Situational Awareness Objects (SAOs), A Collaborative Toolset for Players, Controllers and Analysts

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ABSTRACT

The U. S. Joint Forces Command (USJFCOM), J9 Modeling and Simulation (M&S) Support Team developed tools that allowed experiment subjects to record their individual and collective Situational Awareness (SA) during structured military warfare and peacekeeping experiments. These SA tools were used in planning for, constructing and managing simulation activities during the experiments. Resultant data products from these tools were logged to support real-time and after-action review and assessment of player SA and understanding of dynamic events occurring within their geographic area of responsibility. Experiment subjects used Situational Awareness Objects (SAOs) to share their awareness regarding activities of adversaries, blue forces and civilian population. The Simulation Control Teams (red, blue, and green) shared their intentions and actions regarding activities of the adversaries, blue forces and civilian population using Exercise Control Objects (ECOs), while analysts used SAOs to support real-time, post-experiment evaluation and comprehensive after-action reviews. These SA tools enable the Urban Resolve series of experiments conducted by USJFCOM and the Institute for Defense Analyses (IDA). Throughout the Urban Resolve experiments, the SA tool structure evolved to include new options based on operator's needs and recommendations.

This paper addresses the design and employment of SA tools and proposes that USJFCOM's ongoing success in using SAOs and ECOs, along with the enthusiasm and innovation that operators show in using them, indicates these tools would be useful if implemented in other simulations and operational C2 systems to enable training of 21st Century Joint Forces in exercises where mission focus is aimed at achieving warfighting excellence.

ABOUT THE AUTHORS

Michael Anhalt is retired Navy Surface Line Commander with over 23 years of operational experience, including specialties in Amphibious Warfare, Surface, Undersea, and Strike Warfare, and operational training. Thirteen years experience in planning and directing system-engineering efforts related to modeling & simulation and their integration with military Command and Control (C2) systems. He provides on-site technical support in planning for and conducting warfighting and peacekeeping exercises and experiments, prototype development, and demonstration of advanced technologies for next generation C2 Systems and Command Centers. He holds a Master of Science degree in Educational Technology. Mr. Anhalt authored two related papers selected for presentation at CCRTS 2006, “Situational Awareness Object (SAO), A Simple yet Powerful Tool for Operational C2 Systems”, paper #014, and “Exercise Control Objects, C2 for the Control Team”, paper #015. He co-authored a paper selected for presentation at I/ITSEC 2005, "Developing Situation Awareness Metrics in a Synthetic Battlespace Environment", paper #2218.

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Introduction

As we explore network-enabled warfare/peacekeeping networks, with their ever-expanding scope and complexity, it is obvious that humans are being challenged to achieve accurate situational awareness and understanding of their environment evermore rapidly to support shrinking decision-cycles. While we understand this intuitively, we lack the tools and instrumentation to accurately assess human and human team mental processing capacity and limitations. The Joint military warfare and peacekeeping experimentation arena offers a rich and credible environment for developing and testing Situational Awareness (SA) tools. Situational Awareness Objects (SAOs) and Exercise Control Objects (ECOs) were developed and tested within just this type of environment, where the experimentation and training mission is focused on enabling 21st Century Joint Forces to achieve warfighting excellence. This paper discusses the design and implementation of SA tools for use by experiment subjects- tools that they themselves found useful and thus were willing to use.

The U. S. Joint Forces Command (USJFCOM), J9 Modeling and Simulation (M&S) Support Team advanced the capability of distributed simulation by implementing SAOs and ECOs in support of the Urban Resolve series of experiments conducted over the last three years by USJFCOM and the Institute for Defense Analyses (IDA). These experiments included:

- Urban Resolve (Phase I) in 2004 (UR04)
- Urban Resolve (Current Operations) in 2005 (UR05)
- Urban Resolve 2015 (UR2015)

The M&S Team first implemented Situational Awareness Objects (SAOs) for UR04, an experiment designed to explore new approaches to future urban combat in the 2018 timeframe, to better understand the impact of new technology and to help with the development of command cells, tactics, techniques & procedures (TTPs). SAOs were used, along with Exercise Control Objects (ECOs), in conducting UR05 and are presently being used in Urban Resolve 1015 (UR2015).

In UR05, the experiment construct replicated a vertical slice of the command and control structure and presented players with a proportionate number of operational challenges based on current operations and situations faced by warfighters in Baghdad. The experiment investigated potential improvements related to Command and Control (C2), organizational, and process improvements for integrating and employing forces, sensors, and systems in Baghdad to more effectively anticipate, preempt, and respond to enemy attacks as a basis for actionable recommendations.

UR2015 looks out again to the future to investigate options that ensure Joint Forces will be capable of achieving warfighting excellence, using the right tools and command structures.

Joint Semi-Automated Forces (JSAF) simulation was the centerpiece of the simulation federation for these experiments. JSAF is an entity-level simulation designed for Human-In-The-Loop (HITL) involvement of simulation operators. JSAF runs in real-time and many of its entity maneuvers and behaviors were cued, or directed, by JSAF simulation controllers. The experiment subjects, commonly referred to as players, used JSAF for their Common Operational Picture (COP) and directed the maneuvers and activities of their simulated forces by giving orders to the JSAF simulation controllers. A typical player cell arrangement with its functional positions is shown on the next page.

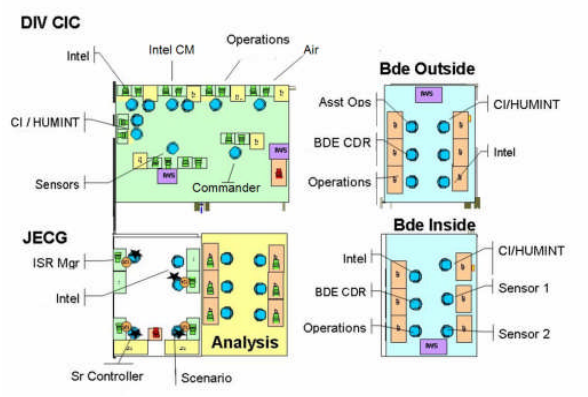


Figure 1 Urban Resolve 05 Experiment Architecture

Players used Situational Awareness Objects (SAOs) to share their awareness and understanding of the battlespace regarding activities of the adversaries, blue forces and civilian population. SAOs are compact packages of information symbolically displayed, as shown below, on the terrain map. They contain the author's identification, location coordinates, time created (or modified), SAO category, player's confidence level, free-text comments, and associated tracks and offer the option to attach graphics and text files to the object.

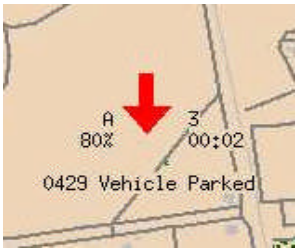


Figure 2 SAO Map Symbol

The SAO Editor, shown in the upper right, allowed players to create SAOs from a selection of optional attributes, including a free text comment field. These preset menu options made it easy for players to make entries and once created the SAO data provided standard attribute markings for the after-action review system queries and callouts. The benefit of SAOs was that they were easy to create and modify to support varied tactical and operational objectives. Throughout each Urban Resolve experiment, the SAOs structure and formats evolved to include additional options based on the player's needs.

The players created SAOs whenever they chose to during event run-time. Some SAOs were entered before run-time based on Intelligence Preparation of the Battlespace (IPB) disclosures, such as Named Area of Interest (NAIs) and Targeted Areas of Interest (TAIs).

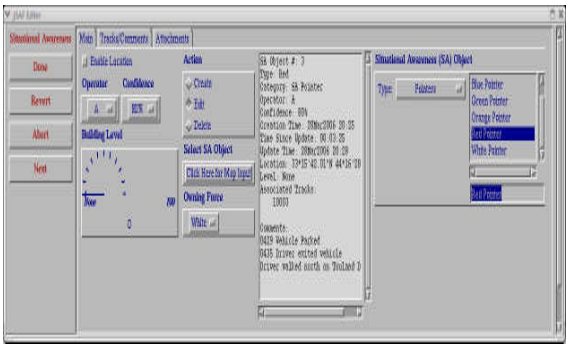


Figure 3 Situational Awareness Editor (Main Tab)

The SAO Editor *Tracks Tab*, shown below, let players associate sensed detection tracks and other SAOs with the SAO being created. This feature allowed players to capture their justification for creating SAOs. When any player selects an SAO, the SAO Editor opens and arrows on the map point to all the associated tracks, which helped to support collaboration and review. Further, if players return to an SAO after lapsed time, they could observe the associated track arrows to see where the tracks had moved. Players had the ability to attach the SAOs to a track object, so that SAOs move along with the track object.

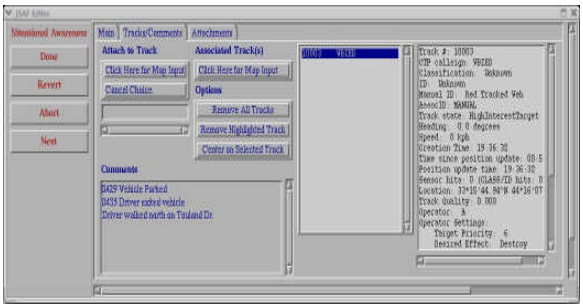


Figure 4 Situational Awareness Editor (Tracks/Comments Tab)

The SAOs were logged during each experiment event to supported both real-time experiment assessments

and post-event comprehensive after-action reviews. Players were instructed that their SA would be evaluated based on a three SA levels, derived from Endsley's (1998) three level approach, along with more traditional analyst observation techniques. Examples of typical player comments and SA categorization are shown below.

SA Level 1 Where is the enemy?	SA Level 2 What is the enemy doing?	SA Level 3 What is the enemy going to do?
Appears to be a mortar site	Appears to be a group of insurgents placing a mortar pad	Expect a launch at sunset
Enemy Recon team on roof	Recon team is waiting until street clears	Recon Team will radio mortar team when all clear
Vehicles and Explosives in bldg	Explosives are being loaded into vehicles	Vehicles likely to move to FOB 3 during the night

Figure 5 SAO Comments

SAO objects were displayed on the JSAF map display. The red arrow below is an SAO and the red dot is a detection track object. The players controlled the display of the attribute flags that they want to see next to the SAO. This display shows an open SAO Editor, with SAO #13 selected. The information about the selected SAO is shown in the Info Box to the upper right, as well as in the SAO Editor at the bottom.

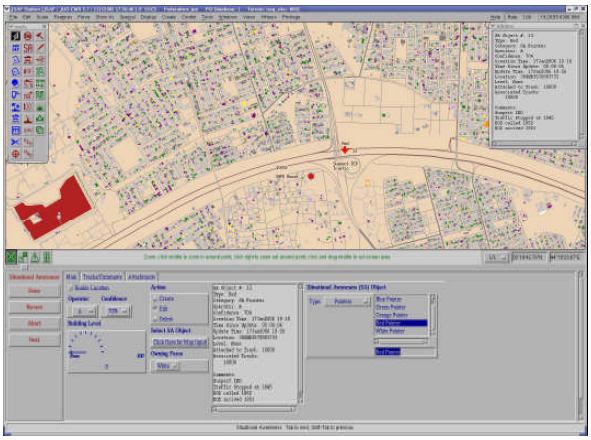
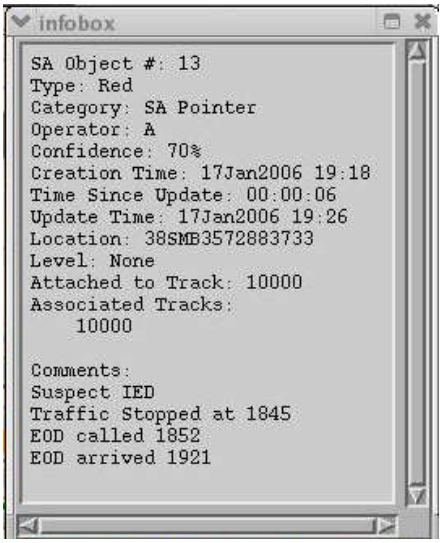


Figure 6 Map Display of SAOs and Track

The JSAF Info box, just mentioned, shows a summary of the SAO data whenever the player clicked on the SAO map object. This functionality made it more convenient to view SAO data without the need for opening the editor. The Info box shows data for tracks, entities and other map features as well, so it is simply a convenient tool for investigating "drill-down to" various forms of data. The Info box with SAO data is shown first and the SAO with ECO data is shown next.



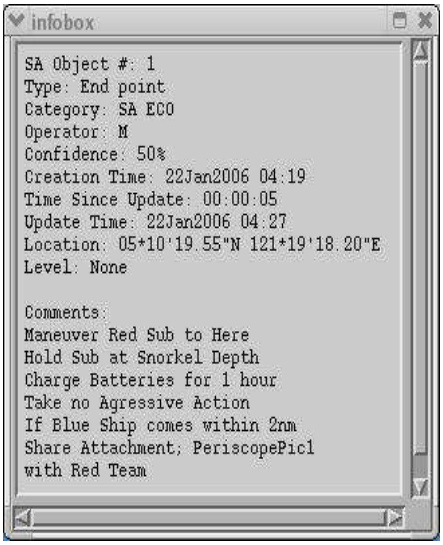


Figure 7 Information Boxes with SAO and ECO Examples

The Situational Awareness Summary, shown below, is similar to the operational Global Command and Control System (GCCS) Track Summary, in that it shows the tracks and attributes in a tabular format. Players often kept this display open during operations for ready reference. They could sort by any of the columns and open the SAO editor by clicking on an SAO line item. The function that sets the SAO process apart from other display tools, such as overlay objects, is that the operator could easily find an SAO by clicking on the "Center" button at the left, which causes the map to center on the SAO. Often, players referred to SAOs by number in chat. This feature eliminates the need for players to type coordinates and long narrative locating-descriptions in chat.

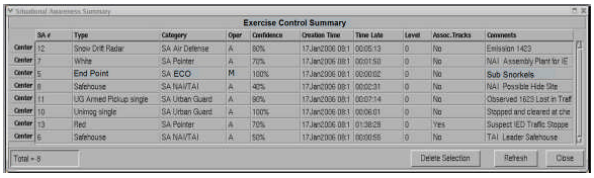
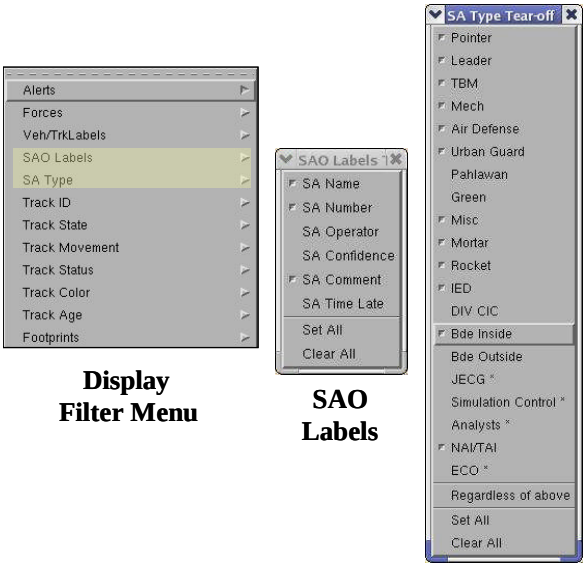


Figure 8 Situational Awareness Summary

Players used filters, as shown in the upper right; to select the categories of SAOs they were interested in. In some experiment events, the Joint Exercise Control Group imposed filters to isolate one command cell from the other to replicate real-world communication limitations. For example, the Brigades (Inside and Outside the Camp Victory fence line) could see their own SAOs, but they could not see each other's SAOs, whereas, the Division headquarters could see them all.



Display Filter Menu

SAO Labels

SA Types

Figure 9 SAO Filters

The SAO Alert function was created to let the players choose the SAO categories for which they wanted to be alerted whenever they were created or modified by other players. Players kept this summary open and checked it occasionally to see if there were new SAOs or tracks of interest to them. The Alert Summary Display is shown below.

Figure 10 SAO Alert Summary Display

SAOs allowed operators to match information to a specific location in time. These functions coupled with the ability to include attachments with the SAO helped players manage and collate information. As shown on the next page, an SAO referring to hostage-taking incident could include attachments with a photo of the checkpoint where the kidnapping took place, a suspect building where the hostages are being held, a floor plan of the building, a photo of the hostage and suspects, the ransom note and other related information.

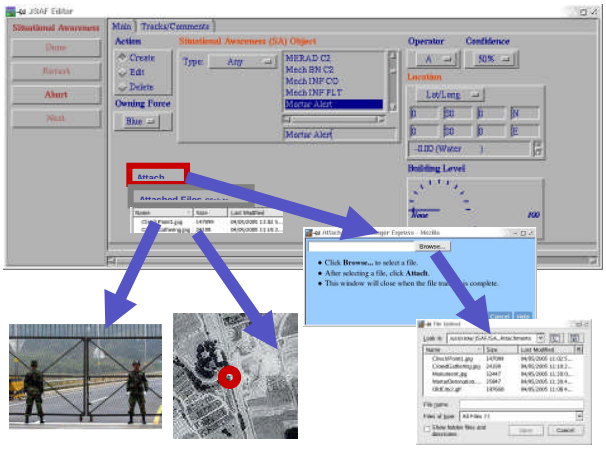


Figure 11 SAO Attach Feature

SAOs could be saved to spreadsheet at any time by anyone operating a JSAF system. This proved to be a convenient method for capturing a snapshot of SA. The spreadsheet is easily converted to a Comma Separated Values (.csv) file for use with Microsoft Excel or other spreadsheet applications, as shown below. The spreadsheet could be modified, and then loaded back into JSAF. This offered a convenient method for preparing Named Areas of Interest and Target Areas of Interest (TAI/TAI) type SAOs in advance for an event. The spreadsheet was typically loaded in JSAF just prior to the event start time.

SAO NUMBER	SAO TYPE	CTP NAME	OPERATOR	OWNING FORCE	LOCATION	CONFIDENCE	ATTACHED FILES	COMMENTS	ASSOCIATED TRACKS	ATTACHED TO TRACK
5	SA NAI/TAI	Mortar	A	Blue	10GEV1843528583	100	Pic1.jpg	NAI Mortar Baseplate		
6	SA NAI/TAI	Safehouse	R	Blue	10GEU4186480416	50		TAI Leader Safehouse		
7	SA Pointer	White	B	Blue	10GET8786391668	70		NAI Assembly Point for IEDs		
8	SA NAI/TAI	Safehouse	A	Blue	10GET4014600864	40	Pic8.jpg	NAI Possible Hide Site		
9	SA Green	Crowd forming	A	Blue	10GET5450871968	70		Crowd picketing factory		
10	SA Urban Guard	Unarmed single	N	Blue	10GEV2803229048	100		Stopped and cleared at checkpoint charlie		
11	SA Urban Guard	UG Armed Pickup single	A	Blue	10GET7005778730	90		Observed 1623 Lost in Traffic		
12	SA Air Defense	Snow Drift Radar	T	Blue	10GET4965074075	80		Emission 1423		
13	SA Pointer	Red	M	Blue	38SMB3572883733	70		Suspect IED Traffic Stopped at 1845 EOD called 1852 EOD arrived 1921	10021	10021

Figure 12 SAO Spreadsheet

Processing of SAOs

SAOs were automatically transmitted over the network to a shared JSAF SAO Database, where they were assigned unique and sequential SAO numbers. The SAOs in the database were made available to all the JSAF machines, depending on the player filter settings, describe earlier. System administrators cleared, saved and reload SAOs from the database. The SAOs were also logged by the Future After Action Review System (FAARS).

The evolution of SAOs

The SAO evolved from the GCCS Over-the-Horizon Gold (OTHGold) JUNIT and Contact report environment. By original design, JSAF was to stimulate operational GCCS Track Database as part of the DARPA Advanced Concept Demonstration (ACTD), Synthetic Theater of War (STOW) effort. The M&S team created a track database in JSAF to store, manage and transfer OTHGold Contact and JUNIT messages, (format is described in reference 1), to GCCS via a gateway. This capability allowed detections from sensors in JSAF to appropriately evolve into tracks and be display on all the JSAF systems. GCCS-like Track Summaries were built into JSAF, along with filters to let operators control their displays. Own-Ship reporting was emulated by having each ship report into the Track DB at an appropriate frequency.

After the STOW ACTD, JSAF ownership transitioned to USJFCOM, J9 Experimentation Directorate, where it was used for various HITL experiments, including Millennium Challenge 2002 (MC02), where more than 40 simulations were federated, some of which stimulated operational C4I systems. The Navy, through the oversight of the Navy Warfare Development Command, included in the exercise the participation of tactical training commands and ships located in port, pier-side. JSAF stimulated GCCS and tactical data links. In a discussion of MC02 lessons learned, reference 2, General William F. Kernan (USJFCOM) described the scope of the experiment.

> "There were 11 major concepts, 27 joint initiatives, 46 service initiatives and 22 different war-fighting challenges that the combatant commanders and services identified that they wanted to look at during Millennium Challenge. The width, breadth and depth of this thing was enormous. The joint operational area stretched the entire width and depth of the United States. There were nine live locations and 17 simulation locations.
>
> We federated 42 different service modeling and simulation programs into a complex federated system. This gave us the synthetic environment that we needed to do some of the analysis and assessment for Millennium Challenge.

> Maintaining the integrity of the experiment was paramount, and we had to do that, and the level of effort was pretty significant when you stopped to consider there was 13,500 soldiers, sailors, airmen and Marines involved in this."

The importance of simulation in an experiment of this magnitude established JSAF as key simulation tool and furthered other C2 developments and improvements.

Prior to the implementation of SAOs, and during each of the USJFCOM HITL experiments, analysts would gather around the players to listen to, and observe their actions and communications to assess their understanding of what was going on in the battlespace. Because of the broad scope of these experiments, this analysis process was in some cases subjective and vulnerable to missed cues and actions.

Urban Resolve (Phase I) experiment went into planning early in 2004. In this experiment, players were to test various futuristic/concept Intelligence, Surveillance and Recognizance (ISR) capabilities and develop Concept of Operations (CONOPS) and Tactics Techniques and Procedures (TTPs). It was clear that the accurate evaluation of SA was going to be crucial in distinguishing subtle changes in player abilities under varied controlled trial conditions. To achieve detailed data and to reduce the reliance on analysts, the concept of SAOs quickly evolved. The M&S team created a tool that would let players record their own impressions during the trial. The tool had to be easy to use, benefit the players as well as the analysts and it had to be produce logable data.

Operational GCCS systems (3x and 4x) did not have tools to emulate SAO functionality and the Operation Specification for Over-The-Horizon Targeting GOLD (OS-OTH-T GOLD) did not have formats that could accommodate the desired data fields. However, the existing GCCS-like track functions in JSAF provided the perfect foundation on which to prototype the SAO functionality in JSAF. The database existed, the summary display process existed and there were already many filters in place to let operators tailor their workstation views.

The SAO Editor was designed to support anticipated operator inputs, with selectable menu options, based on the UR04 exercise constraints and objective. The SAO Summary table filters and Info box and map symbols with attribute flags were designed and implemented. During the workup period for the experiment, players were taught how to use the SAOs and their recommended changes to the SAO Editor and other displays were requested and encouraged. Changes were made over-night in many cases by software engineers. By the time the trials for record began, the players were very familiar with the use and value of SAOs. They began to accept SAOs as tools and exchanged information using SAOs. They talked in terms of SAOs.

Following the successes of Urban Resolve (Phase I), USJFCOM prepared for UR05 Current Operations. The experiment venue changed to Iraq. Instead of exploring future ISR capabilities, the trials dealt with current threats and operations in the Baghdad area and focused on the challenging problems of Mortars, Rockets and Improvised Explosive Devices (IEDs). The SAO menu options were modified to support the new environment and the operator's needs. Again, during the training and workup the players were encouraged to offer recommended changes.

In both exercises, analysts no longer needed to hover over the player's shoulders and take copious notes, since player observations were captured in SAOs and logged. Instead, they monitored SAOs and relied on the Future After-action Review System (FAARS) to provide real-time indication of player situational awareness. SAOs served as a tool for the analysts as well, and allowed the analyst team to focus on observations that would compliment the SAO data.

Another important use of SAOs was enabled by the M&S team as they prepared for UR05. The addition of an Exercise Control Object (ECO) category, piloted during the experiment, allowed experiment designers and simulation controllers to develop scenarios and manage the execution of scenario events within the JSAF's interactive map environment. SAO functionality was inherited from the SAO processes described above and control-like menu options were added to support streamlined collaboration among experiment controllers, effectively giving them their own C2 capability. The spreadsheet-to-simulation and back again feature proved valuable in allowing cut and paste from Mission Event Synchronization List (MESL) documents, which were the primary experiment

control tool used by USJFCOM. An example of SAO and ECOs being used in an exercise is shown below.

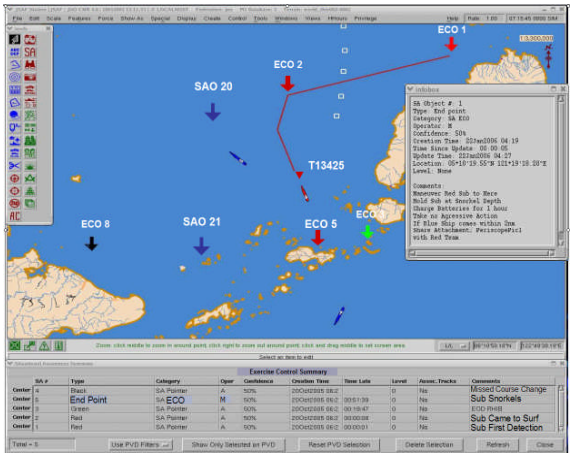


Figure 13 SAOs and ECOs Displayed on JSAF Interactive Map

Discoveries and Recommendations

USJFCOM's success in using SAOs for UR04 and then ECOs for UR05 experiments and the enthusiasm and innovation that operators showed in using them, indicates these tools would be useful if implemented in other simulations or collaborative decision-making system, including operational C2 systems.

In UR2015, high-interest tracks and SAOs are being promoted by players into the Common Operational Picture (COP) and shared with decision-makers, via GCCS, Command and Control, Personal Computer (C2PC) and Command Post of the Future (CPOF).

While this paper addresses the process for engineering and prototyping SA tools for the players and the exercise control group, it will probably leave analysts hungry for resultant data and analysis. This author apologizes for leaving them wanting, however the focus of this work was on developing SA tools that the players and operators would use because they found the tools of value for collaboration. Data was captured and some limited analysis was conducted, however the SAO tool was not structured appropriately to allow mapping of players SAOs into the three discrete categories of SA. Efforts are underway to map the selectable SAO menu items to SA levels. Near-real time displays of player and collective team SA are being designed to provide analysts a view of temporal SA, displayed along with battle rhythm indicators such as numbers of sensor detections and tracks, experiment controller activity and ongoing ground-truth events.

The USJFCOM and IDA experiment venue allowed for flexibility and innovation in SAO and ECO design. Attention to the player's opinions and constructive feedback, coupled with the software engineer's ability to make changes quickly, accelerated the spiral development and work-up process that led up to each of the experiments.

Conclusion

Players, JSAF controllers and analysts used the SAO toolset extensively during the Urban Resolve series of experiments. To this author, their willingness to use the toolset and interest in contributing to its development indicated their support for this SAO toolset approach to collaboration. It appeared that collaborating in real-time using SAOs helped players visualize and capture the details and scope of ongoing events. In challenging exercises, operators do not use tools that have little value to them, just as in battle, soldiers do not carry in their pack things they do not need.

ECOs allowed the Exercise Control Team to create and shape the tactical environment for exercises in a collaborative manner. ECOs gave experiment planners and JSAF operators the ability correlate MESLs and ECOs to enable force lay-down and experiment execution within JSAF, saving time, redundant work and minimizing errors.

SAO and ECOs, when logged by an after-action review system, would provide a valuable link between controller's actions (ground-truth) and the player's activity, however objective mapping of SAO declarations to the three distinct levels of SA is very challenging.

ECO functionality would be useful in other simulations and C2 tools where multiple controllers need to work together to share their intentions and plans regarding geo-spatial events and activities in a time-critical environment.

USJFCOM's ongoing success in using SAOs and ECOs, along with the enthusiasm and innovation that operators show in using them, indicates these tools would be useful if implemented in other simulations and operational C2 systems to enable training of 21st

Century Joint Forces in exercises where mission focus is aimed at achieving warfighting excellence.

ACKNOWLEDGEMENTS

I would like to recognize Ms. Laura Dunleavy, Lockheed Martin Simulation, Training & Support, for her extraordinary software engineering support in developing the SAO tools. She make it happen.

Also, recognizing Dr. Jacqueline M. Curiel for helping me better understand Endsley's work and implications as they relate to cognitive skills and human understanding.

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3. U.S. Joint Forces Command (2002) Gen. William F. Kernan and Maj. Gen. Dean W. Cash discuss Millennium Challenge's Lessons Learned, September 17, 2002.