Applied Meteorology Unit (AMU)

Quarterly Update Report

Second Quarter FY-92

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1. Background

The AMU has been in operation since September 1991. The five tasks which were issued during the first three months of the contract are briefly stated for reference in the following sub-paragraphs of this report. A detailed description of the work planned for each task was contained in our first quarterly report and will not be repeated in this report. The progress being made in each task is discussed in section 2.

1.1. Task 1 AMU Operations

- Operate the AMU. Coordinate operations with NASA/KSC and its other contractors, ESMC and their support contractors, the NWS and their support contractors, other NASA centers, and visiting scientists.

- Establish and maintain a resource and financial reporting system for total contract work activity. The system shall have the capability to identify near-term and long-term requirements including manpower, material, and equipment, as well as cost projections necessary to prioritize work assignments and provide support requested by the government.

- Monitor all Government furnished AMU equipment, facilities, and vehicles regarding proper care and maintenance by the appropriate Government entity or contractor. Ensure proper care and operation by AMU personnel.

- Identify and recommend hardware and software additions, upgrades, or replacements for the AMU beyond those identified by NASA.

- Prepare and submit in timely fashion all plans and reports required by the Data Requirements List/Data Requirements Description.

- Prepare or support preparation of analysis reports, operations plans, presentations and other related activities as defined by the COTR.

- Participate in technical meetings at various Government and contractor locations, and provide or support presentations and related graphics as required by the COTR.

1.2. Task 2 Training

- Provide initial 40 hours of AMU familiarization training to Senior Scientist, Scientist, Senior Meteorologist, Meteorologist, and Technical Support Specialist in accordance with the AMU Training Plan. Additional familiarization as required.

- Provide KSC/CCAFS access/facilities training to contractor personnel as required.

- Provide NEXRAD training for contractor personnel.

• Provide additional training as required. Such training may be related to the acquisition of new or upgraded equipment, software, or analytical techniques, or new or modified facilities or mission requirements.

1.3. Task 3 Improvement of 90 Minute Landing Forecast

• Develop databases, analyses, and techniques leading to improvement of the 90 minute forecasts for STS landing facilities in the continental United States and elsewhere as directed by the COTR. Specific efforts will be designated as numbered subtasks. The initial two subtasks are specified below. Additional subtasks will be of similar scope and duration, and will be assigned by technical directives issued by the COTR.

• Subtask 1 - Two Tenths Cloud Cover

•• Develop a database for study of weather situations relating to marginal violations of this landing constraint. Develop forecast techniques or rules of thumb to determine when the situation is or is not likely to result in unacceptable conditions at verification time. Validate the techniques and transition to operations.

• Subtask 2 - Fog and Stratus At KSC

•• Develop a database for study of weather situations relating to marginal violations of this landing constraint. Develop forecast techniques or rules of thumb to determine when the situation is or is not likely to result in unacceptable conditions at verification time. Validate the techniques and transition to operations.

1.4. Task 4 Instrumentation and Measurement Systems Evaluation

• Evaluate instrumentation and measurement systems to determine their utility for operational weather support to space flight operations. Recommend or develop modifications if required, and transition suitable systems to operational use.

• Subtask 1 - STA Downlink Test Support

•• Provide meteorological and data collection support to the NASA/JSC Shuttle Training Aircraft (STA) winds position data downlink demonstration tests.

• Subtask 2 - Airborne Field Mill (ABFM) Test Support

•• Provide meteorological and data collection support to the NASA/MSFC ABFM FY92 winter deployment.

• Subtask 3 - Doppler Radar Wind Profiler (DRWP)

• Evaluate the current status of the DRWP and implement the new wind algorithm developed by MSFC.

1.5. Task 5

- Evaluate Numerical Mesoscale Modeling systems to determine their utility for operational weather support to space flight operations. Recommend or develop modifications if required, and transition suitable systems to operational use.

- Subtask 1 - Evaluate the NOAA/ERL Local Analysis and Prediction System (LAPS)

•• Evaluate LAPS for use in the KSC/CCAFS area. If the evaluation indicates LAPS can be useful for weather support to space flight operations, then transition it to operational use.

2. AMU Accomplishments During the Past Quarter

2.1. Task 001 Operation of the AMU

Purchase of IBM RISC 6000 Class Computer for the AMU

Robin Schumann completed the KSC KIRMA Purchase Request training on 22 January. This training was the first step in submission of the purchase request for the RISC 6000 class system. Unfortunately, the KIRMA database was not set up to handle equipment purchases on a scale larger than that for standard personal computer configurations. Many hours of follow-up with the KIRMA data base manager, however, allowed MS. Schumann to finally submit the PR for signature on 04 February.

The purchase request took the better part of two months to travel the sign-off path to the Procurement Office. Once it was there, Ms. Schumann worked closely with the Procurement Office answering questions and justifying the need of the items listed in the purchase request. All paper work was signed off and the purchase request was given to the buyer the middle of April. This should enable us to get the equipment in house by June or early July.

The AMU working area does not currently have adequate power for the new equipment nor is there communication capability for the system to receive data from MIDDS. These problems are being worked very hard by the 45th Weather Squadron and the Range Contractor. Solutions appear to be on track.

Forecast Simulations:

The AMU has continued to use the tools available to Cape and SMG forecasters to produce 90 minute, 6 hour and 24 hour go/no go forecasts based on the STS launch and landing constraints. A fairly detailed data sheet is kept for each forecast and highly interesting cases are archived for later review. A copy of our worksheet is provided as Attachment 1. This data collection will be continued and a report made in the future on categories of cases which would be of interest to the STS community. Along with the forecasting exercise, the AMU has continued to look for new ways of displaying data for use by forecasters. An area of increasing interest has been the Doppler Radar Wind Profiler (DRWP) which will be discussed in a later paragraph.

The AMU has participated in forecast discussions with the SMG and CCFF on a regular basis. The interaction with the CCFF occurs at their daily 0930L discussion and then on sporadic occasions throughout the day as interesting weather develops. Discussions with the SMG occur in conjunction with their daily forecast simulations. Currently, we discuss their 10 hour Tanking MMT forecast which they make at 0915L. The interchange with both groups has been valuable in increasing AMU understanding of the process of making operational forecasts and the difficulties faced by operations forecasters.

STS 48 Case Study

The STS 48 Case Study was completed and comments received from reviewers were incorporated into a final version. The final version has been completed. When final clearance is received from NASA, the report will be distributed.

STS 42 Launch

The AMU staff was present for the STS 42 launch on 22 January 1992. The launch was delayed for approximately one hour because of high electric field values from sensors located near the beach in conjunction with scattered cloud conditions. Data collected from the ABFM Winter Deployment may prove valuable in analyses of the LCC which was violated prior to launch. These weather issues, however, are not related to current tasking; therefore, there are no plans to perform any case analyses of the data associated with this launch.

Development of Forecaster Applications of Wind Profiler Data

The 50MHz Doppler Radar Wind Profiler (DRWP) offers many possibilities for use in enhancing support to the STS program. The AMU has been involved in implementation of an improved algorithm developed at MSFC for generation of profiles from the DRWP as well as the NASA certification process for the DRWP. The certification process is aimed at the use of the DRWP in loads analysis by the JSC ascent community. While the profiler is certain to be valuable in loads analysis, it is also an outstanding tool for use by CCFF and SMG forecasters.

The only display currently available to forecasters shows a time series of wind profiles with barbs displayed approximately every 450m in the vertical. There are other ways of looking at the data. For example, in some circumstances, by subtracting the 12 or 24 hour mean flow from the winds, one can clearly see small perturbations in the flow which could represent triggers for showers, discontinuities such as passage of a front or upper level trough, and other weather events. Seeing these events which occurred in the recent past can help forecast events in the near future. Attachment 2 shows an example of profiler data as it is observed. Attachment 3 shows the same data with the mean flow removed.

Current plans are to invite Dr. Greg Forbes of Penn State University to assist the AMU in developing some new DRWP displays for MIDDS. Dr. Forbes has a wealth of experience in the interpretation of profiler data and development of new displays. This activity should occur during the third and fourth quarters of FY-92.

Visiting Scientist

Dr. Donald Resio of Florida Institute of Technology will be associated with the AMU as a visiting scientist during the performance of his NASA Grant to "Determine Effects of Topography and Structures on Wind-Flow Patterns at NASA/KSC." Our role in his work will include exchange of data, information, ideas and results.

2.2. Task 002 Training

A one hour life support session was attended by all in order to complete the area access training required by KSC. One afternoon was spent on a tour of STS facilities and weather equipment. This tour provided AMU personnel a better understanding of the STS processing and points where weather is an impact.

2.3. Task 003 Improvement of 90 Minute Landing Forecast

The majority of the work on the 2/10 cloud cover study during January and February centered on determining clouds less than 10000 feet at the SLF (X68) and entering these data into the overall surface weather database. The clouds heights below 10000 feet were determined by analyzing both surface weather forms 10A and 10B for a period of 5 years (1986-1990). Approximately 22,000 hours of cloud cover data had to be entered into the database. This data along with the remainder of the X68 surface data will be used to study weather conditions relating to landing constraints at the SLF with major emphasis on improving the 90 minute forecast.

After the cloud cover data was entered into the database, AMU personnel concentrated on the development of dBASE programs to analyze the 5 years of X68 surface data (1986-1990). These programs were developed to ingest the surface database and produce statistics of weather conditions 1, 2 and 3 hours after a given initial weather condition. The data shown in figure 1 represents some preliminary statistics for all hours at T_o+1 hour during the 5-year period. These data indicate for initial cloud cover of 3/10 or less there is usually less than a 10 percent chance of a shuttle landing weather violation. In most cases the weather violations were visibility less than 7 nautical miles and/or a ceiling less than 10000 feet. These programs are currently being used to categorize the 2/10 cloud cover database by time of day, year, seasons and various flow regimes (i.e., onshore or offshore flow). Problem cases will be highlighted and analyzed in more detail. An overall statistical analysis will be completed by the end of April with a preliminary report completed by the end of May.

CSR provided the AMU with all the Cape's archived rawinsonde data for the years 1986 through 1991. The AMU then converted the data from archive format to dBASE IV format. During the conversion process, the data were checked for duplicate records and missing data. Table 3.3 below lists the large gaps in the rawinsonde archive. It appears that most of the data missing is prior to 1989. Hopefully, the archive for the more recent years is indeed more complete.

In addition to the large gaps described above, the AMU discovered several isolated days where the data did not make it to the Cape archive. The large amounts of missing data rendered the Cape's archive insufficient for the 2/10 cloud cover study. AMU personnel are in the process of extracting Cape rawinsonde data from a world-wide data base currently used by ENSCO's Melbourne office on another project. It appears this data, though less detailed than what the Cape archive would have been had it been fully populated, will suffice for the 2/10 cloud cover study. Cape rawinsonde data will be utilized in special case studies evolving from the fog and stratus study.

The selection process for the fog and stratus study began during late February by using dBASE IV to select all potential cases for the 5 years of data within the database. The initial part of the study will center on advection type of fog with an offshore boundary layer flow with a rapid deterioration of visibility and ceilings. Once these cases are selected we will want to acquire case-specific data. The type of data that may be needed will include Florida observations, WINDS tower network, satellite data, and surface and upper-air charts.

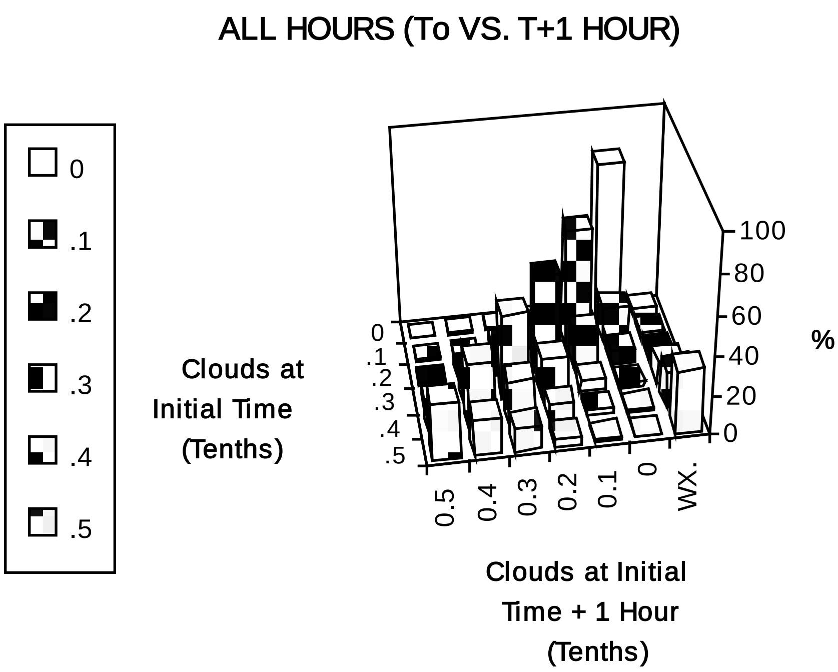

Figure 1: Depiction of the percent of cloud cover at the SLF one hour after an initial cloud cover of 0 through 5 tenths cloud cover. The WX column shows the

percent occurrence of any STS landing weather violation given an initial state of 0 through 5 tenths cloud cover.

The initial selection of cases for the fog and stratus studies was completed during March. Approximately 173 cases over the 5-year period were chosen from the database as a starting place for the analysis. Those cases were compared with X68's form 10's, highlighting the type of fog case. From these 173 cases, the AMU chose 39 cases for inclusion into the study. Particular emphasis was placed on cases with advection type fog with a rapid deterioration of visibility and ceilings. In addition, case-specific data was requested. This included central Florida surface observations from the National Climatic Data Center and WINDS tower network from CSR. To enhance the understanding of the weather conditions for fog formation, a synoptic analysis for the event including the day before and the day after were being prepared for each case. This included a detailed surface and upper-air weather map summary analysis of fronts, troughs, high's and low's along with a detailed summary of the surface observations from X68, TIX, MCO, ORL, DAB, COF, MLB, VRB and AGR for each event. An examination of each case will continue during April with major emphasis placed on the synoptic weather patterns surrounding each event. All the data requested have been received, although there may be some holes in that data. The local wind tower data will need to be put into database format for data comparison and analysis.

Table 3.3: Data Missing from Rawinsonde Archive

Year	Month	Description of Missing Data
1990	July	There are no data after 24 July on archive.
1989	March	There are no data after 23 March on archive.
1988	January	There are no data before 10 January on archive.
1988	April	There are no data after 25 April on archive.
1988	August	There are no data before 22 August on archive.
1987	June	Data are sparse for this month in general. There are only 2 records before 12 June.
1987	August	Data are very sparse. None between 07 August and 18 August.
1987	Septemb er	Data are extraordinarily sparse. There are only 10 data sets for the entire month. No data between 04 and 29 September.
1987	October	Data are very sparse. No data between 16 and 27 October.

1986	March	Data are extraordinarily sparse. There are only 8 data sets for the entire month. No data after 06 March.
1986	April	Data are extraordinarily sparse. There are only 3 data sets for the entire month.
1986	May	Data are extraordinarily sparse. There are only 12 data sets for the entire month. No data between 03 and 20 May.

2.4. Task 004 Instrumentation and Measurement

2.4.1 Subtask 1 STA Downlink Test Support

The STA test occurred on 6-8 January 1992. Wind data were received and displayed in the AMU on the 6 and 7th. A full scale test with video distribution to JSC was done on the 8th. The only deficiency in the test was the loss of data from the STA during the shuttle approach simulation phase of the flight. This was believed to be due to antenna shadowing or transmitter failure. Data received appeared to be of high quality from a qualitative point of view. Further testing and evaluation will be required before the system could become operational.

A copy of the rawinsonde from test day was made and sent to JSC for their data analysis. The AMU has not been involved in any further discussions on any deployments or tests.

2.4.2 Subtask 2 ABFM Test Support

The ABFM aircraft arrived and conducted a night proficiency and calibration flight on 16 January 1992. Subsequent to that, 13 flights were conducted through the end of January for a total of 22 hours 51 minutes of flight time. Of the 13 flights, 12 were in conditions which exceed current launch commit criteria and one was in borderline conditions. Mark Wheeler has provided most of the support from the AMU with occasional backup from Kevin Atchison.

February was a busy month with 13 data collection flights. Of those, 10 were for layered clouds, 3 investigated disturbed weather events. In addition, one also included data collection of an enhanced ground base field mill reading. The disappointment occurred when we found out that there was no radar data from either the Patrick radar or NEXRAD on one of our disturbed weather flights. This resulted from a failure of the McGill radar system during the flight and a simultaneous failure of the NEXRAD EXABYTE tape system. There were several excellent flight profiles/data collection cases with layered clouds. The cloud layers ranged from 4500 to 18000 feet thick and showed very minimal mill readings.

The ABFM deployment ended 8 March 1992. After the end of the deployment, additional work was required to complete all the data flight summaries, update and complete all the data flight folders and replay and make copies of each data flight profile track. Using the MSFC computer, all aircraft data were backed up to EXABYTE format. The data flight folders will be used by Marshall as the first guess data set. These folders had copies of the flight summary, weather charts, McGill radar charts, strip charts, LPLWS plot and satellite pictures. All flight archive data sets were backed up and the originals were set to Marshall Space Flight Center. Copies of the archive data sets for all flights during the past two years have been packed up and sent to Complex 16 for storage. The ABFM computer and additional hardware was taken apart, packed up and sent to KSC for shipping to MSFC.

Overall, the winter 1992 deployment consisted of 31 data or calibration flights. Many of the calibration flights were performed in cloud. The extra calibration flights were extremely important to the overall data flights and accuracy of the gathered data. Target prioritization were provided by the Marshall Principal Investigator. For this deployment the primary targets were layered clouds and disturbed weather exceeding launch commit criteria. Data was also collected on stand-off distance to a thunderstorm and the vertical structure of the electric field in this lowest 1000 feet, several of these flights were completed. Because of excellent cooperation between the different agencies 2 three flight days were completed. Others could haave been supported but the weather was not favorable. A summary of the flights is shown in the table below. The AMU does not anticipate any further involvement in the ABFM project in the near future.

Data Summary	Layered Clouds	Disturbed Weather
Primary Target	22	3
Secondary Target	3	5

2.4.3 Subtask 3 Wind Profiler

Based on data gathered in December, the AMU prepared a report summarizing our evaluation of the status of the meteorological validation of the NASA/KSC 50 MHz Doppler Radar Wind Profiler (DRWP). The report included a brief summary of the meteorological validation performed by MSFC and a description of their new wind processing algorithm. The algorithm description contained an overview of the technique focusing on advantages relative to the current consensus procedure. The report also included recommendations to NASA/MOW regarding the remaining work required to complete the validation of the instrument and its associated software and transition it to operational use. The report was delivered on 24 January 1992.

After the report was delivered and the plan for the completion of the meteorological validation approved, a development environment on ENSCO's MicroVAX II computer was established to transition MSFC's new wind algorithm into the DRWP. Use of this development environment minimizes the impact on operational and research use of the DRWP during integration of the new wind processing algorithm into the Post Data Handler (PDH) software. Setting up the development environment included purchasing and installing a VT 340 terminal at the AMU Facility and installing a copy of the PDH software on the development system.

Once the Post Data Handler software was installed on ENSCO's MicroVax, AMU personnel began the process of understanding its logic and data flow. The first step in that process was to create external documentation of all files contained in the PDH. By the end of March, the documentation contained a list of all files broken out by file type and directory, a list of exactly what C source code files correspond to each PDH executable process, a detailed explanation of how the system is built through a maze of make.com files, and a map of all other *.com files. The map of the *.com files contained the following items:

- Short descriptions of each *.com file (command file).
- An explanation as to how each command file is invoked (i.e. whether it is invoked by the user, by another command file, or both)
- A list of parameters for each command file, and
- Several diagrams illustrating the logic flow through the system and how each of the PDH executables processes is invoked.

The documentation described above is essential for maintenance and modification of any system and is normally provided by the software contractor. A copy of the documentation described thus far was provided to Launa Maier and her staff which will hopefully expedite their understanding of the system.

Since March, the AMU has continued to document the PDH software, concentrating on software directly related to the spectral archive process, in an effort to ensure our understanding of the system is sufficient to begin the modifications necessary to implement MSFC's new wind algorithm into the DRWP. The documentation now contains detailed logic and data flow descriptions of the entire spectral data archival process where MSFC's new wind algorithm will be retrofitted. It also contains a map of all the *.c and *.h files associated with the spectral data archival process similar to the map for all the *.com files described above.

Though this documentation consists exclusively of internal working papers, they are available for the asking to anyone requiring understanding of the software associated with the Post Data Handler of the DRWP. Upon completion of the software development phase of this project, much of this internal documentation will be directly transferable to the required documentation for acceptance by the maintenance personnel.

The AMU is now finishing up the detailed documentation of the spectral archive process and in the process of designing how the new wind algorithm will fit within the current software. The AMU will then begin the process of simulating the PDH processing on ENSCO's MicroVax. This will enable the AMU to retrofit the new winds algorithm into the current software without interfering with the operational use of the DRWP.

In addition to the work with the PDH software, AMU personnel have been refining the requirements for the new wind algorithm through technical interchange telephone conversations with MSFC personnel and by analyzing the MSFC wind algorithm code. As the requirements are defined, the code is being modified for use in the near-real-time environment in the PDH. To date, much of the basic algorithmic code provided by MSFC has been optimized. For example, code used to compute the noise power has been rewritten taking advantage of faster sort algorithms. This enhancement plus other modifications to improve the performance of accessing data stored in arrays have resulted in an 83% reduction in the processing time required to compute the basic spectral moments (i.e., average Doppler shift, spectrum width, and signal-to-noise ratio).

The core algorithmic code for the new wind processing technique has been decomposed into 15 different modules. To date, all of these modules have been designed, coded, and unit tested. The next step is the integration of these modules into two key processes, the moments process and the velocity process. The moments process will ingest the spectral density data from the spectral archive process, perform a temporal median filter on the data, compute the spectral moments, and then notify the velocity process that the moments data are available. The velocity process will then ingest the spectral moments and the median filtered spectral data; compute the velocity profile; output the velocity profile, median filtered spectral data, and first guess data to disk; and then notify the MIDDS Out process that the velocity profile is available.

During the next quarter, modification of the algorithmic component of the MSFC code will be completed and will then be transitioned into the PDH software on ENSCO's microVAX computer. Analyses of jimsphere profiles and time-coincident DRWP wind profiles produced by the consensus technique and MSFC new wind algorithm will also be performed.

2.5. Task 005 Mesoscale Modeling

After a visit with Dr. John McGinnley of NOAA/FSL during December, the AMU began some initial steps toward establishing a capability for real-time mesoscale analysis. Dr. McGinley provided a copy of NOAA's Local Analysis and Prediction System (LAPS) wind analysis software and the AMU performed some preliminary code analysis. It was determined the most efficient manner for testing of the software is to await the arrival of the RISC 6000 system being procured by NASA. This will allow for setup of the analysis software and parallel development of data ingest routines needed for use of the model within the CCFF computer environment. This approach is a deviation from the original AMU plans but will prevent needless duplication of effort in the future.

We have also learned from Dr. Wes Wilson of MIT Lincoln Laboratories that they are rewriting and modifying LAPS for use during the FAA demonstration planned for Orlando this summer. A major part of their effort involves modifying the software to run in a UNIX operating system environment. This is a step the AMU will have to take for implementation of the RISC 6000 system. Dr. Wilson offered to provide us a copy of the modified analysis software when they complete their work. This will represent a savings of several man-months to the AMU.

Along with investigations of LAPS, the AMU has begun looking into the work being performed by Meso, Inc. under a Phase II SBIR contract to NASA. Meso, Inc. presented a briefing on their project on 28 February at KSC. The results presented showed great promise for the future of mesoscale modeling at KSC. They have put together a system which uses a combination of static and dynamic initialization on a nested grid which has a 10 km spacing over the Cape area. For prediction, they use the MASS 5.0 model. Their schedule calls for delivery of the analysis and prediction system and a Stardent 3000 computer to KSC in the Fall of 1992. The AMU will closely follow the developments in this project and once their system is delivered, comparisons can be made between the Meso analysis and LAPS to determine the best method of initializing the MASS model.

3. Project Summary

Most of the short range (first year) and long range (first three years) goals expressed in the AMU's last quarterly report are unchanged. A good course has been charted for the first year and the AMU is continuing on that course.

3.1. Short Range

- To complete the study and deliver a report on the 0.2 Cloud Cover flight rule. The report will contain recommendations on when the rule is applicable and when it is not. Additionally, it will provide CCFF and SMG forecasters with guidelines for forecasting short term changes in cloud cover. A follow-up report will be issued after another year of verification activities.

- To complete the study and deliver a report on Winter fog forecasting at the SLF. The report will contain an algorithm or decision tree which will aid the CCFF and SMG forecasters in predicting this phenomena. A follow-up report will be issued after another year of verification activities.

- To complete the implementation of the MSFC DRWP wind calculation algorithm. This will include development of a user interface for the wind quality control position during STS launches.

The implementation will be demonstrated at the end of the first year with testing, documentation, and final operational implementation by early 1993.

3.2. Long Range

- To complete the implementation of the MSFC wind algorithm on the DRWP and transition it to operational use.
- To complete the implementation and testing of LAPS and if appropriate, transition it to operational use.
- To implement the wind analysis from NOAA/ERL's LAPS system in real time on the AMU RISC 6000 computer by the end of the 1992. This will be followed by implementation and testing of the entire LAPS system.
- To implement and test the MASS model and analysis system to be delivered by Meso, Inc. by the end of 1992.
- To implement a three dimensional meso-beta forecast system which can be initialized from LAPS and which will provide forecasts out to 18 hours.