THE AFRL WEATHER IMPACT DECISION AIDS PROGRAM PROGRESS UPDATE

Paul Tattelman
Air Force Research Laboratory
Space Vehicles Directorate (VSBL)
29 Randolph Road
Hanscom AFB, MA 01731
(781) 377-5956
paul.tattelman@hanscom.af.mil

The Space Vehicles Directorate of the AF Research Laboratory manages a Weather Impact Decision Aids (WIDA) program that develops physics-based software to predict the influence of the weather and other environmental parameters on the operational performance of Electro-Optical (EO) sensors (infrared, laser, visible) used in air-to-ground munitions, navigation systems, and Night Vision Goggles (NVGs).

Products under development include an IR scene visualization system for aircrew situational awareness, capabilities for predicting weather and environmental impacts on the performance of NVG and EO sensors used in navigation, surveillance, and weapon systems, and a methodology for automating weather impacts in mission planning for Air Tasking Order (ATO) generation and reprogramming.

The WIDA program has made some significant advances over the past year, both technologically and in scope. This presentation will report on progress made over the past year and provide an update on anticipated WIDA products over the next several years.

1. Introduction

The Weather Impact Decision Aids (WIDA) program at the Air Force Research Laboratory is developing new products that provide weather-impacted performance predictions for electro-optical (EO) Systems. The goal is to translate conventional weather data into information needed to anticipate and exploit the impact of the battlespace environment on systems used by both friendly and enemy forces. WIDA products provide the warfighter with predictions and visualizations of the influence of weather and other environmental parameters on EO sensors (infrared, laser, visible) used in air-to-ground munitions, navigation systems, night vision goggles (NVGs), and surveillance and targeting systems. These products allow mission planners to factor weather into key decisions such as mission time, target approach heading, tactics, and weapon selection. They provide combat aircrews with detection/lock-on range predictions and/or target scene predictions, facilitating target location and positive identification.

The current WIDA program is divided is the following five projects:

a. Infrared Target-scene Simulation Software (IRTSS) - Develops and upgrades models for predicting and visualizing weather impacts on air-to-ground IR targeting and navigation.

Provides weather-impacted visualization of target scenes in the IR as they would be seen in cockpit displays. IRTSS aids pilots before takeoff by simulating predicted IR target-scenes that provide geographic cues that aid in finding targets in a complex target scene.

b. Night Vision Goggle (NVG) Operations Weather Software (NOWS) - Develops and integrates models for determining the influence of weather and illumination on the performance of NVGs. Provides weather and illumination impacted detection ranges.

c. Target Acquisition Weather Software (TAWS) - Utilizes the models developed in IRTSS, NOWS, and other research programs to predict the impact of weather and environmental effects on IR, TV, NVG (incorporating NOWS in a future version) and Laser weapon and navigation system performance (e.g. lock-on range), and surveillance and targeting systems. This is a joint program with the Navy and Army.

d. Weather Automated Mission Planning Software (WAMPS) - Integrates the models developed and incorporated in the above three projects into a product that will automate the generation EO weather impacts in mission planning. The goal of this effort is to demonstrate and transition WIDA solutions for incorporating weather effects into the Joint Mission Planning System.

e. Joint Environment Exploitation Segment (JEES) – Takes the WAMPS prototype demonstration to a fully working prototype to be included in a test version of Theater Air Planning (TAP) within the Theater Management Core Systems (TBMCS) operational environment.

The above components and recent progress are discussed in more detail in the following sections.

2. IR Target-scene Simulation Software (IRTSS)

IRTSS provides an IR visualization of the target scene (currently 8-12 μm, but 3-5 μm will be added). The visualization capability includes terrain shadowing, realistic vegetation graphics and animated fly-throughs that allow for 3-dimensional positioning of the sensor to view the scene from any angle. A prototype web-based capability will be transitioned to the AF Weather Agency (AFWA) by Sep 00.

Automated data management techniques are being developed for IRTSS. Geographic data sets are generated using ARC/INFO, a commercial Geographic Information System (GIS). Geographic data sets are generated from a variety of sources, including National Imagery and Mapping Agency (NIMA, formerly DMA), USGS, commercial satellites, and national imagery, and can support large areas (e.g. 40 km x 40 km at 10m resolution). The GIS is being programmed to fully automate this process. IRTSS models are also driven using real-time weather derived from the AF Weather Information Network (AFWIN).

Progress over the past year includes the following:

a. A new Java-based user interface with improved ease of use has been added that also allows the generation of animations,
b. An improved atmospheric transmission algorithm that takes advantage of OpenGL 1.1 features has been implemented,
c. An improved sensor performance model has been added that incorporates sensor blur and noise functions,
d. Improved tree rendering developed under the Smart Weapon Operability Enhancement program was incorporated,
e. IRTSS technology was demonstrated for the Army Apache FLIR sensors, and
f. Upgrades to allow validation studies using 3-5 micron field measurements were implemented.

3. Night Vision Goggle (NVG) Operations Weather Software (NOWS)

The NOWS effort began with a deficiency in AFSOC weather support to covert nighttime helicopter air refueling using NVGs. After meeting with pilots of the 9th Special Operations Squadron and AFSOC weather personnel in March 91, Phillips Lab (PL) Geophysics Directorate, an AFRL predecessor, initiated an R&D effort to predict weather impacts on the performance of NVGs. A contractual effort began in FY92. The prototype NOWS was delivered in FY94 and demonstrated to AFSOC and ACC. This led to a greatly expanded list of requirements for NOWS to support differing scenarios, targets, backgrounds and hazards for NVG operations. The NOWS Graphical User Interface (GUI) and products were developed in close coordination with AFSOC and ACC. NOWS Version 1.0 was delivered in FY95 for evaluation by AFSOC weather (16th OSS). NOWS Version 4.0 was completed in Nov 97 and almost 100 copies were distributed to AFSOC and ACC units for feedback.

NOWS has distinct advantages over other NVG support products including:

a. Physics-based models incorporating relevant weather for target detection range,
b. Upward and downward lines-of-sight,
c. Atmospheric attenuation and path radiance effects,
d. NVG sensor modeling,
e. Terrain elevation and features, and
f. An urban illumination model.

NOWS incorporates worldwide map backgrounds for displaying, choosing, and tracking missions. It provides alerts to NVG operations hazards such as loss of horizon and towers, and provides NVG ranges as a function of user-selected probabilities. It also depicts optimum azimuth to approach a target or background.

NOWS progress over the past year was highlighted by the delivery of Version 5.2 in Aug 99 to AFWA, Navy Space and Naval Warfare Systems Center, Navy Research Lab and the Army

Research Lab. It was authorized for operational use by Air Force Air Combat Command in Sep 99. It includes the following additional capabilities:

a. A new operating environment that provides Windows 95/97 look and feel,
b. Maps based on National Imagery and Mapping Agency (NIMA) Vector Smart Map (Vmap) instead of the outdated Digital Chart of the World,
c. Customized NVG sensor option allowing user-defined sensors, and
d. Additional targets.

Currently planned NOWS milestones call for release of Version 6.0 in Jun 00 to the AF, Army and Navy. The U.S. Coast Guard is evaluating NOWS for potential operational use. Subsequently, NOWS will be incorporated into TAWS.

4. Target Acquisition Weather Software (TAWS)

TAWS is the replacement for EOTDA Version 3.1, that was delivered in 1994. TAWS development began in Aug 97 to provide a state-of-the-art PC capability for predicting weather impacts on EO sensor, such as lock-on range. IRTSS and NOWS models are being incorporated to provide the IR and NVG portions of TAWS, which will also include an upgraded TV model and a laser model. TAWS is being developed as a joint AF/Navy/Army program with the AF Research Laboratory as the lead agency. TAWS will provide more accurate acquisition and lock-on ranges, support MWIR in addition to LWIR, improved guidance on tactics, probability outputs, the ability to support multiple taskings, automated weather input, and guidance on weather sensitivities.

The major milestone over the past year was the delivery of TAWS Version 1.1 to the joint services in Dec 99. It has been authorized for operational use by the AF Air Combat Command. TAWS future joint service development will continue to incorporate customer/user feedback from weather forecasters, pilots, and mission planners.

Progress over the past year includes the following:

a. The addition of automated weather reachback from AF Weather Information Network,
b. The capability to run multiple missions/targets simultaneously, and
c. A variety of vastly improved output products that facilitate mission planning and optimize tactics.

Currently planned TAWS milestones call for the delivery of TAWS Version 2.0 in Jun 00.

5. Weather Automated Mission Planning Software (WAMPS)

Currently, weather impacts on systems and operations are not included in automated mission planning systems. In order to support the appropriate selection of weapon and navigation sensors, and tactics, for hundreds, or even thousands of sorties, it is imperative that

mission planners have decision aids that automatically assess weather impacts for specific sensors against selected targets and backgrounds.

WAMPS was originally envisioned as a force-level (24-72 hrs) stoplight weather impact mission planning capability. The goal of WAMPS was to demonstrate how weather effects could be incorporated into the generation of the Air Tasking Order by providing stoplight guidance for each weapon/target combination. By automating this into force level planning, mission planners could better select weapons or alternatives or modify times-over-target. The success of demonstrations over the past year to the Theater Battle Management Core Systems (TBMCS) project office and the AFRL Information Directorate that supports the development of new TBMCS technologies resulted in the initiation of the Joint Environment Exploitation Segment (JEES) described in the next section. The WAMPS effort was redirected to integrate WIDA technologies into the Joint Mission Planning System (JMPS). JMPS will replace the currently operational Portable Flight Planning System (PFPS) that is used at squadron level by pilots to plan mission execution and tactics.

Progress over the past year includes the following:

a. Successful demonstrations of WAMPS to the TBMCS project office and the AFRL Information Directorate resulting in the initiation of JEES, and
b. Demonstration of a WAMPS in PFPS at the Mission Planning Users Conference.

Current plans call for upgrading WAMPS by incorporating feedback from the PFPS demonstration for further coordination and review with the JMPS project office.

6. Joint Environment Exploitation Segment

JEES was conceived to find a comprehensive solution to incorporating environmental impacts into force level planning. It was a direct result of the successful WAMPS demonstrations of how automated weather impacts could be utilized to optimize mission planning without creating an undue burden on the process. Weather impacts are flagged only when they have an impact, and adjustments can be quickly assessed and incorporated into the ATO generation. The initial JEES prototype will interface with "canned" versions of the Target Nomination List (TNL), the Modernized Integrated Database (MIDB), and other available TBMCS databases. The JEES prototype module will be extended to incorporate weather impacts in additional areas. These areas include, but are not limited to Time Critical Target (TCT) applications, and the Joint Mission Planning System (JMPS). The JEES module will meet TBMCS and Defense Information Infrastructure Common Operating Environment (DII COE) program specifications.

7. WIDA Model Validation

An integral part of the WIDA program is product validation. Two separate facilities were used to make comprehensive meteorological and sensor measurements. A fixed site at the Geophysics Directorate at Hanscom AFB, MA., (about 15 miles north of Boston) was used to collect meteorological and EO data required by the IRTSS thermal models. In addition to

comprehensive meteorological and EO-related measurements, imagery was collected using a FLIR 2000 (8-12 μm), a FLIR PRISM (3-5 μm), and a TV camera (visible) observing two simple test targets.

A mobile platform, instrumented for IRTSS and NOWS validation measurements, was used to collect data at the Camp Edwards range at Otis ANGB, Cape Cod, MA. For NOWS, the mobile facility included measurements utilizing three laboratory-grade radiometers, NVGs, and tailored bar targets.

Due to funding cuts, data collection ended in FY99, but a considerable amount of data was collected over the three previous years. These data are still being used to validate and improve IR and NVG models.

Progress over the past year includes the following:

a. Preliminary analysis of the NOWS-related data indicate that the models are performing well, and
b. The MWIR data were used to conduct validation studies for a new MWIR IRTSS model.

8. Closing Remarks and Summary

The Department of Defense has spent considerable sums of money trying to engineer "all-weather" systems that are not impacted by the environment. A recent study by the GAO found that "all-weather" effectiveness was overstated by DoD, that precision guided munitions functioned effectively only in optimum conditions, and that IR, EO, and laser systems were seriously degraded by weather. Considerable improvement could be obtained by tailoring weapon choice, time of attack, and tactics to the weather. The use of validated environmental decision aids in mission execution and the automated mission planning process would bring current "smart systems" closer to the desired "all-weather" capability than trying to engineer-out the weather, and at a small fraction of the cost.

The WIDA program is developing products that translate conventional weather data into information that the warfighter needs to exploit the battlespace environment. This article presented an overview and progress report on the current program, with near-term plans for product deliveries. Future efforts will incorporate joint DoD requirements and model upgrades into decision aids that will enhance all levels mission planning and execution.