in the development and evaluation process of STA algorithms. We implemented, developed, and evaluated several state-of-the-art STA algorithms using our STA testbed (STATB), and we tested them with diverse and wide joint level simulations. For simulation runs we have constructed and used real scale joint level scenarios based on tactical and strategic doctrines. The scenarios include task, mission, and operation level activities for friendly and hostile forces.

We developed and used a scenario editor and simulation tools in the STATB development process and gained experience on the process. The construction and simulation of scenarios have proved to be essential but often underrated parts of the STA development process in our research.

This article describes the experience gained and the requirements for STA development established within our project, as well as some details, such as the testbed structure, the developed scenario data formats, and the simulation methods used for better understanding the STA development issues.

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1. INTRODUCTION

Today, research and development (R&D) dealing with situation and threat assessment (STA) algorithms and systems is widespread. The application areas for STA algorithms and systems in the military domain are varied – from single-sensor systems to large scale joint systems. Common to these systems is the processing of large amounts of data in order to provide the users with a higher level of information awareness. An example of STA results is shown in Figure 1-1. Identified basic entities, identified groups of entities, roles of entities and groups are shown with different kind of ellipses in the figure. Also, there are shown examples of associations between entities and groups such as communication links and threatening possibilities.

In our project in co-operation with the Finnish Air Force Headquarters, we have studied STA methods and developed a dynamic joint-level STA system with hierarchical results of information fusion at JDL (Joint Directors of Laboratories, 1991) levels 0 to 5 (Blasch & Plano, 2002).

The JDL processing levels are presented in Figure 1-2. Level 0 is for the preprocessing of detection-level raw data, in which the sub-object data association and estimation is done with sensor data to get the detection picture. Level 1, the object refinement, is where the observation-to-track association, continuous state estimation (e.g., kinematics) and discrete state estimation (e.g., target type and ID) and prediction are performed to obtain the basic situation picture.

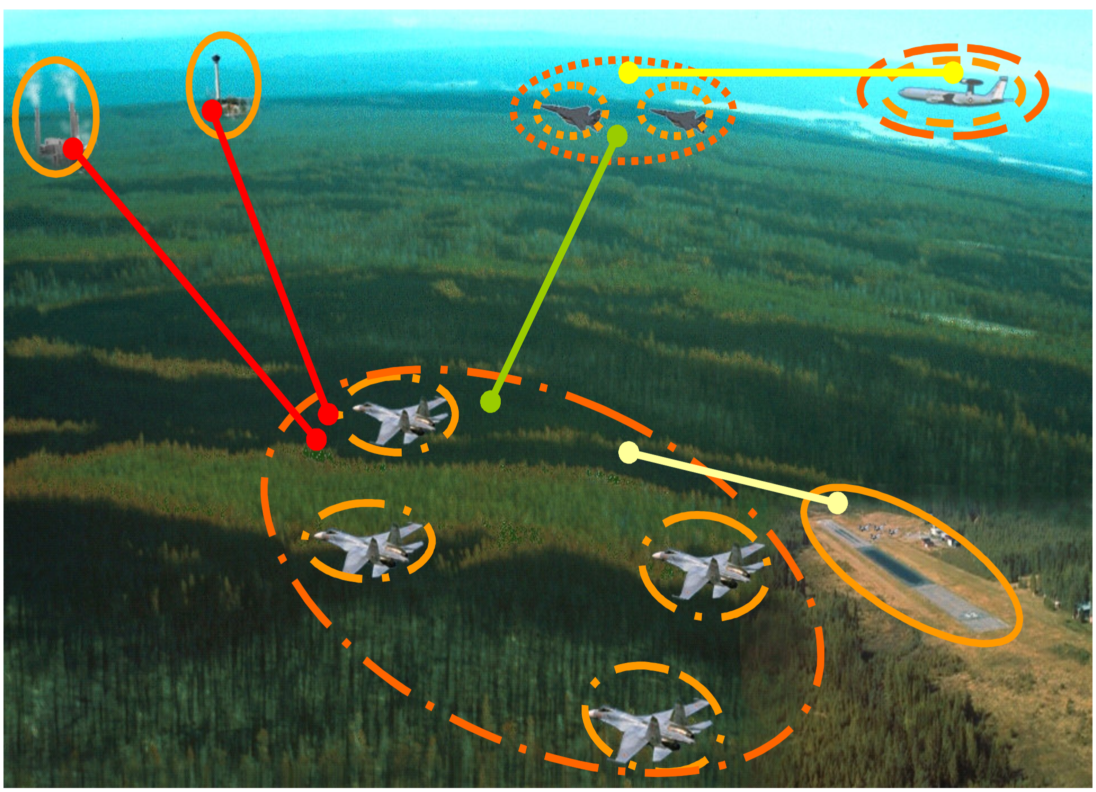

Figure 1–1. Examples of higher-level information types and their associated connections.

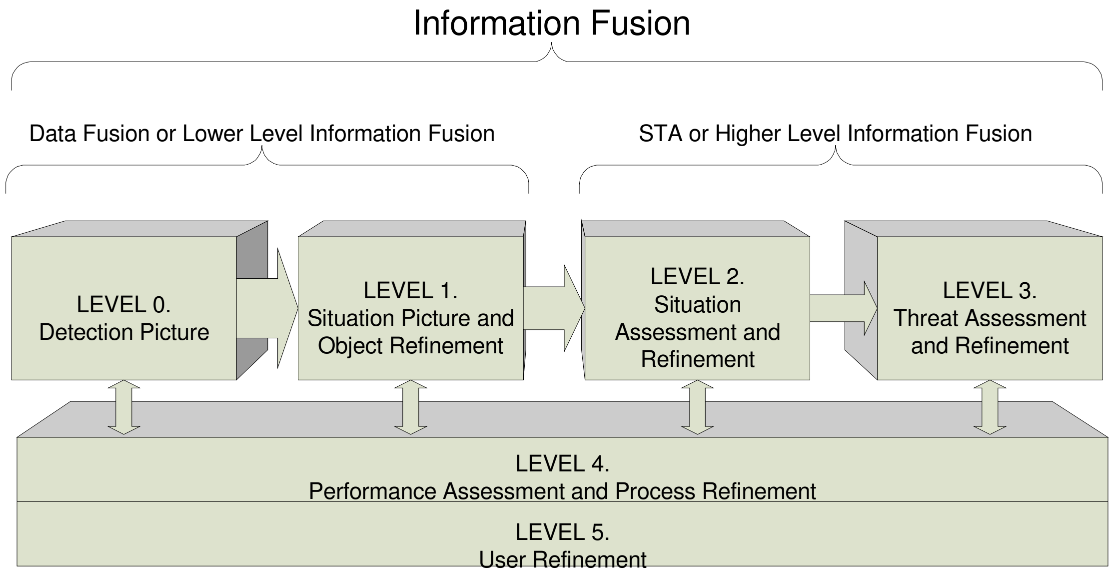

Figure 1–2. Our view of the JDL definition of information fusion.

Level 2, the situation refinement, is an iterative process of fusing the spatial and temporal relationships between entities to group them together and form an abstracted interpretation of the patterns in the order of battle data. The results from this level are called the situation assessment. Level 3, the threat refinement, is an iterative process of fusing the combined activity and capability of enemy forces to infer their intentions and assess the threat that they pose to ally assets. The results from this level are called the threat assessment. Level 4, the process refinement, is an ongoing monitoring and assessment of the fusion process to refine the process itself and to regulate the acquisition of data to achieve optimal results. The process refinement process interacts with each of the other levels. Finally level 5, the user refinement, is the phase where the human interaction supports and monitors the overall process.

There are several approaches to develop STA systems. When the chosen models and algorithms have been created they need to be tested, evaluated, and refined (Tweedale & Nguyen, 2003). Associated test runs can be based on real or simulated data in real time situations, or recorded data can be used. To evaluate and verify the models and algorithms, real data should be used whenever possible. On the other hand, real data cases are rarely diverse enough to develop such complex systems. At JDL levels 0 and 1, recordings and real time data can often be used but with JDL levels 2 and 3 this is not the case. Therefore, simulated situations and scenarios are very important but often have an underrated role in the development of STA systems. In our research we have run a wide range of different scenarios and simulations on our STA testbed (STATB) system and gained experience and observations on the subject.

There are many commercial and tailored simulation environments and STA testbeds reported in literature. Hörling, Mojtahed, Svensson and Spearing (2002) describe the requirements and evaluation processes for choosing an appropriate simulation framework mainly for ground force information fusion purposes. A complete information fusion demonstrator and the corresponding scenario and simulation architecture for ground force situations are presented by Ahlberg et al. (2007). Regarding air operations, Bossé, Roy and Paradis (2000), and Chaib-draa, Kroft and Paquet (2001) explain the simulation architecture for STA and the characteristics of a developed STA module, as well as scenario issues. Tweedale and Nguyen (2004) present a testbed for multi sensor fusion and STA processing in naval command and control systems. Giampapa et al. (2004) describe a testbed for the development of JDL 0 – 4 information fusion algorithms. Despite the amount of R&D in the field, there are not many reports in literature concerning experiences and requirements in scenario making and simulation effects in STA development, about which we are reporting here. In our research we have used an STA testbed that was made by Ness TSG according to our requirements.

The evaluation and development of large information fusion systems is challenging. Testing single algorithms and modules is quite simple, but evaluating the combined performance and results of a complete distributed information fusion system is a complex task. For this purpose, scenarios and simulations that are properly designed and implemented in advance offer remarkable help. The scenarios and simulations should be well tailored for each case. Even when STA systems are designed, one should keep in mind how to construct appropriate scenarios and how to simulate them in order to get the right material for testing purposes.

The use of scenarios and simulations in training for STA systems should also be developed. The scenarios and simulations used in the evaluation and development of the systems can often be easily transformed for training purposes, too, if they are designed properly.

The main goal of our research was to implement an STA testbed, to develop STA algorithms, and to evaluate the maturity of the whole system with a possible future sensor package of the Finnish Defence Forces. While working on the main goal, another issue was also addressed. It is the objective to seek experience and establish the requirements for scenarios and simulations in STA system development work.

In this paper we will first describe the testbed system architecture and its main parts to give perspective for the STA development process. Next we will describe and discuss our scenario making, simulations, and the experience gained in the development process.

In our research project the next step is to produce a prototype of the STA system that will be used in real operative environments for tests and training. The new project is already running and the first results will be obtained soon.

2. THE STA TESTBED

2.1. Overall Structure of the STA Testbed

The STATB consists of two main parts, a simulation and data fusion part (SDF part) and an STA part. The SDF part made by Ness TSG includes a scenario editor, a simulator, and a data fusion element. The STA part, in which our research is conducted, includes pattern recognition algorithms, core STA algorithms, a database (DB), and a graphical user interface (GUI). The overall structure of the STATB architecture is presented in Figure 2-1.

The SDF part is used to assist in developing STA algorithms in the STA part. The scenario editor is used to create complex scenarios with realistic forces, interactions, and sensor networks for detecting the activities of scenarios. The forces can be of any military branch and their actions and movements can be placed concurrent on a single timeline. The simulator element processes forces and sensors according to their actions and characteristics, and transfers the simulated detections of the forces to the data fusion element. The data fusion element fuses the detections into a basic situation picture with air, sea, and ground tracks, and mediates it further to the STA part of the testbed.

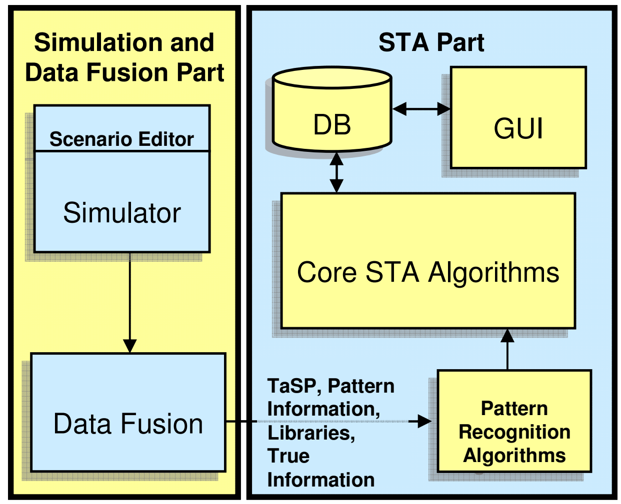

Figure 2-1. Architectural structure of the STATB.

The STA part is divided into two main elements, i.e. the pattern recognition algorithms and the core STA algorithms. The pattern recognition algorithms provide pre-processed results such as the electronic modes of emitters, the ground situation picture, the communication networks, and the air formations for the core STA algorithms. The core STA algorithms fuse the information from the SDF part, the pattern recognition algorithms, and database into higher level situation pictures.

2.2. The Core Algorithms

The core STA algorithms have two main components, i.e. a functions process and a Bayes inference engine. The components are run iteratively based on the current object entities found in the database. The relations and connections of objects in the database may change according to the basic situation picture acquired from the SDF part. In addition to these two components, the STA part employs several background services to maintain the object database and to set timers for the algorithms.

The functions process refines and fine-tunes the input material for the inference engine. This procedure ensures that the Bayes net inference engine starts with the best possible input material. A set of aggregated attributes is calculated for this purpose to combine constant and variable data. These attributes are then used as source inputs for the inference engine.

The inference engine works on top of all the lower algorithms with a dynamic, object-oriented Bayes net (Pfeffer, 2000). Each time the inference engine launches a calculation assignment, it first has to reassemble the attribute association net to correspond to the state of the object database.

The assessment process performed by the core STA algorithms is based on models and doctrine information stored in the rule base. The extent of data inputs used in the STA part of the system is shown in Figure 2–2, where the inference engine consists of roughly the same parts as the core STA algorithms. The operator plays an active role in evaluating the results. More information on the algorithms and the results is found in our earlier articles (Ropponen, Lampinen & Laitinen, 2007) (Lampinen, 2008).

2.3. Input Data of the STA Part

The inputs the STA part uses are diverse. The situation picture from multi sensor tracking (MST) is the main source of real-time data for the STA part. MST is the data fusion item of the SDF part. The situation picture from MST contains tracks and group tracks of airborne, naval, and ground targets, and associated and unassociated detections.

The situation pictures from special purpose sensors, ELINT and COMINT, contain associative information for STA. Intelligence reports contain information on the activity, movements, and other characteristics of the opponent forces. The STA part receives all dynamic information from the SDF part.

Doctrine information on the opponent forces' models, activities, formations, hierarchies, and history is an important source for library and rule data. Basic information on weather, geography, time, date, etc. is used to assist inference. This information is stored and maintained in the STA parts' DB by the operator or some external systems.

The resulting STA situation pictures are formed by fusing the inputs with library data and rules, and are finally shown in the command and control systems to help the operators' work.

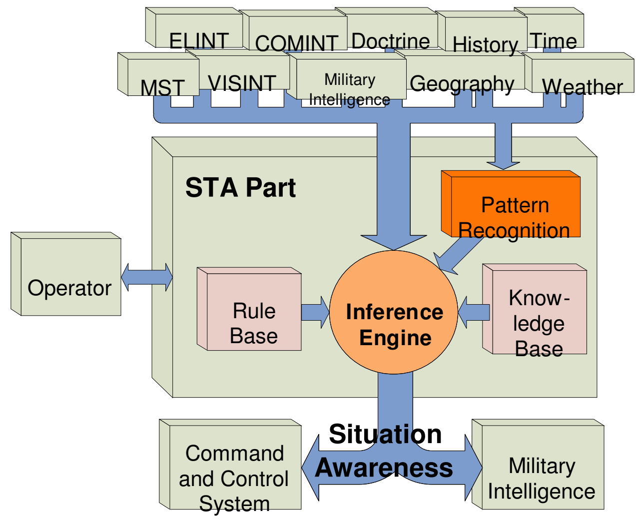

Figure 2–2. Data flow and directions within the STATB.

3. SCENARIOS

3.1. Scenarios in Information Fusion Development

The goal in information fusion is to combine information from many sources and to increase situational awareness of targets. In military applications the targets are usually opponent forces and their state and actions versus own forces are formed. The development and evaluation of information fusion methods requires a data source. The data source can be real or simulated and shall be based on a scenario.

A scenario is a detailed description of activities and events within a certain area at a certain single timeline. Scenarios usually include descriptions of forces, their actions and movements, and of the sensors that provide observations of them. Depending on the purpose, the variation of scenarios can be great. The duration of a scenario can be a few seconds and cover only a small area if, for example, it is used to simulate an emitter. On the other hand, a scenario could describe the activities of joint operations of ground, naval, and air forces over a period of weeks or even years. In the development of tactical algorithms scenarios are usually shorter and have more details than in the development of strategic algorithms. Figure 3-1 shows an example scenario in our scenario editor.

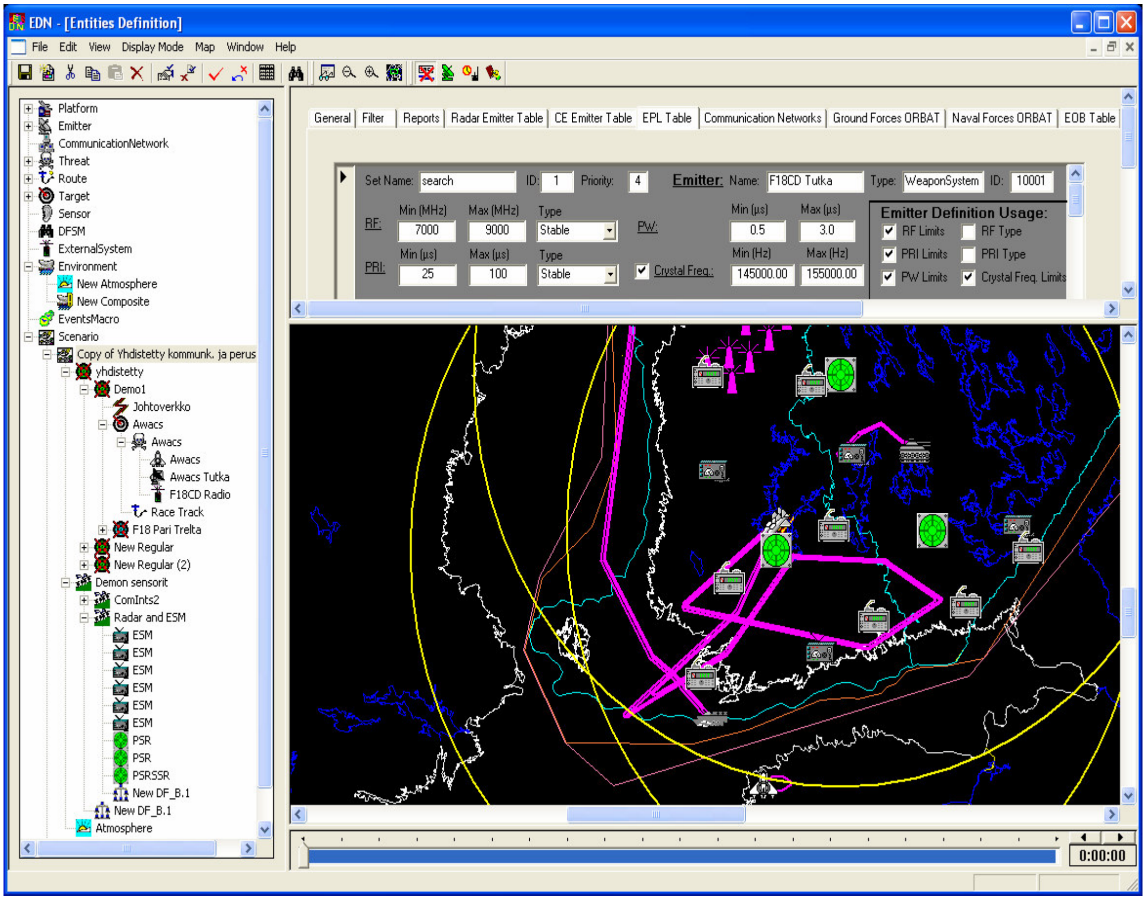

Figure 3-1. An example scenario with air forces, ground bases, naval forces, events and sensors in the scenario editor of the STATB.

There are several pros and cons in using real world and simulated scenarios in the development of information fusion algorithms. The main issues are the as follows:

Real world scenarios:

+ The inputs are real i.e. they are not unrealistically good or bad. There are errors, noise and uncertainties.
- Real world scenarios are usually smaller and harder to interact with than the simulated ones.
- With real world scenarios the ground truth is usually not exactly known.
- The data of real world scenarios can be so confidential that it cannot be used as such and has to be changed, which causes risks for the development of the algorithms.

Simulated scenarios:

+ With simulated scenarios the ground truth is known as exact situations, and forces are self created.
+ The scenarios can be as big and complex as needed.
+ The scenarios can be changed and interacted with easily.
- There is always the danger of focusing on wrong things with simulated scenarios – the input can be unrealistic and the errors, noise and uncertainties are not of the right types. As a result the algorithms may focus on the simulated data and do not directly in real world scenarios.

Thus, simulated scenarios are in many cases the best data source for the development of information fusion algorithms, because with them you know what the inputs to algorithms are and, thus, what to expect as results. However, for evaluation and validation purposes real world scenarios are needed to get realistic results.

3.2. Scenarios in the STATB

The scenarios of the STATB consist of the basic elements described below. The connections between the elements are shown in Figure 3-2, using Martin notation (Martin, 1990).

The total scenario is a combination of a sensor scenario, a target scenario, an environment item, and events. A separate simulation is based on one total scenario.

1. Sensor scenario

- A sensor scenario contains the sensor and data fusion elements of its own and of other sensor scenarios.
  - o The benefit of having other sensor scenarios included is that you can create separate sensor groups that process the inputs from their sensors only and transfer the results to the next sensor scenario level.
- A data fusion element contains algorithms that fuse detections into one situation picture at the sensor or data fusion levels (JDL levels 0 or 1).
- A sensor is an information source that provides detections from its detection range according to its characteristics.

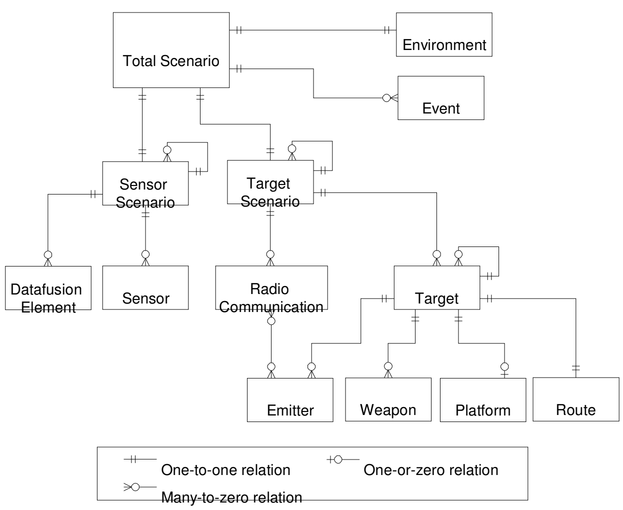

Figure 3-2. The basic elements of STATB scenarios.

2. Target scenario

- A target scenario can contain other target scenarios and its own targets and their radio communications.
  - o With other target scenarios, separate groups of targets can be created and handled separately and given their own sets of parameters, for example.
- A target can contain other targets and their common route, or its own emitters, weapons, platform, and route.
  - o When a target contains other targets it is a group target that can be, for example, an airborne formation.
- A route includes any number of waypoints and other characteristics that define the positions and movements of targets.
- A platform describes the type of the target and its characteristics.
  - o It can be, for example, F18 C/D.
- A weapon contains the characteristics of a certain weapon system.
- Radio communication describes how and which emitters communicate together.
- An emitter describes the characteristics for use of the emitter.
  - o It describes, for example, frequencies and action times.

3. Environment

- An environment item includes terrain data with elevations and waterways, and characteristics of the atmosphere and the weather.

4. Event

- An event item can include change of behaviour for any other items.
  - o An event can, for example, change the frequency used by an emitter or cause the launch of a missile from a target.

With the STATB, element structure scenarios can be created for very different purposes, from small and simple to large and complex ones. Also, the elements can be reused in other scenarios. Scenarios created and used in the STATB can be very diverse in scale and characteristics. They can contain:

- 1 to 100 targets
- Ground, naval, and air targets in joint operations
- Targets from individual actors to division force level
- Activities at a distance from 1 km to 2000 km
- Durations from seconds to weeks
- Tens of ground, sea, and air sensors (radar, ESM, COMINT, IR, acoustic, EO, VISINT), whose individual and common parameters can be changed according to cyclic timetables or events.
- Several emitters for each target, in which the parameters of emitters can be constant or altered according to timetable cycles or events.
- Use of weapon systems and their impacts
- Active and passive jamming
- Radio communication networks with tens of members having their own communication schedules and parameters
- Military intelligence operators' processing results.

Constructing and using this kind of complex scenarios is a long-term process that must be carried out carefully. In the next section we describe our experience of the process.

3.3. Observations and Lessons Learned with Scenarios in STA Development

In our research we have made observations on using scenarios and simulation in information fusion development, and especially in STA development. In this section we will discuss the use of scenarios in the development process, and simulation is discussed in section 4.

There are several stages in the use of scenarios: making of a script for the scenario, creating the scenario, testing the scenario, and the actual use of the scenario. These are presented in Figure 3-3. The stages are similar to software development models that are also presented in Figure 3-3. Making a scenario script is similar to the specification and design phases in software development. Creating a scenario is similar to the implementation phase of software. Testing a scenario is similar to the testing of software. The use of a scenario in the development process is similar to the use of software. The development model in our research is the waterfall model, where it is possible to return to the previous development phases, too.

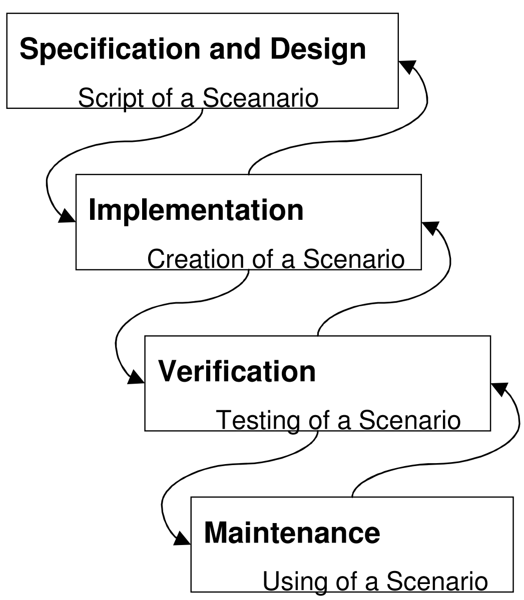

Figure 3–3. Development process.

The main things to consider in scenario development are documentation, version control, and verification of scenarios.

3.3.1. Script for a Scenario

As in software development the requirements for scenarios should be taken into account when the system's scenario tools are designed and when scenarios are created. This phase is as important in scenario development as it is in software development. Mistakes made and tasks not done in this phase may have significant effects in the later phases.

The contents of scenarios should be realistic or intentionally altered real world operations. Military or other appropriate experts should be involved in the process of making scripts to ensure the quality of scenarios.

The detail level of scenarios should be carefully controlled depending on the purpose. In STA algorithms the detected information of a scenario will be compared many times with the prior information in libraries or other data structures. The comparison can only work if the scenario is well designed and implemented, and the algorithms work correctly.

The source information for each developed algorithm should be at the correct detail level in the scenario. The scenario parts should not be too detailed in irrelevant parts so that unnecessary work will be avoided when the scenario is created. However, the scenario should be multiform enough in relevant parts to have all the details the algorithms need. For example, for the recognition of emitter activity the scenario only needs to include the times when emitters are active. On the other hand, in the emitter mode recognition all parameters of the emitters should be defined.

3.3.2 Creating a Scenario

The creation of a scenario is similar to the creation of a code for software. The design tools used and the creation style have a great influence here.

The design tool for creating and editing scenarios, the scenario editor, should be easy to use. Otherwise, the scenarios will not be detailed enough or they may contain mistakes.

To provide good scenarios the editor should be able to warn about design choices that are against the scenario rules, so that the created scenarios will be made according the rules or intentionally against them. The editor should also provide some automatic logic to help in repetitive tasks.

There should be ways to do modular testing. It should be possible to test the operation of a part of a scenario separately from the other parts.

Also, the number of scenario parameters should be moderate and their default values proper. If there are too many parameters the use of the editor is usually complicated, and if there are too few, the necessary battlefield characteristics will not necessarily be included. When the parameters' default values are right for most purposes, it is easy to start with them and then adjust the parameters later.

3.3.3. Testing a Scenario
The verification of a scenario is a phase that is easily forgotten. When the scenario is ready, usually the next thing is to use the scenario for developing an algorithm, although the scenario should be first tested against the script.

If scenarios are not good enough, i.e. they contain errors, algorithm development will be affected, and all parts of the algorithms will not be tested and developed properly.

3.3.4. Using a Scenario
When a scenario is used in algorithm development, there is usually need for updating the algorithm and the scenario. Therefore, the updating and reuse of old scenarios should be possible and well prepared. Version control should be used to help the updating process. The reuse of scenario parts should be possible without rework. There should be libraries of ready made scenario elements available to help the updating and creation of scenarios. At least previously made sensors, emitters, weapons, routes, targets, and environments should be included in the libraries.

3.3.5. Other Aspects of Scenario Development
The scenario making process also involves other considerations. It is a tool for information acquisition in the STA domain. When an expert defines a scenario, it will also include the expert's knowledge of the field, and the rules for algorithms can be extracted from the scenario quite easily.

Making scenarios can also be used as a training exercise for operators, where the forces' action possibilities and sensor configurations are created for both sides. This will give the trainee a good overview of the situation.

4. SIMULATION

4.1. Simulation in Information Fusion Development

When the scenario is ready, the outcome of simulation should be transferred in the right form to the information fusion algorithms. In simulation, the activities of scenario elements are modelled and the outputs for information fusion are formed for the needed simulation level (Adamy, 2003). The needed simulation level depends on the information fusion methods developed, and it is the point where the simulation of a scenario ends and fusion starts.

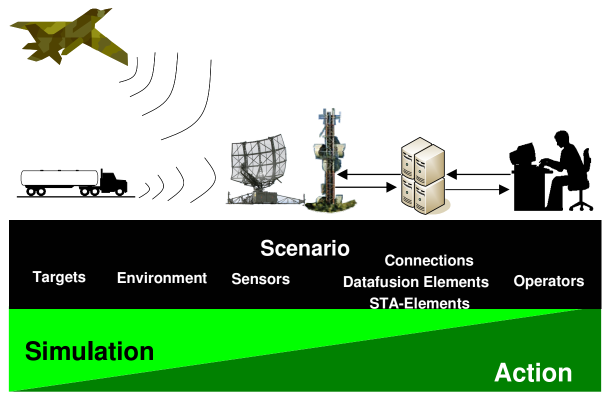

Figure 4–1. The levels of simulation.

The simulation levels are presented in Figure 4-1. The lowest level contains the targets with their routes, emitters, and weapons. Environment affects the targets as well as the signals from them to the sensors. Sensors observe the activities of the targets and send the detections to the data fusion elements. The next level has the STA elements that receive input from the data fusion elements, the sensors, and the operators that are at the last level of simulation. The sensors, information fusion elements, and operators are connected in a way that affects information flow and therewith the whole process.

4.2. Simulation in the STATB

In the STATB, simulation is divided into two main parts: target and sensor simulation. Target simulation manages the scenario's state. The target positions, the emitter activity times and parameters are calculated, the state of the environment is updated and all events are generated at the right moments according to the schedule.

Sensor simulation is divided into two parts, in which the detections for data fusion and STA are generated. First, the emissions from targets to sensors are calculated in signal simulation with signal reduction according to the current state of the environment. Then, detections are generated in detection simulation from the signal received by the sensor. In the generation of detections the decision is made whether the detection is made at all, and then the values of the detection are calculated and, finally, the false detections are fabricated according to uncertainty parameters. Figure 4-2 presents a situation simulated of the scenario in Figure 4-1.

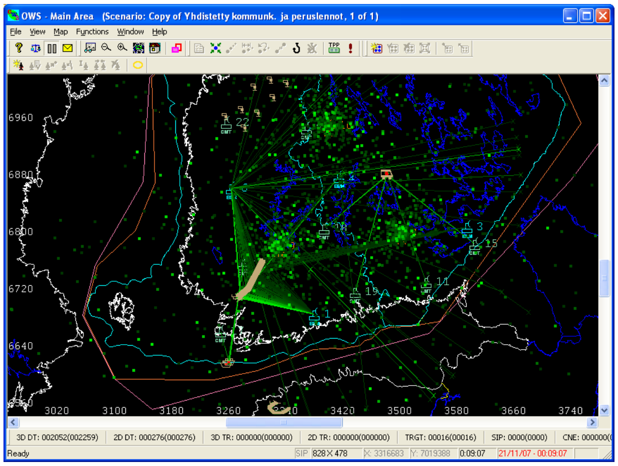

Figure 4–2. A simulated situation with detections and real targets shown.

4.3. Observations on and Requirements for Simulation in STA Development

The requirements for simulation in STA development are similar to the requirements for scenarios. Simulation works on top of a scenario and it can ruin the scenario or aid in hiding the limitations of the scenario.

It is important that the simulated results are realistic, so that the algorithm development based on them is not made on any wrong presumptions and focused on wrong aspects (Hall & Llinas, 2001). The algorithms might recognize the events or characteristics of simulations instead of the actual pieces of scenarios. To prevent this from happening, real data should be used instead of simulated scenarios to verify the results of the development. Especially, if sensors or data fusion elements are being simulated, their simulated outputs should not be unrealistic in quality without good justification. Usually, you should avoid simulating systems that are not available in real life, unless future technologies are tested on purpose.

Simulation can be generally directly based on a scenario script or on simulated models. For example, the route of a target can be realized by following the way points of the scenario. In that case, the scenario creator must take into account all obstacles and affects of the environment and terrain along the route. On the other hand, you may have a model, in which the exact route and speed of the target are calculated. Both options have their challenges. The scenario creator can make unrealistic route choices and time tables. The model for movements in the simulation can be unrealistic, or the simulated routes are not feasible for some other reason. It would be best to adopt a hybrid solution in which the operator can easily make the route.

It is very important in STA development that a simulated situation accurately accords with a scenario, because the STA algorithms use the information of a simulated situation and rely on it in their processing. For example, when simulating an air target, the platform's speed and acceleration ranges must be followed in the simulation. If the simulated air target's speed or acceleration is incorrect, it can interfere with an STA algorithm that uses this information.

5. STATB DEVELOPMENT ROADMAP

The roadmap for the development and operational implementation of the STATB is described in the following list. The list is complemented with the items concerning scenarios and simulation.

1. **Mapping and studying of STA algorithms**
   - Specification of simulator and its basic margins
2. **STA system specification**
   - Specification of test scenarios
3. **Implementation and testing of algorithms**
   - Creation of scenarios
   - Testing of scenarios to validate input for algorithms
   - Testing of algorithms with test scenarios and simulator
4. **Development of algorithms and rules**
   - Using scenarios for development
   - Use of real data for evaluation and development
5. **Evaluation of and training with a prototype system**
   - Training with scenarios and simulator
6. **Operative use of the system**

Our research has now reached phases 4 and 5. We have implemented the STA testbed and tested many techniques of information fusion with scenarios of different military branches, such as air, ground, and naval. We are currently developing the system and starting the evaluation and training phase with operational personnel.

When we are testing and evaluating the system, we will develop it according the feedback from the tests. Next, we will focus on the training use of our system.

Experienced users can evaluate and give feedback of the system, whereas beginners can learn to use the system and the expert rules it is based on.

In training use, the level of scenarios and simulation is as important as in the development phase. Wrong types of scenarios and simulations can give wrong expectations for the users on the STA results. The users may learn incorrectly if wrong results are used in the training process (Adamy, 2003).

6. CONCLUSION

The main goal of our research is the development and evaluation of STA algorithms and the whole STA system in airborne and also ground and naval environments. The secondary goal of our research and the main subject of this paper is the search for specific experience on and requirements for scenarios and simulations in STA system development.

We have been able to implement and develop a broad STA testbed where the algorithms and the system have shown their potential. In the research we have also gained experience and observations that help STA development with scenarios and simulation, which are shown to be a very important part of information fusion development. Often they are the only way to test and evaluate complex situations and the possibilities of future sensor packages. In addition, we have prepared training and operative use of the STA system.

The STA testbed and the evaluation of STA algorithms are now completed. In the next phase we will produce a prototype version of the STA system for testing and training purposes in military exercises with a network centric environment.

REFERENCES

Adamy D. (2003). *Introduction to Electronic Warfare Modeling and Simulation*, Artech House, 2003, pages: 193-194.

Ahlberg S., Hörling P., Johansson K., Jöred K., Kjellström H., Mårtenson C., Neider G., Schubert J., Svenson P., Svensson P., Waltera J. (2007). An Information Fusion Demonstrator for Tactical Intelligence Processing in Network-Based Defense, *Information Fusion, Volume 8, Issue 1*, pages: 84-107.

Blasch E., Plano S. (2002). JDL Level 5 Fusion Model: User Refinement Issues and Applications in Group Tracking, *Signal Processing, Sensor Fusion, and Target Recognition XI, Proc. SPIE Vol. 4729*, pages: 270-279.

Bossé É., Roy J., Paradis S. (2000). Modelling and Simulation of the Design of a Data Fusion System, *Information Fusion, Volume 1, Number 2,* pages: 77-87.

Chaib-draa B., Kroft P., Paquet S. (2001). A Teamwork Test-Bed for a Decision Support System, *Proceedings of EUROSIM 2001: Shaping Future with Simulation, Delft, The Netherlands*, ~~http://www.damas.ift.ulaval.ca/publications/Eurosim2001.pdf~~

Giampapa J., Sycara K., Owens S., Glinton R., Seo Y., Yu B., Grindle C, Lewis M. (2004). Extending the ONESAF Testbed into a C4ISR Testbed, *Simulation, 80(12)*, pages: 681-691.

Hall D., Llinas J. (2001). *Handbook of Multisensor Data Fusion*, CRC Press, Boca Raton, pages: 21-9 – 21-10.

Hörling P., Mojtahed V., Svensson P., Spearing B. (2002). Adapting a Commercial Simulation Framework to the Needs of information Fusion Research, *Information Fusion, 2002. Proceedings of the Fifth International Conference on, Volume: 1*, pages: 220- 227.

Lampinen T. (2008) Threat Assessment Using Hierarchical Analysis and Entity Bayes Net, *Toward Better Situational Awareness, Finnish Defence University, Department of Military Technology, Series 1, No 29,* pages: 39-50.

Martin J. (1990). *Information Engineering, Book II: Planning and Analysis*, Prentice Hall

Pfeffer A. (2000). Probabilistic Reasoning for Complex Systems, *PhD thesis, Stanford University*, ~~http://www.eecs.harvard.edu/~avi/Papers/thesis.ps~~

Ropponen J., Lampinen T., Laitinen T. (2007) Information Fusion for Command and Decision Support, *Military CIS Conference Proceedings 2007*

Tweedale J., Nguyen T. (2003). An architecture for Modelling Simulation and Threat Assessment, *SimTecT, Adelaide, South Australia*, ~~http://www.siaa.asn.au/get/2395358434.pdf~~

Tweedale J., Nguyen T. (2004). Situation and Threat Assessment using the Operator System Integration Environment, *SimTecT, Canberra, Australia*, ~~http://www.siaa.asn.au/get/2396672243.pdf~~

U.S. Department of Defence, Data Fusion Subpanel of the Joint Directories of Laboratories (1991). *Technical Paper for C3*, Data Fusion Lexicon