THE AVIATION ROUTE FORECAST (ARF) PROGRAM
— An Interactive System for Pilot Self-Briefing —

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Introduction

One of the weakest components of current weather service is dissemination, that critical link to the user. If more effective ways of making weather information available to the user could be developed, a significant improvement in weather services could be achieved without requiring any changes to existing observation or forecasting systems. This paper will describe the evolution of the Pilot Self-Briefing program, under the sponsorship of the Federal Aviation Administration (FAA), and the joint National Weather Service-FAA Aviation Route Forecast (ARF) development effort. These two program efforts have been integrated so that users can directly acquire weather information tailored by the computer to their specific needs.

One of the objectives of the ARF program is to provide the meteorologist with the capability to quickly describe meteorological variables through the use of an electronic stylus of a computer graphics system. Amending and updating forecasts ecome much simpler processes, since ARF allows selective variable changes. The user's data base is automatically updated with every new entry, thereby enabling continual availability of the latest information.

Background--Pilot Self-Briefing Development

The Department of Transportation recommended that greater emphasis be placed on the mass dissemination of aviation weather data, since a preflight briefing of accurate, timely, route-oriented weather data is important in planning a safe, expeditious flight. The existing systems, consisting primarily of telephone briefings by Flight Service Station (FSS) specialists, were not satisfying this requirement very effectively, and the one-to-one method of briefing pilots was labor-intensive and costly.

The FAA set out to determine if an improved Pilot's Automatic Telephone Weather Answering Service (PATWAS) could be an effective dissemination method. Via PATWAS, the pilot would be able to obtain some weather data for flight planning prior to the briefing, thus reducing the length of briefing calls. A one-year test involving FAA and NWS in the New York metropolitan area supported this theory. However, the PATWAS information--tape recordings of selected weather for compass quadrants around the FSS-was laborious to prepare and not tailored to the individual pilot's route.

Meanwhile, it was hypothesized that pilots could "brief themselves" by directly accessing a computer data base of geographically-retrievable weather messages. Access would be by means of Direct User Access Terminals (DUAT's) or, alternatively, by using Touchtone telephones for providing input to the system and a Voice Response System (VRS) for output. The greatest uncertainty of these concepts lay in whether the pilots would adapt to their usage.

A prototype development program was undertaken to demonstrate the concepts and resolve the uncertainties. A real-time textual aviation weather data base and DUAT retrieval capabilities were developed on a network of minicomputers assembled at the MITRE Corporation, McLean, Virginia. In this effort, the computer-processing of existing NWS text messages presented difficulties due to lack of standardization; it was evident that rules for the formats were required.

Of some fifteen existing text weather message types, the three most required and relatively structured types--Surface Observations, Terminal Forecasts, Winds Aloft--were selected for VRS output. Touchtone keystroke protocols were designed to allow simplified retrieval by the public. Real-time software was developed to analyze and convert the text messages to VRS vocabulary pointers and retrieve them per Touchtone requests.

The capabilities were favorably tested by a large control group of FAA pilots. Subsequently, FAA advertised and initiated a formal VRS demonstration in the Washington, D.C., and Columbus, Ohio, areas. Public use of the VRS has been substantial, with favorable user opinion apparent in responses to an FAA survey.

Need for ARF

Early developmental efforts in the area of pilot self-briefing highlighted the information overload problems presented by narrative or area types of data when used directly by pilots via DUATS. These messages (e.g., Area forecsts) were generated and retrieved according to large, fixed, multi-state regions. Since a route of flight may have passed through several such regions, the amount of clear text data retrieved was substantial, but often irrelevant when the described phenomena were several hundred miles off the flight path.

The problem became even more evident in the case of VRS where every word of data must be heard, serially, at the VRS's pace. In the process of selecting initial weather message types for the VRS, it became apparent that only those existing messages with a relatively structured format could be output intelligibly. Narrative message types were not amendable to computer VRS processing.

Thus the forecast weather data base needed for pilot self-briefing was seen to include cloud cover, visibility, precipitation, convection, icing and turbulence for the intended route. Existing weather products, such as TWEB's, AIRMET's, and Area Forecasts, provided only some of these data and were inefficient for planning any given route because of their wordiness and fixed areas of coverage.

These factors indicated a need for new methods of describing area-type aviation weather phenomena. A way to permit the forecaster to describe the full range of aviation weather variables geographically was needed, but the user data base should be "granular" to permit retrieval of only that weather relevant to the grid data base concept, the Aviation Route Forecast (ARF). Development of a working ARF prototype was undertaken by the MITRE Corporation for the FAA and NWS.

ARF Concept and Development

The first step was an analysis by NWS of the details of the data which ARF must provide. The "ARF Parameters" that were identified are shown in Figure 1. Next, a graphical forecasting system was designed, and developed to test the concept. In this system, the NWS Forecaster graphically inputs geographic contours to a computer to describe the effective areas of various parameter/value sets. The forecast is entered for three time periods: 0-2, 2-4, and 4-8 hours from time of forecast. Overlayed on his multi-state forecast area is the ARF grid. As each weather contour is completed, the computer determines the affected grid squares and sets them accordingly in the data base. Subsequently, the grids surrounding a pilot's input route are retrieved, and a briefing is assembled.

The ARF "Input Workstation" capabilities that have been developed are illustrated in Figure 2. The hardware consists of a data tablet for graphical input, and a graphical CRT terminal for contour display and parameter/value interaction. A more recent "Operational" version of the Workstation consists of intelligent color graphics hardware. Figure 3 approximates the CRT display for a typical "RANGE OF CLOUD BASES" Forecast for the Washington (WBC) area.

The ARF retrieval test capability that has been developed is illustrated in Figure 4. The pilot's route is Dulles (IAD) to Hickory (HKY) to Charleston (CHS). Route processing software retrieves and orders the grid cells for a corridor around the route. Other programs then assemble the eighteen-parameter cell data into a briefing, a portion of which is shown in DUAT format. The headings to the left ("IAD," "75 SW IAD," etc.) are points at which changes occur, with the intervening indented data being the forecasts for what will occur between the change points. The parameter "Bases" is underlined.

ARF Output Processing Rationals

A one-quarter Limited Fine Mesh (LFM) grid was chosen for ARF use. This is the same grid size used for the NWS Manually Digitized Radar (MDR) system and provides grids of about 22 nmi on a side. ARF retrieval is based on a 50 nmi corridor width (25 nmi on either side of the aircraft course) and is also based on the time the aircraft will be located in or near the grids selected.

In realistic weather forecasting there is a fine balance between averaging the data and thus reducing the output volume, and yet providing accurate information on both bad and good weather that may affect the pilot's flight. Frequent pilot complaints or pessimism in forecasts must also be balanced against the probable legal liabilities of excessive optimism.

In general, the theory behind the low altitude route retrieval algorithms is that if the parameter being processed worsens (e.g., Cloud Cover: Broken going to Overcast - BKN going to OVC) by a predetermined amount according to the values obtained from the prior grids crossed, then the pilot must be advised of that change. Should that parameter improve (OVC going to BKN) for up to two grids prior to returning to the original value, or a worse case, then the improvement will be ignored and not given to the pilot, but three or more successive blocks of parameter improvement will be indicated.

A case which causes a perturbation in the output is the alternating parameter value. This may occur when a proposed flight proceeds parallel to, and near the edge of a contour. For example, a flight from Santa Barbara to Monterey, CA, along the coastal airway, with coastal fog prevalent along the shoreline and predominantly clear weather over the coastal range, may produce this situation, as shoreline and mountain coastal grids are alternately retrieved during the flight. If an alternating pattern is detected, the algorithms then select the worst case and output this as the prevalent condition with the other condition being output as occurring frequently.

Of course, some parameters such as "Weather" (Fog, Rain, Snow, etc.) do not permit averaging or determination of which case is worst, since that is dependent upon the individual pilot and his aircraft type and equipment.

ARF Output Organization

The situation portrayed in Figure 5 illustrates the output problem in general. If the briefing output is oriented primarily to geographic points where a phenomenon changes values (leg ordered), we then must repeat phenomenon that hold true for the entire flight; e.g., P4 would be repeated for each leg (A-B, B-C, ..., G-H). Conversely, a phenomena ordered briefing would define P4 only once (from A to D). Currently this second method is used for ARF briefings. Further experiments will analyze other alternatives; in the case of the DUAT briefing, these will include alphanumeric representations similar to vertical cross sections which are currently supplied on international over water flights in accordance with International Civil Aviation Organization procedures. Other anticipated improvements will include the elimination of data of little interest to the pilot by "filtering," e.g. suppressing high-cloud-only information for low altitude flights.

A second type of output needed, but not yet developed, is to provide area-type briefings from the gridded data base for an area within a radius around a point input by the user.

Pilot Self-Briefing Data Reduction Due To ARF

ARF will be able to efficiently replace all narrative forecast data in the briefing except for the terminal forecast for the departure, destination and alternate airports. Replaced data will include Warning Data (AIRMETS, etc), Terminal Forecasts for enroute locations, and Area Forecasts. Additionally, because of ARF's frequency, ARF should provide a "perfect forecast/nowcast" for the users. If this proves true, then the enroute surface aviation weather observations can be eliminated from the briefing.

Past ARF Testing

By the end of 1979 the development of ARF had advanced to the stage where realistic testing was possible. During 1980, NWS meteorologists and MITRE personnel jointly designed and conducted two tests examining and incorporating the most current state of development, with modifications dictated by test results.

The inital test combined the first attempt at simulating operational forecasting in the ARF environment with evaluating the quality of the briefing which the pilot receives. A "Weather Office" was set up at the MITRE ARF workstation where current weather and guidance information was made available to the meteorologists, including the Service A and Service C teletypewriter data and Facsimile charts. The forecaster utilized this information to produce forecasts of the ARF parameters valid for hours 2-0, 2-4, and 4-8 from forecast time. These forecasts were then entered graphically into the computer data base via the experimental workstation. After processing, the quality of forecasts was scrutinized by the forecaster's retrieval of randomly selected route briefings. Results of this simulation were very encouraging. The forecasters adapted well to the new environment. As could be expected, after the first two weeks they had adjusted enough to the mechanical procedures to concentrate fully on the meteorology. The forecasts were prepared in a timely manner with the two forecasters coordinating the data along their common boundary. It was soon evident, however, that the experimental workstation design was ineffficent and laborious to use.

There were, to be sure, the usual conceptual bugs which required modification and refinement. Nevertheless, the promise of the concept was demonstrated, especially in that the output route briefing proved to be an adequate representation of the forecast input. Thus the impetus for continued development was strong.

The second round of operational simulation occurred during early summer 1980. While the workstation hardware was the same, several system changes were made during the interim to cast the test in a new light. Most of the short-term software modifications which were recommended after the first test were implemented so that integration with the data base was streamlined and more flexible. Once again, good quality forecasts were issued in a timely manner, indicating the average forecaster's ability to adapt to ARF with a minimal amount of training.

At the occasion of the October 1980 Aircraft Owners and Pilots Association (AOPA) Convention held in San Diego, California, NWS forecasters input ARF forecasts at the MITRE workstation in McLean, Virginia which could be retrieved by the pilots attending the convention in San Diego. Pilots thus introduced to the ARF concept received it enthusiastically.

"Operational" ARF Testing

Testing conducted during the summer of 1982 provided a vital simulation of a real-time forecasting environment. The workstation technology, a RAMTEK 9400 color graphics terminal coupled with a PDP 11/34 computer and a digitizing tablet, provided the added ability to translate the forecast parameters into a well formatted product, ready to be disseminated. Seven NWS forecasters and one Environmental Research Laboratory (ERL) meteorologist tested the system from the conceptual level to detailed real-time operation. The forecasters' task consisted of preparing the ARF forecast in contour form on worksheets, entering the weather data by tracing contours from the worksheets on the automated ARF workstation data tablet, and assigning the forecast values by phenomenon and time group. The meteorologists were asked to fill out a questionnaire after each forecasting session in order to evaluate their effectiveness in the entry, deletion and correction of individual parameters and contours. The extensive data consistency checking software and the validity of the available ARF parameters were also evaluated. Questionnaire packages were also sent to approximately 130 pilots in the eastern United States to evaluate the validity of the weather forecasts generated at the workstation.

Analysis of the data obtained from the meteorologists questionnaires provided the following results: The meteorologists overall impression of the system was positive, but the Workstation still needed some fine tuning before implementation. The problems were in the area of man-machine interface, with the menu tree being at times confusing for selecting options. Also, the tracing device and process needed improvement, editing and copying options were not always adequate, contour colors at times were difficult to differentiate and the physical layout of equipment was not optimum. Options within the ARF parameters and additional ARF parameters were requested to provide better forecast accuracy. The consistency checking process was found to be too slow and the contour-to-grid transformation was not always accurate.

The response received from the pilots was unanimously enthusiastic. The ARF system was thought to exactly meet the pilots needs. Occasional inaccuracies in the weather delivered as well as occasional hardware and software problems were reported. The pilots also made suggestions for additional information they would like to see included in the briefing.

Current State

At this time, the man-machine interface aspect of the workstation is being redesigned to integrate changes necessary to alleviate the previously stated problems. Improvements include allowing random access to the subtrees, providing screen line eraser and copying options, redefining contour color and redesigning the physical layout of the equipment. Proposals for the addition of new parameters or descriptive phraseology have been submitted to the ARF working group. Data quality control methods are being improved. Depending upon the importance of the changes brought about within the system, additional testing may be requested.

Future Workstation Capabilities

Improvements to the graphic data entry feature of the ARF workstation yet to be evaluated include variable grid sizing and the development of more accurate geographic and political boundaries for more precise parameter location. The ability to switch to different entry backgrounds--national, regional, state, local, county, etc.--will also be developed. This will allow for more detailed entry of the meteorological parameters needed in providing local weather services.

Some of the elements of a complete aviation weather briefing not in the current ARF are a synopsis and local vicinity forecasts. Use of the workstation to graphically enter positions of major frontal systems and pressure centers and their forecast movement is envisioned. In other aspects of the ARF operation, more frequent updating of current and forecast positions can take place since software will be designed to generate and disseminate the updated synopsis automatically.

Need For Forecaster Analysis Support Systems

The forecast decision source data used in the ARF testing are still very voluminous and the development of required forecasts and analyses are time-consuming. Forecasters today are limited in their ability to make effective use of all the available information because of the vast volume of images and data.

The NWS Automation of Field Operations and Services (AFOS) system provides a degree of structure to many parts of the data base, but in the future a more powerful interactive analytic processing and display system is needed to support this forecasting operations.

Whatever the intended user and forecast projection, extracting essential weather information from this mass of raw data requires a sophisticated real-time information processing system.

Planned Analysis Support Systems.

ARF project participants have become very interested in the development of interactive processing and display systems such as NWS's Centralized Storm Information System (CSIS). It is being adapted for use at NWS's National Severe Storms Forecast Center (NSSFC) in Kansas City. This interactive video display system is designed to facilitate analyses of numerous meteorological fields. The functional capabilities required to support the ARF forecasts i.e., the acquisition, combination and interpretation of a wide variety of meso and synoptic scale observations and forecasts, are similar to those needed by NSSFC forecasters using CSIS.

The Total Forecaster Workstation

The ultimate development goal is to eventually merge the "operational" ARF workstation and other interactive systems into a single workstation which will provide the meteorologist with both an analytical tool for rapid data assimilation and a data base creation capability for direct user access. The incoming data sets will include satellite data, as currently analyzed on CSIS, radar data from the NEXRAD system and conventional data currently carried by the AFOS system.

Among the data that the ARF forecaster must assimilate are pilot reports (PIREPs)--the most important observations of in-flight weather conditions. The number of pilot reports will increase dramatically during the next few years as a result of expected systematic automated collection programs from transducers on board general and commercial aviation aircraft. The PIREPS have been formatted so that sophisticated computer processing can take place.

Future Voice and Other Mass Dissemination Techniques

Until its public demonstration, VRS carried a stigma regarding the feasibility of its use by the general public. The concern was that the voice quality or the automated nature of the briefing would be unacceptable to non-technical persons. The public demonstration put that concern to rest. As technology continues to improve, future automated systems will probably solicit and respond to word commands spoken by the caller. In its simplest form, the word commands issued by the caller will be detected by an Utterance Recognition Device (URD) and matched with the words existing in its own vocabulary. At this stage of development, callers must use only a set of preselected words. The FAA Technical Center in Atlantic City, New Jersey, is developing an URD for pilot self-briefing. Ultimately interactive use of the URD may allow the caller to receive the same briefing as is received today using the current Touchtone entry system.

Although FAA and NWS are directing considerable effort towards VRS dissemination, the effort that industry is making to disseminate a variety of information services to home televisions have been noted. Information is disseminated within the broadcast TV signal and is available to the user through the home television, using a control terminal for product selection. Such systems are currently in use in Europe, Japan, Canada and are coming on line in the United States.

Other Applications for a "Total" Workstation

The flexible, real-time, mesoscale, analytic capability of the total workstation would make short-fuse forecasts almost automatic. The graphics generated for the forecaster's assimilation would constitute the foundation of forecast parameter entry and dissemination system.

Both aviation in-flight advisories (AIRMETS, SIGMETS and Convective SIGMETS) and severe weather warnings relating to the public and other weather program could be generated from an ARF workstation.

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1. J. Uecker, C. Sprinkle, T. Laufer, and M. Tomlinson of the National Weather Service.

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3. Dr. S. Chokhani, J. P. Mittelman, A. M. Scalea, E. Keitz, F. Amodeo, E. G. Livaditis, and A. Mamantov of the MITRE Corporation.

FIGURE 1
ARF FORECAST PARAMETERS AND GUIDELINES

CLOUD COVER AMOUNT
- Ø Clear (default)
- 1 Scattered
- 2 Scattered to Broken
- 3 Broken
- 4 Broken to Overcast
- 5 Overcast
- 6 Partial Obscuration
- 7 Total Obscuration

RANGE OF BASES
- ØØØ-ØØØ (default)
- BLO-nnn Below nnn (in hundreds)
- SFC-nnn Surface to nnn (in hundreds)
- nnn-mmm (in hundreds)
- MSL (default)
- AGL

REMARKS PERTAINING TO BASES
- Ø None (default)
- 1 Mountain Ridges Obscured
- 2 Mountain Passes Obscured
- 3 Mountain Tops Obscured
- 4 Lower Clouds Coastal Regions
- 5 Lower Coastal Stratus

RANGES OF TOPS
- ØØØ-ØØØ (default)
- BLO-nnn Below nnn (in hundreds)
- nnn-mmm (in hundreds)

REMARKS PERTAINING TO TOPS
- Ø None (default)
- 1 Merging Layers
- 2 Multiple Layers

SURFACE VISIBILITY
- Ø Less than 1 mile
- 1 1 mile
- 2 1-3 miles
- 3 2 miles
- 4 2-4 miles
- 5 3 miles
- 6 3-5 miles
- 7 4 miles
- 8 5 miles
- 9 6 miles
- 1Ø Greater than 6 miles (default)

WEATHER
- Ø None (default)
- 1 Sandstorm
- 2 Duststorm
- 3 Haze
- 4 Smoke
- 5 Fog
- 6 Drizzle
- 7 Freezing Drizzle
- 8 Rain
- 9 Freezing Rain
- 1Ø Freezing Precipitation
- 11 Snow
- 12 Snow Flurries
- 13 Blowing Snow
- 14 Ice Pellets

WEATHER TOPS
- ØØØ-ØØØ (default)
- BLO-nnn Below nnn (in hundreds)
- nnn-mmm (in hundreds)

CONVECTIVE ACTIVITY (CA)
- Ø None (default)
- 1 Isolated Showers
- 2 Few Showers
- 3 Many Showers
- 4 Isolated Thunderstorms
- 5 Few Thunderstorms
- 6 Many Thunderstorms

TYPE OF CONVECTIVE ACTIVITY
- Ø Undefined (default)
- 1 Embedded
- 2 Severe
- 3 Severe-Embedded

RANGE OF BASES (CA)
- ØØØ-ØØØ (default)
- BLO-nnn Below nnn (in hundreds)
- SFC-nnn Surface to nnn (in hundreds)
- nnn-mmm (in hundreds)

RANGE OF TOPS (CA)
- ØØØ-ØØØ (default)
- BLO-nnn Below nnn (in hundreds)
- nnn-mmm (in hundreds)

FREEZING LEVEL
- ØØØ None (default)
- SFC at the surface
- nnn at nnn (in hundreds)

ICING AMOUNT
- Ø None (default)
- 1 Light
- 2 Light to Moderate
- 3 Moderate
- 4 Moderate to Severe
- 5 Severe

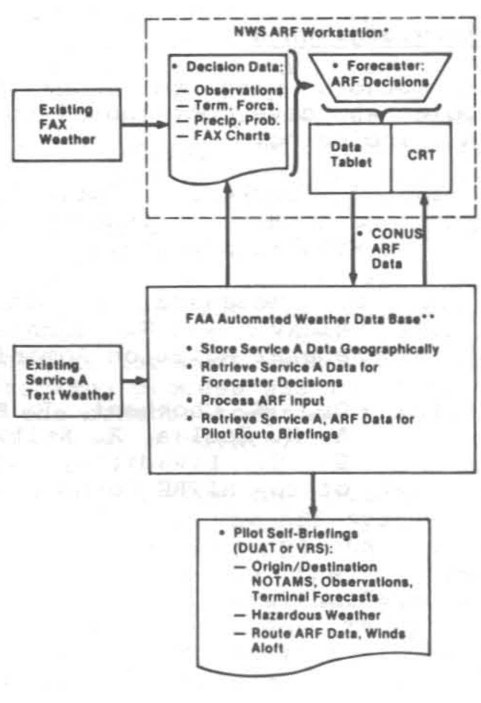
TYPE OF ICING
- Ø Undefined (default)
- 1 Rime
- 2 Clear
- 3 Mixed

TURBULENCE AMOUNT
- Ø None (default)
- 1 Light
- 2 Light to Moderate
- 3 Moderate
- 4 Moderate to Severe
- 5 Severe

TYPE OF TURBULENCE
- Ø Undefined (default)
- 1 Clear Air
- 3 Mountain Wave
- 3 In Cloud
- 4 Low Level Wind Shear
- 5 Strong Surface Winds

HEIGHT OF TURBULENCE
- ØØØ-ØØØ (default)
- BLO-nnn Below nnn (in hundreds)
- SFC-nnn Surface to nnn (in hundreds)
- nnn-mmm (in hundreds)

FIGURE 2
CURRENT ARF DATA FLOW



*Two Workstation Versions: 1. "Experimental" — Storage Tube (Tektronix), and 2. "Operational" — Refresh Color (RAMTEK 9400).
**Prototype is on MITRE PDP-11/70, VAX-11/780, PDP-11/34 Network.

FIGURE 3
ARF INPUT

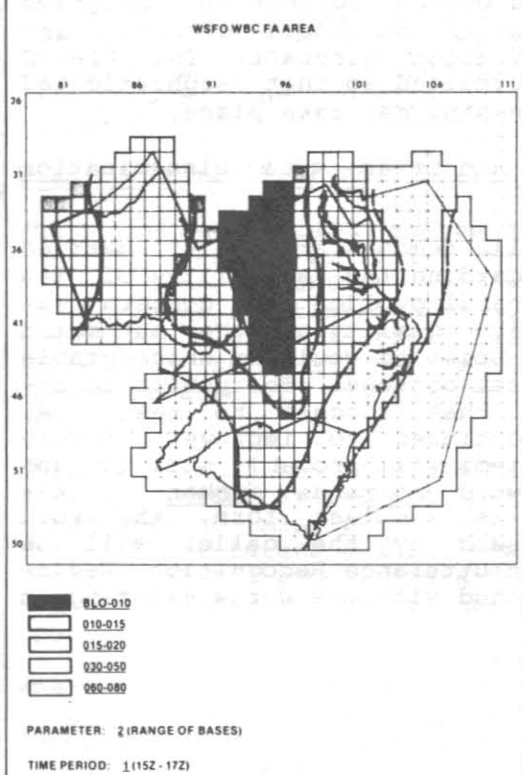
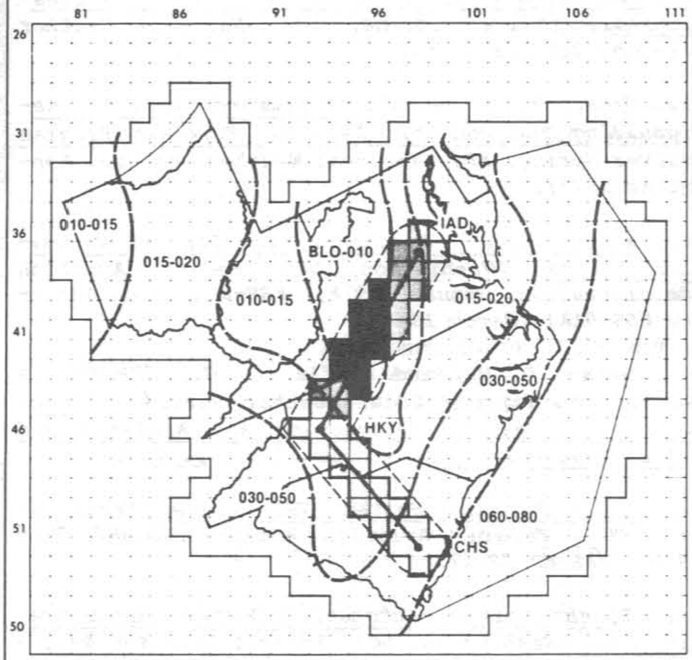


FIGURE 4
ARF RETRIEVAL



**Cloud Cover

IAD
SCT/BKN Clouds Bases 015-020 Tops 100-150

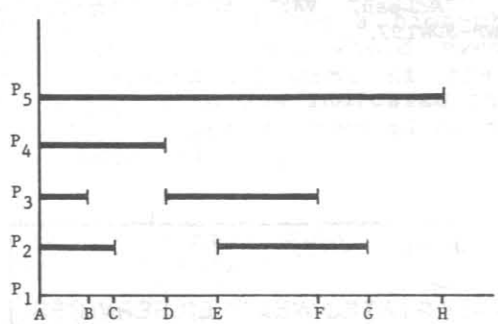
75 SW IAD
BKN/OVC Clouds Bases Below 010 Tops 150-200

HKY
SCT/BKN Clouds Bases 015-020 Tops 100-150

50 NW CHS
SCT Clouds Bases 030-050 Top 080-100

CHS

FIGURE 5
ARF PHENOMENA VS. GEOGRAPHIC LOCATION



P_N Indicates a Phenomenon (Clouds, etc.)

A......H Indicates Geographic Points Along Flight Path

REFERENCES AND FOOTNOTES

1. Ed Gross is the Chief of the National Weather Service's (NWS) Services Integration Branch, responsible for NWS dissemination activities. From 1972 to 1981 he held positions in the NWS Aviation Branch and he was actively involved in the initial design of the ARF concept with Jim Steckbeck and Tom Mitchell. He also worked at NMC from 1965-1972.

He received a B.S. in Meteorology from the City College of New York in 1962 and an M.S. in Meteorology and Air Pollution Engineering in 1969 from New York University.

2. Mr. Mitchell has been associated with MITRE's Air Traffic Control work since 1968. He established and directed the Testbed for Automated Flight Services (TAFS). He is currently Associate Department Head of Flight Service Systems, jointly responsible for all FAA Weather Systems work and National Weather Service development work.

Prior to MITRE, he was with Informatics, Inc., and earlier served as an officer in the U.S. Air Force.

He received a B.S. in Physics from Manhattan College in 1961, and an M.B.A. from American University, 1973.

3. Jim Steckbeck held a B.S. degree in Economics from Villanova University and a M.S. degree in Meteorology from the U.S. Naval Postgraduate School. He was a retired naval aviator/meteorologist and was self employed as a consultant in aviation weather and information systems engineering.

On January 8, 1983, Jim Steckbeck was killed in a tragic auto accident in Fairfax, Virginia. His loss will be felt by his friends and associates in the FAA, NWS and MITRE Corporation. His detailed knowledge of aviation, meteorology and engineering coupled with his spirit and will to achieve inspired the people involved with both the ARF and Center Weather Service Unit Programs. Jim was one of the designers of the initial ARF concept as well as many other aspects of mass dissemination of aviation weather information. Jim was a man who set clear goals and achieved them with a style and wit which will long be remembered by those who knew him. Services with full military honors were held at Arlington National Cemetery, January 13, 1983.

4. Mike Young is a meteorologist and system planning and requirements specialist with the National Weather Service. From 1970 to 1980 he was employed at the National Environmental Satellite Service where he established and operated the Cloud Motion Wind program. Prior to NESS, he worked for the NWS as a meteorological intern, pilot briefer and radar meteorologist, in Chicago, Honolulu and Washington, D.C.

Mr. Young served as forecaster with the U.S. Army Test and Evaluation Command, Meteorological Support Activity, Ft. Huachuca, Arizona. He holds a B.S. in Meteorology from Penn State University and is currently enrolled as a Masters Degree Candidate at the Center for Technology and Administration, American University.

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15. In fairness, it should be noted that this first ARF "single thread" system contained numerous short cuts in order to minimize development expense. The developers had doubts about the feasibility of the concept due to the extensive data transformation involved in the forecaster-input-to-pilot output process.

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