Applied Meteorology Unit (AMU)

Quarterly Update Report

First Quarter FY-93

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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 Attachment 1 to 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.

2. AMU Accomplishments During the Past Quarter

The primary AMU point of contact is reflected on each task and/or sub task.

2.1. Task 001 Operation of the AMU (Dr. Taylor)

Development of Forecaster Applications (Mr. Wheeler)

The AMU worked on several issues associated with the development of forecaster applications during this quarter including the definition of future requirements, the development of new tools, and helping forecasters use existing tools and commands.

To get specific input from the CCFF and SMG forecasters regarding their desires for MIDDS enhancements, the AMU developed and distributed a MIDDS questionnaire. Some responses have been received and the AMU is currently analyzing the data. The AMU will work with the SMG Technical Development Unit (TDU) to determine whether a particular request should be handled by the development of a MIDDS McBasi utility by the AMU or by the development of a core MIDDS program through the SMG.

Other MIDDS issues addressed during this past quarter included adding new site locations to a McBasi program that outputs Lightning Location and Protection (LLP) strikes within a given distance of a site location. File structures and locations of particular bulletins in the new MIDDS sequential file system were also discussed with CCFF personnel.

During the attempted landing of STS-53 at the Kennedy Space Center on December 9, 1992, the AMU assisted the CCFF in using MIDDS to track and forecast the movement of low level clouds. The MIDDS program “TRNIMG” was demonstrated. This program performs a pixel by pixel translation of a digital image (satellite) to simulate the movement of cloud elements over time. In addition to the satellite image, the program requires input of the forecast direction and speed of movement and the extrapolation time period. The program then translates the image producing a forecast of future position of the cloud elements.

AMU Workstations and Equipment Racks

During October and November, several discussions were held with Harris personnel regarding consoles which will replace the existing wood consoles/desks used to house the

AMU computers, monitors, and communications equipment. In support of this upgrade, the AMU developed floor plans and equipment layouts for the new racks. These new equipment racks will significantly improve the functionality and appearance of the AMU laboratory.

Figure 1. AMU Work Area Floor plan layout

Harris Corporation is scheduled to install the consoles in the AMU laboratory during February 1993. The exact time of the installation will depend upon NASA and Air Force launch schedules. It is anticipated that the equipment in the AMU laboratory will be non-operational for about two weeks.

In addition to the equipment racks and consoles, the Air Force ordered new modular personnel workstations for the AMU that match the existing Range Operations Control Center (ROCC) decor. Four new modular personnel workstations arrived and were installed in the AMU in late November. These workstations are similar to those used by Air Force and Computer Science Raytheon (CSR) personnel in the ROCC.

The AMU is still awaiting the installation of power and telephones into the new personnel workstations that were installed in the AMU Facility in late November. Temporary power has been installed in the workstations, and telephones are available in the AMU laboratory area.

Figure 1 illustrates the floor plan for the new equipment racks and consoles and for the new personnel workstations.

2.2. Task 002 Training (Dr. Taylor)

No special training classes or seminars were attended by AMU personnel during the fourth quarter of fiscal year 1992.

2.3. Task 003 Improvement of 90 Minute Landing Forecast (Dr. Taylor)

Sub Task 1: Two - Tenths Cloud Cover Study (Mr. Atchison)

The purpose of this task is to develop databases, analyses and techniques leading to the improvement of the 90 minute forecast for Space Transportation System (STS) landing facilities in the continental United States and elsewhere. This sub task addresses the two tenths cloud cover rule which is in effect for the End Of Mission (EOM) STS landings at KSC. A draft copy of the final report was completed and delivered for review during November. Comments and suggestions were received during December and early January and are currently being incorporated into the report. During February, the two tenths cloud cover report will be published as a NASA contractor report and delivered to all interested organizations.

Based upon the analysis of the two-tenths cloud cover data base, several operational recommendations for STS landings at KSC can be made. A detailed summary of these recommendations will be discussed below.

Analysis of Landing Opportunities

Based upon the climatological analysis of the hourly data, several recommendations can be made regarding the best and worst times to land the shuttle at KSC. These periods, along with their corresponding percent occurrence of no STS landing weather violations, are listed in Table 1. The climatological data indicate the best time of the year to land the shuttle at KSC is during the summer (80%-85% opportunity) while the worst time is during the winter (65% opportunity). When the data are categorized by time of day, the analysis has shown the highest frequency of landing opportunities (i.e., no weather constraint violations) occurs for the 0100-0600 UTC (80%-85% opportunity) and 1300-1600 UTC (75% opportunity) time periods. In fact, the frequency of landing opportunities exceeded 90% for many of the spring and summer months for the 0100-0600 UTC period. The worst time of the day to land a shuttle is near sunrise (1100-1300 UTC) and during the afternoon (1700-2100 UTC). For both of these time periods, the frequency of landing opportunities is approximately 60 to 70%. It is important to note that near sunrise for the months of December to February the frequency of landing opportunities is only 50%. These low percentages are generally associated with fog and stratus which occur more frequently during the winter in the early morning hours. The decrease in landing opportunities during the afternoon are associated with the development of cloudiness and convective type precipitation events especially in the warmer months of the year.

By categorizing the data by surface wind direction, analysis of the data indicates the highest frequency of landing opportunities occurs with a southeasterly or southerly wind flow (85% opportunity) while the lowest are associated with a northwesterly or northerly wind component (65%-70% opportunity). For upper-level wind direction (850 mb and 700 mb), most wind sectors have frequency of landing opportunities of 80%. However, for both 850 mb and 700 mb, the wind sector with the lowest landing opportunity (approximately 70%) is southwest.

Table 1
STS Landing Opportunities

Category	Percent Occurrence of no STS Landing Weather Violations	Category	Percent Occurrence of no STS Landing Weather Violations
May-August	80-85%	December - February	65%
1400-1600 UTC	75%	1100-1300 UTC	60-70%
0100-0600 UTC	80-85%	1700-2100 UTC	70%
S & SE Surface Winds	85%	N & NW Surface Winds	65-70%
		SW 850 mb & 700 mb Winds	70%

Evaluation of Two-tenths Cloud Cover Rule

One of the major goals of this study was to determine the validity of the 0.2 cloud cover rule for all stratifications of the data (i.e., seasons, months, time of day, wind direction, etc.). To address this question, analyses in this report focused on comparing the percent of observed weather violations subsequent (one and two hours later) to initial conditions of 0.2 and 0.3 cloud cover below 10,000 feet at X68. These comparisons were performed by using chi-square tests for homogeneity to determine if the percent of weather violations subsequent to the two different initial conditions are the same.

Statistical tests were performed between 0.2 and 0.3 initial cloud cover for all data categorizations (i.e., seasons, months, time of day, daytime only, surface and upper-air wind direction). For the majority of these data categorizations there is a significant difference in the proportions of weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover. There are, however, a few categories where the differences in the proportions of weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover are not significant. These categories include the month of May and hours 1500 and 1600 UTC (all months). Based on results of the statistical tests, the 0.2 cloud rule is probably overly conservative and could be changed to 0.3 for the month of May and hours 1500 and 1600 UTC.

Table 2
Comparison of 0.2 and 0.3 Cloud Cover Rules

	0.2 Rule (0.0-0.2)		0.3 Rule (0.0-0.3)			
Category	Good landing Hours	Percent of Total Hours	Good landing Hours	Percent of Total Hours	Additional Hours (5-year period)	Total Hours (5-year period)
May	2411	65	2826	75	415	3720
1500 UTC	834	46	1123	62	289	1826
1600 UTC	785	43	1121	61	336	1828

If the rule change was made, the question then arises, "*How many more landing opportunities will occur for KSC landings?*". To answer this question, a comparison of landing opportunities (i.e., no weather constraint violations) using both a 0.2 and 0.3 cloud cover rule is shown in Table 2. The current 0.2 rule assumes landing opportunities for initial cloud cover of 0.0 to 0.2 while a 0.3 rule would mean landing opportunities for initial cloud cover of 0.0 to 0.3. Changing to a 0.3 cloud cover rule for each of these categories will increase the number of landing opportunity hours by approximately 60-70 hours per year per category (Table 2). The largest increase in hourly opportunities occurs during May with about 80 hours per year. These are not large increases over a yearly period; however, even this small increase in available hours would be significant if it allowed one additional landing at the SLF per year.

Wintertime Northeast Flow Case Study

Northeasterly flow cases along the east coast of Florida pose many weather problems for launches and landings at KSC. Among these problems are low-level stratocumulus ceilings, showers, and cross-wind violations for EOM and RTLS landings. An interesting northeast flow case occurred during December 1992 over the KSC area. The major forecast problem for this particular case was bands of stratocumulus clouds advecting inland from the Atlantic. This case was characterized by relatively stable conditions with a very strong low-level inversion near 850 mb. Because of the low-level hydrostatic stability, several forecast tools could be successfully employed to forecast the movement of cloud bands from the Atlantic. The AMU is currently performing a detailed meteorological analysis of this particular event and a preliminary report describing the results will be delivered during early February.

Sub Task 2: Fog and Status at KSC (Mr. Wheeler)

The AMU's goal for this sub-task was to determine precursors for fog formation and develop forecast techniques based on the findings. The major focus of this investigation has been on rapid deterioration in visibility due to fog over a one hour period at X68, between 0500 to 1600 UTC. The results may not apply to all fog events at X68.

During this past quarter, the AMU completed the development of prototype MIDDS tools and fog forecasting decision trees. Based upon the AMU's experience with these tools during the 1992-93 fog season, the tools may be modified and then transitioned to SMG and CCFF forecasters. In addition, the first draft of the fog preliminary report was completed and reviewed internally. Key information from the preliminary report is presented below. This report willl be submitted for external review in January 1993.

Although only 36 cases over a 5 year period were analyzed some important trends in fog formation were noted. The fog cases have naturally fallen into three categories: advection, pre-frontal and radiation. Category definitions are listed in Table 3.

The typical advection fog event is characterized by fog developing west of X68, over toward Orlando or north toward the Daytona Beach area, and generally to the north of a surface ridge line. The surface wind directions reported by the tower network are generally westerly, 180-360° and, in time, gradually veer to a more northwesterly component prior to the fog moving into X68.

The pre-frontal fog cases are very similar to the advection fog cases. The pre-frontal event is characterized by a slight veering in the surface winds from southwest to west-northwest as the front moves closer to X68. In many of the events, there is a weak surface ridge that moves south of the Cape Canaveral area several hours before the fog moves into X68.

Some general statements can be made about radiation fog based on climatology (Cape Canaveral Forecast Facility, Terminal Forecast Reference Notebook) and this study. Radiation fog generally forms near sunrise and the surface winds are typically light (3-5 knots) and variable, from 180° to 360° if the speed is at or above 3 knots. The Cape Canaveral or Tampa rawinsonde typically indicates low level moisture (at or below 900 mb) and dry air aloft.

Table 3
Fog Classification

Classification	Criteria	Description
Advection (21 cases)	Weak high pressure over Florida. Surface ridge axis needs to be south of X68. Sounding is moist below 900 mb and dry above 850 mb. Fog develops west of X68 (St. Johns River valley - Orlando - Daytona Beach) first, prevailing surface wind direction is 180° - 360° and local tower data shows a NW shift. Tower 313, 6 to 492 ft inversion of 3 to 5 °F.	Fog forms west of X68 (St. Johns River valley - Orlando - Daytona Beach) first, generally to the north of a surface ridge line (1 - 2 hours). Local tower data shows a westerly wind component (180° - 360°) and in time the data will show a shift to a more northwesterly component prior to the fog moving into X68.
Pre-Frontal (13 cases)	Presence of a moving frontal boundary, Florida panhandle to X68. The front will pass through X68 during the fog event day. X68 sounding is moist below 900 mb and may have moisture above. Weak surface pressure gradient ahead of front.	Fog occurs ahead of front. First indications are reports of fog west of X68, (Orlando and/or Daytona Beach) and the KSC/CCAFS wind towers will report a westerly wind component (180-360°) at 54 feet.
Radiation (2 Cases)	Sounding has low level moisture (900 mb and below) and will be dry aloft (above 850 mb). Fog occurs at or near sunrise. Surface winds will be light. Land breeze may develop, (240 - 340°) on local towers just prior to fog development. Some central Florida stations may report 4 to 6 miles visibility due to fog.	Fog forms near sunrise with initial heating and mixing of the lower atmosphere. Surface winds are light and variable, from 180° to 360° for speeds above 3 knots.

Figure 2 shows that the initial time of reduced visibilities due to fog at X68 is 0700 to 1000 UTC (21 of 36 events). Three of the five fog cases during the 0500 to 0559 UTC time period were associated with pre-frontal fog events.

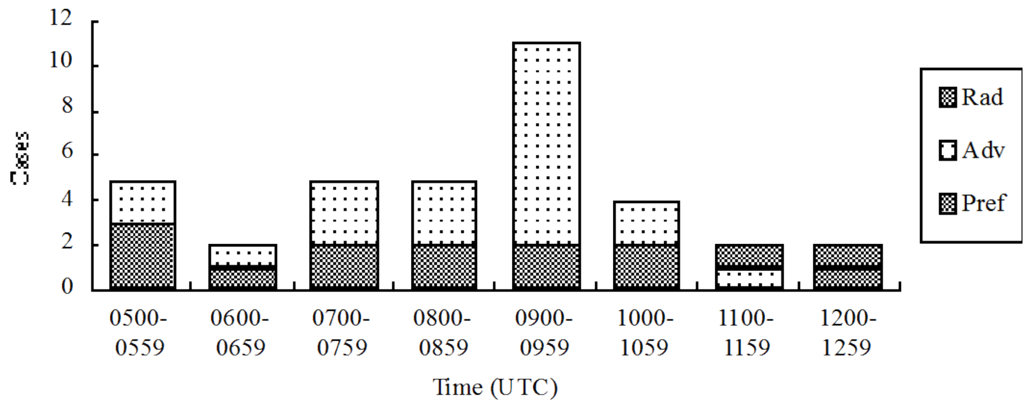


Figure 2. Time of Fog Onset at X68 for All Cases

Figure 3 shows the time of fog dissipation at X68 for all 36 fog cases. Fog dissipation time is defined as the time when the surface visibility becomes 7 miles. The most significant piece of information evident from this graph is the high number of cases (30 of 36) in which the visibility had improved to 7 miles or greater by 1600 UTC.

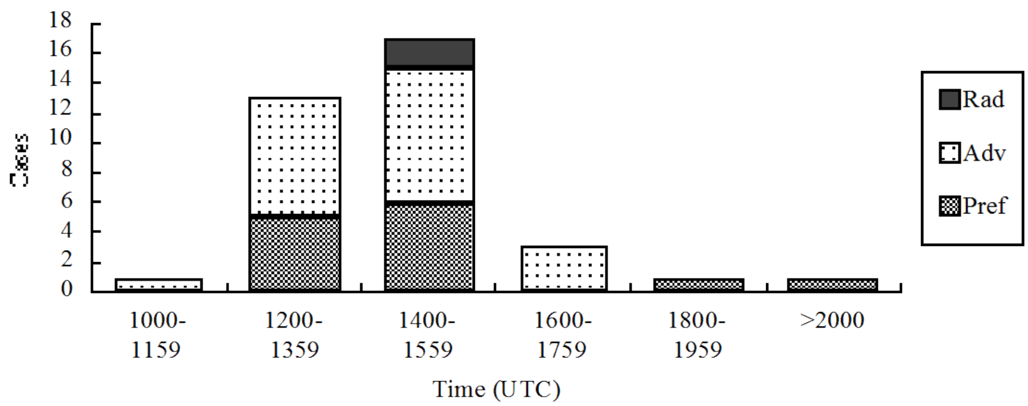


Figure 3. Time of Fog Dissipation at X68 for All Cases

Figure 4 shows X68's reported wind direction at the time of the fog onset or when the visibility at X68 decreased to less than 7 miles. In this figure it is evident that the prevailing wind direction at X68 for most fog events was out of the west (180° - 360°). Of the 36 cases, 34 reported a westerly surface wind component. Half of these 34 events had a surface wind direction from 240° to 299°. Only two cases reported a wind direction outside of the 180° - 360° quadrant. Calm winds were reported at X68 at the time of fog onset in one of the cases (27 April 1989). However, northwest winds of 3 to 5 knots were reported up to two hours before the fog formation. In the second case, the wind direction at X68 was northeast (7 January 1990). This case has been categorized as an advection type because the surface winds from several towers around X68 showed a northwest wind.

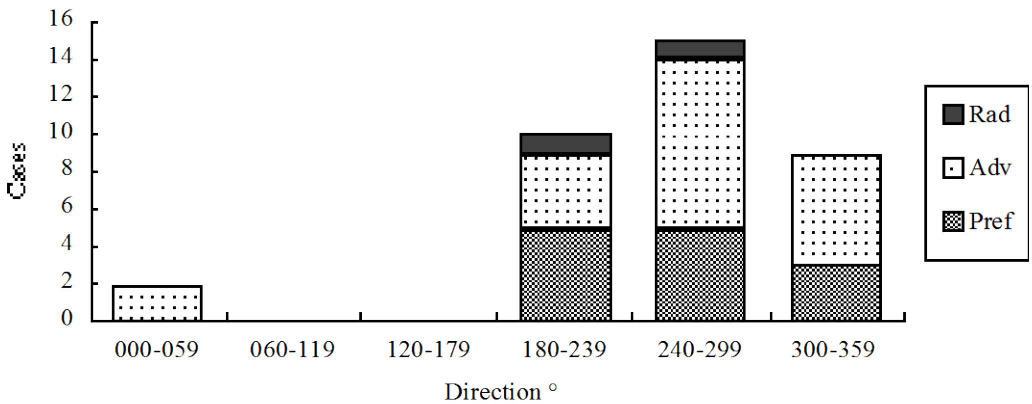


Figure 4. Surface Wind Direction at Time of Fog Onset at X68 (All Cases)

To facilitate analysis of fog precursor information, the AMU developed a MIDDS McBasi utility. The output of this utility, illustrated in Figure 5, is a graphic screen displaying the following data:

- Data from three local wind towers,
- A panel for tower 313 temperature comparison (see figure 6 for location of tower 313) ,
- Tabular data from tower 313 at the 6, 54 and 492 foot levels,
- Observations from Daytona Beach, Orlando, Patrick Air Force Base, Melbourne, and X68, and
- The Fog Stability Index (FSI) and the Fog Susceptibility Index (FSI313), both of which predict the likelihood of fog formation.

The FSI was developed by the Air Weather Service (1) to assist in the forecasting of radiation fog formation. The FSI313 is a modification of the Air Weather Service fog index which incorporates meteorological data from the CCAFS/KSC wind tower network. A more complete description of these indices is contained in the AMU's preliminary report on fog development at KSC.

Figure 5. Example of the McBasi Fog precursor graphic display.

Figure 6 Locations of mesonet towers over Cape Canaveral, Merritt Island, and mainland Florida.

Several flow diagrams or decision trees have been developed to assist the forecaster in estimating the probability of fog formation. These decision trees are preliminary and will be adjusted based on the results of the 1992-93 fog season. Some of the individual parameters can be analyzed up to 24 hours in advance, but the majority will need to be examined in the early morning hours using the 2200-2300 UTC Cape Canaveral rawinsonde and current local observations. Key parameters (i.e., local tower wind data) will need to be monitored up to 2 hours before fog formation.

The decision trees will define the general conditions in the Cape Canaveral area and produce a fog likely or unlikely result which can be used by the forecaster in his decision making process. See figures 7 and 8 for examples of the decision trees.

Figure 7. Fog Decision Tree, step 1

Figure 8. Fog Decision Tree, type of fog event

Development of fog in the central Florida region is associated with several precursors. These precursors can be identified and used to help forecast fog occurrence. The following is a list of precursors associated with the three basic fog types. These precursors are also listed on the prefrontal, advection and radiation fog guidance worksheets.

- Persistence is an excellent forecasting tool. If fog occurred at X68 the previous morning and no significant change is seen in the synoptic features, then fog is likely for the next day.

Advection fog development:

- Small surface dew point depression is important for fog development. If the depression decreases to 0°-3° F, then the probability of fog development is enhanced.

- Fog forms west of the Cape area first (up to two hours prior to development at the Cape). Surface observations from Daytona Beach and Orlando from 0000 UTC through the morning hours are indicators of fog advection.

- Placement of the surface ridge axis is crucial in determining the surface wind flow. If the ridge axis is south of the Cape, the likelihood of fog development is increased. If the ridge is north and forecast to stay north, fog development is unlikely (may have patchy ground fog).

- Time series analysis of tower reports is necessary in determining land breeze flow conditions. Towers 1012 and 719 should be used in this analysis. Westerly wind components increase the chance for fog formation. The wind tower data may show a double shift to a more westerly component. Fog formation often occurs within 30 minutes past the second shift.

- Analyze the 2200 - 2300 UTC Cape sounding. If the lower atmosphere is moist but dries rapidly above 850 mb fog can occur. If the sounding is moist up to 700 mb, fog is unlikely since this limits the radiational cooling.

- Strength of the low level inversion is important to fog formation. The forecaster needs to monitor the 6 foot to 500 foot temperature inversion at tower 313. The stronger the inversion, the more likely fog will develop.

Pre-Frontal fog development:

- If a frontal boundary exists from the Florida panhandle to the Cape and is forecast to pass the X68 area in the next 24 hours, then pre-frontal fog development is possible.

- Small surface dew point depression at X68 is important for fog development .

- If fog forms from Daytona Beach to Orlando, the probability of fog at X68 is increased.

- Time series analysis of the local tower data is necessary to determine the general wind flow. A shift in the wind direction to a more west to northwest direction, increases the probability of fog formation at X68 within 1 - 2 hours.

- Low level temperature inversion is required for fog formation. The forecaster should monitor the inversion from 6 - 492 feet at tower 313.

Radiation fog development:

- Fog development usually occurs near sunrise.
- Low level moisture (up to 900 mb) and drier air above 850 mb is necessary for fog formation.
- Surface dew point depression of 0 to 3° F are generally required for fog formation at X68.
- Surface winds are calm or have a weak southwest to northwest component (3 knots or less).
- A time series analysis of the local wind towers is necessary. Look for a shift in the wind direction to a more west to northwest direction (drainage wind, land breeze). The west shift in the low level wind increases moisture advection and better mixing.

Although this study deals with a small database, 36 fog cases over five years, it seems these fog events at X68, whether categorized as advection, pre-frontal or radiation fog, have similar characteristics. The major results from this study are:

- Many of the precursors for fog development can be monitored using existing sensor networks.
- Using decision trees and utilities for monitoring key elements of the local data sets, the forecaster can monitor environmental conditions and forecast the likelihood of visibility restrictions due to fog or stratus.
- A high number (92%) of the fog cases analyzed show a westerly component to the surface wind. In many cases a more westerly shift in the winds is apparent in the wind tower data prior to the fog development.
- For the advection and pre-frontal cases, 83% of the events had fog develop in the Orlando to Daytona Beach area first, up to 2 hours prior to development at X68.
- The primary onset time for fog development at X68 is between the hours of 0800 to 1000 UTC; the fog typically dissipates by 1600 UTC.

- A low level inversion, generally at or below 1000 feet is required.
- The data indicate that fog can still develop at X68 even when wind speeds are quite high at 500 feet above the surface (tower 313).
- Radiation fog events which produce rapid deterioration of visibility are rare, the vast majority of the fog events associated with rapid deterioration of visibility are either pre-frontal or advection type.

The majority of all the analyzed fog cases indicate that the fog or stratus develops or is advected in from the southwest to northwest. That area, the St. Johns River basin, is an excellent breeding ground for fog formation with its marshy conditions. The instrumentation presently in the area west of the Indian River to the St. Johns River basin is limited to 15 wind towers with wind direction and speed sensor at the 54 foot level. Adding instrumentation to measure temperature, dew point and relative humidity would be very beneficial to monitoring conditions over the fog formation area. In addition to adding instrumentation to the existing towers, installing Automatic Surface Observing Systems (ASOS) west of I-95 from the southwest to northwest would be beneficial. These ASOS sites would provide the SMG and CCFF forecaster with real-time information regarding cloud conditions, visibility with weather restrictions, temperature, dew point, pressure and wind direction/speed for the St. Johns river valley. This information would significantly improve the forecaster's ability to detect fog development over the St. Johns river valley and improve fog forecasting skill at X68.

2.4. Task 004 Instrumentation and Measurement (Dr. Taylor)

Implementation of MSFC DRWP Wind Algorithm

The first build of MSFC's new wind algorithm and associated displays was installed on the 50 MHz Doppler Radar Wind Profiler's microVAX in October. Several minor changes to the software were necessary to accommodate differences between the development and target environments. One major software change, however, was required. In the original spectral data ingestor, the data were not converted from IEEE floating point format to VAX format because the data were written directly to tape rather than stored or used on the microVAX. In order for the system to process the spectral data, the new spectral data ingestor had to be modified to convert the data to VAX floating point format before writing the data to disk for processing by the new wind algorithm.

After the first build of the new software was installed on the DRWP MicroVAX and the spectral data ingestor was modified, transmission of the raw spectral data from the Real-Time Processor to the Data Analysis Processor (i.e., the DRWP MicroVAX) was tested. The data which came across the parallel interface and was subsequently processed by the new wind algorithm behaved as expected and produced reasonable profiles indicating the communications between the parallel interface and the spectral data ingestor had not been compromised by the new software. The integrity of the data will be subjected to additional and more comprehensive testing in January and February 1993.

Development of the user interface controlling the spectral data processing began in early November and continued throughout the rest of the month. The user interface allows the operator to control the following items:

- Automatic or user controlled transmission of wind profiles to MIDDS.
- Selection of which profiles are transmitted to MIDDS when the system is configured for manual rather than automatic transmission of data.
- Display of wind profile data from the lower range gates or the higher range gates when the system is operating in six modes.
- Transmission of consensus generated wind profiles or new algorithm wind profiles to MIDDS.

The user interface was completed early in December. During the rest of the month, the software for displaying data from the most recent wind profiles (up to 10) was developed. Finally in late December, Build 2 of the new wind algorithm was installed on the DRWP MicroVAX.

Once Build 2 was installed performance testing of the system began. Initial results indicated that the new software would not be able to support three minute wind profile updates. Although the requirement for the system is five minute updates and the new software would satisfy that requirement, system response to user requests and prompts would be very slow and hinder system utility. Consequently, software modifications are being implemented to limit system input/output (I/O) which will significantly improve performance.

The necessary software changes should be implemented and tested by the end of January. The new software should then be able to satisfy the five minute update requirement for three mode operation and should then be able to support six mode operation with a dwell time of one minute per mode. A faster processor will be required in order to support more frequent updates.

DRWP Meteorological Evaluation

The preliminary report on the implementation of the new wind algorithm in NASA's 50 MHz DRWP was completed and distributed in December. That report included the software requirement specifications for the new wind algorithm, top-level software design information, and the preliminary results from the evaluation of the new algorithm. Comments and suggestions regarding the preliminary report will be incorporated in the final report to be completed and delivered in March 1993.

An abbreviated version of the preliminary results from the evaluation of the new algorithm were included within the AMU's quarterly report for the fourth quarter of fiscal year 1992.

After the preliminary report was distributed, additional analyses of DRWP data were initiated. The second set of data being analyzed is from a six hour time period on 23 January 1992. As with the first data set, DRWP profiles have been produced for five different DRWP configurations (Table 4). For each configuration, the profiles have been developed using the same first guess velocity profile which was developed from a time proximate jimsphere profile.

Table 4
DRWP Configurations

Configuration Number	First Guess Window Width	Integration Window Width	Minimum S/N Ratio
DRWP #1	6	10	-15
DRWP #2	6	20	-15
DRWP #3	12	10	-15
DRWP #4	6	10	-8
DRWP #5	12	20	-8

The new wind algorithm produced good results without any modifications to the first guess velocities during the 6 hour sample data period for each of the five different configurations. In addition, this data set clearly demonstrated the ability of the first guess technique to effectively track through weak signal regimes.

Figure 9 illustrates the spectral estimates and the resulting radial velocity for the east beam at 1831 UTC on 23 January 1992. For each range gate, the 256 spectral estimates were color-coded based on the relative magnitude of the estimates. For this report, the largest spectral estimates were color-coded black, the smallest spectral estimates were color-coded white, and spectral estimates with mid-range values were color-coded dark gray and light gray.

The radial velocity trace has been overlaid on the color-coded spectral estimates in white. Since the average Doppler shift (i.e., the radial velocity) of a given range gate is typically the largest spectral estimate, the diagram features a white velocity trace through a relatively dark spectral signal.

Most of the spectral estimates above 12 km are color-coded gray or black in figure 9. This indicates that the atmospheric signal is relatively weak for those range gates. In addition, the spectral signal is not very “clean” below 5 km. Even though the atmospheric signal is relatively weak in those regions, the first guess velocity technique was able to extract a signal and estimate a radial velocity. The accuracy of those estimates is still under investigation.

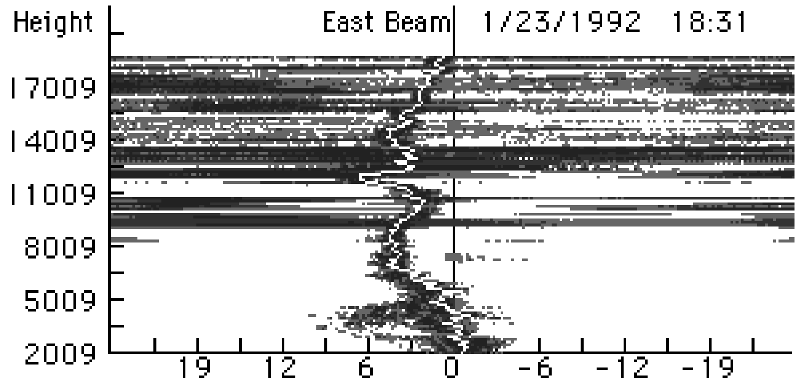


Figure 9 Spectral density display with the resulting velocity trace overlaid for 1831 UTC on 23 January 1992. Height is in meters and the horizontal axis is radial velocity in meters/second.

More important than the ability of the algorithm to extract the “correct” atmospheric signal when the signal is relatively very weak or virtually non-existent, is the ability of the algorithm to extract the atmospheric signal when a significant signal reappears after a period of time with relatively weak returns. This feature of the algorithm is illustrated by figures 9 and 10.

Figure 10 illustrates the spectral estimates and the resulting radial velocity for the east beam at 1852 UTC on 23 January 1992. As evidenced by the figure, the atmospheric signal is relatively strong at most all levels at 1852 UTC in contrast to the atmospheric signal at 1831 UTC. The new wind algorithm has correctly identified the atmospheric signal at all levels including the strong shear region at 12 km. It is important to note that the new wind algorithm did not “lose” the atmospheric signal during the period of weak signal some twenty minutes earlier.

The meteorological evaluation of the new wind algorithm will be completed in February 1993 and the final report will be written and distributed in March 1993. Completion of the evaluation will include a comparison of the 23 January 1992 DRWP profiles to time proximate jimsphere profiles and a comparison of DRWP profiles produced by the new wind algorithm to DRWP consensus profiles.

The final report will include recommendations for the default values for the key parameters within the new wind algorithm and quantitative information about the differences between DRWP consensus averaged wind profiles and DRWP new algorithm profiles.

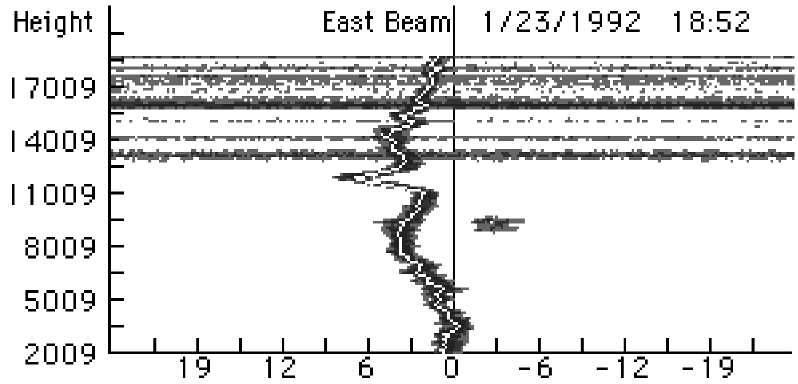


Figure 10 Spectral density display with the resulting velocity trace overlaid for 1852 UTC on 23 January 1992. Height is in meters and the horizontal axis is radial velocity in meters/second.

2.5. Task 005 Mesoscale Modeling

During the last quarter, the AMU has made considerable progress in the mesoscale modeling task. Communications and visits with personnel from both ASTeR, Inc. and MESO, Inc. have helped the AMU to proceed with the necessary preliminary duties prior to the MESO model installation. In addition, a data retrieval methodology has been developed to support model initialization and a wind analysis over the KSC area which uses NGM forecast data as a first guess has been created.

Although the AMU has not been tasked to evaluate the ASTeR, Inc. mesoscale model, it has been proposed as a potential task for the AMU for fiscal year 1994. Consequently, the AMU has expended limited resources to track to the progress of the ASTeR, Inc. SBIR and to ensure compatibility between ASTeR, Inc. and AMU computer resources.

Visit to Boulder, Colorado 19 - 20 October 1992

John Warburton visited the Boulder, Colorado area on 19-20 October 1992. The afternoon of 19 October was spent at ASTeR, Inc. talking to Dr. Walt Lyons about his plans for delivery of the RAMS model and RISC 6000 hardware under an Air Force SBIR contract. Several things were learned about the model to be delivered:

- The model domain is nested with the outer grid covering the Southeastern U.S. and the inner grid covering the KSC/Merritt Island area at a horizontal resolution of 10 km.
- The model to be delivered is essentially the full RAMS model except the cloud micro-physics are turned off. (Note: The model would have to run on a 1 km or less grid to use those features. The inclusion of explicit condensation more than doubles the run time.)
- The model runs in about 2/3 of real time on the RISC 6000 model 550.

- The speed can be increased to 1/4 of real time through vertical nesting over the inner grid. This change is planned prior to delivery.

- The HIPACT or diffusion module can do a diffusion simulation releasing 10,000 particles, covering 3 hours of simulation in 5 minutes of computer time.

Users of the system will be required to perform some interactive data quality control and must be conversant in the local weather system. Dr. Lyons' concept is to have the system show whether the simulation is red, yellow, or green - colors which would reflect the ability of the RAMS model to accurately predict the current weather situation.

Dr. Lyons made two requests, the first of which must be handled by the 45th Weather Squadron. It was requested that a chemical data base be provided as well as several accident scenarios, including amount of chemicals released and types of particles to be dealt with. The second request was for 24 hours of data in a format which would be passed from MIDDS to Dr. Lyons' system. The AMU assumed that when his system is installed, it will be located within the AMU, connected to the other UNIX systems in the AMU and will initially be receiving data via the AMU PS-2/80 computer. Accordingly, the AMU stored 24 hours of NGM grid point data, WINDS data, southeastern US and Caribbean rawinsondes, southeastern US and Caribbean SAO data, and the 50 MHz DRWP.

The morning of 20 October, Dr. Warburton visited NOAA/FSL and was given a demonstration of the DARE workstation and some 3D concepts which will be incorporated into the FX or follow-on DARE workstation. FSL has begun to test the RAMS model with LAPS for forecasting in the Denver area. Model output is displayed using AVS graphics which is a tool kit for developing 3D visualizations. FSL has the capability to do such things as simulate the view a pilot would have when landing at Stapleton Airport by "flying" the viewer through the model output data base. It is also possible to turn off the clouds and depict cold air spilling down through the valleys in a cold frontal passage. The work is visually exciting and would certainly be a great tool for teaching inexperienced forecasters how weather systems evolve. FSL plans to convert the DARE workstation to an open architecture UNIX platform using X-Windows and Motif to handle the graphical user interface.

Data Retrieval Methodology

Since the last quarter, the AMU has completed a method for the retrieval of data for model initialization. This has included the development of scheduling procedures and the development of data ingestors for the local data sets. To accomplish this task several MIDDS McBasi utilities were developed that transfer data from the mainframe MIDDS system to the IBM Model 80 and then to the IBM Model 560. This process, depicted in figure 11, has been used to gather sample data for ASTeR, Inc. and MESO, Inc. This process is also being used to retrieve mesonet tower data and NGM forecast data for a local wind analysis model.

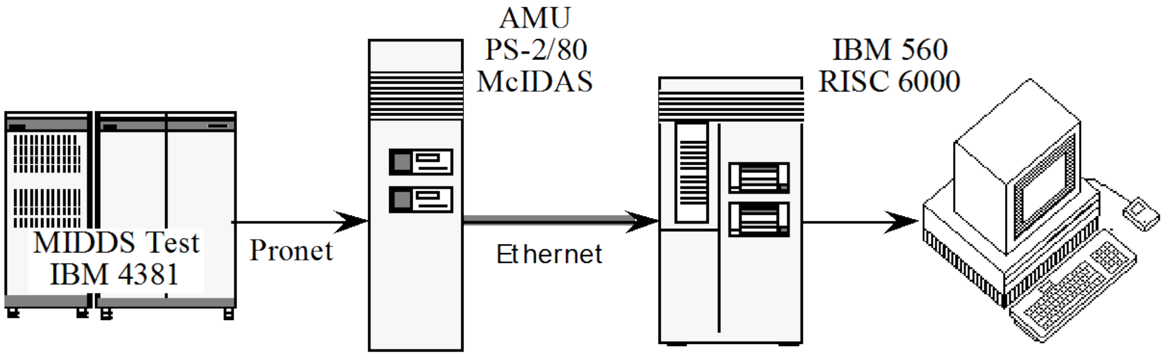


Figure 11. AMU mesoscale modeling data flow.

Meeting With ASTeR, Inc.

Dr. Walt Lyons and Dr. Craig Trembach of ASTeR visited the AMU on 6 November 1992 in conjunction with an update briefing to the Air Force on their Phase II SBIR. During the visit, we provided them with an 8 mm tape containing samples of surface, tower, rawinsonde, profiler, and MIDDS gridded data. The data formats are the same as those which will be used to support the RAMS model when it is installed late in FY-93.

Under the Air Force contract, ASTeR is scheduled to ship their hardware and model to KSC for a two week demonstration period in the July 1993 time frame. At the end of the two weeks, the hardware would be shipped back to Boulder until the end of their contract. We discussed the possibility of using the AMU's IBM Model 560 for the demonstrations. We do not believe this would be a significant impact on AMU resources. However, the AMU computer does not have a graphics board which would support the 3-D AVS graphics package used by ASTeR's software. (Note: when the AMU computers were ordered, we were not certain which graphics accelerator card would be required to support the MESO, Inc. and ASTeR models so we did not include any special graphics capability. It turns out that both vendors have chosen AVS as their graphics engine, making the upgrade decision for the AMU computer an easy choice.)

Meeting With MESO, Inc.

Dr. John Zack of MESO, Inc. visited the AMU on 24 November to discuss issues related to the installation of his computer and model into the AMU environment. He will be delivering a Stardent 3000, dual processor workstation and the MASS 5.0 model, complete with a full data assimilation package. As stated above, his system also includes AVS graphics for visualization of the analysis and model products. In the course of our discussions, it became obvious that it will be best to dedicate the Stardent 3000 to model analysis and forecasting and to ship the model output to the IBM 560 for data visualization. Use of the Stardent for both purposes makes it difficult for the computer to produce the forecast products in a timely fashion.

MESO, Inc. has made several improvements to the MASS model for delivery to KSC. The dynamic initialization scheme makes use of all local KSC data. In addition, one scheme has been developed to infer heating and moistening rates from MDR data and another has been added which derives synthetic relative humidity data from satellite infrared and visible imagery, surface-based cloud observations, MDR data and pilot reports. The model uses USGS land use/cover data and Normalized Difference Vegetation Index to specify surface properties such as albedo, roughness, and thermal capacity. A three layer surface hydrology scheme has replaced a simpler one and other improvements have been made to the model surface and boundary layer physics.

MESO, Inc. has developed a 100 case database for use in Model Output Statistics (MOS). This database will be delivered to the AMU to facilitate updating the MOS at a later date. All 100 cases were created through real-time runs using data obtained via internet from KSC and via dial-up with MIDDS.

In preparation for arrival of the MESO, Inc. system, the AMU will work with CSR to ensure the required data are available and can be transferred to the Stardent 3000 via PRONET and the AMU ethernet. One problem associated with the installation of the MESO system is the planned February 2-25 installation of equipment racks and consoles in the AMU by Harris Corporation. Because of possible conflicts with the console installation, delivery and installation of the MESO, Inc. system was delayed until early March 1993.

After Dr. John Zack’s visit and subsequent discussions regarding data requirements for the MASS model, AMU personnel provided Dr. Zack with an 8 mm tape containing samples of surface, rawinsonde, ship/buoy, tower, radar, and NGM gridded data. The AMU is awaiting a response to verify that these data formats are suitable for use in support of the MASS model; slight modifications may be necessary.

Development of Wind Analysis

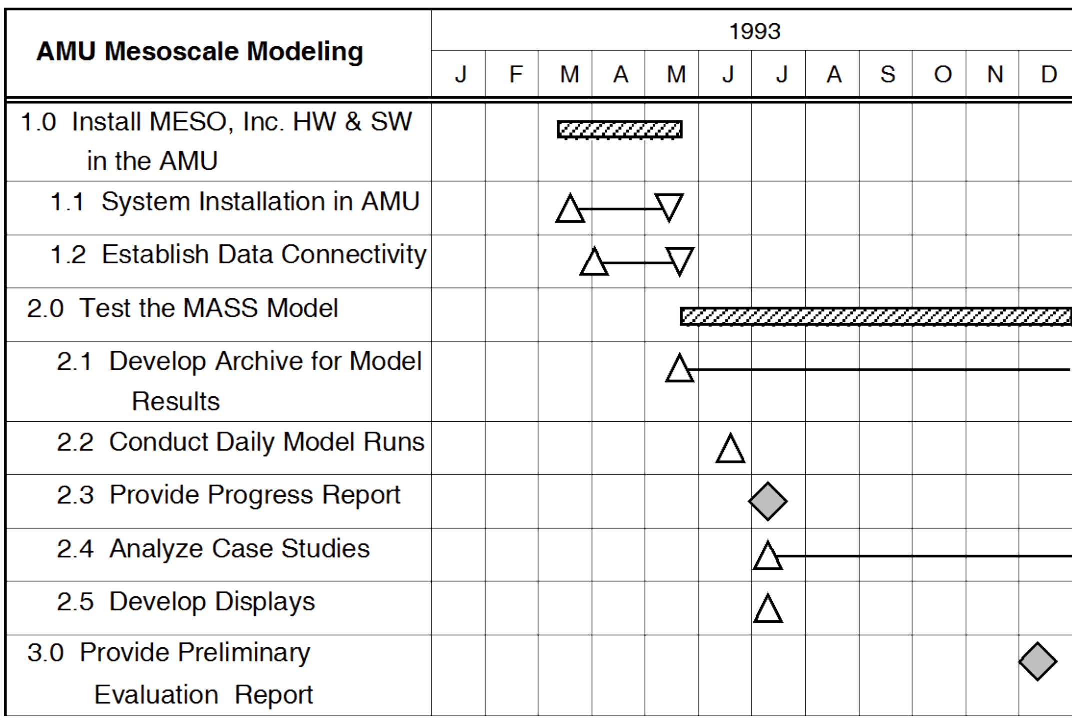
A simplified wind analysis is now working and is capable of running in real-time on the IBM RISC/6000. This wind analysis uses NGM forecast data for the first guess and then reported mesonet tower data to complete the analysis. During the initial development of the system, it was anticipated that the first guess would be provided by the new NMC MAPS analysis. It had been expected that this data would have been available via JSC MIDDS in the November 1992 time frame. However, this data is still not available and probably will not be until early spring 1993. Therefore, the AMU has initiated an effort to incorporate the NMC NGM forecast data into the system for use as first guess data. The NGM data are too coarse for operational use in the wind analysis. However, using the NGM data in the system will facilitate testing the procedures required to transfer the forecast grid data and the mesonet tower data across the network to the AMU computers.

For the wind analysis, a simple user interface was created to allow the user to choose a single height or a range of heights, and the type of graphic display: color or black and white. Figure 12 is an example of the wind analysis. The example shows the Meteorological And Range Safety Support System map background overlaid with wind barbs and wind vectors obtained from the 54 to 75 foot towers. The NGM forecast data was used as a first guess in this analysis.

Figure 12 Sample wind analysis for 8 January 1993. First guess field is based on NGM forecast data.

Mesoscale Modeling Schedule

The 1993 schedule for the mesoscale modeling task is shown below. The scheduled installation of the new equipment racks and consoles in the AMU has caused a slight delay in the delivery and installation of the MESO, Inc. system. However, work in currently underway to facilitate installation of the MESO, Inc. system upon its arrival. In addition, the purchase requirements for the Advanced Visual Systems, Inc. software (AVS) and IBM graphics processor card are being completed. The AMU expects the hardware and software will be installed in the AMU IBM RISC/6000 model 560 in time to support the testing of the MESO, Inc. system.



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 was charted for the first year and the AMU has continued on that course. A meeting to set new AMU priorities was held on 8-9 October 1992. As a result of that meeting, AMU priorities and tasks are being modified for fiscal year 1993. The short term tasks and priorities for the first quarter of fiscal year 1993 remained unchanged. The new tasks for fiscal year 1993 will begin in early calendar year 1993 and be included in the second quarterly report for fiscal year 1993.

3.1. Short Range Goals for FY-92 and 1st Quarter FY-93

- 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 Goals Identified in FY-92

- To complete the implementation of the MSFC wind algorithm on the DRWP and transition it to operational use.

- To implement and test the MASS model and analysis system to be delivered by MESO, Inc. by the end of 1992.

- To implement the wind analysis from NOAA/ERL’s LAPS system in real time on the AMU RISC 6000 computer during 1993. This will be followed by implementation and testing of the entire LAPS system.

- To implement a three dimensional meso-beta analysis and forecast system which is initialized from LAPS, includes 4-D data assimilation, which will produces forecast products out to 18 hours, and transmits graphics to MIDDS.

4. References

(1) *Air Weather Service Forecaster Memo,* February 1990, AWS/FM-9/001.

Attachment 1: AMU FY-92 Tasks

(Will be revised 2nd Quarter FY-93)

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.

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.

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 sub tasks. The initial two sub tasks are specified below. Additional sub tasks will be of similar scope and duration, and will be assigned by technical directives issued by the COTR.

• Sub task 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.

• Sub task 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.

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.

• Sub task 1 - STA Down link Test Support

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

• Sub task 2 - Airborne Field Mill (ABFM) Test Support

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

• Sub task 3 - Doppler Radar Wind Profiler (DRWP)

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

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.

- Sub task 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.