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Functional and Performance Requirements of the Next NOAA-Kansas City Computer System (Appendix G)

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FUNCTIONAL AND PERFORMANCE REQUIREMENTS OF THE NEXT NOAA-KANSAS CITY COMPUTER SYSTEM

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Appendix G

NATIONAL CENTER UPGRADE PROGRAM
TABLE OF CONTENTS

Page No.

I. INTRODUCTION

The development of the Advanced Weather Interactive Processing System for the 1990's (AWIPS-90) will result in more timely and accurate forecasts with improved cost effectiveness. As part of the AWIPS-90 initiative, the National Meteorological Center (NMC), the National Severe Storms Forecast Center (NSSFC), and the National Hurricane Center (NHC) are to receive upgrades of interactive processing systems. This National Center Upgrade program will support the specialized inter-center communications, data acquisition, and processing needs of these centers.

In the preparation of this initiative, a document called "The Functional and Performance Requirements of the Next NOAA-Kansas City Computer System" by Schaefer et al (1983) was prepared. This document outlined the missions, current capabilities and general functional requirements for the upgrade to the NSSFC. The ground rules for preparing this document were to state the requirements without any regard for system costs. In view of limited resources being made available for the National Centers Upgrade, a validated requirements document is needed. An attempt will be made to validate and prioritize the requirements.

A sense of current system capabilities and performance will be given along with the requirements for the upgraded system.

II. BASIC ORGANIZATIONAL RESPONSIBILITIES

II.A. MISSION

The National Severe Storms Forecast Centr (NSSFC) in Kansas City, Missouri is the office responsible for forecasting severe thunderstorms and tornadoes throughout the contiguous United States. In addition to severe weather forecasting, NSSFC responsibilities include a variety of national and regional functions. The 85 meteorologists, meteorological technicians and support staff at NSSFC work round-the-clock and prepare national weather summaries, aviation forecasts and advisories to aircraft in flight.

II.B. OPERATIONAL UNITS

In order to fulfill its mission, the center is divided into semi-autonomous units, each with unique responsibilities and distinctive requirements. The operational units are:

II.B.1. The Severe Local Storms Forecast Unit (SELS)

The Severe Local Storms Forecast Unit has the responsibility for the issuance of severe thunderstorm and tornado watches for the contiguous 48 states. This unit maintains a continuous watch for thunderstorm activity and issues outlooks for general and severe thunderstorms for a 24-hour, 21-hour and 16-hour period ending at 6AM CST the next day. These outlooks are disseminated in both alphanumeric and graphic forms. SELS also issues, as required, from one to six hours in advance, severe thunderstorm and tornado watches for specific areas and time periods. Watches are issued for those areas where thunderstorms are forecast to produce one or more of the following:

1. Hailstones of 3/4 inch diameter or larger
2. Surface wind gusts of 50 knots or greater
3. Tornadoes.

II.B.2. National Aviation Weather Advisory Unit (NAWAU) Convective SIGMET Section

This section issues bulletins to aviation interests for in-flight hazardous weather phenomena of a convective nature (e.g., thunderstorms, tornadoes) for anywhere in the contiguous 48 states. These bulletins are issued hourly and describe the location, intensity, movement and trend of convective storms. This unit also routinely plots hourly radar reports from more than 100 sites in the U.S. and Canada, keeping the SELS forecaster briefed on significant storm development as depicted by radar.

II.B.3. National Aviation Weather Advisory Unit (NAWAU) In-Flight and Area Forecast Section

This section issues aviation forecasts for the 48 conterminous states based on guidance products prepared by NMC as well as terminal and route forecasts prepared by the various WSFOs. These forecasts are issued three times daily for periods up to 18 hours and include ceiling, visibility, precipitation, surface winds, icing and freezing level, turbulence and other weather elements of concern to aviation. The section also issues, as warranted, in-flight advisories on potentially hazardous flying weather for broadcast through FAA facilities to aircraft in-flight and directly to FAA and NWS personnel.

II.B.4. National Public Service Unit (NPSU)

This unit prepares weather information of a national interest. Its products include the National Weather Summary issued four times daily, the Selected Cities Weather Summary and the Travelers Forecasts, both issued twice daily. In times when a hurricane has entered the United States, a special National Storm Summary is produced every 6 hours to describe the storm's progress and the various weather watches and warnings that have been issued by Weather Service field offices. This unit also prepares special forecast summaries for national holidays. National dissemination of all products is achieved through an AFOS link-up with the National Meteorological Computer System which in turn distributes to users through Service C and NOAA Weather Wire Systems.

II.B.5. Satellite Field Services Station (SFSS)

The SFSS routinely receives and processes cloud photographs from the GOES spacecraft. These photos are displayed and interpreted for local use at the NSSFC. The SFSS also relays the satellite data over facsimile circuits to NWS Forecast Offices (WSFOs) in 23 cities within the Central and Southern Regions of the NWS, as well as other government agencies and some private and commercial organizations.

In addition to providing support to the NSSFC, a primary responsibility of the SFSS is to provide interpretative services to the WSFOs. In this capacity, the SFSS meteorologists act as consultants and directly contribute to the decision making process required to produce or amend forecasts and warnings. This is accomplished by direct telephone contact and Satellite Interpretation Messages (SIM), which are prepared and disseminated every six hours. The messages are based on satellite imagery and include information on all significant weather systems in the central portion of the U.S.

Recently the SFSS meteorologists began issuing Meso Update SIMs. This product, based on extensive mesoscale meteorological experience and state-of-the-art technology, is designed to provide the field forecaster a detailed interpretation of what will happen in the next 1-3 hours concerning significant features. Phenomena such as rapidly developing thunderstorms, merging cells, intersecting boundaries, and heavy snow are highlighted.

The SFSS has assumed the responsibility of evaluating the utility of remotely sensed atmospheric soundings from the GOES East VAS (VISSR Atmospheric Sounder). Working closely with NSSFC forecasters, the SFSS is evaluating VAS data as it applies to NSSFC's products in order to determine the value of acquiring high resolution soundings.

II.C. SUPPORT AND R&D TASKS

Support and R&D tasks at the center which require computer support are pursued by:

II.C.1. Techniques Development Unit (TDU)

The Techniques Development Unit of NSSFC is pursuing a program of organized research aimed at general improvement of decision-making procedures in severe storm prediction, the analysis of prediction errors, and the identification of weather conditions leading to warning requirements. The research team has as its main task the introduction of science, advanced technology, and the systematic study of severe storm forecasting. The unit serves as an interface transferring advances in mesoscale meteorology to the operational forecasters. The unit is skilled in the application of digital computers and modern interactive technology, in developing diagnostic programs and procedures, and in the analysis of errors in numerical prediction models. TDU continually interfaces with forecasters to understand the problems faced, to present them with new procedures for resolving these problems, and to sympathetically seek and receive the forecaster's reaction to the application of these procedures. The TDU also conducts the NWS convective watch/warning verification program. The verification activities may be expanded in coming years to include other types of watch/warnings.

II.C.2. Electronic Data Processing Unit (EDP)

The Electronic Data Processing Unit operates an AFOS-type Data General Eclipse computer system which is linked to the NSSFC AFOS computer and to NMC's IBM 360/195's. This computer system is used to process the voluminous amount of data received here at the National Severe Storms Forecast Center. It does much of the select-sorting, and calculations required to support the needs of the Center's various operational programs. The computer is also used extensively for research and the investigation of severe local storms and other weather phenomena.

II.C.3. AFOS Gateway Backup

Backup to the AFOS is supplied by the NSSFC computer system. When the NWS-Weather Monitoring Control Center's Gateway is not functioning, the NSSFC computer relays selected products from the FAA's communication system to AFOS and from AFOS to the FAA's communications system.

II.C.4. Central Region Headquarters (CRH) - Scientific Services Division (SSD)

The NSSFC computer system is used by the colocated CRH/SSD in the development of new AFOS products. The development and evaluation of new application programs are done on the NSSFC computer before they are released to the field. The NSSFC frequently makes use of these new products after preliminary evaluation has been completed by the SSD.

II.C.5. Maintenance and Administrative Support

The NSSFC has a staff of computer operators and electronic technicians tasked with the operations and maintenance of the NSSFC computer systems. In addition, there is currently technical word processing done on the system, center accounting, and inventory control programs run in support of administration activities.

III. CURRENT COMPUTER CAPABILITIES

III.A. DATA GENERAL ECLIPSE S/230

The Eclipse S/230 16-bit computer forms the backbone of the NSSFC computational capabilities. As presently configured (Fig. 1) this computer has 1,024,000 bytes of memory and has auxiliary storage on several disks including two 300 MB disks, diskettes and tape drives. Currently there are 36 terminals and communication lines active on the computer. It is noted that the present system serves as a word processor to the secretaries of TDU, SFSS and CRH-Data Acquisition Division (DATAC). This function is not anticipated for the future system. The requirements and usage of secretarial word processing is such that independent systems are more cost effective (ref: Feasibility Study for Purchase of Word Processing Equipment at the National Severe Storms Forecast Center, 1982) and thus should be used.

The Eclipse is interfaced to the NOAA computers in Suitland, the AFOS systems, the FAA-Weather Message Switching Center (WMSC) computers and CSIS. The Suitland link is via a remote job entry emulator with a 9600 baud line. Effectively, the Eclipse serves as a card reader, line printer to the IBM 360/195 system. Through this link large, computationally involved algorithms are executed in both operational and research modes. This link is also used to create data files on the NOAA computers for inclusion in NMC products. NSSFC products output to NMC over this link include severe storm and tornado watch box coordinates and the daily severe storm activity summary. NMC products input to NSSFC over this line include LFM forecast products not available over AFOS, a hourly bandpass analysis, and a back-up access to the WMSC surface and upper air reports.

Interfaces to both the NSSFC AFOS and the CRH AFOS exist. These interfaces allow products created at NSSFC to be disseminated over the AFOS network. Both charts and forecasts are transmitted this way.

The WMSC interface serves as the principal data source at NSSFC. Surface data, rawinsonde data and pilot reports are all obtained through this interface. This interface also serves as the main dissemination device for the aviation products.

Efforts are being made to get a second Data General Eclipse system to ease some of the current overloading problems as an interim measure until the National Center Upgrade can take over these functions. A Data General MV-4000 computer is being procured to serve as a back-up for the S-230. The MV-4000 will be slightly faster than the S-230, have 6 megabytes of memory and two 356 MByte disks when fully configured.

III.B. AFOS

NSSFC has two WSFO two-computer AFOS configurations. There are nine work stations (one A3G, five A2G, one AG, one AAG, and one AK) connected to the computers. Also the NSSFC AFOS systems are augmented by two tape drives and three 10 megabytes disks. AFOS is interfaced to the Eclipse system (Fig. 2). AFOS is the principal source of NMC products at NSSFC. Virtually all of the synoptic examination functions are performed on the system. A DIFAX facsimile circuit supplements the NMC products displayed at the NSSFC. The Eclipse/AFOS link is used to allow products generated on the Eclipse to be disseminated over AFOS.

CRH also has a WSFO two-computer AFOS configuration. The CRH has four work stations (three AK, one AGG) connected. The primary function of this system is regional monitoring. This function will not be part of the NSSFC upgrade. The CRH system is interfaced to the Eclipse system (Fig. 3). This interface allows the CRH to serve as a backup AFOS dissemination function of the Eclipse system.

III.C. EAS

The Electronic Animation System (EAS) is a microprocessor (Motorola 6800) controlled display system that animates the satellite imagery. The heart of the system is a large double-sided disk, holding 300 tracks (images) per side (Fig. 4). Video images are recorded on the disk by a system of multiple read/write heads which include fixed heads as well as one movable head on each side of the disk. Each head generates an independent channel of video output. Image sequences (generated by the movable heads) can operate in two modes: forward and then reverse or forward only (flyback). Images stored beneath the fixed heads (two more channels) can be combined (overlaid) with either animated sequence, a feature which allows grids to be corrected. The various combinations result in eight channels of video which are sent to channel select switches and then to the output monitor.

Input video signal is generated by a camera at the Data Entry Station (DES). This camera also contains the master synchronizing source for the system. By applying an external synchronizing signal to the camera, it may be gen-locked to that external source. Up to seven external signals can be input into EAS and distributed to the work stations via a channel select switch.

The Data Interpretation Station (DIS) is the remote controller used by the meteorologists. It communicates to EAS through the DES and can be locked out when the DES operator is entering pictures. The DIS has a trackball to control a video cursor. The primary use of the EAS is to maintain long duration animated sequences of satellite imagery. Both GOES-East and GOES-West loops are maintained showing continental views of the previous 24 hours satellite imagery.

The EAS is owned, operated, and maintained by NESDIS through a contract with G.E. Matsco. Although NESDIS is in the process of procuring a national upgrade of EAS type equipment, current plans do not include the NSSFC as an installation site. The current function of the EAS will be taken over by the National Center Upgrade system. The G.E. Matsco contract also provides for the monitoring of the GOES TAP phone line distribution to the approximate 75 users over a 21 state area. This sectorized satellite imagery distribution is transparent to the NSSFC operations. It is a NESDIS responsibility and it is assumed not to be part of the National Center Upgrade.

III.D. CSIS

The CSIS is an experimental four computer network which gives the operational meteorologist interactive capability and access to digital satellite data. It is built around 24-bit Harris/6 computers with 384,000 bytes of memory. Each computer controls a 300 megabytes disk and a tape drive. There are four interactive imaging work stations and four interactive non-imaging terminals connected to CSIS (Fig. 5).

One of the computers serves as a data base manager (DBM). Its function is to ingest data, decode it and store it in an accessible manner. The other three computers are applications processors (AP). These computers control the terminals. The AP's have access to the DBM. Most applications programs are run on these computers. CSIS was structured in this fashion so that data storage is not impacted by applications programs.

The imaging terminals each include an Intel 8085 microprocessor. Two of the terminals have storage for 42 image frames and 13 graphic frames. The other two have 64 image frames and 32 graphic frames. The image frames are six bit storage while the graphics frames have three bits. Each terminal has a keyboard, joysticks and a data tablet for input. Output is via a CRT, a color television monitor and/or a medium speed printer. Images can be colorized (via a false color lookup table), animated, manipulated and interlaced. A cursor can be used to obtain point locations within the image in any of four interrelated coordinate systems (pixels, image pixels, latitude longitude and location name). The graphics frames can be overlain upon the images. The non-imaging terminals consist solely of a CRT and a keyboard.

The DBM is presently connected to a GOES-East mode "A" satellite antenna system. Through this means, direct digital satellite data is ingested in real time into CSIS. The DBM is also connected to the FAA "604" line. This teletype circuit carries conventional data (surface observations, rawinsonde observations, pilot reports, aviation forecasts). There are also two auto-dialers hooked to telephone lines. These enable CSIS to obtain Kavouras radar data and lightning location data from the summer time Bureau of Land Management network in the western U.S. There is also an interface to the NSSFC Eclipse S230 computer. This interface gives CSIS access to AFOS and to the NOAA 360/195. A dial-in telephone port and a card reader are also present. Data ingestion is either by a clock-controlled schedule or by user request from a terminal.

The APs use the data stored in the DBM to generate products. The satellite data is sectorized, enhanced (in colors) and digitally manipulated. Routines exist to treat radar data in a similar manner. Radar data can be remapped into the satellite projection. Also composite presentations from more than one radar can be created. Satellite and radar data are stored as images. The "6Ø4" data can be listed, sorted, plotted, manipulated algebraically, contoured and mapped into various map projections.

The APs, in response to operator commands, totally control the terminals. Display and animation of terminal stored products are functions of the host computer. Responses to all operator interrogations of a terminal come from an AP, because of this the terminals are not classified as intelligent.

One unique feature of CSIS is that it is designed to operate in a "fail-soft" mode. The hardware on all four computers is functionally identical. Only software determines whether a CPU is an AP or a DBM. Terminals can be reconnected to any CPU via a patch panel. Thus, if one or more computer fails, the system can be reconfigured through a simple change of switch settings. Total failure of CSIS is highly improbable.

While CSIS is experimental, it is used in support of operations. The purpose of the experiment was to learn exactly what role an interactive computer could fulfill in the NSSFC environment. It was determined that there is indeed a need for such equipment at the center. The ability to actually manipulate the satellite imagery radiance values to estimate cloud height, motion and growth rate is useful to the forecaster. Further, the capability to rapidly create exotic analyses (e.g., equivalent potential temperature divergence) as direct overlays on the satellite image is an extremely effective tool for gathering information from our measurements. The ability to exactly locate cloud features not only with respect to its geographic location but also with regards to synoptic features is invaluable.

III.E. RADAR RECEIVERS

Radar data is available by a number of means. Manually digitized radar observations are received over AFOS and manually plotted every hour into a national composite (because the national composite from NMC is not available in a timely fashion). Individual radar imagery can be accessed via dial-up services. CSIS has access to radar via the Kavouras network switching center in Minneapolis, Minnesota. A stand alone Kavouras radar system is also available at the NSSFC. An autodialer allows direct access to 96 radar sites equipped with Kavouras transmitters. In addition, two stand alone NWS Radar Information Display (RADID) systems allow access to the FAA's Radar Remote Weather Display System (RRWDS).

Access to NEXRAD type products have been made available to the NSSFC on a test basis via a remote terminal. This terminal is not a permanent installation.

IV. SCOPE OF SYSTEM UPGRADE

IV.A. TIME FRAME

It is anticipated that the National Centers Upgrade will be part of the AWIPS-90 budget starting in FY 1986, with physical installation of the NSSFC system by 1988. The system will have to meet the requirements of the NSSFC through the late 1990s.

IV.B. EXTENT OF SYSTEM UPGRADE

The current computer systems at the NSSFC have been developed in a piece meal, uncoordinated fashion. It is envisioned that the National Center Upgrade system will replace the entire current system of computers and interactive terminals. This would include the Data General Eclipse systems, the AFOS terminal display functions (but not the AFOS communication functions), CSIS, the EAS, and the radar receivers. It is envisioned that future systems and requirements would be interfaced to the basic National Center system such that an integrated system approach would still be preserved, i.e., future data sources and future product requirements would be incorporated into the National Center system without stand alone work stations or processors. This dictates a modular system design with well defined interfaces. Likewise, the system needs to have spare cycles, memory space, and disk space at the time of delivery so that gradual growth and developments can take place. It is envisioned that the National Center system will be allowed to evolve during its lifetime.

IV.C. ANTICIPATED FUTURE EXPANSION

There are several factors which necessitate changes to the system over its lifetime. While it is difficult to fully anticipate future changes and their impacts, the following are some of the factors which must be considered.

IV.C.1. Organizational Changes

Currently there are no planned changes in the roles of the NSSFC. However, it must be noted that the mission of a national center evolves to meet the urgencies of the situation. During the last six years, four major changes in the NSSFC mission have occurred. The TDU research unit was established in 1976. With this addition, the computer demand at the center increased markedly. During 1978 the radar development unit (RADU) was disestablished. In its stead, the convective SIGMET unit with its mission was begun. This unit significantly altered the communication needs of NSSFC operations. All responsibility for local weather products was removed in 1979, when the Public Service Unit with its radar observation program was relocated. This obviated the need for direct communications from NSSFC to the local Kansas City media. In 1982, the aviation area forecast program of the NWS was centralized at NSSFC. This program again incremented the processing demands at NSSFC.

Recently there have been informal investigations into the possibility of transferring the national flash flood forecast responsibility to the NSSFC and expanding the verification program to include all types of watches and warnings. While no decision has been made yet on these additional responsibilities, the message is clear that the possibility exists for additional national forecast units to be added to the NSSFC.

The limiting factor in how many new responsibilities will be added to the NSSFC over the next 15 years will probably be floor space. With the anticipated elimination of the communications center and the EAS equipment room, there would be sufficient floor space for up to two new functional units. Hence, for planning purposes, it is conceivable that the current work environment of five units with ten work stations working round the clock could be expanded to seven units with 14 to 16 work stations. Hence, the National Center Upgrade system needs to have at least a potential 50% growth capability over its lifetime to account for organizational changes.

IV.C.2. VAS

The VISSR Atmospheric Sounder (VAS) is currently an experimental program on the GOES geostationary satellite. It is anticipated to become operational during the mid-1980s. VAS will provide remote temperature soundings in clear air throughout the day. It also will provide the visible, infrared imagery currently supplied by GOES and have additional imagery bands available such as atmospheric water vapor.

The VAS program development plan calls for a VAS Data Utilization Center (VDUC) to be established at the NSSFC. While the main VAS sounding processing will be done at NMC and transmitted to the field, the NSSFC VDUC will need to be able to ingest the raw VAS imagery, distribute the imagery to different users within the NSSFC, communicate with the NMC VDUC for access to processed fields, and process on demand soundings and sounding products over limited regions of interest.

The VAS VDUC functions should be incorporated into the National Center Upgrade system at the very beginning of the National Center Upgrade.

IV.C.3. NEXRAD

The next generation radar (NEXRAD) system for the weather service will start to be deployed in the late 1980s and be completely deployed by 1993. This system will not only replace the present WSR-57 radars, but will also augment their capabilities with the inclusion of Doppler measurements and onsite computer processing of the radar data. The onsite radar image and products data base will be accessible remotely via dial-up phone circuits with speeds up to 4800 baud. A large selection of products will be available, such as reflectivity and velocity image displays, echo tops, wind shear, severe weather probability, gust fronts, icing, etc.

The current radar access is through the dial-up capabilities of the NWS Radar Information Display (RADID) accessing the FAA Radar Remote Weather Display System (RRWDS) or through the commercial Kavouras system. Since there will be a five year period during which NEXRAD will be partially deployed, the National Center Upgrade system will have to support both radar access systems simultaneously during this transition period.

IV.C.4. GOES-NEXT

The current geostationary satellite system (GOES) will be replaced around 1990 by a new series satellite. The government is still preparing a request for proposals for this satellite system, and the exact details of data rates, etc., will depend somewhat on the vendor selected to build the system. The new satellite will have simultaneous sounding and imaging capabilities. The imaging system will have five simultaneous channels (visible, 11 micron window infrared, split window low level water vapor, 6.7 micron high level water vapor, and 3.9 micron near window infrared). The visible channel will have a one kilometer field of view at subpoint, the window channels will be four kilometers and the water vapor channel will be eight kilometers. The visible channel will be eight bits deep and the infrared will be ten bits. The imaging system will be able to scan the U.S. every five minutes, or the full disk every 25 minutes. The sounding system will be an infrared remote sensing system with fourteen channels. It will be able to sound the U.S. every 40 minutes. The data rate of GOES-NEXT will be approximately the same as the GOES mode AAA data (2.2 MBits/sec).

IV.C.5. Profiler

The wind profiler developed by ERL will probably be deployed in a nationwide network by the early 1990s. The profiler is a ground based microwave active sounding system. It can produce vertical wind soundings every five minutes with a vertical resolution of better than one kilometer. A test network of four wind profilers is currently in operation in Colorado. As part of the proposed STORM program and expansion of the basic weather service capabilities, a network of 70 or more profilers will be deployed by 1990. National distribution of the profiler network data will probably be hourly.

IV.C.6. Lightning

Lightning location data is currently not one of the data sets routinely used by the weather service. However, lightning location networks exist covering over half of the U.S. The Bureau of Land Management maintains a summer network west of the Rockies. The State University of New York at Albany has an East Coast network, and NSSL has a network covering Oklahoma. Outside access to these networks is generally available through dial-in ports over 300 or 1200 baud lines.

The technology for sensing lightning location is new and has not been standardized. Several groups in the government operations and in the research field are actively developing systems and networks. The weather service is looking into the technology of sensing lightning with the ultimate goal of producing lightning forecasts. It seems highly possible that lightning location will be one of the basic data sets available in the 1990s.

IV.C.7. Automated Surface Observing System

The deployment of Automated Surface Observing Systems (ASOS) is aimed toward further automation of observations. The principle goal of this program is to replace or augment the human observer at selected weather observing sites. While the current goal is to replace existing human observers, it is not inconceivable that automated observing stations would be deployed beyond the current surface observation stations.

IV.C.8. AWIPS-9Ø

The Advanced Weather Interactive Processing System for the 199Øs (AWIPS-9Ø) will replace the current AFOS communications network in addition to replacing the interactive AFOS display capabilities. The National Center Upgrade system will initially communicate with AFOS and then with AWIPS-9Ø when it is deployed. The basic communication system will probably change from a land based ring configuration to a satellite based system. It will probably have a high bandwidth broadcast function from a central site to all the field sites with a limited bandwidth return from each NWS office. Specifications for the AWIPS-9Ø communications are still being developed.

IV.C.9. ARF

The Aviation Route Forecast (ARF) is a digital gridded weather product designed for direct user access. The concept is being developed as part of the FAA's National Service Automation System. Forecasts are entered into a digital grid which are stored. When a pilot requests a briefing, route processing software retrieves the grid values along a corridor around the route he will be flying, and a briefing is assembled. ARF will allow site specific, user specific forecasts to be assembled by computers without manual intervention by a weather brief.

The FAA has been developing the ARF concept through contracts with the MITRE Corporation. This has included prototype forecast entry work stations as well as pilot briefing terminals. The goal is to have an operational system by 1987. The decisions as to which forecast offices will be responsible for the general forecast entry into ARF grids have not been made yet. However, since the NSSFC has some aviation forecast responsibility, it should be assumed that the forecast products produced by the NSSFC will have to be put in ARF grids. Hence the National Center Upgrade system needs to have the ability to prepare and disseminate forecasts on ARF grids.

V. REQUIREMENTS

The following are the perceived requirements for the National Center Upgrade at the NSSFC. Many of the requirements are reflections of current capabilities on one or more of the current systems. The following requirement section will try to include the basic requirements, a brief explanation of the reason for the requirements, the critical factors associated with each requirement such as timeliness, data volumes, etc., and a brief description which and how the current systems handle these requirements.

V.A. INPUT DATA

The NSSFC needs a large number of input data from a variety of sources. These data must be collected, processed, and displayed in a timely fashion in order to monitor the evolving weather situation.

V.A.1. Surface Data

Surface observations are one of the principal quantitative data sets used by the NSSFC. Such observations include readings of temperature, dewpoint, wind velocity and direction, sea level pressure, altimeter setting, ceiling height, cloud amount, visibility, any occurring weather, and added remarks. Surface observations are taken hourly at approximately 1100 sites in the contiguous United States, northern Mexico, and southern Canada. As weather conditions deteriorate observation frequency increases and special reports are transmitted. Synoptic observations are also reported by approximately 250 stations every 3 hours and summary reports every six hours. The hourly reports are used by all the forecast units, while the synoptic reports are used primarily by the National Public Service Unit.

Surface reports come from a variety of sources. About 25% of the observations originate from the NWS and are transmitted over AFOS. The rest of the observations are primarily made by the FAA and are collected at the FAA Weather Message Switching Center (WMSC). The current WMSC is in Kansas City, but future plans call for new centers at Salt Lake City and Atlanta by 1986. Data from the FAA and the NWS are relayed to each other through the NWS-System Monitoring Control Center's Gateway. The NSSFC provides the operational backup for the Gateway. The WMSC uses an FAA developed synchronous protocol.

Surface reports currently enter the NSSFC through a number of different circuits. The Eclipse has a direct synchronous link to the WMSC. Observations are continually ingested and decoded. Over 80% of the observation reports are available during the first 15 minutes of each hour. The com- puter operator has a continuous status report of the obser- vations received. When a sufficient number of reports are received, hourly maps of various parameters are produced. These map products have generally been completed by 20 minutes after each hour.

CSIS obtains surface observations from monitoring the FAA 604 teletype circuit which originates at the WMSC. Observations are continually ingested and decoded. Products are produced from the data file on demand of the forecasters and use all of the available reports up to the time of the request. The timeliness and completeness of the data from CSIS and the Eclipse are essentially identical.

AFOS also has surface observations which are primarily used as simple listing of observations because of the limitations of AFOS for locally generated derived products. The timeliness of AFOS data is essentially identical to the other two systems.

The NSSFC currently has three quasi-independent means of obtaining surface observations. Experience has shown that it is frequently possible for one reason or another that one of the sources will be inoperative while the others are supplying data. Because of the importance of the surface observations for the NSSFC operations, the National Center Upgrade system should be connected to two quasi-independent data sources, one NWS and one FAA. Data from both sources need to be continually ingested and decoded to insure operations. Because of the duplication of data, only one of the decoded data files needs to be processed.

The data volume of surface observations each hour from any one source is typically 80 to 100 kilobytes. Because of the growing number of observations made by automated stations, this volume should increase in coming years, possibly by a factor of two or more. Because of the need for time change analysis and synoptic overview considerations, the surface data must be maintained on the system for at least 24 hours. The surface data currently is archived onto tape every day. The archived surface data is used for case studies and local research programs. The National Center Upgrade system needs to have the capability to archive the surface data, read the archived data back into the system, and support simultaneous processing of current and archived data sets.

V.A.2. Satellite Imagery

Geostationary satellite imagery forms one of the main data bases of the NSSFC operations. Data is currently received directly from GOES-East via a roof-top antenna, and from GOES-West via phone line connections to GOES-TAP and the University of Wisconsin McIDAS system. Full resolution GOES-East coverage of the entire U.S. is provided from CSIS. Continental coverage by GOES-East and West is currently provided by the EAS displays. The National Center Upgrade system needs to provide full resolution GOES coverage from at least longitudes 65°W to 128°W, latitudes 24°N to 49°N. For synoptic surveillance, data with at least a 4 km resolution must be maintained over the area 50°W to 170°W longitude, 60°N to 10°N. Since no one satellite can adequately cover this region, both GOES-East and GOES-West data is required.

The current GOES satellites have a visible channel with a 1 km field of view and a window channel infrared channel with a field of view of about 8 km (which is over-sampled to 4 km for transmission). The current mode A data rate is 1.8 megabits/sec. Normal operations provide a new GOES image from each satellite every half hour except during severe weather RISOP mode when data is provided every 15 minutes. Research data sets are frequently produced with frequency as often as every three minutes.

When the National Center Upgrade is operational, the VAS instrument will be operational and the mode AAA will be the normal GOES transmission operations. Mode AAA will have a data rate of 2.2 megabits/sec, 1 km visible data, two simultaneous infrared channels, and a data block of approximately 120 kilobits per spin or 27 megabytes per image. Multiple spins per line allow the VAS to produce multiple infrared channels. The National Center Upgrade system needs to be able to ingest GOES mode AAA from both satellites, extract the visible, 11 micron infrared and at least one other infrared channel (such as water vapor) for display purposes, extract the multiple infrared channel data for sounding retrieval and other VAS processing, and extract the auxiliary data block. The auxiliary data block will contain some processed VAS data and other meteorological data of interest.

The VAS allows very flexible scanning schedules for the GOES satellite. The National Center Upgrade System needs to have the capability to ingest any of the scanning sequences which the GOES satellite may be used in. This would include rapid scan sequences, multiple spin sounding sequences, etc.

As discussed in Section IV.C.4., GOES-NEXT will become operational during the lifetime of the National Center Upgrade system. It will have simultaneous sounding and imaging capabilities, more channels, and more frequent scanning. The system needs to be expandable to include GOES-NEXT data. Since both GOES satellites will probably not be replaced simultaneously, the system needs to be able to support one GOES-VAS and one GOES-NEXT simultaneously during the transition period.

The current policy of maintaining a two geostationary satellite system is enforced by limited lifetimes of the satellites, and the cost of ground station equipment. Research and severe storm forecasting efforts would be greatly benefitted by a third GOES-Central satellite. While it is improbable that this would happen any time soon, it is conceivable that this could occur during the lifetime of the National Center Upgrade system. The ability to expand to ingest three simultaneous GOES satellites would be a desirable, but not required, feature of the National Center Upgrade system.

The data storage requirements for the National Center Upgrade system will largely be dictated by the volume of stored satellite data. The full resolution visible requirements stated in the previous paragraphs require an array of approximately 2400 lines by 6000 elements, or 14.4 megabytes per image (the six-bit visible data is stored as an eight-bit byte) for each satellite. The 4 km resolution data requires an array of approximately 1200 lines by 2400 elements or 2.9 megabytes per image for each satellite. The infrared is currently transmitted as a 4 x 8 km pixel, and stored as a 4 km pixel even though the radiometric field of view is 8 km. The storage requirements are based on a 4 km infrared pixel storage.

A 24 hour storage of the 4 km data base is required for synoptic surveillance purposes. A time interval of 30 minutes between images is required for this data base. During severe storm operations, RISOP data is obtained every 15 minutes. The NSSFC operations require a three hour sequence of the full resolution data. The GOES satellite can transmit at higher time resolutions. While the NSSFC operations do not currently ingest rapid scan data, and does not have an absolute requirement for this data, it would be highly desirable to have this capability in the National

Center Upgrade system. Rapid scan data of five minutes between images would need to be stored for the previous one hour.

VAS ingests will add a second infrared image (generally the water vapor) for storage and distribution to users. In addition, dwell sounding data would be ingested for computations of VAS retrievals and other products. The 12 VAS channels at 14 km resolution can sound the U.S. every 1 1/2 hours with current transparent VAS operations. This would require an array of at least 300 lines by 600 pixels to cover the area of responsibility. The VAS data is stored as 16 bit data. Each VAS U.S. data set thus requires 4.3 megabytes of disk storage. This data needs to be kept for one day.

The following is the anticipated satellite image storage requirements for the National Center Upgrade system. It assumes a worse case rapid scan operations on both satellites.

a. 1 hour visible U.S. every 5 minutes	346 megabytes
b. 1 hour IR U.S. every 5 minutes	22 megabytes
c. 3 hour visible U.S. every 15 minutes	346 megabytes
d. 3 hour IR U.S. every 15 minutes	22 megabytes
e. 24 hour IR hemispheric every 30 minutes	276 megabytes
f. 14 hour visible hemispheric every 30 minutes	161 megabytes
g. 24 hour water vapor (8 km) hemispheric every 30 minutes	69 megabytes
h. 24 hour VAS U.S. dwell soundings every 1 1/2 hours	69 megabytes
TOTAL	1311 megabytes

When GOES-NEXT becomes operational, the basic storage requirements will remain valid. Additions due to increased IR imaging channels would add 552 megabytes. The increased sounding frequency would add 69 megabytes. The 10 bit word length of the IR would add 97 megabytes to the basic data storage and an additional 138 megabytes to the additional IR imaging channels. The basic storage requirements already handle the rapid scan and higher spatial resolution of GOES-NEXT. Hence, GOES-NEXT will be expected to increase the satellite data storage requirements by 856 megabytes.

The system will not have an archive requirement for GOES data as this is being done by NESDIS. However, the system needs to be able to save and restore selected data sets for use in research and case studies. The system needs to have the capability to store at least one research data set in addition to the operational data sets. A research data set will be defined as three hours of 15 minute data from one satellite, or 184 megabytes of data. In addition to the capability to save and restore locally received satellite data, the system needs to have the capability of reading tapes of satellite data obtained from the official U.S. GOES archive at NESDIS.

The satellite data needs to be available in near real-time. Current operations of the GOES has the starting scan of the U.S. at three minutes after the half hour, and completing it by six minutes after. Current CSIS capabilities start loading satellite imagery at six minutes after the half hour and have completed all the various loads to all the various terminals by ten minutes after the half hour, or four minutes after availability of the data. As part of the requirements on the terminal load times in a later section, this four minute time period to load all the images would go to three minutes.

V.A.3. Radar Data

Along with surface observations and satellite imagery, radar forms the backbone of the information required for weather monitoring. These data are currently available in two forms, both of which are required for any future system.

National radar coverage is provided by the manually digitized radar (MDR) coded observations. These observations are taken nationally every hour on the half hour. The observations are on a grid of approximately 22 nmi resolution which contain the maximum reflectivity within the grid cell. Information on echo heights and movements is appended to the messages. AFOS is used to transmit the observations. The NWS guidelines for issuing SIGMETs specify MDR thresholds as criteria for issuance of SIGMETs. These SIGMET messages must go out at ten minutes before the hour. While a national compositeof MDR data is produced in Washington and transmitted over AFOS (and routinely used by the NPSU), it is not timely enough to be useful in issuance of SIGMETs.

Consequently, the MDR data is hand plotted as it is received over AFOS and is generally available 2Ø minutes before the hour.

Radar images for any specific site are available via dial-up services from over a hundred separate locations. Current capabilities use a Kavouras receiver, a dedicated CSIS interface to the Kavouras network, and two Weather Service RADID displays. These radar image products have an image size of 256 x 256 pixels, with threebits per pixel (25 kilobytes per image) and are received over a voice grade phone line (either 12ØØ or 24ØØ baud depending on the system used). The data generally take one to four minutes to be ingested into the system. Each radar has a limited diameter of coverage of about 25Ø nmi. Several radar sites are generally required to cover the area of interest of a forecaster, so the ability to ingest several radars, remap them into a common projection and display the resultant loops is required. CSIS currently provides this remap capability in a satellite projection. Radar loops are frequently displayed with satellite loops.

The radar image data is used in several fashions by different forecast groups. The SIGMET section use the radar image data to clarify and localize the information received from the low resolution MDR product (the MDR has a severe smearing of individual cells). The SELS forecasters monitor the radar along with the satelliteto determine the initial occurrence of convection in an area suspected of potential severe weather. The radar is also used to determine if watch boxes should be extended or the placement of new areas inside regions which have had heavy convection with extensive cirrus blow off.

The National Center Upgrade system needs to access the raw coded MDR data from AFOS, any national radar composites from NMC, dial-up radar image data, and NEXRAD image and graphic products. The MDR data needs to be received, processed, and displayed in a national composite within 1Ø minutes after the beginning of data reception (within two minutes after the end of data reception). The radar image data needs to be ingested from a number of separate sites, remapped and composited. The frequency of radar data needs to be consistent with the frequency of satellite coverage (15 minutes between images). Two separate forecast units (SELS and SIGMET) require access to radar data loops (either in original projection, or as composites), while a third (SFSS) could make use of the radar data on occasion. At least two and frequently three radars are needed for the composite by each forecast unit. Hence, the National Center

Upgrade system needs to be able to access and process at least six radar sites every 15 minutes. A growth potential to access and process an additional six sites (12 total) every 15 minutes would be desirable for support to the SFSS and potential future missions. The radar image data needs to be maintained for three hours to maintain consistency with the satellite data, making a storage requirement of 1.8 megabytes (3.6 with growth potential).

The NEXRAD radar system will start to replace the current radars by the end of the decade as described in section IV.C.3. The system needs to be able to support both the current radar access and the NEXRAD access during the transition period when NEXRAD is being deployed. The system needs to have the ability to access any of the NEXRAD products available to remote users. The NEXRAD products most likely to be used routinely by the NSSFC units will be the processed products such as the composite hazards chart. The system needs the ability to access at least three NEXRAD products per site for six sites every fifteen minutes. An expansion capability of either the number of products or the number of sites would be desirable.

The system needs to be able to save radar data. The ability to save image data should parallel the requirements of satellite, i.e., the ability to save the current data set and the ability to restore and process both current and historic data sets.

V.A.4. Pilot Reports

Quantitative reports of in-flight weather conditions directly transmitted by pilots form one of the primary data bases of the aviation forecasters at the NSSFC. Approximately 3500 reports of about 320 bytes each are transmitted a day (1.1 megabytes a day). They contain information on turbulence and icing in addition to cloud cover, heights, bases, winds and temperature. Of the reported conditions, less than 10% are of portentious conditions of turbulence or icing and require immediate attention. Primary transmission of pilot reports is via the FAA circuits.

The primary current use of the pilot reports is for information on turbulence and icing. Current capabilities of CSIS and the Eclipse AOS include complete listings of reports and edited listings of reports containing turbulence and icing information. The aircraft meteorological information is not routinely processed because of the extensive manual editing required of the pilot meteorological observations, and the non-synoptic nature of the observations. New systems such as ACARS and ASDAR promise an improved meteorological data base if they are ever deployed in sufficient numbers.

The National Center Upgrade system needs to have the ability to receive and decode pilot reports. Reports with icing and turbulence information need to be made available to the aviation forecasters as soon as they are decoded. The ability to decode the meteorological parameters should be included to support potential future efforts at generating an aircraft meteorological data base, and should have access to ACAR and ASDAR reports.

The system should have the ability to archive messages which contain reports of moderate or greater turbulence, moderate or greater icing, or low level wind shear, read these archived data back into the system and process both current and historic data sets.

V.A.5. Plain Language Messages and Coded Forecasts

Severe weather warnings, statements, summaries, forecasts, etc., are transmitted over NWS circuits and represent an important information source for all the forecast units. Message headers are used to route the messages to the appropriate forecast unit. Current operations use AFOS CRT displays or printers to read the various messages. For instance, SELS gets a printer output of all severe weather warnings and statements, which is used to update the SELS log of severe weather activity. The NPSU scans various statements and summaries on AFOS to obtain the background information required for the national summary products.

The total AFOS message traffic is approximately 14 megabytes per day, which represents a current upper bound on message traffic to be handled. (Since AFOS communication channels are currently saturated, if the communication rate is increased in the future, the potential exists for increased message traffic demand.) Additional message traffic is also currently received from FAA sources. Much of the current message traffic is not used by the NSSFC.

The National Center Upgrade system needs to have the ability to monitor message traffic and route appropriate messages to different work stations. The system should have the capability to store and display messages for the length of the duty cycle of the work station (typically between 6 and 24 hours except for verification activities which require an archive of messages). The system should have the ability to decode selected types of messages and automatically enter events into a log. (Current loggin operations are manual.) Logs would include the SELS log of severe weather events and an aviation hazards log.

V.A.6. Upper Air Observations

Upper air observations are a critical piece of information for all the NSSFC operations. The principal current source of upper air reports are rawinsonde observations which are routinely collected and transmitted every 12 hours (at 00 and 12 GMT). There are approximately 100 rawinsonde stations over the section of North America that the NSSFC has responsibility for. These data contain temperatures, dewpoints, wind direction, and speeds for various vertical points (typically 50) over each station. Rawinsonde information is contained in about 80 kilobytes and is transmitted twice a day. The data flow is essentially limited to 90 minute spans. Upper air observations are received via FAA Switch (WMSC) on the Eclipse, the FAA 604 on CSIS, and the AFOS.

While rawinsonde data is the only current source of upper air information, VAS soundings and Profiler wind soundings will be available routinely during the lifetime of the National Center Upgrade. VAS soundings and sounding derived products will be routinely available from NESDIS starting in 1986. These will provide upper air observations in clear regions throughout the day. Approximately 200-300 temperature and moisture soundings per hour could be produced with approximately ten levels of information. The wind profiler is a ground based active microwave wind sensor. A network of over 70 profilers may be in place starting in 1988. The profiler will have all weather capabilities. While wind data can be obtained every five minutes, the data available routinely to locations such as the NSSFC will probably be hourly. Approximately 20 levels of data can be obtained from the profiler. Plans for distribution of VAS and profiler data have not been made yet, but will probably be over conventional means of data communcations.

The National Center Upgrade system must be able to ingest, decode and store upper air observations from the U.S., Canada, and Mexico. Rawinsonde, VAS and profiler soundings should be ingested and processed. The option to include or exclude various types of upper air observations will need to exist for processing algorithms. Because of the needs for synoptic overview and change analysis, the upper air soundings need to be kept on the system for at least 36 hours and then archived in a manner similar to the surface observations. Also, similar to the surface observations requirements for two semi-independent paths of data entry, the rawinsonde observations should be available from two sources.

V.A.7. Centralized Charts

Charts distributed over the national NWS circuits form an integral part of the NSSFC data base. These NWS produced charts consist of analyzed fields (such as upper air observations), forecast products, and other graphical fields (such as the national radar composite). These charts are used by all the forecast units in the NSSFC. Previously these charts were received over a DIFAX line with hard copy output. The current operations have these charts coming mainly from AFOS displays. They are viewed either on the AFOS video display or printed and put on the wall. Wall mounted charts are saved for the month and then stored for use in case studies.

AFOS transmits charts using a line segment vector graphic technique. Future systems such as AWIPS-90 are expected to transmit chart information in a digital gridded format with the local processor drawing the lines through the gridded fields. Likewise many of the locally generated graphical displays described in later sections will use grids as an intermediate product.

The current AFOS graphics represent about 3 megabytes of data per day. Storage of locally generated intermediate grids will require approximately 13 megabytes additional. The National Center Upgrade system must have the ability to collect, store, and display charts generated externally and transmitted over AFOS. It must be able to be modified to accomodate charts or grids intended for chart generation which will be transmitted over AWIPS-90. It must have the ability to produce inexpensive wall mountable hard copy of these charts in addition to video displays.

V.A.8. NMC Fields

In addition to forecast fields received as charts over AFOS, the NSSFC requires additional numeric guidance products which are not available over AFOS. A remote job entry (RJE) port into the computer complex at the NMC is currently used to obtain these forecast fields. The fields are obtained either as an analyzed map composed of alpha-numeric characters and printed on the AOS system printer, or as a gridded field and transferred to CSIS for video display. Currently about 200 fields, twice per day, are obtained from NMC. This number is expected to increase in coming years. In addition to more operationally produced fields, it is anticipated that experimental mesoscale numerical model evaluation activities will require substantially more gridded fields sent from NMC to the NSSFC. As many as 600 grids of 1.6 kilobytes each could be expected twice per day, for a data volume of 2 megabyte per day.

The National Center Upgrade system needs to communicate with the NMC computer complex over a moderate speed link (9600 baud or greater). It must be able to receive, store, and display data produced at NMC. This NMC data could take the form of alpha-numeric observations or gridded fields. In addition, a capability to remotely program the NMC computers and to receive printed alpha-numeric output from NMC is required.

V.A.9. Lightning

As discussed in section IV.C.6., there exists a possibility that lightning may be one of the data inputs to the NSSFC during the lifetime of the National Center Upgrade system. As part of a NASA sponsored experiment, the NSSFC has received lightning data from the Bureau of Land Management network in the Western U.S., and judged the data to be useful. Lightning data is accessible remotely via dial-up phone connections and asynchronous protocols.

If, when, or how a national lightning location system would be developed is still not clear. It is desired that the National Center Upgrade system have expansion capability to allow future dial-out phone circuits (up to four) for lightning data collection.

V.A.10. Data Collection Platforms

The GOES satellite has the capability to relay data from remote data collection platforms. This capability is currently being extensively used at remote sites for river level monitoring instruments, buoy instruments, etc. None of this data is of interest currently to the NSSFC. However, the capability seems ideal for future deployment of remote automated surface observations, and as such may represent a future source of data.

The GOES data collection platform data is received via a standard GOES antenna and receiver, but with different electronics after the receiver. It would be desirable that the National Center Upgrade system have capability to add a data collection platform interface at some future date. Data volume would probably be less than two megabytes per day.

V.A.11. Input Data Summary

The following is a summary of the anticipated data inputs into the National Center Upgrade system. Table 1 lists the various data connections envisioned, types of data collected, line data rates, protocols used, and status of current usage.

V.B. Output Data - Forecasts

The main output product from the NSSFC consists of forecasts and watches. These are alphanumeric text data which must be transmitted to AFOS (and AWIPS-90), the NMC computer complex, and the FAA Weather Message Switching Center. Each of the five NSSFC forecasting units generate forecast messages with the length and frequency varying between units. Convective SIGMET messages go out hourly, aviation area forecasts (FA) go out three times per day, the NPSU Weather Summary reports go out four times per day, the SELS watches go out as needed, the SELS convective outlooks go out three times per day and the satellite interpretation messages go out four times per day. The text length varies according to the product but can be up to several pages long.

Forecast preparation is a major part of a forecaster's duties and needs to be made as time efficient as is possible. The National Center Upgrade needs to assist the forecaster preparing the messages by using word processing capabilities and graphical message generation assistance. The system also will need to support ARF type output products.

V.B.1. Forecast Text Preparation

The National Center Upgrade system will require word processing capability similar to standard secretarial word processing systems. Some of the required features would be:

- o ability to automatically perform carriage returns and line feeds as one types

- o ability to use "speed typing" where simple codes and/or keys are automatically expanded into stock words, phrases, sentences, or paragraphs o ability to easily cancel a command either before or <u>after</u> it has been requested (an undo function)

o ability to use pre-formatted forms fill-in

o ability to scroll up or down a document either by line, paragraph, or page

o ability to rapidly and easily locate the text which requires editing, such as using a cursor to locate the word, line, sentence, paragraph, etc.

o ability to edit and delete characters, words, lines, sentences, paragraphs, pages, etc.

o ability to insert characters, words, sentences, paragraphs, etc.

o ability to highlight and/or correct spelling errors using a programmable spelling dictionary

o ability to store and edit documents in user definable names

o ability to search for and locate characters, words, phrases, etc.

o ability to move characters, words, lines, sentences, phrases, paragraphs, etc.

o ability to handle multiple messages composition simultaneously from a single terminal and switch quickly and easily between the separate message (up to six simultaneous messages being processed)

o ability to copy and move phrases, lines, sentences, paragraphs, pages, documents between the separate messages

o ability to easily switch between word processing mode and system command modes.

o ability to accept textual information generated by processes other than keyboard data entry (such as graphic processor described next).

V.B.2. Forecast Preparation Using Graphical Inputs

Forecast messages contain frequent mention of geographically oriented information, such as lists of cities or regions affected by the forecast. This information can be most rapidly generated using interactive graphical means. A current example on CSIS is the generation of the SELS tornado or severe storms watch areas. The program allows the forecaster to put a watch area on the graphic overlay on top of the satellite and other displayed information. The system then allows the forecaster to interactively reposition and/or change shape of the watch area until it is oriented exactly over the area of maximum threat. The computer will then give the forecaster the geographic information necessary for the watch message (such as: 70 statute miles either side of a line from 20 miles south of Burlington, Iowa to 40 miles east-northeast of Benton Harbor, Michigan, and the latitude/longitude locations of the four corner points). Another example would be in order to define a region of a forecast, the forecaster would draw a line on the inter- active graphics and the computer would locate the string of weather station offices (or other appropriate landmarks) closest to that line which could be used as a textual description of the line.

V.C. Data Processing

An extensive amount of data manipulation is required for the National Center Upgrade System. Data must be ingested, decoded, checked, stored, retrieved, manipulated, intercompared, and displayed.

V.C.1. Sizing of Processing Development

The sizing of the computer processing requirements is difficult to do in detail at this time. One measure of the required computer sizing and development task is the existing systems at the NSSFC. The National Center Upgrade System must take over all the functions of the combined current systems. While there is a minor amount of overlap between current system functions, it is not significant. The current systems have consumed all current capacity so that any new system needs significantly more capacity than is currently available.

The current CSIS package has 1380 major software modules with 194,000 lines of code. The AFOS system has approximately 100,000 lines of code in the basic system and display functions used at the NSSFC. The AOS operational code is estimated at well over 100,000 lines of code although an actual count of lines is not available. While some code may be able to be salvaged from current systems, it is unlikely that extensive amounts of current code will be utilized in the Nationl Center Upgrade System because of the basic differences and incompatibilities among the current systems.

Hence, a development effort of well over 400,000 lines of code can be anticipated for the National Center Upgrade System at the NSSFC.

The sizing of the computer requirements needs to be based on processor load requirements and timeliness requirements. The current system has eight computers with a combined processing speed of approximately 2.4 million instructions per second and disk storage of over 2.5 gigabytes. As mentioned, the current systems are inadequate, so the National Center Upgrade must anticipate significantly more computer resources than are currently available.

As part of sizing the computer processing tasks for the National Center Upgrade System, the following is a brief description of the basic processing requirements.

V.C.2. Data Ingestors

Ingestors are required for all the input data types discussed in section V.A. This includes surface hourly observations from two quasi-independent sources, geostationary satellite imagery from two antenna sources, manually digitized radar data, dial-up radar data, pilot reports, plain language messages, coded forecasts, radiosonde observations, VAS sounding products, profiler products, centralized NWS distributed AFOS charts, NMC gridded digital forecast products, and probably lightning data collection platform, GOES-NEXT, and NEXRAD products. Refer to section V.A for details on the different data types and Table 1 for data speeds, protocols, etc. Format information on each of the data types required for writing ingest software will be provided in later documents.

As part of the ingest systems, provisions must be made to scan product header records and determine if the product should be ingested. As part of the AFOS ingestor, currently over 7500 separate header identifiers are ingested. The current system allows growth to up to 10,000 headers. Other data sources such as FAA products require header record identification, but are much more limited in number of headers as compared with AFOS.

V.C.3. Decoders

Many of the data products require decoders to extract the required quantitative information from the text originally designed for manual reading. Decoders currently in use include a surface hourly observation decoder, a ship and buoy decoder, a mandatory level radiosonde decoder, a significant level radiosonde decoder, a terminal forecast decoder, a manually digitized radar decoder, a pilot report decoder, a remarks decoder, a FP4 forecast decoder and special decoders for Mexican and Canadian data sources. Future plans call for FOUS R1, R2 and R3 decoders of forecast data products, and possibly decoders on watch, warning messages for use in automating verification efforts.

Decoders are required for several reasons. The primary is to process quantitative observations into a form where they can be stored by the data base management system. A second is to allow computer monitoring of message traffic and alert the forecaster to messages and conditions which require attention. For instance, pilot reports are currently monitored for remarks concerning turbulence and icing. Surface observations are monitored for remarks on high wind, sudden pressure changes, particular cloud types, severe weather, thunder, etc. These particular remarks are listed out for the forecaster. In the case of extreme conditions, the CSIS system uses a voice sythesizer to alert the forecaster to the hazard. The National Center Upgrade System requires decoders similar to those currently in use and the ability to monitor message traffic for pertinent information.

V.C.4. Quality Control of Incoming Data

After data has been ingested and decoded, it needs to be quality controlled before being filed. If carried to extremes, quality control of data can be an enormous task. While sophisticated quality control algorithms would be desirable, for most cases rudimentary checks would be sufficient. Surface and upper air data should be checked for physically realistic values. Temperatures greater than boiling, winds greater than 300 mph, etc., would be discarded. This rudimentary check could use climatological values of observations as a base line for what is physically realistic. Dew point temperatures should be checked to be less than or equal to the temperature. Radiosonde data should be checked for vertical consistency using a hydrostatic check.

In addition to the required gross error checking just described, a "buddy checking" quality control algorithm would be desirable for both horizontal planes of data, and time series of data. Data which radically departs from neighboring stations, and/or from the time history of data from a given station should be flagged in error. Buddy checking threshold criteria need to be made flexible so that they can be changed by operators if desired. Also, the buddy checking flags should be able to be overridden by the forecaster. He should be able to see what data has been flagged and unflag it for analysis if desired.

Quality control of the high data rate image data is limited by the shear volume of data. Satellite and radar image data should be checked for existence. Scheduled ingests which fail to occur should be flagged such that any subsequent processing steps would not be started. Any routinely available quality figure such as bit error rates from the ingestors should be filed with the image document.

In addition to automatic quality control algorithms, the system should also support manual quality control. Individual stations or parameters within a given station's observations (such as the dew point) should be able to be flagged so as to be excluded from further processing such as on objective analysis. The flagging should be either for a given observation period, or until further notice (lists of permanently flagged stations should be readily available so that flagged stations don't get "lost" forever).

Image data quality enhancement routines should be available on demand rather than automatically executed for every image. (Image data quality is generally quite good so quality enhancement routines are not normally needed.) A routine to detect missing, noisy, or repeated lines and replace the bad line with a combination of bracketed good lines should be available on demand. Likewise, an algorithm to do an image brightness normalization to correct for sun angle changes would be desirable for demand call up, as would be an algorithm for removing stripping of the visible image.

V.C.5. Plotting and Listing of Observations

The system needs to be able to support simple plotting and listing of incoming data. Listing of data needs to be in a variety of formats and access patterns. The system should support lists of observations in various geographic regions, such as the entire U.S., the upper Midwest, South Dakota, a group of states, etc. Within any given region the system should be able to list observations which exceed any given threshold, such as temperatures greater than 90°F, dew points less than 60°F, present weather beginning with thunder, precipitation greater than or equal to one half inch, etc. The system should be able to list remarks flagged by the decoder in any given geographic region. The listing of remarks should also be able to use thresholds, such as pilot reports with moderate or greater turbulence or icing.

The system should be able to list a time series of observations for any given station (and produce graphics of a time series of any given parameter of any given station). The system should be able to list the current observations within any given radius around any given point designated on the satellite/radar image or map.

Listings should be able to be directed either to a CRT or a printer. Likewise, incoming messages such as warnings, statements, storm reports, etc., should be able to be automatically routed to either a printer or CRT. Observations or remarks which exceed critical thresholds set by the forecaster should set off an alarm/alert device.

In addition to lists of data, the system should be able to support horizontal plots of observations on either printers, graphic devices, or as overlays on satellite and/or radar images. The printer plots should be able to use preprinted map background forms. Both surface and mandatory level upper air observations are currently plotted on base maps and then hand analyzed. In addition to plots of base observations, the system should be able to plot changes of parameters such as altimeter (pressure) changes, dew point changes, height changes, etc., over user specified time intervals (2 hours, 3 hours, 12 hours, etc.). Plots of data should be able to be used either as simple plots of numbers or as plots of observations combined with the contours of an objective analysis. The plotting routines need to be flexible enough to support complete station model plots, several parameters, or only one depending on the users needs. The system should be able to support various scales or zooms of data without overplotting. When various parameters are being plotted, color should be able to be used to distinguish between the parameters. When data is being printed on preprinted map backgrounds, colors such as black and red would also be desirable. Likewise, having wind observations printed as wind barbs or special symbols showing wind direction is highly desirable.

V.C.6. Analysis of Data

After the incoming data has been ingested, decoded, and filed, it must be objectively analyzed. The gridded data resulting from the objective analysis can then be used for further processing (such as computing parameter advection) or contoured for display. Current NSSFC systems use Barnes analysis routines. They are satisfactory for most single variant analysis tasks, although higher order multivariant analysis schemes would be desirable. Likewise, an objective analysis scheme which flags data void regions would be desirable.

The grid resulting from the objective analysis should be treated as a fundamental data type which is filed by the data base management system. The surface data should be routinely analyzed over the continental United States and adjacent Canadian and Mexican land masses with a grid resolution of approximately 50 kilometers. The upper air grid should have a grid resolution of approximately 200 kilometers and cover at least the North American continent.

The surface objective analysis should be computed hourly for the following parameters; temperature, dew point, pressure, u component of wind, v component of wind, equivalent potential temperature, mixing ratio and altimeter change. Every three hours analysis of precipitation and snow cover should be available. In addition, grids of manually digitized radar products, terminal forecast products, observed and forecast ceiling height need to be derived from the coded messages.

The upper air objective analysis at the mandatory levels should have grids of height, temperature, dew point, u component of wind, v component of wind and the vertical component of the wind if it is available. The upper air grids need to be computed every 12 hours for radiosonde data, and up to every hour for VAS and profiler data. The upper air grids can be computed at a national location such as NMC and transmitted to the NSSFC, but some local upper air analysis capability is required as a back-up capability.

In addition to an upper air data base in pressure coordinates, several other coordinate systems should be maintained. A sigma coordinate system of height above terrain needs to be maintained for the aviation forecast sections. It needs grids of temperature, relative humidity, u component of the wind and the v component of the wind. It should have grid levels consistent with the NMC Nested Grid Model (NGM). The bottom nine levels of analysis (all levels below approximately 500 mb) should be routinely maintained in the system. A isentropic coordinate system would also be desirable. Grids of temperature, mixing ratio, u component of wind, v component of wind, pressure levels, and Montgomery stream function would be desired at five degree intervals between isentropic surfaces in the range of 275 to 340 degrees Kelvin.

Once the basic meteorological variables have been objectively analyzed, additional products should be able to be derived from the grids using algebraic and/or finite difference manipulations. These derived grids should be able to be either scheduled or called on demand. The derived products would include streamlines, time change of any variable, vorticity, divergence of any parameter, band pass of any parameter, shear and stretching deformation, addition, subtraction, multiplication and division of any two parameters, gradient of any parameter, creationof a constant grid, creation of a grid containing only values greater than, less than, or equal to a given value, square root of a grid, etc. The derived product's utility should be able to be used to computer output grids of any meteorological equation.

Once the data has been gridded, contoured displays of the data is required. The contour interval, color, and smoothing factor should be able to be specified by the user. Likewise, the forecaster should be able to specify the display geometry. Mercator, polar stereographic, Lambert conformal, satellite, and radar image projections should be supported. Any of the contoured fields need to be able to be displayed at any given center point and at any given integer blow up or blow down factor.

In addition to the horizontal analysis just described, the system should be able to support vertical cross sections between any two points. The system should either automatically select the radiosonde profiles closest to the line between the two points or allow the forecaster to specify the desired radiosonde stations. Contours of potential temperature, mixing ratio, and wind speed should be supported. The system should allow derived products such as Richardson numbers, etc., to be calculated from the cross sectional analysis.

Another vertical display required is radiosonde single station analyses. Skew T/log P and Stuve diagrams showing temperature, dew point, and wind as a fraction of height with background lines of constant potential temperature, mixing ratio, and equivalent potential temperature are required. Vertical plots of wind shear, observed potential temperature, equivalent potential temperature and wet bulb temperature are also required. Computed stability indices of the SELS lifted index, K index, total-totals index energy in the "positive area" of the sounding, precipitable water, etc., are required with the sounding diagram. A one dimensional convective model would be desirable for computing potential cloud top heights, vertical velocity, hail sizes, etc. Another desirable feature would be for the system to be able to compute changes in the vertical profile due to surface heating and display a modified profile for current conditions. Another desirable feature would be the ability to modify a sounding (without destroying the original data) and display the resulting stablity parameters. This would be used to see the effects of forecast changes in the environment.

V.C.7. Geographic Data

Locations of towns, counties, state boundaries, and topography form an important background for forecast operations. The current systems at the NSSFC support a variety of geographic data bases which the National Center Upgrade System should also support.

One of the larger data bases is a file of the location of all the towns in the United States. The data base was generated at the NSSFC from detailed Rand McNally maps. It is used in a variety of ways. Whenever severe storm reports come in, the forecaster can ask the system where it is. The location, county, and distance from the nearest Weather Service Office will be displayed on the CRT, and the cursor will move to that location on the satellite image. The location of the report will also be used by forecast verification programs. The system also allows for searches of all towns within a state which start with any given combination of letters. This is useful in trying to locate misspelled town names. Another use of this data base is to locate the 2Ø nearest towns to the location of a cursor on the satellite (or radar) image or the 2Ø nearest towns closest to any given town. The distance between two towns is also a well used function in the determination of the number of separate severe storm reports.

Another geographic data base supported is the location of all the weather observing sites in North America and aircraft VOR locations. This data is also used in a variety of ways. The system can be asked the full name, location, and the cursor to be put on a map background or satellite image of any three letter weather observing or VOR site. This also includes the ability to locate positions relative to a station, such as 3Ø NW MCI (3Ø miles northwest of the Kansas City International Airport). This data base can also be used to plot the location of all the weather observing stations on the satellite or radar image. The plot can be either a large dot, the station letter identifiers, or the numeric identifiers.

Because severe storm warnings are issued on a county basis, counties form an important geographic data base.

Current NSSFC systems support a county outline file for gridding satellite and radar images and for determining if any given location is in any given county. In addition to the county outline, information is kept on the county geographic center, the Weather Service Office responsible for the severe warnings in that county, the county seat, the county area, and the county population. This information is used primarily for verification programs.

Geographic grids superimposed on satellite and radar images is a critical feature in the usefulness of remotely sensed data. The grids are computed from files of latitude longitudes forming the boundaries of states, major lakes, and rivers. In addition to the state boundaries, the system supports files showing the boundaries of SIGMETs offshore area of responsibility, the CWSU boundaries, major jet traffic ways, major highways, and river basins used for snow mapping. The National Center Upgrade needs to support the existing gridding capabilities and be flexible enough to add additional boundaries dictated by future requirements.

Another geographic file maintained deals with graphical message composition. In section V.B.2 there was discussion of message composition using graphical inputs. The forecaster draws on a map on the satellite image the box, line, etc., required for his forecast message. The system then picks up the appropriate town or location names and inserts them into the message. Current capabilities have lists of approved towns for severe storm watches and for convective SIGMETs. In the coming year, the names used in area forecast messages will be added to the system. The National Center Upgrade System should support the existing message composition capabilities, and be flexible enough to add to these capabilities in the future.

Terrain data also forms an important input to forecasters. The current system uses station elevation in the computing of upslope winds (elevation advection) in the western United States. Another terrain data base supported is a grid of elevation every 1/6 degree of latitude and longitude. This data base is used to form an image of terrain which is remapped into the satellite or radar projection. Another use of this terrain data base planned for the coming year is to compute turbulence in mountainous regions caused by high winds interacting with the terrain.

V.C.8. Satellite Data Processing

Satellite data forms one of the primary data bases for the NSSFC operations. The satellite imagery forms a back drop for all of the other data sources as well as being used as a surveillance tool. In addition to the qualitative uses of the image data, a modest amount of quantitative processing of satellite data is necessary for the National Center Upgrade System.

The qualitative uses of satellite data require a number of different loops at various locations and resolutions. They will be described in greater detail in the section on the terminal display. The control of the loops needs to be kept quite flexible and easy to use. The forecaster should be able to specify for up to eight different loops, the earth located center point, the resolution, the number of frames in the loop, the loop which is opposite (such as the infrared loop which is opposite a visible) and the time interval between images in the loop. The loops should be able to be activated or deactivated and any loop which is active would be automatically updated with current data. The forecaster should be able to switch rapidly (less than three seconds) between loops. The forecaster should be able to rebuild loops over a new area from data stored on the system disk. He should be able to have a graphic depiction of the specified area to be rebuilt prior to the rebuilding process to insure that the specifications are correct. The loop control should also allow false color enhancements specified by the forecaster to correspond to critical thresholds to be automatically restored to the images whenever the loop is called up. Likewise graphic overlays such as state boundaries, watch boxes in effect, and other critical graphic overlays should also be automatically restored whenever a loop is switched on for viewing.

As part of satellite data processing, navigation support is a vital part for many of the uses of the system. (Navigation is the precise location of the satellite and its altitude which is used as part of the system for converting from earth coordinates to satellite image coordinates and vice versa.) The ability to quickly and easily compute the earth location on a satellite image is required for loading of aligned loops, the computation of grids for overlays, the remapping of graphics and other data into the satellite projection, the positioning of geographic data like cities, counties, etc. Parameters necessary for the navigation calculations are encoded into the infrared line documentation of the GOES data. The system needs to extract the necessary information and make it available to all processing requiring navigation information. This should also include historic data being used for case studies.

The quantitative image processing required of the National Center Upgrade System is generally little more than the extraction of a subset of digital values under the direction of the forecaster and then computing derived products rather than the intensive processing which is more typical of image processing in other disciplines. The system should be able to extract the digital values inside a cursor and display them as counts or temperatures (for infrared data). It should be able to take the temperature data from inside the cursor and compute the cloud height using radiosonde (or VAS) profiles for the conversion of temperature to height. It should be able to track cloud features and compute the velocity and height of the cloud feature. It should be able to use a cursor to draw around a feature and extract the digital data inside the outline. This digital data could then be used to extract information such as area of the cloud, growth rate of the area, etc. The ability to image process entire images would be desirable for research studies (but are not expected to be used operationally at first). Image processing capabilities desired for a single image would be the ability to detect and remove bad lines, to form an equal occurrence of brightness values auto enhancements, to perform a high pass filter, to perform a low pass filter, to perform a shot noise filter, to perform a digital stretch, to perform a gradient operator, to add, subtract, multipy, or divide the data by a constant, to perform an interpolated blow-up of the data, and to average the data down for blow-downs. Other standard image processing capabilities such as fast fourier transforms, etc., would be acceptable for the National Center Upgrade System, but are not currently used at the NSSFC. Desired image processing capabilities for multiple images would include averaging of images, minimum brightness composites, maximum brightness composites, weighted linear combination of images, cloud threshold composites (clouds only excluding the ground), addition, subtraction, multiplication and division of images, and mosaicing of images. The functional combination of images and gridded data would also be desired, such as the ability to display infrared data whose gray scales are relative to the tropopause temperature (or equilibrium temperature) at any given location.

Another image processing capability required would be a remapping capability. The system should support the remapping of various data into the projection of other data. While the satellite data will frequently be the base projection of the display because of its high data volume, the ability to remap the satellite data into other projections is still required. The ability to remap the satellite into the projection of another satellite, a polar stereographic projection, a mercator, a Lambert conformal projection and a radar projection is required. The ability to rotate an image would be desirable for research purposes. When an image has been remapped (or any other geometric transformation has been done) the system needs to keep track of the transformation so that overlays of other data would still be possible.

In addition to processing visible, infrared images, the National Center Upgrade System will also have to perform the functions of the VAS Data Utilization Center (VDUC) system. The exact VDUC requirements for the NSSFC are still being developed with the following being projected VAS processing requirements. The system will have ingest and distribute the VAS imagery to all forecast stations requiring VAS data. In addition the system should be able to compute composite images based on various sounding bands, such as a low level moisture image and a composite stability image. The system should be able to compute a limited number of sounding retrievals and associated products (with the main retrieval tasks being done routinely at NMC). The system needs to be able to access the routinely processed NMC VAS retrievals and use them as sounding data as was discussed in section V.A.6 and V.C.5 and 6.

V.C.9. Radar Data Processing

Radar data process is very similar to satellite image processing. The ability to request specific radar ingests, loops of the radar, composites of several radars, radar images in satellite projections, and tracking of radar features is required. In addition, the ability to highlight by flashing or similar means specific radar reflectivities would be required. The ability to overlay other data sources, grids, etc., on the radar loops is required in the same fashion as the satellite data.

V.C.1Ø. Aviation Data Processing

In addition to the normal ingest, listing, plotting, etc., of aviation related observations, several special processing capabilities are required for the aviation forecasting groups at the NSSFC. In addition to plots of forecast products derived from NMC such as NGM gridded displays and FOUS displays, the system should also support terminal forecast displays as a function of both space and time. Because terminal forecasts are manually developed, they frequently contain hedging (such as a forecast for partly cloudy with a chance of thunderstorms). The system should be able to show plots of the forecast data and also to display the hedging information if desired.

The system should support an algorithm for determining icing potential, such as the algorithm developed by the U.S. Air Force. It should have an algorithm for objectively determining mountain wave turbulence threat areas, capability for plotting a nephanalysis of instrument flight rules (IFR) areas caused by low clouds, an analysis of ceiling height above ground and above sea level, an algorithm for determining areas affected by turbulence caused by winds interacting with terrain, an algorithm for determining areas affected by clear air turbulence, etc. It should be able to support displays of forecast winds, temperatures, dew points, and ceiling heights.

V.C.11. Numeric Guidance Processing

It is anticipated that the system will have gridded numeric guidance products which can be used for custom displays and further diagnostic processing. The ability to produce displays of derived products (such as streamlines, etc) produced by manipulating objectively analyzed observational data as described in section V.C.6, should also be available for gridded forecast data, as should the ability to produce contoured displays. In addition to these capabilities, the ability to further process forecast data is necessary. One product would be an hourly lifted index produced from observed surface data and forecast 500 mb temperature grids as is currently being done for the SELS unit. Another processing product would be the interpolation of 6-hourly forecast fields to any given time. This would allow forecasters to ask "what is the state of the atmosphere right now" as well as for some specific forecast time in the future. Another product desired would be indicators of how well the model has been doing recently. This would take the form of difference fields between forecasts and recent observations, and phase speed errors determined by bandpass analysis of forecast and observed fields with a correlation analysis to determine errors in the speed of propagation of forecast features.

V.C.12. Verification Processing

The NSSFC currently collects and verifies all severe storm and tornado watches and warnings in the United States. Weekly status and monthly verification statistics for each Weather Service Forecast Office are generated by the NSSFC/TDU and sent to the appropriate offices. Currently the data collection and data entry is semi-manual. The computer will look for appropriate message header information and send the messages to a printer. The verification specialist codes the information, puts it into appropriate files, and then runs various programs for the generation of verification statistics. The severe storm event files then become the basis for severe storm climatologies. The verification program at the NSSFC will probably be expanded to include winter storms, flash flood and high wind events. It is also anticipated that the data collection and data entry functions will be made more automated in the future. The National Center Upgrade will have to support the verification programs by allowing the automatic collection of appropriate data, data entry, manual quality control, background processing of the statistics, and dissemination of results over AFOS/AWIPS-90 and printer output for mailing.

V.C.13. Lightning

It is anticipated that lightning location data will be available within the lifetime of the National Centers Upgrade System. Beyond ingest and filing of the lightning data, the required processing includes displaying stroke location as overlays for other data with color being used to designate timeliness. The ability to outline a cloud or a region, derive statistics on number of strokes as a function of time, and derive statistics on the time rate of change of strokes would be required. Other processing routines will probably be developed as lightning research progresses.

V.D. Workstation Requirements

The interactive workstation forms the main focus point of the National Center Upgrade System. Here the forecaster controls all the processing of tasks pertinent to his forecasting duties, receives all the necessary information required for the generation of his forecast, and does all of the forecast product generation. The workstation combines all of the capabilities of the current AFOS, CSIS, Eclipse AOS, and EAS workstations.

V.D.1. Workstation Functions

The forecaster workstation should consist of a command and control module, an alphanumeric display module, a high resolution graphic display module, an image display with graphic overlay module, and an extended looping image display module. A workstation is required for each forecaster on duty as well as a research and development facility. The actual characteristics of each work station (such as the number of image frames, etc.) will vary according to the needs of the different units. A total of thirteen workstations are required initially although the sys- tem should be expandable to at least 20 workstations to accomodate any future expansion as described in section IV.C.1. The initial twelve workstations would be used as follows with type A terminals having more frame space than type B terminals.

	Number	Type Terminal
SELS lead forecaster	1	A
SELS assistant	2	B
SFSS	2	A
Convective SIGMET	1	A
FA	3	A
NPSU	1	B
TDU	1	B
SFSS R&D	1	B
Maintenance	1	B
	13	7A and 6B

V.D.2. Workstation Command and Control Module

The man-computer interface forms a critical node in the successful deployment of the National Center Upgrade System. The specification of the interface is difficult because of the rapidly changing technology in this field. Traditional interfaces have used a CRT keyboard with either a menu or command language for system control. Menus have the advantage of ease of learning by offering visual cues. They have the disadvantage of lack of flexibility and slow responsiveness for experienced users. Command languages have the advantage of rapid, flexible control but suffer from difficulties in learning the language and poor retention of seldom used commands. The man-computer interface required of the National Center Upgrade should combine the advantages of both menus and command language without any of the disadvantages of either. The perfect interface does not yet exist, but the several systems have prototype interfaces which show promise. The data tablet of CSIS allows the forecaster to easily chain together a command is an example of a way to use a visual control device to a command language. While the CSIS data tablet can support many different command configurations it, by itself, is not adequate for an operational system. A means of having the computer write the command set-up on the data tablet would be required. The command interface at PROFS likewise is a good example of having a flexible visual control device overlaying a menu-driven system. Commercial examples of this type of control are demonstrated by the Apple Lisa system and other new business oriented systems.

The National Center Upgrade system designer should try to develop a user interface which is fast, flexible, and easy to use. A computer written command display which has a large number of options for system control would be suggested.

Whatever the eventual design of the user interface, it must have certain devices and functions. A keyboard will be needed for message text generation and could be used for system control functions also. The interface must allow the chaining of commands into functional tasks which can be executed with a single command. The system must allow for at least 100 of these user defined functional commands for each terminal in addition to general command and control functions common to all workstations. The interface also must support position dependent controls of cursors on all the different displays. These controls will be used for pointing to specific locations on the display and also for contouring graphics. A combination of interactive control devices could be used for different control functions as long as the system was still easy and efficient to use.

The man-computer interface must be sophisticated enough to allow the computer to alert the forecaster to obvious human errors made in entering commands and errors which occur during system procedures. Also, there must be an operator selectable mechanism by which the system alerts the user to such items as the receipt of significant information, impending deadlines and any requirement of further input.

The system requires a scheduler which can initiate procedures at defined times and automatically recover from most error conditions. The scheduler should start requested procedures within a specified time window. It must be able to handle multiple requests for different procedures within requested overlapping time windows. The scheduler should be able to start either interactive or batch type commands.

The system should allow one program to initiate another program. Many control decisions are based on data dependent factors. If a satellite starts transmitting data, then the appropriate ingest program should be started. Likewise, when a given amount of conventional data has been ingested, then a decode program should be started.

V.D.3. Alphanumeric Display Module

The alphanumeric CRT and associated keyboard must have a 132 columns by at least 48 lines of display. A four "window" splitscreen capability with a simple copy capability to transfer portions of text from window to window is required. It must have a scrolling (up and down) display capability for each window. The keyboard must have the standard typewriter keys, cursor control keys, unique AFOS character keys, tab keys which can be set via the computer for message composition and special purpose keys which can be defined for meteorologically or image processing unique commands. It must set up for rapid word processing control as discussed in section V.B.1.

V.D.4. High Resolution Graphic Display Module

A high resolution (1,000 lines or better) display is needed for graphic and alphanumeric displays. The device should display at least three graphic fields plus a map background simultaneously. The graphic fields should be able to be displayed and removed independently of one another. The removal of one must not affect the remaining fields. The graphics must be color coded, with the colors under operator control to accommodate color blind people who may require different color combinations than other users. Solid, dashed and dotted lines for contours must be possible. Operator assigned lengths for dashes and dash gaps is also a desired feature. The capability to rapidly change between types of lines and to cause them to fade is required. Labels on graphics must be standardized and located such that they do not interfere with each other when fields are superposed.

It must be possible to loop through graphic products. Considering a single graphic display as a single frame, at least 24 frames of graphics are required for the loop. Simultaneous looping through three different graphics with a constant background must be possible. The looping should be selectable to be either under manual or computer control for the stepping between frames. Loop speed will be hardware controllable and vary between five displays per second and one display every ten seconds. Flyback or reverse animation is to be the user's option. While only 24 graphic frames would be available for immediate use, capability to store a larger number of graphic products on the computer should be provided. The system should be able to store up to 2000 graphic products per terminal.

The display must have zoom and translation functions. Additionally, it must also be available for use as an auxiliary CRT display. When used in this mode, it will have the same basic features of the CRT previously described. The main and auxiliary CRT functions should be independent so that two messages can be displayed and worked on simultaneously.

V.D.5. Image Display Device

Image data from satellites and associated graphic overlays are needed. The image must have 256 gray shades (eight bit display). A medium resolution display of 480 lines or better is required. A minimum of 48 frames is required with 64 to 96 frames being highly desirable for type A workstations. A minimum of 24 frames is required for a type B workstation with 48 to 64 frames being highly desirable.

Looping must be under both manual and computer control. Automated loop speed should be operator controllable with a maximum loop rate of five frames per second for the entire frame space and up to fifteen frames per second for a loop of up to six frames. The user must be able to vary the loop bounds, rate and mode of transition. The system should allow the loop to dwell on the most recent image and have either flyback or reverse animation.

A large amount of meteorological image data is "paired" such as the visible and infrared data from the geostationary satellites. The terminal must, therefore, allow instant transfer between paired images.

A capability to perform a pixel-replication "zoom" on the contents of any frame or sequence of frames is required. This should be an instantaneous capability centered over a cursor designated location at 2 and 4 times resolution. The intent is not to display more information; rather it is desired to "enlarge" or "blow-up" what is currently displayed on the frame.

The system must have a graphic capability of the same resolution as the image. The graphic must be able to be superposed over images with noninterference of labels. It must be a nondestructive overlay which can be superimposed or removed without affecting the underlying image. Four separate graphics (three graphic products plus a map background) are required to overlay a given image frame. The interaction of the graphics should be nondestructive. The graphics should be able to be color coded according to the desires of the individual user. The graphic color should have a higher precedence than the underlying image.

While a maximum of four individual graphics are to be shown at any given instant, the system should have the capability of looping graphic overlays either along with or separately from the underlying image.

The system should allow false coloring of the data. Each of the image's 256 gray shades should be able to be colored differently. The false coloring system should also allow black and white enhancements of the image. Separate loops of data on the system should have separate false coloring and enhancements available so that when loop bounds are changed, the enhancements will automatically change. Up to eight loops of images and associated enhancements are desired. The graphic colors should also be under the control of the individual user.

In addition to false coloring of a single image loop, the system must support the functional combination of images with false colors. An example would be to have the infrared image loop tint the visible loop according to the temperature of the clouds in the infrared images.

The normal false color configuration is an input of two eight bit images and an output display of three color channels. Howver, it is desirable to have this basic 16 bit enhancement system available for nonstandard configurations using functional combination of several images and graphics. Finally, the ability to animate these functional combinations must exist.

V.D.6. Extended Looping Display

An extended looping capability is required for the purposes of presenting background information on large-scale atmospheric processes. This information is required at all the workstations and as such can be a shared resource. This essentially takes over the function of the present EAS system. There is a requirement to display loops of one day's worth of half hour satellite images. Hence at least 48 images in a loop are required. Since a satellite puts out two simultaneous channels (visible and infrared) each loop of 48 images needs to have an "opposite" loop of images of the other channel with instant transfer between the two loops. A pair of working loops for each satellite is required. In addition, loops of water vapor from each satellite (one image/hr) should be supported with 24 images in each loop.

Along with the extended loop, there must be false color capabilities which access the full bit range of the infrared data. There needs to be a graphic overlay of geographic and state boundaries. There should be instant transfer between the opposite loops. In addition, there should be a capability for the functional combination of paired loops. This should include coloring the visible according to the temperature of the infrared image. A capability to juxtapose any two of the six working loops side by side should also exist.

Looping rate must be hardware controllable (5 frames per second maximum). Transition from the end of a loop to its beginning must be either instantaneous (flyback) or by reverse animation at the meteorologist's option.

The basic display of the extended loops should be on a TV standard RGB image of 480 lines or better. At each workstation, the forecasters should have the ability to switch to any of the working loops, to zoom, start, stop, change loop end points, change transition mode or step through the loop. Operations on one loop should not impact any other. A master control station should not only have the capability to do these functions but also be capable of loading backup loops, creating enhancements, etc. The master control station can override the commands of the workstation loop monitors. There must be communications between the workstations and the master control station.

V.D.7. Map Plots

There is a requirement for the generation of paper maps with computer plotted station models and contours. These paper plots should be able to be hand contoured (only station model plotted including wind direction and speed symbols) or be machine contoured. The paper must be such that it can be drawn on with colored pencils or pens. Erasing should not destroy the computer drawn information. It would be desirable for the plotter to have capability for different colors, for different parameters in the station model or different contours. The map background must be variable between plots without the need for constant operator intervention. Up to six different map backgrounds should be supported at a time.

V.D.8. Printers

There is a requirement for low-noise printers of approximately 100 lines per minute in the immediate work area of each CRT terminal. These slow printers are for hard copy alphanumeric output of data and information. One printer is required for each of the six work areas. Additionally, there is a requirement for one central printer facility for large file outputs. Two printers of 300 lines per minute or one printer of 600 lines per minute or faster would meet the needs for program files, data files, archive print files, etc.

V.D.9. Image and Graphic Copies

There is a need to document and display various image and graphic products from the video monitors. Such hard copy outputs should be approximately 8" x 10" or larger. The hard copy can be black and white with colors being converted to gray shades. A true color copy capability is highly desirable but not required. The copy must be able to be written on and erased with colored pencils without destroying the original imager with the erasures. The copy's lifetime should be several days or longer. Each of the graphics/video monitor must be accessible to the hard copy device. The use of the hard copy device should not disrupt the use of the monitor for more than ten seconds.

In addition, there is a requirement for a high quality color photographic copy capability. These copies would primarily be used for publication purposes. These copies should be either 35 mm slides or color prints of 4" x 5" or larger. Also, there is a requirement for video copies (either tape or disk) from the video monitors. These copies would be used for training and documentation. The video copy capability requires the original recording function, a playback function, and an edit function. The ability to do simplex studio editing functions of fades, insets, single frame edits, etc., is desired. There is a need for only one of each of these units which can be assessed by any workstation.

V.D.10. Ergonomic Requirements

The workstations should be designed with human factors carefully considered. Control devices, monitors, table space for map analysis and telephone set must all be within an arm's length.

The workstations must be designed to reduce visual and physical fatigue. The lettering on the CRT displays should be large enough that they can be easily read without eye strain. Flicker, jitter and/or shimmer of the monitors must be minimized. Thirty Hz flicker of the presentations cannot be tolerated. The terminals should be designed for use in lighting compatible with an office environment where documents are routinely read. Means should be available for controlling glare problems.

The work space design should be considerate of differences in heights and body builds by allowing variations in chair and keyboard height adjustments. Sufficient table space should also be available for documents, charts, etc., to be layed out and worked on in the terminal area. Noise due to cooling fans, etc., should be kept to a very low level. The work stations must be able to stand the shock of operators rolling about on chairs bumping into them inadvertently.

V.E. System Utilization

While a system such as the National Center Upgrade can do almost anything, it does not do everything all the time. The following is an estimate of the anticipated hourly work load of the system for current tasks. As mentioned in section IV.C.1, the current forecast responsibility may grow by a factor of 50% during the lifetime of the system. Likewise, the system should have some growth capabilty to accommodate normal growth of desires for system capabilities. (Past experience has been that within a year after any system installation, all the computing resources have been used and the demand exists for still more.) A total growth factor of 100% should be anticipated over the lifetime of the system.

V.E.1. Conventional Data Utilization

Every hour, an objective analysis of the United States at 50 km resolution is required for the temperature, dew point, pressure, altimeter change, u component of the wind, and v component of the wind, mixing ratio, and equivalent potential temperature. From these basic grids contoured displays should be computed for all of the working loops at each terminal. Each loop defines an area, resolution, and projection of interest. Type A teminals will have up to eight loops. Assuming three pairs of loops, then there will be five different basic projections. Type B terminals will have up to four loops of which one will probably be paired leaving three basic projections. For each loop, the forecaster should be able to have precomputed displays of temperature, dew point, pressure, streamlines, isotachs, altimeter change, and up to four other contoured fields derived from the same basic gridded fields. A total of 10 displays for five loops, for seven type A terminals and three loops for four type B terminals for a total of 470 precomputed contoured fields per hour should be available. These precomputed contoured fields would be available for rapid loading onto the graphics overlay. The basic objective analyses of the base data should be completed within five minutes after receipt of data. The six displays for each loop of temperature, dew point, pressure, streamlines, isotachs, and altimeter change should be available within 10 minutes after receipt of data and all ten fields should be available within 15 minutes after receipt of data.

In addition to precomputed displays of contoured surface data, the system should support station plots of temperature, dew point, pressure, wind speed and direction, and altimeter change. These station plots should be available for either hand analysis or overlaying on the contoured graphics. The station displays should be available at each of the seven type A terminals either as a graphic or hard copy within 10 minutes after receipt of data.

The system should also support listing of observations at any time. Approximately 10 requests per hour per terminal for a total of 110 could be expected per hour. Listing operations should be completed within 30 seconds of each request.

The system should also be able to support "non-standard" requests of data analysis and displays which are not precomputed. Approximately four per hour per terminal could be expected for a total of 44 per hour. These displays should be available within two minutes after the request.

Upper air data is available every 12 hours. Contoured fields should be routinely available at the 850, 700, 500, 250, and tropopause levels. Fields of streamlines, isotachs, temperature, dew point, heights, height changes, wind direction change and temperature advection should be made available on a U.S. scale display for all the workstation graphics within 15 minutes after receipt of data. Station plots of the observations and change of observations should be available at the same time. Fields derived from radiosonde data, such as stability parameters, should also be available within 15 minutes after receipt of data. Any of the basic upper air data should be able to be plotted or contoured on top of any loop of satellite or radar within 30 seconds of the request. Requests for non-standard upper air displays requiring grid manipulation (such as band pass, etc.) and contouring should be supported. These displays should be available within two minutes after the request. Four per terminal per hour could be expected for a total of 44 per hour. Requests for displays in other coordinate systems, such as sigma or isentropic, should be supported if requested. Contoured fields, etc., appropriate for that coordinate system should be available within fifteen minutes of the request. A request for this other coordinate system could be expected from one workstation every 12 hour period.

It can be assumed that this request would not overlap the time required for processing the upper air data in pressure coordinates.

Plots of single station data, such as a skew-T/log P or Stuve diagram should be completed within 30 seconds of a request. Approximately 3 request/hr/workstation is anticipated for a total of 33/hr. Cross sections should be completed within two minutes of a request. Two per hour from three terminals can be expected for a total of six cross section/hr.

V.E.2. Satellite Data Utilization

Up to date loops of satellite imagery form the backbone of most of the NSSFC operations. During severe weather situations, fifteen minute satellite imagery is routinely available. Of the eight loops on the type A terminal, seven will probably be satellite imagery and one radar. The radar will also probably be updating at a fifteen minute cycle. The four loops on the type B terminals will probably be mainly satellite imagery. Hence, within each 15 minute period, 8 loops on 7 type A and 4 loops on four type B loops for a total of 72 TV frame loads (288 per hour) can be expected. However, because of the demand for timeliness in satellite displays, the system should be able to load seven loops on seven type A and four loops on four type B terminals for a total of 65 TV frames) within three minutes after receipt of data. In addition to loading the workstation loops, the system must also load the extended looping device every 30 minutes for four loops and every hour for two more (for a grand total of 298 loads/hour). Also, the system should support rebuilding of loops in a new region from data stored on the system disks. A loop of six images should be able to be reloaded within two minutes after the request.

VAS processing will consist of both image display functions and computational intensive retrieval tasks. The VAS image display utilization tasks are contained in the previous paragraphs. The anticipated retrieval tasks would be the generation of up to 100 sounding retrievals within 10 minutes of request. It can be assumed that one terminal per hour would require VAS processing capabilities. Display of VAS products generated at NMC would be similar to the display of radiosonde data discussed in section V.E.1. It can be assumed that VAS data displays would take place during hours when radiosonde data is not being processed.

In addition to VAS data processing, quantitative processing of satellite imagery such as cloud growth, cloud displacement, image manipulation, etc., is anticipated. It can be assumed that half the terminals (5) will request some type image processing program each hour.

V.E.3. Radar Data Utilization

Radar from six radar sites ingested every 15 minutes is specified in section V.A.3, of input data, with an anticipated expansion to 12 radar sites during the lifetime of the system. The radars should be able to be displayed in a loop or composited. The display requirements are included in the previous satellite section. The remapping and compositing would be for either two or three radars. It can be assumed that six remaps and three composites will be required every 15 minutes. (The remaps will probably be into the satellite projection.) The time required for the two remaps and one composite should be three minutes or less. All of the radar data received in each 15 minute period should be processed within the 15 minute period (including the anticipated expansion to 12 radar sites).

In addition to radar image data manually digitized radar (MDR) displays including reflectivity levels, heights and motion of cells should be generated from coded observations. The MDR data is taken every hour on the half hour. The national display of MDR data must be completed within 10 minutes of the beginning of data reception (or 2 minutes after the end of data reception).

NEXRAD products will include computer processed products as well as imagery. It is anticipated that the NEXRAD imagery utilization would be covered by the previously stated radar imagery requirements. In addition, NEXRAD processed products should be used as graphic overlay displays. A total of three graphics per radar site per 15 minutes (total of 18-36 graphics/15 min) can be expected.

V.E.4. Forecast Data Utilization

Currently, approximately 120 AFOS forecast displays and 200 grids of LFM forecasts are received at the NSSFC. The gridded products can be expected to expand to 600 or more in coming years. The system needs to support the contoured display of gridded data. Any given display of gridded data should be completed in 30 seconds or less. Each workstation can be expected to request 15 fields per hour for a total of 165 contouring request per hour. In addition, derived products such as vorticity advection which require grid manipulation can be expected. Approximately 4 requests per terminal per hour can be expected for a total of 44 grid processing and display operations.

V.E.5. Diagnostic Model Utilization

In addition to displays of observations and forecast fields, the NSSFC operations require the utilization of special diagnostic models. An icing potential model, a mountain wave model, a clear air turbulence potential model, and a low level terrain induced turbulence model are routinely used at the NSSFC. Simple numeric models such as a one dimensional thunderstorm model and a two dimensional advection model are also currently used. The use of diagnostic models can be anticipated to increase in coming years. It can be anticipated that half the terminals (5) will request the running of some diagnostic model during each hour.

V.E.6. Forecast Product Preparation

The various units have forecast products described in section II.B, which require word processing capabilities described in section V.B.1. All workstations should be able to simultaneously generate messages without interference with one another. However, for sizing purposes, it can be assumed that only three workstations will be generating messages during any given time.

V.E.7. Research and Development Utilization

The National Center Upgrade system is anticipated to be a dynamically growing system throughout its lifetime. It must support both meteorological research and program development in addition to the normal forecasting workload. The meteorological research workstation display requirements have been included in the work loading specifications of the previous sections. However, the data base of images, observations, and grids will be for a different time period than the current forecast operations. Two of the workstations (TDU and SFSS research) could be processing historic data. The system needs to support at least one historic data set per research workstation (two for the entire system).

Program development and system support activities will require interactive CRT terminals and the ability to do system development activities concurrent with system operations. A total of 19 programming type terminals are required for the following groups:

TDU	5	Computer Operators	1
Verification	2	SFSS Research	1
EDP	2	Administration	2
Maintenance	2	Forecast Units	4

The system should be able to support an average of six people working simultaneously on program development, each with an average of four Fortran compiles, links, and loads per hour for a system total of 24 per hour.

The system also must be available for general computational work loads, such as verification, general scientific development activities, administrative functions, etc. A total throughput of approximately 10 jobs per hour can be expected.

VI. System Support

The system must be maintainable and capable of future expansion. It must be able to maintain 24 hr/day, 365 day/year operations. It must be developed so that a dedicated staff of professional electronic technicians, computer operators, and programmers can operate, maintain, and expand the system.

VI.A. Software Development Aids

Because of the changing environment throughout its lifetime, the system must supply software development aids such as programming compilers, macro expansion capabilities, editors, a source level debugger, and documentation routines.

VI.A.1. Programming

The system must support popular compiler languages including at least Fortran, at least one other high order scientific programming language, and Assembly Language. Utility programs such as data access subroutines must be available to programs written in all the high level languages. The compilers must have informative error messages which aid in the debugging of programs. They must be available either from foreground or background devices such as interactive image terminals, interactive non-image CRTs, a card reader, and tape drives.

VI.A.2. Higher Order Command Procedures

The interactive command procedures discussed earlier will allow a user to initiate applications programs. However, there needs to be a means of stringing modular applications programs into procedures. Higher order command procedures are needed in order to build macros of the command controls. This macro facility should be simple but effective. It must include standard programming features such as arithmetic and logic operations, program jumps, and decision constructs. The macro control logic should be able to be controlled by outputs of commands within the macro.

VI.A.3. Interactive Editors

The system must support interactive programming via a CRT editor. This interactive programming capability must include the standard features of an advanced interactive editing system. These editors must be user friendly since many of the programmers will be meteorologists, not computer specialists. The system should support a source management system.

VI.A.4. Utilities

The system must support program development. It must contain libraries of utilities which can be used as parts of new programs. These libraries must include standard scientific, mathematical, image processing, word processing and statistical support functions in addition to system specific functions for data access and manipulation.

VI.A.5. Processing on Remote Computers

The Central Computer Facility in FB4 must be accessible from this system. The system must allow Remote Job Entry (RJE) access to the NMC Central Computing Facility to start production run programs, for remote data access, and for programs (such as models), which require the use of a larger computer. Also, medium to high speed computer to computer data transfers between the Central Computer Facility and the NSSFC system must be possible.

VI.A.6. Software Documentation

The software must be maintainable and expandable by in-house programmers. The software should be carefully designed and be highly modular in nature. The interfaces between modules should be easily identifiable and well documented. The system documentation should have a clear overview of the software system including the control logic, flow of processing, data base management philosophy, libraries available for use, etc. Every program and subroutine should be documented with comment cards to include input data, output data, what general processing has been done to the input data to get the output data, and any transfer of control other than a return to the calling program. Sufficient comment cards should be used throughout the program such that an experienced programmer can follow the flow of logic in the program. Common blocks should be documented as to what other programs use the common block. All file structures and protocols should be carefully documented.

In addition to the general system overview and the individual program documentation, a directory of all software with a brief description of every software module should be provided. A means to search the directory for software program names or for program functions should be provided.

All of the documentation must be in a form such that it can be updated as changes are made to the system. Paper listings in binders of the software should be provided in addition to the disk based source management system.

The computer operating systems should be supported by the computer vendors throughout the lifetime of the system.

Any firmware developed for system should also be documented to the same level of detail as the software written in assembly language. Listing of the firmware code should be included as part of hardware documentation.

VI.B. Hardware Maintenance

The system must be able to be maintained by technicians other than the original designers of the system. A complete set of spares must be provided for all the hardware not supported by vendor maintenance agreements. At least one of every board, module, etc., should be available such that a failure occurs, the failed equipment can be unplugged and a good module plugged in. The time to get the system back in operation should be one half hour or less. A maintenance facility should also be provided such that the failed module can be brought back to the maintenance facility and fixed as time permits. The maintenance facility should be provided with sufficient stock of components to maintain the system over a projected ten year lifetime. The maintenance facility should have sufficient test equipment (or specifications for required test equipment) for all aspects of system maintenance.

Thorough operations and maintenance manuals should be provided. Manuals on the general system overview, module specific theory of operations, trouble shooting aids, etc., are required. Complete schematics, layout charts, and cabling diagrams are required. All OEM vendor manuals available for components of the system should be provided.

VI.C. Training

Comprehensive training courses for hardware maintenance, software maintenance, computer operations, and forecaster users should be provided. A means of training new personnel throughout the lifetime of the system should be provided.

VII. System Reliability

Because of the critical nature of the mission of the NSSFC, the system must be able to operate 24 hours/day, 365 days/year. Total failure of the system would be catastrophic. The system should have fail-soft characteristics so that it can continue to operate, albeit in a degraded mode, rather than failing completely. There should be no potential single point failures in the system which could bring the entire system down.

While the system should be designed for very high overall availability, fail-soft failure modes can be tolerated for short periods. A loss of up to one half the terminals and one half the computing processing could be tolerated for up to eight hours if all data input and output functions were maintained. The loss of any one data input could be tolerated up to eight hours if a complimentary data source were available (such as the loss of one satellite ingestor if the other satellite ingestor were still available). Highly critical data such as conventional surface and upper air data should be available from two complimentary data sources (one NWS and the other FAA).

FIGURE 1
NSSFC Eclipse S/230

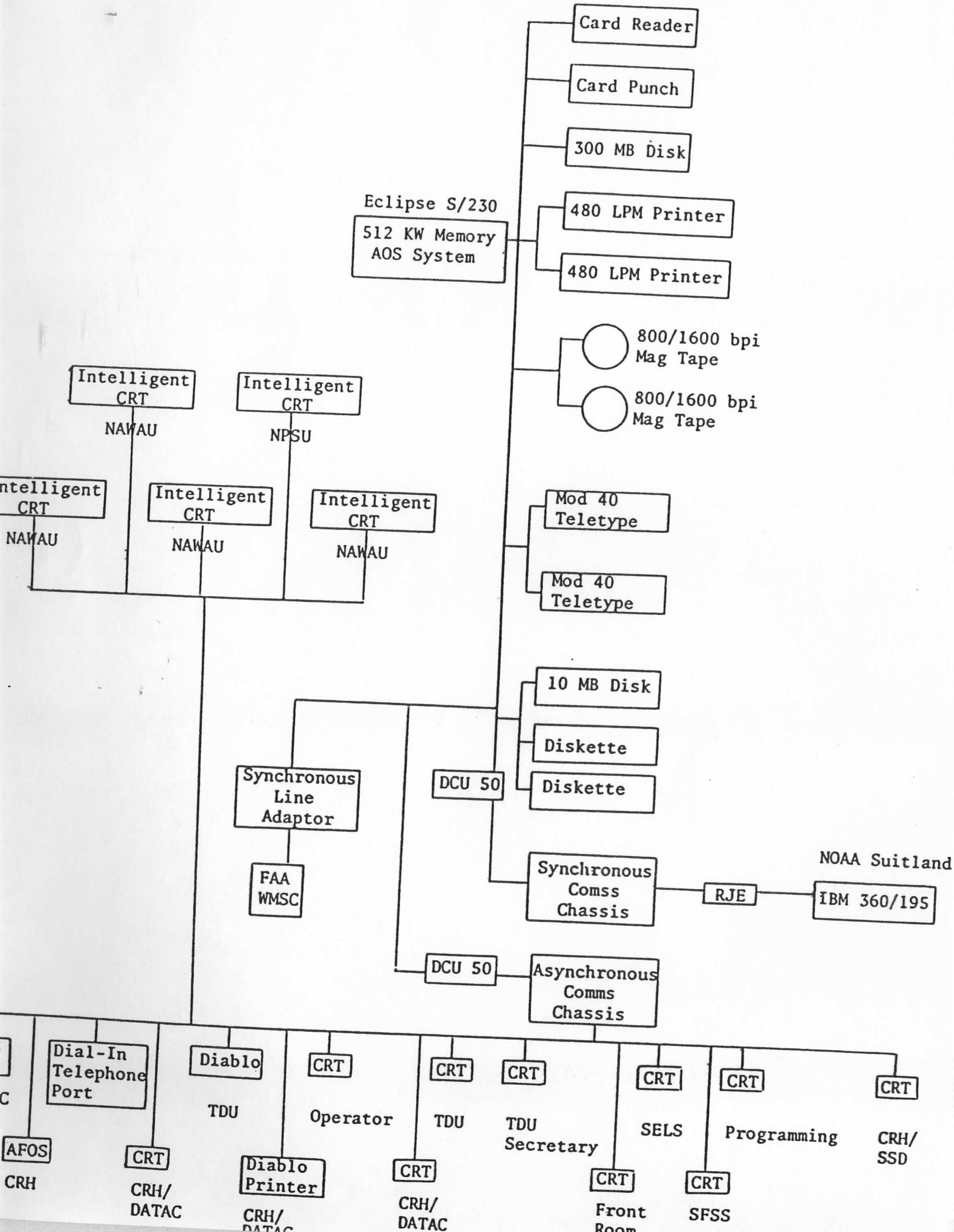

FIGURE 2
NSSFC AFOS Systems

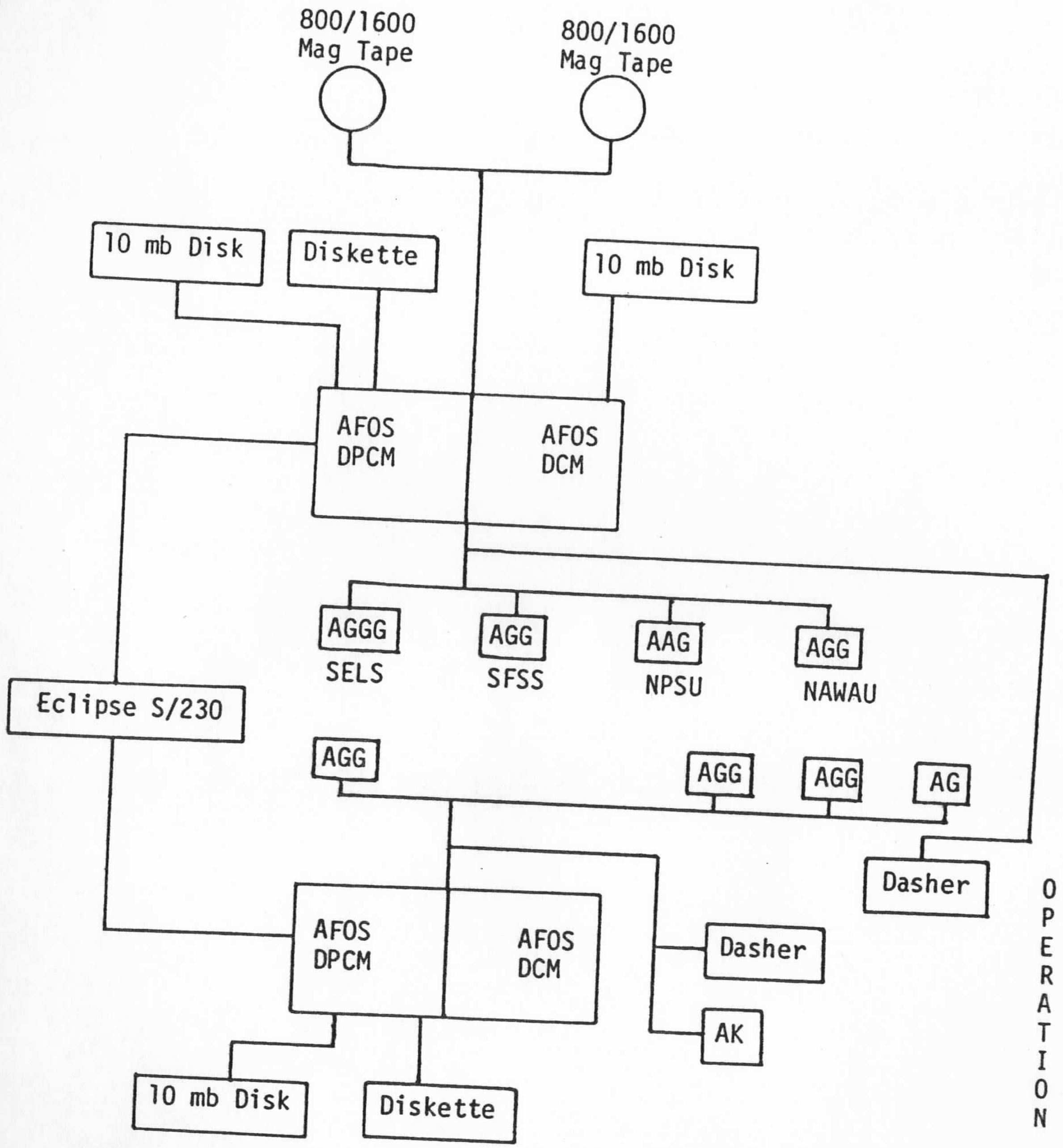

FIGURE 3
CRH AFOS SYSTEM

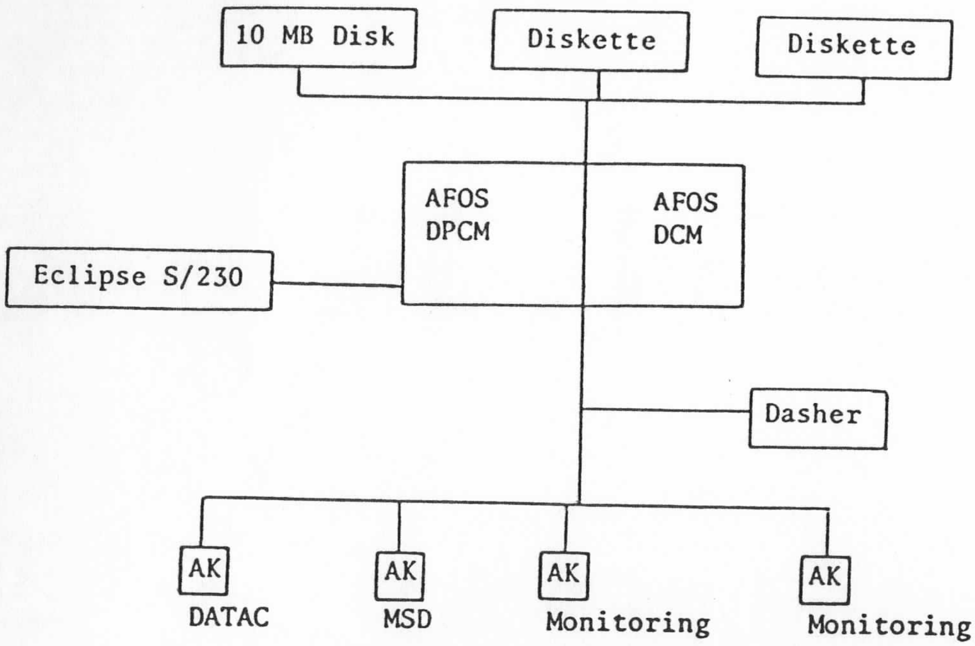

FIGURE 4
EAS SYSTEM

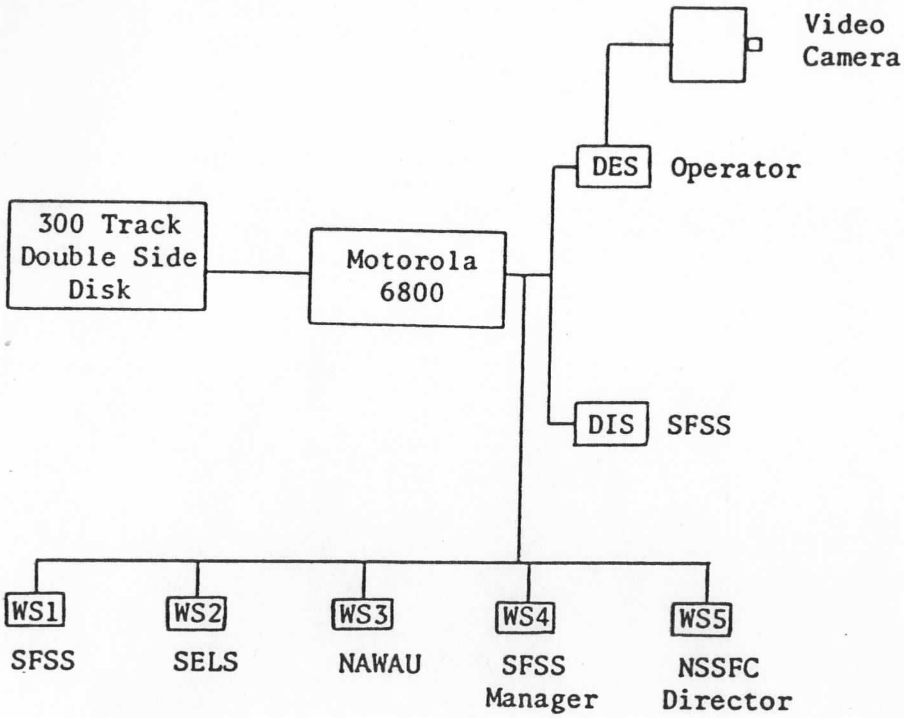

FIGURE 5
CSIS FULL CONFIGURATION

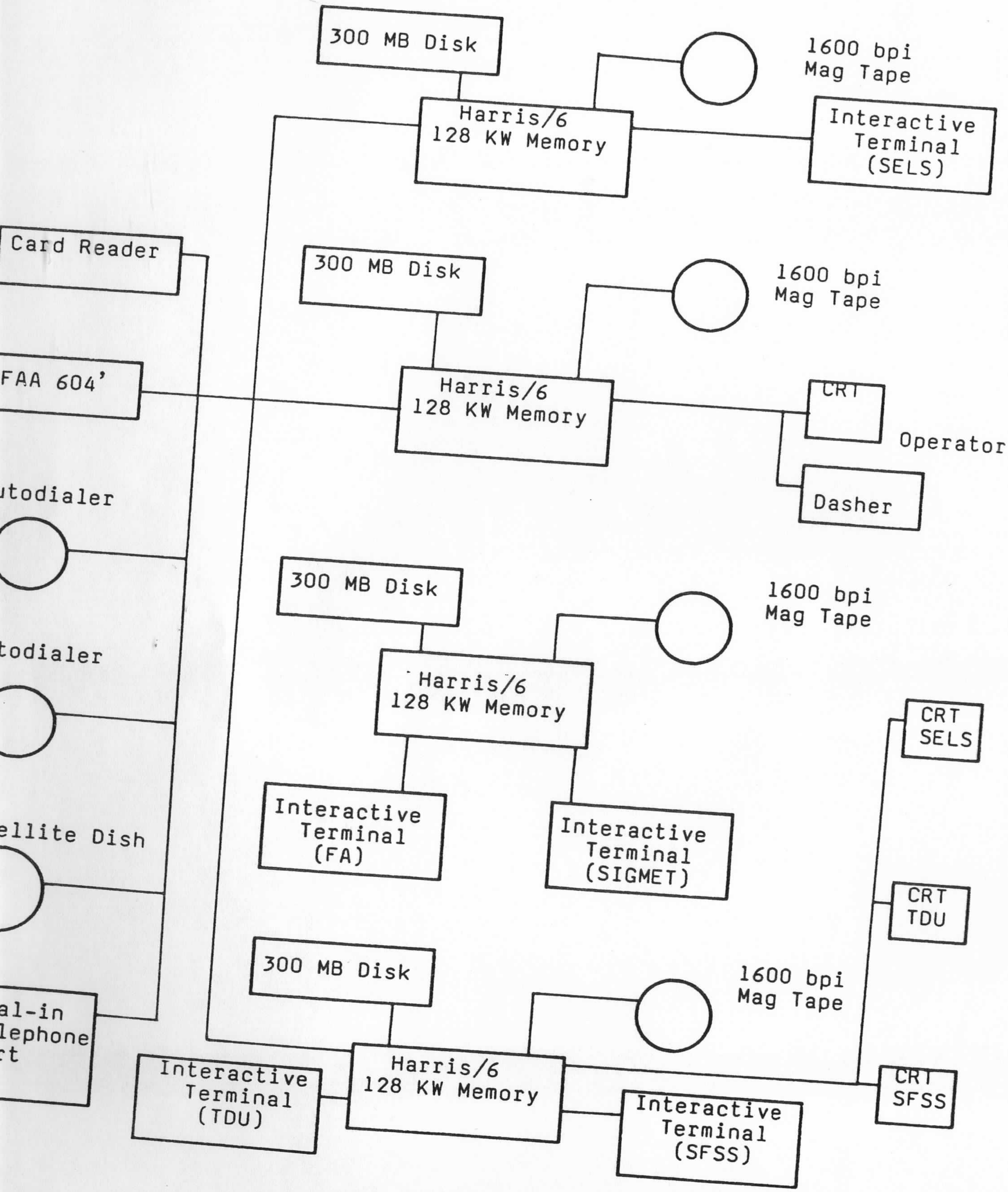

TABLE 1
National Center Upgrade Input Data

Data Source	Data Collected	Current Data Rate (bits/sec)	Future Data Rate	Data Protocol	Data Storage Volume (Megabytes) (initial) /(projected)	Current Status
FAA WMSC	Surface Observations, Upper Air Observations, Pilot Reports	2400	9600?	FAA developed	2.5 / 5.0	on AOS; on CSIS (through FAA 604 circuit)
GOES-East; GOES-West	Satellite Images	1.8×10^6 (Mode A)	2.2×10^6 (Mode AAA)	Binary data stream	1311 / 2167 operations + 184 / + 368 research	GOES-East received on CSIS in Mode A
Dial up Radar (RRWDS) (2-4 phone lines needed)	Radar Images	2400	4800 (NEXRAD)	SDLC	1.8 / 3.6	Kavouras/RADID Currently used
AFOS/AWIPS-90	Observations graphics MDR	2400	?	ADCCP/Async	18.1 / ?	AFOS displays used
NMC	Forecast grids, display grids, VAS data	9600	?	Bisync	14 / ?	RJE link
Lightning via phone line	Lightning location	1200	?	Async	1 / ?	Experiment on CSIS
					1532.4 / 2544+ Total	

TABLE 2
ARI WEATHER PARAMETERS

CLOUD COVER

COVERAGE	REMARKS PERTAINING TO BASES	REMARKS PERTAINING TO TOPS	OBSCURATION PHENOMENA
Scattered	Mountain Ridges Obscured	Merging layers	Fog
Scattered-broken	Mountain Passes Obscured	Multiple layers	Haze
Broken	Mountain Tops Obscured		Dust
Broken-Overcast	Lower Clouds Coastal Regions		Smoke
Overcast	Lower Coastal Stratus		Sand
Partial-obscuration			Snow
Total-obscuration			Drizzle
			Rain
			Blowing snow
			Volcanic ash

RANGE OF BASES	RANGE OF TOPS
BLO-nnn Below nnn	BLO-nnn Below nnn
SFC-nnn Surface to nnn	nnn-mmm
nnn-mmm	

SURFACE VISIBILITY

OBSTRUCTION	INTENSITY	REMARKS
Blowing Sand	Light	In Low Lying Areas
Blowing Dust	Moderate	Over Higher Terrain
Haze	Heavy	Locally
Smoke		
Fog		
Drizzle		
Freezing Drizzle		
Rain		
Freezing Rain		
Freezing Precipitation		
Snow		
Snow Showers		
Blowing Snow		
Ice Pellets		

RANGE OF TOPS	SURFACE VISIBILITY
BLO-nnn Below nnn	nn-mm
nnn-mmm	L1-mm Less than 1 mile to mm
	nn-G6 nn to greater than 6
	L1 Less than 1 mile
	G6 Greater than 6 miles

CONVECTIVE ACTIVITY

ACTIVITY	COVERAGE	COVERAGE REMARKS	THUNDERSTORM TYPE	SHOWER INTENSITY	INTENSITY REMARKS
Showers	Isolated	Diminishing	Embedded	Light	Diminishing
Thunderstorms	Widely Scattered	Increasing	Severe	Moderate	Increasing
	Scattered	In Mountains	Severe-Embedded	Heavy	
	Numerous				

RANGE OF BASES	RANGE OF TOPS	VISIBILITY
BLO-nnn Below nnn	BLO-nnn Below nnn	nn-mm
SFC-nnn Surface to nnn	nnn-mmm	L1-mm Less than 1 mile to mm
nnn-mmm		nn-G6 nn to greater than 6
		L1 Less than 1 mile
		G6 Greater than 6 miles

ICING

TYPE	INTENSITY	INTENSITY REMARKS	COVERAGE	COVERAGE REMARKS
Rime	Light	Diminishing	Isolated	Diminishing
Clear	Light-moderate	Increasing	Scattered	Increasing
Mixed	Moderate		Widespread	
	Moderate-severe			
	Severe			

HEIGHT

BLO-nnn Below nnn
SFC-nnn Surface to nnn
nnn-mmm

TURBULENCE

TYPE	INTENSITY	INTENSITY REMARKS	COVERAGE	COVERAGE REMARKS
Clear Air	Light	Diminishing	Isolated	Diminishing
Mountain Wave	Light-moderate	Increasing	Scattered	Increasing
In Cloud	Moderate		Widespread	
Low Level Wind Shear	Moderate-severe		Over Rough Terrain	
Strong Surface Winds	Severe			

HEIGHT

BLO-nnn Below nnn
SFC-nnn Surface to nnn
nnn-mmm

****

All RANGE's and HEIGHT's are given in hundreds of feet MSL.
All VISIBILITY's are given in nautical miles and default to G6.
All other values default to "none."