Cockpit Weather Graphics Using Mobile Satellite Communications

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ABSTRACT

Many new companies are pushing state-of-the-art technology to bring a revolution in the cockpits of General Aviation (GA) aircraft. The vision, according to Dr. Bruce Holmes - the Assistant Director for Aeronautics at National Aeronautics and Space Adminstration's (NASA) Langley Research Center, is to provide such an advanced flight control system that the motor and cognitive skills you use to drive a car would be very similar to the ones you would use to fly an airplane. We at ViGYAN, Inc., are currently developing a system called the **Pilot Weather Advisor (PWxA),** which would be a part of such an advanced technology flight management system. The PWxA provides graphical depictions of weather information in the cockpit of aircraft in near real-time, through the use of broadcast satellite communications. The purpose of this system is to improve the safety and utility of GA aircraft operations. Considerable effort is being expended for research in the design of graphical weather systems, notably the works of Scanlon[1], and Dash [2]. The concept of providing pilots with graphical depictions of weather conditions, overlaid on geographical and navigational maps, is extremely powerful.

SYSTEM OVERVIEW

The PWxA works in three broad steps:

• Ground Processing System
• Satellite Communications System
• Airborne Processing System

Ground Processing System

To begin with the weather data is collected and analyzed at a central location. The analysis of the data includes extraction of relevant portions of the data, data compression, and encoding. This step is known as the Ground Processing. Next, the data are automatically transmitted to an earth station of a satellite communication system. These systems are illustrated in figure 1 below.
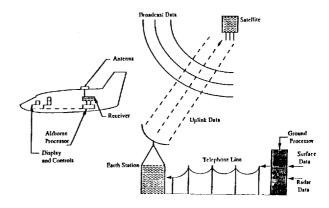

Figure 1. The Pilot Weather Advisor System Concept

Satellite Communications System

Data is received by the antenna and satellite communications receiver on board the aircraft, and transferred via a RS-232 interface to the airborne processing system on the aircraft. During Phase I [3] of this project, we used an Quallcom's OmniTRACS Mobile Communications System. This system consists of a mechanically steered antenna, and an OmniTRACS Communications Unit. The data was received using a Comstream Modem at 9600 bits per second (bps). We are currently working on an aerodynamic Ku-band microstrip antenna. The communication system has a low level of fault tolerance built into it, to detect and correct any faulty operations.

Airborne Processing System

The airborne system processes it into the required display formats, and stores these formats into a database on the airborne computer for later use. The control system allows the pilot to graphically display the information in a user friendly manner so that it does not distract him from his primary functions. The airborne system needs minimal interaction from the user, and is fairly fault tolerant. The PWxA is a broadcast receive-only system. All the information for the entire Continental United States (CONUS) is broadcast over the satellite system and received by all aircraft within the satellite's footprint. The on board processor selects the data needed to be displayed based on the pilots actions described below. No two-way interaction between the aircraft and the ground system is required.

The initial map that shows up on the screen is a CONUS map with about 60 surface sites. Surface Weather, Ground Based Weather Radar, and other products described below, are shown on this map at the pilots discretion. The pilot then inputs the following information:

1. The departure airport
2. The destination airport, and
3. An alternate airport

With these inputs, a suitably scaled trip map, just accommodating the route, can be displayed North-up with again about sixty (60) sites. The Global Positioning System (GPS) or LORAN interface supplies the position of the aircraft. The system utilizes this positional information to display the aircraft position on the CONUS, TRIP, or LOCAL map, whichever is selected. These maps are updated every minute to display the map in accordance with the current aircraft position.

Currently the plan is to update weather data at least four (4) times every hour, although the system does have the capability of updates every seven minutes. A looping function provides the historical trend of the weather on the map-type depictions in a forward time direction using a fast display technique. The display is always north-up, and a history of the aircraft track information is an option. All the maps are displayed using a map projection which renders great circles as nearly straight lines, and very nearly shows areas in their true relative sizes.

The control system of the PWxA system is mostly menu driven with user control provided by function keys. Currently it is planned to provide for the display of three data sets:

Data Set 1 - Airport Category + Ground Weather Radar + Lightning + Alert Severe Weather Watch "Boxes"

Data Set 2 - Airport Weather + Ground Weather Radar + Lightning + Alert Severe Weather Watch "Boxes"

Data Set 3 - The TREND depiction of any one of the 550 sites for which surface observations are available.

The Airport Category symbol depicts the five Federal Aviation Agency (FAA) ceiling and visibility combinations which are representative of the VFR, MVFR, IFR, LIFR, or less than Category I IFR conditions. The Airport Weather symbol gives information about existing weather conditions such as liquid precipitation, or any obstructions to vision (eg. fog, haze, blowing snow), hazardous weather such as thunderstorms, tornado, hurricane, or any solid precipitation, or winds greater than 20 knots.

The TREND depiction compares the surface observations with the terminal forecast, hour by hour. This should be useful in determining whether the actual weather is developing according to the forecast.

FUTURE ENHANCEMENTS

The PWxA System as described here is designed to provide basic weather information to the enroute pilot for strategic planning purposes. The system could also be used pre-flight, to quickly obtain an overall view of the weather without having to read pages of alphanumerics. In the future, the depictions could be displayed directly on navigation moving maps to provide a powerful integrated weather/navigation flight management tool. As the NWS modernization program unfolds, we will be able to provide near real-time data such as winds and temperatures aloft, 3D radar products, automated pireps on

turbulence and icing etc. With slightly more computation power, we may even be able to provide trip profiles, by showing cross-sections of the trip with the winds, temperatures, and radar. Our satellite communications link could be stretched to update data 10 (ten) times an hour instead of 4 (four) times an hour. The limiting factor is not the PWxA system, but the weather acquisition and dissemination systems.

We have also begun considering how to use this information with an expert system to provide a continuous recommendation to the pilot for the course and altitudes he should fly, based on both the current observations and the forecast. We believe the forecasts have to get considerably better, and the Expert System formulation will have to get much more complex before such a system can provide reliable answers.

We have demonstrated the PWxA concept in flight in 1991 [4], on a Piper Malibu aircraft, as part of our Phase I work on a NASA Small Business Innovative Research (SBIR) contract. We are at present in Phase II of that contract, developing the operational prototype.

ACKNOWLEDGEMENTS

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[3] W. Allen Kilgore , N.L. Crabill , S.T. Shipley, J. O'Neill , D. Stauffacher , I. Graffman, and S. Seth :"Pilot Weather Advisor, Final Report for SBIR Phase I, Contract No. NAS1-19250", September 1991.

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