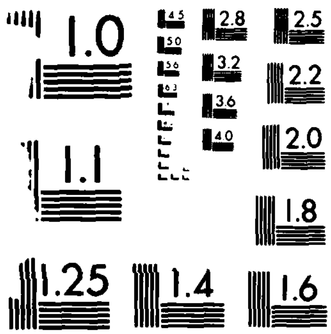
AD-A164 969 MODERNIZATION OF WEATHER SUPPORT TO THE SPACE TRANSPORTATION SYSTEM(U) WEATHER SQUADRON (2D) PATRICK AFB FL DETACHMENT 11 J E ERICKSON ET AL. 11 APR 85 1/1

UNCLASSIFIED 2WS/CP-85/003 F/G 4/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

(5)

REPORT DOCUMENTATION PAGE

1a. Report Security Classification: UNCLASSIFIED

3. Distribution/Availability of Report: Approved for public release; distribution is unlimited.

4. Performing Organization Report Number: **2WS/CP-85/003**

6a. Name of Performing Organization: Eastern Space and Missile Center

6b. Office Symbol: ESMC/WER

6c. Address: Patrick AFB, FL 32925

11. Title: **Modernization of Weather Support to the Space Transportation System** (UNCLASSIFIED)

12. Personal Authors: Lt Col John E. Erickson, Maj Thomas M. Myers, Billie F. Boyd

13a. Type of Report: Final

14. Date of Report: 11 April 1985

15. Page Count: 5

16. Supplementary Notation: ~~Announcement only~~. Presented at Second International Conference on the Aviation Weather System, Montral, Canada, 19-21 June 1985.

17. COSATI Codes: Field--04, Group--02

18. Subject Terms: *METEOROLOGY, *WEATHER, *WEATHER FORECASTING, SPACE SHUTTLE, SHUTTLE LANDING FACILITY

19. Abstract: Describes Space Shuttle launch and recovery weather requirements and constraints, Shuttle support mission of Detachment 11, 2d Weather Squadron. Discusses NASA-USAF Meteorological Systems Modernization Program (MSMP), and the group formed to administer it. Group is co-chaired by Directorate of Space Station and Advanced Projects, Technology Projects Office (PT-TPO) of Kennedy Space Center (NASA) and Detachment 11, 2d Weather Squadron (ESMC/WE) of Patrick AFB. Group's purpose is to upgrade in-place forecast technology to ensure the challenges of Shuttle weather support can be met.

20. Distribution/Availability of Abstract: Same as report.

21. Abstract Security Classification: UUNCLASSIFIED

22a. Name of Responsible Individual: Billie F. Boyd

22b. Telephone: 305 494-5915 22. Office Symbol: ESMC/WER

86 3 073

(5)

MODERNIZATION OF WEATHER SUPPORT TO THE SPACE TRANSPORTATION SYSTEM

Billie F. Boyd, John E. Erickson
and Thomas H. Myers

Office of the Staff Meteorologist
Eastern Space and Missile Center
Patrick AFB, Florida

1. INTRODUCTION

Probably the most difficult, and certainly the most visible mission of Detachment 11, 2d Weather Squadron of the United States Air Force's Air Weather Service is support to the Space Transportation System, commonly referred to as the Space Shuttle. In addition to the crucial weather support provided for launch and landings, we also have forecasting responsibilities for Cape flow operations. These operations begin with the arrival of the payload(s), which go to the various processing facilities where they are prepared for flight and eventually end up on the launch pad ready for mission. For the first nine Shuttle launches, the processing time varied from 668 days for the first launch to as few as 54 days for the eighth. Needless to say, there was a lot of contingency time during the first seven Shuttle launches so any weather delays could be absorbed. In the future, however, the goal is to reduce the processing time to 14 days between missions. A two week turnaround does not provide contingency time for weather. Any future delays in Cape flow operations caused by weather will have a resultant delay in the launch which could result in thousands, if not millions of dollars in excess costs. With this in mind, NASA and the USAF, at the local level, formed a joint Meteorological Systems Modernization Program (MSMP). This group is co-chaired by Directorate of Space Station and Advanced Projects, Technology Projects Office (PT-TPO) of Kennedy Space Center (NASA) and Detachment 11 (ESMC/WE) of Patrick Air Force Base (USAF). The purpose of this group is to upgrade the inplace forecast technology to ensure the challenges of Shuttle weather support can be met.

2. GEOGRAPHIC EFFECTS ON WEATHER

Foremost of the geographic effects on the area is the Atlantic Ocean and the associated land/sea breeze. The sea breeze occurs year round but is most common in the spring, summer and early fall. Florida's interior temperatures generally are 10-15 degrees higher than the surf temperature before the sea breeze begins during mid-morning. It normally lasts until around 3 hours after sunset. Speed of the sea breeze is generally 7-8 knots with gusts to 12-13 knots. With the Banana and Indian Rivers so close, a land breeze is not so discernible. When a land breeze occurs, it is generally from the southwest to northwest at less than 5 knots. The sea breeze creates an area of convergence referred to as the sea breeze front. The sea breeze front is the area of most frequent convective activity in the Cape area. The front generally penetrates 25-30 miles inland. Thunderstorms and rainshowers are common, but generally dissipate before the sea breeze retreats to the Indian River. The area borders on the highest frequency of thunderstorms in the United States, and in the summer months approaches as high a frequency as anywhere in the world. Central Florida has over 100 thunderstorm days per year, with approximately 60% of these occurring in three months, thus the chance of a thunderstorm on any given summer day is approximately 50%. Steering level winds (8000-12000 feet) with a westerly component will invariably bring these showers across KSC/CCAFS. When there is a strong discernible land breeze of over 10 knots, nocturnal thunderstorms and rainshowers will occur 30-55 miles out in the Atlantic Ocean. An easterly component steering level wind will bring these showers into the Cape area. The most frequent time of occurrence of these nocturnal showers is just before sunrise. Ample moisture in the area also can produce troublesome fog and stratus, especially from late fall through early spring. A slight upslope in the St. John's River valley is a frequent formation area for fog and stratus formation. However, most of this fog and stratus remain in the valley area unless gradient level winds (500 feet) are from a southwest to west-northwest direction at over 15 knots. Sea fog and stratus are rare in the area. These occur in the spring when the Gulf Stream meanders further westward than normal and there is a subsequent intrusion by the colder Littoral Current off Cape Canaveral. Generally, two or more days of persistent northwesterly flow precedes sea fog occurrences. Sea fog forms in the eddy areas between the two currents, and the onset of a northeasterly component sea breeze will move this fog and stratus inland.

3. CAPE OPERATIONS

The Shuttle Landing Facility (SLF) is located 4 miles northwest of pad 39A and is orientated 330-150 degrees. The SLF is 15,000 feet long and 300 feet wide with a 1,000 foot overrun on either end. The Shuttle Landing Facility is used only for landings of the orbiter and for practice landings and take-offs by the astronauts. All other landings in the area, for example by C5 cargo aircraft are done at the Cape Canaveral Air Force Station on what is called the Skid Strip. Payloads brought in by C5's are unloaded and convoyed back to the various processing facilities at KSC. When a payload is returned from outer space aboard the orbiter, the vehicle is towed back along the tow road to one of the Orbiter Processing Facilities (OPFs). In the OPF the payloads are removed, the payload bay is reconfigured for the next mission, broken tiles are repaired, brakes are fixed, etc. Once the orbiter is ready, it is towed to the Vehicle Assembly Building (VAB) where it is put in an upright position and stacked on top of the Mobile Launch Platform where it is mated with the Solid Rocket Boosters (SRBs) and the External Tank (ET). Once this process is complete the entire Mobile Launch Platform is transported along the crawlerway 4.1 miles to Launch Complex 39A, typically a 6 to 8 hour trip during which the vehicle is vulnerable to weather. The Mobile Launch Platform, along with the vehicle, is left on the pad after the crawler pulls out from underneath it. The vehicle is launched from the Mobile Launch Platform.

4. WEATHER CONSTRAINTS

When the vehicle is on the pad it can withstand steady-state winds up to 49 knots from any direction. Being in a hurricane area, NASA needs 48 hours notice of any hurricane or tropical storm expected to arrive in our area in order to allow time to get the vehicle back to the VAB. For launch, surface winds can't exceed 23 knots steady state or gusts to 34 knots (23G34) from any direction unless the winds are within a 60° arc centered on south. In that case, it can only take 15G24 knots. The reason for this difference is that when the vehicle is launched it has a tendency to drift northward towards the fixed service structure. If the winds are southerly in excess of 15G24 knots, the vehicle may drift too far north and possibly hit the fixed service structure. As far as landings are concerned, (Return to Launch Site (RTLS), Abort Once Around (AOA), and End of Mission (EOM)) the maximum gusts can be no greater than 25 knots head wind, 10 knots crosswind, or 10 knots tail wind. The 25 knot head wind and the 10 knot tail wind usually are no problem. Crosswinds, however, continue to be a problem. We also have ceiling/visibility constraints for RTLS, AOA, EOM; the cloud coverage cannot be greater than 5/10 and the visibility cannot be less than 7 miles. The landing process is still a manual operation requiring the pilot to guide the orbiter in; hence, the pilot must be able to see the runway. Temperatures cannot be greater than 99° or less than 31°. Greater than 99° is no problem because the maximum temperature ever recorded at the SLF is only 98°. Temperatures less than 31°F, however, can be a problem. During liquid oxygen (LOX) loading of the external tank the cold temperatures have a tendency to enhance ice buildup on the outside of the external tank. This ice buildup could then come loose during launch and would damage the thermal protection system tiles on the orbiter. In January 85, the launch of mission 51-C was delayed due to the occurrence of below freezing temperatures. For similar reasons, precipitation cannot be occurring at KSC or forecast for any of the return to launch sites, or end of mission locations nor for the period of ET loading through launch. In addition to these weather constraints, we also have severe weather constraints. Launch is not allowed when thunderstorms are within 5 miles or if the trajectory would be within 3 miles of an anvil cloud. Flight is also restricted through clouds with tops above -20°C. These constraints are due to the concern with induced lightning strikes. This actually occurred during the launch of Apollo 12 and, although it didn't affect the vehicle, NASA is very concerned with the effect a lightning strike would have on the highly computerized Orbiter. This concern was illustrated during the August launch of STS-8. Two hours prior to the launch, the Launch Director was ready to stop the count and delay for 24-hours because of thunderstorms. However, based upon the radar and the satellite pictures, we recommended he continue the count because we felt the system would move through and allow him to launch. Based on our forecast, he continued the count and NASA was able to successfully launch STS-8 with only a 17 minute delay due to weather. As mentioned before, thunderstorms and the associated lightning are a significant concern to KSC and CCAFS because we are in one of the highest areas of thunderstorm activity in the United States. The constraints for landing are the same as those for launch with the addition of no light to moderate turbulence. Although the crew can no longer eject, we still have "recovery area" constraints for the recovery of the SRBs.

TABLE 1

PROBABILITY OF NO-GO FOR NORMAL END OF MISSION FOR ANY ONE OF THE FIVE LISTED CONSTRAINTS

LOCAL TIME	HR 03	HR 09	HR 15	HR 21
MAR	46	57	65	44
JUN	30	47	75	39
SEP	37	51	75	47
DEC	45	49	49	40

Constraints:

1. Thunderstorms
2. Precipitation
3. Ceiling ≤ 20,000 feet or visibility < 8 nautical miles
4. Peak head wind > 25 kts
5. Peak crosswind > 10 kts

It's important that we be able to visually see the SRBs, thus the visibility cannot be less than 15 nautical miles and the cloud cover can not be greater than 3/10's in the SRB reentry section. Also, in the splash-down area, seas cannot be greater than 8 feet. A probability of no-go for weather constraints for normal end of mission landing is contained in Table 1 as extracted from the referenced NASA report.

5. IMPROVEMENT EFFORTS

It should now be apparent why we are undertaking this Meteorological System Modernization Program. The reasons are twofold: (1) because of the increased mission frequency and (2) because of increasing landing opportunities at KSC in the future. The mission frequency will increase from 3 in 1983 to as many as 24 launches per year in 1987. The net effect is that the time between launches will decrease from about 4½ months to as little as two weeks. This means the extraordinary effort on the part of the forecasters in the past must become ordinary effort in the future. It also means that critical weather decisions, such as occurred during STS-8, will occur more frequently. Secondly, there are the increased KSC landings. To illustrate the impact this has on weather forecasting, let's go through a landing scenario. The forecasting process actually starts about 24 hours prior to landing, at which time important decisions are being made. For example, do we deploy a convoy to Edwards, when do we start expending gasses, etc.? The forecast is continually up-dated and at the three hour point the decision as to where to land is made. The forecast is then up-dated again at the 90-minute point--the decision as to when to land is made. Somewhere near the 60-minute point, just after the last revolution passes over the United States, the final landing decision is made and the reentry rockets are fired. Once the reentry rockets are fired the Shuttle is committed to landing. While landing, it's essentially a 99 ton glider with no go around capabilities in the case of a miscalculation or unforecast severe weather. How to improve forecasts was not so obvious. We have undertaken a four pronged approach as follows:

5.1 Weather Towers

We had 16 permanent weather instrumented towers located throughout the CCAFS and KSC. These vary in height from 54 feet up to 500 feet. We had thirteen 54 foot towers, two 200 foot towers, and one 500 foot tower. To this system we have added nine temporary towers which extend the system westward. These temporary towers will give us better resolution of the low level flow and hopefully improve our forecast capabilities for thunderstorms which develop locally. The output from these towers is in both tabular and graphic display. The data are also input into our diffusion prediction model. Given the location of a toxic spill, the concentration, and the spill rate, the model calculates the direction of the diffusion, the span of the angle in which it will spread, and the distance down range the pollutants will travel.

5.2 Lightning Detection System

The second prong in our modernization effort was to upgrade our Lightning Location and Protection System (LLP). The objective is to improve accuracy of detection and location accuracy of cloud-to-ground lightning. We really have two systems; the initial system which was purchased in 1981 and an upgrade to this system. The original system consists of three medium gain direction finders (DF's) located at Melbourne, north KSC, and Orlando. This gives the system a base line of 37 to 43 miles. When a cloud-to-ground lightning strike occurs, the direction finders sense the azimuth of the electromagnetic wave associated with the strike and send the information back to a position analyzer which triangulates the position of the lightning strike. A DF consists of a pair of magnetic loop antennas and two flat electric field antennas. The system upgrade added a low gain subsystem embedded within the medium gain system. One low gain DF is located at Titusville-Cocoa Airport and the other shares the existing medium gain location at north KSC, producing a baseline perpendicular to the Titan Launch Complex 40. The upgrade gives us a video display output that allows one to see where the lightning strikes are occurring on a near real-time basis. The low-gain upgrade is being driven by four Titan requirements. First, they wanted better position accuracy; with the low gain system the detection accuracy of a lightning strike should be within 200 meters. Second, positive stroke detection was also required in the upgrade. In Florida about 99% of the lightning strokes are negative strokes which lower negative charges to the ground. The remaining 1% are positive strokes which lower positive charges to the ground. These positive strokes are much more powerful so our Titan customers also wanted the capability to detect them. Third, they wanted the LLP system tied to the Range timing system. Fourth, was the capability to record the output from the LLP system. Another lightning system on KSC/CCAFS is called the Launch Pad Lightning and Warning System (LPLWS). The LPLWS consists of [illegible] electric field mills on CCAFS and KSC. These field mills sense the static field at the ground level associated with a build-up of electric charge within the cloud. The information is sent to the Range central computer complex where it's processed and displayed on a terminal in graphic and tabular form.

5.3 Radar

The third prong in our modernization effort was to procure a new weather radar. The objective here is to replace the aging FPS-77 radar, with it's 60's design and 50's architecture, with a new WSR-74C radar. An unusual feature of this system is that the radar dome is located [illegible] miles to the south on top of building 423 at Patrick AFB while operational control is located [illegible] the Cape Canaveral Forecast Facility. The reason we have remoted the system is the RFI constraints [illegible] the Cape associated with processing of [illegible] payloads. Technically, the 74C has the capability to detect rainfall at the rate of [illegible] per hour. The reason we need this capability [illegible] detect very light precipitation is because of the errosive effect that even light precipitation [illegible] on the Shuttle tiles when the vehicle [illegible] in to land at Mach 1.

5.4 Analysis and Display System

The fourth prong in our modernization effort was to develop a weather analysis and display system. The Cape Canaveral Forecast Facility currently contains over 12 independent systems. The important point is that all of these systems are independent; before a forecaster can make a forecast, he/she must physically move around the room to analyze, interpret and integrate the data and then correlate the data to make a forecast. Needless to say, this is both time consuming and labor intensive. What we want to do with our weather analyze and display system is take all of these independent data sets and merge them into one central location where we can display them for the forecasters. We expect to accomplish this with our Meteorological Interactive Data Display System (MIDDS). The MIDDS is based on McIDAS architecture where the acronym McIDAS stands for Man-computer Interactive Data Access System. It's a computer aided weather display system developed by the Space Science and Engineering Center (SSEC) at the University of Wisconsin. One of the reasons that we went with SSEC is the 15 years experience they have in developing this weather display system. More importantly, however, are the three years of experience they obtained by putting in the Centralized Storm Information System (CSIS) at the National Severe Storm Forecast Center in Kansas City. CSIS is a user friendly system that was developed for the operational forecaster. Another benefit of SSEC's McIDAS based system is the fact that MIDDS will give us a state-of-the-art system as early as within two years. Additionally, it will expand our communications capabilities, not only locally but also to the decision makers at Johnson Space Center (JSC); it will provide additional data, especially with the improved radar data capabilities incorporated and near real-time satellite data; it will improve our short range forecasting capabilities; and probably as important as all of the above, it provides a strong technology foundation so that as forecast models become available we'll be able to incorporate them into our system. Also, MIDDS gives us off-the-shelf technology so there's very little in-house development effort to make the system work. MIDDS system configuration is shown in figure 1.

6. FUTURE PLANS

The MIDDS is designed with a "Bottom Up" philosophy. This design allows easy modification of the system for tailoring to locally unique sets, local area weather peculiarities and mission requirements. In this regard, the MSMP group hosted a workshop of government and university people last fall to assist in preparation of a 5 year plan to most fully utilize projects underway and locate what is currently available as "off-the-shelf" weather technology. This plan is expected to be completed this summer. As of the writing of this article, KSC is processing bids for a proposal for "Weather Forecasting Expert Systems Evaluation and Feasibility". The stated final objective of the Weather Forecasting Expert System project is "---to capture the mesoscale/nowcasting expertise and to have it resident in a set of expert system software, thus providing a real-time aid to new as well as experienced forecasters when under normal as well as stressed conditions. The project will also provide a system for training new weather forecasters in forecasting techniques for the endemic climatological conditions at the Kennedy Space Center. The existing forecasting expertise will be captured by incorporating the knowledge of the weather forecasting domain experts into an expert system set of software."

7. SUMMARY

The problem that we have is with weather support shortfalls for Shuttle operations, in particular the landings, because of the spacial and temporal accuracies required. The resolution to this problem has been a joint NASA/Air Force acquisition program with which we expect to minimize the impacts of weather delays on all facets of Shuttle operations.

8. REFERENCES

__________ (1985): Request for Proposal RFP #10-2-0049-5 for the Weather Forecasting Expert System Study, John F. Kennedy Space Center.

Erickson, J. E., (1984): Overview presented to the Meteorological Systems Modernization Program (MSMP) Workshop, Kennedy Space Center, October 3-5, 1984.

Erickson, J. E., B. F. Boyd, and J. W. Oliver (1985): Meteorological Interactive Data Display System (MIDDS) Data Base. Preprints International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Los Angeles, Amer. Meteor. Soc., 173-175

Landsberg, H., (1958): Physical Climatology, Gray Printing Co., Du Bois, PA, 446 pp.

Myers, T. M. and B. F. Boyd (1985): Status Report on the Upgrade of Weather Forecast Support to Shuttle Operations. Submitted for Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985.

Oliver, J. W., and Erickson, J. E. (1984): Meteorological and Interactive Data Display System. Proceedings Twenty-first Space Congress, Cocoa Beach, FL, 6-15 - 6-18.

Simoncic, A. A. (1983): Weather Support to the Space Transportation System, Preprints Ninth Conference on Aerospace and Aeronautical Meteorology, Omaha, Amer. Meteor. Soc.

Smith, O. E., G. W. Batts, and J. A. Willett (1982): Atmospheric Constraints Statistics for the Space Shuttle Mission Planning, NASA Technical Paper 2069.

Suomi, V. E., R. Fox, S. S. Limaye and W. L. Smith (1983): McIDAS III: A Modern Interactive Data Access and Analysis System, J. Clim. Appl. Meteor., 22, 766-778

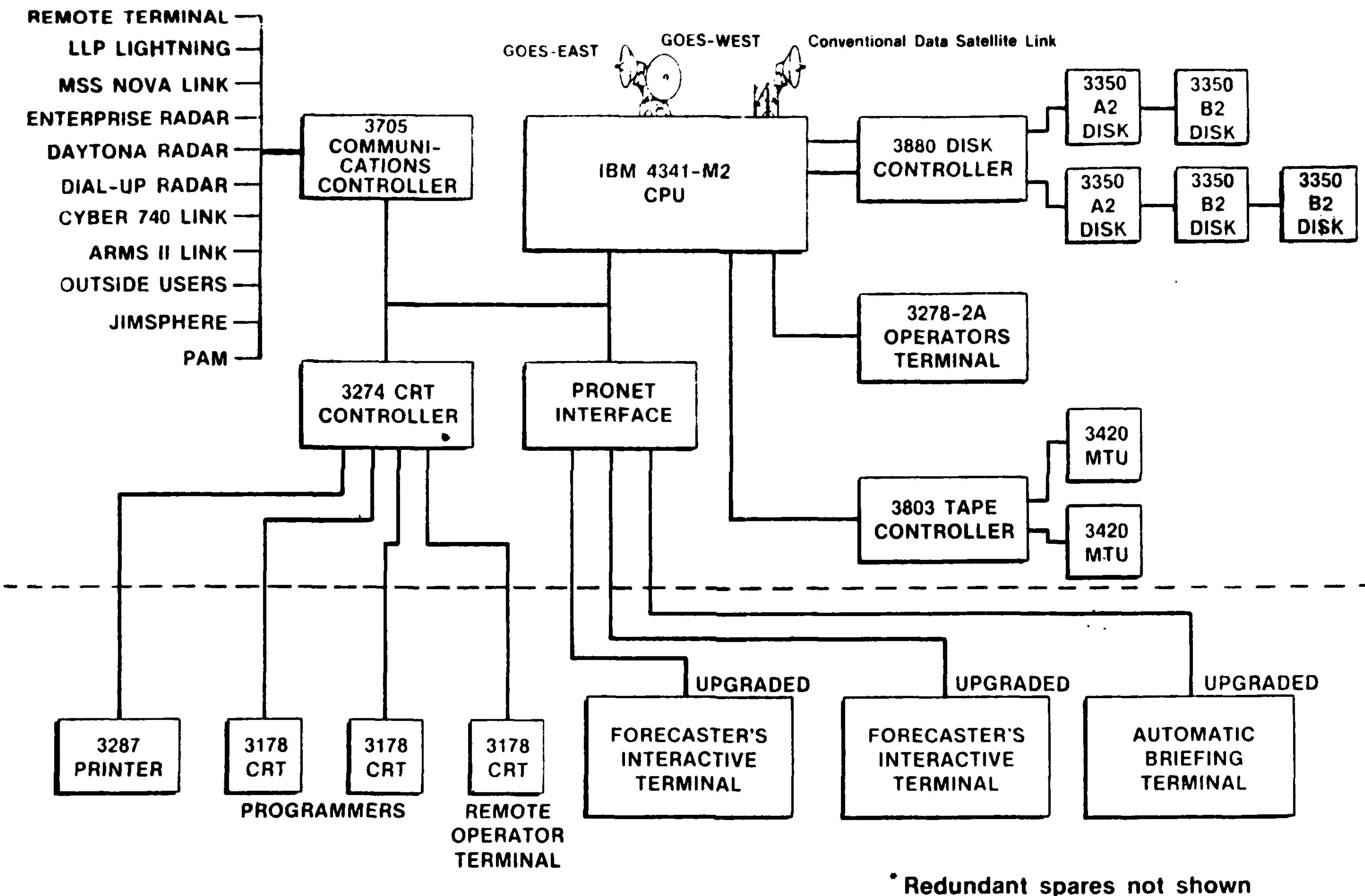

REMOTE TERMINAL
LLP LIGHTNING
MSS NOVA LINK
ENTERPRISE RADAR
DAYTONA RADAR
DIAL-UP RADAR
CYBER 740 LINK
ARMS II LINK
OUTSIDE USERS
JIMSPHERE
PAM
GOES-EAST
GOES-WEST
Conventional Data Satellite Link
3705 COMMUNI-CATIONS CONTROLLER
IBM 4341-M2 CPU
3880 DISK CONTROLLER
3350 A2 DISK
3350 B2 DISK
3350 A2 DISK
3350 B2 DISK
3350 B2 DISK
3278-2A OPERATORS TERMINAL
3274 CRT CONTROLLER
PRONET INTERFACE
3420 MTU
3803 TAPE CONTROLLER
3420 MTU
UPGRADED
UPGRADED
UPGRADED
3287 PRINTER
3178 CRT
3178 CRT
3178 CRT
PROGRAMMERS
REMOTE OPERATOR TERMINAL
FORECASTER'S INTERACTIVE TERMINAL
FORECASTER'S INTERACTIVE TERMINAL
AUTOMATIC BRIEFING TERMINAL
* Redundant spares not shown

FIGURE 1

END
DTIC
FILMED
4-86