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THE STATUS OF THE FAA CENTRAL WEATHER PROCESSOR (CWP) PROGRAM

Eric Mandel and Kevin Young
Federal Aviation Administration
Washington, D.C.

David Panzer and Hal Ludwig
Stanford Telecommunications Inc.
Washington, D.C.

1. Introduction

A. NAS Background

As a blueprint for modernizing the nation's Air Traffic Control system, the National Airspace System (NAS) plan first appeared in 1981. The modernization includes the replacement or upgrade of all Federal Aviation Administration (FAA) operational, training, and maintenance facilities with state-of-the-art technology. A large portion of this plan includes the replacement and upgrade of weather data collection, processing, and distribution facilities. This paper will address the latter two areas.

B. FAA Interest in Weather

According to the National Transportation Safety Board (NTSB), over twenty percent of all general aviation accidents are weather related, as are nearly half of the air carrier accidents. Also, roughly 80 percent of airline delays over 30 minutes are caused by weather. Additionally, weather-related operations and services are among the most often cited areas of dissatisfaction among the users of the ATC System.

The NTSB cited the unavailability of adequate weather information to controllers as a cause of the crash of a Southern Airways DC-9 at New Hope, Georgia in 1977. This event precipitated a 1978 cooperative FAA/National Weather Service (NWS) agreement to improve the synthesis and dissemination of weather information. The establishment of Center Weather Service Units (CWSU) in the Air Route Traffic Control Centers (ARTCC) was a result of this agreement.

The processing and dissemination of weather information in the ATC system begins in the ARTCC CWSU, manned by NWS meteorologists. The Memorandum of Agreement between FAA and NWS that established the CWSU's requires the FAA to furnish all necessary supporting equipment. In addition to the CWSU's, there is a Central Flow Weather Service Unit (CFWSU), located in the Central Flow Control Facility (CFCF), who is responsible for providing NAS-wide weather support.

2. CWP Background

A. CWP Description

The FAA conceived the CWP as the single source of weather information in the ARTCC and CFCF. This system would provide GOES, NEXRAD, NWS, and AWOS data to the CWSU/CFWSU meteorologist. It would also provide mosaicked radar and other graphic and alphanumeric products to air traffic and traffic management specialists. A sophisticated weather data analysis function would allow the creation of station model plots, contour analyses of selected parameters, thermodynamic diagrams, and many other products. A full range of man-machine interface (MMI) capabilities included animation, overlay of different product types, and the combination of several commands into a "procedure" file. These procedure files are used to display or manipulate meteorological products for operational briefings.

B. Restructure of CWP

The CWP was to have been deployed in 1994. The Jet Propulsion Laboratory (JPL) was chosen to develop the CWP. JPL had just entered the preliminary design phase when the FAA reassessed the entire program in the Spring of 1987.

The motivation for re-examining the CWP approach was to attempt to provide the meteorologist with improved service and capability sooner. Most of the CWP's interfacing systems would not be in place until the 1994 time frame. In particular, the Advanced Automation System (AAS), which supports air traffic controllers, and through which the CWP would provide near real time data to controllers, was not to be deployed until 1995. One way of speeding up improved service to the meteorologist was separating those functions which provide data to the ACCC from those which provide data to the meteorologist, since many of the latter were commercially available. Subsequently, this path was chosen and resulted in a decision to divide the CWP project into two separate but complementary subsystems; the Real-Time Weather Processor (RWP) and the Meteorologist Weather Processor (MWP).

3. System Descriptions

A. RWP System Description

The RWP is a computerized weather data acquisition, processing, and dissemination system designed to support air traffic control operations. The FAA has directed JPL to transition from CWP to RWP prototype development, which is now underway. The prototype consists of Ada software and Digital Equipment Corporation (DEC) hardware upon which the software will be developed, integrated, and tested. Upon acceptance by the FAA in January 1991, a system integration contract will be awarded for the procurement of production hardware upon which the software (as GFE) will be hosted. This effort will also involve the development of pre-planned (e.g., an MWP interface) and unforeseen enhancements. This production phase will last until June 1995, when RWP systems will be in place at all ARTCC's.

By providing a direct connection to the AAS, the RWP serves its primary mission of delivering near real time weather data to enroute air traffic controllers. Radar mosaics from NEXRAD and reformatted surface observations, forecasts, warnings and advisories from NWS are sent to the controllers' screens. The CWSU meteorologist can create graphic products depicting areas of hazardous weather, called Hazardous Weather Outlines (HZW's), on the RWP's screen and send them to the controllers. Pilots will also receive NEXRAD and other products disseminated from the RWP via the Data Link Processor (DLP).

While the chief mission of the RWP is controller support, it will also provide a limited amount of meteorologist interactive capabilities. As mentioned above, the meteorologists can create graphic and alphanumeric products on the screen. They can also display products in overlay and can pan and zoom them. Although not as sophisticated as the MWP, the RWP MMI does provide the display of mosaics as seen on the controller's screen. It also provides the capability to request and display any product directly from a selected NEXRAD.

The RWP software will consist of approximately 200,000 lines of computer code, 70,000 of which will be developed by the FAA. The RWP is the first FAA system to be developed using Ada technology. This software must be highly reliable given the real time nature of the system and the major safety considerations. It is also important that the code be portable as it must be re-hosted on the production hardware.

The hardware for the prototype system is configured in a loosely coupled distributed architecture. Digital Equipment Corporation (DEC) microVAX-based processors are connected using a DECnet LAN. There are separate computers for each NEXRAD connected (as many as 27 depending on location), for alphanumeric distribution and system control, for MMI, and a redundant pair for radar distribution. This redundancy helps insure the necessary high availability of NEXRAD data.

B. MWP System Description

Weather Information Processing capabilities such as gathering alphanumeric data, graphic data, weather satellite data, and weather radar data are available in several systems. Generation of surface and upper air charts and analyses, and a host of MMI functions (looping, overlay, annotation, pan, and zoom) are also available "off-the-shelf." The FAA plans to lease these services and capabilities. The leases will each be for five years over a 25 year period. At the beginning of each new lease, installation of state-of-the-art systems will provide sophisticated weather products to meet the CWSU meteorologist requirements.

The near term deployment of the MWP I provides modern meteorological systems in the ARTCC's and CFCF. Besides replacing all existing CWSU equipment and improving the capabilities of the CWSU meteorologist, the MWP will include briefing stations in the Traffic Management Unit and at the Air Traffic Area

Supervisors' positions. These briefing terminals are independent of the CWSU work station and can access products in the MWP's data base.

MWP II will include all the capabilities required in MWP I, and it will interface with the Weather Message Switching Center Replacement (WMSCR), and the RWP. The interface to the RWP will pass meteorologist-generated products to controllers and pilots for direct use. The WMSCR interface will pass CWSU/CFWSU meteorologist generated products to other ARTCC/CFCF MWP's and to the NWS.

The FAA in conjunction with the NWS is studying the use of AWIPS-90 work stations to meet the end-state MWP requirements. The FAA has funded the study as part of the AWIPS-90 Concept Definition Phase Contract. A draft set of functional requirements was provided to the NWS. The results of the study will show the differences between the MWP and the AWIPS-90 requirements. It will also show the cost of modifying AWIPS-90 to make up any deficiencies. Comparison of the total costs of equivalent AWIPS-90 work stations with that of a separate FAA procurement will determine the end-state direction of the MWP program.

4. Use of the CWP System in the NAS

A. Meteorologists Point of View

The mission of the CWSU meteorologist is as follows: "the primary function and responsibility of the CWSU is to provide meteorological advice and consultation to center operations personnel and other designated FAA Air Traffic Facilities, Terminal and Flight Service Station (FSS), within the ARTCC's area of responsibility." Also, in the CFCF, the responsibilities of the CFWSU meteorologist are to provide meteorological advice to CFCF personnel on weather conditions which may affect the NAS.

The CWSU/CFWSU meteorologist's daily responsibilities are:

- Preparing and disseminating near term (0-2 hour) aviation forecasts known as Center Weather Advisories (CWA).

- Disseminating Urgent Pilot Weather Reports (PIREP) and other hazardous weather aviation advisories.

- Preparing and delivering briefings to ATC personnel.

- Preparing and disseminating medium term (2-4 hours) aviation forecasts known as Meteorological Impact Statements (CWS).

In the preparation of forecasts and briefings, the meteorologist draws information from a variety of data sources: radar, satellite, surface, and upper air observations, and other alphanumeric and graphic weather products. The CWP as a whole gives the meteorologist an interactive means of viewing and manipulating data. Primarily, the MWP element supports the viewing and manipulation of the data. For a more detailed, real time view of the ARTCC, the meteorologist will use the RWP to view a routinely received set of NEXRAD products individually or as mosaic products. The RWP will also allow viewing of any individual NEXRAD product on a request basis.

When hazardous weather conditions exist (thunderstorms, turbulence, icing, etc.), the meteorologist will use either the MWP or RWP work station to draw line segments, annotated with information describing the hazard, enclosing the affected area. This product is called a Hazardous Weather Outline (HZW) and can be disseminated to ATC via the RWP and the briefing terminals.

B. Air Traffic Controllers Point of View

Air traffic controllers are responsible for maintaining safe separation between aircraft, maintaining a safe, efficient, and orderly flow of traffic, and receiving information from, and disseminating information to, pilots and other controllers. Each ARTCC is responsible for these tasks within the boundaries of the regional-sized ARTCC area. Weather data is provided for an additional 150 nm "buffer" surrounding the ARTCC area. The ARTCC area is divided into "sectors," each of which is handled by one team.

The ACCC, as stated above, receives weather data from the RWP (and MWP via the RWP). These products include mosaics of NEXRAD reflectivity (three layers), turbulence (three layers), and what are known as "point products" (hail, storm tracks, mesocyclone). The controller's display screen will show lines depicting airways and the location of each aircraft (including flight number, airline, speed, and altitude). The mosaicked NEXRAD data will also be visible on the screen. The controller will thereby be able to direct planes away from areas of turbulence and other hazardous weather. NEXRAD's ability to distinguish between areas of precipitation and those of turbulence will allow the controller to determine the most efficient rerouting, rather than simply avoiding all areas of reflectivity.

Another product which will appear on the screen is the HZW, described above. This will be of particular benefit in routing aircraft and can show hazards not depicted by the NEXRAD products.

The controller position will have an alphanumeric display terminal. This will display surface observations and terminal forecasts for stations within the controller's sector. The RWP will have converted these products to an easy-to-read tabular format. Additional alphanumeric products will include SIGMET's, PIREP's (from other centers), hurricane advisories, and CWSU meteorologist-generated nowcasts and short term forecasts (CWS) and CWA). This information will aid the controllers in routing decisions, and will allow them to provide information directly to pilots (via voice communication) upon request.

Controllers will receive hourly from the RWP three-dimensional forecasts of upper air wind and temperatures valid for the current hour. These forecasts are generated in the RWP using Gridded Binary (GRIB) model data from NWS. The RWP will generate upper air wind and temperature values at as many as 39 flight levels (in thousands of feet) by interpolating the information at the standard pressure levels in the GRIB data. Temporal interpolation between GRIB forecasts will provide the data for each hour.

These hourly GRIB forecasts will be of significant value in the future when a greater degree of automation becomes part of the air traffic function. The Automated En Route Air Traffic Control (AERA) system will detect conflict and provide suggested resolution and will determine the most efficient traffic routing. The GRIB data will be used as one input to these algorithms.

Besides providing information to pilots, the controller also receives PIREP's from them. These are entered into the ACCC and disseminated to the RWP and are then distributed throughout the NAS.

C. Traffic Management System Point of View

There are two parts to the Traffic Management System (TMS), the CFCF, and the ARTCC Traffic Management Unit (TMU). To function properly, both parts must coordinate as needed to develop a national traffic management plan.

The CFCF provides national level monitoring of current air traffic flow, aircraft operations, enroute sector and airport utilization and loading, and future system use. The CFCF estimates ground delay in the NAS and determines and resolves the bearing on ideal national traffic flow among the flight advisory areas of the ARTCC.

The ARTCC TMU provides aid to air traffic controllers in the ARTCC and Air Traffic Control Towers to establish efficient traffic flows. The TMU monitors traffic loads in each of the sectors and airports, redistributes traffic among the sectors, and coordinates flow management directives to minimize the effect on all traffic.

The main factor in delay activity is weather. Weather at or near major hub airports (e.g., Chicago, Atlanta, Denver, or New York City) or on major jet airways causes delays from a few minutes to hours in length. The TMS will use weather data differently in the ATCCC than in the ARTCC. The CFWSU meteorologists and the Traffic Management Specialists focus mainly on strategic planning using long range forecasting (3-12 hours). Weather-influenced airport capacity forecasts are fed into computer programs to determine delay duration and traffic re-routing.

The CFWSU meteorologists view larger segments than ARTCC's. In some cases, they review the entire country at one time to identify developing weather trends and potential problem areas. The CFWSU meteorologist will obtain an overview by using the MWP to display a graphic depiction of the NWS hourly national radar summary and low resolution satellite data. More detailed analysis can be done using high resolution satellite imagery, individual radar data, and analysis products derived from GRIB and observation data. This information, verified by comparison to FT's, FA's, and SIGMET's, will provide the meteorologist with near term details of impacted airways and airports. The next step is informing Traffic Management personnel of an impending problem. If coordination is required with the CWSU meteorologist, they will discuss the conditions via telephone and prepare a joint forecast for TM personnel use.

TM specialists use these forecasts, along with products displayed at their briefing stations to determine impacts to airways and airports. With this information, the specialists can judge projected capacity, and take the steps necessary to route traffic most efficiently.

For the Traffic Management Coordinators (TMC) in the ARTCC, the need for forecast data is more near term (0-3 hours). In addition, tactical planning will accommodate unanticipated deviations (e.g., fronts move in more quickly than planned, or not at all). TMC's are also responsible for monitoring intra-ARTCC traffic capacity and coordinating with adjacent centers.

D. Pilot Point of View

Pilots of commercial aircraft in flight receive weather data today from controllers via direct voice communication, as described above. Besides limiting the types of data available (e.g., no graphics), this arrangement also limits the frequency of data, since controllers are often too busy with their separation duties to respond quickly to individual requests for weather. Future NAS plans provide a means for automating this function. The Data Link Processor (DLP) will handle requests for a variety of weather products, both alphanumeric and graphic, from pilots. All commercial aircraft will be equipped with Mode-S transponders and displays on which requested products can be seen.

A major source of data for the DLP will be the RWP. DLP will receive NEXRAD mosaics, upper air wind and temperature, PIREP's, and observations. The DLP will also receive PIREP's from pilots and will transfer these to the RWP for storage and dissemination.

5. Conclusion

The CWP consists of two complementary subsystems, the RWP and the MWP. This total integrated system will provide weather data distribution, processing, and services tailored to all of the personnel responsible for meteorology within the NAS. The CWP will furnish state-of-the-art NAS weather support well into the 21st century.

6. References

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