NOAA TM ERL SDL-16

NOAA Technical Memorandum ERL SDL-16

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Environmental Research Laboratories

A Satellite Recording and Data Base System

RALPH J. SLUTZ
ROBERT B. DOEKER
THOMAS B. GRAY, JR.
RICHARD N. GRUBB
CHARLES E. HORNBACK
EDWARD R. SCHIFFMACHER
GEORGE R. SUGAR
JAMES R. WINKELMAN

Space
Disturbances
Laboratory
BOULDER,
COLORADO
December 1970

ENVIRONMENTAL RESEARCH LABORATORIES

SPA[illegible]Y

Technical Memoranda are used to insure prompt dissemination of special studies which, though of interest to the scientific community, may not be ready for formal publication. Since these papers may later be published in a modified form to include more recent information or research results, abstracting, citing, or reproducing this paper in the open literature is not encouraged. Contact the author for additional information on the subject matter discussed in this Memorandum.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

BOULDER, COLORADO

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

NOAA Technical Memorandum ERL SDL-16

A SATELLITE RECORDING AND DATA BASE SYSTEM

Committee Report By

Ralph J. Slutz
Robert B. Doeker
Thomas B. Gray, Jr.
Richard N. Grubb
Charles E. Hornback
Edward R. Schiffmacher
George R. Sugar*
James R. Winkelman

*Aeronomy Laboratory

Space Disturbances Laboratory
Boulder, Colorado
December 1970

TABLE OF CONTENTS

A SATELLITE RECORDING AND DATA BASE SYSTEM

Ralph J. Slutz, Robert B. Doeker, Thomas B. Gray, Jr.,
Richard N. Grubb, Charles E. Hornback, Edward R. Schiffmacher,
George R. Sugar, and James R. Winkelman

1. INTRODUCTION

The Space Disturbances Laboratory, in its role as the national center for space environment forecasting, provides monitoring, warning, and forecast services for solar flares, associated proton and x-ray events, and magnetic storms. Messages and data on these and related geophysical phenomena are transmitted to customers throughout the United States and the world. Automated data recording and dissemination now plays a major role in the successful operation of these services, by providing and maintaining a real-time data base for use both by the SDL forecaster and by others.

The real-time data base is not only an effective and flexible system but also is a pioneering effort in this field. The capability of any user to obtain through telephone and teletypewriter any portion of the data base at any time he desires is fundamental to the system's effectiveness. However, a re-thinking and expansion of the real-time data base system is required now. This is due, basically, to the following two facts.

1. There is a known and committed large increase of satellite data to be incorporated into the real-time data system in the next several years.

2. SDL is now responsible for maintaining a real-time data base service through the 1970's.

With the above background in mind we have proceeded to outline a plan that will augment the present data system to provide vital new functions and to provide for planned growth to meet essential new requirements during the seventies. In this plan, given below, we have treated the various requirements in a coherent way, rather than piecemeal, since it is clear that by doing so we will achieve maximum effectiveness at minimum cost.

In view of the rapid changes that are occurring in computing technology we must consider the following to be a plan, not a shopping list for new equipment. The final systems will probably differ somewhat from this plan but only insofar as the details of the requirements change or we find more effective ways of achieving the necessary results.

2. FUNCTIONS

The following functions are needed in a system which combines the recording of satellite data and the creation of a data base for near-real-time monitoring and forecasting:

1. Record the full satellite and ground-based sensor data for later research.

   This is an essential step for both research and operational purposes. The "raw" data must be obtained and stored in such a manner as to provide the resolution needed by research efforts and to act as a backup to the "screened" data used by the real-time operational effort.

2. Issue routine summary messages of selected data.

   This function serves operational needs. It provides for average (or spot) values of each sensor on a time scale appropriate to that sensor. These summary messages serve to maintain a high degree of awareness, yet without saturating the data base.

3. Issue alert messages when disturbances are detected.

   This step serves as the "flag" to augment step #2 above when sensors detect changes that would not be adequately described by the routine messages. In this step, thresholds are established for each sensor, and a special data distribution system (according to the needs of individual users) is activated whenever these thresholds are passed.

4. Provide interactive presentation of fuller data summaries.

   This function will permit comparisons of data from different sensors on a common time scale. It will provide the forecaster with complete flexibility in his examination of the real-time data. Known empirical analysis and forecast techniques can be applied in real time to improve the quality of the forecasts issued. This interactive display may be through printers or by CRT or TV presentations of the data available in the system.

5. Provide real-time analog displays in the Space Environment Services Center.

   This is primarily a backup action to provide the Space Environment Services Center with a data presentation in case the fuller presentation of #4 is not available. These analog displays do not provide the flexibility of the system described in #4, but the forecaster would not be deprived of data as might otherwise be the case.

6. Permit real-time remote monitoring of individual satellite or ground-based sensor inputs.

   This will permit scientists who are concerned with a unique situation to monitor a specific sensor without regard to the total data system. This might arise when one is concerned about the performance of one's own experiment, or when one decides that one particular sensor response is sufficient to determine future actions, such as timing a rocket launch.

7. Prepare selected data summaries for data center archival and publication.

   This transforms real-time data from a perishable state to a permanent record. This action assists researchers in determining "gross" and "specific" time periods to study in greater detail. If these actions were not taken, the data would be lost, except for the very detailed sensor response as recorded in #1.

The data system which is presently functioning within the Space Disturbances Laboratory includes some version of each of these functions, but not in an integrated system. A sketch of it is shown in Figure F. Functions 1, 3, 5, and 6 are carried out now for ground-based data by the Table Mountain data-logging system (XDS-930), which records the full output from its 30+ sensors for research purposes, and provides analog displays to the Space Environment Services Center of both individual sensor outputs and data derived from several sensors to give alert messages. The alert-message feature has also been used in the past with the Anchorage data-logging system. The remaining functions are currently carried out by the data-base system (using the SCC 650 and XDS 940 computer) which uses as its input the routine summary messages and alert messages which are prepared elsewhere and received over the ATN (Automated Teletypewriter Network, formerly SOFNET, Solar Flare Network). It is the purpose of the present plan to combine all of these functions into a single system.

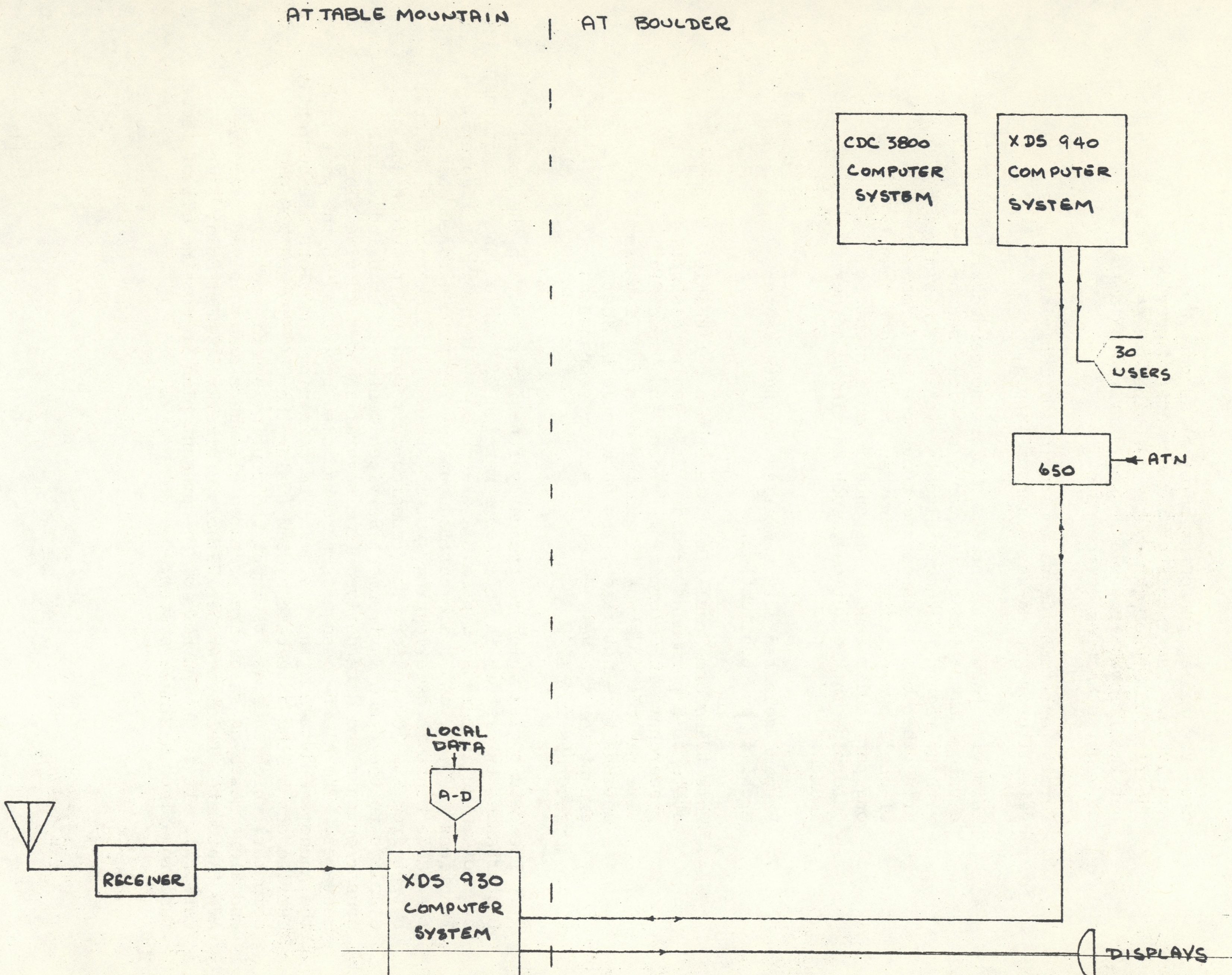

AT TABLE MOUNTAIN
AT BOULDER
CDC 3800 COMPUTER SYSTEM
XDS 940 COMPUTER SYSTEM
30 USERS
650
ATN
LOCAL DATA
A-D
RECEIVER
XDS 930 COMPUTER SYSTEM
DISPLAYS

Figure F

3. PRINCIPLES

The following principles were used in guiding the development of the plan:

1. Reliability. The most important functions of the system, such as recording the raw data from a satellite, must continue without interruption or degradation in spite of failure on any one part of the system. These functions should also make use of equipment and software as nearly as possible independent of the operation of the rest of the system, in order to reduce the probability of outages from multiple failures. Other functions should continue to be performed, but perhaps with some degradation, in spite of failure of any one part of the system. For instance, if the equipment or software which is preparing data summaries were to fail, the user should be able to obtain access to more primitive data so that he can prepare rough summaries himself if needed.

2. Continuous operation. The system must be capable of continuous operation, 24 hours a day, without any outages for regular or irregular maintenance. It must be possible to make modifications or additions to both the hardware and the software without interrupting the currently-working primary functions.

3. Growth. The plan should allow for the possibility of presently-foreseeable growth, through the addition of hardware and software as necessary.

4. Relation to other systems. The XDS 940 computer presently in use provides much more extensive processing ability and interactive access to its files than would be reasonable to duplicate in additional equipment, but it cannot be expected to be continuously available. Its service has interruptions from regularly-scheduled preventive maintenance and from breakdowns. Therefore, any function carried out using the full capability of the 940 can only be performed in a degraded fashion at times when the 940 is not available.

   The COED system, a Command Editor proposed for the 940 and 3800 computers at Boulder, if it becomes available will give higher reliability and continuity of access to its files, but at times that the 940 is not available there will be only limited manipulation ability. Thus COED will give better performance than the 940 alone, but there will still be times when some degradation will be necessary in the service which uses its features.

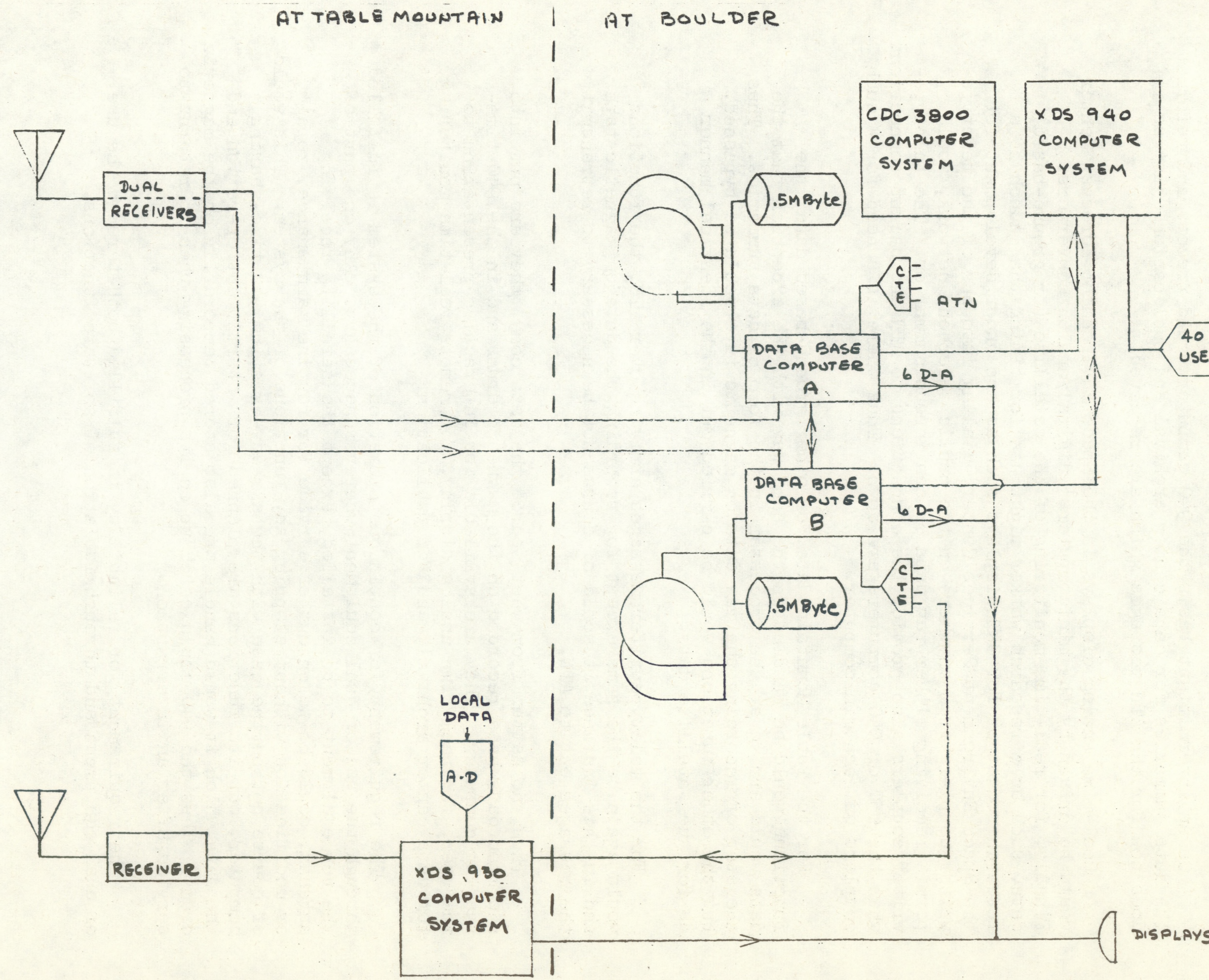
4. SYSTEM G (GOES)

The configuration for the first installation, that for handling the data from the GOES satellite, is shown in Figure G. To satisfy the above requirements for reliability and flexibility, the plan is formed around the use of two processors (using minicomputers) working in a dual mode, with each processor receiving signals directly from the satellite data receivers and bit conditioners. Each of these processors would have two magnetic tape units associated with it, a magnetic-drum storage unit memory extension, digital/analog converters, a 4-way teletypewriter coupler, and a coupler to the other processor.

These minicomputers should not be thought of in the popular sense of the word "computer" where the primary emphasis is on extensive mathematical computations. The minicomputers use a short word length --- typically of 16 bits compared to a general purpose computer which uses 32 bit to 60 bit words. Recent models are only a little larger than an office typewriter, and have a full purchase price less than one month's rental of a fairly small general purpose computer. Thousands of them are now in use, frequently, as in this application, as a dedicated part of integrated equipment where their logical control functions are primarily to their purpose.

Data inputs to this system would be the raw data from the GOES satellite, teletypewriter summaries of ground-based data recorded by the data-logging system at Table Mountain, and teletypewriter messages arriving over ATN.

In carrying out its functions for the GOES data, each processor would separately decommutate the data and record it on one of its magnetic tape units. This provides two separate copies of the data for later research analysis, but one of the two magnetic tapes can be reused whenever it is decided that the other one is full satisfactory. One reel of magnetic tape is estimated to hold something like five days of the GOES data, so changeover to another reel is an infrequent process, and the other tape unit on the processor is available for other functions (or repair) between changeovers. At changeover, the processor would switch recording to the second magnetic tape unit, and the first reel of magnetic tape can be removed any time during the next five days. Thus no critically-timed manual operations are required. Each processor would process the data to prepare convenient summaries in engineering units, and scan the data for alert conditions such as sudden signal changes from selected sensors. Some selected data summaries and alert messages would be automatically transmitted out onto ATN for general distribution. The full set of summaries and alert messages would be stored continuously on the associated magnetic drum, and transmitted intermittently to the 940 computer. Interactive presentation of the data summaries would be achieved by the user logging into the 940 time-sharing computer and using its processing capacity to analyze the data summaries and present them in the format that his application needs.



AT TABLE MOUNTAIN
AT BOULDER
DUAL RECEIVERS
.5M Byte
CDC 3800 COMPUTER SYSTEM
XDS 940 COMPUTER SYSTEM
C T E
ATN
DATA BASE COMPUTER A
6 D-A
40 USERS
DATA BASE COMPUTER B
6 D-A
C T E
.5M Byte
LOCAL DATA
A-D
RECEIVER
XDS 930 COMPUTER SYSTEM
DISPLAYS

Figure G

On an intermittent basis the 940 computer would process and reformat the data summaries for data center archival and publication, just as it does now for the ATN messages which are received.

Real-time analog displays in the Space Environment Forecast Center would be driven by the minicomputers' digital/analog converters. Finally, for real-time monitoring of the satellite (or ground-based) data, such as a research worker might use for timing the launch of a research rocket or for CRT displays such as are under development for the Space Environment Services Center, dialing into one of the teletypewriter couplers from anywhere on the public telephone network, would permit receiving either raw data or continuous summaries. The teletypewriter couplers also provide the connections to ATN and backup connections when the 650 or 940 computers are down. Thus there is a need for 4 such couplers on each minicomputer.

For the Table Mountain data, or other ground-based data, the functions would be handled in the same way with the exception that the data would arrive at the processor in the form of data summaries. Thus the step of recording the raw data on magnetic tape would be bypassed, but the other functions would be carried out in the identical manner as for the satellite data.

For the teletypewriter messages arriving over ATN, the functions would again be the same except for recording the data on magnetic tape and in this instance it would of course not be necessary to retransmit the messages out to ATN.

Thus, no matter from what source the data come, they are put into a common data base recorded on the magnetic drums and in the 940 time-sharing computer. They are available for interactive presentation to the user, for real-time analog display, for remote real-time monitoring, for data center archival, and for publication.

The requirement for continuous operation of the system is fulfilled through the use of dual equipment wherever necessary. Any one part of the new equipment to be installed, except the satellite receiving antenna, could be taken out of service for routine maintenance, repair, or modification without stopping any functions of the system. This would of course not be the case with the already-existing 940 time-sharing computer, but its functions are planned for intermittent operation and the data which it would handle are also stored temporarily on the magnetic drums. Thus the 940 could catch up on its processing when it returns to service after an interruption.

The requirement for reliability is fulfilled both through the use of dual equipment and through isolation of software functions.

Each processor would have a section of its core memory set aside exclusively for decommutating the satellite data and controlling its recording on magnetic tape. The software for this purpose would interact with the rest of the system only to the extent that it provides data words to be processed by the rest of the system, but would not have any inputs from there. Thus the magnetic drums could fail, the transmission between computers could fail, the couplers, the 940 computer, the COED computers could all fail, and the satellite data would still be recorded on magnetic tape for later research or archival processing. By including the decommutation in the processors, it is not necessary to build duplicated separate decommutating interfaces. The two processors would operate entirely independently for this data recording function, so either one could fail completely without the recording function in the other. In fact, for future growth additions to the system, one of the processors could be taken out of service while changes or additions are being made in its software or hardware, and the other processor would continue the recording function --- but now with the hazard that a failure of that one processor would lose data until one of the two could be brought back into operation.

For functions 2 and 3, issuing routine summary messages and intermittent alert messages, a slightly less reliable operation is planned. One of the two processors would contain the program for these functions, while the corresponding memory space of the other processor would contain a program to back up the 940 time-sharing computer by providing a limited method for analysis and formatting of the data summaries. However, the magnetic drums would contain copies of both of these programs. Thus when checks in the programs indicate that the summary and alerting program has failed --- or its processor has failed --- the second processor would automatically replace its analysis and formatting program with the summary and alerting program, and the function would continue uninterruptedly. This scheme is slightly less reliable than full duality would be, in that some faults might slip by the checking programs, but it reduces expense by allowing processors to carry out different needed functions.

The real-time analog displays, and real-time remote monitoring would have high reliability because they would be provided on both of the processors.

The interactive examination of the data summaries, normally carried out on the 940 time-sharing computer, would be degraded during those times that the 940 is out of the service, but would not disappear. By connecting to one of the teletypewriter couplers on the processors, a user could obtain a more limited ability to examine and format the data summaries which are also stored on the magnetic drums. As explained above, however, this backup capability would only be present when both processors are in operation and the regular summary and alerting program is operating properly. Otherwise there would still be programs allowing examination of the stored data, but with no flexibility of formatting.

The preparation of material for data center archiving and for publication is done on an intermittent basis, and the necessary data would be stored on the magnetic drums for at least a couple of days. Thus failure of the 940 time-sharing computer, which would do this processing, would delay the output, but when it comes back into operation it could catch up on the data that have been stored in the meantime.

This system provides no backup, however, to the data-logging system recording ground-based data at Table Mountain, nor to the incoming side of the ATN system (for outgoing messages, backup is provided by connecting through the telephone system to the teletypewriter couplers on the minicomputer, where the outgoing messages to ATN are also available).

From the foregoing description it can be seen that the whole question of reliability is treated as a priority matter. The highest reliability is given to recording the data from the GOES satellite for later analysis. This is achieved by full duality of equipment. The next highest reliability is given to preparing data summary and alert messages for the forecast centers and for distribution via ATN. This is done by having a single program for the purpose, but with provision for swapping automatically another copy of that program into the second processor when needed. Still lower reliability is given to examination of the back-data base. When the 940 time-sharing computer is out of service, a degraded backup capability would be available through the processors if both of them are working fully, otherwise an even more degraded capability of examining the data base without any flexibility of formatting would be available.

A major gap in reliability engineering still exists in this system, however. This is in the areas of primary power and telephone lines from Table Mountain to Boulder. Data would be lost if the commercial power system fail either at the receiver site on Table Mountain or at the processor site in Boulder, or if the telephone lines are broken. Protection against such data loss is provided the expanded systems described below.

The hardware cost of this system is estimated at $146,400, exclusive of the GOES receiving antenna, RF receivers, and bit conditioners. A detailed cost breakdown is given in Appendix C. The software cost is estimated at $50,000, of which about $25,000 is allocatable directly to recording and summarizing the GOES data and the remaining $25,000 would be programming for the data base interactive and backup features.

The primary function and critical timing for this system is to handle data from the GOES satellite. The system must therefore be ready for use by November, 1972. Appendix T gives a time schedule for the procurement and installation of this system and the ones which follow.

5. SYSTEM H

The next level of system capability, called "H" because it follows "G", would provide the required facilities for data input from the SOLRAD-HI series of satellites, for improved access to the data base, for backup of the Table Mountain recording system for ground-based data, and for backup of power. Specifically, System H would augment System G by adding:

1. Two additional magnetic tape units for recording the basic data from SOLRAD-HI.

2. More magnetic drum capacity in the original system, to provide for storage of more data, and also storage of additional programs for more extensive processing of the data.

3. A display system to provide an interactive display capability for the Space Environment Forecast Center. This would provide for high-speed graphical displays, and control of video displays, rather than being limited to typewriter output as in the previous system. The display system would include a minicomputer with 16K words of core memory, a magnetic drum memory extension, parallel input-output busses, and high-speed digital/analog converters. The appropriate display units are also required.

4. Backup for the 930 data-logging system recording ground-based data at Table Mountain. This would consist of analog/digital and digital/analog converters and another minicomputer at Table Mountain, with two magnetic tapes but without magnetic drum. (Note that the 930 system, purchased in 1964, is now obsolescent and that providing this backup is the first step toward replacing the 930.)

5. Backup for primary power at both Boulder and Table Mountain. Five KW of power should be ample at Table Mountain, and about 10 KW should cover all the equipment of this system at Boulder.

A diagram of the system with these additions is given in Figure H.

As presently planned, the interactive displays should include the following features:

1. Recall of any data contained within the system memory and display in a very flexible format defined by the operator.

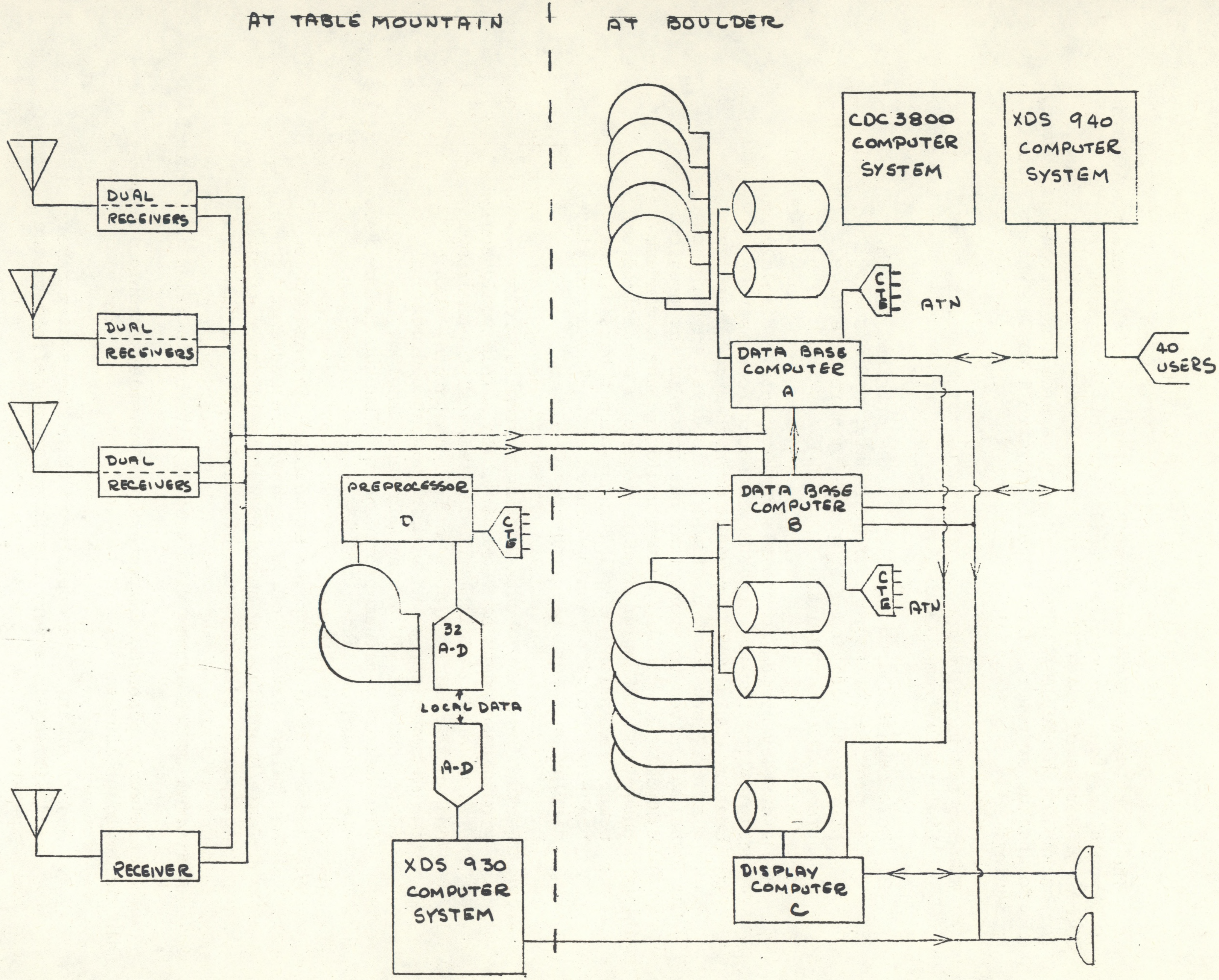

AT TABLE MOUNTAIN
AT BOULDER
DUAL RECEIVERS
DUAL RECEIVERS
DUAL RECEIVERS
RECEIVER
PREPROCESSOR D
32 A-D
LOCAL DATA
A-D
XDS 930 COMPUTER SYSTEM
CDC 3800 COMPUTER SYSTEM
XDS 940 COMPUTER SYSTEM
40 USERS
DATA BASE COMPUTER A
DATA BASE COMPUTER B
DISPLAY COMPUTER C
ATN
ATN

Figure H

2. Indication of threshold levels and ability for the operator to reset thresholds while observing the effects on alarm performance.

3. Limited manipulation of gray scale data derived from H solar image data.

The critical event for installing System H is the launch of the SOLRAD-HI satellites. Thus the augmented system must be ready for use by November, 1973.

6. ADDITIONAL SATELLITES

With very minor additions, System H would be able to handle the additional data from the GMS (Geophysical Monitoring Satellite) expected early in FY 75. It would only be necessary to add the receiving antenna, the RF receivers and bit conditioners, and two magnetic tape units with their controllers. It might also be necessary to increase the core storage of the processors by 8K words each at this point, but no additional processing capacity should be required at this level of workload.

At about this level of expansion the system would be running at nearly full capacity. For still further satellites, major additions would be required to handle their data streams.

7. SYSTEM I

In the next phase of expansion, additional capacity would be gained by using separate preprocessors to record the raw data from the satellites, while the original two processors would be devoted entirely to data base management. A second processor would be added to the one already at Table Mountain as part of System H, and the use of the 930 would be discontinued. The magnetic tape units necessary for recording all of the raw satellite data would be moved from Boulder to Table Mountain, and tape units added for the new satellites. The two preprocessors at Table Mountain would then be dedicated to decommutating the satellite data, gathering ground-based data, recording all data on magnetic tape, and transmitting selected data to the data-base processors at Boulder. There would be no need for magnetic drum memories at Table Mountain, but teletypewriter couplers would provide a backup access to the data stream in the event that the processing by the data base units failed. High-speed data modems would be required at Table Mountain and at Boulder to handle the total data rate required.

This system is shown in Figure I. The two preprocessors at Table Mountain would receive and record the raw data, both from satellites and from the ground-based sensors located there. (This would completely bypass the 930 computer.) Two data-base processors at Boulder would do the preparation of data summaries, alert messages, transmission of data into the 940 time-sharing computer, and storage of data on their magnetic drums. The third processor at Boulder would be the display controller for the interactive and video data displays in the SESC.

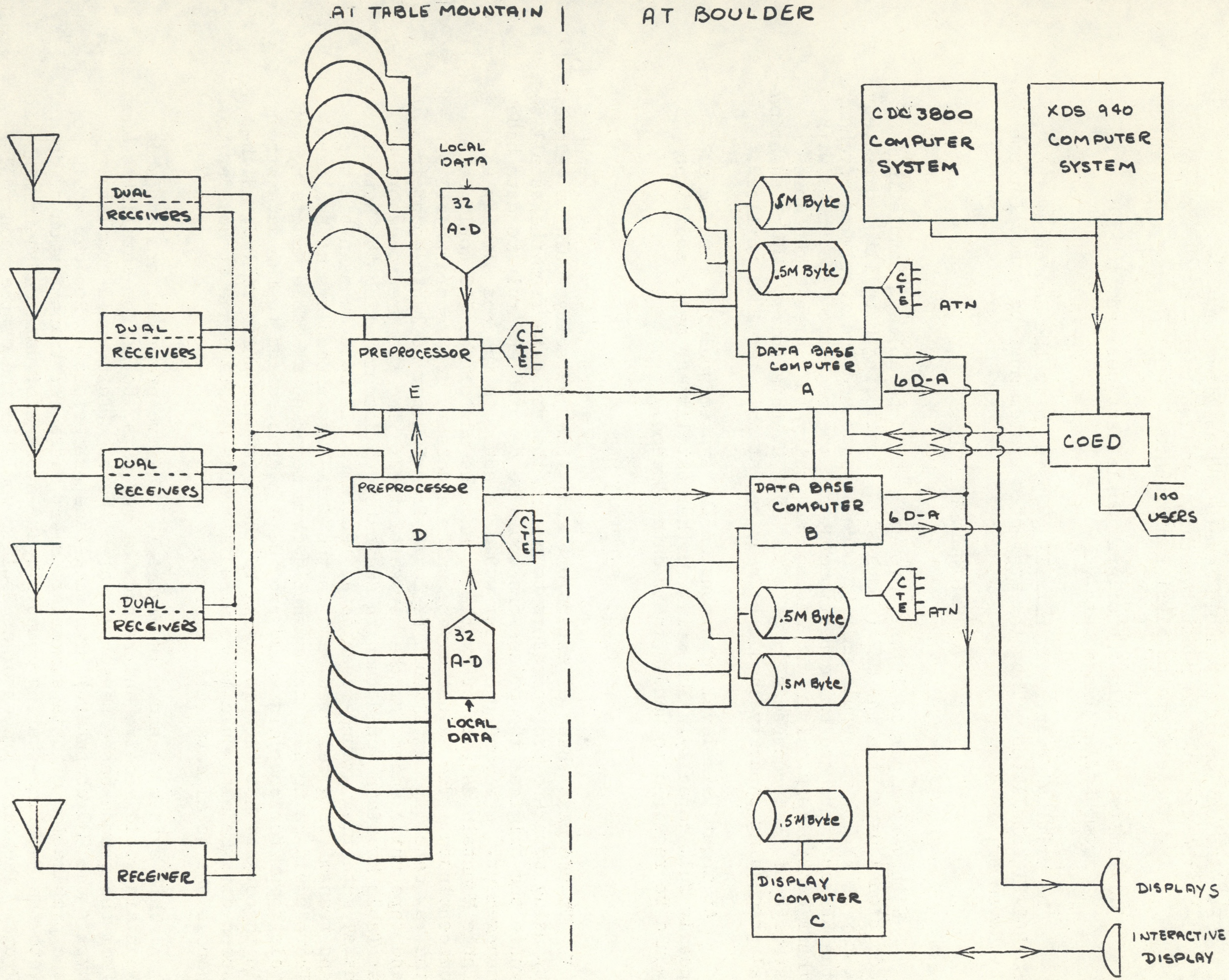

AT TABLE MOUNTAIN
AT BOULDER
DUAL RECEIVERS
DUAL RECEIVERS
DUAL RECEIVERS
DUAL RECEIVERS
RECEIVER
LOCAL DATA
32 A-D
PREPROCESSOR E
C T E
PREPROCESSOR D
C T E
32 A-D
LOCAL DATA
.5M Byte
.5M Byte
C T E
ATN
DATA BASE COMPUTER A
6D-A
DATA BASE COMPUTER B
6D-A
C T E
ATN
.5M Byte
.5M Byte
.5M Byte
DISPLAY COMPUTER C
CDC 3800 COMPUTER SYSTEM
XDS 940 COMPUTER SYSTEM
COED
100 USERS
DISPLAYS
INTERACTIVE DISPLAY

Figure I

The costs for this system will depend heavily on the characteristics of the satellite data streams that will be added after the GOES equipment. In order to make some estimate of the costs, these have arbitrarily been assumed to be the same as the GOES costs, and the system has been configured to include five such data streams.

Data from two new satellites are expected early in FY 76, TIROS -N and STP (Solar-Terrestrial Physics Satellite). System I should thus be installed and ready for use by July of 1975.

8. COSTS AND SCHEDULE

Appendix C summarizes the estimated hardware costs of each of the above systems. These estimates do not include the costs of antennas or receivers associated with the individual satellites, or the development of software programs to process the data.

Appendix T shows the time schedules that each of the systems must follow to be ready for the anticipated satellite data streams.

APPENDIX C. COST ESTIMATES

ESTIMATED PRICES FOR COMPONENT GROUPS

Processor - $36,400

Includes 16 K of 16 bit memory, power fail detection and restart, multiply and divide, clock, 33ASR teletype, coupler with 4 TTY lines, 6 analog outputs, oscilloscope controls, multiprocessor adapter, and enough slots for the peripheral controllers, which include the parallel I/O.

Tape Controller - $4,000

Tape Unit - $8,100

7-level magnetic tape at 24 inches per second. The cabinet will hold a disc and a processor.

Disc Controller - $3,000

Disc Unit - $6,900

.5 megabytes of fixed head disc storage.

Analog Input - $6,500

32 analog inputs, 14 bit precision

Communicator - $4,700

High speed communications interface with 2400 baud modem and parity generation and checking.

SYSTEM G - (FY 72)

1	Processor	$36,400	
1	Tape Controller	4,000	
2	Tape Units	16,200	
1	Disc Controller	3,000	
1	Disc Unit	6,900	
	Contingencies -- at 10%	6,700	
	Single System	$73,200	
1	Duplicate of Above	73,200	
	TOTAL FOR SYSTEM G	$146,400	$146,400

SYSTEM H - (FY 73)

	Interactive Displays - (3)		
1	Processor	$36,400	
1	Disc Controller	3,000	
1	Disc Unit	6,900	
3	Oscilloscopes	3,000	
	Contingencies -- at 10%	4,900	
		$54,200	
	Additions to System G		
2	Tape Units	$16,200	
2	Disc Units	13,800	
2	Communicators	9,400	
	Contingencies -- at 10%	3,900	
		$43,300	
	Table Mountain Equipment		
1	Processor	$36,400	
1	Tape Controller	4,000	
2	Tape Units	16,200	
1	Analog Input	6,500	
1	Communicator	4,700	
	Contingencies -- at 10%	6,800	
		$74,600	
	Power Backup Equipment	$40,000	
2	Tape Units - (FY 74)	$17,800	
	TOTAL FOR SYSTEM H	$229,600	$229,600

SYSTEM I - (FY 75)

1	Processor	$36,400	
1	Tape Controller	4,000	
8	Tape Units	64,800	
1	Analog Input	6,500	
1	Communicator	4,700	
	Contingencies -- at 10%	11,600	
	TOTAL FOR SYSTEM I	$128,000	$128,000

SUMMARY OF COSTS (Excluding Software and Satellite Antennas and Receivers):

FISCAL YEAR 1972

New Hardware	$146,400
Maintenance on 650 and 930	22,000
Maintenance on System G (6%)	8,800
Phone Charges - (3030 new)	4,900
Total Costs Fiscal Year 1972	$182,100

FISCAL YEAR 1973

New Hardware	$211,800
Maintenance on 930	20,500
Maintenance on System H	19,100
Phone Charges	4,900
Total Costs Fiscal Year 1973	$256,300

FISCAL YEAR 1974

New Hardware	$17,800
Maintenance on 930	20,500
Maintenance on System H	20,200
Phone Charges	4,900
Total Costs Fiscal Year 1974	$63,400

FISCAL YEAR 1975

New Hardware	$128,000
Maintenance	27,850
Phone Charges	5,250
Total Costs Fiscal Year 1975	$161,100

CONTINUING:

Maintenance	$27,850
Phone Charges	5,250
Total Continuing Costs	$33,100

APPENDIX T: Time Schedule

	FY-71	FY-72	FY-73	FY-74	FY-75	FY-76	FY-77	FY-78	FY-79
Satellites in service									
GOES			ooooo	oooooooo	oooooooo	oooooooo	oooooooo	oooo	
SOLRAD-HI				ooooo	oooooooo	oooooooo	oooo		
GMS					oooooooo	oooooooo	oooooooo	oooo	
STP						oooooooo	oooooooo	oooooooo	o
TIROS-N						oooooooo	oooooooo	oooooooo	o
Support Requirements									
System G									
Design and specify	****	*							
Acquire hardware		****							
Program and test		*****	***						
In service			XXXXX	XXX					
System H									
Design and specify		****							
Acquire hardware			****	**					
Program and test			*****	***					
In service				XXXXX					
Two additional tape units					XXXXXXXX				
System I									
Design and specify				****					
Acquire hardware				**	**				
Program and test					********				
In service						XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX