

## The Environmental Visualization (EVIS) Project

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### Introduction

Emerging technologies and increasing requirements for precision strike have changed the face of modern warfare. As the speed of command and the amount of information increases, electronic and digital processes must replace manual information gathering and time-consuming data analysis. In order to maintain a competitive edge, the relevant information needs to be automatically processed and tailored in a way that allows the warfighter's "situation awareness" and forecasters' mental model of the battle space to keep pace with each other. This is essentially workflow automation which eliminates the busy data request/retrieval work, yet maintains the human in the decision-making process.

The EVIS project is developing and evaluating a prototype visualization capability for air strike and amphibious warfare operations that delivers tactically relevant meteorology and oceanographic information to forecasters and warfighters, including environmental effects on sensors and weapons. This capability has been derived from an information interaction model, which is a description of the information delivery requirements of warfighters. The model is based on cognitive and systems analyses of workflow and visualization processes at shore and ship facilities.

### Background

The EVIS project is a collaborative effort among the Naval Research Laboratory, the Naval Undersea Warfare Center, Newport, SPAWAR System Center, and the Applied Physics Laboratory, University of Washington. The EVIS team is multidisciplinary, and includes physical scientists, computer scientists, and human factors psychologists.

The EVIS project evolved from an ONR-funded, 6.2 research project that investigated the human systems component of the Naval meteorology and oceanography (METOC) community. Researchers studied several components of the forecasting system: gathering the necessary METOC data and information from both numerical forecast

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models and observations; processing that information; forming a mental model of the weather; and providing an external explanation of the weather or the ocean's effect on a warfighter's mission. From this research an applied project was developed to help solve some of the problems noted.

A recent Ocean Studies Board report on the need for METOC information (National Research Council, 2003) defined the issues that need further research and development:

- ensure that environmental information is presented in a manner that conveys to the warfighter an appropriate level of confidence in its content;
- ensure that efforts to enhance environmental information are carried out in a cost-effective manner that maximizes resources; and
- create a system for information exchange that allows a high degree of informed involvement by warfighters.

The information that EVIS project's prototype needs to deliver must include the effects of the atmosphere and ocean on critical mission areas plus the effects on sensors and weapon systems. In addition, it is essential that the METOC information be delivered with the correct spatial and temporal granularity needed to affect successful decision making.

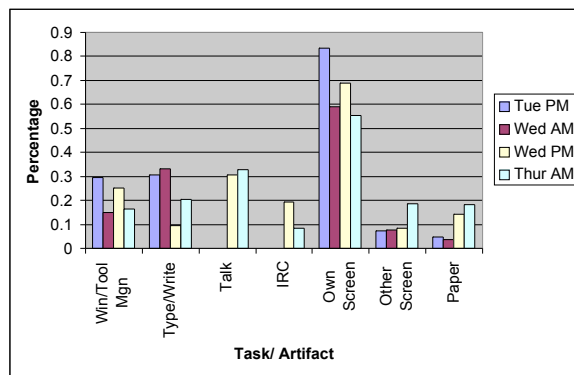


Figure 1. Forecasters Task and Artifact Usage (in percentage)

A central tenet of the EVIS project has been to focus first on understanding the human in the decision system. Researchers analyzed the observations collected from locations where the METOC products are made and used. Four separate experiments had been conducted, either ashore or at sea on the *USS Carl Vinson* (CVN-70).

One of the areas studied was the tools forecasters used in the process of providing tailored METOC information. Forecasters were observed as they

developed the METOC products needed for a simulated air-strike scenario. Figure 1 shows the kind of information that can be derived from an analysis of forecaster workflow.

The most important observations made during this initial human systems research came during the at-sea period spent on the *Carl Vinson*. The METOC personnel on *Carl Vinson* made a daily product that used pre-defined rules to generate a METOC threshold matrix. This spreadsheet-like matrix listed a series of missions and systems affected by weather, and included color-coded cells in columns of progressing time change. Each cell was also hyperlinked to a METOC graphic. The product was shared among the units in the *Carl Vinson's* battle group via an intranet site.

It was observed that while the product was well received by the decision makers who used it, it was a time consuming and complex product to make. (During the *Carl Vinson's* 2001 deployment a variant of this product was provided to the Knowledge Web, an html-based information exchange system that was put to excellent use during Operation Enduring Freedom (Majeranowski, 2003).)

The EVIS team was interested in the threshold matrix product because the use of rules seemed to help forecasters organize their complex workflow. The product also helped decision-makers quickly assess weather impacts and allowed them to investigate beyond a simple green/yellow/red color-coding when they needed a higher level of detail (through the inspection of the hyperlinked METOC graphic).

The EVIS team decided to investigate how the use of rules helps forecasters and decision makers, and then from that knowledge develop a prototype tool to speed and improve the processing of METOC rules.

### METOC Rule and Rule Services

In the context described here, rules are typically environmental limits for military weapon systems or operations. For example, a particular weapon sensor may have a maximum rain rate in which it can successfully operate. A mission such as search and rescue may be halted if winds reach a certain magnitude.

Rules provide a foundation and a common framework for people. Rules can also be flexible and can be adapted to changing circumstances. Weapon systems and operations have defined environmental rules set in doctrine and manuals, but forecasters may need to change a pre-defined rule or threshold when they receive feedback from a customer who requests different thresholding limitations.

Rules can help those with limited expertise in METOC forecasting for military operations. The rules represent a codification of weather effects experience.

Their use ensures a base-line consistency, which can then be improved upon with additional training and experience.

Rules are also essential for automated systems. A system can be designed to run rules against environmental data and provide forecasters with much more weather-effects information than the forecasters can produce on their own.

### EVIS System Architecture

The EVIS team has developed a prototype system that can provide rule services over the Navy enterprise. This development has utilized human-centered and mission-relevant design to ensure that the capability will be usable and have immediate military application. Human-centered design involves task and workflow analyses to determine user interface and interaction requirements, and the timelines needed by customer products to ensure that the final capability yields the most accurate forecasts in the time available for any operational decision. In the initial phases of the research the design was focused on support for strike mission forecasting research.

The goal was to develop a capability that will enable forecasters to produce mission-based visualizations and products in a timely manner well within the tactical commander's decision cycle. The capability will support the assessment of alternative Courses of Action (COAs).

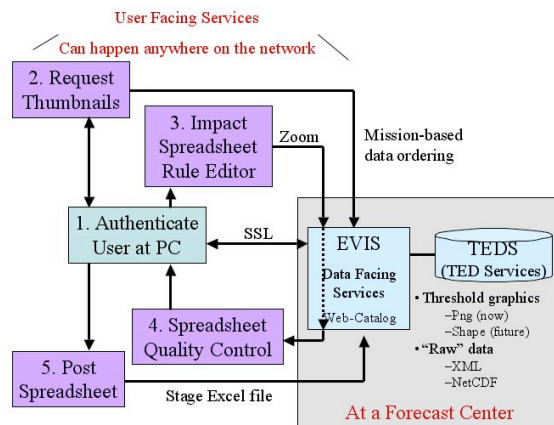


Figure 2. EVIS Services Concept Diagram

The figure above (figure 2) outlines an overview of the workflow for one type of EVIS service (which will be explained later in this paper). EVIS currently draws METOC data from the Navy's Tactical Environmental Database System (TEDS), and in the future it will utilize the web services version called TED Services. This data is cataloged on the EVIS Data Facing System (or what is also known as a server). Only those data needed by

known rules are made available on EVIS. New rules or new parameters needed by the rules require human intervention. In the EVIS concept of operations, this would be handled at the METOC forecast centers, or in the future TED Services might handle it automatically.

The EVIS Data Facing System is responsible for a variety of actions, as described in figure 3. It can receive requests from multiple applications, or in the new terminology, User Facing Services, and provide data to different types of rule-based systems. At the present time there are two EVIS data facing systems, one at the University of Washington and the other at the Naval Research Lab in Monterey.

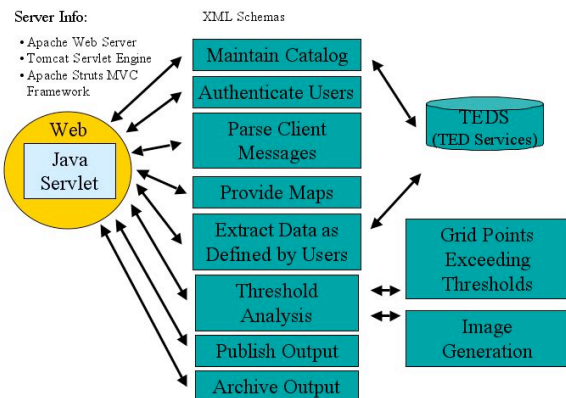


Figure 3. EVIS Data Facing System Architecture

One of the important design features of the EVIS system architecture is the use of XML for all services-related communications across the network. A schema was written that handles: rule definition; rule tailoring; data thresholding; and delivery of overlays of geographic maps that display the threshold information.

### Example of an EVIS Application

The EVIS Mission Effects Services (EMES) is an example of an EVIS web service. It provides a user interface for rule generation, and allows the user to request environmental thresholding for a user-defined set of METOC limits.

#### 1. EMES Start-Up

The EMES interface is written in Java and utilizes Java Web Start technology. First time users of EMES would open a session with the data facing system via a web browser. They then download the EMES interface. Past users have can have the interface resident on their computer; during start-up, Java Web Start checks to see if the computer has the most up-to-date version of the

interface. After login formalities are completed the user can select the appropriate data facing system. The user then starts an EMES session.

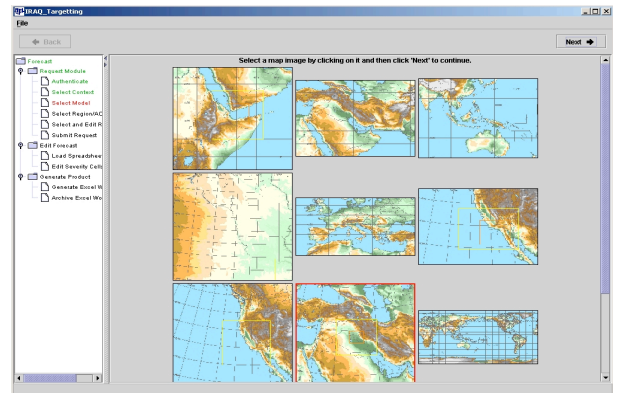


Figure 4. Area of Interest Selection

#### 2. Area of Interest Selection

In this task window (figure 4), the users are provided a series of thumbnails that represent the different model data sets EVIS has available to run METOC rules. User can discover additional information such as the resolution of the model and its domain coverage.

Users then select the thumbnail for their area of interest and can refine their geographic window with a zoom control. They can also select the specific model run and forecast times on which their rules will be run.

#### 3. Rule Selections and Tailoring

The Rule Selection panel consists of three sub panels (figure 5). The loaded rules (by default, the "air strike rules") and their directory tree are displayed in the upper left panel. Other choices and locations for rules are displayed in the lower left panel. The current rule set is displayed in table (spreadsheet) format in the right panel

The displayed rule set lists rule numbers, mission type, operation, evolution, environmental parameter of interest, and marginal and severe impact thresholds for the specific environmental parameter with respect to the mission context (mission, operation, evolution).

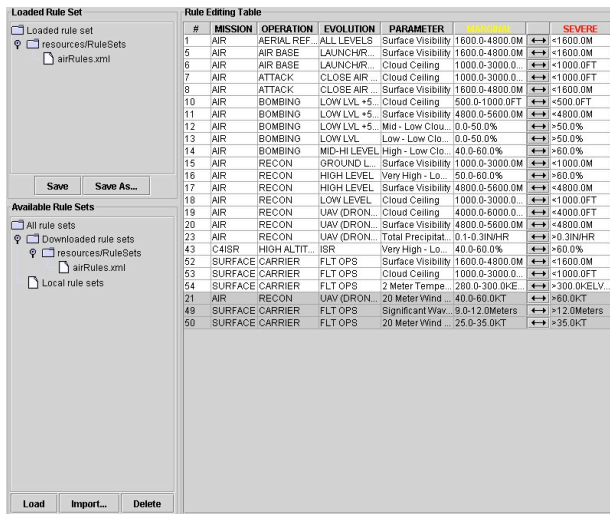


Figure 5. Rule selection and tailoring

The thresholds are editable by mousing on the double-headed arrow in between the MARGINAL and SEVERE threshold values (figure 6). The slider adjusts the values, or the user can manually enter the correct value in the appropriate text box.

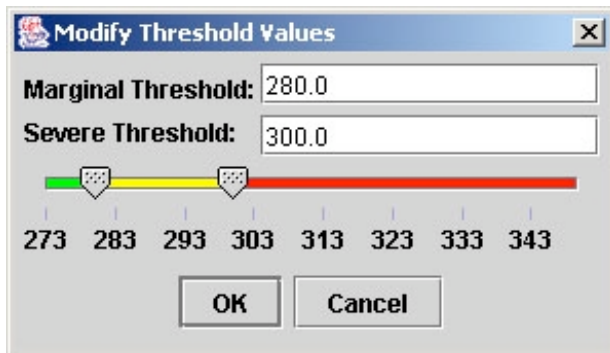


Figure 6. Modify Threshold Values

Displayed rules whose parameter types are unavailable will appear grayed out and at the bottom of the list. They may still be included in the selected rule set, but no model data will be returned for that rule from the request.

Users may select rules from a default rule set, or may load a previously saved rule set from the "Available Rule Sets." Rules may be selected from the displayed rule set by click, shift-click, or click-and-drag mouse movements. A right mouse click then offers the opportunity to delete the selected rules or restore rules that have been inadvertently deleted. The rules that are not removed from the spreadsheet become the list of rules to send to the server.

Rule sets may be named and saved by either a right mouse click or the "Save As..." button on the "Loaded Rule Set" sub panel. Once users are satisfied with the chosen rule set (and possibly have saved it for later recall), they press "Next" and "Confirm Choices and Submit Request" appears on the screen.

#### 4. Rule Responses and Product Tailoring

During the period between the time the user submits the rule request and receives a reply, the data facing system runs all the requested rules for the threshold limits and generates threshold overlays tied to the user-defined geographic zoom area. Figure 7 is an example of the reply.

Holding the mouse over a forecast time cell produces a tooltip indicating the number of model grid points and the number of those points whose value exceeded the marginal and severe thresholds. The actual thresholded and contoured image (contoured intervals based on the marginal and severe thresholds in the respective rule) appears on top of the base map when the user clicks on the corresponding color-coded cell.

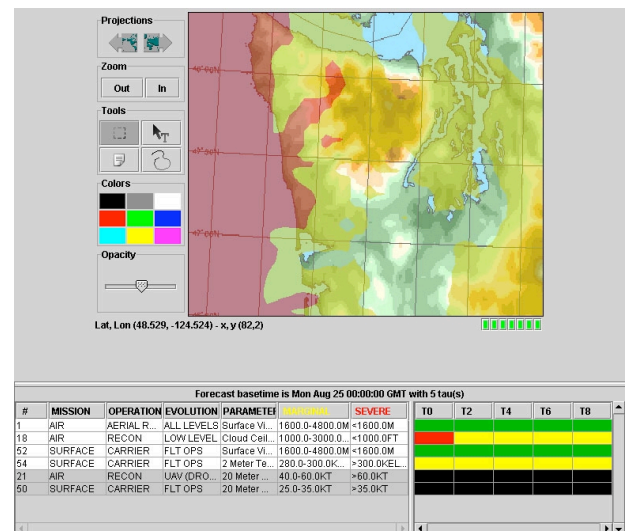


Figure 7. Threshold product tailoring

Even though a forecast time for a particular rule might be red, it does not necessarily mean that the mission component cannot be carried out. This is an example of the need for the forecaster in the loop to assure a quality forecast. Depending on the context for the operation, the area of the map where severe threshold values are exceeded may be very small or in a region some distance from the center of the operation (e.g., location of a carrier during launch or recovery). This may be a reason to change the color of a forecast time cell and/or make notations on the threshold image itself.



The forecast cell colors may be edited by selecting the cell (an outline will appear around the border) then right clicking, which will display a color selection box. Clicking on a color in the box will cause the cell to change to that color. An "X" will appear in the changed cell to indicate that some change has been made from the initial values. The original cell color may be reset similarly by choosing "Reset Color."

## 5. Mission Effects Product Generation

Once users have completed tailoring of the final product, they can publish it as an XML representation of an Excel spreadsheet (figure 8). Since this output is in XML, it is envisioned that EMES will create additional exports such as a Java Server page or a Power Point file (output in other representations is based on their schema descriptions).

#	MISSION	OPERATION	EVOLUTION	PARAMETER	MARGINAL	SERVICE	T0	T3	T6	T12	T18	T24	T36
1	AR	AERIAL REFUEL	ALL LEVELS	Surface Visibility	1500.0-4500.0M	<+1600.0M							
12	AR	BOMBING	LOW LEVEL	Low Cloud Cov	0.0-50.0%	<+50.0%							
13	AR	BOMBING	LOW LEVEL	Low Cloud Cov	0.0-50.0%	>+50.0%							
14	AR	BOMBING	MID-H LEVEL	Low Cloud Cov	40.0-60.0%	>+60.0%							
43	CASR	HIGH ALTITUDE	ISR	High - Low Cloud C	40.0-60.0%	>+60.0%							
48	SURFACE	CARRIER	FLT OPS	Significant Wave Hgt	0-12.0meters	>+12.0meters							
50	SURFACE	CARRIER	FLT OPS	10 Meter Wind Speed	25.0-35.0KNT	>+35.0KNT							
52	SURFACE	CARRIER	FLT OPS	Surface Visibility	1500.0-4500.0M	<+1500.0M							
53	SURFACE	CARRIER	FLT OPS	Cloud Ceiling	3000.0-3000.0FT	<+1000.0FT							
54	SURFACE	CARRIER	FLT OPS	3 Meter Temperature	0.0-300.0KELV	>+300.0KELV							

Figure 8. Excel Spreadsheet Product

## EMES Testing & Demonstration

In August 2003, the EVIS team conducted an end-to-end demonstration of the EMES system at the Fleet METOC Advance Concepts Lab at North Island, CA. Two sets of forecasters were tasked with providing a mission effects matrix for a simulated strike planning scenario. One team had use of EMES and the other did not.

Preliminary analysis of the observations shows that EMES not only sped up the process, but also helped the forecasters organize and synthesize the information they needed to provide to warfighters.

During this same period an additional demonstration was conducted at the SPAWAR System Center, San Diego, CA. The Real-time Execution Decision System (REDS) was able to extract METOC information from EVIS and process it for a simulated mission plan. REDS displayed the effect of METOC on numerous components of a mission plan. REDS is an

example of another user facing service that can use the EVIS data facing service because of the standardization of the XML requests.

## Conclusion

The EVIS team has developed a prototype system that can deliver real-time threshold data and graphics via a user-specified rule services system. The August demonstration has shown that EVIS is moving in the right direction, yet there are several issues that will need further investigation and development. These include: the management of rules across the Navy enterprise, the availability of METOC data for rule processing and the extensibility of the system for uses beyond thresholding.

The EVIS team will continue to work with users and warfighters to help find the correct solution. Finally, with the goal of successfully transitioning this future naval capability, the team is currently working closely with the METOC organizations responsible for fielding forecaster tools.

## Acknowledgement

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## References

- Jones, D. W., Ballas, J. Miyamoto, T. Tsiu, T., Trafton, G. & Kirschenbaum, S, 2002, *Human Systems Study on the Use of Meteorology and Oceanography Information in Support of the Naval Air Strike Mission*. APL-UW TM 8-02. Seattle, WA.
- Majeranowski, Pete, 2003, *Knowledge Web Plays Big in Transformation*. U. S. Naval Institute Proceedings, Annapolis, MD, July.
- National Research Council, 2003, *Environmental Information for Naval Warfare*. The National Academies Press, Washington, DC.