Annex 2

Military Simulation Systems

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INTRODUCTION

Simulation systems known as CGF (computer generated forces) or SAF[1] (semi-automated forces) play a critical role in modern warfare by supporting activities like training, experimentation, acquisition, and analysis. Mainly, these activities can now be conducted at lower cost as they limit the unnecessary movement of troops and equipment and allow for the study of different scenarios efficiently. For instance, when training senior commanders in the execution of defense plans, simulation is used as an alternative to moving troops, planes, tanks, and ships. In addition, different scenarios that consider different troop levels and different types of planes reflecting different strategies can be studied in a short period of time. Simulation systems provide cost-effective, repeatable, and quantitatively analyzable means of "practicing" different scenarios. Scenarios range from joint/coalition strategic to tactical levels involving members from every branch and rank in the military hierarchy. In order to support missions, for instance, CGF simulations contain real-world terrain, human behavior (soldiers in a simulation get tired), weapons, and buildings among others. Although simulations systems can be standalone, they are used as a distributed system that runs different simulations simultaneously. For instance, one system simulates tanks, while another simulates planes, while yet another simulates soldiers. These three simulations

[1]SAF is differentiated from CGF in that in the former entities have some human input while in the latter they are autonomous. Behaviors of SAF and CGF rely on some level of artificial intelligence. Modern simulation systems support both.

Engineering Principles of Combat Modeling and Distributed Simulation, First Edition.
Edited by Andreas Tolk.

are put together (in a federation) which would allow its users to train in a scenario that contains tanks, planes, and soldiers.

Simulation systems execute virtual or constructive simulations. In virtual simulations, real people interact with simulated systems allowing individuals to acquire a special skill such as flying an aircraft. In constructive simulations, simulated people interact with simulated systems. This allows a simulation to receive initial inputs without affecting outcomes. Virtual and constructive simulations can be used in tandem with live simulations (real people interacting with real people and/or systems) in what is called live virtual constructive (LVC) simulations.

Simulation systems, in their current technological form, can be traced back to the 1970s Lawrence Livermore Laboratory and its Janus program for conflict simulation using a graphical user interface. According to Shimamoto (2000), "the Livermore simulations have proved highly valuable to the military. They have been employed in Operation Just Cause in Panama and Operation Desert Storm in the Mideast, as well as for combat planning in Somalia, Bosnia, and other international trouble spots." The development of these simulations took off in the 1990s and they now exist in different forms to satisfy different needs. Currently, simulation systems are specialized by activities which usually translate into military branches. For instance, OneSAF is used mostly by the US Army for training, experimentation, and acquisition, while JSAF is used for joint training exercises.

In order to facilitate the study of simulation systems, this annex will provide a description of some of the most commonly used systems and a categorization according to their characteristics.

SIMULATION SYSTEMS

As previously mentioned, different simulation systems are used depending on particular needs. For instance, if the need is training for a mission where individuals from the Navy, Army, and Air Force are required to work together, there is a system for that. They seek to represent realistic scenarios where friendly and enemy forces are present for training or analysis purposes. They rely on physics-based models of missile trajectories and physiological factors in different environment and urban conditions. Visualization varies across simulation systems, from 2D considering high levels of granularity (brigade, for instance) to 3D considering low levels of granularity (soldier or squad level). These systems rely on frameworks or infrastructures to exchange data in a distributed environment. They are HLA[2] and DIS[3] compliant and are quickly relying on web services for interoperability. They use XML[4]-based languages to initialize scenarios (MSDL[5]) and

[2]High Level Architecture.

[3]Distributed Interactive Simulation.

[4]Extended Markup Language.

[5]Military Scenario Definition Language.

to exchange data between C2 and simulations and provide a common operational picture (BML[6] and C-BML[7]). In the following subsections, brief descriptions of the most commonly used simulation systems are presented. If the reader wants to know more, please refer to the simulation systems manuals.

Joint Semi-Automated Forces (JSAF)

JSAF was developed in the 1990s under the Synthetic Theater of War (STOW[8]) program. JSAF is a simulation system used to generate entity level units such as tanks, soldiers, munitions, ships, and aircraft in a synthetic environment. These entities can be controlled separately or organized into meaningful military units such as a platoon or a company. The entities seek to replicate their real-life counterparts, so they are affected by events such as getting tired (in the case of soldiers), obstacles due to terrain (trees), and limited line of sight (weather conditions). According to JSAF *User's Guide* (2003) JSAF entities exhibit realistic behaviors such as tanks driving along a winding road, ships following an intended course, units suffering combat damage, missiles exhibiting realistic trajectories, and ammo and fuel being depleted. Figure A2.1(a) shows a partial screen capture from JSAF as shown in the *User's Guide* (p. 78) and Figure A2.1(b) shows a screen capture of the main screen (JSAF Quick Guide, 2008, p. 2). Figure A2.1(a) shows the pull-down menu that allows users to select the desired level of granularity to be displayed. In addition, it shows the different tools available for creating and controlling artillery fire, checking gun ordnance inventories aboard units and selecting/firing guns, activating/deactivating radar, firing missiles, and controlling UAV (unmanned aerial vehicle) flight dynamics, among other things.

JSAF is an open environment where entities' attributes, tasks, and behaviors can be modified. This adds flexibility, but it may generate consistency issues with other simulations known to interoperate with it. For instance, we have two simulations, one for a tank and one for a plane. If within the tank simulation an attribute is added to the tank that it has a crew (before tank and crew were one entity), when the tank receives an impact from a missile launched by the plane, now the tank simulation may show a crew surviving the impact. This generates an inconsistency with the plane simulation as it expects the tank and crew to be killed.

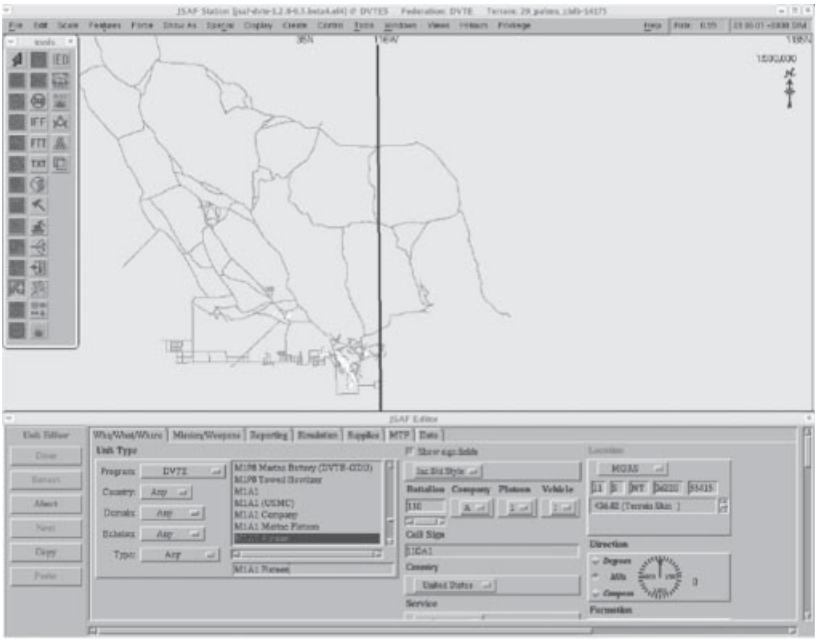
JSAF is DIS and HLA compliant. DIS and HLA allow technical interoperability between simulations as highlighted in the previous example. DIS and HLA allow simulations to share data and synchronize actions in a federation on

[6]Battle Management Language.

[7]Coalition—BML.

[8]According to Lenoir and Lowood (2002), STOW was a large Department of Defense Program in M&S to "construct synthetic environments for numerous defense functions. Its primary objective is to integrate virtual simulation (troops in simulators fighting on a synthetic battlefield), constructive simulation (war games), and live maneuvers to provide a training environment for various levels of exercise."

(a)



(b)

Figure A2.1 (a) JSAF partial screen capture (*User's Guide*); (b) JSAF main screen (*JSAF Quick Guide*).

a set of entities. In the previous example, the plane and tank are entities that are shared by the two simulations with probably their complete corresponding attributes, tasks, and behaviors.

JSAF is used by the Deputy Director J7 for Joint and Coalition Warfighting (DDJ&JCW), the Navy Warfare Development Command (NWDC), the Air Force Research Lab, and the US Marine Corps within the Deployable Virtual

Training Environment (DVTE) providing 2D strategic, operational, and tactical level support for joint navy and marines training in air, water, and land exercises.

JSAF profile:

- Type of simulation: constructive
- Main use: joint
- Main purpose: training and experimentation
- Other users: Navy, Marines, and foreign governments such as Australia and the UK
- Level of support: strategic, operational, tactical
- Data model infrastructure support: HLA and DIS
- Display: 2D
- Military unit: up to brigade

One Semi-Automated Forces (OneSAF)

Born in the 1990s, OneSAF is a simulation system developed by US Army Simulation, Training, and Instrumentation Command to support training, experimentation, and acquisition activities ranging from the troop up to the command level. It is envisioned that OneSAF is the path to modernizing simulators across the US Army, especially for virtual trainers such as Aviation Combined Arms Tactical Trainer (AVCATT), Close Combat Tactical Trainer (CCTT), and the Common Gunnery Architecture (CGA). OneSAF has many JSAF features: replication of their real-life characteristics such as getting tired (in the case of soldiers), obstacles due to terrain (trees), and limited line of sight (weather conditions). OneSAF is HLA and DIS compliant in addition to supporting MSDL, JC3IEDM,[9] and BML. Unlike JSAF, OneSAF is Army centric (quickly being extended to support US Air Force, Joint, US Navy, and US Marine Corps simulation needs) and provides a wider range of support for land entities than for sea and air entities. This extended support is reflected in the higher detail fidelity of represented entities (buildings, land vehicles) and units (squad, brigade) and their range of behaviors. It can represent fully automated friendly and enemy forces, in addition to neutral.

OneSAF has had two incarnations: OneSAF Testbed (OTB) and OneSAF Objective System (OOS). OTB SAF is the successor of Modular SAF (ModSAF) and it provides an interactive, detailed, entity level simulation. According to the OTB SAF Overview (2000)

> *OTB SAF entities can exhibit combat damage to their mobility and firepower according to the type of weapon used, the location and angle of incidence of the hit, and the range of the weapon. Similarly, an entity's weapons system exhibits realistic rates of fire and trajectories, and resource depletion is accurately simulated for both fuel and ammunition. Other simulated capabilities include intervisibility, target*

[9]Joint Consultation Command and Control Information Exchange Data Model.

detection, target identification, target selection, fire planning, and collision avoidance and detection. These capabilities are based on, but not limited to, such appropriate realistic factors as range, motion, activity, visibility, arc of attention, direction, orders, and evaluation of threat.

Figure A2.2 shows a screen capture of OTB SAF (OTB SAF Overview, 2000). As can be seen, OTB SAF has a similar look to JSAF. The limitation with OTB SAF was that it required its user to be a good programmer and knowledgeable in military doctrine and tactics in order to modify entities and units' characteristics and behaviors.

OTB SAF was discontinued in 2006 and replaced by OOS SAF which had been in development since 2003. OOS SAF is a completely new system that allows composition of operations, systems, and control processes up to the brigade level. The current face of OneSAF is OOS SAF. In this incarnation, OneSAF is the next generation simulation system.

OneSAF is highly and easily scalable. Its premise of composition allows modelers the flexibility to represent different tasks and missions by modifying entities, units, and behaviors without the need to be programming or subject matter experts.

OneSAF profile:

- Type of simulation: constructive
- Main user: US Army

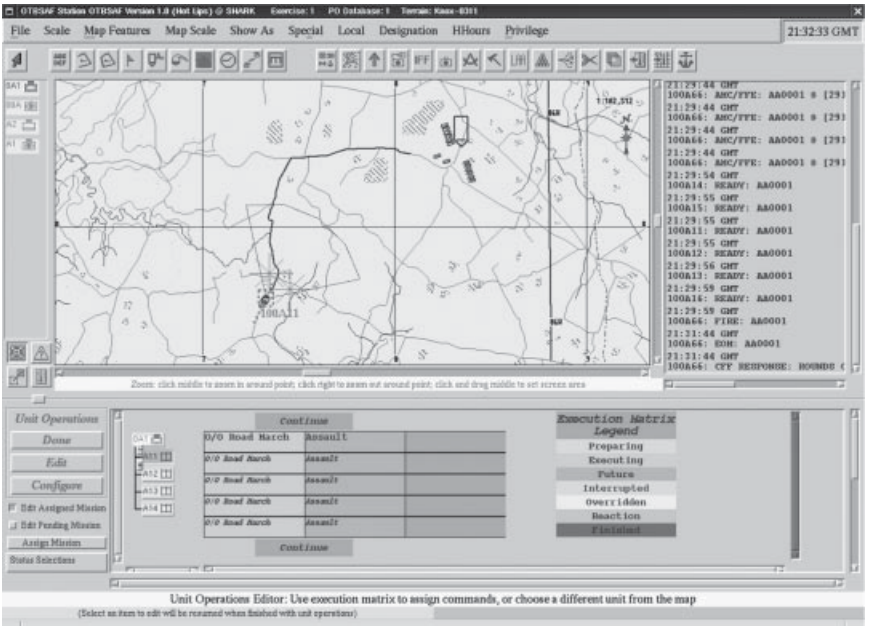


Figure A2.2 OTB SAF screen layout (OTB SAF Overview, 2000).

- Main purpose: training, experimentation, and acquisition
- Other users: Air Force, Joint, US Navy, US Marines, and foreign governments such as Canada, UK, and Australia
- Level of support: strategic, operational, tactical
- Data model infrastructure support: HLA, DIS, MSDL, BML
- Display: 2D and 3D
- Military unit: up to brigade

Joint Conflict and Tactical Simulation (JCATS)

Born in the 1990s, JCATS was developed by the Lawrence Livermore Laboratory and is currently sponsored by US JFCOM; it supports sea, land, and air exercises by the US Navy and US Marines. It is also used by the Department of Homeland Security (DHS) for training purposes. JCATS is similar to JSAF and OneSAF as it supports a large number of entities, generates realistic scenarios based on physics-based models, and is HLA and DIS compliant. Its advantage relies on its special support for training and rehearsing at the tactical level. Mission planning and rehearsal makes JCATS appealing to organizations such as DHS and the Department of Energy (DOE), among others. JCATS supports training and experimentation in a variety of environments and in special, urban environments where it provides a high level of detail of entities such as buildings (with doors, windows, and floor plans for instance), people (armed forces and civilians), and activities such as close air support and mount/dismount of vehicles. Figure A2.3 shows the JCATS workstation display (*JCATS: Simulation User's Guide*, 2003, p. 4-1).

US JFCOM uses JCATS in their LVC simulations in tandem with other systems such as VBS2 to provide different levels of detail in their training.

JCATS profile:

- Type of simulation: constructive
- Main user: joint
- Main purpose: training, analysis and experimentation
- Other users: US Navy, US Marines, DHS, DOE, NATO
- Main level of support: tactical
- Data model infrastructure support: HLA, DIS
- Display: 2D
- Military unit: up to battalion

VR-Forces

VR-Forces is a commercial of the shelf (COTS) simulation system developed by VT MÄK as an option to government solutions such as JSAF, OneSAF, and JCATS. It is used mostly for training at the tactical level providing a high level

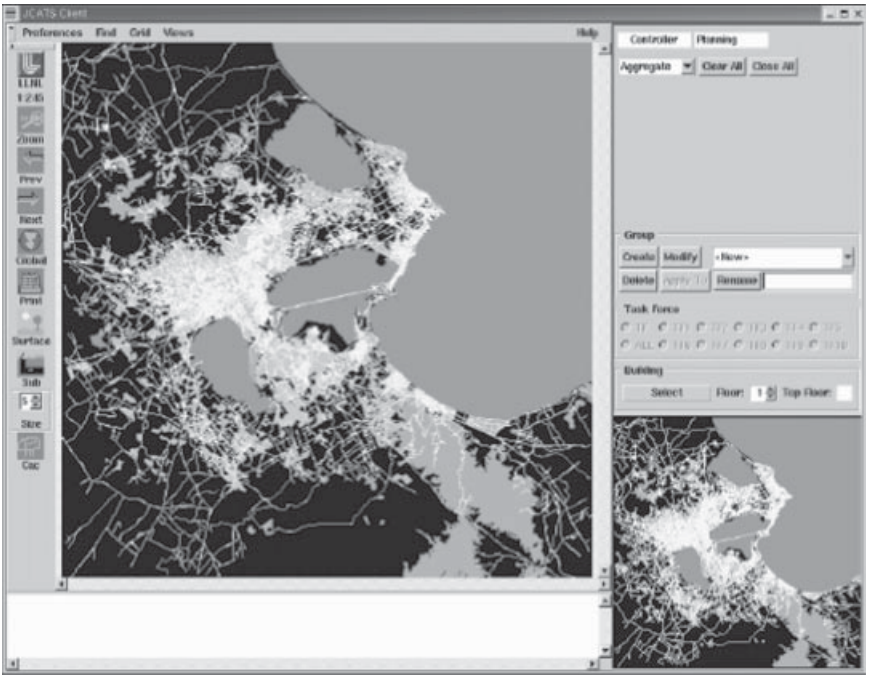


Figure A2.3 JCATS workstation display (*JCATS: Simulation User's Guide*, 2003).

of detail of the battlefield. Like its government-sponsored counterparts, it is HLA and DIS compliant and, given that it has a programmable toolkit, modules can be built to make it complaint with XML-based languages. The toolkit can also be used to modify entities' characteristics and behaviors. It is used as a desktop solution by the US Air Force and the US Marines and by foreign governments such as Spain, Norway, and the Netherlands.

VR-Forces profile:

- Type of simulation: constructive
- Main user: all branches
- Main purpose: training and experimentation
- Other users: Spain, Norway, and the Netherlands
- Main level of support: tactical
- Data model infrastructure support: HLA, DIS
- Display: 2D and 3D
- Military unit: up to platoon

Virtual Battlespace 2 (VBS2)

VBS2 is a COTS simulation system developed by Bohemia Interactive Simulations to train and rehearse missions at the tactical level. Small combat teams

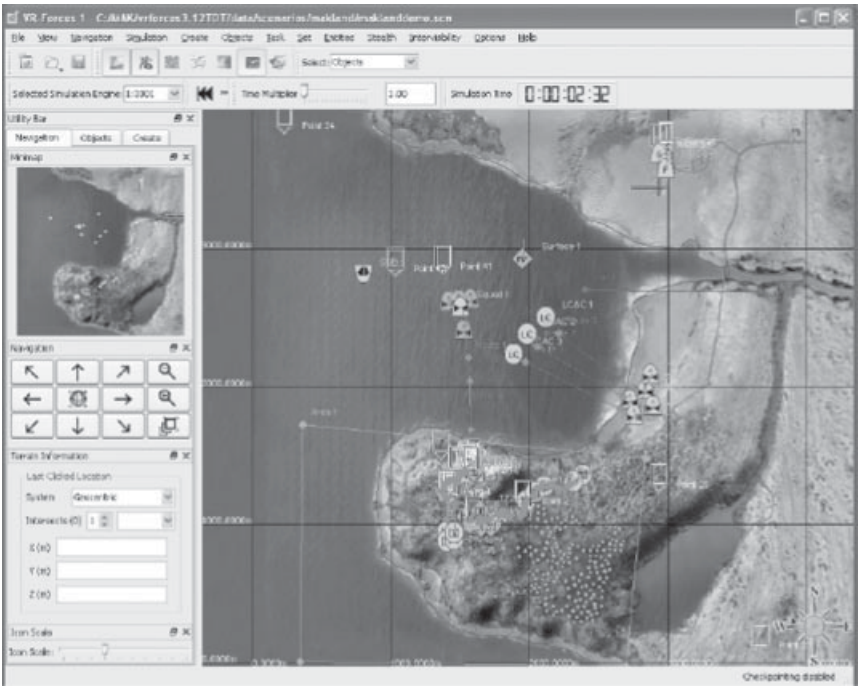


Figure A2.4 VR-Forces interface and demo scenario (*VR-Forces: Getting Started Guide*, 2009, p. 10).

rely on realistic environments for convoy training, fire support, visualization of weapons effect, and training in an urban environment. VBS2 has an extended database to simulate sea, air, and land vehicles and other miscellany. The database has objects (car batteries and water cooler, for instance), people (Afghan civilian, Iraqi police, or US civilian), vehicles (planes, ships, or armor vehicles from different nations), and weapons (a variety of handguns and rocket launchers). VBS2 is mainly used by the US Army. US JFCOM uses it in their LVC simulations. In an LVC simulation, a trainee uses a helmet with an eyepiece and a gun. The VBS2 simulation shows the trainee (as an avatar) within a squad. The trainee can shoot his/her gun and kill enemy forces within the simulation. USMC uses it as part of their DVTE program. Countries such as the UK and Canada use it as well as NATO.

Like previously mentioned simulation systems, VBS2 is HLA and DIS compliant allowing distributed simulation and connectivity with higher granularity simulation systems such as JSAF or JCATS. Figure A2.5 show the level of detail of some of the simulations using VBS2 (Bohemia Interactive Simulations, 2011). Figure A2.5(a), for instance, shows a screen shot of an interactive simulation to train a soldier how to greet and observe a person while looking for anything suspicious. In this case, the person has a large mid-section which may be indicative of explosives. Figure A2.5(b) shows the avatar of an Iraqi policeman

(a) (b)

Figure A2.5 (a) Cultural awareness simulation; (b) water purification unit training.

communicating to the trainee's avatar (not in the screen) that there is a problem with the water purification unit.

As can be observed, unlike previous simulations VBS2 provides a highly detailed environment for individual or small team training.

VBS2 profile:

- Type of simulation: constructive, virtual
- Main user: US Army
- Main purpose: training and mission rehearsal
- Other users: US Secret Service, US Marine Corps, UK, Canada, and New Zealand among others
- Main level of support: tactical
- Data model infrastructure support: HLA, DIS
- Display: 2D and 3D
- Military unit: squad

Air Force Synthetic Environment for Reconnaissance and Surveillance Model (AFSERS)

The MUSE (Multiple Unified Simulation Environment)/AFSERS, developed by the Joint Technology Centre/System Integration Laboratory (JCT/SIL), is a simulation system mainly used for unmanned aerial vehicle (UAV) and intelligence, surveillance, and reconnaissance (ISR) training. Unlike previously mentioned simulation systems, the AFERS is focused on simulating systems that relate to air missions such as air vehicles (different UAVs, P-3, and U-2), landing systems, and radars. According to McClung and Jones (2002), the MUSE was developed as a Hunter UAV simulation and has evolved to include ISR platforms and sensor models (infrared), theatre and national capabilities, tactical communications and advanced mission planning. Like other simulation systems, AFSERS is HLA and

DIS compliant and it is used by the JCT/SIL in distributed simulation scenarios with other simulation systems such as AWSIM.

AFSERS profile:

- Type of simulation: constructive and virtual
- Main user: US Air Force
- Main purpose: training and mission rehearsal
- Other users: US Army, Joint, South Korea
- Main level of support: tactical
- Data model infrastructure support: HLA, DIS
- Display: 2D and 3D
- Military unit: battalion

Air Warfare Simulation (AWSIM)

AWSIM, developed in the 1980s by the Warrior Preparation Center in Germany, is the favored simulation system of the US and NATO Air Force for conducting simulation exercises in air warfare (air-to-air, air-to-surface, and surface-to-air combat) and space operations. Some of the simulations that AWSIM has are surface-to-air missiles (SAM), surface-to-surface missiles, (SSM), short range air defense systems (SHORAD), aerial refueling, and air-to-air engagement while considering variables such as speed, altitude and fuel consumption. According to Training Transformation Defined (2006) AWSIM was developed to

> *train senior commanders and battlestaffs in the execution of wartime general defense plans that emphasize joint and conventional operations. . . . Today, it is the core model of the Air and Space Constructive Environment Suite used worldwide to train senior battle commanders and their staffs within the Air Force across the Department of Defense (DOD). It provides the opportunity to train for joint and combined prosecution of war using interactive computer simulations that replicate a realistic battlespace, incorporating various audiences through worldwide distribution.*

AWSIM can be used with other simulation systems in order to conduct joint and coalition exercises. Perhaps the best known case in which AWSIM is used with other simulation systems is the Ulchi-Focus Lens (UFL), now known as the Ulchi-Freedom Guardian (UFG). The UFG is a large scale war fighting exercise and the world's largest command and control simulation driven exercise that takes place yearly between the South Korean and US Government military. The UFG's purpose is to train both military for the case of a North Korea attack. In the 2010 exercise, it was reported by the Xinhua News Agency (2010) that the exercise included about 55,000 South Korean soldiers and 30,000 US troops in South Korea and abroad. AWSIM is used in UFG exercises in conjunction with other systems such as the US Marine model Marine Tactical Warfare Simulation (MTWS) and US Army Corps Battle Simulation (CBS).

AWSIM profile :

- Type of simulation: constructive
- Main user: US Air Force
- Main purpose: training, mission rehearsal, experimentation
- Other users: NATO, NASA
- Main level of support: operational, tactical
- Data model infrastructure support: HLA, DIS, ALSP[10]
- Display: 2D
- Military unit: wing

Research, Evaluation, and System Analysis (RESA)

RESA, developed by SSC[11] San Diego, provides the US Navy with a simulation system for theater level naval warfare. According to Neyland (1997, p. 110), RESA was designed

> *to support research and development and training of senior naval officers, focusing on command and control of battle group or force operations. . . . RESA has been used for requirement analysis, technology evaluation, concept formulation, system testing, system design, architecture assessment, operation plan evaluation, command and control training, joint operation interoperability, and distributed war gaming.*

RESA is ALSP, DIS and HLA compliant which allow simulations to work in a distributed environment. RESA, being Navy focused, allows for the simulation of naval warfare such as submarines, sensors, warships, and C3[12] architectures as well as ground forces.

RESA profile:

- Type of simulation: constructive
- Main user: US Navy
- Main purpose: training, acquisition
- Other users: Joint, South Korea
- Main level of support: operational, tactical
- Data model infrastructure support: HLA, DIS, ALSP
- Display: 2D
- Military unit: –

[10]Aggregate Level Simulation Protocol.

[11]SPAWAR (Space and Naval Warfare Systems Command) Systems Center Pacific.

[12]Command, Control, and Communications.

Marine Air Ground Task Force (MAGTF) Tactical Warfare Simulation (MTWS)

Developed by SSC San Diego as well, MTWS's main purpose is to support tactical training exercises for the US Marine Corps. Despite the Marines using other simulation systems, MTWS provides the right mix of air, ground, maritime, and amphibious operations: MAGTF provides these combat operation elements in a wide range of tactical conditions while MARS (MTWS Analysis Review System) provides exercise review and analysis capabilities (Hardy et al., 2001).

MTWS profile:

- Type of simulation: constructive
- Main user: US Marine Corps
- Main purpose: training, analysis
- Other users: Joint, South Korea
- Main level of support: tactical
- Data model infrastructure support: HLA, DIS, ALSP
- Display: 2D
- Military unit: –

CATS TYR

CATS TYR was developed by C-ITS (back then named "Mandator") in collaboration with the Swedish Defence Research Agency (FOI) starting in 1996. The original purpose was to simulate and evaluate conventional wargaming with asymmetrical forces on a larger scale. Several core processes generated robustness and good scalability with multiple processors. Doctrines and models were supplied by FOI. Quite early support for civil units and PSO orders was introduced. Focus shifted towards operations other than war and disaster relief. Also the need for multi-resolution dictated that models would support smaller units as well.

When CATS TYR was put to use internationally additional features such as terrain, night vision capability, extended logistics, and decoys were added. In recent years optimization has enabled extended number of units as well as exceptional stability for the system.

TYR has served as the back-bone and core system in all VIKING CAX (Computer Assisted Exercises) events in an integrated environment containing other virtual and constructed simulation systems and C2 systems. VIKING events are international joint exercises, coordinated by the Swedish Armed Forces, that involve not only the military but also civilians and police forces. So far, there have been six VIKING events (99, 01, 03, 05, 08, and 11). VIKING 11 (conducted in April 2011) had the participation of about 2600 trainees representing Governments, the United Nations, Red Cross, and military forces among others. The event was distributed over nine remote sites, four in Sweden and five in other countries (Austria, Georgia, Germany, Ireland, and Ukraine).

CATS TYR is supported by a range of optional tools such as simplified scenario construction using MSDL and stand-alone AAR[13] tools with time sliders and "take home" packages, all integrated using HLA standards. Today, CATS TYR is developed into separate modules able to support other systems in a larger federation while supporting external models Fig. A2.6 shows a screenshot of CATS TYR (Karlström, 2011).

CATS TYR profile:

- Type of simulation: constructive
- Main user: Swedish Armed Forces in conjunction with police and civil organizations
- Main purpose: training and experimentation in PSO,[14] disaster relief, and conventional joint wargaming
- Other users: United Nations, other nations
- Level of support: strategic, operational, tactical
- Data model infrastructure support: HLA, MSDL, XML
- Display: 2D
- Military unit: –

GUPPIS/KORA OA (Korpsrahmen Simulationsmodell für die Offizierausbildung — Corps Frame Model for Officers Training)

KORA, developed by IAGB (Industrieanlagen-Betriebsgesellschaft mbH), is the software component of the GUPPIS[15] joint simulation system. It is used by the German Federal Armed Forces to train in air (surveillance, airspace control, air transport, among other capabilities), land (mounted and dismounted infantry among other capabilities), and naval (anti-surface and anti-air among other capabilities) warfare. In addition, KORA is also used for concept development and experimentation.

According to IABG (2010), the core of KORA is made up of a group of sub-models (Air Force, Navy, Logistics, Communications, Medical Services, and Reconnaissance, among others). Other components support the "generation of military structures and exercise scenarios, evaluation of exercises, editing of terrain data, processing of weapon system data and system administration" (p. 4). KORA is HLA and DIS compliant and is based on JC3IEDM standards.

[13] After Action Review.

[14] Peace Support Operations.

[15] Gefechtssimulationssystem zur Unterstützung von Plan/Stabsübungen und Planuntersuchungen in Stäbenvon Großverbänden und an Schulen/Akademien mit Heeresaufgaben (Combat simulation system for support of map and staff exercises within the HQs of major units or at schools and academies with army tasks).

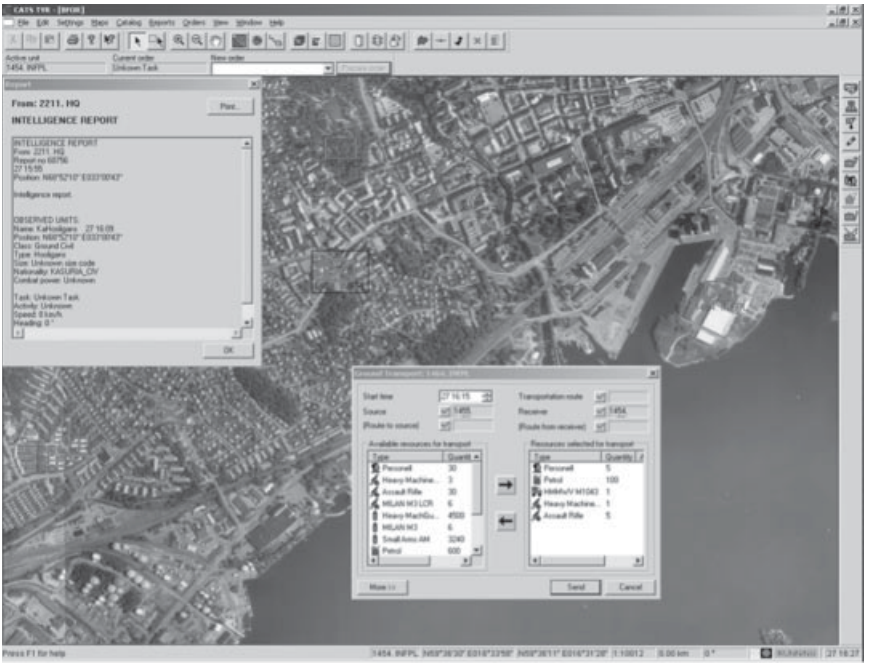


Figure A2.6 CATS TYR main screen.

KORA profile:

- Type of simulation: constructive
- Main user: German Federal Armed Forces
- Main purpose: training and experimentation
- Other users: Training Academies of the German Federal Armed Forces
- Level of support: strategic, operational, tactical
- Data model infrastructure support: HLA, DIS, JC3IEDM
- Display: 2D
- Military unit: –

Other Simulation Systems

- **Corps Battle Simulation—CBS:** a constructive simulation system that provides theater level training using ground battle scenarios
- **Joint Theater Level Simulation—JTLS:** a constructive, multi-sided simulation system used by joint and coalition forces with main focus the operational level of war

- **Modular Semi-automated Forces—ModSAF:** a constructive simulation system that precedes OneSAF and provides a scalable architecture allowing users to control different levels of military units in a wide range of scenarios
- **Warfighters Simulation—WARSIM:** a constructive simulation system that provides mission rehearsal capabilities for Army and joint commanders and their staff and supposed to replace systems such as the CBS
- **Janus Simulation System:** a 2D, multi-sided, ground combat interactive simulation system
- **Extended Air Defense Simulation—EADSIM:** a constructive simulation system that provides simulation of air, space, and missile warfare, managed by the Future Warfare Center (FWC), Modeling and Simulation Division (MSD), US Army Space and Missile Defense Command (SMDC)
- **Joint Warfare System—JWARS:** a constructive simulation system that provides operational, planning, system trade analysis, and execution support in joint settings

Table A2.1 shows a rough categorization of the previously mentioned simulation systems. The table is not meant to be a comprehensive list as there are many more systems that did not make it to this review.

FINAL REMARKS

Simulation systems are powerful tools that assist the military in their training, analysis, mission rehearsal, acquisition, and experimentation needs. However, there are some important considerations worth mentioning. First is that of interoperability. Although systems seem to be interacting with one another, it does not mean that the output of this interaction is consistent, as previously mentioned. This is more an issue of modeling than of simulating as the modeler needs to address polymorphism, data availability multi-scope and multi-granularity issues, among other things, during the modeling of the federation. A second consideration is that of achieving training objectives. Designing training objectives is a major challenge as a federation is used to train different people, at different levels, at the same time, and individuals have different training needs. Despite these systems saving money, they are by no means inexpensive and their cost/benefit effectiveness relies on achieving those training objectives. Notice that the training objective is tightly tied to the interoperability consideration. As more than one simulation is required to achieve the training objectives, consistency is key for the training to be effective and avoid cost overruns by solving inconsistencies due to poor modeling. Finally, when referring to cost reduction, the idea of reusability comes to mind. When reusing existing simulations one expects to reduce costs by using simulations to achieve training objectives they were not designed for. In this sense, to establish reuse, both previously mentioned considerations need to be maintained.

Table A2.1 Categorization of Simulation Systems

System	Type		Purpose					Main user	Other users	Level of support			Military unit (up to)
	C	V	T	E	A	M	Q			S	O	T	
JSAF	×		×	×				US Joint	Navy, Marines, Joint, Coalition, UK	×	×	×	Brigade
OneSAF	×		×	×			×	US Army	Navy, Marines, Joint, Canada, UK	×	×	×	Brigade
JCATS	×		×	×		×	×	US Joint	Navy, Marines, DHS, DOE, NATO			×	Battalion
VR Forces	×		×	×					Spain, Norway, the Netherlands			×	Platoon
VBS2	×	×	×			×		US Army	Secret Service, Marines, UK,			×	Squad
AFSERS	×	×	×			×		US Air Force	Army, Joint, South Korea			×	Battalion
AWSIM	×		×	×		×		US Air Force	NATO, South Korea, NASA Langley		×	×	Wing
RESA	×		×				×	US Navy	South Korea		×	×	-
MTWS	×		×		×			US Marines	Joint, South Korea			×	-
CATS TYR	×		×	×				Sweden AF	United Nations	×	×	×	Battalion
KORA	×		×	×				German AF	Training Academies of German AF	×	×	×	-
CBS	×		×					US Army	Joint			×	-
JTLS	×		×			×		US Joint	Coalition		×	×	Theater
ModSAF	×		×	×	×			US Army	Joint		×	×	-
WARSIM	×		×			×		US Army	Joint, Coalition		×	×	-
EADSIM	×		×	×	×			US Air Force	Joint, Coalition	×	×		Theater
JWARS	×				×			US Joint	Navy		×		Theater

Type: C, constructive; V, virtual. Purpose: T, training; E, experimentation; A, analysis; M, mission rehearsal; Q, acquisition. Level of support: S, strategic; O, operational; T, tactical.

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REFERENCES

Bohemia Interactive Simulations. VBS Worlds Demos. http://www.bisimulations.com (last accessed 4 July 2011).

Hardy D, Allen E, Adams K, Peters C and Peterson L (2001). Advanced distributed simulation: decade in review and future challenges. *Space and Naval Warfare Systems Center, San Diego, Biennial Review*, San Diego, US Navy, pp. 165–175.

IABG (2010) *GUPPIS/KORA:* Model Profile. IABG, Germany.

JCATS: Simulation User's Guide, Version 4.1.0. (2003) Lawrence Livermore National Laboratory.

JSAF Quick Guide. JCATS: CA. http://www.i-mef.usmc.mil/external/wss/deployable_virtual_trianing_environment/dvte_handouts/can/jsaf/jsaf_qg.pdf (last accessed 4 July 2011).

JSAF User's Guide (2003) *Volume 1, Introduction and Basic Controls.* Joint Semi-Automated Forces.

Karlström M (2011). *Personal Communication*, July 14, 2011.

Lenoir T and Lowood H. *Theaters of War: the Military–Entertainment Complex.* Stanford University, Palo Alto, CA. http://www.stanford.edu/class/sts145/Library/Lenoir-Lowood_TheatersOfWar.pdf (last accessed 4 July 2011).

McClung S and Jones J. *Up and Away, Equipment, Training and Support News.* http://www.metavr.com/aboutus/articles/ETSspring02muse_up%2Baway.pdf (last accessed 4 July 2011).

Neyland D (1997) *Virtual Combat: A Guide to Distributed Interactive Simulation.* Satckpole Books, Mechanicsburg, PA.

OTB SAF Overview. University of Pittsburgh, Pittsburgh, PA. http://usl.sis.pitt.edu/wjj/otbsaf/USER_VOL1.HTML#OTB%20SAF%20Overview (last accessed 4 July 2011).

ShimamotoF (2000) Simulating warfare is no video game. *Sci Tech Rev*, 4–11.

Training Transformation Defined (2006) National Defense University Press, Joint Force Quarterly 42, 55–56.

VT MÄK (2009) VR-Forces: Getting Started Guide. VT-MÄK, Cambridge, MA.

Xinhua News Agency (2010) *S Korea Conducts Anti-Terrorism Drills as Part of UFG Exercises.* http://news.xinhuanet.com/english2010/ world/2010-08/17/c_13449108.htm (last accessed 4 July 2011).