AD-A162 878 INTERACTIVE INFORMATION AND PROCESSING SYSTEMS USED FOR METEOROLOGICAL SU. (U) EASTERN SPACE AND MISSILE CENTER PATRICK AFB FL B F BOYD ET AL. 1985 ESMC-TR-85-06 1/1

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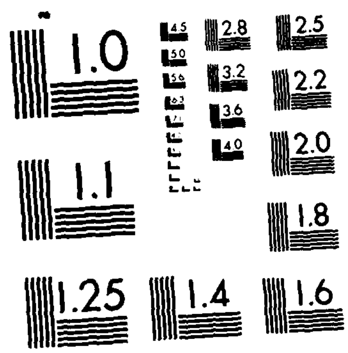

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SECURITY CLASSIFICATION OF THIS PAGE

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The report details various interactive meteorological systems in use at the Cape Canaveral Forecast Facility (CCFF) to support the Space Shuttle and missile launch operations at the Eastern Test Range (ETR). Weather requirements are discussed and data input/output described.

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INTERACTIVE INFORMATION AND PROCESSING SYSTEMS USED FOR METEOROLOGICAL SUPPORT TO THE EASTERN TEST RANGE

Billie F. Boyd and Lt Col Thomas M. Myers

Office of the Staff Meteorologist
Eastern Space and Missile Center
Patrick Air Force Base, Florida

1. INTRODUCTION

The United States Air Force (USAF) Air Weather Service's Detachment 11 of the 2nd Weather Squadron is tasked to provide meteorological and environmental support to the USAF Eastern Space and Missile Center (ESMC), the National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC), and the Department of Defense (DOD) Manager for Space Shuttle Support Operations. They provide weather support to the Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base (PAFB), KSC, and the entire Eastern Test Range (ETR) primarily through the Cape Canaveral Forecast Facility (CCFF). The CCFF is a 24-hour-a-day forecasting and observing operation. As part of its normal support, it provides specialized forecasts for all missile and space launches from the ETR/KSC and weather services for recovery forces. By far, the launch, landing, and ground operations of the Space Shuttle require the most precise weather support. All aspects of Space Shuttle operations are sensitive to some meteorological parameter. As the Shuttle proved itself in its early missions (see Table 1 for number of missions), and became operational with a significant increase in the number of scheduled missions (Table 2), it was evident that weather and weather support would become critical elements in achieving and maintaining the higher launch rate.

TABLE 1

SHUTTLES LAUNCHED BY YEAR

YEAR	TOTAL LAUNCHED
1981	2
1982	3
1983	4
1984	5

TABLE 2

PROJECTED SHUTTLE LAUNCHES BY YEAR

YEAR	TOTAL LAUNCHES
1985	13
1986	17
1987	23
1988	24

To deal with this problem, NASA and the USAF, at the local level, formed a joint Meteorological Systems Modernization Program (MSMP). This group is co-chaired by the Technology Projects Office of the KSC and the Office of the Staff Meteorologist of the ESMC. Part of that modernization effort involved improvements through utilization of interactive information and processing systems. Descriptions of those major systems currently in use are presented as well as a look at possible improvements.

2. THE METEOROLOGICAL INTERACTIVE DATA DISPLAY SYSTEM (MIDDS)

To assist the forecaster with the problems of integrating data from various sources and producing mission support products which use all of the available data in an internally consistent manner, the MIDDS was developed under contract with the Space and Science Engineering Center (SSEC). The MIDDS (Young, 1985) consists of an IBM 4341 computer with appropriate peripherals and workstations in supporting a variation of the Man Computer Interactive Data Access System (McIDAS) software (Suami, 1983). The system provides integration of the data sources available to the CCFF into a single data base where the various types of data can be melded and displayed together for forecaster use. It also provides growth for new data sources and allows for a significant increase in the applications which the forecasters and system users are expected to make after they become more familiar with the power of the system.

2.1 Global Data Bases

The data base consists of two general areas: global and local data. The global is (or will be) received via three sources: real time Geostationary Operational Environmental Satellite (GOES) data (including rapid scan data during critical mission periods), hourly meteorological data via an FAA 604 circuit, and gridded data via the National Weather Service Numerical Meteorological Center's products circuit. The first two are already in-place.

2.2 Local Data Bases

Unique local data sets consist of the following:

2.2.1 Micrometeorological Tower System

The Weather Information Network Display System (WINDS) currently consists of 28 met towers plus instruments on the launch complex towers. These locations are depicted in Figure 1. Sensors are mounted at heights of 30 to 54 feet plus one tower with sensors to 500 feet and two other towers instrumented to 200 feet. The tower sensors provide wind direction and speed, temperature, dew point and atmospheric pressure. Measurements are recorded at six second intervals and averaged to five minute reports.

2.2.2 Lightning Data

Lightning and lightning potential data are input from two systems. The first system is the Lightning Location and Protection System (LLP). As originally purchased in 1981, it consisted of three medium gain direction finders (DF's). These are now located at Melbourne, North KSC, and Orlando. This gives the system a base line of 37 to 43 miles. A low gain system has since been embedded within the original system. One low gain DF is located at Titusville-Cocoa Airport with the other sharing the medium gain location at North KSC, producing a baseline perpendicular to the Titan Launch Complex 40. To optimize accuracy and reduce background noise, the DF electronics are designed to respond to only those field waveforms characteristic of return strokes in cloud-to-ground flashes (Maier, 1984).

The other lightning information input into the MIDDS is the Launch Pad Lightning Warning System (LPLWS). The LPLWS consists of a network of 34 electric field mills located throughout KSC and CCAFS (Figure 2), and feeds into two primary software routines. The field mills measure the vertical component of the atmospheric potential gradient at ground level and permit the contouring of that information. During lightning activity, the LPLWS program determines which charge center was the source of the lightning activity and determines location and counts the number of flashes. Note that this system does not distinguish between cloud-to-cloud or cloud-to-ground lightning strokes.

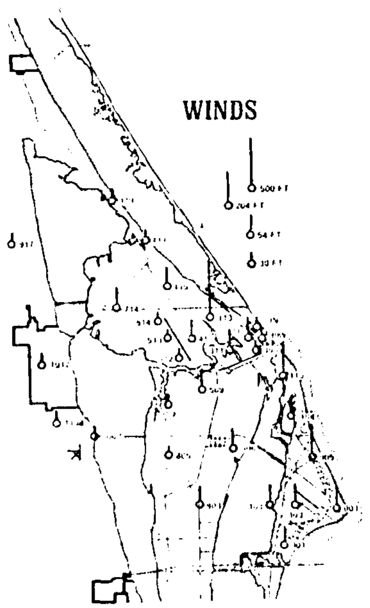

Fig. 1. Location of the Weather Information Network Display System (WINDS) Towers.

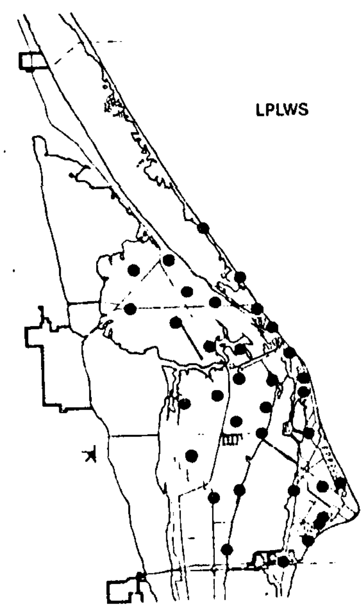

Fig. 2. Location of the Launch Pad Lightning Warning System (LPLWS) Sensors.

2.2.3 Weather Radar Inputs

Radar data are not yet input to the MIDDS; however, when the system is completed, local radar will be input, with major improvements. Currently a WSR-74C specially modified for C-band and for high density binning, with the antenna located at Patrick Air Force Base (PAFB), has a separate real time remote display in place at the CCFF. The CCFF also has a dial-up communications capability at 2,400 bits per second which is most frequently used to access the National Weather Service (NWS) WSR-74S (S-band) radar at Daytona Beach. The major improvement in radar to be input to the MIDDS will be volumetric scan data from the PAFB radar. This will be added to the MIDDS using techniques developed by the McGill University radar group and will be patterned after their Short-Range Automated Radar Prediction (SHARP) system. This system will send Constant Altitude PPI (CAPPI) scans, arbitrary vertical slices, and short term forecasts of radar echo movements to the MIDDS.

2.2.4 Upper Air Data

Other local data input to the MIDDS are frequent upper air measurements taken for

mission support. These data are input through interfaces with Nova and Cyber computers, and consist of radiosonde, rocketsonde, windsonde, and Jimsphere data.

2.3 Computer System

The heart of the current system (Figure 3), installed in January 1985, is an IBM 4341-M2. It is an intermediate sized computer with eight megabytes of real memory and 16 megabytes of virtual memory. The system as currently configured has 2.5 gigabits of disk storage and four forecaster workstations with supporting equipment. Plans are to upgrade the main computer to an IBM 4381, with the current system becoming a hot spare for redundancy, eliminating a single point failure. Upgrade of the work stations is also in progress, to smart terminals by use of a modified IBM A/T.

The MIDDS software can be divided into four categories of interest to the meteorologist. They are support software, interactive workstation software, meteorological software, and image processing software. The support software includes the ingestors which collect and file data coming into the system in real-time. These monitor the incoming data for

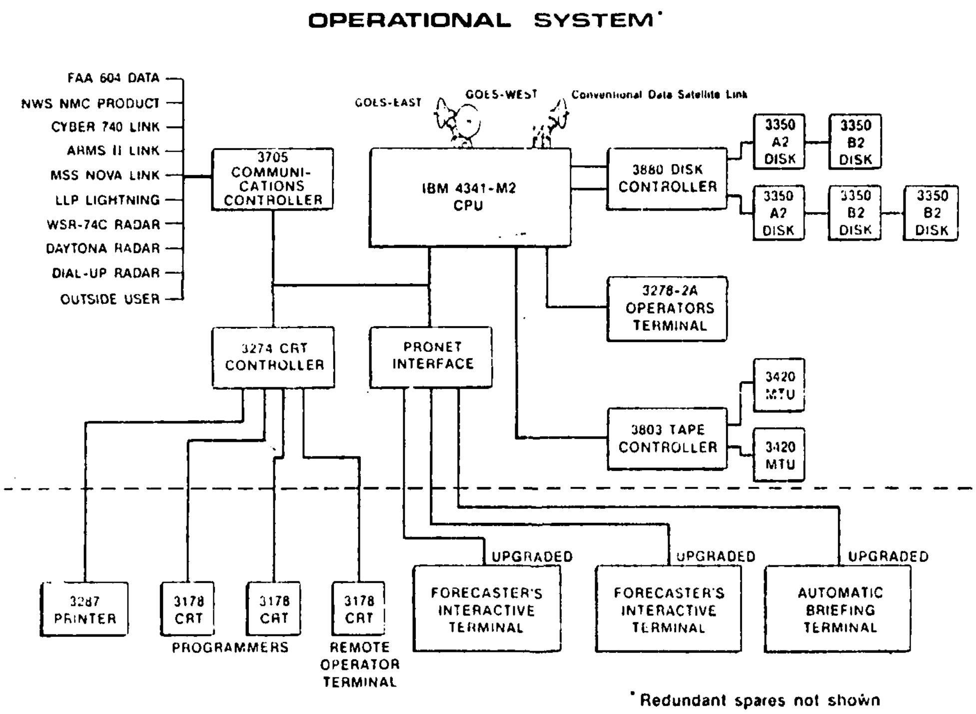

Fig. 3. MIDDS Computer Configuration.

unique events (e.g., Florida hourlies are in, a radar image is complete, the satellite has finished scanning Florida, etc.) and trigger other programs which sideplay or analyze the data based on these events. The system scheduler repeatedly starts any kind of activity based on time. This powerful facility builds displays of various products and maintains them automatically without forecaster intervention. The other major category of support software is the user interface building sub-system. This set of programs allows the user to create or modify plain language menu templates which invoke commands and processes with single stroke action by the user.

The interactive workstation software controls the workstation, and provides instant access to the image and graphic displays stored in the workstation. Other workstation commands provide looping of graphics, images, or both; annotation of graphics; superposition of graphics on images; interactive gray scale modification; and functional compositing of two images (e.g., for temperature enhancements of the visible satellite images, or satellite and radar compositing).

The meteorological software provides extensive capabilities for the forecaster to create products of interest. While it is not possible to detail all of the possibilities, the forecaster is able to:

1) list or print selected hourly surface, special and radiosonde observations in North America,

2) plot maps and meteorograms of the surface observations and NMC MOS forecast products,

3) objectively interpolate observations to a uniform grid and then generate streamlines, plots or contours,

4) plot and contour derived meteorological parameters, such as divergence, vorticity, equivalent potential temperature, forecast products, etc.,

5) plot hodographs, meteorograms, and Skew-T and Stuve thermodynamic diagrams which include stability parameters for the radiosonde information,

6) overlay plots and contours of conventional and special data on various map projections including satellite and radar projections,

7) track clouds to derive cloud motions, and

8) earth locate any point on the satellite image and to grid the image (using the navigation information supplied in each image by NESDIS).

The image processing software provides image display, image enhancement in gray scale and frequency domains, multi-image combination products, and dynamic 3-D loops of the satellite images. Navigation of all images uses first principles navigation when possible and allows transformation from an image or graphic coordinate system to latitude, longitude

coordinates or weather station locations. The various meteorological data bases and imagery can be integrated for quantitative information using a tailored graphic or cursor image to point to the location of interest.

3. THE METEOROLOGICAL AND RANGE SAFETY SUPPORT (MARSS) SYSTEM

The MARSS system is a primary safety tool in use at the CCFF to support the ESMC and KSC in all operations involving toxic chemicals. It is interfaced with the ETR Cyber 740 which provides data from the WINDS. Other than data input, the MARSS is a stand-alone, microcomputer driven, color graphics display system. The hardware configuration for the system consists of a TEKTRONIX 4109 nineteen inch smart color graphics terminal, a 4170 Local Graphics Processor (microcomputer), and a 4695 ink-jet color copier. The ink-jet copier allows the user to obtain a full color hard-copy dump of any display entered.

The primary use of the MARSS is to forecast the path and concentration of toxic clouds in the event of a spill or leak of toxic chemicals. This requires that it contain a good representation of the local wind field; consequently the system provides several very beneficial side uses for wind and thunderstorm forecasting. The system is entirely menu driven, with on-line help displays for all system functions. Major display functions are: BARDS, DIFFUSION, FIELD, HELP, REED, D.C./PLOT, and COMM/EXIT.

3.1 Field Display

Using the tower data at any selected level, a wind field can be generated, as illustrated in Figure 4 . (Note. actual display is in color.) MARSS uses the Barnes Objective Analysis technique (Barnes 1967, 1973), which is a successive correction algorithm with adjustable smoothing. The default parameters in the system for generating a wind field have been tuned to the CCAFS/KSC weather tower network. The vectors point in the direction that the wind is flowing. The length of the vector indicates the relative magnitude of the wind speed. The wind speed in knots of the largest vector displayed is indicated in the lower left of the map, above the date and time.

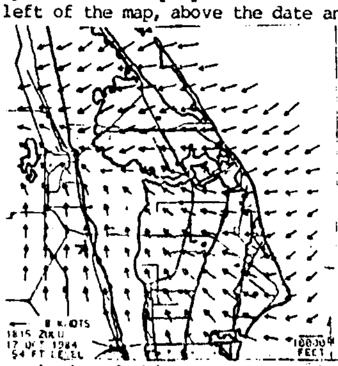

Fig. 4. Black and White representation of the local area wind field as displayed by the MARSS, FIELD function.

3.2 Dosage/Concentration (DC) and Diffusion Displays

The functions most frequently used are the BANDS, FIELD and TOWER. When required, the DC and Diffusion display functions provide the information required to assist ESMC and/or KSC safety staff on actions needed concerning hazardous spills or leaks of toxic chemicals.

Via the DC function, reference plots of downwind distance versus release rates for specified chemical species are available on an XY plot. The downwind distance is plotted along the X axis and the release rate along the Y axis. The corresponding spill pool size and spill volume are listed next to the release rate. The weather conditions and chemicals are listed above the graph. The Permissible Exposure Limit (PEL) concentration and the Emergency Exposure Limit (EEL) concentration levels are listed below the graph. The PEL curve is plotted in one color and the EEL curve is plotted in another color. The algorithm used to compute the downwind distance from the source to reach a specified concentration is the Ocean Breeze/Dry Gulch algorithm (Haugen, 1963). The name, Ocean Breeze/Dry Gulch, refers to the conditions under which actual test releases were performed during the early 1960's. These tests were held at the Cape Canaveral Air Force Station and Vandenberg Air Force Base to collect empirical data for algorithm development and verification.

The DIFFUSION function displays isopleths of four items, based on the wind field as discussed above. The four items displayed are:

1) a straight line forecast with a colored wedge outline, using only the wind measured (calculated) at the spill source. The width of the wedge is based on the standard deviation of the horizontal wind direction. Four standard deviations are used to define its vertex,

2) a different color display of a similar wedge type area derived from computed winds at each grid point along the trajectory corridor,

3) within the wedged area, the PEL is displayed with a colored ellipse (it is generated assuming off-axis Gaussian diffusion), and

4) the fourth item displayed is the EEL within the PEL.

4. MODEL SUPPORT

The third area where an interactive system is currently in use is the area of rocket exhaust and blast focus special models to support Space Shuttle launches. These models are routinely run, with graphic displays of both input and output used to assist the forecaster in providing Range Safety operational support.

REEDM is the name of the model used to forecast the diffusion of the rocket exhaust ground cloud. The REEDM computer code includes basic mathematical expressions for atmospheric dispersion models, cloud-rise models and models for calculating the gravitational deposition of acid droplets from the exhaust cloud. In addition to tabular output, four input parameters (temperature, potential temperature, wind speed and wind direction) are graphically output for easy identification of atmospheric changes. Figure 5 illustrates the vertical graphic representation of those four items, as well as a two dimensional layering of the atmosphere computed by the model. Isopleths of ground level HCl deposition shown by the example in Figure 6 represents the primary output of the model. MARSS also has the ability to display this output in color (via function REED).

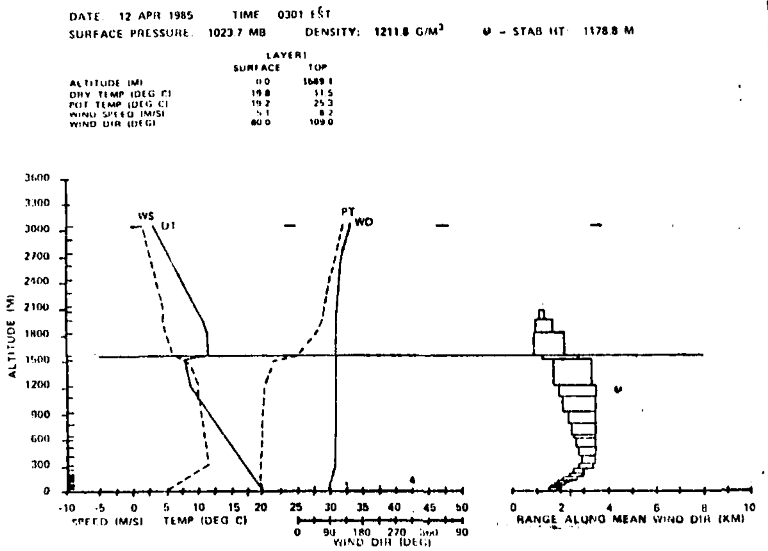

Fig. 5. Display of input fields to the REEDM (case illustrated is one for 12 Apr 85).

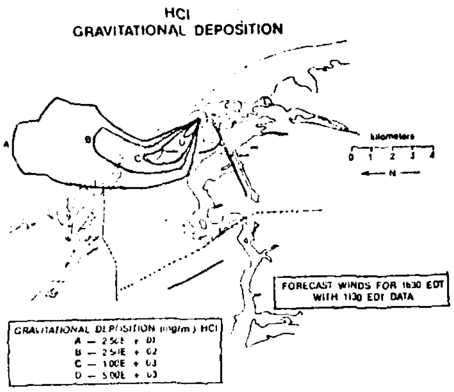

Fig. 6. REEDM ground level HCl deposition isopleths (case illustrated is one for 12 Jul 85).

The BLAST model evaluates inadvertent detonation hazards as a function of meteorological conditions. It is an interactive model, but currently all input and most output are in tabular format. One graphic used for rapid analysis is the change in the speed of sound with height as shown in Figure 7. Investigation is underway to better utilize graphics with this model.

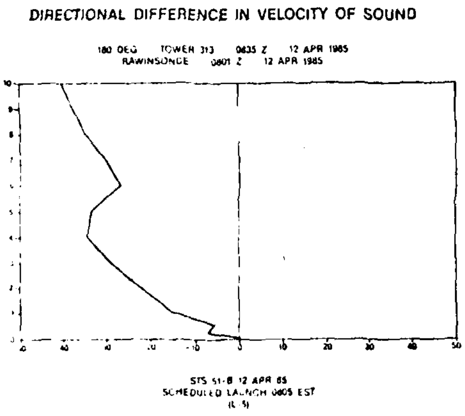

Fig. 7. Sample case (for 12 Apr 85) of directional difference in velocity of sound along the 180 degree azimuth as output by the BLAST model.

5. FUTURE PLANS

Improvements in both MIDDS and MARSS are under contract to the original developers: SSEC and ENSCO, Inc., respectively. At the time of the writing of this article, A. D. Little, Inc. has a contract with KSC for a "Weather Forecasting Expert Systems Evaluation and Feasibility". Pending results of this study, the possibility of including an Expert System would further involve interactive computers.

The Automated Weather Distribution System (AWDS) is under development by the Air Weather Service and when installed will add an additional system. The AWDS will provide five data types, as described by Ambros (1985):

1) alphanumeric, shipped from the Automatic Digital Weather Switch at Carswell AFB, Texas ,

2) formatted Binary, derived at the Air Force Global Weather Central (AFGWC) by computer from raw (alphanumeric) data inputs,

3) uniform Gridded Data Fields provided by AFGWC from analysis and forecast model outputs ,

4) Vector Graphics products, which are strings of points and instructions for displaying the points , and

5) Raster Products produced primarily from satellites.

6. SUMMARY

The Cape Canaveral Forecast Facility which supports today's modern space program utilizes the state-of-the-art interactive weather systems through the combined efforts of NASA and the USAF.

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