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WFO-ADVANCED OVERVIEW

Forecast Systems Laboratory

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1 Background

1.1 National Weather Service Modernization

For several years, the National Weather Service (NWS) has been engaged in activities directed toward modernizing and restructuring its operations. The activities include as major components the development of a new radar system (NEXRAD; the individual hardware units are known as WSR-88D), a new automated surface observing system (ASOS), and a new communications and forecaster workstation system, the Advanced Weather Interactive Processing System (AWIPS).

In order to make more effective use of the talents of its staff of professional meteorologists, the NWS plans to reorganize its operations. Currently, 52 Weather Service Forecast Offices (WSFOs) perform the bulk of the forecasting functions for (generally) statewide areas, and 180 Weather Service Offices (WSOs) and other small offices provide local adaptive forecasts. Both WSFOs and WSOs issue severe weather warnings, though many WSOs operate on a less-than-24-hour schedule and must be backed up by their parent WSFO at night.

The restructured National Weather Service will include 118 Weather Forecast Offices (WFOs), roughly collocated with WSR-88Ds. AWIPS will provide the communications and forecast support functions for these offices.

1.2 AWIPS

In the early 1980s, the NWS Office of Meteorology, along with representatives of NWS administrative, development, and field offices, plus what is now the Forecast Systems Laboratory (FSL), prepared requirements for AWIPS. These form the basis of the functional requirements included in the AWIPS System Requirements Specification (SRS) and the AWIPS Development Phase contract.

In preparation for the development and deployment of AWIPS, the NWS has asked FSL to participate in several risk reduction activities. The primary activity has been developing and testing a series of forecaster workstations at the Denver and Norman WSFOs. Currently, systems known as DARE (Denver AWIPS Risk Reduction and Requirements Evaluation) in Denver and Pre-AWIPS in Norman are being used by the WSFO staffs. These systems have provided valuable insight into modernized operations; experience gained in Denver and Norman has been used to refine the specifications that are being used by the AWIPS contractor.

The AWIPS Development Phase contract was awarded to Planning and Research Corporation (PRC) in December 1992. By early 1994, it had become apparent that PRC's progress was being hindered by the vast number of requirements in the AWIPS SRS. An independent review team recommended restructuring the AWIPS development process, giving the NWS more responsibility for application development and allowing PRC to concentrate on the basic workstation and communications systems. Goals of the restructuring include:

- ensure development of a system that supports life-cycle AWIPS requirements;
- establish a system development process that facilitates rapid, incremental development, testing, and deployment; and
- redefine the scope of the initial deployment baseline and scheduled upgrades as necessary to preserve the basic deployment schedule and minimize impact to the overall NWS modernization.

The Techniques Development Laboratory (TDL) has been given the responsibility of developing most of the meteorological applications for AWIPS. The NWS is currently working to define the AWIPS application programmer interface, which will allow TDL to proceed with this work. Joint PRC-NWS teams are also working to define the basic user interface (menu system), database structure, data interfaces, etc. for AWIPS. PRC is presenting the high-level system architecture to the NWS this month.

The NWS has planned a series of incremental prototype AWIPS systems, beginning in mid-1995 with Pathfinder at a few future WFOs and collocated River Forecast Centers (RFCs). (See Section 4.1 for more on Pathfinder.) Build 2, which will support initial operations, is scheduled for late 1996, with subsequent upgrades scheduled into 1998.

1.3 FX and FX-ALPHA

The DARE/Pre-AWIPS systems, as have all FSL-built forecaster workstations, use VAX/VMS computers and Ramtek display hardware. Acknowledging the advent of the open-systems computing philosophy, FSL initiated in 1992 a new workstation development known as FX (for FSL X-based forecaster workstation). In 1993, the NWS requested that this effort be expanded and redirected to broaden and extend support for operations at Denver and Norman. This new system was known as FX-ALPHA, for FSL X-based AWIPS-Like Prototype for Hydrometeorological Applications (Bullock and Grote, 1994). The primary objectives were to continue the AWIPS risk-reduction work that cannot be supported by the current systems, and to develop, at FSL, expertise in the AWIPS environment. This latter emphasis allows FSL to continue its role as a technology-transfer organization, and also provides an independent perspective on AWIPS issues.

2 Goal

FSL has begun to develop a new forecaster workstation system known as WFO-Advanced. The goal of this project is to develop a workstation that will support modernized NWS WFO operations. This includes data ingest, management, and display, automated product generation, hydrometeorological applications, and product dissemination, which together provide the opportunity to address the Congressionally mandated staffing requirements for the modernized weather service. Such modernized

WFO operations will be demonstrated in 1995 using a WFO-Advanced system in two real-time forecast exercises.

3 Components

The following components constitute the WFO-Advanced system:

- national and local data feeds, including a local data monitor to perform quality-control functions;
- FSL's Local Analysis and Prediction System (LAPS), providing high-resolution analyses and short-range forecasts;
- an interactive display system (forecaster workstation), for data access and manipulation;
- the AWIPS Forecast Preparation System (AFPS), which supports computer generation of routine forecast products;
- 3-d visualization, primarily for viewing LAPS output;
- hydrology applications developed at the NWS Office of Hydrology; and
- an FSL-built dissemination system, providing data to local governments and emergency operations staffs.

Figure 1 illustrates these WFO-Advanced components. Items within the dashed line will have a "presence" on the display. Both AWIPS and WFO-Advanced are being developed on Hewlett-Packard equipment; the plan is to use the "workspace" feature of the HP Visual User Environment to provide independent windows for these applications.

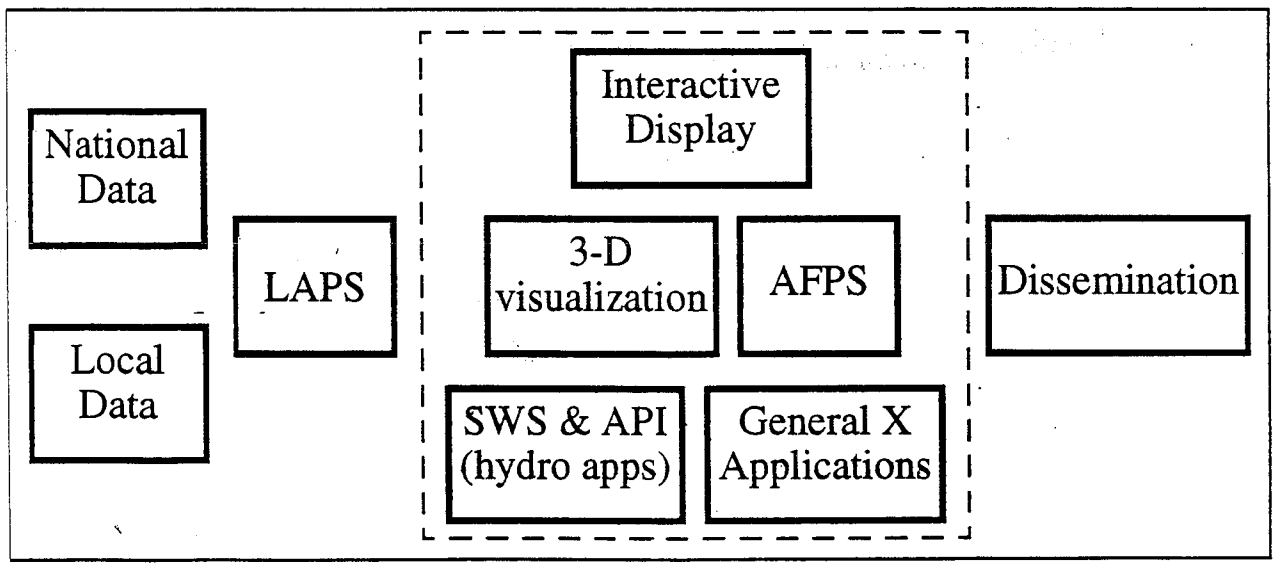

Figure 1 - WFO-Advanced components

3.1 Forecaster Workstation

The forecaster workstation is the central element of the WFO-Advanced system. This will be a continuation of the FX-ALPHA work.

Design considerations include

- meeting AWIPS graphics performance specifications,
- exploring trade-offs between pre-generated and on-the-fly graphics displays,
- providing support for interactive-graphics techniques, and
- ensuring transportability.

A key area of investigation is the user interface – in particular, considering how menus and windows interact. For example, in a multiple-window system, is there one menu whose commands are directed to a selected window? a drag-and-drop system? one menu per window?

3.2 LAPS

The goal of FSL's Local Analysis and Prediction System (McGinley et al., 1992) is to provide real-time, three-dimensional, local-scale analyses and short-range forecasts for operational use. LAPS fuses meso-beta-scale (20 - 200 km) data from existing and future data platforms, including Doppler radar, wind profiler, surface sensors, satellite, and aircraft, producing high-resolution analyses and forecasts over a WFO's area of forecast responsibility. Running LAPS at operational weather facilities allows high-resolution data to be used locally without the need to transmit large volumes of data and model results.

LAPS is being developed by the Local Analysis and Prediction Branch of FSL's Forecast Research Division. Their work addresses the needs of many government agencies in the areas of data analysis, data fusion, data assimilation, quality control, three-dimensional display and visualization, and numerical modeling.

LAPS work for WFO-Advanced covers three specific areas:

- Creating a "locatable" LAPS grid, that can be easily tailored to run at any WFO.
- Standardizing the data ingest components, in particular to accommodate site-specific local data sources.
- Developing the predictive component of LAPS for use in WFOs. The Colorado State University Regional Atmospheric Modeling System (CSU-RAMS) mesoscale model supports this component of LAPS. Work is needed to produce a version that will run in real time on desktop/desk-side workstations.

3.3 AFPS

The NWS, as part of its modernization and restructuring program, has specified that WFOs will maintain a set of gridded digital forecasts from which routine forecast products will be automatically generated. An AWIPS component, the AWIPS Forecast Preparation System (AFPS), provides the tools with which the forecaster will prepare and manage these gridded forecast datasets (NOAA, 1993;

Wakefield and Mathewson, 1994). AFPS is being developed at FSL and TDL. It will support preparation of most routine forecasts at WFOs when it is deployed in the late 1990s.

For decades, NWS forecasters have generated weather forecasts using the same basic process. After reviewing numerical model output and regional observations, they spend roughly half of their shift composing forecasts in the form of text messages and disseminating them to various clients. AFPS will not only relieve the forecasters of the burden of typing these text messages, but promises to fundamentally change the way forecasts are produced by shifting emphasis from text composition to interactive editing of gridded datasets.

FSL has developed a suite of graphical forecast editing tools, which are designed to allow WFO forecasters to efficiently visualize and revise the weather elements needed to produce forecasts for all services (public, marine, aviation, etc.). For WFO-Advanced, these editors will be tied together with database initialization techniques developed at TDL (using Model Output Statistics, or MOS) and FSL (RUC, Eta, LAPS), and text generators from TDL.

3.4 3-d Display

FSL has been experimenting with three-dimensional visualization for several years. The primary focus has been work with the LAPS and MAPS (Mesoscale Analysis and Prediction System) grids. Examples of FSL model visualization have appeared in several publications (e.g., the covers of the *Bulletin of the American Meteorological Society*, **75**, no. 3, March 1994, and the *Preprints, Tenth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, AMS, Nashville, Tennessee, January 1994).

Such visualizations of LAPS forecast fields are used frequently in FSL's daily weather briefings. For WFO-Advanced, a suitable user interface will be developed so that WFO forecasters will have access to these displays in support of routine operations.

Other recent 3-d work at FSL includes a visualization and editing system for aviation impact variables (AIVs) such as turbulence and icing. This will not be part of the initial WFO-Advanced complement.

3.5 Dissemination

The NOAA Emergency Management Weather Dissemination Project (Subramaniam and Jesuroga. 1995), managed within FSL's Aviation Division, conducts experiments to see how advanced meteorological information can be used by local governments. Initial interaction has been with the City of Boulder and Boulder County emergency management offices, where an experimental decision-support system is being tested. In addition to general weather data, it includes information about flash flood potential, conditions for wild fire initiation, severe convective and winter storms, and other weather-related information important in emergency management operations.

For WFO-Advanced, the official forecast database, as embodied in the AFPS grids, will be tied to the system to provide improved forecast data to emergency operations staffs.

4 Related Projects

Other government organizations have been involved with projects that are similar to parts of WFO-Advanced. We are examining these projects in order to take advantage of others' expertise in this work. Other NWS groups also have experience with modern computer networks and computer graphics, notably the Office of Hydrology, which has been working on RFC-related systems, and the NWS Alaska Region, where forecaster-programmers have developed a number of UNIX/X applications to support forecast operations.

4.1 Pathfinder

As noted in Section 1.2, the NWS and PRC are working on an initial AWIPS prototype known as Pathfinder. It is to be deployed at two operational sites and NWS headquarters in June 1995. The objectives are to demonstrate in an operational setting

- selected features of the system architecture, including an initial satellite broadcast network (SBN), local communications, and network control
- selected modernization-era datasets and techniques
- system operations and maintenance functions

and to provide feedback to system design and operations and maintenance plans.

Components of Pathfinder are drawn from the NWS Office of Hydrology (OH) and the Alaska Region's ARONET (Alaska Region Operations Network). GOES imagery, local WSR-88D data, and Eta and Rapid Update Cycle grids will be available. Applications include the NWS River Forecast System and WFO hydrology applications.

These hydrology applications are shown in Figure 1 as "SWS and API (hydro apps)," which refers to the Shared Window Server and Application Programmer Interface prototypes being developed at the NWS Advanced Development and Demonstration Laboratory and OH. For WFO-Advanced, the plan is to adapt these applications to run in one of the HP workspaces.

4.2 N-AWIPS

National Centers' requirements for forecaster workstations differ in many ways from those of WFOs. The AWIPS SRS includes specific requirements for National Center operations.

The National Centers for Environmental Prediction (NCEP, formerly the National Meteorological Center) is developing a distributed computing and communications system, N-AWIPS, to support National Centers forecast operations. This X-based system is being used at NCEP and some other NWS and academic sites. N-AWIPS provides access to operational and experimental numerical model graphics and grids, geostationary satellite data, surface and upper-air observations, and text products.

Perhaps the most significant feature of N-AWIPS is its GEMPAK-based (desJardins and Petersen, 1985) grid access module, which allows forecasters to perform virtually any mathematical operation on model grids. A similar flexible grid-access interface is planned for WFO-Advanced.

4.3 ICWF

In the early 1970s, TDL began development of an automated computer worded forecast system (CWF). It initially produced city forecasts from MOS guidance. In the early 1980s, the program was expanded to include zone forecasts and terminal forecasts. The forecaster was presented with the end product, a text forecast, for editing.

The ICWF ("Interactive") program began in 1985 to develop a forecast support system for AFOS (Automation of Field Operations and Services, the NWS' current operational forecaster computer system). It presented the forecaster with a zone-based basic weather matrix, which the forecaster could interactively view and modify before the text forecast was generated. This version of the ICWF was limited to the forecast projections available from MOS guidance. A demonstration of ICWF began at several WSFOs in 1986. WSFO Charleston still actively uses the ICWF, and much of its operation is built around the ICWF digital database.

In 1992, ICWF was made part of the Pre-AWIPS demonstration at WSFO Norman. Several enhancements and recommended modifications have resulted from this experience. The current version of ICWF uses a new set of weather elements that makes it easier for a forecaster to depict the desired weather. Further, a graphical editing system similar to that being developed for AFPS is being implemented at Norman and Charleston to support generation of quantitative precipitation (QPF) grids for RFC use.

The initialization and text-generation portions of ICWF are being adapted for AFPS, and will undergo further operational tests when WFO-Advanced is deployed in Denver.

5 Development Schedule

As suggested earlier, WFO-Advanced is intended to demonstrate a number of AWIPS functions, in advance of AWIPS development. Accordingly, it is necessary to prepare an initial release of the system quickly, to provide useful assistance to the NWS in creating AWIPS.

The basic schedule includes three milestones:

- A convective-season exercise in August 1995. This will be a single-shift, 5-day-per-week shakedown of WFO-Advanced. In-house (e.g., ERL, NCAR) forecasters will work this 4-week exercise.
- A complete WFO emulation in October and November 1995. This round-the-clock, 7-week, operation will pair FSL and NWS forecasters in an exercise to demonstrate that the AWIPS operations concept is valid.
- Operational testing at WSFO Denver, beginning in mid-1996. WFO-Advanced systems should be installed at Denver in February 1996, with non-local data supplied by the AWIPS SBN developed for Pathfinder. After a period of familiarization and training, the Denver staff will begin to use WFO-Advanced for their day-to-day forecast duties. DARE equipment will be removed.

At a later date, the Pre-AWIPS system at Norman will be replaced by WFO-Advanced workstations.

6 References

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Information on FSL and several of the projects mentioned in this overview is available on the World-Wide Web via URL http://www.fsl.noaa.gov/.