FINAL REPORT

IN-47-CR
185588
5P

WEATHER FORECASTING SUPPORT FOR AASE II

NASA GRANT NAGW-2792, SUPPLEMENT: BASIC

and

SPA-AFEAS, INC. CONTRACT CTR SP91-17.2

Covering the period 1 October 1991
through 30 March 1992

Gregory S. Forbes
Department of Meteorology
The Pennsylvania State University
University Park, PA 16802

22 April 1992

OBJECTIVES

The AFEAS Contract and NASA Grant were awarded to Penn State in order to obtain real-time weather forecasting support for the NASA AASE-II Project, which was conducted between October 1991 and March 1992. Because of the special weather sensitivities of the NASA ER-2 aircraft, AASE-II planners felt that public weather forecasts issued by the National Weather Service would not be adequate for mission planning purposes. A likely consequence of resorting to that medium would have been that scientists would have had to be at work by 4 AM day after day in the hope that the aircraft could fly, only to be frustrated by a great number of "scrubbed" missions. Thus, the Pennsylvania State University was contracted to provide real-time weather support to the AASE-II mission.

PERSONNEL

Penn State provided a forecaster at the NASA base of operations in Bangor, Maine during each of the periods when flights were based from that location (monthly, from November through March). During October, flights were conducted from Anchorage, Alaska, and forecasts were prepared at the Department of Meteorology at Penn State University (University Park, PA) and sent by FAX and telephone to the Project Director there. The Penn State forecasting team consisted of:

Gregory S. Forbes, Associate Professor of Meteorology,
        Principal Investigator, PhD
William Syrett, Meteorologist with M.S. degree
Lee Grenci, Meteorologist with M.S. degree
Arthur Person, Research Assistant with M.S. degree
        in meteorology
Christopher Peters, Graduate Student with B.S. degree
        in meteorology
Thomas Salem, Graduate Student with M.S. degree
        in meteorology

Logistical and programming assistance at Penn State was provided by Rose Auld Miller, Research Assistant with M.S. degree in meteorology, and Art Person, listed above.

WEATHER FORECASTING TASKS PERFORMED

During each of the monthly sessions in Bangor, Maine, forecasting responsibilities were handled by two members of the Penn State team. One person arrived about two days prior to the first potential ER-2 launch in order to begin preparing weather forecasts for planning purposes. About midway through the flight session, another member of the Penn State team travelled to Bangor; the first forecaster headed back to Penn State a day or two later. This gave a day or two of overlap in which the first forecaster could bring the newcomer up to speed.

On a daily basis, the weather forecaster periodically posted charts obtained from a DIFAX machine provided by NASA Ames

2.

and from Penn State via computer network (described further below). He examined these charts and generated additional weather information through accessing the Penn State Department of Meteorology computer system. He also generated satellite imagery displays and loops on the satellite workstation provided by NASA Ames and examined this imagery as part of the forecasting process. At 12:15 PM each day, a weather briefing was given orally and visually (using overhead projector) to the Project Director (Jim Anderson) in the presence of the congregated scientiifc team at Bangor. A written forecast and forecast maps were then posted for further inspection by scientists at their leisure. A preliminary forecast was delivered informally to the Project Director in mid-morning and an update was normally delivered in late afternoon. Though the 12:15PM briefing was the major event of non-flight days, the forecaster usually worked from about 8:00 or 8:30 AM through 5 PM (with perhaps a mid-afternoon break), and often also an evening shift in order to keep up with the weather and a never-ending stream of maps to be posted.

On days when flights were scheduled, the forecaster normally reported for duty by 4:00 AM in order to prepare short-term forecasts of the weather at the 8:00 AM launch and 3:00 PM landing times for use by the Project Director and pilot in making decisions about delaying, cancelling ("scrubbing"), or proceeding with the day's mission. These proved helpful when the FAA's terminal forecast was for a marginally acceptable weather situation. Due to the necessarily weather-cautious approach in terminal forecasting, the FAA's terminal forecasts predicted weather to be considerably worse than observed most of the time. Hence, many situations appeared borderline for ER-2 missions. On a number of occasions, however, it could be ascertained that there was no basis for such pessimism, either in the recent history of the weather system about to affect Bangor or in the numerically predicted evolution of the weather system.

The Penn State forecasting team also provided some support to the DC-8 mission planning. Because of access to data and software (see section below) not available at NASA Ames, the Penn State team was able to generate maps of forecasted cirrus clouds at 300 and 400 mb and forecasted turbulence in the 200-300 and 300-400 mb layers. These were based directly on grids of forecast data distributed from the National Meteorological Center, ouput from either their Nested Grid Model (NGM) or Medium-Range Forecast (MRF) model. These maps were then sent by FAX to Rennie Selkirk at NASA Ames, or given to the DC-8 support team when present in Bangor.

SOFTWARE AND PRODUCT SUPPORT

Art Person's primary duty at Penn State involves computer programming and upkeep of the Department of Meteorology's mete-

orological computer system. He was dispatched to Bangor early
in the project so that he could assess the unmet meteorological
data and derived product displays needed for optimum weather
forecasting operations at Bangor. As a consequence, many real-
time weather products were obtained by networking between NASA
computers and the Penn State Department of Meteorology computer
system. He created batch job procedures on the Penn State
computer system which were initiated automatically at certain
times of day, and which output hard-copy displays on the NASA
computer system operated by Paul Newman at Bangor.

In addition to the products generated and sent automatic-
ally (described above), each forecaster relied on a network
connection to the Penn State Department of Meteorology computer
system for obtaining real-time weather observations for Bangor
and other sites, for terminal forecasts (for Bangor and other
airports) distributed by the FAA, and for an assortment of
other weather analysis and forecasts products. Forbes, Miller,
Syrett, and Person wrote applications programs to meet the
needs of the NASA AASE-II project, including:

        Wind Chill Temperature Calculation Program
        Pilot Report (PIREP) Search Programs
        Terminal Forecast Search Program
        Sequential Data List Program
        50 mb Absolute Potential Vorticity Analysis Program
        Layer Richardson Number Analysis Programs

The Wind Chill Temperature Calculation program uses
inputted values of observed or forecasted wind speed and air
temperature to output a value of wind chill temperature. This
product was used in mission planning because of the health and
efficiency ramifications for the ground support crew, who
needed to work outdoors and often without gloves.

The Pilot Report (PIREP) Search Program searches the rather
random operational data base to find reports by pilots of air-
craft icing, clear turbulence, and other weather conditions.
The program was written so that all reports within a user-
specified geographical area are located. This made it possible
to identify reported hazards without the need to visually scan
hundreds of screens worth of data from all over the country in
a hunt for reports in the vicinity of Bangor. This information
was used in support of the 5:00 AM launch decision.

The Terminal Forecast Search Program was written to allow
the Penn State forecaster to keep track of what the FAA Flight
Service Station at Bangor would be telling the pilots about the
forecasted weather conditions. The software made it possible
to let the computer hunt for the Bangor forecast without resort-
ing to a protracted visual search of the somewhat random oper-
ational data file containing these forecasts.

The Sequential Data List Program was used to generate hard-copy listings of recent chronology of weather observations at Bangor. There were no other ready sources of local weather data in the AASE-II Weather Forecast Office.

The 50 mb Absolute Potential Vorticity Analysis Program was written to allow NASA investigators to obtain a look at the most current conditions at 50 mb. Paul Newman and his associates displayed forecasts of this quantity output from the NMC MRF model, and used the forecasts in mission design. However, there is a considerable delay between the time rawinsonde data are collected and time that the MRF model forecasts are distributed. During that time period, AASE-II scientists were able to use the most current rawinsonde observation-based analyses of 50 mb potential vorticity as a check on MRF forecasts. Hardcopy plots of this parameter and of the observed temperatures, heights, and winds were generated for use by the scientists.

Layer Richardson Number Analysis Programs were written so that the DC-8 missions could avoid areas of potentially strong turbulence. The Richardson number (Ri) is calculated from the vertical wind shear in a layer, the temperature lapse rate in a layer, and the mean potential temperature of the layer. When the Ri value is small, turbulence is likely. Programs were written to generate Ri maps from observed and from numerically predicted data.

The Penn State weather forecast team also fielded several requests for data that AASE-II scientists needed to help analyze mission data. Forecast team members also tried to field questions from AASE-II scientists about atmospheric structure (such as tropopause height) and generated displays to help answer the questions. At least one of these collaborations is likely to be ongoing as NASA scientists further examine their data and need to assess atmospheric structures and atmospheric dynamical processes affiliated with interesting features in the atmospheric chemistry data.

FINANCIAL SUMMARY

All of the awarded funds have been expended. In the course of the project there were some minor re-allocations of funds from one area of expenditure to another. For example, less graduate student time was used than budgeted, and these funds were used to cover greater-than-budgeted amounts of time spent on software development (by Miller and Person). Some economies of travel were obtained through advance bookings and through combination of trips to Bangor with other travel (by Forbes). Savings in this area were applied to a fair share of charges incurred in greater-than-anticipated use of the Penn State Department of Meteorology computer system.