NOAA Technical Memorandum ERL SDL-17

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

Five-Year Plan
for Space Environment Laboratory
FY 1971 - FY 1975

Space
Disturbances
Laboratory
BOULDER,
COLORADO
February 1971

ENVIRONMENTAL RESEARCH LABORATORIES

SPAC RY

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

BOULDER, COLORADO

U.S.

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FIVE-YEAR PLAN FOR SPACE ENVIRONMENT LABORATORY
FY 1971 - FY 1975

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FIVE-YEAR PLAN FOR SPACE ENVIRONMENT LABORATORY

FY 1971 - FY 1975

1. SEL IN THE 1970's

1.1 Introduction

For three decades the Department of Commerce has provided services and has initiated and conducted research in the field of solar-terrestrial relationships. This continuing effort has stemmed from an early recognition that the entire solar-terrestrial environment (sun-earth system) must be considered in order to understand, predict and improve man's daily interaction with his immediate earth environment. This work was first pursued within the Department by the Interservice Radio Propagation Laboratory and the Central Radio Propagation Laboratory in the National Bureau of Standards (1941), followed by the Space Disturbances Laboratory of ESSA (1965) and at present by the Space Environment Laboratory of NOAA (1971).

Since the advent of satellite technology in 1957, great strides have been made in furthering our understanding of the solar-terrestrial environment. From the space research program conducted by the United States, Europe, and the Soviet Union, have come the discovery and mapping of the earth's radiation belts, the discovery and mapping of the earth's magnetic field configuration in space, the discovery and investigation of the nature of the interplanetary medium including the solar wind and the interplanetary magnetic field, investigations of the nature of the interaction between planetary environments (Earth, Moon, Venus, and Mars) and the interplanetary medium, and initial investigations of the planetary environments themselves (Earth, Moon, Venus, and Mars).

SEL not only participates in and contributes to these studies but also continues the Department of Commerce function of applying our knowledge of the solar-terrestrial environment to man's environmental needs on earth. Some of these needs can be met by (a) maintaining a real-time data base containing current information on the state of the solar-terrestrial environment; (b) development of accurate predictive techniques to forecast impending solar disturbances and their subsequent effects on the earth environment; and (c) continued research in solar-terrestrial physics. Recognition of the importance of such solar-terrestrial activity and support for its continuance has consistently been expressed at national and international space physics planning sessions for the past several years (e.g., see Woods Hole Summer Studies of 1968 and 1970).

Some of the environmental needs to which the SEL effort in solar-terrestrial relationships directly apply are:

(a) Electrical Power Distribution Systems Requirements. Electrical power systems in the northern latitudes of the United States experience inconveniences and interruptions during energetic magnetic storms. A group of electric power companies is conducting research on the causes and effects of these disruptions. With advance warnings of magnetic storms capable of producing these disturbances in power distribution systems, the power operators and dispatchers are in a position to maintain high reliability of electric service. In the past, geomagnetic storms have been responsible for power blackouts in large cities as well as extensive interruptions in long distance telephone communications. There is a continual growing possibility that large geomagnetic storms, if not forecast, can increase the incidence of serious power interruptions especially during periods of "brown-outs", now a routine summertime condition in the northeast U.S.

(b) Communication Requirements. Military and civilian programs require forecasts and real-time information concerning high latitude communication capabilities. For example, the Air Weather Service cooperates extensively with SEL and relies heavily on the SEL real-time data base and forecast service. High-altitude, high-latitude civilian programs (SST) already utilize the SEL capability -- in radiation warning as well as communication problems. Extensive communication forecast and monitoring services are provided in Alaska by SEL to such users as FAA, FCC, FBI, State of Alaska Communications System, Bureau of Indian Affairs, oil industries and fisheries.

(c) Research Requirements. National and international space research programs require real time and forecast support in order to optimize and, in some cases, implement a particular research mission. For example, the SKYLAB program of NASA requires SEL real time and forecast support to determine the most promising regions of the sun to study at any particular time. Rocket programs requiring specific environmental conditions for launch also regularly utilize the SEL capability.

(d) Radiation Hazards. APOLLO missions require both up-to-the-minute information concerning the solar-terrestrial environment and forecasts of impending activity. For example, SEL provided NASA crucial current information on radiation-belt intensities during the return phase of the crippled APOLLO 13 mission. As man remains in space for longer periods of time (up to 60 days in the forthcoming SKYLAB mission) these services become more critical. Future SST operation will require the prediction and measurement of radiation capable of penetrating to altitudes used by these aircraft.

The advent of satellites and the corresponding increase in available in-situ environmental data, the increase in our knowledge of the morphology of the solar-terrestrial environment, the increased need of solar-terrestrial environmental services, and the required extension of our understanding of the impact of the solar-terrestrial environment on man's daily environmental interaction on earth has prompted SEL to reevaluate its activities and prepare a program for the 1970's. This document describes in detail the current and proposed SEL program.

In drawing up a plan for space environment monitoring and forecasting into the 1970's, we have recognized that SEL is a unique laboratory in the sense that it combines basic research, applied research, and service activities under one roof. This means that the latest results of our basic research program are used in technique development by our applied research program to provide advanced and more accurate forecasting techniques to be used routinely by our services. These ties between the basic and applied research activities and continuing on into the service area are being strengthened and heavily relied upon in the development of our mission during the 1970's. The SEL program for the 1970's has three general goals:

1. The development of an operational solar-terrestrial environment model (STEM) beginning at the solar surface and extending into the upper atmosphere and lower ionospheric regions. This model will be used in a real-time mode to predict the nature of geomagnetic and upper atmospheric disturbances. It will interface the atmosphere by providing transient energy input information to the upper atmospheric regions on a real-time and forecast basis.
2. The development of reliable and accurate forecasting techniques to enable our service personnel to describe the state of the solar-terrestrial environment in both short and long range forecasts.
3. The development of a flexible and effective real-time data service in order to provide accurate, up-to-date information concerning the state of the solar-terrestrial environment.

1.2 Space Environment Laboratory Mission

SEL conducts research in the field of solar-terrestrial physics, develops techniques necessary for forecasting of solar disturbances and their subsequent effects on the earth environment, and provides environment monitoring, forecast and data archival services on a continuing basis.

Theoretical and experimental research studies are conducted in order to understand the fundamental physical process responsible for and causing, (1) the observed energy release in the form of electromagnetic and particle radiation at the solar surface during solar disturbances; (2) the propagation of this energy through the interplanetary medium to the near-earth environment; (3) the transfer of this energy from the near-earth interplanetary medium into the earth's magnetic field, the magnetosphere; and (4) the behavior and subsequent effects of this energy within the magnetosphere, the ionosphere and upper atmospheric regions. These studies are conducted utilizing data from NOAA and other agency-supported satellite experiments, rocket launches and ground-station operations.

The knowledge gathered from these studies is applied to the development of prediction techniques which are required for accurate temporal and spatial forecasting of solar disturbances and their subsequent effects throughout the near-earth interplanetary medium, the magnetosphere, the ionosphere, and upper atmosphere. These techniques when proven, together with the extensive real-time data service maintained by the laboratory, are applied directly to the routine forecasting of solar events and provide early warning and real-time information concerning the state of the solar terrestrial and, particularly, the near-earth environment. The laboratory is the national and international focal point for current information concerning the solar terrestrial environment and supplies this information as a continuing service to a wide variety of users.

The laboratory also provides ERL with expertise and advice concerning satellite instrumentation and interface techniques within NOAA and other agency satellite programs in the area of solar-terrestrial physics.

1.3 Tabular Summary of SEL Activities

To facilitate a discussion of the SEL program in the 1970's, the present and future programs are synopsized in four tables at the end of this section. Frequent references will be made to these tables in the following discussions. Table 1 displays the overall SEL program while Tables 2 and 3 list major satellite and non-satellite projects, in operation and planned within SEL. Note that Tables 2 and 3 do not list continuing R&D and S&E funds. Thus, funds in a given year will not match the overall values shown in Table 1. Complete details of FY-funding breakdowns are shown in following sections for a given fiscal year. See also Appendix D for overall budget breakdowns by Fiscal Year according to recurring allocations plus increments. Table 4 shows the SEL other-agency funding estimate.

For All Tables:

- Description and Comments columns are self-explanatory.
- All funding values are given in thousands of dollars.
- Solid lines through FY columns are ongoing programs.
- Dashed lines through FY columns are planned programs.
- Vertical lines in FY columns mark project start times, satellite launch dates, and project end dates.

1.4 New Initiatives and Objectives for the 1970's

1.4.1 Solar-Terrestrial Environment Model (STEM)

The major overall objective of SEL in the 1970's is the development and operation of a working model of the solar-terrestrial environment. The ultimate development will permit continuous updating of a computer program (in accordance with time-varying solar, space and magnetosphere parameters) to predict the nature of upper atmospheric and geomagnetic disturbances in direct support of the needs listed earlier. This model will include the concentration and release of energy at the solar surface, its propagation through the interplanetary madium, its access to and distribution within magnetospheric regions, subsequent magnetospheric energy release, propagation, and interaction with ionospheric regions. Energy forms to be considered are both particles and electromagnetic.

This is an ideal time to begin the construction of such a model as many parts of a solar-terrestrial environment model (STEM) now exist. It is necessary to join and calibrate the various parts using available data to obtain a first step toward an overall STEM. Existing portions are:

Magnetospheric Model. Using either solar wind parameters or geostationary magnetic field observations as input, a time-varying magnetic field model is available, including dipole tilt, which can describe quiet-time particle population distributions, cosmic ray cutoffs, spatial location of particle precipitation regions, and certain time variations in these phenomena.

Interplanetary Medium Model. This model includes a description of the solar wind plasma and the embedded interplanetary magnetic field. Densities, temperatures, velocity, and particle species of the plasma as well as strength, direction, and radial gradient of the magnetic field can be included.

Propagation Model. These include models of shock propagation in the interplanetary medium and the propagation of energetic solar flare particles from the sun to 1 AU. These models yield intensity-time profiles, radial gradients, and anisotropic features of the propagation based on flare location and ambient interplanetary conditions.

Examples of models yet to be developed and joined to the above in formulating STEM are:

Solar Flare Model. Using solar observations of white light, H_α, CaK, cm and mm wavelength radio noise, magnetic field polarity and strength, etc., this model should allow for the development of a flaring region and an estimate of its energy release with emphasis in X-ray, ultraviolet, and particle emissions. Intensities, spectra, and release mechanisms should be included. We note that initial tractable models of solar proton and electron storage in the corona are now becoming available and should be of great help in estimating flare effects at 1 AU for a given particle event.

Energy Transfer Into Magnetosphere. In this instance a model is required to explain the transfer of energy, magnetic and particle, into the magnetosphere. This is needed to obtain the final disposition of the transferred energy within the magnetosphere. For example, the formation and behavior of the geomagnetic tail and plasma sheet depend almost exclusively on the energy transfer function. The entry of energetic solar particles is greatly affected by the magnetosphere and large time delays and structural features are found in observations of these particles within the magnetosphere. Such effects are important as they determine the temporal and spatial extent of subsequent upper atmospheric and ionospheric interactions, disturbances and energy inputs.

Ionospheric Interaction Model. This is to specify the ionospheric and upper atmospheric response to the solar-terrestrial environment and its variations. Communication effects, observable ground effects, and changes in the chemistry of the upper atmosphere should be obtained given the energy input function and its time history. Here also is the possibility of a direct interface with upper atmospheric problems as transient energy inputs will be specified for these regions. Close cooperation with parts of the National Weather Service and with the Aeronomy Laboratory are required.

It is emphasized that the above discussion requires an active and viable research and service program. Each sample element described above, even calibrating the existing models, is an ambitious undertaking. However, the existence of many sub-models needed for STEM indicates the feasibility of its construction and operation in the 1970's.

The following items are examples of SEL goals and initiatives to be satisfied in order to accomplish our STEM objective in the 1970's. Specific initiatives and goals are described where known. General descriptions are included where a long-term goal can be foreseen.

1.4.2 Real-Time Data Service

A plan is made to convert the prototype SEL real-time data service into an operational data service capable of routinely satisfying real-time needs of users such as the Department of Defense, Air Weather Service, NASA, national and international satellite and rocket research programs, high-altitude aircraft programs, electric power companies, etc. To be operational, the data service must satisfy the following requirements:

(a) Operational - on a 24-hour/day basis.
(b) Reliable - backup modes of operation must be available to avoid problems of "down-time".
(c) Growth - must be able to accommodate future inputs on a cost-effective basis.

The SEL system satisfies these requirements and is described in detail in Appendix B. This system is a pioneering effort in the field of real-time data services and provides a cost-effective and efficient data handling and dissemination system. The real-time data service consists of a four-day compilation of all available space environment data (NOAA, DOD, NASA) residing in a time-share computer system and provides the user with the following:

(a) Routine messages describing the current state of the solar-terrestrial environment.
(b) Customized alerts whereby individual users can be automatically notified based on their own specified alert formulae.
(c) Interactive user capability whereby any user anywhere in the world with access to a telephone and teletype can interact directly with the data service and obtain any data anytime he wishes.

As it appears that NOAA/SEL will become the national and international focal point for real-time information concerning the state of the solar-terrestrial environment, it is necessary to establish such a reliable operational real-time data service in the near future. The minimum operational system can be established using the SEL FY 1972 budget request for the GOES data-handling facility ($50 K for antenna and front-end equipment, $150 K for data handling and real-time data service system).

1.4.3 Research

A continuing research effort is required as outlined in section 1.2 and is aimed at an understanding of the physical processes responsible for solar-terrestrial phenomena in sufficient depth to be able to accurately predict the time and spatial occurrence of solar disturbances and their subsequent effects in the solar-terrestrial and near-earth environment. Tables 2 and 3 show that a substantial body of data is becoming available in both the research and service areas of SEL. A strong continuing research effort utilizing these data will enable large strides to be made toward the day when accurate space environment forecasting is possible. One major result of this effort will be the construction of an operational model of the solar-terrestrial environment (STEM) including its dynamic interaction with the upper atmosphere and ionosphere.

1.4.4 Joint Operation of the Aerospace Solar Physics Observatory

This is a most cost-effective means of significantly advancing the SEL Solar Physics Program which is aimed at understanding energy transfer processes at the sun and in the interplanetary medium, particularly solar flare eruptions with accompanying energetic particle production. The Aerospace Solar Physics Observatory consists of a staff of 12 professionals, a high-resolution H-alpha telescope, a 6-inch filter telescope with digital output yielding magnetic maps of the solar disk, and a 24-inch spectroheliograph yielding high-resolution magnetic field information over the solar disk. Simultaneous H_α and CaK observations will be available very shortly. For approximately one-third of the full operating costs, SEL can participate as a full partner with the Aerospace Corporation in the operation of the Solar Physics Observatory. SEL will have observing privileges and share in the data analysis. The digital magnetic field information will be available in real time for inclusion into the real-time data service. By appropriately summing the information, sector boundaries at the solar surface may possibly be identified and thus greatly increase our predictive capability. The observation of a sector boundary near the east limb of the sun indicates high probability of enhanced magnetic activity in the earth's field at the time that the sector sweeps past the earth several days hence.

1.4.5 Application of Long Baseline Interferometer

SEL contains a unique combination of talents with which to apply the long baseline interferometer technique to problems of interest to other primary operational elements of NOAA including accurate geodetic mapping at ranges of hundreds and thousands of miles, measurement of variations in the earth's rotational period, magnitude and direction of continental drift, etc. Applications to maritime geodesy are also being pursued.

In addition, this technique is capable of detecting discontinuities in the solar wind in the interplanetary medium which is of great value to the Space Environment monitoring effort.

1.4.6 Instrumentation

Instrumentation will be developed to provide cost-effective space environment monitoring instruments for the NOAA space environment monitoring program. This requires an increased commitment for advanced instrument development. Tightening budgets in the last few years have greatly inhibited SEL opportunities to supply instrumentation for satellite and rocket programs and thus adversely affected both the service and the research programs. Development of space environment monitoring instrumentation by SEL with flights provided by NOAA, DOD, and NASA (rides are readily available) is a very cost-effective way of providing such monitoring.

The badly outmoded equipment in the Space Environment Service Center will be replaced or refurbished. Advanced display equipment such as a video playback system will also be installed.

1.4.7 Remote Ground-Based Terminals

Development of remote unmanned ground-based terminals to monitor sky glow and emissions, magnetic fields, and possible ionospheric disturbances will provide an inexpensive portable monitoring platform. Used in conjunction with synchronous satellites such as GOES, simultaneous observations can be made on the same geomagnetic field line as the satellite without placing any restrictions on the satellite's longitudinal position. Such a station can also be used on ocean platforms in remote locations of interest (e.g., South Atlantic Anomaly).

1.4.8 Services

Services will be continued and improved through the provision of real-time early warning data concerning the state of solar-terrestrial environment using the improved data service described in 1.4.2.

Improvements in services concerning the occurrence of solar flares and near-earth disturbances will be made taking advantage of research findings, i.e., an applied research effort will be conducted whereby research results will be utilized to directly improve our environment forecasting techniques.

1.4.9 Support

This item includes

(a) Provision of sufficient laboratory equipment to keep pace with state-of-the-art instrumentation. This is simply the requirement of maintaining a laboratory capable of testing the instrumentation it designs and builds.

(b) Staffing, operation, and maintenance of the Table Mountain facility, the Anchorage station and the Gunbarrel Hill station. Includes also operational equipments for reception of data, real-time reduction and processing for data service needs and off-line reduction and processing.

(c) Travel and computer time.

1.4.10 Base Salaries on NOAA Funds

An administrative objective is to increase SEL flexibility by reprogramming activities in order to more expeditiously meet NOAA's future needs. This can only be done by increasing NOAA's contribution to SEL salaries.

Table 1. SEL Overall Program and Program Requirements

TYPE	DESCRIPTION		FY 71		FY 72		FY 73		FY 74		FY 75		FY 76		FY 77	
			Sal.	0.0	Sal.	0.0	Sal.	0.0	Sal.	0.0	Sal.	0.0	Sal.	0.0	Sal.	0.0
Research and Development	Theoretical and experimental studies leading to an understanding of the entire range of solar-terrestrial phenomena beginning at the solar surface and ending in the upper atmosphere data received and analyzed from a substantial SEL ground-station and satellite program. Application of results of above studies to (a) development of techniques necessary for accurate forecasting of solar events and their subsequent effects on the earth environment, and (b) terrestrial measurements. Development of instrumentation necessary for (a) the conduct of the above experimental research program, and (b) routine, accurate, and cost-effective monitoring of the solar-terrestrial environment.	NOAA	700	35	792	173	1020	1009	1364	1297	1500	1449	1650	1616	1815	1800
		OA	562	293	527	288	256	163	65	45	50	50	50	50	50	50
Services	Provision of early warning, environment monitoring, environment forecasting, and real-time data dissemination. Maintenance of real-time data service for up-to-date information on the state of the solar-terrestrial environment. Maintenance, repair, and updating of all operational equipment: Table Mountain facility, Alaskan facility, Gunbarrel Hill facility, SPAN Network, Space Environment Services Center equipment, and laboratory equipment. Provide contract and communications funding.	NOAA	413	246	447	257	800	472	909	847	1000	838	1100	1077	1210	1198
		OA	305	90	315	95	286	76	0	0	0	0	0	0	0	0
Major Other Objects	Computer & Travel	NOAA						360		360		360		360		360
Facilities & Eqpmt.	GOES	NOAA				200										
	Lab. Data System	NOAA						212		18		128				
Sub-Totals			1980	674	2081	1015	2362	2292	2338	2567	2550	2825	2500	3103	3075	3408
		NOAA	1394		1869		3873		4795		5275		5803		6383	
		OA	1260		1227		781		110		100		100		100	
			2654		3096		4654		4905		5375		5903		6483	
Aeronomy and Space Data Center	Serves governmental agencies, international groups and individuals, universities and other research organizations, industrial firms, and the general public in archiving, reproducing, disseminating solar-terrestrial data. The Data Center is jointly funded by EDS (77%) and SEL (23%).	NOAA	182	40	202	46	246	240	Expected transfer of A and SDC to EDS							
		OA	70	76	70	76	80	66								
Totals			2232	790	2353	1137	2688	2598	2238							
		NOAA	1616		2117		4359		4795		5275		5803		6383	
		OA	1406		1373		927		110		100		100		100	
		Total Funding	3022		3490		5286		4905		5375		5903			

Sal. = Salaries
0.0 = Other objects

Table 2.1. *SEL Satellite Projects: Ongoing and Planned*

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
IMP F,G	NASA: R&S Orbit: Apogee~34 R_ε highly elliptical	Solar Proton Monitoring Experiment: Interplanetary observations at energies $1\leq E_p\leq 10$ MeV $E_p\geq 10$, 30, and 60 Mev	IMP F data 5/67 thru 5/69. IMP G data 6/69 thru present. Hourly averaged intensities published on monthly basis in Solar-Geophysical Data.	IMP F → IMP G →	DA → →	→ →	→ →		
IMP I	NASA: R&S Orbit: Apogee~34 R_ε highly elliptical	Solar Proton Monitoring Experiment: Interplanetary observations at $0.25\leq E_p\leq 10$ MeV $E_p\geq 10$, 30, and 60 MeV	To be launched 1/71. Hourly averaged intensities to be published on monthly basis in Solar-Geophysical Data.	→	IMP I →	DRA →	→	→	
IMP H,J	NASA: R Orbit: 30-40 R_ε circular	Proton, electron, and alpha-particle observations in interplanetary space magnetosheath and the magnetotail. Angular distributions obtained at following energies: 0.015-8.5 MeV protons, several energy bands 0.015-.45 MeV electrons, several energy bands 2.4-35 MeV alphas, several energy bands	To be launched 1/72 and 1/73. These data will yield new and unique information on particle production in solar flares, particle propagation in the interplanetary medium, and particle access to the magnetosphere from external regions.	40	105 IMP H →	100 → IMP J →	90 DRA → →	→ →	→ →
OGO F-17	NASA: R Orbit: low altitude high inclination	Trapped, precipitated, and backscattered electrons at $E_e>30$, 100, 300 and 1000 keV and	OGO F data 7/69 thru present. These data will provide new knowledge on wave-particle interactions in magnetosphere, auroral-particle production and effects, and source, loss, and transport of magnetospheric particles.	74 OGO F17 →	105 DRA →	→	→	→	
OGO F-15		Auroral electron observations in several energy bands from 0.5 keV → 20 keV		20 OGO F15 →	50 DRA →	→	→	→	

R = Research
S = Service
DA = Data Analysis
DRA = Data Reception and Analysis

Table 2.2. SEL Satellite Projects: Ongoing and Planned

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
S^3 Small scientific satellite	NASA; R Orbit: Apogee 6R$_E$ elliptical	Study of earth's ring current wave-particle interactions in magnetosphere, and source, loss, and transport mechanisms affecting magnetospherically trapped particles. 0.5 keV-5 MeV protons; several energy bands 0.5 keV-500 keV electrons; several energy bands $\gtrsim$250 keV/$_{\text{nuC}}$ alpha particles; several energy bands. $\gtrsim$250 keV/$_{\text{nuC}}$ Li, Be, B $\gtrsim$250 keV/$_{\text{nuC}}$ C, N, O DC, AC magnetic fields DC, AC electric fields	To be launched 6/71. A new and unique set of coordinated data designed for studies listed in DESCRIPTION.	13	28 S^3 DRA →	20 →	→	→	
ATS F	NASA: R Orbit: Geostationary 6.6R$_E$ circular	Study of protons and heavy ions at 6.6R$_E$ 0.02-5 MeV protons, several energy bands 800 keV - several MeV alphas, several energy bands $\gtrsim$250 keV/$_{\text{nuC}}$ Li, Be, B $\gtrsim$250 keV/$_{\text{nuC}}$ C, N, O	To be launched early 1973. These data will provide new insights to source loss and transport mechanisms of particles observed in the magnetosphere. The heavy ion channels will also be very valuable in studies of particle production in solar flares.	 46	10 46	20 ATS F → 59 ATS F →	10 DRA → 41 DRA →	→ →	
ATS F		Radio beacon: multifrequency studies of ionospheric propagation from 6.6R$_E$ to the earth's surface.							
HELIOS	W. Germany:R Orbit: earth escape to sun; operate to ~ 0.3 AU.	German solar probe, low energy protons, electrons, and alpha particles with angular distributions.	To be launched ~ mid-1973. Spatial gradient from 0.3-1 AU of particle intensities, energy spectra and angular distributions will be obtained by using simultaneous IMP J data.				HELIOS →	DRA →	→

Table 2.3. SEL Satellite Projects: Ongoing and Planned

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
Rockets	NASA/NOAA NORWAY: R	Proton, electron, and heavy ion observations in a proton aurora. Four payloads, two NASA/NOAA and two Univ. of Bergen, to be flown in coordinated research program.	To be launched 11/71. SEL is supplying two complete payloads and particle instrumentation on the Norwegian payloads.		DRA				
	NOAA: R	Proton, electron, and radio observations. Coordinate ground study performed in conjunction with Geophysical Monitoring satellite.	Launch mid- to late-1974.						
ATS-1	NASA: S&R Orbit: Geostationary	Observations at $6.6R_E$ of solar protons, $EP \geq 20$, and 60 MeV and magnetic field. These observations used in our real-time data base for early warning and forecast services.	Data now received in real time at our Table Mountain station in Boulder, Colo.	ATS 1	RT Data Base				
ISIS A,B	NASA: R Orbit: low altitude high latitude	Ionogram processing for NASA and interested researchers.	ISIS A data being received at Gunbarrel Hill station and processed in SEL. ISIS B to be launched 3/71. Data to be received and processed for two years after launch.	202 ISIS A ISIS B	200 Data Reception and Processing Data Reception and Processing	150			
ATM SKYLAB	NASA: S	Provision of forecast and early-warning services to NASA for SKYLAB. Extended manned stays require such services. In addition, will provide real-time information and forecasts of solar activity in attempt to maximize scientific usefulness of SKYLAB mission.	Phase-out in FY 1973 as NASA has no manned mission scheduled beyond SKYLAB.	65	96	75			

Table 2.4. *SEL Satellite Projects: Ongoing and Planned*

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
TIROS M ITOS	NOAA: S&R Orbit: low altitude high inclination	Proton and electron observations $0.2 \leq Ep \leq 10$ MeV $Ep \geq 10$, 30, and 60 MeV $E_e \geq 150$ keV Polar cap proton observations used in real-time data base for forecast services.	Six launches scheduled. TIROS N up and operating from late 1969 to present and providing near real-time polar cap data on solar-proton intensities. **Second launch 12/11/70.** Proton data to be used to provide long-term monitoring service.	1 RT Data Base 2	RT Data Base Remaining ITOS as needed				
SMS GOES	NOAA: S&R Orbit: Geostationary	Proton, X-ray, and magnetic field observations at $6.6R_E$ 0.5-500 MeV protons in several energy bands 0.5-9 Å X-rays in two wavelength bands. 3-axis vector magnetic field These data to be used in real-time data base for early warning and forecast services.	Three launches scheduled. First due in late 1972. The environment-monitoring data will be received on a 24-hour/day operational real-time basis with reception at the Table Mountain station in Boulder.		SMS 1 Real-Time Data Base	SMS 2	Real-Time Data Base	GOES 1 when required	
SOLRAD HI	DOD: S&R Orbit: $20R_E$ circular	Interplanetary magnetosheath, and magnetotail observations. 15 keV-100 MeV protons, several energy bands 15 keV-5 MeV electrons, several energy bands. Solar wind X-rays Monitoring data to be included in real-time data base for early warning and forecast services.	To be launched in mid-1973. 3 satellites spaced 120° apart. Data reception being planned at Table Mountain station in Boulder, Colorado.			SOLRAD HI	Real-Time Data Base		

Table 2.5. SEL Satellite Projects: Ongoing and Planned

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
TIROS N	NOAA: S Orbit: low altitude high inclination	Solar proton observations over polar cap and measurement of total energy deposition into atmosphere due to particle precipitation from aurora and radiation belts. $0.1 \le E_p \le 10$ MeV $E_p \ge 10$, 30, and 60 MeV 10 eV-500 keV; trapped and precipitated electrons and protons. Data to be used in real-time data base for early warning and forecast services.	Launch ~1975. Data will also provide long-term monitoring of energy budget of upper atmosphere. SEL to have instrument packages available for this mission.					TIROS N	Real-Time Data Base
GMS Geophysical Monitoring Satellite	DOD/NOAA: R&S	Cold plasma injection used to stimulate aurora and ionospheric disturbances. 10 eV-1 MeV electrons and protons in several energy bands Magnetic fields Cold plasma injection Will include data in real-time data base.	Can launch mid-1974. Data reception at Table Mountain station in Boulder, Colo. Proposal submitted to ARPA for SEL to conduct study for feasibility and costs of program.					GMS DRA	Real-Time Data
STP Solar Terrestrial Physics	NASA: R&S Orbit: 1 AU circular 10^7 km from earth	Interplanetary observations of solar wind, solar cosmic rays, and magnetic fields. Monitoring data to be included in real-time data base for early warning and forecast services.	Can launch ~1975. Not yet a NASA program.					STP DRA	Real-Time Data Base

Table 3.1. SEL Major Non-Satellite Projects

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
SPAN	NASA: S	Solar Proton Alert Network. Three-station solar patrol giving near 24-hr data on solar activity. Hα observations 6, 11, and 21 cm radio noise observations Used in real-time data base for early warning and forecast services.	Ongoing. Funded by NASA through FY 1973 with implied commitment by NOAA to pick it up in FY 1974. Stations: Boulder Canary Islands Australia	350	350	350			
ARPA	DOD: R&S	Development of techniques to predict propagation effects on any specified radio link given data which indicate characteristics of propagation medium.	Requires determination of characteristics of ionospheric irregularities with simultaneous observations of distortions on signals passing through ionospheric regions of interest. Statistical optics and scattering theories to be used in identifying irregularity characteristics and interpreting results.	375	325	150			
Antarctic Riometer	NSF: R	Study of PCA events using riometer techniques.	To be discontinued at end of FY 1971.	39					
Solar	NASA: R	Solar physics research. Specific area covered: chromospheric motions as observed in Hα; magnetic field-gas pressure interactions in active regions; organization of flare reports with flare-index values; east-west asymetry of sunspot areas; relation of solar-proton entrance to magnetosphere with magnetic activity.	A 30-K/year effort is shown as planned in future years.	18	18 15	15 15	15 15		
Very Long Baseline Interferom-	NOAA: R	The novel technique of independent, atomic-clock interferometry is used for establishing latitude, longitude, and height of widely separated antenna locations (even between continents).	Applications in the fields of Geodesy (earth's polar motion, continental drift) and Marine Science (precision location of busy positions, etc.).	87	187	462	512		

Table 3.2. SEL Major Non-Satellite Projects

NAME	AGENCY & TYPE	DESCRIPTION	COMMENTS	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76
Solar Physics Facility (Aerospace)	NOAA: R&S	Existing high resolution Hα telescope, mm radiometer, and production of magnetic field maps of the solar disk. Plan to incorporate output available in Space Environment Services Center for early warning and forecast services. Also will have use of facility and data for SEL solar physics research.	Joint funding and operation of this existing facility by NOAA/SEL and Aerospace. Represents a very inexpensive way of greatly increasing our research and service efforts concerned with the sun.			150	150	150	150
Real-Time Data Service	NOAA: S	Data service in time-share computer system containing real-time information on state of solar-terrestrial environment. Date from large array of satellites and ground stations supply data continually on state of solar activity, condition of interplanetary medium, magnetospheric activity and ionospheric disturbances. Data used to forecast future space weather conditions. Combines techniques of routine messages, individual user alerts and direct-user interface with the data base via teletype-telephone.	Real-time data base statistics critical requirements of DOD/AWS, NASA, national and international upper atmospheric and space research programs, future SST program, power companies. Any user in the world is able to obtain the data he desires anytime.		200	256 (one-time requests)	63	161	
Optical	ARPA: R	Optical measurements on the ionosphere (heated with Office of Telecommunications radar) provide information on size and temperature of region.	Ongoing in FY 1971. Probably tapes in FY 1972, ending by FY 1973.	28	28	0	0	0	0

Table 4. Estimated Other-Agency Funding for SEL FY 1971 through 1974.

O/A Project	Agency	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975
Research:						
1) Antarctic Riometer	NSF	38.8	0	0		
2) Ionospheric Propagation	ARPA	412.6	325.0	150.0	?	
3) ATM SKYLAB	NASA	65.5	96.0	75.0	0	
4) ATS-F Radio Beacon	NASA	62.3	56.0	74.0	20.3	
5) Electron Precipitation	ARPA	50.0	?	?	?	?
6) IMP H & J	NASA	32.0	105.0	100.0	90.0	0
7) OGO F-17	NASA	73.0	105.0	0		
8) OGO F-15	NASA	20.0	50.0	0		
9) Optical Ionospheric Measurements	ARPA	22.8	16.6	0		
10) Solar Physics	NASA	18.3	33.0	?	?	
11) S^3	NASA	13.0	28.0	20.0	0	
12) Data Evaluation	AFTAC	29.4	0			
13) Lightning Discrimination	AFTAC	16.8	0			
Services						
14) ISIS	NASA	202.4	200.0	150.0		
15) SPAN	NASA	192.9	211.7	211.7	0	
16) Ent AFB	AF	1.5	0			
17) UCLA	U of Cal.	8.0	0			
Aeronomy and Space Data Center						
18) NASA Data Services	NASA	8.0	8.0	8.0	8.0	?
19) SPAN	NASA	138.3	138.3	138.3		
TOTALS		1405.6	1372.6	927.0	118.3	

2. SEL FY 1971 (February 1970)

In FY 1971, SEL established research projects in relevant areas of solar-terrestrial physics, effected improvement in services, greatly increased the satellite observing and research program, and made fresh starts in new areas as listed below.

2.1 Highlights of Ongoing and Developing Activities

(a) Current involvement in 14 ongoing satellite and rocket programs representing a total of 29 SEL research and monitoring experiments.

(b) Current involvement in five planned satellite and rocket programs representing more than seven SEL research and monitoring experiments.

(c) Continue strong research programs in solar-terrestrial physics (solar physics, interplanetary and magnetospheric physics, ionospheric physics).

(d) Continue development of long baseline interferometry program capable of measuring continental drift rates, the earth's rotation irregularities and applications in any precision measurement problem over long baselines, e.g., marine geodesy.

(e) Continue operation and maintenance of worldwide solar patrol network (SPAN).

(f) Continue development, operation and maintenance of a unique real-time data base providing up-to-date information concerning the state of solar-terrestrial environment.

2.2 Statistical Summary of SEL Funding, Manpower, etc.

2.2.1 Manpower

Approximately a 107-man-year effort is made up of 96 FTP plus varying numbers of PTP, WAE, and FTT employees.

2.2.2 Funding

NOAA R&D	$ 822 K
NOAA S&E	794
Other Agency	1,406
	$ 3,022

2.2.3 Salaries

NOAA	(56%)	$ 1,307 K
Other Agency	(44%)	937
		$ 2,244

2.2.4 Other Objects

Table 5 shows a breakdown using complete FY 1970 funding level. Percentages in various categories are expected to remain the same in FY 1971.

Chapter 2 - FY 1971

Table 5. FY 1970 Other Objects Funding

TYPE	NOAA Amount $K	%	O/A Amount $K	%	TOTAL
Travel	$ 35	67	$ 17	33	$ 52.0
Computer	99	60	67	40	166.0
Rents, Communication and Utilities	90	86	15	14	105.0
Contracts	181	80	45	20	226.0
Equipment	40	68	19	32	59.0
Purchases and Stores	66	53	58	47	124.0
TOTAL	$ 501	69	$ 221	31	$ 722.0

2.2.5 SEL Organization

Three areas of equal strength in manpower are:

(a) Research

(b) Support and development

(c) Services

The laboratory structure and personnel listing according to program areas is given in Appendix A.

2.2.6 Publications (published or in press)

Fiscal Year	Professional Journals	NOAA Publications	Data Center Report
1970	38	11	30
1971 (Jan 19)	33	10	15

2.3 Fiscal Status Remarks

The great payroll dependence on other agency funds (Other-Agency funds provide 44% of SEL salaries) has two serious negative effects:

(a) It significantly reduces flexibility to guide research and services along lines appropriate to NOAA's mission within the Department of Commerce.

(b) It creates a significant moral problem within SEL.

An additional problem is the inability to maintain an up-to-date laboratory capability. For example, only NOAA Equipment funds, as shown in Table 5 above (40 K, 1.4% of total SEL budget), were available for general laboratory test equipment. This poses a serious problem as SEL must conduct a major effort in the instrument and hardware area in order to provide effective research and services.

2.4 Achievements of Present Program

2.4.1 Research

(a) An analysis of high-resolution magnetograms gives evidence that the solar surface magnetic field may be quantized into small elements of strength of about 20 Gauss.

(b) Periodic brightenings of H-alpha mottles having periods of about 5 minutes and wavelengths of about 30,000 km have been identified with phase velocities of acoustic-gravity waves.

(c) Cooperative studies with researchers at Berkeley have shown that there is a good correlation in the occurrence of extreme ultraviolet (EUV) radiation and hard X-ray bursts from solar flares. In fact, the energy of electrons required to explain the hard X-rays by bremsstrahlung also seems adequate to account for the EUV through ionization and subsequent radiative recombination in the lower chromosphere.

(d) Another study has shown that white light emission in some flares is well correlated in its intensity variations with a strong flux of EUV (10-1030 Å) radiation and that the flux enhancement in white light is approximately equal to that in the range 10 to 1030 Å. Such a correlation is of interest as the occurrence of white light flares seems to be intimately connected with the collisions between two sunspot groups.

(e) Theoretical and experimental results have also been obtained concerning the transport of the energy released at the solar surface through the interplanetary medium to the vicinity of earth. Theoretical studies of shock wave formation have shown that inclusion of a finite conductivity yields realistic results when compared to data obtained from spacecraft. This study pertains specifically to piston-type shocks released at the solar surface and which propagate through the interplanetary medium. The energy transferred in such a shock ranges between 5×10^{31} to 5×10^{32} ergs, the largest energy transfer of known shocks studied.

Important implications in these studies are their connection with terrestrial magnetic storm activity. The requirement of finite conductivity implies the presence of large-scale turbulence in the piston shock produced by wave-particle interactions. The passage of such a turbulent region over the magnetopause may be very important in the energy-transfer process from the interplanetary medium into the magnetosphere. In addition, these interplanetary shocks can also be used to produce sudden brightenings of comets (e.g., the Schwassman-Wachman comet which is in a nearly circular orbit at 5 to 6 A.U.) and may allow such comets to be used as a natural solar-wind probes at presently inaccessible regions of space.

(f) A study of sources, losses and transport of magnetospherically trapped particles has been completed. One result of this study is that the inclusion of pitch-angle diffusion processes within the magnetosphere allows a uniform description to be made of outer-zone electrons from energies of 10's of keV to several MeV.

(g) A magnetospheric model has been constructed using realistic dipole orientation. Studies using this model have shown that particle cutoffs and auroral precipitation and disturbance indices display a strong dependence on the dipole orientation.

(h) Experimental studies have provided initial results showing strong interaction between atmospheric disturbances (thunderstorms) and the ionosphere. A resonant oscillation of the ionosphere occurs due to the presence of acoustic waves emanating from passing thunderstorms.

(i) Rocket results on atmospheric emissions during infrared aurora strongly imply the existence of significant sources of infrared emissions in addition to particle precipitation.

(j) A spectroheliosope has been constructed and put into use allowing routine observations of sunspot and plage magnetic polarities. Instrument reliability is such that corrections are occasionally made to the Mt. Wilson magnetic polarity assignments. In conjunction with the H_α characteristics of active regions, these measurements are used to make routine forecasts of solar flares. In fact, it is now possible to predict locations of about 80% of all flares. However, much additional work is required before accurate forecasts of the time of flare occurrence become commonplace. These results plus refinements in magnetic observations being planned by this laboratory should materially aid the temporal forecasting effort.

(k) Ground-based experimental observations of interplanetary scintillations at wavelengths of 11.4 m progressed to the point where daily figures for the product of solar-wind speed and effective wave number were obtained from September through April. These ground-base observations yield information on the velocity and small-scale structure of the solar wind which complements the suprathermal observations with particle detectors by spacecraft.

(l) Construction of a portable 11-m antenna array has been completed and preliminary long baseline experiments at these long wavelengths are now under way.

2.4.2 Support and Services

(a) A prototype real-time data base was incorporated into the SEL computer system whereby all space environment data are stored, processed and formated in real time. These data are then available to a variety of users via TTY facilities. Users are able to directly interact with the data base and receive only the data they want when they want it. In fact, during the year, the Air Weather Service Forecasting Center at ENT Air Force Base subscribed to this service to assist in meeting military requirements for space and ionospheric disturbance forecasting. In addition, the Preliminary Report of Solar Geophysical Data is printed weekly from this data base and circulated to approximately 700 users.

(b) Inclusion of real-time solar proton data as obtained over the polar caps from the NOAA ITOS satellite into the real-time data base. One ITOS satellite is in orbit and routine real-time operations are in effect. A second ITOS was launched December 11, 1970. These data, which also include radiation-belt information, have been used for real-time support of Apollos 11, 12, and 13.

(c) Real-time solar proton and magnetic-field data from the ATS-1 satellite are routinely received at the SEL Table Mountain facility. These data are used continuously in our early warning and forecasting operations.

(d) Contract negotiations were completed with NASA MSC, whereby SEL assumed responsibility for the solar-proton alert network (SPAN) consisting of three stations spaced to allow continuous solar observations with radio and optical telescopes. Data from SPAN are used primarily to detect the occurrence of solar-proton events and the inclusion of this activity within SEL establishes Boulder as a world data center for solar data from ground-based solar observing equipment.

(e) Inclusion of solar data from SPAN into SEL archiving operations as well as the real-time operations mentioned above.

(f) Development of techniques to use H-alpha pictures of the sun to infer certain magnetic field characteristics, primarily field polarities, in the vicinity of active regions.

(g) Establishment of a major SEL satellite and rocket program having direct applications throughout the laboratory's research and service responsibilities.

(h) Establishment of excellent working relations with the Air Weather Service in the area of space environment monitoring and forecasting. Results of recent discussions with both Headquarters AWS and the working levels of AWS have led to the development of coordinated NOAA-AWS effort in this area for the early 1970's which seems to meet the requirements of all concerned.

2.5 Implications for Future Program

2.5.1 Research

(a) Increased commitment in manpower and computer time for research of the data to be available from the extensive number of research projects listed in Tables 1 and 2.

(b) Stronger liaison between SEL research and services so that new results may be quickly and effectively incorporated into the service functions.

2.5.2 Support and Services

(a) Increased commitment for advanced instrument development and laboratory equipment.

(b) Expansion of real-time data service to provide

1. capability of handling impact of satellite data shown in Table 2,
2. reliable 24-hour/day operation,
3. services for an expanding requirement in the 1970's.

Chapter 3 - FY 1972

3. SEL in 1972

3.1 Program Highlights

The basic program carried out in FY 1971 will be continued at approximately the same level in FY 1972. In addition, the following requests were made and results obtained for additional NOAA funding in FY 1972.

		Requested		Received	
	Type	Funds	New Personnel	Funds	New Personnel
(1) GOES ground-based facility and real-time data service	FEC	$ 200 K	0	0	0
(2) Forecast center improvements	S&E	125 K	2	0	0
(3) Long baseline interferometer	R&D	475 K	2	100	0

Item 3 (as received) is included in FY 1972 budget. Because of the key role played by Item 1 in the SEL 5-year plan, it remains listed in the FY 1972 budget and is discussed in detail below.

3.1.1 GOES Ground-Based Facility and Forecast Center Improvements

As mentioned earlier, SEL has many years of experience in serving the national needs for solar-terrestrial research and services. A number of factors indicate that the present is a propitious time for SEL to assume new initiative for solar-terrestrial data services.

(a) There are increasing needs by civilian and military agencies for real-time data which can only be met using modern data processing methods and by utilization of a combination of satellite and ground-based observations.

(b) There is increasing reliance on SEL by other agencies, particularly NASA and the AWS, to meet their future needs.

(c) There is improved understanding of the solar-terrestrial processes resulting largely from satellite experiments of the last few years which can now be used to improve the services.

(d) There are opportunities within NOAA to obtain the satellite data required in the solar-terrestrial monitoring program.

(e) Solar proton and trapped electron data are currently available in near real time from the ITOS satellite.

(f) A major improvement in the quality of SEL services will result when solar X-ray, solar proton, and geomagnetic field data are available from the GOES satellite in 1973.

(g) A prototype data system developed in SEL has demonstrated the feasibility and versatility of a real-time data service accessible to users via TTY.

The SEL report, "A Satellite Recording and and Data-Base System", attached as Appendix B, describes how the existing prototype data system can be improved and extended on a year-to-year basis to meet the needs for up-to-minute solar-terrestrial environment data in the 1970's. The plan, briefly described in section 1.4.2, discusses in detail:

(a) processing, storage, and display of all available data, present and future,
(b) dissemination of data,
(c) direct-user interaction with real-time data base in time-share computer,
(d) data recording for analysis and research,
(e) cost (hardware and maintenance) schedule.

The following schedule is proposed in FY 1972 for initial implementation of the SEL real-time data system (pp. 17, 18, app. D).

FY 1972 System G

(1)	Processor	$ 36.4 K
(2)	Tape controller	4.0
(3)	Tape units	16.2
(4)	Disc controller	3.0
(5)	Disc unit	6.9
(6)	Contingencies @ 10%	6.7
	Single system	$ 73.2
	Duplicate of above	73.2
	Total hardware	$ 146.4 K

See Appendix B for detailed discussion of these items and necessity of dual system to provide reliability.

In addition, maintenance and phone costs total $35.7 K and will be provided by SEL through reprogramming.

Thus, the total SEL FY 1972 GOES request of $200 K breaks down as follows:

$150 K -- implement real-time data service System G
$ 50 K -- antenna, amplifiers and front-end gear.

In summary, SEL has demonstrated the feasibility of a real-time data service which has the approval and confidence of NASA and the AWS. SEL has a detailed plan for incorporating the data from future NOAA satellites and ground sensors into a real-time data service which is accessible to users via TTY.

3.1.2 Forecast Center Improvements

The loss of new funds ($125 K) and two positions for the Forecast Center in FY 72, has serious consequences since these funds were to be used to finance additional and new efforts to integrate existing ground-based data with new satellite data. Specifically, these efforts were expected to increase the quality and timeliness of our geomagnetic forecasts using Pioneer, ATS-1, and ITOS satellite data. Improvements in these forecasts are needed to support commercial and government interests in radio communications systems, geomagnetic surveys and electric power transmission systems. These efforts cannot be undertaken, except in a very minor way, without these fund increases. Unfortunately it is not feasible to shift persons engaged in other basic activities into this area as basic support activities must continue for other reasons as well as being a necessary "first step" in this specialized geomagnetic forecast support.

3.1.3 Long Baseline Interferometry (FY 1972)

The expected increment of $100 K for LBI work in FY 1972 will permit continuation of experiments at meter wavelengths. A number of highly successful decametric LBI runs were carried out in October and November, 1970 between Boulder, and Haswell, Colorado. These experiments, in addition to sharpening LBI skills, yield a great deal of useful information about the interplanetary medium and the ionosphere. An attractive next step in this program, still possible within the scheduled level of funding, would be to use the large 22-acre antenna at Jicamara, Peru in conjunction with a small portable array. A much larger sample of weaker sources would then be observable and the results of the earlier decametric experiments could be extended to meter wavelengths.

Also in FY 1972, a start can be made in LBI geodetic surveying at 1.6 GHz using steerable parabolic antennas at the Cal Tech radioastronomy site in the Owens Valley, and at the U.S. Navy facility at La Posta, California. The NOS (C&GS) has already scheduled a survey of this baseline (533 km) for comparison with the LBI technique. This path crosses the San Andreas fault and is of considerable interest to NOAA solid-earth geophysicists. We do not expect to achieve better than 1:500,000 accuracy at 1.6 GHz. For precision work, an extension to C- and X-band is required as proposed for FY 1973. The Owens Valley-LaPosta experiment, however, would provide the necessary experience with the new SEL recording equipment, interfacing with the computer-controlled radiotelescopes at each site, etc., before the establishment of an X-band facility at Boulder, Colorado. Such work is also a prerequisite for baseline determinations between Boulder, Colorado and Alaska (see sec. 4).

3.1.4 Satellite and Rocket Programs

The increased involvement of SEL in satellite programs, which began in 1971 and extends into FY 1972 are listed in Table 2 and are summarized below.

IMP F, G and I will provide interplanetary observation of solar protons. These data will be used in studies of particle propagation in the interplanetary medium, particle access to the magnetosphere, and particle energization and injection characteristics of solar flares. Hourly average intensities will be published in the monthly Solar Geophysical Data.

IMP H to be launched in February 1972 will provide proton, electron and alpha particle observations in interplanetary space, the magnetosheath and the magnetotail. These data provide new and unique information on solar-flare particle production, the propagation of particles through the interplanetary medium and particle access to the magnetosphere from external regions.

OGO F-17 and OGO F-15 will provide data on trapped, precipitated and back-scattered electrons and new information on wave-particle interactions in the magnetosphere, auroral particle production, etc.

S^3 Satellite to be launched in June 1971 will provide proton, electron and alpha-particle data important to studies of the earth's ring current, wave-particle interactions in the magnetosphere, and source, loss, and transport mechanisms affecting magnetospherically trapped particles.

ISIS A and B Satellites will continue to be monitored at Boulder to provide topside ionograms for NASA and interested researchers.

ATS-1 Monitoring will continue to provide solar-proton and geomagnetic field data in real time to Space Environment Service Center (SESC) for early warning and forecast purposes.

ITOS (and TIROS M) to continue providing near real-time data on solar-proton and trapped-electron intensities. These data are displayed in SESC and used in early warning, forecasting, and in particular, in support of Apollo missions.

Rockets to be launched in November 1971 in cooperation with the University of Bergen, Norway, will observe protons, electrons, and heavy ions in a proton aurora. SEL will supply two complete payloads of its own and particle instruments for the Norwegian payloads.

Operational Real-Time Data Service. Plans have been made to transform the existing prototype real-time data service into the minimum operational system described in Appendix B.

Studies will be continued for future satellite launches including those listed below:

IMP-J to be launched in January 1972.
ATS-F to be launched in early 1973.
HELIOS to be launched in mid-1973.
TIROS M to be launched annually.
SOLRAD HI to be launched in mid-1973.
Geophysical Monitoring Satellite (GMS) now in proposal and study stage with possible launch in 1974. This satellite would produce artificial aurora and ionospheric disturbances as well as monitor electrons, protons, electric and magnetic fields.

3.2 FY 1972 Summary of SEL Funding, Manpower, Etc.

Table 6 summarizes the SEL fiscal and personnel requirements for FY 1972 in order to carry out the programs described in section 3.1 which include a continuation of the FY 1971 level of support plus the four new initiatives described in sections 3.1.1, 3.1.2, 3.1.3, and 3.1.4.

Table 6. SEL Budget Estimate for FY 1972

Program Area	Personnel				Salaries		Other Objects			Salaries*
	New	FT	PT	Total	Base	+59%	NOAA	Other Agency	Total	Other Objects
Solar Physics	0	8	1	9	151	240	15	36	51	291
Interplanetary Magnetospheric Physics	0	10	0	10	162	258	14	104	118	376
Ionospheric Physics	0	11	5	16	194	309	13	140	153	462
Radio Astronomy	0	5	2	7	82	129	100	0	100	229
Numerical Analysis & Computer Techniques	0	8	2	10	157	250	17	8	25	275
Instrument Development	0	5	0	5	83	132	29	0	29	161
Real-Time Data Services	0	9	0	9	134	213	86	0	86	299
Off-Line Data Service	0	7	0	7	106	169	0	31	31	200
Space Env. Services Center	0	18	8	26	239	380	156	66	222	602
Aeronomy & Space Data Center		15	4	19	171	272	46	76	122	394
TOTALS		96	22	118		2352	476	461	937	3289 + 200 ** 3489

* Includes 6%/annum increase in cost of living plus 50% overhead.

** GOES Increment.

FY 1952 Increments

Item	Requested		Received		Remarks
	Funds	Staff	Funds	Staff	
1) GOES ground facilities	200	0	0	0	GOES monies remain in the FY 1972 budget as a key item in 5-year plan.
2) Forecast Center improvements	125	2	0	0	Resubmit for FY 1973.
3) Very long baseline interferometer	475	2	100	0	Modify request for FY 1973.

3.2.1 Manpower

Personnel requested in FY 1972 total 100 full-time permanent and approximately 22 part-time positions.

3.2.2 Funding (All NOAA funds include recurring FY 71 allocation plus 6% payraise.)

NOAA R&D	$ 1,052
NOA S&E	865
NOAA FEC*	200
Other Agency	1,373
TOTAL	$ 3,490

*GOES funds shown due to importance of this item.

3.2.3 Salaries

NOAA (61 %)	$ 1,441
Other Agency (39 %)	912
TOTAL	$ 2,353

3.2.4 Other Objects

NOAA	$ 676
Other Agency	461
TOTAL	$ 1,137

3.3 Achievements To Be Expected

(a) Real-Time Data Service. This will be the initial step in creating a reliable 24-hour/day real-time solar-geophysical monitoring system and a data service available to the SDL forecasters as well as to users outside SDL via TWX.

An evolutionary plan to provide this service and to improve it from year to year is described in Appendix B.

Failure to implement this service would result in extreme embarrassment to NOAA in that working arrangements have been made with the Air Weather Service calling for these data and services.

(b) Research through Increased Satellite Data. Work on various sub-models required for construction of STEM.

Studies beginning the calibration of magnetospheric models using OGO F data, interplanetary particle propagation using IMP data, and access of particles to the magnetosphere using IMP and ITOS data.

(c) Preliminary Work on Very Long Baseline Interferometry. During FY 1972 it is anticipated that $100 K will be received for the LBI program. This reduction in appropriation will still permit continuing observations of interplanetary scintillations at metric wavelengths and making a start in precision geodetic surveying at 1.6 GHz using steerable parabolic antennas at La Posta, California, and Owens Valley, California, through the cooperation of the

University of Maryland and the Naval Research Laboratory. These tests will provide valuable operating experience prior to obtaining L and X-Band facilities in NOAA as requested in FY 1973 (sec. 4.2.2).

(d) Ionospheric Irregularities. In a study funded by ARPA, it is expected that new knowledge will be obtained on the various mechanisms contributing to the distortion of radio frequency transients traveling from the earth to satellites and between distant points on the earth via ionospheric reflection. Several existing techniques will be brought together to study the overall problem and to partition the distortion between the various causative mechanisms for producing distortion. These studies have very strong bearings on the performance of ground-based and satellite-based military communications systems.

(e) Rocket studies will continue at high latitudes to study the occurrence and effects of ionosphere plasma instabilities and to measure auroral ion precipitation which is relevent to inferring the primal source of auroral particles.

4. SEL in FY 1973

The FY 1973 plan assumes the receipt in FY 1972 of $100 K (currently approved) to continue the long baseline interferometer program and $200 K (currently not approved) to implement the minimal operational real-time data system as described in Appendix B. Information on total NOAA and Other Agency funding is summarized below to aid in identifying for FY 1973 the estimated:

Total Laboratory Budget, i.e., NOAA plus Other Agency (OA) funding.

Incremental Laboratory Budget, i.e., the increase in NOAA funds requested for FY 1973 over FY 1972.

	FY 1972	FY 1973	Difference
(a) Total Funding	$ 3490	$ 5286	$ 1796
Salaries	2353	2688	335
Other Objects	1137	2598	1461
(b) NOAA funding	2117	4359	2242
Salaries	1441	2066	625
Other Objects	676	2293	1617
(c) Other Agency	1371	927	- 444
Salaries	912	622	- 290
Other Objects	459	305	- 154

(a) indicates the total laboratory budget for FY 1973 is $5286 K,

(b) indicates the increment in NOAA funding for FY 1973 is $2242 K and consists of an increase in Other Objects of $1617 K (discussed in sec. 4.2) and an increase in salaries of $625 K (discussed in sec. 4.3) ,

(c) indicates the OA support will decrease by $444 K .

Table 7 summarizes the SEL fiscal and personnel requirements for FY 1973. Changes in funding and personnel from FY 1972 to FY 1973 can be identified by comparing tables 6 and 7. These changes are discussed in later sections.

4.1 Program Highlights

The FY 1973 program promises a productive and exciting year in NOAA/SEL for both services and research in the solar-terrestrial environment. The GOES satellite, with a space environment monitoring package, is scheduled for launch in late 1972 and Phase-H of the real-time data system is expected to be placed into operation in FY 1973. The availability of solar X-ray, solar-proton, and geomagnetic field data in real time will place NOAA and SEL in the forefront of the national effort in space environment services in 1973.

Advances will be made in the Solar-Terrestrial Environment Model (STEM) by using new satellite data and by reprogramming manpower to assign limits and to calibrate the theoretical models including the production of ionospheric and geomagnetic disturbances by solar X-rays and particles as outlined below.

The ATS F satellite will be launched early in 1973 and will be of special importance to SEL since it will provide both particle and radio propagation data for data

Chapter 4 - FY 1973

analyses and STEM calibration. Protons will be observed in several energy ranges from 0.02 to 5 MeV, and alpha particles will be observed in the energy range from 800 keV to several MeV. These data will provide new insights into source loss and transport mechanisms of particles observed in the magnetosphere. Heavy ion data obtained in this experiment will be very valuable in studies of particle production in solar

Table 7. SEL Budget Estimate for FY 1973

Program Area	Personnel				Salaries		Other Objects			Salaries +
	New	FT	PT	Total	Base	+68%	NOAA	Other Agency	Total	Other Objects
Solar Physics	0	8	1	9	148	248	190	19	209	457
Interplanetary Magnetospheric Physics	0	10	0	10	162	272	157	50	207	479
Ionospheric Physics	0	10	5	15	187	314	165	86	251	565
Radio Astronomy	1-GS 12 1-GS 13	7	2	9	130	218	375	0	375	593
Numerical Analysis & Computer Techniques	1-GS 9 1-GS 5 1-GS 7	11	2	13	183	308	34	8	42	350
Instrument Development	0	5	0	5	83	140	210	0	210	350
Real-Time Data Services	1-GS 9	10	0	10	144	241	145	0	145	386
Off-Line Data Services		7	0	7	106	177	25	0	25	202
Space Env. Services Center	1-GS 11 1-GS 12	20	8	28	265	444	180	76	256	700
Aeronomy & Space Data Center	1-GS 7 1-GS 11	17	4	21	194	326	240	66	306	672
TOTALS		105	22	127	1602	2688	1721	305	2026 572 2598	4714 + 572 5286
Other Lab Costs:										
Travel	60									
Computer Use	300									
FEC Item	212 572									

flares. SEL acts in the capacity of principal investigator for the radio beacon experiments which will provide multifrequency transmissions at HF and VHF from the satellite to ground-observing stations, one of which will be located at Boulder.

In addition to the particle and radio data from the ATS F satellite, data will also be available for research from five IMP satellites, two OGO satellites, the S^3 satellite, the ISIS satellites and from several rocket launches conducted in cooperation with the University of Bergen, Norway.

The particles and field data from satellites will greatly increase our knowledge of solar-proton events, the propagation of energetic particles through the interplanetary medium and the interaction of these particles with the earth's magnetic field and atmosphere. It is reasonable to expect significant advances in the understanding of processes leading to ionospheric and magnetic storms.

The state of knowledge of solar physics and the ability to predict the occurrence of solar flares is difficult to anticipate for 1973. At this time (1970) the concensus[1] is that the most promising approaches are those employing observations of the solar-magnetic field and mm-wavelength radio observations of active solar regions. Consequently, it is believed that the understanding and prediction skills in SEL in 1973 will depend to a great extent on whether the Aerospace facility will be utilized by SEL. The uses made of this facility may well set the pace for developments in solar-flare forecasting during the next few years as there does not appear to be any comparable facility available. It is reasonable to expect that in 1973, greater skill will be developed in flare forecasting so that the beginnings of a reliable and accurate forecast service can be put into operation.

In FY 1973 SEL will begin to develop and produce advanced space environment monitoring instrumentation in order to produce a cost-effective means of providing a space environment monitoring service.

4.2 Incremental Funding Summary for Other Objects in FY 1973 ($1617 K)

The NOAA support for other objects in FY 1972 is assumed to be $676 K, which includes the $200 K GOES request and the $100 K increment for LBI (see table 6). The requests for Other Objects in FY 1973 total $2293 K which reflect an increase of $1617 K over the FY 1972 level and are described in incremental form below and in detail on a Zero Base Budget in Appendix C.

4.2.1 SEL Real-Time Data System ($229.6 K)

(See sections 1.4.2 and 3.1.1.) To provide for inclusion of additional data, improved access to the data service, backup of ground-based data recording and power backup at the Table Mountain facility, SEL proposes to implement System H described in Appendix B. Improvements of System H over System G are described on page 11 of

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[1] Physics of the Earth in Space, The Role of Ground-Based Research. Report of a study by the Committee on Solar-Terrestrial Research of the Geophysics Research Board Natl. Res. Council, July 1969, p. 24.

Appendix B (assumed implemented in FY 1972) and the funding schedule is listed on pages 17 and 18.

Requested Hardware Costs	$ 229.6 K	
Maintenance and Phone Charges	44.5 K	(will be met by SEL).

It should be noted that this item includes hardware items listed in the previous FY 1972 Forecast Center improvement request which failed. The need for these improvements is more crucial in FY 1973 due to increased commitments of services to SEL users, going "operational" in the real-time monitoring service, the continued deterioration of present outmoded equipment and inappropriateness of present display techniques.

4.2.2 Very Long Baseline Interferometry (VLBI) ($275K)

The R&D increment of $100 K in FY 1972 will enable a continuation of experimental observations of interplanetary scintillations at meter wavelengths and making a start in precision geodetic surveying by using steerable dish antennas at other agencies as outlined in section 3.1.3. This experience will be very valuable in preparation for the implementation of precise geodetic surveying techniques at L and X Band in FY 1973.

The $100 K increment in R&D, authorized in FY 1972, is to be reprogrammed into the total coast of $375 K, thus making the increment for FY 1973, $275 K.

In FY 1973, the increment of $275 K requested is to permit carrying out precise geodetic measurements using steerable parabolic antennas at L Band between the La Posta Radio Observatory dish antenna near San Diego, California and one of the Owens Valley Radio Observatory dish antennas at Big Pine, California, a baseline distance of approximately 533 km. The National Oceanographic Survey (NOS) has scheduled a first-order Class II accuracy survey of these observatory locations for comparison purposes. The fact that this baseline bridges the San Andreas Fault provides an additional incentive for developing a rapid, precision surveying technique for monitoring possible earthquake effects.

Also, in FY 1973, a permanent VLBI terminal will be established at the Table Mountain field site near Boulder, Colorado by purchasing new equipment and by modifying and upgrading a 60-ft parabolic dish antenna at the site as indicated in the breakdown of costs below:

L-Band and X-Band receivers (cooled paramps)	75.0
Hydrogen maser oscillator	100.0
Small control computer	40.0
Computer interfacing and software development	25.0
Antenna drive modifications (digital pickoffs, etc.)	40.0
Antenna feed, broadband	20.0
Radome and cryogenic cooling (for paramps) at feed	25.0
Labor costs	50.0
	$ 375.0 K

In FY 1974, a portable antenna system and associated microwave equipment would extend precision VLBI experiments to points in Alaska, Baja, California and other areas. It is expected that in FY 1975 such a terminal would be turned over to NOS for operational use.

4.2.3 Aerospace Contract for Solar Physics Facility ($150 K)

There is general agreement between researchers that studies of solar-magnetic field and mm-wavelength radio emissions are most likely to provide new information on solar activity. The inference of solar magnetic fields from Hα observations has been advanced in SEL. Use of a laboratory-type spectrohelioscope at Boulder, Colorado has led to the ability to monitor solar-magnetic field polarities and to predict the locations of solar flares. There is a need for an instrument capable of more versatile operational uses. Solar observations at mm-wavelength can provide high-spatial resolution for correlation with the optical and magnetic observations. SEL does not have a mm-wavelength radiometer. Accordingly, SEL proposed in FY 1972 to purchase or start construction of a solar-magnetograph and a mm-wavelength solar telescope. These budget requests did not survive.

An unprecedented opportunity for FY 1973 has come to light, however, which could put the SEL solar-physics plans and activities years ahead. The opportunity is an offer to NOAA to jointly fund the unique Aerospace Corporation Solar Observatory which is located near Los Angeles, California. This facility consists of a high-resolution H-alpha telescope, a high-resolution 24-inch spectroheliograph, and an additional 6-inch filter telescope with digital output yielding magnetic maps of the solar disk. For approximately $150 K, or one-third of the full operating costs, SEL will participate as a full partner with the Aerospace Corporation in the operation of the solar-physics observatory, participating with the 12-man staff of the observatory in data analysis and, in turn, will have observing privileges on the telescopes. In addition, service needs will be met by incorporating digital maps of the solar magnetic field in real time into the SEL data base.

4.2.4 Space Environment Monitoring Instrumentation (SEMI) ($257 K)

In section 1.4.6, the development of space environment monitoring instrumentation is listed as a new initiative for the 1970's. SEL now has the scientific and engineering capability to produce space environment monitoring instrumentation for flights on future NASA, NOAA, and DOD satellites. As rides for SEMI are readily available (NASA, NOAA, DOD), the provision of such monitoring instrumentation by SEL is a very cost-effective method of fulfilling service needs for solar-terrestrial data in the 1970's.

An FEC one-time request of $160 K (INST Development Group) is made to improve the laboratory capability to engage in space environment monitoring instrumentation and to take advantage of satellite-flight opportunities in the 1970's. These funds are listed in Appendix C.

In addition, an S&E continuing request of $97 K per year is made for the development, test, construction, and flight, of space environment monitoring instrumentation. An initial instrument to be built up as a flight package is a total-energy detector to be used in monitoring the total-energy deposition into the upper atmosphere due to particles precipitating from the outer radiation zone and auroral zone.

Other instruments required for monitoring purposes are solar-proton detectors (100 keV to 1 GeV), magnetometers and trapped-particle detectors (electrons and protons). These instruments are inexpensive when produced for several flights, highly reliable and simple in construction and operation.

Thus, the total request in FY 1973 for SEMI is $257 K.

4.2.5 Rocket Program ($190 K)

SEL is concerned with perturbations in the earth's atmosphere by various phenomena including solar-flare effects, aurora, solar-cosmic ray events, and energy inputs to the atmosphere in the UV and IR ranges. Two laboratory studies making use of rocket experiments are:

(a) D-region studies in the Ionospheric Physics area at an estimated budget in FY 1973 for other objects of $125 K.

(b) F-region studies in the Interplanetary Magnetospheric Physics area at an estimated budget in FY 1973 for other objects of $65 K.

In situ observations via rocket are requested in these research programs to obtain better understanding of atmospheric processes governing the production of ionospheric and geomagnetic storms. In fact, the most cost-effective, and in many ways, the best, method of observing transient energy-input effects in the upper atmosphere and ionosphere is via rocket experiments. These scientific programs are described in some detail in Appendix C.

Separate rocket experiments are required since important interactive effects occur throughout the altitude range of 75-100 km. The D-region studies concern the 60 to 90 km region and the F-region studies are concerned with the 200 to 500 km region. F-region launches are not suitable for D-region studies because of the very small amount of time spent in the D region by a rocket proceeding upwards to study the F region.

4.2.6 Computer Use and Travel ($100 K)

In FY 1973, SEL has, for the first time, designated funds for computer time and travel at the Laboratory level. The total funds in these categories break down as follows:

Computer time	$300 K
Travel	60
Total	$360 K

This represents an increment of $100 K ($90 K for computer use and $10 K for travel). Computer usage is detailed below:

	FY 70	FY 71*	FY 72	FY 73
	(in thousands of dollars)			
NOAA	98.6	112	120	210
Other Agency	67.7	118	130	90
Total	166.5	230	250	300

* projection based on usage through Dec. 12, 1970

4.2.7 Services ($302 K)

Funding increases totaling $302 K are listed below to cover the SEL expanded commitment to provide solar-terrestrial environment services.

Space Environment Services Center

An increase of $24 K is requested for new communication lines and for additional contract support to provide STE data.

Real-Time Data Service

An increase of $59 K is requested for increased costs of operating the Table Mountain and Anchorage, Alaska field stations and for improving the services provided on predicted and current ionospheric and geomagnetic conditions in Alaska. Improved information is required by Arctic aircraft operations serving the North Cape, users of high-frequency radio communications - both internal and external to Alaska, geomagnetic surveys in Alaska, and by military operations in arctic regions including those of the AWS and the U.S. Navy. Data for the latter users are made available via the SEL data system.

Off-Line Data Service

An increase of $25 K is requested for development of equipment for reducing satellite data including a bit synchronizer, PCM documentator, digital-tape recorder, interface equipment to produce computer-compatible tapes. Equipment currently in use is NASA title-vested. The possible recall of this equipment by NASA would alter the needs.

Aeronomy and Space Data Center

An increase of $194 K is requested. A detailed request for the Aeronomy and Space Data Center has been submitted to the Environment Data Service by A.H. Shapley, Office of Geophysical Service.

4.2.8 Research ($113.4 K)

Other Objects requests for research programs in addition to those discussed earlier in this section are listed below and total $113.4 K.

Solar Physics

A request for $40 K is made to cover the cost of further improvements and operation of a 3-cm wavelength polarimeter antenna and for completion of a video record and playback system for recording solar-optical data. The 3-cm polarimeter will be used on one of the 60-ft dishes at Table Mountain to provide data pertaining to the development of solar flares which emit X-rays. The video recording system is an operational research tool which will enable the observer to replay solar-optical data preceding the occurrence of solar flares. This ability will enhance the capability to observe significant variations preceding the emission of X-rays, protons, etc.

Interplanetary Magnetospheric Physics

A request for $33.4 K is made to purchase equipment for observing auroral backscatter. Items include Doppler-shift electronics, analog tape recorder, and a radar transmitter and receiver.

Ionospheric Physics

A request for $40 K is made to purchase apparatus including an ionosonde, tape recorders and other smaller items to conduct the observations on atmospheric coupling described in Appendix C.

4.3 Incremental Funding Summary for Salaries in FY 1973 ($634 K)

The total incremental salary request for FY 1973 is $634 K. This request is required to accommodate increased NOAA funding of $334 K required by the SEL program ($202 K for new hires, $132 K for present staff salary increase) and to accommodate an anticipated reduction of $300 K in other-agency funding of laboratory salaries. The changes in NOAA and other-agency-funded salaries in FY 1973 are tabulated in Table 8 and are summarized below. Appendix B contains a detailing of personnel within SEL for FY 1973 by program area.

4.3.1 R&D Salary Increase of $228 K

Breakdown

(1)	Loss of other-agency funds	$ 271 K
(2)	New Hires	73 K
(3)	Salary increase based on present staff	75 K
(4)	Shift of salaries to services	- 191 K

Discussion

(1) Loss of other-agency funding of an amount of $263 K is expected to occur in the Solar Physics, Interplanetary and Magnetospheric Physics, and Ionospheric Physics areas. Since these Program Areas carry the brunt of the effort in developing STEM, it is requested that NOAA R&D funds be made available so that the 8 SEL personnel previously working on other-agency projects be able to devote their full efforts to STEM.

(2) Two new hires totaling $73 K (including overhead) are requested in the Radio Astronomy Program Area. These positions had previously requested and rejected in FY 1972. They are required in FY 1973 in order to implement the long baseline interferometry program outlined in section 4.2.2.

(3) AN R&D salary increase of $75 K (6%) is anticipated in the four program areas based on present personnel.

(4) In the past, the laboratory-support programs (Numerical Analysis & Computer Techniques and Instrumentation Development) have been funded with R&D dollars even as the services provided by SEL evolved to where they constitute approximately one half of the laboratory's activities. Since the support groups work for both

Table 8. Personnel and Salary Changes from FY 1972 to FY 1973

Program Area	Personnel Changes FT	Personnel Changes PT	Salary Changes NOAA	Salary Changes OA	Comments Justification for Increase in NOAA Salaries.
Solar Physics	0	0	+ 8	- 37	+ 8 K for 6% pay raise of existing staff + 37 K to convert researcher from diminishing NASA program to develop model of active sun - part of STEM.
Interplanetary Magnetospheric Physics	0	0	+ 14	-106	+ 14 K for 6% pay raise for existing staff +106 K to convert researchers from diminishing NASA program to develop interplanetary and magnetospheric models - part of STEM.
Ionospheric Physics	-1	0	+ 5	-120	+ 5 K for 6% pay raise of staff + 20 K to convert researchers from diminishing ARPA work to develop models of ionospheric storms, etc. Part of STEM.
Radio Astronomy	+2	0	+ 88	0	+ 8 K to cover 6% pay raise and salaries for 2 additional staff to develop LBI geodetic survey techniques.
Numerical Analysis & Computer Techniques	+3	0	+ 58	- 8	+ 58 K for 6% pay raise and three new staff required to process increased amount of satellite data.
Instrument Development	0	0	+ 8	0	+ 8 K for 6% pay raise of existing staff
Real-Time Data Services	+1	0	+ 28	0	+ 10 K for 6% pay raise of existing staff + 18 K for one new staff required in operation of laboratory data system .
Off-Line Data Services	0	0	+ 8	- 29	+ 8 K for 6% pay raise for staff + 29 K to replace reduction in NASA support for ISIS program.
Space Env. Services Center	+2	0	+ 64	0	+ 64 K for 6% pay raise for existing staff plus two new staff for manning forecast center.
Aeronomy & Space Data Center	+2	0	+ 54	0	+ 54 K for 6% pay raise of existing staff plus two new staff for archiving data.
TOTALS	+9	0	+335	-300	

research and services, it is appropriate they be funded from both R&D and S&E appropriations. Therefore, the laboratory plan calls for a shift of one half of the support groups salaries from R&D to S&E in FY 1973.

4.3.2 S&E Salary Request for $353 K

Breakdown

(1)	Loss of other-agency funds	$ 29 K
(2)	New hires	96 K
(3)	Salary increase	37 K
(4)	Shift of salaries from Research	191 K

Discussion

(1) A $29 K decrease of other-agency funds is expected in the Numerical Analysis and Computer Techniques and Off-Line Data Services groups.

These efforts will be redirected to programming and processing activities required by the real-time data service and by the satellite data to be received in FY 1973 (see table 2).

(2) Six new hires are requested at $96 K with three in the Numerical and Computer Techniques group. These positions are required to provide programming and computer analyses for STEM, real-time data service, real-time data display, and processing of the satellite data shown in Table 2.

One position is required in the Real-Time Data Services group due to the expanded workload represented by the GOES SEM data reception.

The FY 1972 request for Forecast Center Improvement for $125 K and two positions, failed. Consequently, SEL Real-Time and Forecast services remained unimproved and, in some areas, deteriorated due to lack of manpower and new and/or refurbished equipment. This need is more critical in FY 1973. The hardware portion of this request is now included in the FY 1973 data-service increment, section 4.2.1

Two new positions at a cost of $44 K are requested for the Space Environment Services Center to permit actual development and implementation of specialized forecast techniques that will improve the quality and timeliness of geomagnetic forecasts. These forecasts are of direct and useful application to both government and commercial interests engaged in radio communication and radar systems, geomagnetic surveys and high-voltage electric power systems.

This specialized work cannot be accomplished without additional funds as existing funds are needed to maintain the current basic support program -- a necessary ingredient to this expanded and specialized support service.

(3) A S&E salary increase of $37 K (6%) is projected in our service areas based on present personnel.

(4) This reflects the shift in support program areas salaries (Numerical Analysis and Computer Techniques and Instrumentation Development) from R&D to S&E funds to more accurately reflect the support these groups provide to the research and services activities of SEL.

4.3.3 Aeronomy and Space Data Center Salary Increase of $54 K

Since ASDC may become a part of the Environmental Data Service, its increment is broken out separately for FY 1973 in the SEL plan. The request consists of:

$ 20 K	Pay raise of present personnel,
$ 33 K	Two (2) new hires to enhance the archiving effort.

4.4 Statistical Summary of SEL Funding, Manpower, Etc.

The Aeronomy and Space Data Center (ASDC) funding summaries are shown separately.

4.4.1 Manpower

An approximate 127-man/year effort is made up of 105 FT and 22 employees in part-time categories. This is an increase over FY 1972 of 9 FT personnel.

4.4.2 Funding

SEL			
	NOAA R&D	$ 2,029 K	
	NOAA S&E	1,272 K	
	NOAA FEC	512 K	
	Other Agency	781 K	$ 4,594 K
ASDC			
	NOAA R&D	$ 152 K	
	NOAA S&E	334 K	
	Other Agency	146 K	$ 632 K
		TOTAL	$ 5,226 K

4.4.3 Salaries

SEL	NOAA	$ 1,820 K	
	Other Agency	542 K	$ 2,362 K
ASDC			
	NOAA	$ 246 K	
	Other Agency	80 K	$ 326 K
		TOTAL	$ 2,688 K

Chapter 5 - FY 1974-79

5. SEL FROM FY 1974 THROUGH FY 1979

The major overall objective of SEL in the 1970's is the development and operation of a working model of the solar-terrestrial environment (sec. 1.4.1). Key steps toward this objective are planned for FY 1972 and 1973 and discussed in detail in chapters 3 and 4. Highpoints are summarized below.

In FY 1972, within the laboratory base budget, research will be enhanced through preliminary developments of solar flare, interplanetary, propagation, magnetospheric, and ionospheric interaction models. Further, satellite data will be used to calibrate a magnetospheric and an interplanetary model.

With an increment of approximately $200 K for other objects, a minimum configuration operational real-time data system will be installed (funds not currently authorized). This is a very important first step in the overall plan for an operational real-time data service.

A start can be made with the $100 K increment scheduled for LBI in accurate geodetic surveying. It is planned that this program will develop during the next 2 or 3 years and taper thereafter with the completion of equipment for use by other components of NOAA.

The largest yearly increment in NOAA funds (see table 9) is requested in FY 1973 to make the earliest redirection of SEL towards the development and operational use of the solar-terrestrial environment model. The main changes planned are:

Enhancement of research by reprogramming of existing staff from other agencies to SEL programs and the addition of nine new staff members.

Development of space environment monitoring instrumentation facilities.

Establishment of an operational real-time data service.

Conduct of precise geodetic surveys between points in the U.S. and Alaska and possibly to a ship using the long baseline interferometer technique.

The largest yearly increment in FY 1973 is followed by 10 percent yearly increment in FY 1974 and thereafter. It is planned that the projected level of funding and staffing for FY 1973 is adequate for the next several years to achieve the main objectives of the laboratory. Other-objects increases in FY 74-77 reflect the construction and delivery of flight hardware to NESS in SEL's space environment monitoring program.

The program outlined in this request is believed to be a good mixture of research and practical application. The laboratory in FY 1971 has essentially the staff required to conduct the required research but is particularly deficient in laboratory facilities for observations required to calibrate the theoretical models and to provide real-time solar-terrestrial data service. The availability of real-time solar and space data from the NOAA, GOES and ITOS satellites will greatly improve the national position and secondly, will advance SEL and NOAA to the forefront in this field.

(a) Research. The plan will make NOAA/SEL the national focal point for current information on solar-terrestrial information. SEL will keep abreast of developments made on a national and international scale to insure that the most effective techniques and combinations of models are used to meet the national needs.

(b) Data Service. With a basic data service available from NOAA, Other Agencies are willing to fund additional developments required to meet their individual needs; however, there is an understandable reluctance on the part of Other Agencies to fund the basic observational and development programs which fall within the NOAA mission. A result of the program described herein will be the establishment within NOAA of the first truly operational space weather service -- a service destined to become continually more critical in the future.

(c) Relationship to Other Agency Needs. The unique needs of Other Agencies for special interpretations of solar-terrestrial data are recognized by SEL. SEL has taken the initiative in contacting other agencies and reaching agreements on sharing of data, collection and operational facilities to the mutual benefit of all agencies. For example, the AWS has agreed to aid in staffing of the SEL Alaskan data collection facility and of the Forecast Center at Boulder, Colorado.

Table 9. SEL Funding for FY 1973 through FY 1977.

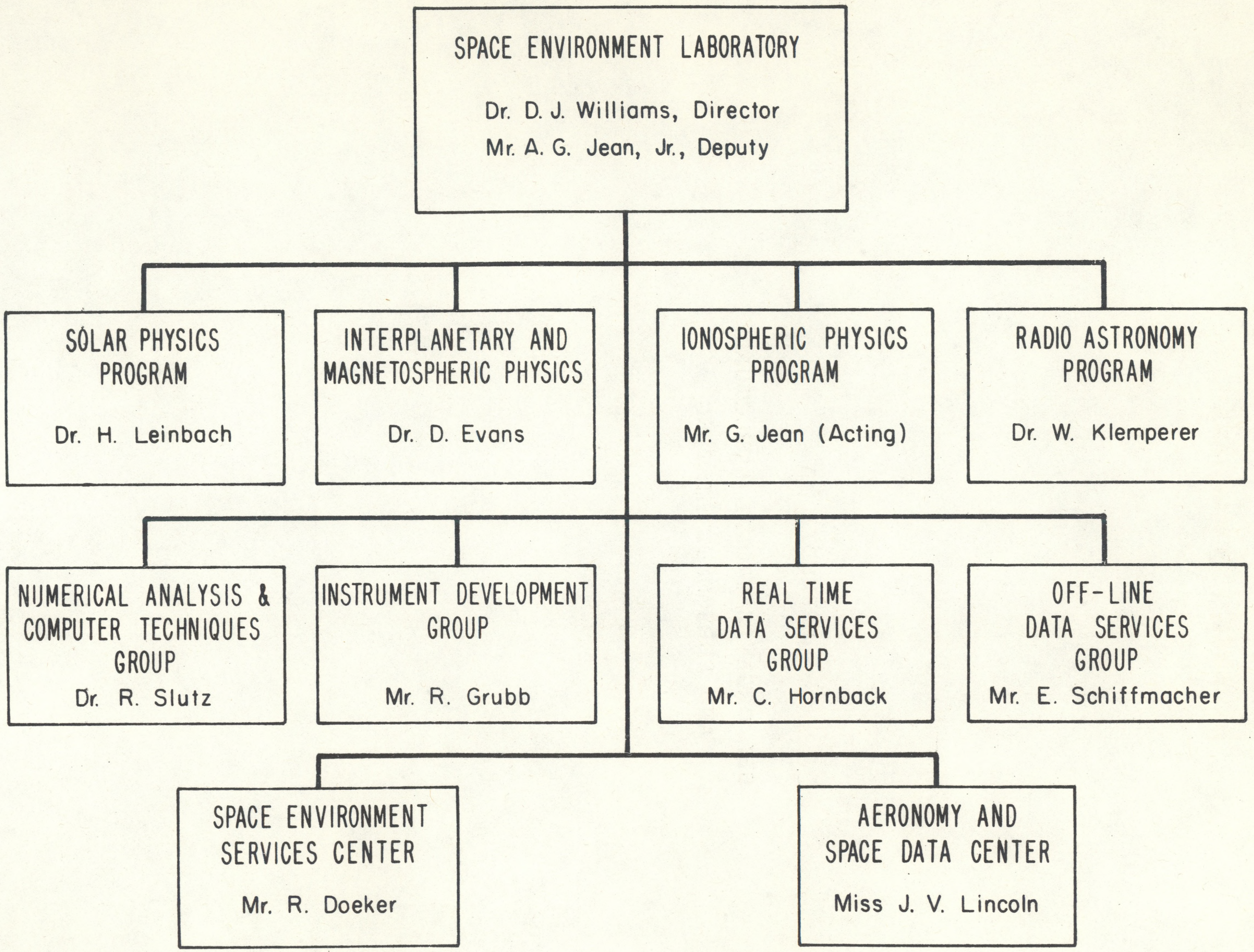
	Fy 1973	FY 1974	FY 1975	FY 1976	FY 1977
Total Funding	$ 5286	$ 4905	$ 5375	$ 5903	$ 6483
Salaries	2688	2338	2550	2800	3075
Other Objects	2598	2567	2825	3103	3408
NOAA Funding	4359	4795	5275	5803	6383
Salaries	2066	2273	2500	2750	3025
Other Objects	2293	2522	2775	3053	3358
Other Agency	927	110	100	100	100
Salaries	622	65	50	50	50
Other Objects	305	45	50	50	50

It is anticipated that the A&SDC will be moved from SEL to the Environmental Data Service (EDS) during FY 1972-73. The A&SDC funding is shown separately for FY 1973 (sec. 4.4.2) and is not included in the FY 1974-77 figures above.

Appendix A - Laboratory
Organization

APPENDIX A

SEL ORGANIZATIONAL STRUCTURE
AND PERSONNEL LISTING


SPACE ENVIRONMENT LABORATORY
Dr. D. J. Williams, Director
Mr. A. G. Jean, Jr., Deputy
SOLAR PHYSICS PROGRAM
Dr. H. Leinbach
INTERPLANETARY AND MAGNETOSPHERIC PHYSICS
Dr. D. Evans
IONOSPHERIC PHYSICS PROGRAM
Mr. G. Jean (Acting)
RADIO ASTRONOMY PROGRAM
Dr. W. Klemperer
NUMERICAL ANALYSIS & COMPUTER TECHNIQUES GROUP
Dr. R. Slutz
INSTRUMENT DEVELOPMENT GROUP
Mr. R. Grubb
REAL TIME DATA SERVICES GROUP
Mr. C. Hornback
OFF-LINE DATA SERVICES GROUP
Mr. E. Schiffmacher
SPACE ENVIRONMENT SERVICES CENTER
Mr. R. Doeker
AERONOMY AND SPACE DATA CENTER
Miss J. V. Lincoln

SPACE ENVIRONMENT LABORATORY

Office of the Director

D. J. Williams, Director
D. A. Belsher, Secy

A. G. Jean, Deputy Director
J. Bennett, Secy (WAE)

W. F. Hilsmeier, Adm. Officer
C. M. Yetzbacher, Adm. Asst.
H. E. Carlson, Adm. Aid

M. B. Kiefer, Secy (PT)

D. K. Bailey, Physicist

February 11, 1971

PT = Part Time
WAE = When Actually Employed
CO = Commissioned Officer

SPACE ENVIRONMENT LABORATORY

Research Programs

SOLAR PHYSICS

LEINBACH, F. H.

Hill, V.V., Secy
Sawyer, C.B.
Haurwitz, M.W.
Lund, D.S.
Donnelly, R.F. (LWOP)
McIntosh, P.S.
Schutz, S.A. *
Smith, J.B. (WAE)
Lemmon, J.J. (WAE)
Wilcox, J.M. (Consultant)

INTERPLANETARY AND MAGNETOSPHERIC PHYSICS

EVANS, D. S.

Wilson, I.M., Secy
Dryer, M.
Sauer, H.H.
Fritz, T.A. (EOD, 1-1-71)
Green, R.G.
Ecklund, W.L.
Suess, S.J. *
Cowley, F.C.
Retallack, W.M.
Smith, Z.A. (PT)
Nerney, Steven F.

* Assigned to Director's Office, ERL.

IONOSPHERIC PHYSICS

JEAN, A. G.

Beebe, M.L., Secy
Davies, K.
Megill, L.R.
Lerfald, G.M.
Adams, G.W.
Haslett, J.C.
Fritz, R.B.
Jurgens, R.B.
Joselyn, J.C.
Jones, J.E.
Burkey, W.S.
Mutel, R.L. (WAE)
Flanagan, M.S. (WAE)
Teitelbaum, J.M. (WAE)
Alford, W.A. (WAE)
Green, S.J. (WAE)

RADIO ASTRONOMY

KLEMPERER, W. K.

Pickering, G.K. Secy (PT)
Cronyn, W.M. *
Rufenach, C.L.
Como, R.J.
Sargent, H.H.
Brink, C.A. (WAE)
Neal, K.L. (WAE)
Bouricius, G.M.W. (WAE)

* Assigned to Director's Office, ERL.

SPACE ENVIRONMENT LABORATORY

Support and Applied Research

NUMERICAL ANALYSIS AND COMPUTER TECHNIQUES

SLUTZ, R.J.

McRae, A.E., Secy
Winkelman, J.R.
Gray, T.M.
Lewis, L.D.
Matheson, L.D.
West, M.L.
Hill, V.J.
Candelaria, M.C.
Bath, L.M. (PT)
Kellner, P.A. (WAE)
Endrud, G.H. (CO)

INSTRUMENT DEVELOPMENT

GRUBB, R.N.

Coss, S.G., Secy
Cessna, J.R.
Wasmundt, D.F.
Orswell, P.L.
Dayhoff, R.E.
Haybrock, R.F.
Holmes, C.R.

OFF-LINE DATA SERVICES

SCHIFFMACHER, E.R.

Coss, S.G., Secy
Haynes, R.L.
Miller, L.W.
Taylor, J.H.
Sullivan, K.W.
Schroeder, M.W.
Brown, R.I.

REAL-TIME DATA SERVICES

HORNBACK, C.E.

Coss, S.G., Secy
Gray, A.M.
Berger, E.L.
Hale, H.D.
Hines, R.G.
Jones, P.H.
Larsh, M.M.

Service Groups

SPACE MONITORING AND FORECAST CENTER

DOEKER, R.B.

Huber, R.D., Secy
Abbott, E.A., Secy (PT)
Baker, D.M.
Sutorik, J.A.
Hilliard, D.L.
Heckman, G.R.
Hirman, J.W.
Recely, F.J.
McKinnon, J.A.
Przywitowski, R.
Haas, R.H.
Kildahl, K.J.
Schroeder, J.D.
Schwartz, W.A. *
Hanks, D.E.
Garcia, P.
Goehringer, B.C.
Wilcoxon, M.A.
Allen, J.E. (WAE)
McFadyen, G.G. (WAE)
Eason, L.L. (WAE)
Scheiber, B. (WAE)
McCallum, W.R. (WAE)
Allen, K.C. (WAE)
Dominy, J.F. (WAE)
Fuller, G.C. (CO)
Bush, Y.A. (CO)
Sroga, J. (C))
McCallum, W.R. (WAE)
Sullivan, J.E. (WAE)

AERONOMY AND SPACE DATA CENTER

LINCOLN, J.V.

Bower, J.J., Secy
Wood, M.K., Secy
Bucknam, D.B.
Leighton, H.I.
Blacker, H.V.
Smith, H.P.
Wickoff, B.A.
Harrison, D.G.
Shanks, C.T.
Jackson, F.C.
Wilcox, M.M.
Neill, E.G.
Starr, J.M.
Dunnan, P.R.
Broline, L.C. (WAE)
Kroehl, H.W. (WAE)
Meador, M.W. (WAE)

Appendix B - Data System

APPENDIX B

A Satellite Recording and Data Base System

(separate attachment)

Appendix C - Other Objects
FY 1973

APPENDIX C

OTHER OBJECTS REQUESTS AND JUSTIFICATIONS FOR FY 1973

APPENDIX C

FY 1973

PLANS AND REQUESTS FOR OTHER OBJECTS
by
PROGRAM AREA
(Referenced to Zero Base Budget)

Summary of Other Objects Requests:

	Program Area	Total
(1)	Solar Physics	$ 190.0 K
(2)	Interplanetary and Magnetospheric Physics	157.0
(3)	Ionospheric Physics	165.0
(4)	Radio Astronomy	375.0
(5)	Numerical Analysis & Computer Techniques	34.0
(6)	Instrument Development	210.0
(7)	Real-Time Data Services	59.0
(8)	Off-Line Data Services	25.0
(9)	Space Environment Services Center	180.0
(10)	Aeronomy and Space Data Center	240.5
		$1721.0 K

NOTE: This appendix does not include
salaries (see Table 7) nor
list requirements.
Computer Use and Travel Expenses
(see Table 1).

C(1). JUSTIFICATION - SOLAR PHYSICS

The Solar Physics research in SEL is closely tied to the operational problems of the Forecast Center, in their attempts to provide accurate forecasts and warnings of solar activity. All three of the requested budget items in Solar Physics pertain to operationally oriented research.

A. Video Record and Playback System

One of the prime requirements in developing forecasting techniques is to obtain optical observations at Hα and other pertinent wavelengths of the dynamic changes in solar-active regions, particularly those that immediately precede flares. Likewise, the proper tests of existing flare models depend heavily on appropriate optical data. A video record and playback system will greatly improve our capability for obtaining an adequate data base for such purposes. The value of the video system can be appreciated when one realizes that the dynamic changes on the sun are generally slow enough so that they are not readily apparent during the course of real-time observations. However, when the observations are recorded and then played back (speeded up by factors of 2 to 10) the changes become readily visible. The ability to record for short stretches of time, with immediate replay capabilities, makes the video system particularly useful in analyzing solar activity in near real time. This capability is not currently available to us through our routine photographic patrols of the sun.

B. Continued Development of a 3-cm Polarimeter

Optical observations of solar flares and other dynamic events in the solar atmosphere usually do not give very direct information on the acceleration and ejection of energetic particles or the generation of shock waves. However, it is these energetic particles and shock waves which are ultimately responsible for significant disturbances at the earth, such as magnetic storms and polar cap ionospheric absorption events.

Solar radio bursts on the other hand are a direct consequence of the passage of particles and shock waves through the outer solar atmosphere. Therefore, adequate radio observations play a fundamental role in our understanding of solar-terrestrial effects. The two most important qualifications for the radio observations are high spatial resolution, and information on the polarization characteristics of the bursts. The observations ideally should be carried out over a wide frequency range in order to explore the propagation of the disturbances through the outer solar chromosphere and the corona.

Monies are requested to assist the further development and utilization of a 3-cm polarimeter which, in conjunction with other radio receivers at NOAA, and radio data from cooperating observatories, will enhance our abilities to more fully utilize the radio data for diagnostic and prediction purposes.

The 3-cm polarimeter will permit us to deduce characteristics about the source mechanisms of bursts and about the magnetic field in the source region, located in the upper chromosphere. When correlated with optical observations of solar activity, these radio data will help to further our understanding of the types of solar activity associated with solar-terrestrial disturbances.

C. Contract with Aerospace for Joint Operation of the San Fernando Observatory

The San Fernando Observatory is one of the newest and best equipped solar observatories in this country. The primary instrument is an evacuated 24-inch reflecting solar telescope, which provides a large high resolution image for further analysis by a large vacuum spectroheliograph. With this instrument it is possible to obtain spectroheliograms with spatial resolution of better than 1-arc sec. The observatory is equipped with photographic facilities which permit photographic subtraction to obtain Leighton-type magnetograms and Dopplergrams of a quality not obtainable in the past.

Besides the large 24-inch telescope and its accessories, the observatory is also equipped with a high-resolution Hα telescope, a white light telescope, and several small radio telescopes for monitoring the solar noise from the whole sun. A video output magnetograph using a filter telescope is also available.

The staff of the observatory is well trained and competent in solar physics. Their interests are in the active sun and such problems as forecasting solar activity.

There is now a consensus among most solar astronomers that the key factor in solar flare occurrence (and hence, also in the prediction of solar flares) is the dynamic magnetic topology of active regions. Joint operation of the Aerospace observatory would permit the SEL solar physicists direct access to high-quality magnetic field and velocity field observations with the option of executing our own observational programs for specific research tasks. In addition, the Aerospace observatory would be able to provide patrol-type magnetic field observations with the video magnetograph for use by the SEL Forecast Center in their daily operations.

(Note: The earthquake of February 1971 caused considerable but not irreparable damage to the San Fernando Observatory. According to Dr. Earle Mayfield, Director of the observatory, complete repairs should be completed within a year with most instruments fully operational before that time. Repair costs are to be borne by the Aerospace Corporation.)

OTHER OBJECTS REQUEST FOR FY 1973

Solar Physics

(1)	Aerospace Contract (see sec. 1.4.4)	$ 150.0 K
(2)	Request to Further Develop SEL Facilities	
(a)	Further refinements and operation of a 3-cm wavelength polarimeter	10.0
(b)	Video record and playback system providing 1000-line scan with digitizer and electronic processor for optical telescope.	30.0
	TOTAL	$ 190.0 K

C.(2). PLANS AND JUSTIFICATION - INTERPLANETARY AND MAGNETOSPHERIC PHYSICS

The Interplanetary and Magnetospheric Physics program at SEL may be conveniently divided into two areas: the study of solar protons associated with flares, and the study of the overall solar wind-magnetosphere-ionosphere interactions during both quiet and disturbed times. Work in the former area has been pursued for some years with particular emphasis on:

(a) the physics of solar flares and the production of solar protons,

(b) the physics of the propagation of solar cosmic rays through the interplanetary medium,

(c) the trajectories of these solar cosmic rays near the earth and their subsequent entry into the upper atmosphere. This area is of particular importance in understanding ionospheric and communications disturbances.

We plan to continue much of this work maintaining the prior emphasis while extending our study of area (c) into very high particle energies -- those particles which produce minor ionospheric effects but could produce effects at those altitudes at which the SST flies.

The latter area (magnetospheric physics) has in the past and will in the future receive the majority of our attention. These studies will include the entire set of interrelated studies including:

(a) the properties of the solar wind,

(b) the interaction of the solar wind with the magnetosphere and transfer of energy across the magnetospheric boundary,

(c) the transport of energy and particles within the magnetosphere together with the production of energetic particles in this region,

(d) the role of the ionosphere as the ultimate sink for most of the solar energy intercepted by the magnetosphere.

These four sub-subjects are intimately coupled to one another through the vehicle of the magnetospheric electric fields. These fields (or voltage drops) are produced, according to some, by the solar wind "interacting" with the magnetosphere in effect, a magnetohydrodynamic power generator. The resultant electric fields govern the transport of energy and particles within the magnetosphere together with providing some particle acceleration. The dominant "electrical load" on this generator lies not in the outer magnetosphere but rather in the ionosphere, i.e., the energy dissipation due to the ohmic losses of currents flowing in the ionosphere driven by these electric fields far exceed the energy involved in particle acceleration.

Some estimates place the equivalent resistive load of the ionosphere as one-tenth of the "internal impedance" of this magnetospheric generator -- in effect, a limited power station attempting to drive a large load. Thus changes in the electrical conductivity of the ionosphere -- for example, by enhanced particle precipitations, can exert a delicate control on the geometry of the magnetospheric electric field thus influencing the transport of energy and particles -- perhaps to the point of enhancing or diminishing particle precipitation or transfer of energy across the magnetospheric boundary.

In the past, much of the effort in magnetospheric physics has been directed toward the observation of energetic particles. The role of plasma phenomena (conductivities, MHD generators, etc.) is equally important. Consequently, while the IMP plans to continue its studies in the traditional areas of energetic particles, we will increase our ability to study the behavior of the ionospheric, magnetospheric and interplanetary plasma so as to better unravel the complex processes which result in solar wind energy incident upon the magnetosphere being dissipated in the earth's ionosphere.

OTHER OBJECTS REQUEST FOR FY 1973

Interplanetary and Magnetospheric Physics

(1)	Sounding Rocket Program		
	(a)	Low-energy particle detectors, HV supplies, channel multipliers, analyzers, amplifiers	$ 27.5 K
		Radio noise experiment, 5-channel	
	(b)	Radiometer	10.0
	(c)	PCM Encoders	12.0
	(d)	Connectors, wire relays, timers, LV power supplies, etc.	5.0
	(e)	Machine work	7.5
	(f)	Shipping of materials	3.0
(2)	Auroral Backscatter		
	(a)	Doppler-shift electronics	5.0
	(b)	Analog tape recorder	12.2
	(c)	Radar transmitter & receiver	20.0
(3)	Total Energy Detector		
	(a)	Scintillation material, machine work, testing	1.5
(4)	Electrostatic Analyzer		
	(a)	Drafting, machine work, testing	5.3
(5)	Plasma Instrumentation		
	(a)	Plasma diagnostic equipment	15.0
	(b)	Equipment, instrument design	20.0
	(c)	Improve radiometer	5.0
(6)	Data Analysis		
	(a)	Desk computer/plotter	8.0
			$ 157.0 K

C.(3). PLANS AND JUSTIFICATION - IONOSPHERIC PHYSICS

A. D-Region Studies

Many of the ionospheric phenomena of interest are the result of perturbations of the earth's atmosphere by various solar phenomena. These include flare effects, aurorae, solar cosmic ray events and energy inputs to the atmosphere in the UV and IR ranges. The study of such phenomena may be justified, depending on one's orientation, either as a study of solar physics or a study of atmospheric physics.

In studying ionospheric effects the problem usually separates itself into two parts. The first is the study of the production of electrons in the ionosphere. To a fairly large extent this involves the determining of the solar output in terms of UV and X-ray fluxes or particle fluxes. While the atmospheric constituents are important in this problem, the production rates are relatively independent of the minor constituent models used. (There is one major exception to this statement -- the production of electrons by $Ly\alpha$ ionizing NO.) When it comes to describing the processes by which electrons are lost in the ionosphere the minor constituent models become all important, with the D region being the most important example of this statement.

The awareness of these problems has led us, over the past several years, into attempts to measure both minor constituents and electron loss parameters in the region from about 50 km to 120 km. In this region there are many minor constituents of importance. The "major" minor constituents are O and O_3, with NO being a close third. Because of the effect of the hydrogenic molecules (H_2O, OH, and HO_2, as well as H and H_2) on these constituents, the concentration of water vapor and its products is also of importance. At the present time O has never been measured below 120 km with the possible exception of a recent measurement by Watson Henderson of the Aeronomy Lab. O_3 is measurable up to about 70 km and can be inferred to about 95 km from the measurement of $O_2({}^1\Delta_g)$. Nitric oxide densities have been measured on about three occasions by Dr. Barth's group at LASP. Water vapor densities have not been measured above about 50 km.

A by-product of these studies has been the participation in several studies of infrared emissions in the aurora. At the present time all such studies are in a very rudimentary state. It can be fairly stated that so many unexpected results have come out of the preliminary work that it is likely that study of these phenomena over the next few years will yield a great deal of information with regard to energy sources and sinks in the polar ionosphere.

Plans for the Future

Over the next few years, mesospheric trace constituents will probably continue to be a very important area of study in atmospheric physics. Most of these species require in situ measurement (which in turn implies rockets), although many monitoring activities of importance are possible using ground-based emission measurements. At present it appears that two types of measurement are valuable. One approach involves the measurement of everything of conceivable importance all at one time. This is quite expensive and as a consequence only relatively few such flights will be made. Another type of approach which also has considerable value is that which measures in reasonable detail the diurnal variation of one (or at most a few) important constituent. We expect to more or less concentrate on this second technique and to use the time variations to test various theoretical models. We find that most experiments can be designed into relatively small rockets at a cost which makes such a program feasible. For example, we flew several payloads on boosted Arcas II rockets into PCA's to measure electron densities and proton intensities and spectra. These payloads, after development, cost about $4000 each. The rockets cost $4200 each. More capable rockets are now available at about the same price. With a three-man group as used in the past, it would be possible to fly at least one diurnal "series" per year or one "bus type" rocket per year with a budget of the order of $150 K per year in excess of salaries. The way we compute budgets, this number includes things like data analysis, theoretical work and publishing.

B. Ionospheric Storms, Sudden Ionospheric Disturbances and Radio Beacon

The most widespread disruption to ionospheric telecommunications is the ionospheric (or magnetic) storm which causes a narrowing of the usable HF spectrum. These storms result from particle bombardment of the upper atmosphere which produces ionization and heat. The heat input, together with changes in the electric and magnetic fields in the outer regions of the ionosphere, brings about a redistribution of the ionization which has important economic consequences to the radio communicator. A considerable amount of information is now available on the morphology of ionospheric storms and the temperature changes in the topside of the ionosphere. These data will enable us to establish models of the storms and hence, their effects on radio telecommunication, space experimentation, etc.

Sudden ionospheric disturbances are short-lived events resulting from bursts of solar X-rays and ultraviolet radiation and which are essentially simultaneous with the visible flares. SID's affect the propagation of very low, low and high frequency radio waves. The purpose of the study is the determination of the radio effects resulting from model flares (based on satellite data) and suitable models of the upper atmosphere. The results of these studies will be directly applicable to the ionospheric disturbance forecasting service.

Satellite-to-ground radio communications and uses of satellites in navigation is becoming increasingly important. Because of the great economic investment in communication equipment, the bulk of satellite communications is carried on radio waves of very high frequencies. These frequencies are affected by ionospheric radio propagation, e.g., polarization fading, time of flight, pulse broadening, signal distortion, etc. For navigation purposes it is essential to know the contribution to the time of flight of the variable electron content. Continuous monitoring of the electron content is best accomplished by multifrequency radio beacon measurements using geostationary satellites. Presently measurements are being made at Boulder of the ATS-1 satellite on a single frequency near 137 MHz. In 1973, a comprehensive beacon will be launched on board ATS-F using a number of frequencies. Eventually it will be possible to produce world maps of the distribution of electron content similar to the maps of maximum electron density used extensively in ionospheric radio predictions.

C. Ionospheric Effects of Thunderstorms

The interaction between the various levels of the earth's atmosphere is of vital importance to the work of NOAA. There have been many claims over the past half-century of evidence linking weather phenomena in the troposphere with effects in the ionosphere. Few of these claims have been substantiated. However, in recent years, we in NOAA have discovered and studied an ionospheric effect over the central U.S.A. which is reproduced in many cases. This is the existence of acoustic-like disturbances in the ionosphere with periods in the range from 3 to 4 1/2 minutes which originate in severe thunderstorms. Such effects have been observed over Kansas, Arkansas, Alabama, and especially over Oklahoma. The observations consist of the measurement of magnetic tape of the very small frequency changes in radio waves brought about by the variations in the levels of reflection. Preliminary studies show that these disturbances originate in localized cells which can be detected by radio observations with spaced transmitters on several frequencies. Using such obvations and a model atmosphere it is possible to trace the rays of the acoustic waves back to the sources. Results so far are very promising.

Future progress in this area will require more comprehensive experiments than those hitherto conducted. For example, measurements are necessary at more than three spaced locations because the source is relatively close to the area of observation (in the ionosphere) and, therefore, the assumption of plane wave fronts may not be valid. Further, it is essential to obtain ionograms from a conventional ionosonde to determine the electron density profile in the ionosphere in order to locate the heights of reflection of the probing radio waves.

OTHER OBJECTS REQUESTS FOR FY 1973

Ionospheric Physics

(1) D-Region Studies	
(a) 3-rocket payloads, including Direct probes (O, O_3, NO, Lyα) Laser Scattermeter (Na, Li, CO_2)	$ 105.0 K
(b) 1 Bullpup-Apache rocket	5.0
(c) Ground telemetry equipment	
Telemetry-receiver (Nems-Clark)	5.0
Decommutator	7.5
Test panel	2.5
(2) Ionospheric Storm, SID and Radio Beacon Studies	
(a) Publication costs	5.0
(3) Atmospheric Coupling	
(a) Ionosonde, tape recorders, etc.	35.0
	$ 165.0 K

C.(4). PLANS AND JUSTIFICATION - RADIO ASTRONOMY *

A small group has been formed at SEL in the Radio Astronomy Program Area for the purpose of developing precision geodetic surveying methods using Very Long Baseline Interferometry (VLBI). The theoretical underpinnings for this new departure have been known for some time. Applicable studies of the atmospheric limitations to accuracy (the only serious limitations, since other errors can be made negligible) have been made by Department of Commerce scientists (Gordon Thayer, Michael Jones, M.C. Thompson, Jr., and others) as well as outside groups. Because of budgetary limitations and the continuing lack of a suitable parabolic antenna, experimental VLBI work at SEL has concentrated on pioneer work at decametric wavelengths. A number of VLBI experiments have been successfully carried out at 26.3 MHz ($\lambda = 11.4$ m). An extensive set of observations were carried out in October and November 1970 between Boulder and Haswell, Colorado (265 km) using large, circularly polarized arrays. Data of a number of radio sources with better than 10-sec-of-arc resolution showed that many of them still had significant unresolved flux at this relatively long wavelength. The strongest source observed (the small diameter component of the Crab Nebula) yielded fringes with an average S/N ratio of 80:1.

For baseline determinations of really precision geodetic quality, steerable parabolic antennas and microwave receivers will be required. Starting in July 1971, we plan to set up an L-band (1600 MHz) VLBI experiment between the La Posta radiotelescope near San Diego and one of the Owens Valley Radio Observatory dishes at Big Pine, California, a baseline distance of about 533 km. The NOS has already scheduled a first-order, Class II accuracy survey of the observatory locations for comparison purposes. The fact that this baseline bridges the San Andreas fault provides an additional incentive for developing a rapid, precision surveying technique for monitoring purposes.

In FY 1973, a permanent VLBI terminal should be established at the Table Mountain field site north of Boulder -- probably by upgrading an existing 60-ft dish. In the same year, a portable hydrogen maser oscillator would be ordered for local oscillator and timing use. Significant reduction in computer time charges are then possible with the increased stability obtainable.

For FY 1974, we plan to order a portable antenna system and associated microwave receiving equipment to extend precision VLBI experiments to points in Alaska, Baja, California, and other areas.

It is expected that in FY 1975 such a terminal would be turned over to NOS for operational use.

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* A report "Project Development Plan for Very Long Baseline Interferometry," by Dr. W. K. Klemperer, is available from the Radio Astronomy Group of the Space Environment Laboratory, Boulder, Colorado.

OTHER OBJECTS REQUEST FOR FY 1973

Radio Astronomy

Breakdown of costs required to modify and upgrade a 60-ft dish antenna at the Table Mountain field site near Boulder, Colorado.

(a)	L-band and X-band receivers (cooled paramps)	$ 75.0 K
(b)	Small control computer	40.0
(c)	Computer interfacing and software development	25.0
(d)	Antenna-drive modifications (digital pickoffs,etc)	40.0
(e)	Antenna fed, broadband	20.0
(f)	Radome and cryogenic cooling (for 2 paramps) at feed	25.0
(g)	Labor costs	50.0
(h)	Hydrogen maser oscillator	100.0
		$ 375.0 K

C.(5). PLANS AND JUSTIFICATION -
NUMERICAL ANALYSIS AND COMPUTER TECHNIQUES GROUP

With the increased satellite data workload, it is planned to add three programmers to the Numerical Analysis and Computer Techniques Group. The Other Objects budget provides desk calculators for them, and the local computer terminals necessary for them to do their work on the timesharing computer. It also provides for purchasing one local computer terminal that is now rented at a higher average cost. The increased work on the Data Base also requires a graphical terminal and a high-speed printer terminal to work with the timesharing computer for real-time access to the data base. In summary, the requirements are:

OTHER OBJECTS REQUEST FOR FY 1973

(a)	4 Typing Timeshare Terminals	$ 14.0 K
(b)	2 Desk calculators	2.0
(c)	1 Graphical Timesharing Terminal	5.5
(d)	1 High-speed Timesharing Printer	8.5
(e)	Printing and miscellaneous stores	4.0
		$ 34.0 K

C.(6). PLANS AND JUSTIFICATION - INSTRUMENT DEVELOPMENT GROUP

A. Facilities for Development of Space Environment Monitoring Instrumentation

As outlined in section 4.2.4 of the plan, it is a Laboratory objective to further develop our present scientific and engineering capability for the design of Space Environment Monitoring Instrumentation. This requires the provision of adequate in-house facilities to be able to develop and test flight quality hardware. This capability is essential for proper specification, supervision, and acceptance testing of contractor-produced assemblies. It will also permit the fabrication of special flight experiments in an expeditious and cost-effective manner where quick reaction or state-of-the-art scientific instrumentation is involved.

Funds for two new facilities are requested. The first is for updating existing, and for providing new, environmental testing facilities; the second provides a minimum capability to inspect, modify, and experimentally fabricate hybrid microcircuits. This type of electronic assembly technique is becoming increasingly essential to minimize weight and volume in flight hardware systems and also permits important gains in circuit performance to be obtained. The facilities requested are:

B. General Purpose Electronic Test Facilities

These two facilities for which funds are requested are becoming almost essential for the efficient development and testing of electronic systems both for Space Environment Monitoring Instrumentation and for the development of other systems for general laboratory use. They are:

1. Automated Swept Frequency Network Analysis System

Large amounts of time are at present consumed in step-by-step measurements of networks in the frequency domain. Although much of the design of the network can now be accomplished very efficiently using computer aid, the verification of performance and final optimization is, by comparison, very inefficient. Swept frequency analyzers providing complex transmission and reflection coefficients are now available which provide computer compatible data for immediate analysis and print-out of results. A system of this type covering most of our applications in the 10-kHz to 2-GHz range is available at a cost of $35 K. The increased productivity resulting from the use of this equipment is estimated to be more than equivalent to the use of one additional skilled electronic technician. The investment can, therefore, be regarded as being returned in one year or less.

2. Real-Time Low-Frequency Spectrum Analyzer and Correlator

Real-time spectral analysis of low-frequency phenomena has had many applications to the analysis and understanding of natural processes which are difficult or impossible to analyze in the time domain. A class of hybrid digital-analog instruments is now available which provide more flexibility and capability than the purely digital transform approach. Work in progress on severe weather ionospheric interactions and the development of instrumentation for monitoring magnetospheric wave phenomena require an improved facility for this type of analysis. The cost is estimated to be $50 K.

OTHER OBJECTS REQUESTS FY 1973

(1)		Basic Environmental Test Facilities for Flight Hardware	
	(a)	Small thermal vacuum chamber, including control and vacuum equipment	$ 15.0 K
	(b)	Addition of a better automatic control system to present thermal chamber to permit automatic temperature cycling for early failure detection	2.0
	(c)	Minimum vibration test system for small monitor assemblies	5.0
	(d)	Small bench-top-type thermal chamber for quick evaluation of breadboarded or other small subsystems	3.0
(2)		Minimum Facility for Utilizing Hybrid Microcircuit Technology	50.0
(3)		General Purpose Electronic Test Equipment	
	(a)	Sweep frequency network analysis system	35.0
	(b)	Real-time low-frequency spectrum analyzer	50.0
			$160.0 K

C.(7). PLANS AND JUSTIFICATIONS - REAL-TIME DATA SERVICES GROUP

Data for SEL purposes are acquired from two groundbase stations at Table Mountain, Colorado, and Anchorage, Alaska. Computers at these sites perform the acquisition, some of the processing, the recording, and the dissemination of the data. The data feeds the SEL real-time data service system (see app. D).

In FY 1972, the following should have been accomplished.

(1) The GOES ground-based equipments should have been installed, i.e., the antenna, receivers, demodulators, and the G system of the real-time system should have been installed at Table Mountain and the Boulder Laboratories.

(2) Completion of the SESC console should have been made.

(3) The Anchorage station should have been converted to AWS operation and SEL maintenance.

During FY 1973, the operational requirements at the Table Mountain and Anchorage stations will be increased. At Table Mountain the GOES data will be coming in and preparations must be made to start taking the SOLRAD HI data in 1974. The Anchorage system should be modified to improve the quality of the ionospheric and geomagnetic service to the Alaskans (a NOAA responsibility in Alaska) and also to improve the data base for the AWS and SEL needs. There will undoubtedly be modifications required in the SESC data display console system.

An increase of $59 K is requested for the following purposes:

OTHER OBJECTS REQUESTS - FY 1973

(1)	Table Mountain requires more operational items such as magnetic tape because of the increased data-taking for GOES.	$ 10.0 K
(2)	Modifications and new developments for parts of the SESC console should be made as experience and requirements indicate.	10.0
(3)	Improve the Anchorage system to better serve the Alaskan and AWS-SEL data needs:	
(a)	Install equipments for monitoring HF circuits to the north part of Alaska. This requires the purchasing of communication and radio receiver parts.	20.0
(b)	Improve the communication and magnetic field message quality by utilizing the AWS or ITS facilities.	5.0
(c)	Arrange for better dissemination of the communication and magnetic messages in Alaska, i.e., utilize existing NWS or NOS facilities.	14.0
(4)	Recurring base budget	86.0
		$ 145.0 K

C.(8). PLANS AND JUSTIFICATIONS - OFF-LINE DATA SERVICES

Details cannot yet be specified, but in FY 1973 we will need to expand and upgrade off-line data processing hardware to handle data from additional satellites. Likely Other Objects equipment includes that for handling PCM data such as bit synchronizer and PCM decommutator. Strip-chart recorders will be required for "quick-look" and tape evaluation, and a digital tape recorder with the necessary interface gear will be needed to produce computer-compatible tapes for experimenters.

Other Objects Requests for FY 1973 for the above requirements will total $25 K.

C.(9). PLANS AND JUSTIFICATIONS - AERONOMY AND SPACE DATA CENTER

An increase of $240.5 K is requested in this report. However, an expanded request in greater detail for the Aeronomy and Space Data Center has been submitted to the Environmental Data Service by A. H. Shapley, Office of Geophysical Services, Rx10, and J. V. Lincoln, R437, using a different base against which the greater increases are computed. In this presentation the major requests are (a) for development of an INFOL-type of computer program to access data inventory files for on-line or interactive use; (b) for undertaking contracts for monitoring type of data acquisition to fill longitude gaps in standard observing programs or to provide unique data; and (c) increased costs of general data services and monthly publications.

OTHER OBJECTS REQUESTS - FY 1973

(1)	R&D	
(a)	Contract AAVSO - for American sunspot numbers and SID reports.	$ 1.8
(b)	Contract NBS - for GEOALERTS broadcast by WWVH	2.0
(c)	Travel - One trip overseas to CCIR Interim; two domestic trips for meetings.	1.6
(d)	Printing - IUWDS RWC-circulars.	.5
(e)	Photo - Slides, miscellaneous illustrations.	.5
(f)	Computer - Develop INFOL and data publication programs.	50.0
	Subtotal	$ 56.4

(O.O. Requests continued next page)

OTHER OBJECTS REQUESTS - FY 1973 (Cont'd)

(2) S&E

(a)	Travel - One trip overseas (URSI) and two domestic.	2.0	
(b)	Asheville printing "SGD" - anticipate page increase from satellite monitoring.	15.0	
(c)	Asheville printing "UAG" - to print more data compilation as recommended by IUCSTP and other international organization.	12.0	
(d)	Keypunch rental	.8	
(e)	Timeshare terminal rental	.9	
(f)	Photocopy contracts - to contractor in order to supply data to World Data Centers B and C and to requesters entitled to equivalent of data supplied to WDC.	5.5	
(g)	Field Station supplies - specialized supplies to stations in worldwide ionosonde network utilizing equipment loaned by NOAA.	9.0	
(h)	Transportation - for sending supplies, paying custom fees, etc.	1.0	
(i)	Computer Request System - to manage orders, prepare use statistics, etc.	4.0	
(j)	Computer data orders - to supply data in automated form and maintain growing automated data files.	12.0	
(k)	Computer compilation - to run programs for processing data for "Solar-Geophysical Data" and other reports.	15.0	
(l)	Photo Lab for compilations - photo copy and background work for "Solar-Geophysical Data".	1.0	
(m)	Equipment - furniture, typewriter and reader-printer replacement.	1.0	
(n)	Maintenance of equipment - reader-printers.	.2	
(o)	Supplies - miscellaneous.	.4	
(p)	Subscriptions - magazines and reference books.	.3	
(q)	Reproduction Services - in-hour charges for data copies in photo lab, quick copy and print shop.	4.0	
(r)	Solar-geophysical Data Contracts - new contracts for data acquisition to fill longitude gaps in standard observing programs.	100.0	
	Subtotal	$ 184.1	K
	Subtotal page 65	56.4	
	Total	$ 240.5	K

C.(10). PLANS AND JUSTIFICATIONS - SPACE ENVIRONMENT SERVICES CENTER

A. Contracts

Funds are needed to continue and expand the dollar support to solar observatories which provide needed real-time solar data. Examples of support are shown in Other Objects Requests FY 1973.

These observatories provide data needed to complete our real-time global solar flare patrol. The cost of contract operation is many times less than the cost would be if NOAA built and operated similar facilities.

B. Communications

Funds are needed to continue our real-time data gathering and dissemination systems. Specifically, these funds will provide for teletype circuits and telecopier installations as shown in Other Objects Requests FY 1973.

These circuits and equipment provide rapid and effective means of transferring data to the Forecast Center and disseminating warnings and forecasts on a worldwide basis to satisfy international and national real-time needs for space environmental information.

OTHER OBJECTS REQUESTS - FY 1973

(1)	Contracts		
(a)	University of Michigan - observations of the sun in calcium, white light and solar magnetic polarities.	$ 35.0	K
(b)	Stanford University - observations of the sun in 9.6-cm radio wavelengths.	10.0	
(c)	Manila Observatory - observations of the sun in calcium, hydrogen alpha and white light.	5.0	
(d)	University of Colorado - observations of the sun in 7 to 81 MHz radio wavelengths.	15.0	
(e)	University of Sydney - observations of the sun in 20 and 40-cm radio wavelengths.	15.0	
(f)	CSIRO - observations of the sun in hydrogen alpha optical and 80MHz radio wavelengths.	20.0	
	Subtotal	$100.0	K
(2)	Communications	$ 80.0	K
(a)	Five teletype circuits at Boulder including line charges off-line refile charges and equipment.		
(b)	Seven zerox telecopier installations at Boulder, Colo., NRL, Aerospace, Canary Islands, Carnarvon, McMath, and Mt. Wilson.		
	Subtotal	$ 80.0	K
	TOTAL	$180.0	K

Appendix D - Budget Summary

APPENDIX D.

SPACE ENVIRONMENT LABORATORY FUNDING FOR FISCAL YEARS 1971, 1972, and 1973

D. SPACE ENVIRONMENT LABORATORY FUNDING FOR FISCAL YEARS 1971, 1972, and 1973.

	FY 1971	FY 1972	FY 1973
(1) Research	$	$	$
(a) R&D, Recurring	$ 735.0K	$ 790.4K	$ 965.1K
(b) Increment		100.0	988.9
(c) Pay Raise Factor		74.7	75.0
Sub-Total NOAA		$ 965.1K	$2029.0K
(d) Other Agency	854.5	814.6	419.0
Total Research	$ 1589.5K	$ 1779.7K	$2448.0K
(2) Services			
(a) S&E, Recurring	$ 659.3K	$ 659.3K	$ 704.2K
(b) S&E, Increment		0	530.8
(c) Pay Raise Factor		44.9	37.0
Sub-Total NOAA		$ 704.2	1272.0
(d) Other Agency	404.8	411.7	362.0
Total Services	$ 1064.1K	$ 1115.9K	$1634.0K
(3) Aeronomy & Space Data Center			
(a) R&D, Recurring	$ 87.0K	$ 87.0K	$ 87.0K
(b) S&E, Recurring (from EDS)	135.2	135.2	160.6
(c) NOAA, Increment (from EDS)		10.0	217.4
(d) Pay Raise Factor		15.4	21.0
Sub-Total NOAA		$ 247.6K	$ 486.0K
(e) Other Agency	$ 146.3	146.3	146.0
Total ASDC	$ 368.5K	$ 393.9K	$ 632.0K
FEC Funding (GOES)		200.0	
Lab Data System			212.0
Lab Computer & Travel			360.0
TOTAL SEL FUNDING	$ 3022.1K	$ 3489.5K	$5286.0K