3.17 **MEDIUM INTENSITY AIRPORT WEATHER SYSTEM (MIAWS) ***

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1. INTRODUCTION

Operational experience with the Integrated Terminal Weather Systems (ITWS) (Evans and Ducot, 1994) and Airport Surveillance Radar, Model 9, (ASR-9) Weather System Processor (WSP) (Weber and Stone, 1995) demonstration systems, studies of pilot weather avoidance decision making (Rhoda and Pawlak, 1999), and recent accidents have demonstrated the need to provide timely, accurate information on the location and movement of storms to air traffic controllers, pilots, and airline dispatch.

At medium-intensity airports, generally those with too few flight operations to justify the presence of Doppler radar systems like the Terminal Doppler Weather Radar (TDWR) or the WSP, terminal air traffic surveillance is currently provided with the ASR–7 and ASR-8 radar systems. The ASR-7 and ASR-8 do not provide calibrated precipitation intensity products or any storm motion information.

The Medium-Intensity Airport Weather System (MIAWS) program is intended to address these terminal weather information deficiencies. MIAWS-generated products would be displayed to tower and Terminal Radar Approach Control (TRACON) supervisors and delivered to aircraft cockpits and airline dispatchers to assist pilots during landings.

Initially, the MIAWS will provide a real time display of storm positions and motion based on Next Generation Weather Radar (NEXRAD) product data using a product generation and display system derived from the WSP. Airport wind and wind shear information will be acquired from an FAA Low Level Wind Shear Alert System (LLWAS). A demonstration system will be installed and demonstrated at experimental sites in Memphis, TN and Jackson, MS in 2000 and potentially at a third site in 2001. This demonstration system will be used to assess technical and operational issues such as compensation for the relatively slow updates of the NEXRAD products and Anomalous Propagation (AP) ground clutter.

The ASR-11 is a replacement for the ASR-7/8 radars that feature a weather reflectivity processing channel. When it becomes available at MIAWS locations, the MIAWS processor will acquire and display precipitation and storm movement products derived from the ASR-11. Likewise, when an LLWAS Relocation/Sustainment (LLWAS-RS) (Nilsen, et al., 1999) becomes available at MIAWS locations, the MIAWS will acquire wind and wind shear information derived from the LLWAS-RS.

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2. SYSTEM ARCHITECTURE

Figure 1 shows the overall MIAWS data sources and users. Weather data, specifically composite reflectivity, is acquired from a nearby NEXRAD site via one of the dedicated FAA product ports. The wind information is acquired from an LLWAS through one of the tower/TRACON display ports.

The MIAWS processor uses the NEXRAD reflectivity and LLWAS wind information to support a situation display (SD) that provides air traffic controllers with an up-to-date portrayal of the weather and associated precipitation hazards within the terminal air space. Each MIAWS will support a number of situation displays that will be positioned throughout the air traffic control tower, typically in the TRACON and tower cab.

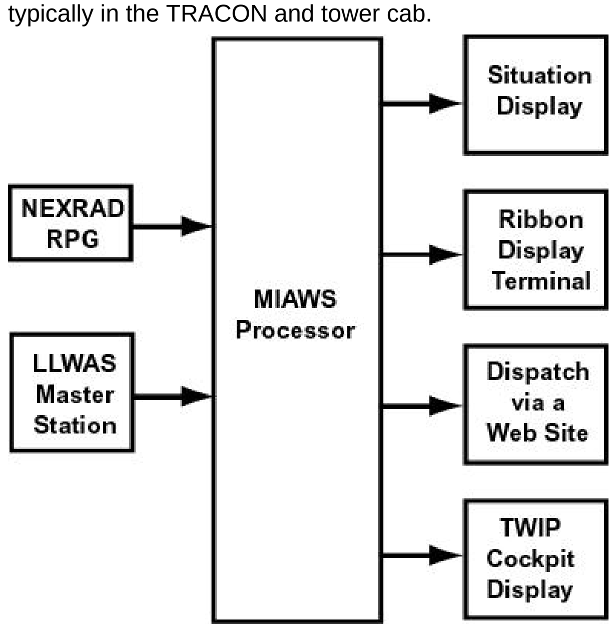

Figure 1. MIAWS system architecture.

A situation display may also support one or more ribbon display terminals (RBDT). An RBDT provides a simple set of alphanumeric text messages that provide air traffic controllers with weather summaries for operational airport runways. Other FAA weather alert systems, including ITWS, TDWR, and WSP, also support RBDT devices. RBDT weather summaries from MIAWS include information about weather hazards; that is, heavy or moderate precipitation within the three-mile runway approach, the first expected area in which significant weather will be encountered, and current threshold wind direction and speed. The RBDT summaries may be relayed by controllers to pilots via radio announcement.

For near-term MIAWS demonstrations, MIAWS SD images will be made available, along with ITWS and WSP demonstration system SD images, on the Lincoln Weather Sensing Internet and CDMnet web sites. The web site provides recent SD images and movie loops to a restricted set of users (passwords are required), including airline dispatch personnel, ramp tower personnel, air traffic controllers at nearby airports, and FAA support facilities[1].

As part of an on-going effort to establish a channel for information directly to in-flight pilots, the MIAWS SD images will be relayed to cockpit displays. The FAA Terminal Weather Information for Pilots (TWIP) (Denneno, et al., 1996) program has developed a mechanism by which limited-resolution images and text may be transmitted to commercial aircraft cockpits to provide pilots with roughly the same hazardous-weather information available to air traffic control supervisors. MIAWS SD images and runway alert messages can be included in the set of products available to pilots.

3. MIAWS DEMONSTRATION

In the fall of 1999, the FAA tasked MIT Lincoln Laboratory to develop and evaluate a demonstration system. Existing software technology developed at Lincoln for the WSP demonstration system and transferred as baseline software to the Northrop Grumman Corporation for its production WSP systems (Newell, 1999a) facilitated low-cost, rapid development of the MIAWS demonstration system. Two field sites were selected: one in Memphis, TN to make use of existing access to NEXRAD basedata at Lincoln's ITWS field site, and the second in Jackson, MS.

The MIAWS demonstration systems were assembled entirely with Commercial-off-the-Shelf (COTS) components: a Personal Computer (PC) for interfacing to the NEXRAD, a workstation dedicated to product generation, communication hardware, and a site-adaptable number of SDs. Figure 2 illustrates the MIAWS demonstration system network architecture. All processing hardware is connected via Local Area Network (LAN) to simplify future component replacement. Wide Area Network (WAN) communication hardware attached to each MIAWS LAN provides access to all demonstration sites from the Lincoln Weather Sensing group in Lexington, MA. While operating at field sites with little or no Lincoln staffing, the MIAWS demonstration systems will be remotely monitored.

The LLWAS wind information is acquired via the asynchronous serial data Tower/TRACON display port on the master LLWAS station. Two-minute centerfield average wind speed and direction, gust speed, and sensor wind speeds and directions are acquired at 10-second intervals.

[1] It is anticipated that the MIAWS products will be available on CDMnet and Internet servers operated by the Volpe Center.

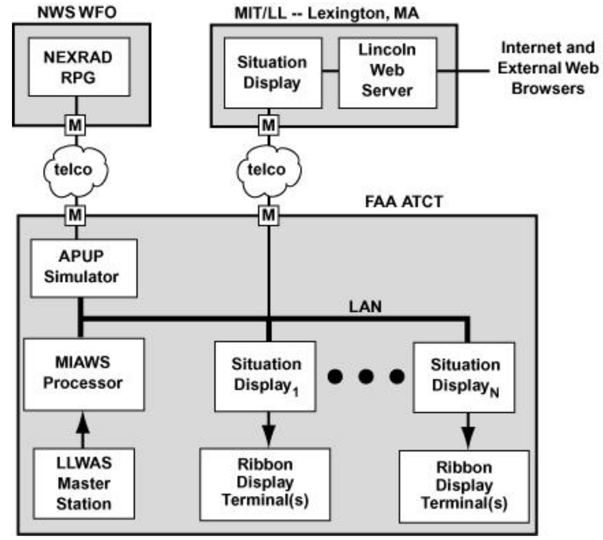

Figure 2. MIAWS demonstration system network architecture.

The NEXRAD interface, referred to as an APUP Simulator, was developed by the ACT-320 branch of the FAA Technical Center (FAA/TC) in Atlantic City, NJ and was approved by the NWS Operating Support Facility (OSF) in December 1999. The APUP Simulator, consisting of a PC, an X.25 interface card, and software created at the FAA/TC, provided a convenient mechanism for acquiring NEXRAD products. An APUP Simulator attaches to a NEXRAD Radar Product Generator (RPG) via one of the dedicated FAA narrowband modem ports and emulates a Class I Principal User Processor (PUP) display. A set of products required by the MIAWS are requested by the APUP Simulator and delivered by the RPG whenever products become available.

The set of products currently requested by the APUP Simulator for the MIAWS include the following (FMH No. 11, 1991):

(a) Composite Reflectivity (CR, Product Code 37) is a 1-km resolution raster image containing reflectivity maxima from any of the elevation scans of the current NEXRAD Volume Coverage Pattern (VCP). The CR product is a high-resolution product suitable for an SD background.

(b) Layered Reflectivity Maxima – AP Removed (LRM-APR, Product Code 67) is a new NEXRAD product recently introduced with Build 10. The LRM-APR is a 4-km resolution raster image containing reflectivity maxima from the surface to 24,000 feet. The LRM-APR product is used by the MIAWS as a source of AP-free data when editing the CR product.

(c) General Status Messages (GSM Product Code 2) contain flags and calibration data that describe the current status of the NEXRAD. The GS messages indicate changes in NEXRAD operational status that could impact the MIAWS processing and data quality.

(d) Free Text Messages (FTM Product Code 75) contain alphanumeric messages entered by NWS personnel to inform users about upcoming changes in NEXRAD operational status.

MIAWS software functional components perform data acquisition, data translation and archiving, algorithms, and graphical situation display. A majority of the MIAWS software was written in C++; however, a number of shared communication and graphic support libraries were written in C. The MIAWS situation display software was written in C++ and Tcl/Tk, a public-domain graphic user interface and scripting language. Data are transported among MIAWS software modules using data packaging and inter-process communication (IPC) software created at Lincoln during the development of the WSP demonstration system (Newell, 1999b). Although the NEXRAD interface was implemented on a PC running Windows NT operating system (O/S), the remainder of MIAWS software runs on either Solaris or Linux platforms.

Figure 3 illustrates the MIAWS demonstration system software architecture. The *NEXRAD Product Server* acquires NEXRAD product messages from the APUP Simulator and distributes them to the MIAWS algorithms. The *Precipitation Server* process generates an AP-edited raster image (see Section 4.2) that is also oriented towards magnetic North, as required for air traffic terminal display. The *Storm Motion* algorithm, which relies on the cross-correlation tracker and storm extrapolation software libraries also used by the Lincoln ITWS and WSP demonstration systems (Chornoboy and Matlin, 1994), generates storm leading-edge lines and 10- and 20-minute predicted positions. The *Precipitation Impact* process evaluates storm cell position and storm motion information and detects current and predicted airport arena impacts. Impact predictions are projected out to 20 minutes to drive the situation display weather alert panel. The *Runway Server* maintains information about the current airport runway operations. Runway configuration information, provided by ATC personnel, is used by the *Alert Server* when generating configured alert messages, tailored to active runways, that appear on RBDT devices and the SD alert panels. *TWIP* generates alphanumeric graphic and text messages suitable for transmission to aircraft cockpit displays when TWIP interfaces become available. Finally, the *Product Multiplexor* combines all products into a single product stream suitable for display and archiving.

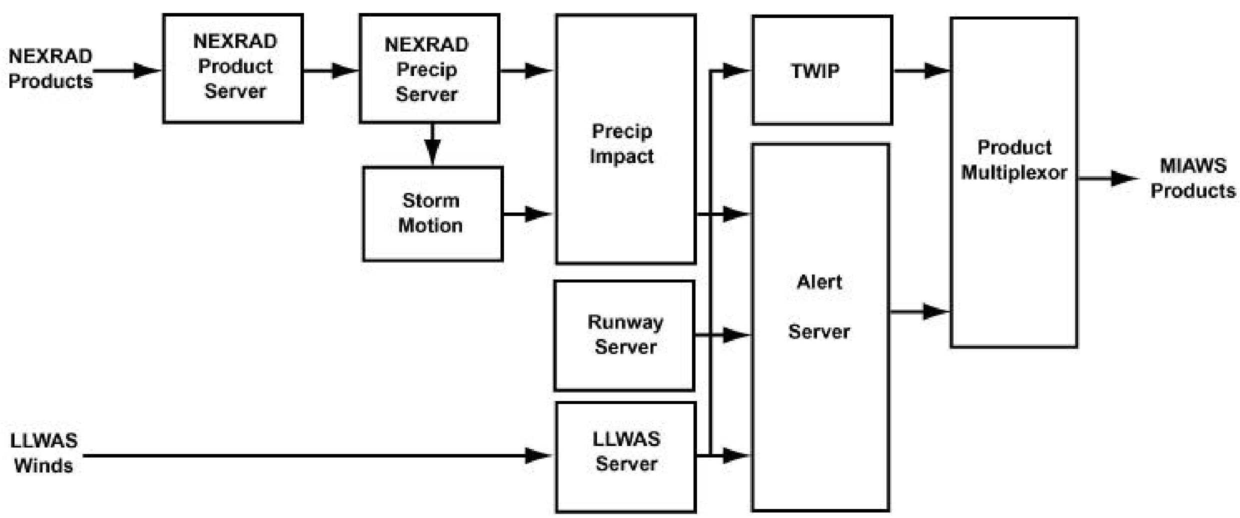

Figure 3. MIAWS software architecture.

The output of the MIAWS is a set of products that are distributed to all configured SDs attached to the MIAWS LAN/WAN. For each proposed MIAWS installation, a site-adaptable number of SDs may be installed throughout the control tower, typically in the TRACON and tower cab. For each demonstration site, one of the SDs at Lincoln is dedicated to providing MIAWS SD images to the Lincoln Weather Sensing Web host which services a password-protected Internet Web page.

4. TECHNICAL CHALLENGES

A number of technical challenges were encountered during the development of the MIAWS demonstration system hardware and software: NEXRAD product latency, Anomalous Propagation (AP) mitigation, NEXRAD product data quality, and MIAWS component and communication reliability.

4.1 NEXRAD Product Latency

Depending on the NEXRAD scanning pattern, products are generated between five and ten minutes apart. Displaying reflectivity products that are up to ten minutes old to air traffic controllers could inhibit timely warnings and reduce airport safety, particularly for fast-moving storms approaching airport runways. To enhance the timeliness and accuracy of the MIAWS product display, MIAWS software uses the motion information provided by its storm motion algorithm to advect, or project, the latest NEXRAD weather data and related products based on the computed storm motion. A 30-second advection interval was selected. The display shows the age of the NEXRAD precipitation product being displayed.

4.2 Anomalous Propagation (AP) Mitigation

The NEXRAD Composite Reflectivity product, preferred as an SD background for its 1-km resolution, occasionally suffers from AP contamination caused by atmospheric conditions. To mitigate the effects of AP, the MIAWS pre-processing software makes an effort to edit out AP contamination using the LRM-APR product. By matching corresponding raster bins (accounting for the differences in resolution) of the CR and LRM-APR products, the regions of AP may be identified and edited.

4.3 NEXRAD Product Data Quality

Occasionally, the NEXRAD is switched to a test or maintenance mode and products containing test patterns are unintentionally released on the RPG product stream. The resultant products are unsuitable for presentation to air traffic controllers and may result in unwanted false alarms and/or missed hazards on the airport. Although the NWS has taken steps towards preventing the release of test patterns, a solution was introduced into the MIAWS front-end processing software. Evaluation of the General Status message from the NEXRAD is expected to help detect non-operational states and provide notification to MIAWS SD users.

4.4 Component and Communication Reliability

The NEXRAD product source and, in some cases, the LLWAS wind data source may be distant from the MIAWS product generator. Dedicated phone lines are therefore necessary to acquire the input data. At unmanned MIAWS demonstration system facilities where no Lincoln personnel are overseeing system hardware and communication links, it is important to monitor the health of the communication links. Remote monitoring function (RMF) software, also used in the Lincoln WSP demonstration systems at Albuquerque and Austin, was developed to detect and report faults. A number of differing types of automatic fault detection and isolation methods were implemented as part of the MIAWS demonstration system. Although Lincoln personnel may not be immediately available at the remote site, fault detections will be relayed to the appropriate personnel via e-mail and/or maintenance display terminals so that appropriate steps can be taken to resolve the problem.

5. SITUATION DISPLAY

The MIAWS SD, shown in Figure 4, portrays current weather, winds, storm cell position and motion information, and hazardous weather alerts to air traffic controllers. Many of the MIAWS user interface features were carried over from the WSP demonstration system to maintain general consistency with other terminal weather displays, including TDWR, ITWS, and WSP.

The MIAWS SD includes the following items:

(a) AP-edited NEXRAD composite reflectivity with a 60-mile outer range, 1-km resolution, and six-level NWS color map,

(b) Storm cell leading edge lines, storm cell motion vectors, and extrapolated storm cell position lines,

(c) LLWAS wind vectors,

(d) NEXRAD weather age; that is, the time since last product update,

(e) Heavy (Level 5 & 6) and moderate (Level 3 & 4) precipitation alert indication for precipitation-impacted active runways,

(f) Weather impact countdown timer when significant precipitation (Level 3 and above) is expected to impact any airport runway within 20 minutes,

(g) Airport runway alert messages including precipitation impact magnitude (heavy or moderate), first arena (1MF, 2MF, 3MF, 1MD, 2MD) in which aircraft can expect to encounter significant precipitation, and LLWAS wind direction and speed (when available), and

(h) System and product availability status.

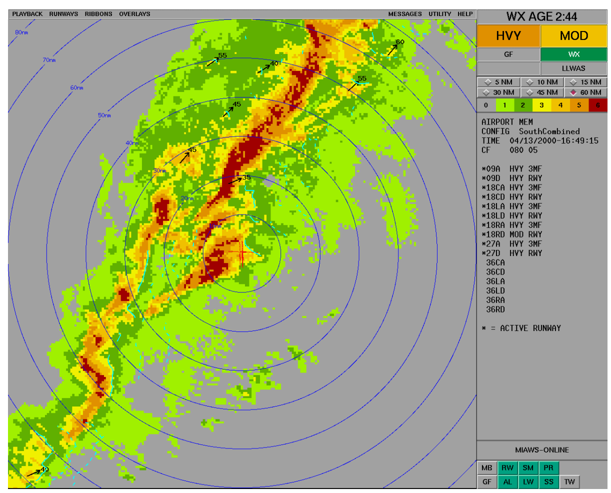

Figure 4. MIAWS situation display.

6. MIAWS DEMONSTRATION SYSTEM STATUS

In April 2000, the first MIAWS demonstration system was installed at the Lincoln ITWS demonstration system in Memphis but was not actually connected to the NEXRAD RPG, pending permission from the NEXRAD Operational Support Facility (OSF). Although not presented to air traffic controllers directly, the Memphis demonstration system will be available for inspection by controllers. The second MIAWS demonstration system is scheduled for installation in Jackson, MS by mid-June 2000. At Jackson, MIAWS situation displays will be installed in the TRACON room and tower cab. Following system calibration and site adaptation adjustments, the Jackson MIAWS demonstration will begin an operational demonstration and evaluation in July 2000. Following that evaluation, the Memphis and Jackson situation display information will be made available on the Lincoln real-time terminal weather information Web site.

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