The Integrated Weather Effects Decision Aid: A Common Software Tool to Assist in Command and Control Decision Making

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Abstract

Military operations and weapon systems are adversely affected to some extent by the environment, even those advertised as "all weather capable". However, presenting this information to the command and control decision maker has been somewhat nebulous, incomplete, and time consuming. As a result, the Army Research Laboratory has developed an automated software decision aid (the Integrated Weather Effects Decision Aid – IWEDA) to assist the commander in making intelligent command and control decisions regarding the allocation or use of weapon systems and in mission planning. IWEDA produces detailed graphic and text information regarding the what, when, why, and where of pertinent environmental impacts on 70 weapon systems (including 16 threat systems). Impacts are displayed graphically in terms of a Weather Effects Matrix (WEM) which color codes the impacts on the system(s) of interest with green (favorable), amber (marginal), and red (unfavorable) cells over time. Map overlays allow a detailed inspection of the spatial distribution of the impacts. Efforts associated with integrating physics based model output (e.g., target acquisition routines, heat stress algorithms, etc.) have either been completed or are ongoing. Additional weapon system rules (to include Air Force and Navy systems) are being collected for incorporation into a tri-service IWEDA.

1. Introduction/Background

Military operations and weapon systems (friendly and threat) are adversely effected to some extent by the environment, even those advertised as "all weather capable".[1] According to G.R. Svoboda, "Weather and terrain have a greater impact on battles than any other physical factor – including weapons." [Svoboda, 1986]. If the commander can be provided guidance with respect to environmental impacts on his operations and weapon systems, he can better plan his missions. An Army Science and Technology Objective ("Automated Weather Decision Aids", STO IV-M.3) recognizes this requirement. The Integrated Weather Effects Decision Aid (IWEDA) provides the technological solution to this STO.

[1] For an excellent summary of environmental impacts on a wide variety of weapon systems and platforms see the Aberdeen Test Center Meteorology Team's web site at www.atc.army.mil/meteorology/index.html

In the following discussions, IWEDA refers to the software application as operational under the Army's Task Force XXI (TFXXI) Battlefield Functional Area (BFA) architecture[2], i.e., a Unix based platform (Sun Microsystems hardware) running XWindows. The Army's Terrain Evaluation Module (TEM) is utilized as the map server (i.e., map display and interaction) for the images captured in the following figures, however, testing of IWEDA integrated within the Joint Mapping Tool Kit (JMTK) environment was undergoing final testing at ARL in April 1999. A personal computer (PC) version of IWEDA is also available with the same systems and rules, however, the map graphics and meteorological ingest capabilities are severely limited.

IWEDA is currently being fielded as part of the Army's tactical weather system, the Integrated Meteorological System (IMETS), Block II. As IWEDA is obviously a tool that has relevance to elements other than those associated directly with weather, IWEDA currently is available on prototype versions of the All Source Analysis System (ASAS), Maneuver Control System (MCS), Air and Missile Defense Work Station (AMDWS), Advanced Field Artillery Tactical Data System (AFATDS), and Combat Service Support Control System (CSSCS) of the Army Battle Command System (ABCS). This will insure a common depiction of environmental impacts on weapon systems within the ABCS. The required environmental data to run IWEDA will be obtained in an automated fashion from the IMETS within echelon, or a surrogate system at echelons which IMETS is not doctrinally located. The Staff Weather Officer (SWO) at the IMETS will insure that the IWEDA input parameters are valid before allowing use by the clients.

2. **IWEDA Software Overview**

Raw environmental data (such as wind speed, temperature, relative humidity, etc.), as such, does not provide the commander with the type of information that he may require to make intelligent decisions regarding what weapon systems to employ or where and when to employ them. IWEDA transforms this raw weather data (provided by Army, Air Force, and Navy models or analyses) into the requisite weather intelligence in a readily understood graphical format with associated concise text messages. With IWEDA, the commander can quickly determine the environmental effects on 70 weapon systems (including 16 threat), their subsystems, and components over both space and time. Once the required data has been ingested and processed, impacts can be displayed over a 24 hour forecast period (soon to be extended to 48 hours) and at a high fidelity (10 km grid resolution) over a variable domain (specified by the SWO and ranging from 200 km x 200 km to 500 km x 500 km).

2.1 ***Weather Effects Matrix (WEM)***

Figure 1 shows the IWEDA Weather Effects Matrix (WEM) which displays a matrix of stoplight color coded impacts on up to 8 systems or missions over time, in this case a 24 hour forecast period. [A mission is defined as being comprised of one or more weapon system and allows the

[2] A primary initiative of TFXXI is to digitize the battlefield at all echelons to enable the sharing of information between BFAs. TFXXI experiments will pave the way for the First Digitized Division (4th Infantry Division) in the year 2000

user to configure a group of systems into one entity. For example, the user could setup (via easy to use graphical interface input screens) a mission of "Close Air Support" consisting of whatever systems from the available list of 70 they chose. He can then save this mission and readily determine impacts on the selected mission(s) without selecting the individual systems one by one.] Threat systems are visually highlighted in red text and also have an exclamation point preceding and following their name. "R" (red), "A" (amber), or "G" (green) are displayed in the center of the cells for aiding in the interpretation when printed to a black and white printer (or viewed by a color blind individual). The cell widths correspond to the forecast periods as produced by ARL's Battlescale Forecast Model (BFM, a prognostic model that is run in a tactical environment on the IMETS to predict the values of numerous meteorological parameters required as IWEDA input). Depending on the BFM output values, cell colors (i.e., impacts) will vary over time and system/mission. The WEM provides a high level overview in terms of what items are being impacted, when they are impacted, and what the impacts are (via an optional on demand pop up window of "condensed impacts" which list the meteorological parameter(s) effecting a specific cell).

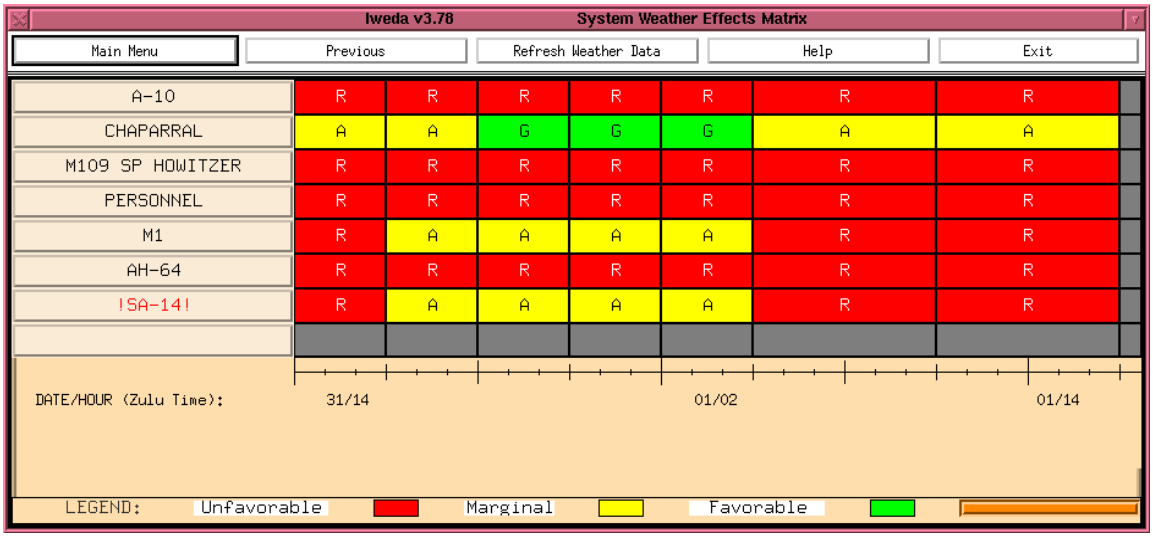

Figure 1. IWEDA System Weather Effects Matrix

Unused WEM system or mission buttons on the left portion of the matrix (e.g., below the !SA-14! text) can be clicked to pop up a new window in which the user can manually enter impact information for systems or missions not currently in the IWEDA inventory. This window will prompt the user for the system or mission name, the impact color, forecast period, and text to associate with the impact statement. Upon exiting, the WEM will show the item name in brackets (to denote a manually entered item) below existing systems/missions with the cell(s) to the right of the name appropriately colored. As with other cells, a right mouse click within the cell boundaries will pop up a new window with the impacts that the user previously entered. There are no map displays (see discussion in next paragraph) for these manually entered systems, however, as no information about the spatial distribution of the impacts is entered. This functionality allows the

user to quickly visualize the impacts over time for new systems or systems not yet included in the IWEDA database.

2.2 ***Map Overlays***

Map overlays (using the same color schema) allow a detailed inspection of the spatial distribution of the impacts for a specific forecast period (fig. 2). The user is allowed to interactively query the map overlay via a mouse click at any location to determine and display the exact environmental impact(s) on the system in the form of a text message of up to 200 characters in length (to include the source of the rule). In the example of figure 2, the Chaparral surface to air missile has a marginal (amber) impact due to freezing rain intensity greater than light for the point indicated by the circle overlain on the map background (center region). This represents a powerful tool for the BFA user to be able to interactively query the impacts on their chosen systems for the region of his interest independent of consultation with the SWO (of course, if there are questions or additional information is required, the SWO is still available for assistance). IWEDA map overlays can be displayed over a Common Tactical Picture (CTP) along with other relevant tactical information (e.g., unit locations) to provide a more complete depiction of the battlespace to the commander.

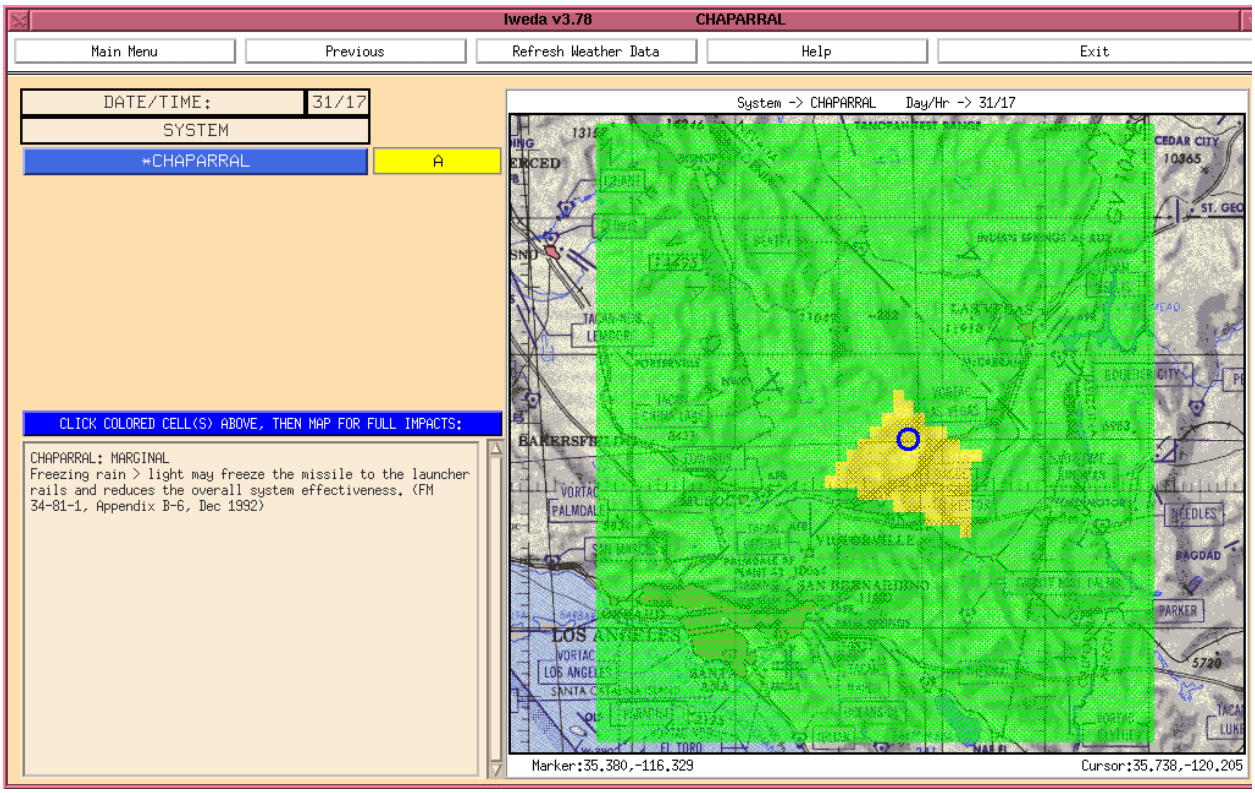

Figure 2. IWEDA spatial distribution of impacts for Chaparral

2.3 *IWEDA Hierarchy*

Another important aspect of IWEDA is the hiearchical setup in which the top level systems can have subsystems and components associated with them. Note the "*" in front of the text "Chaparral" in the upper right portion of figure 2. This indicates that there is at least one subsystem and/or component associated with the Chaparral. Clicking on the Chaparral button will bring up a new screen (not shown) with the spatial distribution of the impacts on the subsystem(s). In this case, the "Tracked Platform" is a subsystem of the Chaparral and would appear on the next screen. Any impacts on the "Tracked Platform" components would then be available to view (there are none) in a separate window upon the user clicking the "Tracked Platform" button. In the "System Setup" module of IWEDA (fig. 3), the user can easily toggle off any non-mandatory subsystems or components. Mandatory subsystems or components are preceded with a "#" symbol in front of the subsystem or component name in this module and cannot be toggled off by the user. The overall impact on the parent system will then be computed ignoring any deactivated subsystems and/or components. This allows the user to configure weapon systems as they would likely be employed. In figure 3, the subsystems for the AH-64 (Apache) helicopter are displayed. The component(s) for any subsystem (in this case the Generator) can be displayed by clicking the subsystem name. Diesel Fuel is then displayed as a mandatory component of the Generator, and thus, cannot be deleted from the configuration (a generator is of no use without diesel fuel).

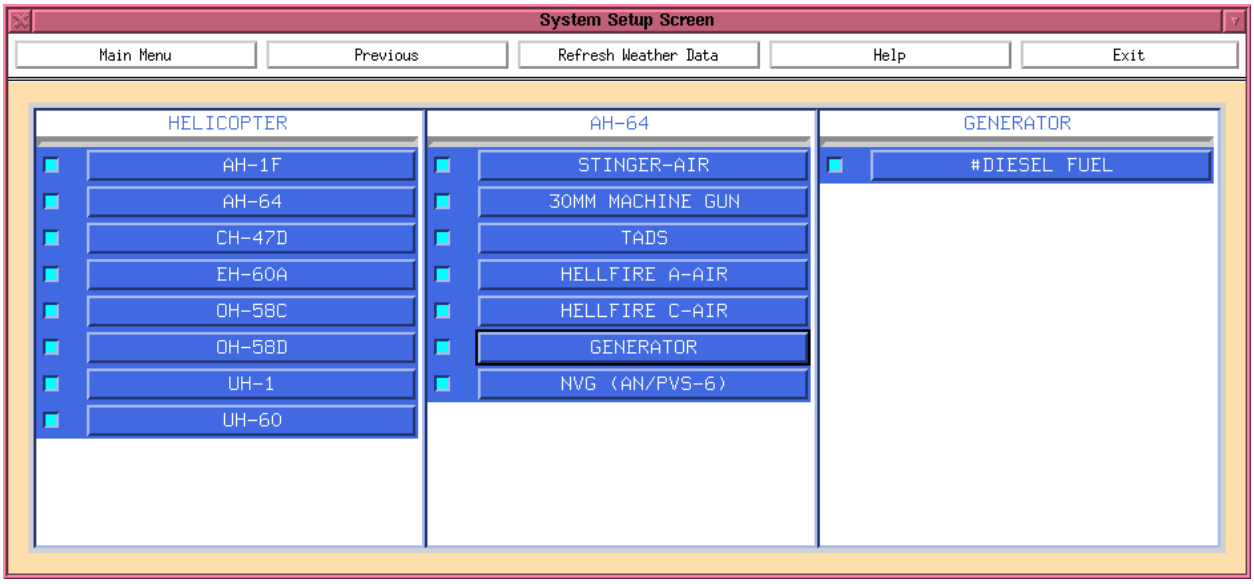

Figure 3. Hiearchical setup for the AH-64 helicopter

2.4 *IWEDA Rules*

As the validity of IWEDA is dependent on the accuracy of the rules that the impacts are based on, significant resources have been expended in the collection and validation of the existing ruleset. Initial data collection for the existing rules was begun in 1992 at the 1st Cavalry Division at Ft. Hood. Staff weather officers, intelligence officers, and weapon system subject matter experts

were consulted to develop an initial set of 400+ rules for over 50 systems. Rules for numerous threat systems were obtained from Army Field Manual 34-81-1 (Department of the Army, 1992) in 1995. Most recently, the entire ruleset was revalidated (Chesley and Grocki, 1997) resulting in several systems being deleted (no longer in the inventory) and numerous rules modified or deleted. This revalidated ruleset has been incorporated into both the Unix and PC IWEDA programs.

3. **Software Development and Demonstration**

3.1 ***ABCS Initiative***

In an effort to insure the smooth transition of IWEDA to the ABCS BFAs, ARL personnel and contractors have been participating in the TFXXI experiments and exercises. IWEDA was successfully demonstrated under the Army's Common Hardware and Software (CHS) environment on MCS, ASAS, AMDWS, CSSCS, and AFATDS at the Brigade TFXXI field experiment held at the National Training Center at Ft. Irwin, CA in March 1997. Using the tactical local area network in place within an echelon, the ABCS clients were able to retrieve the required IWEDA database tables from the IMETS server via the Distributed Computing Environment (DCE) protocols. For the first time ever, commanders could use IWEDA on their own local BAS to query and display the effects of the environment on the weapon systems of interest to them in an automated fashion. More recently, IMETS and IWEDA successfully participated in the Division and Corps Advanced Warfighting command post experiments of TFXXI at Ft. Hood (November 1997/December 1998). However, in these more recent experiments, the IWEDA database resided on the IMETS workstation and clients made remote queries to the tables. These experiments are proving to be extremely valuable to ARL in terms of providing guidance on the utility of IMETS/IWEDA and in preparing for the actual fielding of IWEDA within the ABCS structure.

ARL maintains a presence at the TFXXI Central Technical Support Facility (CTSF) at Ft. Hood to continuously integrate improvements to the IWEDA program on both the IMETS server and BFA clients and to prepare for upcoming TFXXI sponsored experiments and exercises.

3.2 ***Tri-Service Initiative***

ARL has hosted or participated in several meetings with the Navy and Air Force since early 1998 in an effort to assist in the development of an IWEDA capability for those services. Sample rules and rule formats have been provided to the Navy and Air Force to insure that service specific rules collected are compatible with the existing database. Work is currently underway with the Navy to populate the IWEDA database using the Navy's Tactical Environmental Data Server (TEDS) as opposed to the Army's GMDB. Navy rules initially collected by ARL will be used to demonstrate an initial capability of IWEDA for the Navy during an exercise in August of 1999. Coordination is also ongoing with the Air Force with respect to potential support for an Air Force exercise (also in August 1999) using a Java version of IWEDA. Eventual migration by the services to a common format Joint Meteorological and Oceanographic (METOC) database will allow for a single routine to access and transform the raw weather data into the requisite IWEDA database tables.

4. IWEDA Enhancements

Embracing the Army's evolving strategy for the development of command, control, and communication systems using spiral development and early user feedback, experimentation and demonstrations, ARL plans to incorporate a number of enhancements to IWEDA:

- Continue the coordination with the Air Force and Navy to work toward an IWEDA type capability for these services (ongoing).

- Incorporation of a target acquisition algorithm into IWEDA that computes quantitative detection and recognition ranges for a number of target acquisition devices and a variety of targets at a specific point and time via a mouse click over the existing IWEDA map display. This would provide detailed information to the user and augment the current IWEDA favorable/marginal/unfavorable guidance. (initial capability FY99).

- Complete a Java version using the JMTK for map display. This will introduce a level of platform independence that has been lacking to date (late FY99/early FY00).

- Integrate IWEDA into the ASAS Intelligence Synchronization Matrix (ISM). The ISM depicts a timeline and critical interactions between various tasks associated with the battle plan. An Army Concept Evaluation Program (CEP) to provide this capability has been proposed and funded for FY99/00. One of the deliverables for this CEP will be the addition of a weather icon to the ISM. Clicking on the icon will invoke the IWEDA application for further examination of the weather effects (early FY00).

- Ingest output from the prognostic mesoscale meteorological model "MM5" into the GMDB as provided by the Air Force to allow IWEDA to display weather effects out to 48 hours (summer 1999).

- Expansion of the existing rule editor module to allow the SWO to add new systems and rules to the IWEDA database in addition to editing/deleting existing rules (FY00).

- Incorporation of a heat stress algorithm into IWEDA to populate the underlying database with values of parameters that are tied more closely to the performance of personnel. Existing IWEDA rules for personnel (based primarily on temperature and relative humidity) will be replaced with more realistic rules tied to work rest cycle times and/or probabilities of casualties as predicted by the heat stress algorithm (completed April 1999).

- Addition of a capability for the user to query the specific meteorological values that triggered the impact for a specific point and time via a mouse click on the map display. The IWEDA impact statements currently provide information that a critical value has been exceeded but no guidance with respect to the exact value of the rule firing parameter (FY00).

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- Rehosting of the IWEDA database tables from the IMETS workstation to the Army Common Database (ACDB) under the ABCS architecture. This will be a step toward eventual operation under a common Joint database environment (late FY99/early FY00).

- Increase the number of systems and rules. Work is currently ongoing at Ft. Huachuca to collect and validate additional rules for systems that are not in the IWEDA inventory. As soon as these are made available they will be incorporated into IWEDA. This data collection is proceeding on a functional area basis with the first set of expanded rules for the Aviation function anticipated in the spring of 1999.

5. Summary

The Army has recognized the need to automate command, control, and communications to exploit the advanced capabilities associated with the Information Age. In order to accomplish this, common software applications must be available horizontally within echelons and vertically across echelons in a tactical environment. Furthermore, these applications must be easy to use and interpret and should be common throughout the services. The TFXXI initiative is providing the means for the ABCS BFAs to integrate, test, and evaluate these applications within the Army. Ongoing coordination with the Navy and Air Force will shortly provide for common IWEDA applications within the tri-service community. IWEDA allows non-meteorologists (i.e., BFA operators other than the SWO) to readily query and determine the what, when, why, and where of weather effects on the weapon systems and operations of interest to them. In addition to the stand alone capability of the software, however, IWEDA map overlays can be captured and displayed along with overlays associated with BFA specific functions (e.g., an IWEDA map overlay depicting the impacts on maneuver related systems can be displayed along with the actual locations of maneuver units) to provide a truly integrated view of the battlefield for the commander.

6. References

[Svoboda, 1986] G.R. Svoboda. *Proceedings of the First Army Weather Conference*, 1986.

[Department of the Army, 1992] *FM 34-81-1 Battlefield Weather Effects*, Headquarters, Department of the Army, 1992.

[Chesley and Grocki, 1997] C.H. Chesley and V.P. Grocki. *Verification and Validation of Current IWEDA Rules*, STC Technical Report 3157, Science and Technology Corporation, Hampton, VA, December 1997.