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EOI READOUT JANUARY 1971 REPORT

I. INTRODUCTION

The purpose of this report is to present EOI configuration designs developed during Phase I System Definition and to summarize appropriate program costs and schedules through FY 76. In addition, the report summarizes the status of the technology development programs and identifies the required funding, within the approved total, for the balance of FY 71.

In accordance with the July and November 1970 ExCom decisions and NRO directives, BYE 13054-70 (23 July 1970) and BYE 13267-70 (24 November 1970), Phase I Readout System Definition was conducted from 14 August 1970 to 15 December 1970. The Phase I work statement and work packages specified a system design and analysis for both an [redacted] best nadir GSD Imaging Satellite (I/S) (Configuration A) and an 18-inch best nadir GSD (Configuration B). Appropriate Configurations A and B Processing Facilities were specified in parallel Phase I System Definition design studies. During the same period, Phase I studies of three candidate Relay Satellite (R/S) configurations were conducted by SAMSO. The R/S configurations analyzed included two [redacted] satellites, two [redacted] satellites and one [redacted] satellite.

This report is based on the extensive data presented by the four I/S, three Processing Facility (P/F) and two R/S contractors during the Phase I effort. Formal monthly reviews were conducted with each contractor and their detailed Interim (2 November 1970) and Final (15 December 1970) Reports were evaluated in depth. The Final Report included five documents: Configuration Studies, Design Studies, Phase II Plan, Preliminary Interface Specifications and Costs/Schedules. Numerous interface meetings were scheduled between the I/S and P/F contractors as well as all the subsystem contractors, particularly optics and transducer.

In the technology area, the following were accomplished:

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(a) Preliminary and Critical Design Reviews were conducted at the transducer contractors' facilities.

(b) Regular meetings and reviews were held with the optics, [redacted] and other technology development contractors.

(c) Formal reports and test data packages were delivered in December to summarize the various projects' status.

II. SUMMARY

The results of Phase I demonstrate readiness in all instances to proceed with Phase II. There is basic technical agreement on the configurations from all contractors and no technical, interface or schedule problems were identified. Particular attention was given to system and equipment compatibility as well as operational timelines, checkout, test procedures and training.

All milestones were achieved with the exception of the final surface quality of the [redacted] primary. It is expected that the goal will be reached in February 1971, approximately forty-five days late.

III. I/S CONFIGURATIONS

Two I/S configurations were studied in depth by the I/S contractors during Phase I System Definition. The primary difference between the two configurations is the [redacted] best nadir GSD Technical Intelligence (TI) requirement and the 12-inch GSD Strategic Intelligence (SI) requirement for Configuration A and the 18-inch GSD SI requirement for Configuration B. In addition, the TI requirement includes the capability to acquire 1,500 stereo pairs and at least ten geometric accesses to all targets at less than 12-inch GSD per six months. Configuration B meets only the SI requirement with an 18-inch nadir GSD. There are no specific stereo requirements for Configuration B other than providing the capability to obtain some stereo imagery.

Typical system performance for both Configuration A and B is shown in Table I. Best nadir GSD is defined as the GSD obtained at nadir for the minimum altitude of an I/S, which is also the condition that defines the minimum frame size. Maximum obliquity is the largest off-nadir angle required to achieve daily access to 17 degrees latitude. Image quantity performance is based [redacted] I/S operating against two types of target models. The Distributed Target Model measures a desired capability to image targets that are distributed throughout an extensive area along-track, while the Clustered Target Model evaluates the capability to acquire frames of imagery within a nominal 50 n. mi. diameter area of densely clustered targets.

A. Configuration A

[redacted]

TABLE 1

TYPICAL SYSTEM PERFORMANCE CHARACTERISTICS

Parameter	Units	Config. A	Config. B
Intelligence Objective	--	TI/SI	SI
GSD (Best Nadir)	Inches	[redacted]	18
SNR (Δ B = 400 f-1)	--	5:1	5:1
Frame Size (Min Nadir)	n. mi.	2 x 2	2 x 2
Sino-Soviet Access	--	Daily	Daily
Maximum Look-Angle	Degree	60+	60+
Image Quantity:			
Daily Total	Frames	[redacted]	
Dist. Tgt Model	%		
Clustered Tgts (50 n. mi. dia)	Frames		
TI Stereo Pairs:			
Total/6 mo.	--	1,500	--
TI Geometric Access			
Per 6 mo.	--	> 10	--

[redacted]

The I/S will be designed to operate in a range of elliptical orbits with a perigee of 188 n. mi. and an apogee between 283 and 424 n. mi. Final selection of the apogee altitude will be based on results of additional trades between the quantity of imagery against clustered and distributed targets, the quality (GSD and SNR) and the contiguous area coverage. Maximum propellant sizing will be based on the highest drag, 283 n. mi. apogee and the worst drag years of the solar activity cycle. During the period [redacted] the [redacted] I/S will provide complete access down to 17 degrees latitude every two days and approximately 50 percent of the clustered and distributed target coverage performance of the two I/S system. The [redacted] I/S will, however, provide the capability to return [redacted] images per day and [redacted] images per pass.

Table 2 lists typical characteristics of the Configuration A I/S.

B. Configuration B

This configuration is a lower performance and lower initial cost configuration designed to perform only the SI mission with a best nadir GSD of 18 inches at a SNR

[redacted]

TABLE 2

TYPICAL I/S CHARACTERISTICS

Parameter	Units	Config. A	Config. B
Number of I/S	--	2	2
Orbit Type	--	Elliptical	Circular
Apogee/Perigee	n. mi.	188/283-424	200
Design/Mean Mission Duration	[redacted]	[redacted]	
Optics:			
Focal Length	Inches		
Aperture	Inches		
D^2 T_o MTF	$Feet^2$		
Transducer:			
No. of Arrays	--		
Detectors/Array	--		
Detector Area	Mils		
Pitch	Mils		
Integration Time	msec		
NES	$\mu J/m^2$		
Data Encoding	--	DPCM	DPCM

TABLE 2 Cont'd

TYPICAL I/S CHARACTERISTICS

Parameter	Units	Config. A	Config. B
Bits/Sample	Bits	4 + refresh	5 + refresh
Data Rate (Max.)	MB/S		
Attitude Control:			
Tracking Accuracy	(μ Rad/Sec)	38	--
On-Orbit Weight	Lbs.	14,500	12,500
Moment of Inertia	Slug Ft^2		

[redacted]

A list of typical Configuration B I/S characteristics is shown in Table 2.

IV. RELAY SATELLITE

A. Technical

The four I/S contractors and two SAMSO R/S contractors have considered a variety of R/S configurations. All contractors studied synchronous equatorial R/S systems in depth. In addition the SAMSO contractors and one I/S contractor selected elliptical satellite configurations as the preferred approach. The principal requirements and capabilities for these configurations are summarized below.

All configurations employ an [redacted] link for imaging data, telemetry, command and ranging between the R/S and the I/S. The designs consider both [redacted] between the R/S and the Receiving Facility (R/F).

The coordinated EOI and SAMSO [redacted] advanced technology programs are proceeding on schedule. The antennas, receiver/exciters, parametric amplifier and traveling wave tube amplifiers are achieving the desired performance on schedule.

Relay Satellite Configurations Studied

1. A network of two R/S's in [redacted] [redacted] orbits provides worldwide coverage and relays

[redacted] of imaging data to the R/F. This configuration confines the R/S downlink imaging data to the CONUS by selecting appropriate locations for the R/S's and the R/F to deny sufficient signal to eavesdroppers thereby preventing them from reconstructing usable images. The long cross link between the two [redacted] R/S's required for Sino-Soviet coverage leads to a significantly higher cost and slightly lower reliability than the [redacted] R/S configurations.

2. Two R/S configurations that employ [redacted] were studied:

(a) The first configuration uses two R/S's [redacted] coverage. Most of the downlink beam from the R/S can be confined to the CONUS.

If one of the R/S's fails, the remaining satellite can provide readout support to the I/S for portions of the Sino-Soviet area.

[redacted]

(b) Another configuration uses one R/S in [redacted] year. Detail studies of orbit perturbations may show this approach is not satisfactory for the full [redacted]

This configuration is substantially less expensive than either of the others since only one R/S is required in orbit. However, having a single R/S in orbit may result in outage periods of up to forty-five days if an unexpected R/S failure occurs. Control of the R/S downlink imaging data footprint is not feasible with this orbit due to the longer ranges and varying angles above the R/F horizon.

B. Selected Configuration

[redacted] R/S configuration is recommended for implementation. The preferred approach uses an existing [redacted] spacecraft which can be operated in either a [redacted] orbit. During the next month SAMSO will study elliptical systems using either [redacted] for the R/S downlink and will evaluate final consideration of the coverage capability problem, outage and footprint implications for the [redacted] system. The acceptability of a [redacted] spacecraft program for the [redacted] system will also be reviewed to determine the best cost/technical approach.

Initial guidance on the R/S orbit, number of spacecraft and wideband downlink frequency will be given to SAMSO in late February and the final determination will be made in March. This approach permits final review of critical factors while permitting basic spacecraft design to proceed.

V. GROUND FACILITIES

A. There are various options concerning the locations of the ground facility segments. Final selection of the course of action will be determined during Phase II. The selection is independent of the I/S configuration and only the R/F is influenced in a minor way by R/S considerations.

The two principal options of interest are:

1. All ground facilities collocated - in this situation a minimum acceptable distance from central [redacted] is 50 miles to the west.

2. Collocation of the O/F and P/F in the central [redacted] area and installation of the R/F a minimum of 50 miles to the west.

There are variants of these options which address the specific locations of equipment and users, but the basic engineering and design considerations are the same.

B. Receiving Facility

Since it is necessary to situate the R/F at least 50 miles from [redacted] due to R.F. electromagnetic interference considerations, candidate sites have been evaluated as far west and southwest as 400 miles to cover a range of allowable footprint conditions. Sufficient data has been gathered to identify over twenty possible locations. These will be screened to identify four to six good prospects for detailed examination including R.F. frequency surveys.

Design studies of the R/F installation were submitted by all four I/S contractors during Phase I. No problem areas were identified and Configurations A and B differ only in data rate and degree of redundancy provided. There is little impact of the I/S configuration on the R/F facility and only moderate effect on the equipment.

C. Operations Facility

In depth studies of the O/F were completed by the four I/S contractors during Phase I. Requirements for both Configuration A and B were developed. Differences between the two configurations are minimal since the control functions relate to the number of segments and basic type of operations which are identical for A and B.

The O/F consists of consoles, displays, general purpose computers and software. The monitoring of I/S and R/S telemetry and the transmission of commands are primary functions. Control of all segments of the system is exercised at the O/F. Incoming tasking from the user community is implemented using the target history files, targeting algorithm software, weather and system status data. Orbit determination for I/S and R/S is continuously carried out and necessary adjustments are made.

The only significant difference in characteristics is the need for a wideband data link in Option 2.

D. Processing Facility

The three contractors have demonstrated system feasibility on the basis of analysis, breadboarding and simulation. Extensive experimental work was carried out to demonstrate operation of the required digital processing circuits. All of the contractors have concluded that on-line, [redacted] processing is the most efficient and cost effective way of handling the image data for any system configuration. In depth studies revealed that the large buffer or storage requirement for non [redacted] processing is costly and technically less desirable.

Each contractor has derived basic designs and circuit technology for [redacted] digital processing utilizing readily available transistor-transistor-logic (TTL). All three have used their own breadboard laser image reconstruction devices during system simulation experiments. Some new techniques have been proposed and simulated including: (1) automatic calibration of the photosensor array detectors by using normal scene statistics, (2) automatic editing of data bit errors and (3) automatic dynamic range adjustment.

Good estimates on the number and types of circuits, failure rates/reliability, size of equipment, facility layout details and personnel to operate the P/F on a 24-hour basis have been derived for both configurations.

Configuration A consists of four identical sets of digital processing equipment, [redacted] Four Laser Image Reproducers generate the hard copy, one for each subframe. One additional set of processing equipment is provided for redundancy. Minimal storage will be provided and adequate photo processing and viewing stations are included in the P/F design. The P/F equipment is operated by a control center subsystem which determines equipment readiness, switches items as necessary during malfunctions and provides access to data files for calibration and MTF correction. Table 3 lists characteristics of the Configuration A P/F.

The Configuration B design approach is guided by the different characteristics of the I/S wideband data stream and by the goal of minimum cost. Since the Configuration B I/S baseline uses [redacted] the P/F requires only one set of digital processing equipment. An additional set is recommended for the same redundancy considerations analyzed in Configuration A. The Configuration B Control Center requirements are less due to the use of [redacted] Table 3 describes Configuration B.

Conversion of Configuration B to Configuration A poses primarily cost and facility requirements. If the equipment and facility are initially sized to Configuration B, virtually a completely new A fabrication and installation effort is required.

VI. PROGRAM PLAN

The results of Phase I in both the I/S and the P/F reports were comprehensive and in close agreement. All contractors converged on comparable overall system configurations, segment designs and schedules. The excellent progress makes it possible to revise the Phase II schedule to provide both time and overall cost savings.

The revised plan provides for Acquisition Phase proposals to be delivered 30 July 1971. As in previous plans, a two months' evaluation period is scheduled. This provides six weeks for selection and report preparation and three weeks for review and approval. System Acquisition will begin 1 October 1971 and the earliest first I/S launch will be April 1975. The R/S plans and schedule integrate well with this approach. Whereas SAMSO previously anticipated an extended waiting period following their completion of Phase II and selection of the acquisition contractor, they now can proceed in October 1971 with some cost saving and better integration of design reviews and other milestones in the overall EOI schedule.

TABLE 3

P/F CHARACTERISTICS

	Configuration A	Configuration B
Data Rate	[redacted]	
Data Rate/Channel	[redacted]	
No. of Processing Channels		
Image Size		
MTF Compensation	5 x 5 matrix	Optional
Image Reconstruction	Laser Image Reconstructor (on film)	Same
MTBF for P/F	4,122 Hours	8,445 Hours

Planning for the subsystem technology development programs also fits well with this schedule. Rather than extending their work through the first half of FY 72, they can be converted to acquisition at the end of the first quarter. Projects such as Image Chain Analysis, the Image Processing Laboratory, the [redacted] and other analytical/test efforts have been planned to support Phase II and System Acquisition in appropriate areas.

Figure 1 is the schedule for the EOI program through FY 76 and Table 4 lists key near-term milestones.

VII. CONFIGURATION SELECTIONS AND COSTS

From both technical and cost considerations, it is recommended that the Configuration A I/S program be selected. During Phase II all specifications will be reviewed to determine whether some programmatic advantage could be gained by time phasing portions of the complete A performance requirements. Phase II studies may show that specification values for Optical Quality Factor, attitude control system accuracy and transducer noise equivalent signal should be budgeted differently for the various flight vehicles. If some advantage is identified, the first one or two vehicles could be deployed using initial capability specifications which are then revised for subsequent flight systems. The costs for Configuration A are within funding limits with a minor exception in FY 72 and the better GSD provides both near-term and long-term capability benefits. Table 5 summarizes funding for the NRO segments. Note that [redacted] of FY 72 funding can be deferred to stay within the [redacted] guideline. Table 6 presents additional details of the FY 72-76 funding. The figures do not include any out-year allowance for engineering or hardware associated with block redesigns. The I/S launch schedule used for costing estimates was May 1975, [redacted]

Configuration B costs for the FY 72-76 time period are presented in Tables 7 and 8. This data assumes no block changes and is based on launch dates of May 1975, November 1975, November 1976 and yearly thereafter.

Tabular data is not presented for the B change to A since the yearly values are completely dependent on the desired first

FIGURE 1

ELECTRO-OPTICAL IMAGING (READOUT) PROGRAM

MASTER SCHEDULE

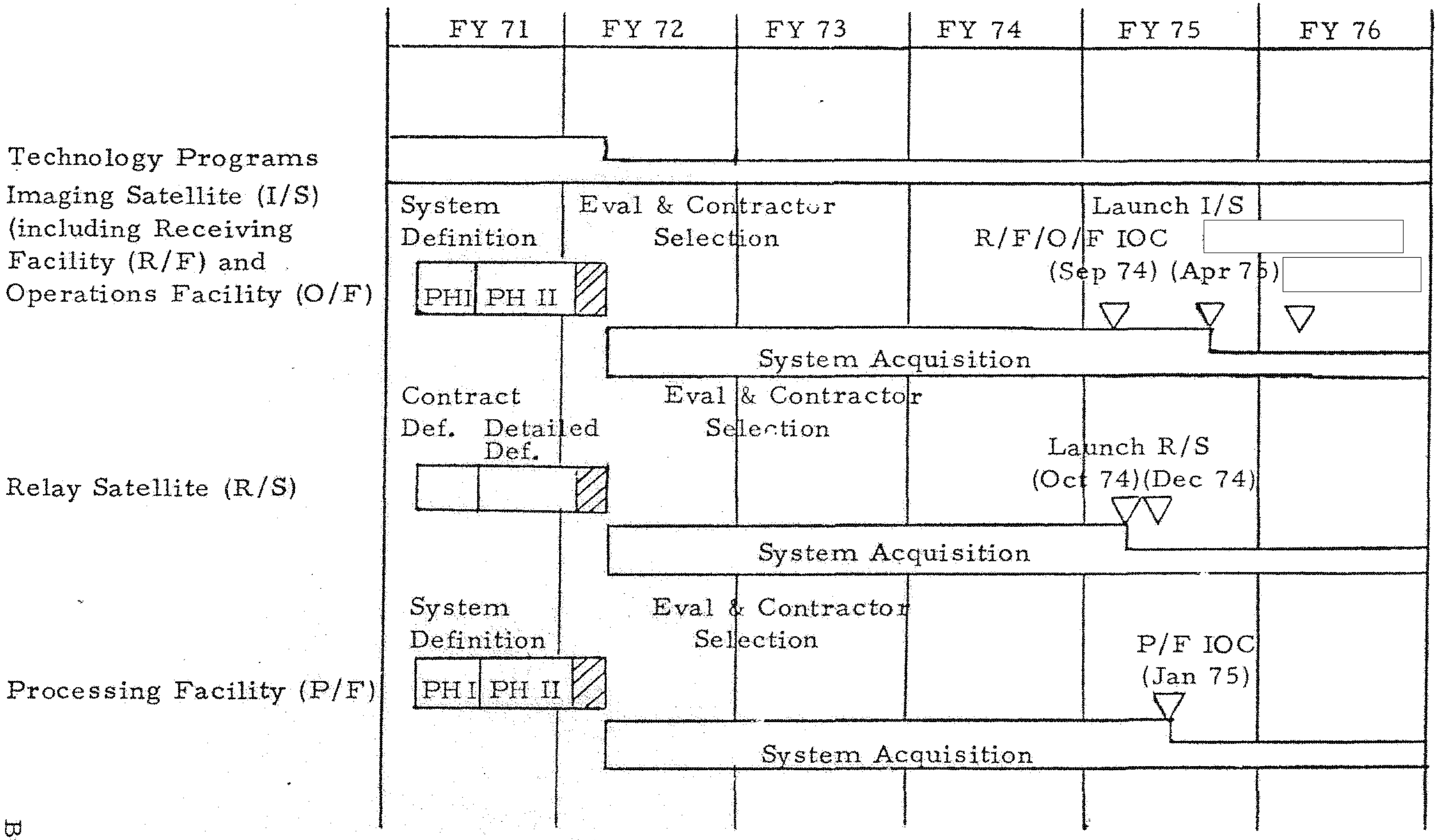

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TABLE 4

EOI (READOUT) PROGRAM

PROGRAM MILESTONES

EVENT	DATE(S)
Initiate System Definition Phase II	1-3 February 1971
I/S Contractor submit R/S Requirements	19 February 1971
Revise Phase II R/S Specifications	19 March 1971
Final Reports/Proposals for System Acquisition Phase delivered by I/S and P/F contractors	30 July 1971
Conduct I/S and P/F contractor evaluation and source selection	31 July 1971 - 15 September 1971
Submit Program Report	15 September 1971
Initiate System Acquisition Phase	1 October 1971

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TABLE 5

EOI PROGRAM

FY 72 - FY 76 NRP COST BREAKDOWN

CONFIGURATION A

($ Millions)

	FY 72	FY 73	FY 74	FY 75	FY 76	Total
A. Imaging Satellite R/F and O/F						
B. Processing Facility						
C. Image Chain Performance						
D. Technical Consultant						
E. Launch Vehicle/LVI						
F. Ground Operations						
TOTAL						

TABLE 6

EOI PROGRAM

COST DETAILS

CONFIGURATION A

($ Millions)

	FY 72	FY 73	FY 74	FY 75	FY 76	TOTAL FY 72-76
Imaging Satellite						
Non-Recurring	[redacted]					
Recurring						
Technology Programs						
Total I/S						
Ground Facilities						
Receiving Facility						
Operations Facility						
Total R/F - O/F						
Processing Facility						
Operations						
Receiving Facility						
Operations Facility						
Processing Facility						
Total Operations						

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TABLE 7

EOI PROGRAM

FY 72 - FY 76 NRP COST BREAKDOWN

CONFIGURATION B

($ Millions)

	FY 72	FY 73	FY 74	FY 75	FY 76	Total
A. Imaging Satellite						
R/F and O/F						
B. Processing Facility						
C. Image Chain Performance						
D. Technical Consultant						
E. Launch Vehicle/LVI						
F. Ground Operations						
Total						

TABLE 8

EOI PROGRAM

COST DETAILS

CONFIGURATION B

($ Millions)

	FY 72	FY 73	FY 74	FY 75	FY 76	TOTAL FY 72-76
Imaging Satellite						
Non-Recurring						
Recurring						
Technology Programs						
Total I/S						
Ground Facilities						
Receiving Facility						
Operations Facility						
Total R/F - O/F						
Processing Facility						
Operations						
Receiving Facility						
Operations Facility						
Processing Facility						
Total Operations						

flight date for the upgraded system. If a first flight were desired in late 1979, costs through FY 76 would be [redacted] The ten-year costs for this approach are about [redacted] more than the ten-year Configuration A costs.

In view of the cost difference SAMSO has identified for the Relay Satellite segment, [redacted] configuration is recommended. Two [redacted] relays can meet system requirements. A final examination of the [redacted] relay will be made during Phase II but since there may be unacceptable coverage characteristics, it is recommended that the [redacted] funding level be reserved for budgetary purposes. An additional [redacted] option using an unmodified [redacted] will also be reviewed for potential cost savings. The figures presented in Table 9 show actual estimated totals and also the contingency and inflation factors applied by SAMSO. FY 71 technology and system study costs have not been included. It is felt that the 15% contingency is less applicable to the [redacted] relays using [redacted] spacecraft hardware. Table 10 shows the costs including contingency and inflation distributed by fiscal year.

Table 11 lists the FY 71 funding status and identifies the items required to proceed into Phase II System Definition. Approval of the withheld optics and Image Chain Analysis funds is also requested.

VIII. TECHNOLOGY DEVELOPMENT

A. Optics

Design, analysis and fabrication demonstration work continue at [redacted] Preliminary design has been [redacted] with lower performance [redacted]

Work on the shorter focal length system began in August 1970. The objective was to define a reduced performance system with attendant lower development costs. Parametric studies were performed to optimize the primary mirror f number and a f 3

TABLE 9

COST - MILLIONS

FY 72 - FY 76

Space Vehicles	
Non-Recurring	
Recurring	
Launch Vehicles	
Other	
Total	
Contingency	
Total	
Inflated Total*	

*4.2% Per Year

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TABLE 10

RELAY SATELLITE FUNDING SCHEDULE

	FY 72	FY 73	FY 74	FY 75	FY 76	TOTAL FY 72-76

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TABLE 11

EOI (READOUT) PROGRAM

FY 71 FUNDING STATUS

($ Thousands)

	Present FY 71 NRO App.	Withheld FY 71 NRO App.	Total FY 71 Reqt.
Imaging Satellite			
1. System Definition			
2. Solid State Transducer			
3. Optics			
4. Digital Tape Recorder			
5. Communications Technology			
6.			
7. Flight Computer			
8. Materials Evaluation			
9. R/F Measurements			
10. R/F Site A&E			
Processing Facility			
1. System Definition			
2. Laser Image Reproducer			
Image Chain Performance			
1. Image Chain Analysis			
2. Image Processing Lab			
Technical Consultant			
Itek, Additional Tasks			

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configuration was determined to be most cost effective. A diffraction limited optical formula was obtained with a flat field and two corrector elements. A number of structural concepts were evaluated and the Invar tube approach was chosen as the baseline.

The choice between a tube structure and a tripod for secondary support was not final; if the [redacted] receives more attention during Phase II of System Definition, a very thorough structural dynamic analysis will be performed to finalize the choice. The thermal control is similar to that for the high performance system but with lower electrical power demands reflecting the lower performance requirements. A choice of the alternate structural concept would entail a change in the thermal control configuration also. The impact on electrical power is minimal with either configuration. Table 12 lists the significant optics dimensions for the two designs.

Optical element fabrication programs are underway at both [redacted] Two lightweight secondary mirrors have been completed at [redacted] The first, configured to the initial lens design, was completed in five months to [redacted] rms. This was over seven months ahead of schedule. The second mirror was figured to . [redacted] This mirror was originally scheduled for completion by 31 December 1970 but three weeks were used in changing the vertex radius to conform to the revised requirements of the Optical Assembly Test Configuration (OATC).

Using the completed optics, [redacted] will build the OATC and perform both catoptric and catadioptric tests. This testing is scheduled for initiation in May 1971. An alignment subsystem and a focus drive will be incorporated into this assembly. Design drawing release and fabrication of the OATC are on schedule. The secondary mirror (alignment) actuators have been successfully tested at the breadboard level and deliverable units are in manufacture. Design drawings for the focus drive have been released. Initial tests of the OATC will utilize an available [redacted] for autocollimation testing. A full aperture flat [redacted]

TABLE 12

COMPARISON OF [redacted] CONFIGURATIONS

Aperture (Inches)	[redacted]
Focal Length (Inches)	
System f	
Primary Mirror f	
Central Obstruction (%)	
Field Width (Inches)	
Radius of Curvature of Image Surface (Inches)	
Primary to Secondary Distance (Inches)	
Primary to Focal Surface Distance (Inches)	

has been ordered from [redacted] and will be delivered to [redacted] on 1 February 1971. Fabrication and test techniques will thus continue to be upgraded during this pre-acquisition phase of the EOI program. This blank will be finished and used for later autocollimating tests of the OATC as well as flight optics.

The lightweight primary [redacted] in July 1970 has been figured to a surface of [redacted] by mid-March 1971. An analysis is in process to incorporate the completed mirror into a [redacted] collimator being designed and built by [redacted] to specifications agreed to by [redacted] The collimator will utilize many of the structural and thermal control concepts developed during the recently completed [redacted] Optical Subsystem Design Study. Upon completion (June 1971) the collimator will be shipped to [redacted] and installed above the OATC, thus permitting optical imaging tests.

[redacted] has also been tasked to finish a [redacted] lightweight mirror (same radius of curvature as the large primary) on their computer automated optical surfacing (CAOS) machine, preparatory to performing cold tests (to 40 degrees F) to determine the change of surface figure at the reduced temperature. The possible preference for colder operation of the optics is a saving in electrical heater power on flight systems. After determining the amount of surface change, predictions will be made of the required refiguring at room temperature to provide a correct surface at the low temperature. This task was preceded by an [redacted] study which addressed the critical aspects of cold temperature operation. One is the surface figure change, which may be solved by the [redacted] approach or by careful selection and placement of the ULE fused silica used in fabricating the blanks. Another is mirror mount induced strain. The current mount designs can be modified to minimize temperature induced strain if low temperature operation is chosen.

B. Transducers

1. System Design

In November a preliminary design review of the prototype flight system (one-quarter of an array) was held at [redacted]. Delivery is scheduled for June 1971. The Critical Design Review in January finalizes the design.

A Critical Design Review on the [redacted] single module system (8 chip) January delivery and on the prototype flight system (one-half array) May delivery was conducted in November.

[redacted] completed preliminary designs for a Configuration B transducer and held interface meetings with [redacted] during November. One result of the interface meeting was a radiant cooling design concept for the transducer that should minimize thermal interface conditions with the optics. Both [redacted] have initiated programs to determine the nuclear radiation susceptibility of the photodetector chips. On 15 January both contractors delivered a detailed mechanization report on the prototype flight hardware. Copies of these reports will be distributed to the Phase II I/S and P/F prime contractors.

2. Chip Design

[redacted]

Burst noise was the most significant problem encountered. Experiments have been performed seeking the source of the noise. Although the results are inconclusive, there is good correlation with details of processing techniques. The production line processes were stabilized near the end of December and the first chips from the stabilized line became available during the week of 4 January. Eight chips have met the noise performance specification of the mean chip noise less than 1.2 $\mu J/m^2$ with no detector greater than 2.0 $\mu J/m^2$. After the production line yield has been evaluated, a determination will be made on the production rate necessary to produce required chips meeting performance specification. Initial indications are that requirements will not be excessive.

The performance of the 2P 195 element chip continues as expected and production of the 4P 125 chip has been stopped. A data package on 20, 2P 195 chips will be delivered in February 1971.

[redacted]

Production of the 775 series chip has been discontinued and has been replaced by the 808 chip. The 808 chip has several improvements - there is a third level of metal to mask any undesired photosensitive areas of the chip, and changes in the diffusion pattern of the end detectors allow closer laser cutting. Noise performance of this chip continues to be good - mean chip noise less than $1.2 \mu J/m^2$ and no noise greater than $2.0 \mu J/m^2$. A data package on twenty chips was delivered on 15 January 1971. There has been no evidence of burst noise in any [redacted] chips.

C. Hardware Development

1. [redacted]

The single module system (12 chips) delivered originally in June 1970 is being retorfitted with new 4P 125 chips. The retrofitted system will be delivered to the Image Processing Laboratory (IPL) the last week in January 1971 for two weeks of testing.

The design of the prototype flight system (one-quarter of an array) is continuing and is nearing completion. A variable integration time is being incorporated into the design. This system will be delivered to the IPL in June 1971 for three weeks of testing. Flight testing of the unit is being considered, as well as integration into the OATC subsequent to the IPL evaluation.

2. [redacted]

The [redacted] single module system (SMS) consists of an 8 chip module and a PCM processor. It will be delivered to the IPL in February 1971 for approximately two months of testing. Beginning the first of April, the SMS is scheduled for flight tests. The SMS will then be returned to [redacted] to begin two weeks of thermal vacuum testing.

The [redacted] Prototype Flight System (PFS) consisting of a one-half array with flight configured electronics will undergo thermal vacuum testing at [redacted] during June 1971. Testing of the unit in the OATC is being considered.

[redacted]

[redacted]

In order to meet need dates for engineering model CMG's, a design phase for the flight model units will be initiated in March 1971. The design effort will permit a hardware acquisition authorization by the selected I/S prime contractor in October 1971.

E. Wideband Digital Recorder Development

Design and breadboarding of a digital, high-data rate magnetic tape recorder for both space and ground use is underway. The Ampex development program will demonstrate operation of a tape recorder having the characteristics listed on Table 13. Electronics for 14 channels operating at a total of [redacted] will be implemented to prove feasibility. The recorder can be expanded from [redacted] by procuring the additional electronics. The technology obtained from the program will provide the basis for both ground-based and spacecraft recorders. The development program includes evaluation of head-to-tape interface, bit packing density, bit error rate (BER), multiplexing, deskewing, overall data handling and reliability. Three months after initiation of the contract, Ampex has the feasibility model, two-inch tape transport operating with servo lock up. Two-inch Permalloy heads (28 track/head, 15 micro inch gap) were mounted on the tape transport for initial skew measurements on 13 January 1971. A new, improved one-inch Ferrite head (28 tracks, 15 microinch gap) is under test for response characteristics. Two-inch Ferrite heads are being fabricated for the final feasibility model. Motorola (Phoenix) is under subcontract to Ampex for design studies of the electronics required. The Motorola study will be completed on 22 January and the decision concerning the design and/or fabrication of electronic units will be made in early February.

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TABLE 13

TAPE RECORDER CHARACTERISTICS

Data Rate	[redacted]	Head Material	Ferrite
No. of Tracks	56	BER	$< 5 \times 10^{-6}$
Data Rate/Track	[redacted]	Capacity	100 Frames
Reel Size	12 In.	Interchangeable	Yes
Track Width	24 Mil.	MTBF	200 Hours
Tape Width	2 In.	Start/Stop Time	1 Sec.
Tape Speed	120 IPS	Deskew (static and dynamic	Internal
Bit Density/Track	[redacted]	Frame Search	Yes
Head Gap Length	15 Micro In.		

An alternate space recorder technology program was initiated in mid December 1970 at [redacted] The objective of this effort is the development and evaluation of a functional model wideband longitudinal tape recorder applicable to both space and ground use. The purpose of the program is to demonstrate the technology and the capabilities required for an I/S wideband recorder subsystem by the design and test of a functional model. The model will be designed to operate at the full image data rate of [redacted] with electronics implemented for 24 percent of the channels. The principal objective of the functional model testing is to verify performance of the (a) head-to-tape interface and (b) capability to record and accurately reproduce the specified per channel wideband data rate. The technology program includes two major feasibility demonstrations. The initial demonstration will be conducted mid-June 1971 utilizing the functional test model that will include the following elements:

1. A spacecraft type two-inch tape transport (fabrication complete 1 March 1971).

2. A multichannel longitudinal head assembly (Initial head construction and wiring begins 1 February 1971.)

3. Seven operational digital channels employing delay modulation encoding and decoding together with the necessary skew correction electronics. (Breadboard tests complete 2 April 1971.)

The demonstration of the equipment at the six-month milestone (mid-June 1971) will consist of (a) per channel bit error rates and (b) interchannel time displacement after skew correction. The data record/reproducer goal is a bit error rate of 1 in 10^{-6} and an interchannel time displacement not exceeding $\pm$ 1/4 of a bit period. In addition the potential area bit packing density of the demonstration equipment will be verified with a goal of 2×10^6 bits/in^2.

F. Image Chain Performance Program

The Image Chain Performance Program consists of three areas of activity, including the Image Chain Analysis (ICA), Image Processing Laboratory (IPL) and the [redacted] These activities all form an integral part of the program and are interrelated through the IPL, which is the central location for the generation of all simulated imagery for the ICA and reconstruction of imagery data obtained from IPL array tests and the [redacted]

1. Image Chain Analysis

Significant developments have taken place in this area of activity where the ICA contractor [redacted] has defined and analyzed a detailed end-to-end model of the image chain. This model of the image chain was incorporated into an analytical computer program and used to develop image chain parameter sensitivities and support to quality measures studies. Image quality trade studies were conducted to define parameters for use in generating simulated imagery at the IPL. A photo-evaluation approach was developed for evaluating the simulated imagery. A list of questions based on the mosaics used as input scenes was prepared for use in each experiment for assigning a relative score to each image evaluated. The results of these simulated imagery experiments will be coupled with the results of the analytical studies in determining the appropriate image quality parameters.

These ICA studies will be expanded during Phase II System Definition to incorporate the entire range of operating conditions including off-nadir imaging, varying illumination and atmospheric conditions, use of selectable integration time and various scanning mode effects. Selected experiments will be conducted at NPIC using the simulated imagery to determine the effect on intelligence value of the various ranges of operating conditions.

2. Image Processing Laboratory

The most significant achievement at the IPL was the development of an advanced image scanner and reconstruction device. This device is designed for the generation of all simulated imagery for the ICA activity and for the reconstruction of all array test images and [redacted] images. The device has been designed, fabricated and tested and is in operation at the IPL. This device and the newly developed software package provide the capability for generating high quality imagery exhibiting the effects of all the key elements of the image chain. Elements simulated include atmospheric and scene variables, optics and sensor subsystems, data encoding and communication and ground processing.

The IPL has also continued to conduct both imaging and engineering tests of actual breadboard array hardware. These tests have provided a valuable source of data on the transducer and data processor performance for feedback to the transducer manufacturers. Modification work is nearing completion for testing of the transducer array modules incorporating flight design hardware early in 1971.

3. [redacted]

Phase I of the [redacted] ended in January with two very productive [redacted] returning more than 150 frames of imagery. [redacted] images were forwarded to the IPL for final processing. The quality of the 12-inch GSD imagery was good and correlated both with IPL array tests and with simulated imagery, although numerous equipment and procedural problems were encountered.

[redacted]

An improved [redacted] test program will be implemented to test the [redacted] and the [redacted] array during 1971. The new equipment will provide both for the larger arrays including their increased data rate and for initial assessments of haze and other atmosphere effects. Data will also be collected to evaluate effects of dynamic range, DPCM encoding, gain nonuniformity and calibratibility.

G. Communications Technology

Work has continued in coordination with SAMSO to develop [redacted] traveling wave tubes (TWT), high efficiency antennas and to carry out supporting studies and analyses.

[redacted] Additional TWT and antenna work is planned during the second half FY 71.

Supporting studies include R. F. measurements and propagation work, Architect/Engineer site surveys and link privacy evaluations.

The technology development and study work for the second half FY 71 were described in detail in BYE 109403-70 dated 6 January 1971.

H. Flight Computer

The Imaging Satellite Command and Control Subsystem will utilize several small, reliable, high-speed general purpose computers. Design and breadboard of a Central Processing Unit (CPU) will be initiated during FY 71.

The objectives of this program are:

1. To design, develop and establish feasibility of a computer CPU suitable for the I/S.

2. Verify that critical technology areas can reliably support the flight computer program to follow this breadboard activity.