The following paper is being submitted for consideration in the 2004 Command and Control Research and Technology Symposium to be held at Loews Coronado Bay Resort, San Diego, California

The Topic for which this paper should be considered is:

C2 Experimentation

The Title of the Paper is:

The Coalition Aerial Surveillance and Reconnaissance (CAESAR) Simulation Exercise 2003: Results and the way ahead

The Authors details are:

Thomas Kreitmair (Author, Point of Contact), Joe Ross (Co-author)
NATO Consultation, Command and Control Agency, The Hague
PO Box 174
2501 CD The Hague
Netherlands

Phone: +31 70 374- 3765 (Kreitmair, Point of Contact)
- 3777 (Ross)

Fax: +31 70 374-3079

Email:
Thomas.Kreitmair@nc3a.nato.int
Joe.Ross@nc3a.nato.int

# The Coalition Aerial Surveillance and Reconnaissance (CAESAR) Simulation Exercise 2003: Results and the way ahead

**Thomas Kreitmair, Joe Ross**
NATO Consultation, Command and Control Agency
PO Box 174
2501 CD The Hague
The Netherlands

Abstract

The Coalition Aerial Surveillance and Reconnaissance (CAESAR) Project involves seven Nations in developing future Aerospace Ground Surveillance and Reconnaissance (AGS&R) applications. In October 2003, the CAESAR project conducted a combined joint simulation exercise at the NATO Consultation, Command and Control Agency (NC3A) in The Hague. Various sensor system simulations, their associated ground stations and national exploitation stations were integrated in one exercise. About 80 national military operators and technical experts trained and conducted combined and joint AGS&R operations. For operational and procedural interoperability, the exercise validated large portions of a Coalition Concept of Employment for AGS&R. Concerning technical interoperability, the exercise proved the application of a Coalition Shared Database (CSD) and various Standardisation Agreements such as for Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR). In October 2004, the CAESAR project will conduct a final Technical Interoperability Experiment. For the years 2005 to 2009, the Multi-Sensor Aerospace-Ground Joint Interoperable Intelligence Surveillance and Reconnaissance Coalition (MAJIIC) project is being developed to expand on the findings of CAESAR.

## Coalition Aerial Surveillance and Reconnaissance (CAESAR)

### *A short introduction to Aerospace Surveillance and Reconnaissance*

The Coalition Aerial Surveillance and Reconnaissance (CAESAR) Project involves seven Nations in developing future Aerospace Ground Surveillance and Reconnaissance (AGS&R) applications.

AGS&R assets are part of an overall Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) Architecture. ISTAR architectures can include a variety of platforms supporting sensor that make use of a wide range of the electromagnetic spectrum, from optical wavelengths to radar. Figure 1 provides an example of some of the platform and sensor classes used in ISTAR operations. In addition, ISTAR architectures require integration of the gained information into a command and control system as well as into an intelligence network.

It was clear from the very beginning of CAESAR that the scope of work for an overall solution of ISTAR associated problems was beyond feasibility. Therefore, CAESAR focused on Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR), but did not consider electro-optical or infrared sensors.

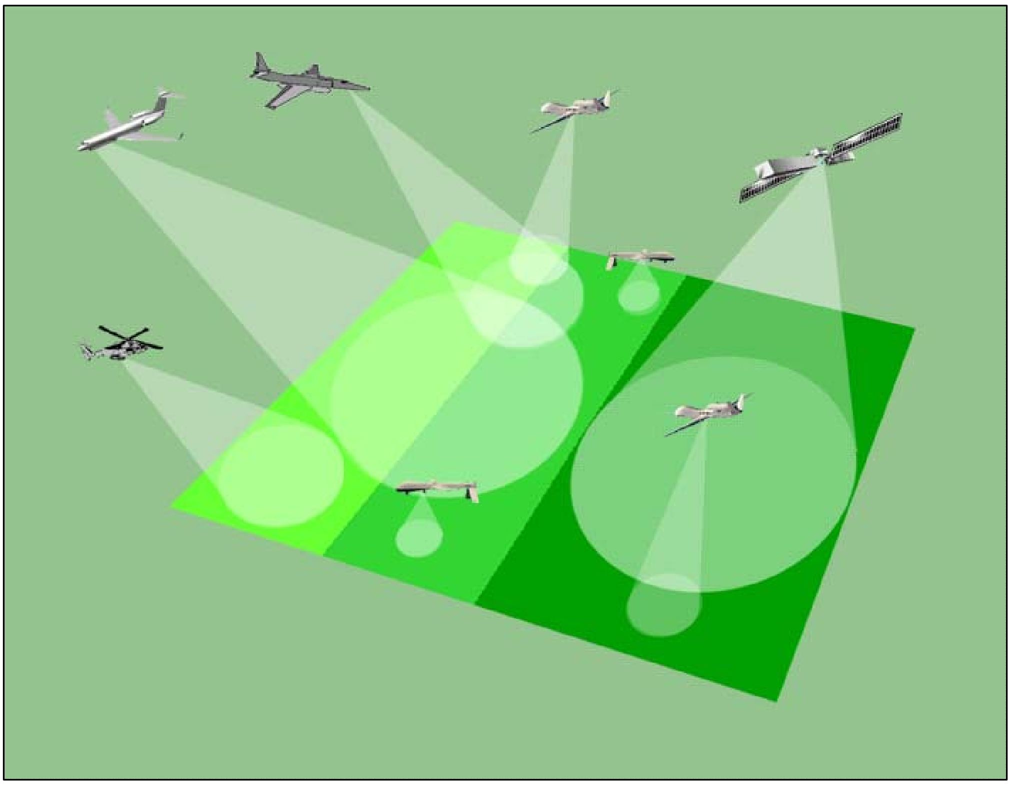

***Figure 1 Various Aerospace Ground Surveillance Systems***

***A short history of CAESAR***

In 1997, immediately after the Paris Air Show, the NATO C3 Agency and six Nations participated in the Paris Interoperability Experiment to prove that various AGS&R sensor and exploitation systems could be made to operate with each other in a real world environment. The participating Nations were France, Germany, Italy, Norway, the United Kingdom and the United States of America. Two years later in 1999, US Joint STARS and U2 and French HORIZON all flew in Kosovo. Despite the efforts of many, they were never integrated into a true interoperable capability during that conflict.

***The CAESAR Nations and organizational structure***

The CAESAR Project was initiated to overcome some of these observed problems and to achieve operational and technical interoperability among the MTI and SAR platforms of many Nations. In 2001, the seven CAESAR Nations initiated the CAESAR Project. These are, in alphabetical order: Canada (CA), France (FR), Germany (GE), Italy (IT), Norway (NO), the United Kingdom (UK) and the United States of America (US). Each nation funds and manages a national program in support of CAESAR, which is coordinated via a Project Officers (PO) group. The Nations have tasked NC3A in The Hague, The Netherlands, to provide technical management and expertise to help achieve the goal of coalition interoperability.

The project is managed by a group of nationally appointed Project Officers, one from each nation, and is supported by the Technical Manager from NC3A and the Chairmen of three separate but interrelated working groups. The three working groups, the Operations Working Group, the Architecture Development Working Group and the Technical Interoperability Working Group, address topics of specific interest to their group and support the other groups efforts. This interrelationship is clearly demonstrated at each CAESAR conference, where cross group meetings are an important fixture for problem solving. NC3A and the CAESAR Nations provide equipment and personnel to participate in working groups and exercises that are focused to identify and solve problems.

***CAESAR main emphasis and previous exercises***

Experience with system development has shown that technology alone will not provide an enhanced capability. Operational procedures and integration into existing processes are required or even the best technology will not succeed.

When CAESAR started, the main emphasis was to develop the Concepts of Operation (CONOPS), the Tactics, Techniques, and Procedures (TTP) and the technology to make Coalition Ground Surveillance assets interoperable. Operational, procedural and technical interoperability are covered with this approach. The plan was to achieve this by developing and evaluating technologies for the integration of diverse GMTI/SAR platforms, by maximising the military utility of surveillance and reconnaissance resources and by optimising data collection and exploitation of GMTI/SAR assets.

Military operators have always been involved during the interoperability development and demonstrations during CAESAR so that the technology, when integrated into existing systems, is understood by the users and available to the right people. CAESAR simulations, real AGS&R systems and military operators participated in various combinations in exercises. This included live exercises (e.g., Strong Resolve 2002), as well as in simulation exercises (e.g. Clean Hunter 2001, Cannon Cloud 2002, Dynamic Mix 2002).

**Preparation and Conduct of SIMEX 2003**

***Goals of SIMEX 2003***

Early in 2003, three draft documents concerning NATO Alliance Ground Surveillance Core Capability [Ref. 1], Alliance Ground Surveillance System Architecture Interfaces [Ref. 2] and Tactics, Techniques and Procedures (TTP) for Coalition AGS&R [Ref. 3] were mature enough to be tested in an exercise. The decision was made to conduct an exercise in October 2003.

The operational and procedural goals of the exercise were:

- Testing the draft Concept of Operations (CONOPS) and TTP;
- Tasking and Planning Coalition use of AGS assets in an operational environment from Combined Joint Task Force (CJTF) to Division level;
- Operations in a time-sensitive targeting (TST) cell.

The first technical goal was focused in verifying compliance to common formats, including a number of NATO Standardisation Agreements (STANAG):

- Dissemination of GMTI (NATO EX 2.01) and SAR (STANAG 4545);
- Use of the STANAG 4559 for NATO Standard Imagery Library Interface;
- Use of a subset of STANAG 5516 for LINK 16 format messages.

The second technical goal was to extensively use the CAESAR Shared Database (CSD) prototype to support:

- Various sensor capabilities in a single, common scenario;
- Data dissemination from sensors in near-real-time;
- Data exploitation from multiple sensors on a number of national workstations;
- Dissemination of data exploitation results.

***Simulations involved in SIMEX 2003***

Figure 2 shows the simulated sensor systems participating in SIMEX 2003: RADARSAT-2 (CA), Hélicoptère d'Observation Radar et d'Investigation sur Zone (HORIZON, FR), Systèmes Intérimaires de Drone Moyenne (SIDM, FR), Complesso Radar Eliportato di Sorveglianza (CRESO, IT), Airborne Stand-off Radar (ASTOR, UK), Joint Surveillance and Target Attack Radar System (JSTARS, US), Global Hawk (US), U-2 Advanced Synthetic Aperture Radar System (ASARS) Improvement Programme (AIP, US), and the NATO Airborne Early Warning and Control (NAEW&C, NATO), along with associated ground stations. The national exploitation stations include Système d'Aide à l'Interprétation Multicapteur (SAIM FR), Interoperable Imagery Exploitation System (IIES GE), Mobile Tactical Operations Centre (MTOC, NO), Joint Services Work Station (JSWS, (US), Moving Target Indicator Exploitation (MTIX, US), Transportable Mission Support System (TMSS, US) and Motion Analysis, Tracking and Exploitation (MATREX, US). The capabilities of the various systems are described in Ref. [3] and will not be discussed here further.

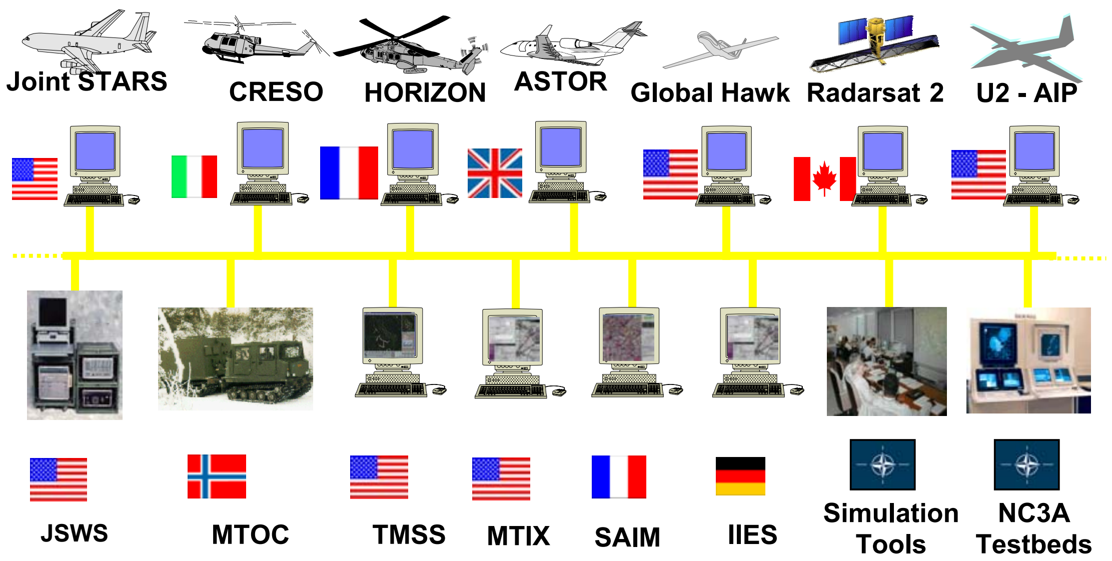


***Figure 2 AGS&R sensor and exploitation stations in SIMEX 2003***

A single common scenario was created by combining the outputs from three simulation drivers. The Joint Combat and Training System (JCATS) was used to generate the military ground movement operations. The Integrated Training Capability (ITC) was used for air operations of aircraft and helicopters. The Ground Vehicle Simulator (GVS), provided by the US Air Force Research Laboratory, produced background, non-military ground movements. All three simulations reported Distributed Interactive Simulation (DIS) Entity State Protocol Data Units (PDU) to a single socket, from which the sensor simulations received their input. The sensor simulations were used to determine which entities would be visible to their respective sensors, based on characteristics of the sensor, the terrain, and the movement of the vehicles. The sensor simulations then provided their resultant data and information to a local area network. This data was disseminated over a wide area network to all of the ground stations, exploitation stations, and to the CSD, which were distributed throughout the simulated theatre. Based on this data, military operators and commanders planned, monitored, and managed the operations.

Figure 3 below shows operators of the sensor simulations Global Hawk, JSTARS CRESO and RADARSAT-2, working next to each other. Other features provided in the simulation network included a network email capability, GPS clock synchronisation, Internet Protocol (IP) telephones, message recording and check utility, Network Traffic Monitoring and more. The network was composed of seven subnets with a total of more than 120 computers. About 400 $m^2$ of laboratory room were used to house all equipment. In addition to the laboratory space, briefing rooms and offices were also provided. The entire exercise was run in a classified configuration.

***Figure 3 AGS&R sensor simulations in laboratory during SIMEX 2003***

***Technical Interoperability Exercise (TIE)***

In order to prepare for the exercise, a two week Technical Interoperability Experiment (TIE) was conducted in June 2003. The various simulations and simulators were brought from the Nations and integrated with each other at NC3A. Within three days, most of the sensor and exploitation simulations were integrated into networks representing the theatre. Figure 4 shows the SIMEX 2003 network diagram. To achieve the first technical goal, compliance of the information exchange between the systems was extensively tested for seven days. The TIE provided valuable experience for a fast exercise build up. A large number of STANAG compliance problems were identified and corrected; most of them immediately during the TIE or later, in preparation for the SIMEX. This facilitated a smooth conduct of the exercise in October and allowed the military operators to focus on conducting their tasks.

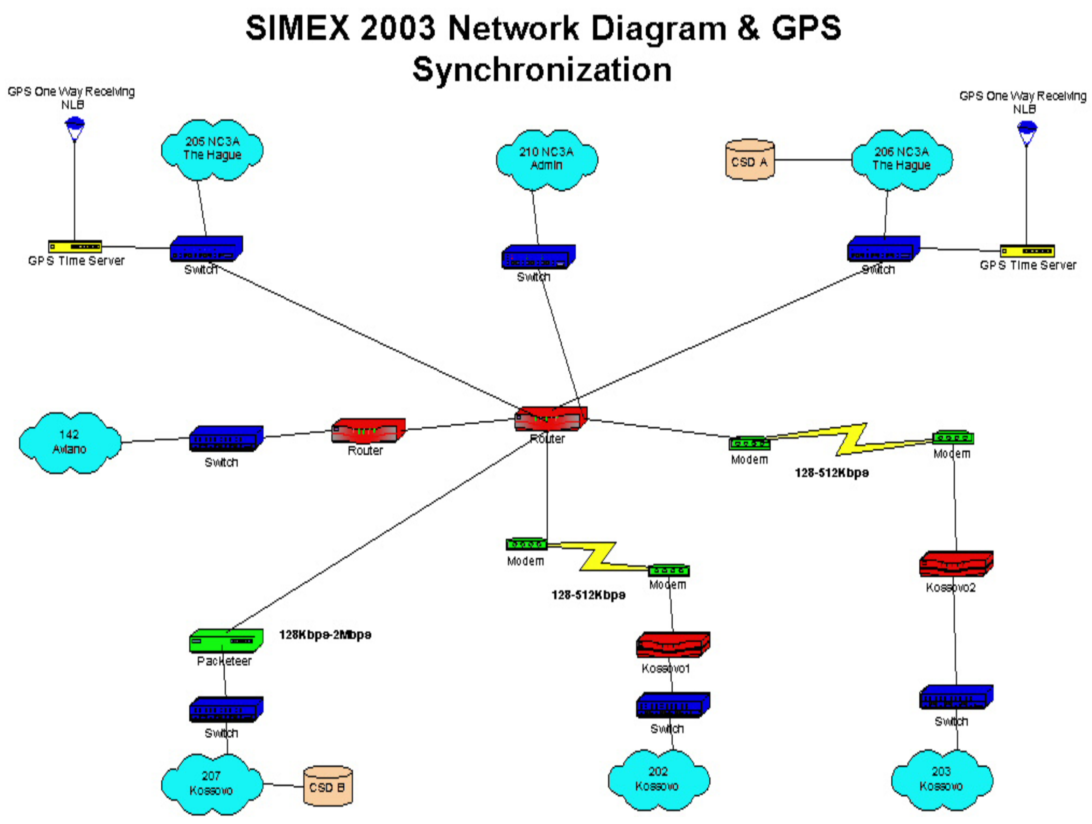


*Figure 4 SIMEX 2003 network diagram*

***Weekly schedule for SIMEX 2003***

The exercise was conducted during 6 October to 24 October 2003, with about 80 active participants. The SIMEX 2003 had four distinct phases: two days of network setup, five days of military operator training, seven days conducting AGS&R operations and one final day for de-briefing. Almost 90% of the integration work was achieved within the first two days. This was clearly a return on investment from the TIE in June. The military operators were first trained for their particular role at a workstation or in a staff position and were then trained to function as a team. As a final preparation, the entire exercise plan was tested, where all stations were manned and all procedures where applied. At the end of the training period everyone was familiar with their required tasks. Figure 5 provides a graphical representation of the weekly schedule of SIMEX 2003.

Conduct of AGS&R operations started on Wednesday, 15 October. For the next seven days, a strict daily schedule was followed. The core of the exercise ended on Thursday, 23 October, in the early afternoon. At that time the operational staff prepared their quick-look analysis reports while the technical staff began to disassemble the network, pack the equipment and prepare it for shipment. On Friday, 24 October, all participants met for a debriefing.

***Daily schedule for SIMEX 2003 during conduct of AGS&R operations***

During seven days of the exercise, the network experienced no outages because of technical reasons. The only outages noticed were initiated by the evaluation team so they could measure the effects of network outages. The common single scenario ran without interruption in near-real-time, for seven days, for 6 hours each day.

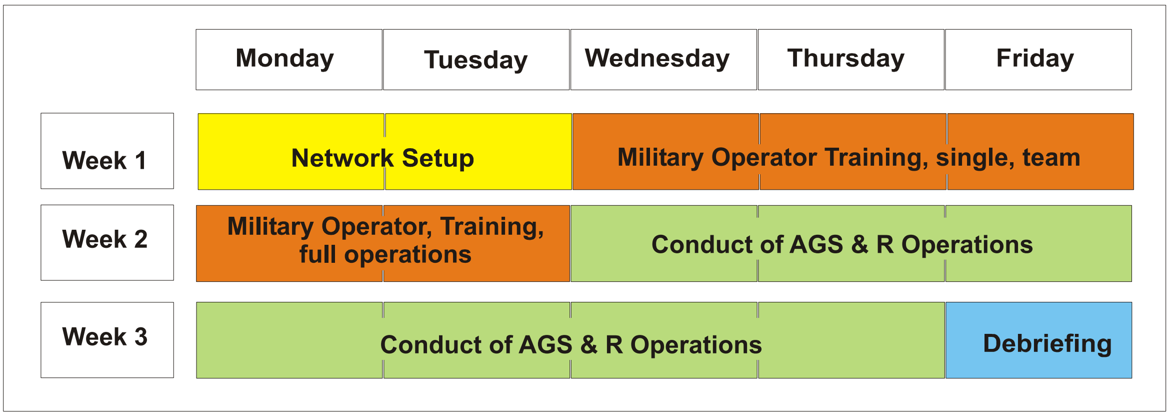


***Figure 5 Weekly schedule for SIMEX 2003***

During the exercise, four distinct groups of personnel worked in various functions: simulation, sensors and exploitation, military operators, and white cell and evaluators. Figure 6 shows the daily schedule maintained during the exercise for different groups.

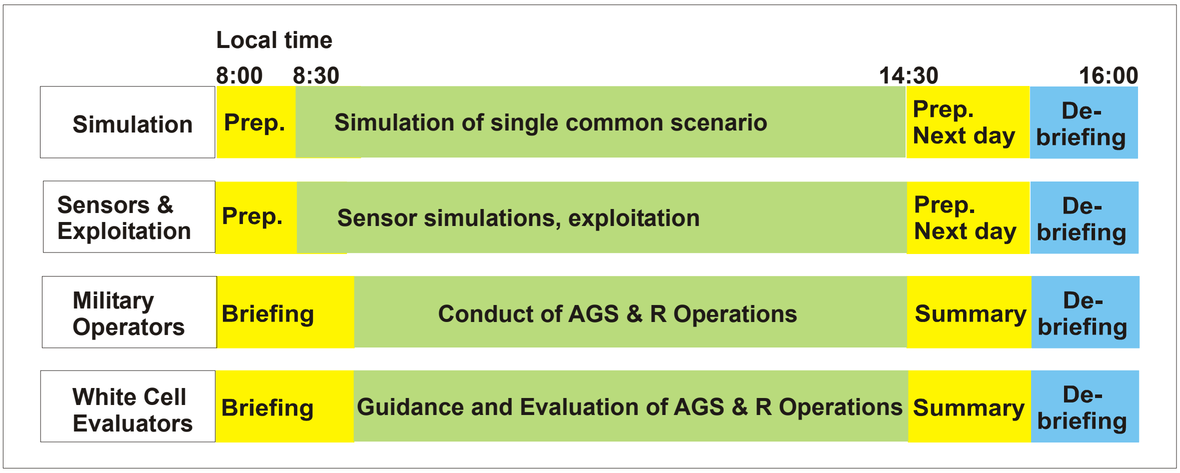


***Figure 6 Daily schedules during AGS&R operations***

Each morning, military operators received an intelligence briefing for the previous and current days' activities, the collection plan for the day, planned white cell activities and a short report from the evaluators on the previous day of the exercise. After the briefings, the military operators manned their positions, evaluated the surveillance and exploitation results, that had been collected and prepared during their briefing time and familiarized themselves with the current operations. Based on operator experience, some time is necessary to observe and follow the tactical situation to get full appreciation of the activities. Between 10:00 and 14:30, the operations continued without any interruption. From 14: 30 to about 15:30, the military operators, the white cell and the evaluators summarized their observations for the day. The day finished with an out-briefing, which usually went until 16:00.

***Scenario for SIMEX 2003***

The scenario was focused on ground operations to stimulate AGS&R operations. JCATS was applied for this purpose. Air operations for both sides, with fixed and rotary wing aviation were also included and coordinated with the ground situation. Under the lead of Mr. Allan Gray, Dstl, UK, a military operations plan was developed for seven days of operations. The seven days of operations covered three days of force build up, one day of border violation and invasion, two days of combat operations with offensive and defensive forces, and one day of retreat and re-constitution of borders. Based on the military operations plan, NC3A created the JCATS simulation input files; generating one file for each day. The operations area was located in the Balkan region and stretched over about 400 km in a North-South direction and about 300 km in an East-West direction.

Own forces and opposing forces were involved in the simulation. The opposing forces consisted of two corps of an Army supplemented with special rocket forces. In addition to the battle forces, 20 truck convoys were modeled to represent supply traffic with between 10 and 25 vehicles per convoy. Two railroad lines were also introduced to supplement the road based supply convoys. The own forces consisted of a multi-national division made up of five brigades: an Italian-Norwegian Brigade in mountainous scenario regions, a multi-national Armoured Brigade, a US-led interim Brigade Combat Team, a French Brigade and a brigade of local forces. The scenario is well documented and can be shared with interested users on request.

The various forces were modelled at the single vehicle level, which resulted in the movement of about 6000 single vehicles per day. The marching distances varied over wide ranges, depending on the kind of maneuver; such as administrative marches to deployment areas, attack operations or logistic supply.

***Military operators and their roles in SIMEX 2003***

The military operators exercised roles in the NATO and multinational command centres as shown in Figure 7 below. Depending on the command relations of the various AGS&R sensors and exploitation stations, the roles changed. For example, the command authority of a helicopter-based AGS&R sensor could be delegated to a Brigade-Commander for a limited time, to directly support his operational needs. This then would require different planning, tasking and management for all of the AGS&R sensors in the coalition.

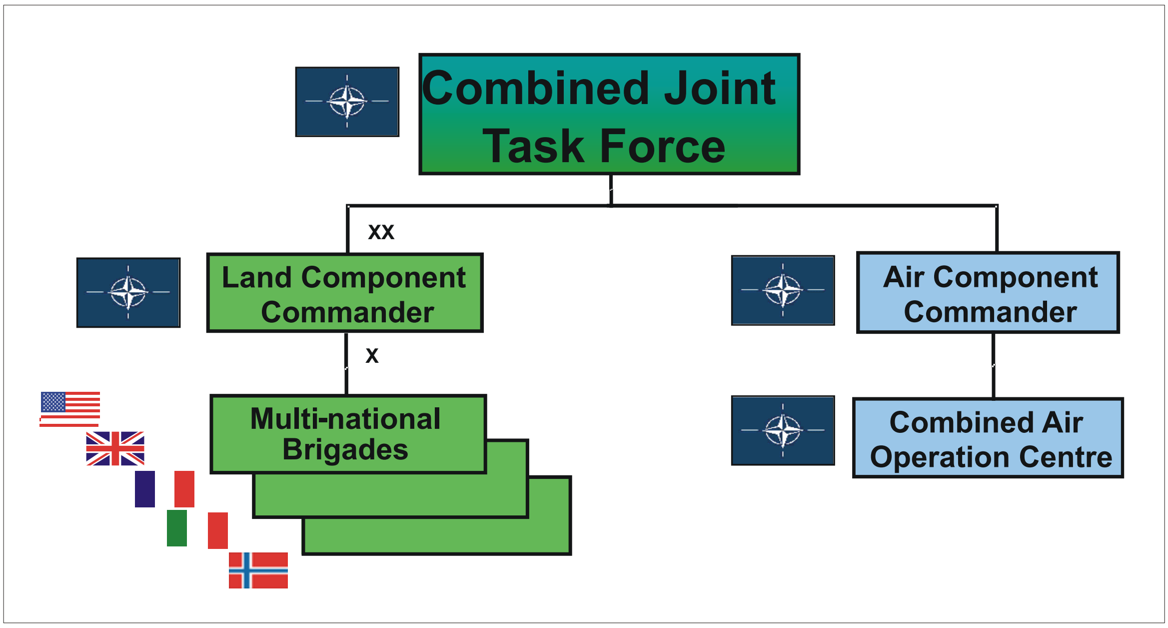


***Figure 7 Military command hierarchies exercised in SIMEX 2003***

The military operators provided by the various Nations were all experts in their area, whether they were sensor, exploitation, or command areas. Those that represented sensor systems had extensive experience in the operations of their particular national sensors. Some came from recent experience in military operations such as Operation Iraqi Freedom. Nevertheless, use of these systems in coalition operations creates a new set of problems, not all of which were solved during the exercise. Figure 8 below shows a multi-national coalition AGS&R manager planning session, in which the Theatre Collection Manager is discussing options with sensor system Liaison Officers.

***Figure 8 Multi-national coalition AGS&R manager planning session***

In summary, the weekly and daily schedule resulted in well-trained military operators who were fully aware of their tasks and with sufficient training time to exercise their roles. While the implementation of the scenario was challenging because of its size, attention to detail, and inclusion of special vignettes to support evaluation of specific missions, the comments of all participants were positive.

**Results of SIMEX 2003**

***Technical findings***

Overall, the performance of the various simulations and the network in total was solid. The network was not troubled by technical problems. Since the technical interoperability had already been tested during the TIE exercise in June 2003, there were only a few new problems found in October 2003. Most of the technical problems which were observed during the TIE were solved until begin of SIMEX. However, for some difficult problems the time was to short for corrections. The format problems that were observed during the exercise were documented. The largest discrepancy had to do with the command and control aspects of the network used, e.g. the use of and reliability of the messaging systems used to communicate between exploitation workstations and the AGS&R management staff. This problem is currently under investigation and a way ahead will be developed by the CAESAR operational staff for evaluation during the next TIE. A detailed list of the deficiencies was developed and these will undergo testing during the TIE scheduled for October 2004.

***CAESAR Shared Database (CSD)***

One of the findings of the CAESAR project has been that there is a need for searchable, persistent storage of AGS&R data and data products. This need resulted in the design and implementation of the CAESAR Shared Database (CSD). The CSD was designed by the CAESAR team and a prototype has been produced by NC3A under the direction of Trond Skaar. NC3A has provided the CAESAR partners with software that assists the development of thin client and thick client interfaces with the CSD. In addition, a web browser based thin client has been developed to interface to the CSD.

The CSD provides users with a single interface through which they can search for GMTI, SAR and other imagery and exploited data products. Data produced by the CAESAR sensors and exploitation stations is gathered by the CSD, is automatically tagged using metadata inherent in the data standards, and then stored in the database. This data is then available for search by time, geographic region, platform type, data type and other parameters. In this way, data that may not have been received in real time due to local or network equipment failure can be retrieved.

Once data is stored in the CSD, it is available for the rest of the exercise. For example, GMTI observations from day 1 can be combined with SAR from day 2. Similarly, collection plans, selected data from Air Tasking Orders (ATO) and other document based information can be stored and exchanged. The following figures provide a screen capture of the CSD File Search page and the results of a particular search.

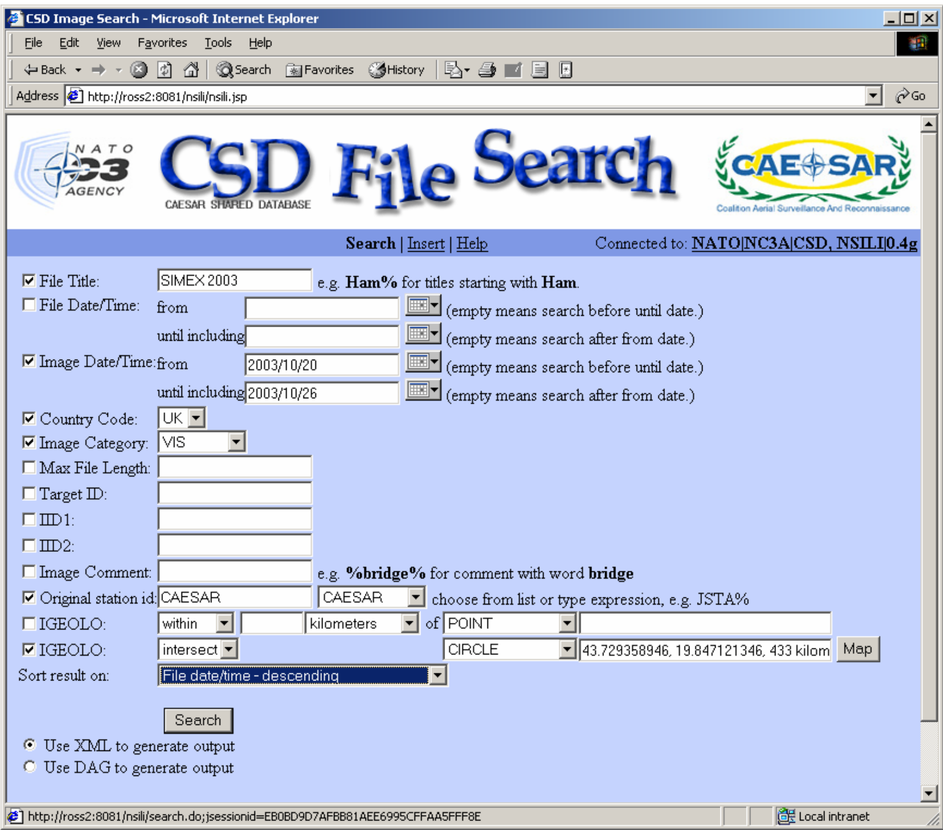


***Figure 9 CSD file search menu***

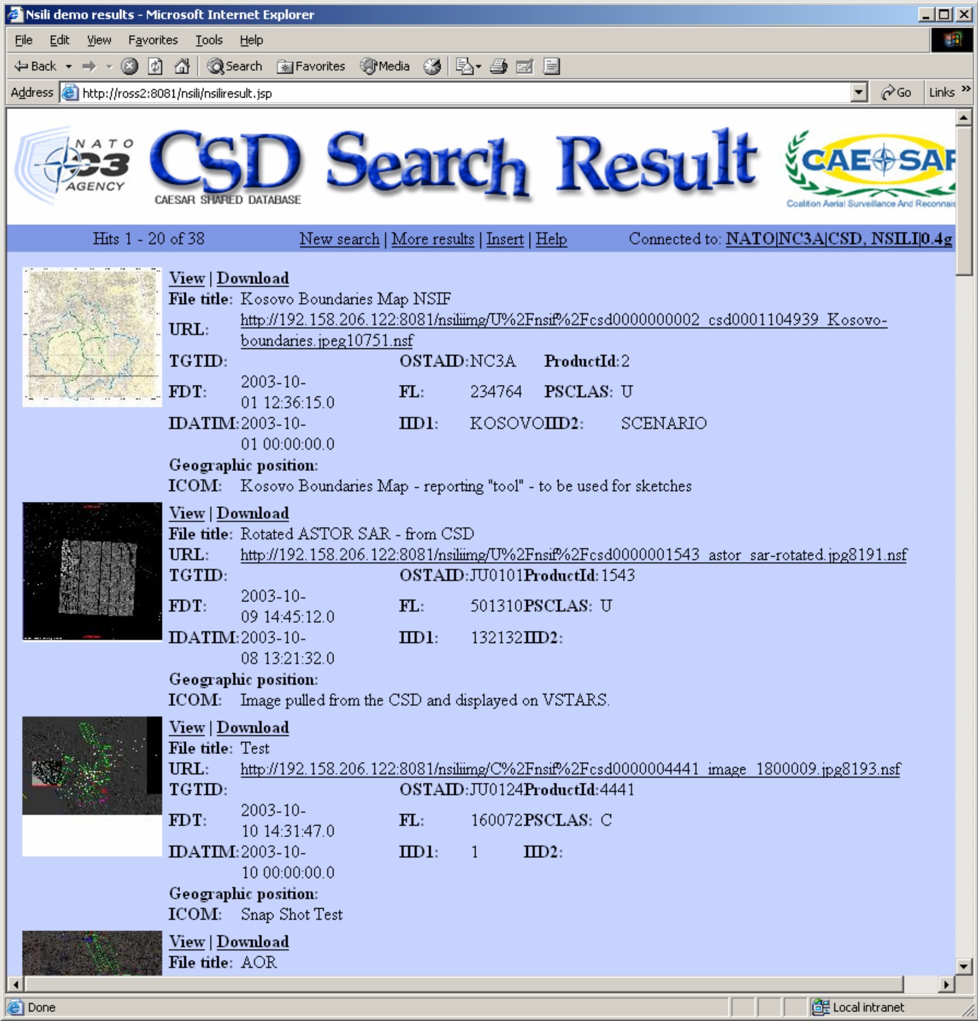


***Figure 10 CSD file search results***

Based on the search results, the user can either view or download a selected file. Images are provided in STANAG 4545 (NSIF) format and GMTI data is provided as an XML file representing STANAG 4607 data. The following figure provides an example of an image that has been downloaded.

While the CSD is still a prototype, its use demonstrated the ease of achieving interoperability for C2 systems that need data and information to support decision makers. The delivery of data using established STANAG formats and XML schemas provided global availability. The use of the web browser based thin client interface allowed users from any location to retrieve the AGS&R data in near real time through user friendly query interfaces. The thin client provides a basic visualization capability for imagery and a GMTI playback capability providing a dynamic geographic situational display. The CAESAR capability provides a network enabled data storage, retrieval, and dissemination capability that is available to all users on a network. Current discovery services are based on the CORBA Naming Service and a Web Services based discovery and retrieval mechanism is in development. The CSD provided a technical foundation for successful conduct of the planned operations.

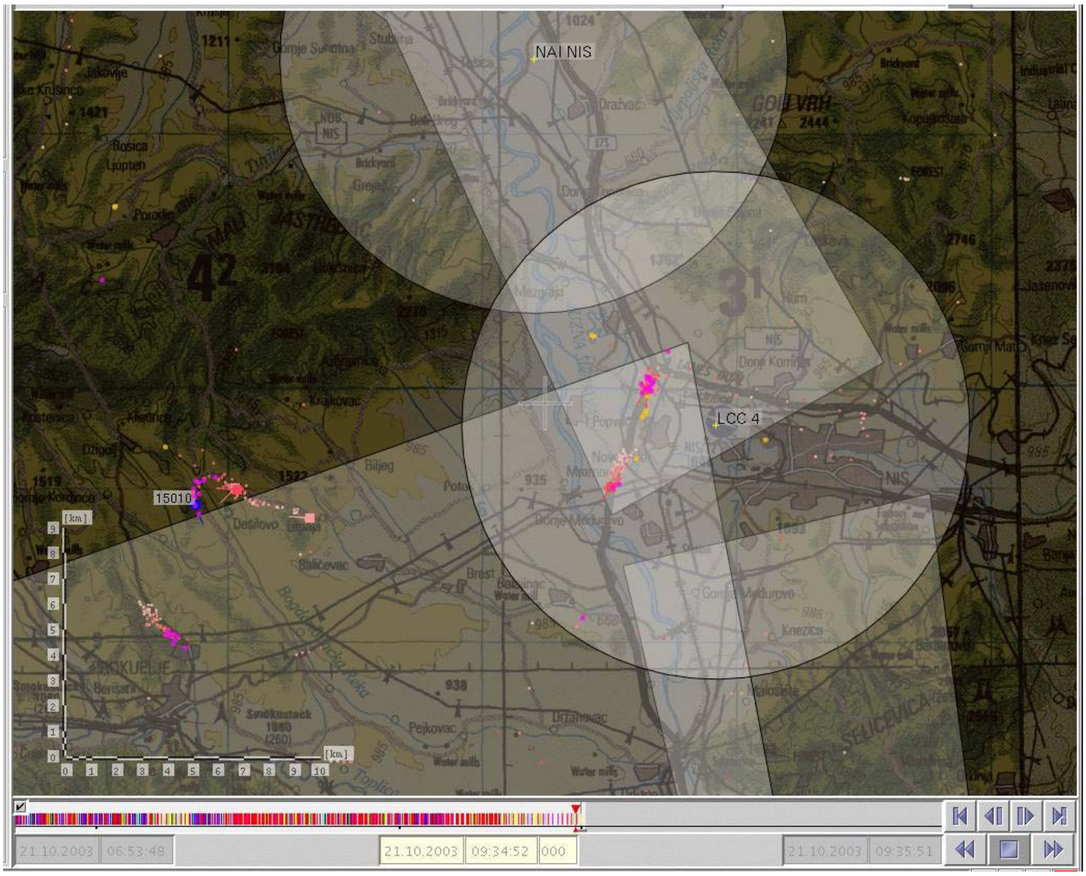


***Figure 11 Detailed data retrieved with CSD file search***

***Operational findings***

After seven days of un-interrupted AGS&R operations, three operational findings became evident. First, many portions of the draft TTP document were evaluated and the weaknesses were identified. Second, there are no existing tools to support planning, tasking and management of coalition AGS&R assets. While each AGS&R system has a specific tool to support planning and tasking, there are no computer-based tools that support coordinated tasking, planning and management of coalition AGS&R assets. Third, the time sensitive-targeting (TST) process, as exercised during SIMEX 2003, identified the need for some additional clarification and definition on various issues. This does not mean that TST in general is not feasible, but the way it was exercised during SIMEX 2003 was not conclusive. All three operational and procedural objectives were exercised.

To catalogue the findings of the exercise, a conference was held in February 2004 for the finalization of the TTP document. In addition to national representatives, the conference was supported by representatives from the ISR management offices from Allied Forces North (AFNORTH), Air Forces North (AIRNORTH), Air Forces South (AIRSOUTH), Supreme Headquarters Allied Powers Europe (SHAPE), and the Allied Rapid Reaction Corps (ARRC). It is rare to gather such a group of experts together in one room and the CAESAR project was the lucky recipient of their combined knowledge and drive. The experts provided clarity and expansion to several areas of the TTP that were identified during the SIMEX as requiring updates. As of March 2004, the document is in final editing (Ref. [4]).

***Assessment by the Advanced Concept Technology Demonstration***
To support the US CAESAR Advanced Concept Technology Demonstration (ACTD), which provides the US support to the coalition project, a Military Utility Assessment (MUA) was performed by the US Defense Information Systems Agency (DISA). The purpose of the MUA was to perform an independent evaluation of the CAESAR capability as it was demonstrated in SIMEX 2003. Such an assessment is a requirement for all US ACTD. In order for the technology to be approved, it must demonstrate that it provides a real military utility. The summary of the MUA states that the CAESAR concept technology provides military utility to the warfighter and enhances surveillance, situational awareness and battle management It also states that implementation of the CAESAR System Architecture Design Principles and revisions to the CAESAR TTP will improve the ability of the U.S. and its NATO partners to exchange GMTI track information, retrieve archived GMTI data from the CSD server, and manage the employment of multiple GMTI and SAR resources (Ref. [4]).

**The way ahead**
***Multi-Sensor Aerospace-Ground Joint Interoperable Intelligence Surveillance and Reconnaissance Coalition (MAJIIC)***
The CAESAR project and its extension will be completed in March 2005. However, based on the success of the project, the CAESAR nations and two new nations, The Netherlands and Spain have created a new project that will build on the CAESAR principles. This project, the Multi-Sensor Aerospace-Ground Joint Interoperable Intelligence Surveillance and Reconnaissance Coalition (MAJIIC) project, will begin in April 2005 and continue until March 2009. The goal of the project will be to make the information from more sensor types available to more users using and expanding on the network enabled methodologies developed in CAESAR. The additional data will include Electro-Optic and Infrared (EO/IR) imagery, Motion Video sensors, and processed Electronic Support Measure (ESM) data. In addition, a tasking, planning, monitoring, and management capability will be investigated along with enhanced tracking and sensor fusion capabilities. MAJIIC will continue to base itself around a strong interaction with the user community and will continue to enhance and support the development of NATO and national doctrine.


*Figure 13 MAJIIC logo and participating Nations*

The MAJIIC project organization described above for CAESAR, with Project Officers and three working groups, will be maintained. As in CAESAR, national programs developing capabilities to support coalition operations will benefit from the new coalition project. The focus on live fly and simulation exercises will again be used to as the methodology for demonstrating the operational, system and technical interoperability proof of concept for coalition ISTAR assets. These exercises will also provide a robust training capability and will be used to demonstrate distributed coalition and network enabled capability operations.

The CAESAR coalition has demonstrated and proved that the operational and technical objectives can be met. With new partners, the team is ready to face new challenges.

References

[1] NC3A Technical Note 986 (Revision 1), Proposed overarching NATO Intelligence, Surveillance and Reconnaissance Architecture and its relationship to the NATO Alliance Ground Surveillance Core Capability, J. Ross, P. Lee, T. Kreitmair, J. Mahaffey, December 2003, The Hague, NATO Unclassified

[2] NC3A Technical Note 995, Alliance Ground Surveillance Core Capability System Architecture Interfaces, J. Ross, P. Lee, T. Kreitmair, J. Mahaffey, December 2003, The Hague, NATO Unclassified

[3] CAESAR Tactics, Techniques and Procedures, Version 4.2 Editor: J.E Ross, , The Hague, July 2003 NATO Unclassified

[4] Defense Information Systems Agency, Joint Interoperability Test Command, Coalition Aerial Surveillance and Reconnaissance, Military Utility Assessment Report, Executive Summary, December 2003