P7.7 BUILDS FIVE AND SIX OF NOAA'S NWS WEATHER EVENT SIMULATOR

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1. Introduction

The National Oceanic and Atmospheric Administration's (NOAA) NWS Weather Event Simulator (WES) is a Linux-based software package that allows the playback and simulation of weather events using operational software and archived datasets from the NOAA's National Weather Service (NWS). The WES software is released with an operational build of the NWS's Advanced Weather Interactive Processing System (AWIPS) software (Fig. 1). Development and release of WES is managed by the Warning Decision Training Branch (WDTB) in collaboration with the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS).

Over the four years since its release, the role of WES has steadily expanded inside and outside the NWS (see Magsig and Page 2002, Ferree et al. 2002, Magsig and Page 2003, Magsig 2004, Magsig et al. 2005). The WES is used yearly by every NWS forecaster with forecast and warning responsibility to fulfill required training in preparation for significant weather seasons. The WES has also played a significant role in WDTB courses, including the Distance Learning Operations Course (DLOC) (Grant 2002), and the core, severe, and winter weather tracks of the new Advanced Warning Operations Course (AWOC) (Ferree et al. 2004).

The expansion of WES collaboration outside the NWS (Magsig et. al 2004) has been significantly improved with the establishment of a new File Transfer Protocol (FTP) distribution system that is managed through the WDTB's WES website, http://wdtb.noaa.gov/tools/wes/index.html . NWS collaborative partners now have easy access to the latest versions of the WES in concert with the NWS. WES training and support resources have also been improved on WDTB's new WES website.

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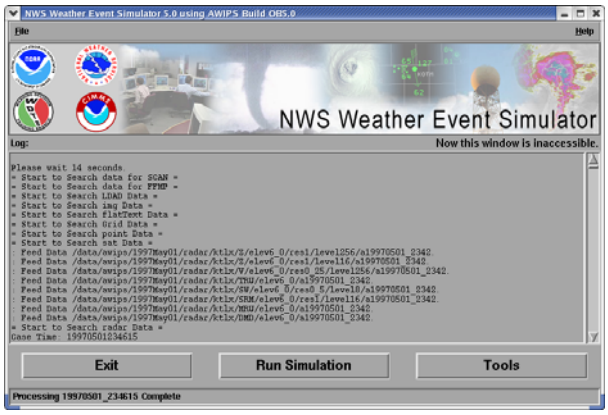

Figure 1. NOAA's NWS Weather Event Simulator version 5.0 main graphical user interface.

In order to stay current with NWS operational needs, the WES has had to continually evolve in step with new developments in AWIPS. WES5.0 was released in August 2005 to include AWIPS OB5.0, featuring support for Terminal Doppler Weather Radar data, the new "Dig Digital Mesocyclone Detection" product. Significant improvements in static case review were also added to WES5.0 to better support the Flash Flood Monitoring and Prediction System (FFMP) (Smith et al. 2000) and the System for Convection Analysis and Nowcasting (SCAN) (Smith et al. 1998). WES software is also continually modified to fix bugs and improve processing.

Significant enhancements to WES are being developed to coincide with the AWIPS Operational Build 6.0 deployment in early 2006. This paper will document the recent advances and successes of WES up to and including WES6.0, which is currently in development.

2. Recent Roles in Training

One of the primary uses of WES in local training at NWS weather forecast offices is to fulfill NWS Directive 20-101. Directive 20-101 requires every forecaster with forecast and warning responsibility in the NWS to run through at least two simulations per significant weather season (e.g. severe convective weather, winter weather, fire weather, etc), with a minimum of two seasons

per year. WES also complements the local training plan by providing a means to develop training and review cases outside of NWS Directive 20-101.

The WES has played a significant role in many WDTB courses, including DLOC and AWOC. The focus of DLOC is on radar fundamentals and basic concepts of warning decision making. DLOC is delivered on a yearly basis to new NWS employees using teletraining, local facilitation, and an in-residence workshop. At the end of the course, a laboratory version of the WES is used to deliver severe weather simulations at the WDTB Research and Training (WRAT) lab (Yu et al. 2004).

The WES also played a large role in WDTB's core and severe tracks of AWOC, delivered in 2005. AWOC represents an evolution in training which leverages a blend of distance learning techniques (recorded internet training modules, on-station simulations, and teletraining) to deliver advanced warning decision making training to every NWS forecaster. Four cases and simulation guides, each with multiple simulation examples, were developed for use with the WES to illustrate how to apply AWOC techniques in an operational context. The local AWOC facilitator at each NWS office could choose to modify the examples and cases to fit local needs or use them as templates to develop their own simulations with local cases. The simulation guides featured new situation awareness measuring techniques that were developed specifically for NWS warning decision making with collaboration from cognitive scientists at Klein Associates (Fig. 2).

The WES continues to play a key role in the development of WDTB's new winter weather track of AWOC, to be delivered in 2006. The simulations component of the winter weather AWOC track is much like the core and severe tracks, only with a single multi-day case and simulation guide. The focus of the simulation guide is on the longer-term winter weather watches, warnings, and nowcasting associated with winter weather.

3. WES5.0 Release

Over the last few years, WES has been regularly updated once per major AWIPS build cycle to include new AWIPS functionality and other training improvements. The latest version of WES is vesion 5.0 which was released in August of 2005. WES5.0 contained the following updates to support AWIPS build OB5.0 and improvements to WES processing and WES Scripting Language (WESSL) simulation support software:

3.1 AWIPS OB5.0

Deployment of a new AWIPS operational build is preceded by a thorough real time Alpha and Beta testing period. During this phase, Alpha and Beta versions of the new AWIPS software are released to participating WFO test sites and other NWS agencies. Beginning with AWIPS OB5.0, WDTB has more aggressively used these early releases to identify problems with AWIPS functionality and WES.

Each Alpha and Beta version received by WDTB is installed and tested carefully to be sure that all new and previous functionality are operational. Once testing is complete, each version is made available on a public machine at WDTB for AWIPS training development. In new efforts to provide AWIPS build training coincident with or prior to national deployment, the timely installation and testing of each AWIPS Alpha and Beta version will be critical.

Terminal Doppler Weather Radar (TDWR) data (Fig. 3) and the "Dig Digital Mesocyclone Detection" (Fig. 4) were two of the new warning-related improvements in AWIPS OB5.0. Several AWIPS configuration files were also updated on the WES using the AWIPS National Dataset Maintenance (NDM) server. These files included interstate and radar shapefiles along with the afos2awips and afosMasterPIL text files. The text quality control for WarnGen (textQC) was also turned off due to a large number of popup errors on the default templates from the AWIPS release CDs.

Three major problems with archived data backward compatibility were identified in OB5.0. OB5 SCAN, FFMP, and DMD displays did not work to varying degrees with archived data sets from previous AWIPS builds. The AWIPS program's unfulfilled requirement for backward compatibility with archived cases has been an ongoing problem that significantly impacts training. In WES5.0, workarounds were developed to recreate data using OB5.0. For FFMP, the fix is for users to create new data using the standard FFMP data creation tool in WES. For DMD and SCAN, the fix is to run a simulation to create the OB5 data, then copy the new files permanently into the case using a script provided (all this is documented in the WES5.0 user guide).

3.2 WES5.0 - WES Software

The following are new additions to WES processing:

Name **SADRT- Situation Awareness Decision Requirements Table**

Type of information we are looking for…a sample "answer sheet" for stop 1,2

Stop Time: 18:30z

Events/Assessments so far? Squall line developing with isolated storms (showing supercell characteristics) out ahead. Very saturated ground and potential training echoes.
What watches/warnings if any do you have out? Flash flood watch; Svr tstm**.**
What are you worried about now? Training echoes; Storms moving into area with few spotters. Concerned about high winds in developing bows. Area of rf masking parts of the line. Line configuration makes it hard to sectorize (potential warnings overlapping or being lost). Workload is becoming an issue – difficult to do good base data analysis on all storms.
What data is most important right now? Radar ref, hi-res v and srm. Mesonet data may show storms moving into more conducive environment.
What data or information do you need that you=re not getting? Spotter reports. Low-level velocity data at far end of squall line.
What is this situation going to look like in _1__ hour? Could have additional isolated storms develop. May have large scale damaging wind event underway. May also have ff threat near metro area.
What will be your next action? Notify law enforcement/Ham operators of need for reports in remote areas. Experiment with PRF changes. Get someone to do updated mesoanalysis. Probably need to redistribute workload and see who is available to come in and help. Order pizza.

Stop Time:18:50z

Events/Assessments so far? Tornadic supercell currently underway. Line has accelerated. FF threat has diminished. Gigantic hail being reported.
What watches/warnings if any do you have out? Tor, Svr
What are you worried about now? Tornado threatening metro area within the hour; numerous outdoor events underway. Difficult to keep warnings out ahead of line as motion is now >50kts. Re-sectorized to tor/svr but orientation of line approaching tornadic cell may cause further re-sectorizing. Storm approaching office and may need to prepare backup operations (safety of staff).
What data is most important right now? Ground truth needed for numerous statements regarding tornado location. Hi res v,srm. Monitoring TV coverage.
What data or information do you need that you're not getting? Could benefit from TDWR data on storm approaching metro but feed is currently down.
What is this situation going to look like in 1 hour? Tornadic storm will be in metro area (if it goes on same course). Northern and central parts of CWA could have wind damage. Storms currently in south should continue to diminish as they move into less favorable environment.
What will be your next action? Check status of generator. Call adjacent offices to notify of backup possibilities

Figure 2. Example of a Situation Awareness Decision Requirements Table (SADRT) form designed for NWS warning decision making. This form was utilized extensively in the WES simulations component of AWOC to evaluate forecaster perception, comprehension, and projection.

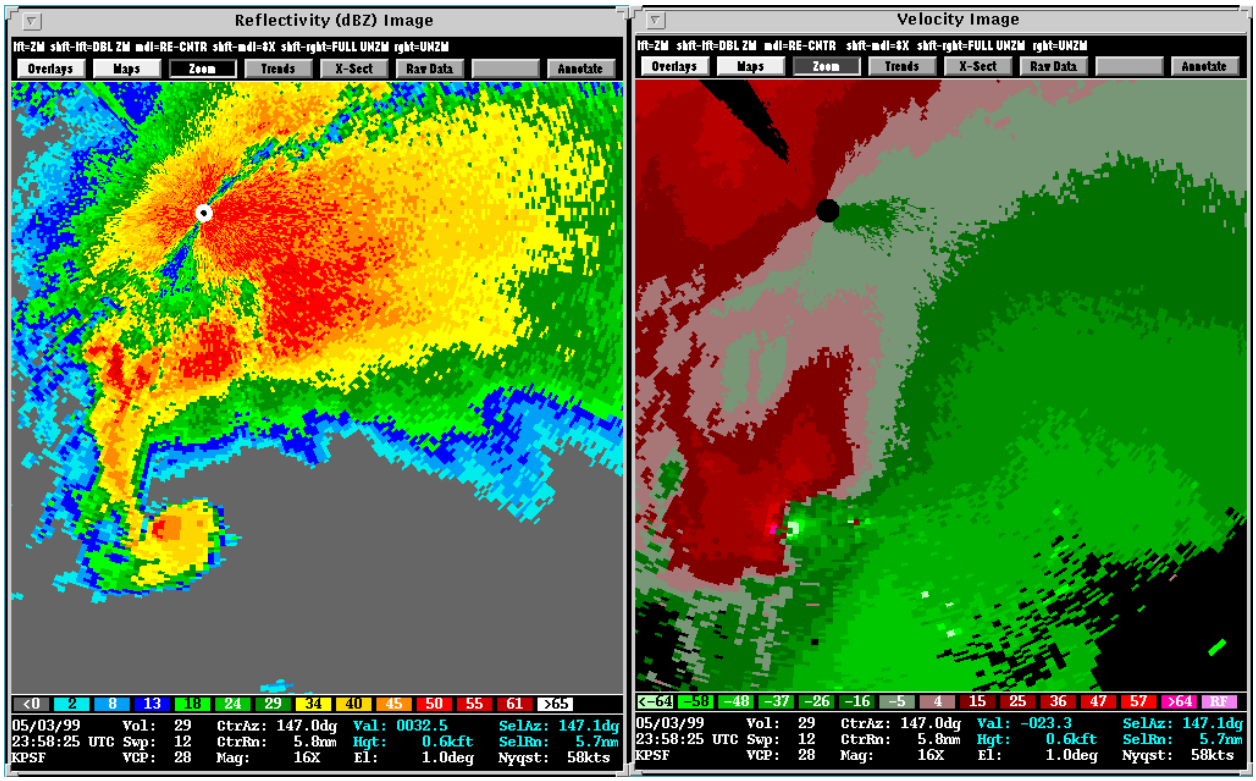

Figure 3. Terminal Doppler Weather Radar (TDWR) reflectivity (left) and base velocity (right) for the May 3, 1999 Oklahoma City tornadic storm. Incorporating TDWR data into AWIPS is a significant improvement in NWS warning decision making for many offices.

TDWR Support: The TDWR data from the Federal Aviation Administration (FAA) is a new radar dataset now becoming available in AWIPS for NWS warning decision making. TDWR data is a unique radar dataset due to the complex volume scan strategy (See Fig. 5). In WES5.0, a new method of determining simulation delay times was developed for TDWR data. For the WSR-88D data, the product directory is used to determine the tilt and delay time. This relationship failed for the TDWR data due to the varying tilt sequence and the AWIPS data storage convention. The new approach uses the elevation index and VCP from the product header in the files to define delays. The current behavior effectively resembles live processing.

Enhanced Case Review: Prior to WES5.0, there were two main applications in the WES software, start_simulator and start_awips. The start_simulator application is used to run a simulation using archived data, and start_awips is used to display case data using D2D. Static case review using start_awips was somewhat limited for the SCAN and FFMP applications because using just D2D did not allow for full functionality. To fully function, the dynamic SCAN and FFMP tables need the notificationServer and CommsRouter running. A

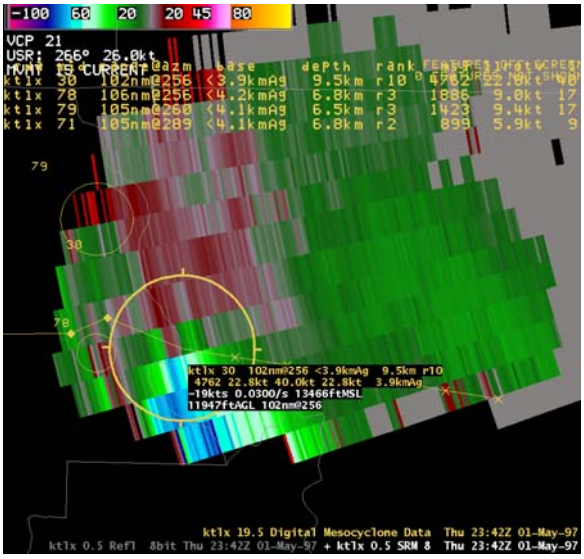

Figure 4. New "Dig Digital Mesocyclone Detection" product. The Dig DMD provides a simple approach to overlaying algorithm output over base data with cursor readout of the table information.

third application named enhanced_case_review was developed to start these two AWIPS processes along with D2D.

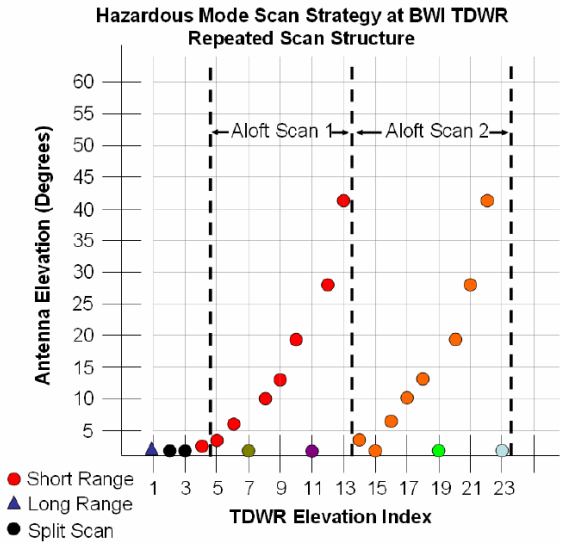

Figure 5. TDWR volume scan strategy for the hazardous weather mode with one minute 0.5 degree data integrated into the scanning strategy. Each color represents a separate volume scan in AWIPS.

The enhanced_case_review application enables full SCAN and FFMP functionality in static case review.

15 Second Frequency: Prior to WES5.0, the start_simulator application searched the archived data once per minute to trigger updates in the D2D display. With one minute processing, some radar elevation angles aloft would arrive at identical times. In WES5.0 the start_simulator application was modified to search every 15 seconds. This allows just about every tilt to arrive uniquely in time. Caution needs to be used in making the search frequency too short or the simulation may be compromised by falling behind.

Data Visibility After Conversion: Previously, a start time needed to be set to make the data visible after converting a case to DRT format. WES5.0 was modified to create symbolic links in the conversion process, so all data are immediately visible after conversion.

Other fixes: In the OB5.0 Beta testing, the volume browser was not working for AWIPS localizations that were moved around to different machines. This was due to OB5.0 D2D creating a symbolic link in the <case_name>/localizationDataSets/XXX/$DISPLAY directory (e.g. 1997May01/localizationDataSets/OUN/:0.0/crossSectionVC.txt) that pointed to a full path. The link would become stale when the localization was moved to a machine without that mount point. The start_awips and enhanced_case_review applications were modified to delete and recreate the crossSectionVC.txt link.

Bugs found in previous WES versions were also fixed in WES5.0. Now the STI motion (if archived) can be used to set the storm motion used in display of 8-bit SRM data during a simulation. Other fixes include 1) preventing failures due to missing directories (FFMP and DMD) and 2) running FFMP immediately after creating new FFMP data.

Patches: Two patches have been released following deployment of WES5.0. The WES_VCP_patch.csh fixes a simulation bug with VCP12 and VCP 121 radar data that affects three WES builds. The second patch, WES_VB_patch.csh, fixes a new problem with the OB5.0 volume browser failing to start on some machines when the data disks are separate from the disk containing AWIPS. We suspect this is due to a problem with D2D file access control across mounted disks. The solution involved modifying the start_awips and enhanced_case_review applications to make a relative link for crossSectionVC.txt in the localization. These two patches are available on the WDTB WES website.

3.3 WES5.0 – WESSL

A couple of new features were added to the Weather Event Simulator Scripting Language (WESSL) program. Changes were made to give the WESSL image tool the ability to display a larger number of image formats including .jpg, .png, .bmp, and .gif.

A new scrolltext tool was also added to the latest version of WESSL. The scrolltext tool includes a vertical scrollbar to the right of a line of text. This tool is useful in keeping long lines of text from inadvertently disappearing off the bottom of the screen.

4. WES6.0 and Beyond

Development of version 6.0 of WES is ongoing at the time of this manuscript. Final contents of a particular WES build are complicated by many of the unknowns in retrofitting training functionality on future AWIPS builds that are not designed for training functionality in the operational baseline. Currently, WES6.0 is expected to include version 6.0 of AWIPS, which is scheduled to be

released in early 2006. In WES6.0 we are going to attempt to improve the responsiveness of WES by using a stable beta version of AWIPS to release a fully tested WES prior to AWIPS national deployment.

Along with AWIPS OB6.0, AWIPS is migrating from a Redhat 7.2 distribution of Linux to a Redhat Enterprise 3 distribution of Linux. Starting with WES6.0 Redhat Enterprise 3 will be the standard Linux distribution for WES, though many other distributions of Linux are still anticipated to continue to work with AWIPS and WES.

One of the major changes in WES6.0 will be the switch from using flat files for warning generation to using the Postgres database. This switch is coincident with the AWIPS migration to Postgres. Migrating to Postgres has become necessary due to the difficulty in regularly retrofitting flat file capability on operational AWIPS builds for WES. Postgres will open the door for other database components of AWIPS to be enabled on future builds of WES, including many hydrological components such as Hydroview and RiverPro. Along with the migration to Postgres, the WES will evaluate merging with the River Forecast Center's Simulating Hydrologic Activities during Real Time (SHARE) application (Jones et al. 2005).

Plans for the next version of WESSL, which will accompany the release of WES6.0, include the addition of a pause command and a Local Storm Report (LSR) importer tool. The pause command will allow a WESSL script to pause both a simulation and WESSL functions at a predetermined time. The LSR importer tool, designed by Brian Walawender (Information Technology Officer at the NWS Topeka, KS office), downloads LSR's from the Storm Prediction Center (SPC) and formats them for immediate import into a WESSL script.

Other applications are being considered for inclusion in WES6.0 and beyond. Replay and simulation capability for archived grids in the Graphical Forecaster Editor (GFE) and the Graphical Hazard Generator (GHG) will be necessary for local WFO winter weather training and the winter weather track of AWOC. Another application being considered for integration with WES is the Linux version of the WSR-88D Open Radar Product Generator (ORPG). The first stage of the ORPG would allow creation of full data cases (highest data resolution and most recent algorithms) from any archived level II data available from the National Climatic Data Center (NCDC). This is essentially providing others the same radar data generation capabilities currently existing at the WDTB. The second stage would allow the ORPG to be connected to a WES during a simulation to allow creation of cross sections and other RPG interactions.

Future WES build contents will ultimately depend on the unknown workload necessary to incorporate new AWIPS builds and functionality into the WES. Highest priority will be given to releasing timely WES builds, and any functionality not ready for a particular build will be pushed to the next major WES build, or perhaps a special release of primarily WES code. WDTB and CIMMS will continue to improve operational software capabilities and training functionality in WES for the foreseeable future. WES developers are currently working with the NWS AWIPS program to submit a proposal called AWIPS Software Training Capability through the Operations and Services Improvement Process (OSIP). This OSIP proposal will guide operational software developers in integrating training functionality into the AWIPS software development baseline in the years ahead. This would optimize AWIPS training development resources, improve over existing AWIPS functionality, and provide for more timely training capabilities in future versions of AWIPS.

5. WES Support/Distribution

Each new version of WES is distributed on CD to all NWS Forecast Offices, River Forecast Centers and Regional Headquarters. CD's are also sent to any other NWS agencies by request. WES 5.0 marked the first time a WES version was made available to non-NOAA entities via FTP. Users are asked to send an e-mail request to Timm Decker at timothy.b.decker@noaa.gov including their contact information. A reply is then sent containing instructions for downloading and creating a WES CD. For tracking purposes, each e-mail request and download is logged.

Starting with WES 5.0, efforts were taken to improve the level of support available to WES users in the NWS. A WDTB WES website was created to provide up to date information on past, present, and future versions of both AWIPS and WES. This information includes WES release notes, installation instructions, patch information, frequently asked questions, future AWIPS/WES content and any other information deemed useful to WES users. A

recorded online training module was also made available on the WES website to provide an overview of the new and changing features of WES 5.0. The WES website is located at the following address: http://wdtb.noaa.gov/tools/wes/index.html.

6. Conclusions

The WES's role inside and outside the NWS continues to grow as more functionality is added. With time, the use of simulations in NWS training continues to grow on a national scale in WDTB courses and training at NWS forecast offices. The WDTB plans to continue working with CIMMS to develop and release more effective versions of the WES, including new versions of AWIPS and enhanced training support software. The WES will continue to be managed through the WDTB until the capability is designed in AWIPS. WDTB's long-term WES goal is for the NWS operational software development to adopt training functionality into the software architecture design, allowing training resources to shift toward developing higher level learning and evaluation tools.

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WES is available free of cost by emailing Timothy.B.Decker@noaa.gov.

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