VOLUME 3

SPIN-SCAN

FOR

CRISIS RECONNAISSANCE

This briefing describes the spin-scan concept, how it works, and the operational performance which is expected from the system.

The spin-scan concept has been under study for about four years. Originally, the concept involved the deployment of very simple satellites at 150-nmi circular altitude, with the objective of providing resolution of 6-10 feet. The 450-pound satellite was to be launched piggyback on Program 467.

As the concept has evolved, the initial simplicity has gradually given way to more stringent requirements. Larger optics, extensive maneuvering, and maintenance of a 90 x 210 nmi orbit for a month or more have necessitated abandonment of the piggyback idea in favor of launch-on-demand using Atlas E/F. The baseline satellite proposed here weighs 1600 pounds; and although more than three times the weight of the original version, it is still a practical concept, but its simplicity and economy have to some extent given way to provide coverage flexibility and high resolution performance unexpected from the original concept.

OUTLINE

SYSTEM DESCRIPTION

CAMERA OPERATION

SPACECRAFT

PERFORMANCE

ALTERNATE CONFIGURATIONS

COSTS AND SCHEDULES

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This sketch shows the overall concept of the spin-scan system.

The satellite is a rectangular box, about 4 feet by 7 feet by 2 feet in size, weighing 1600 pounds at launch. The satellite is placed into a sun-synchronous polar orbit by a refurbished Atlas E/F booster from VAFB -- either at the onset of a crisis [redacted] (b)(1) (b)(3)

If launched when needed for crisis surveillance, the satellite is placed on its operational orbit of 90 x 210 nmi with perigee near noon at the latitude of the crisis area. [redacted] (b)(1) (b)(3)

The satellite is spin-stabilized, with a panoramic camera mounted normal to the spin axis. Photographic operations are programmed and commanded daily through the Satellite Control Facility (SCF). During photography, the spin axis is parallel to the earth's surface to provide an access swath of 180 nmi centered over the crisis area.

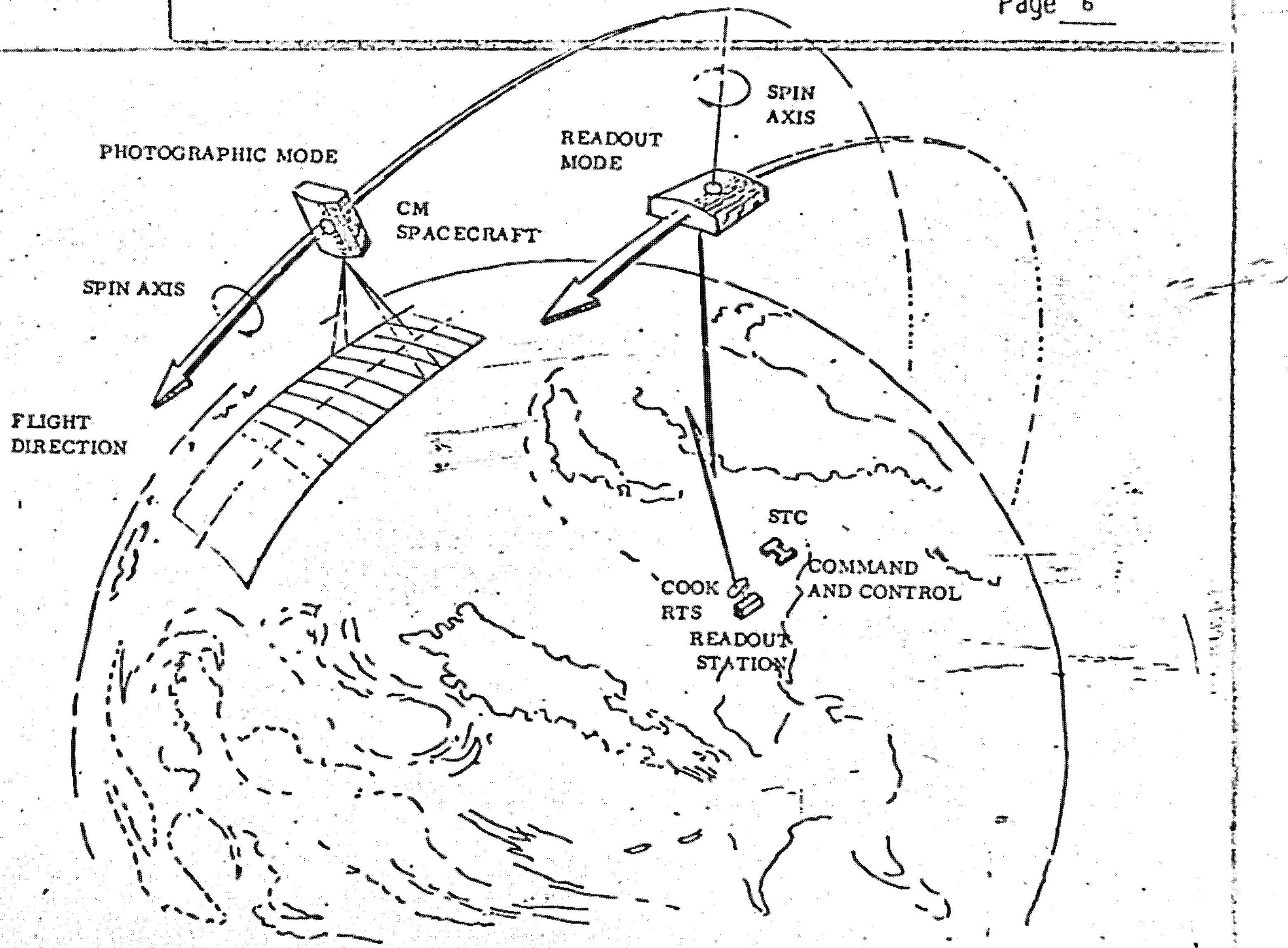
After passage of the satellite over the crisis area, the spin axis of the satellite is pointed toward the sun to provide maximum exposure of solar cells on the broad side of the satellite, as well as to reduce drag by orienting the satellite so that it flies "edge-on" (approximately) at perigee when no photography is to be taken.

The exposed film is developed by a bimat processor on board the satellite as soon as the photo pass is completed, and stored until some minutes or hours later when the satellite is within view of the New Boston, New Hampshire ("Boss") or Vandenberg AFB, California ("Cook") stations of the SCF.

The film is scanned by a laser scanner and the resulting video (76 Mhz bandwidth) is transmitted to the tracking station where the pictures are reconstructed with a laser recorder.

The satellite has expendables to permit about eight weeks' operation during a crisis, even if [redacted]

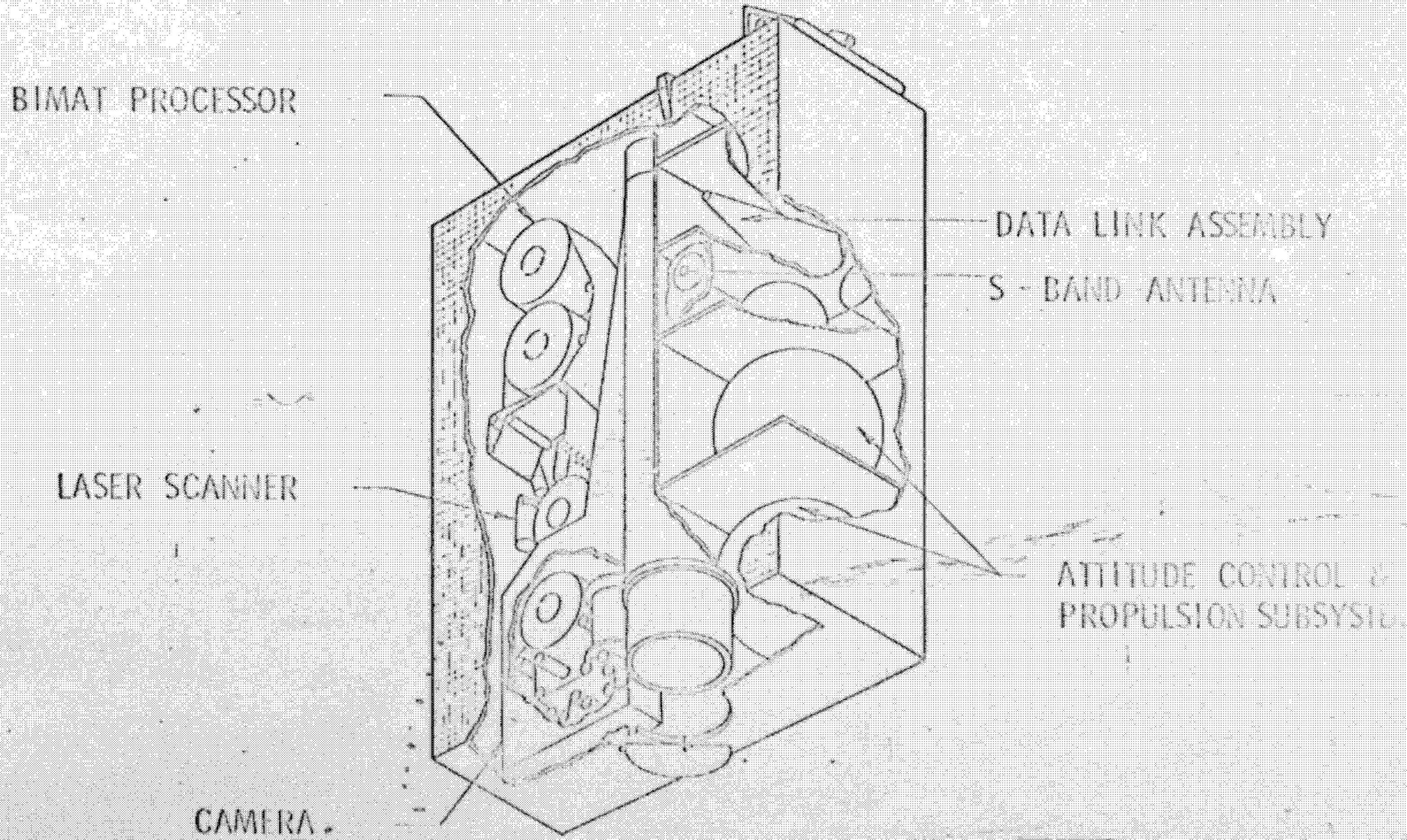
(b)(1)
(b)(3)


SPIN
AXIS
READOUT
MODE
PHOTOGRAPHIC MODE
CM
SPACECRAFT
SPIN AXIS
FLIGHT
DIRECTION
STC
COMMAND
AND CONTROL
COOK
RTS
READOUT
STATION

This sketch shows a conceptual design of the spin-scan satellite. The optics, film handling, and laser scanner occupy about 2/3 of the satellite volume. The remaining portion of the satellite houses attitude control and orbit adjust propellants and the electronics for programmer, TT&C, servos, and for the photographic data link.

The data link to the ground station uses a steerable horn antenna at 12 GC.

SATELLITE CONFIGURATION



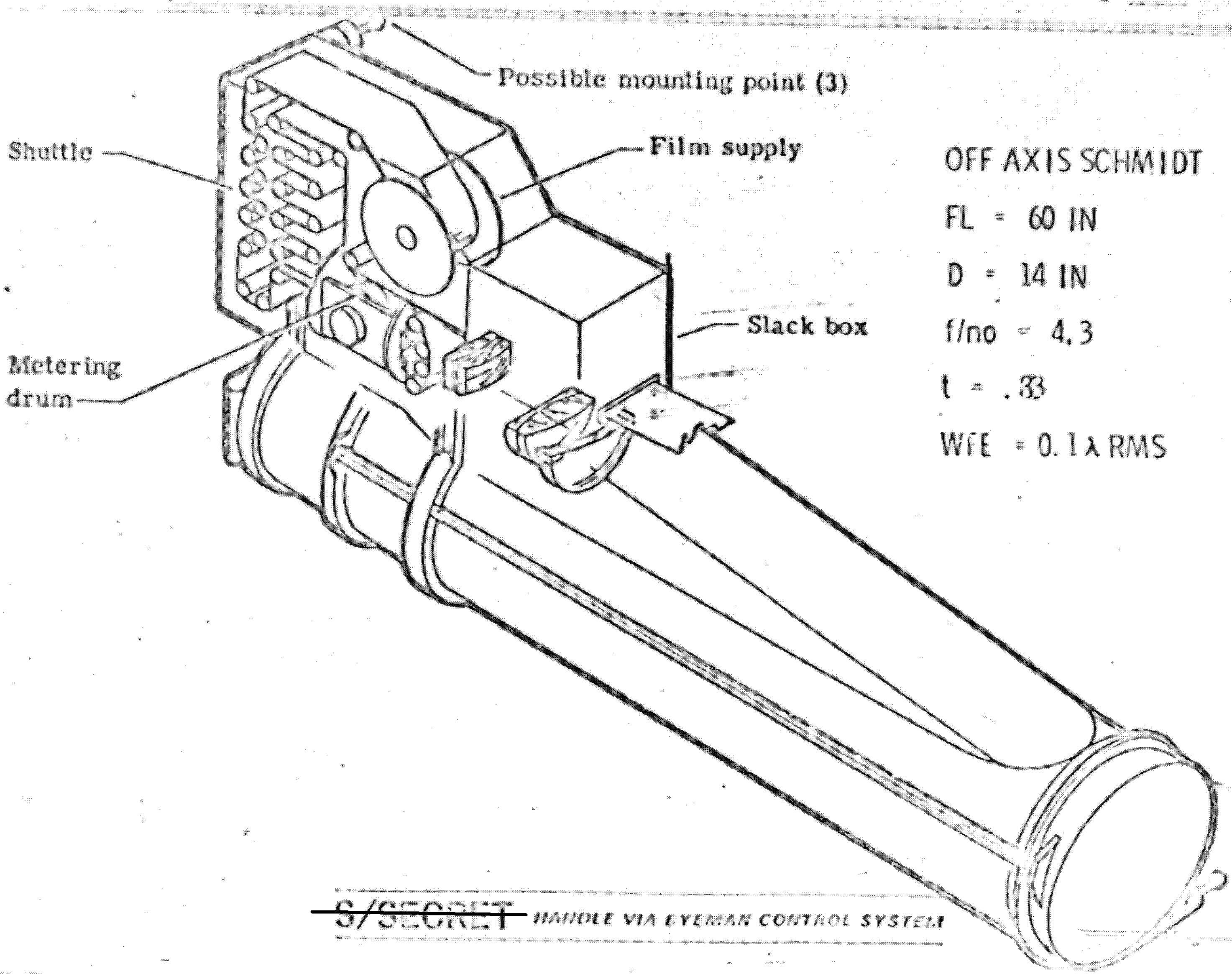
This table summarizes some of the important parameters of the Spin-Scan satellite.

SPACECRAFT FEATURES

SPACECRAFT WEIGHT	1600 LB
LAUNCH VEHICLE	ATLAS E/F
RESOLUTION	2.5/ 3.0 FEET
ORBIT	90 X 210 NMI
OPERATING LIFE	8 WEEKS
OPTICS	60 IN., f/ 4.3
FILM WIDTH	6.6 IN
FILM LENGTH	3,000 FEET
SPIN RATE	29 RPM
DATA LINK--FREQUENCY	12 GHz
BANDWIDTH	(2) 38 MHz
6 IN X 6 IN FRAMES/ MIN	4

This sketch depicts the payload camera. The overall length of the camera is about 6 feet; the subsystem weighs 350 pounds. The next chart shows the details of the camera design somewhat better.

CAMERA SYSTEM CONCEPT



OFF AXIS SCHMIDT

FL = 60 IN

D = 14 IN

f/no = 4.3

t = .33

WfE = 0.1λ RMS

This is a drawing of the payload camera. The optics are of a Schmidt design, except that the length has been substantially shortened by moving the corrector plates closer to the primary.

The prescription is based on the design of a symmetrical Schmidt of about 43-inch aperture and 60-inch focal length. However, this lens uses only a segment of that design, producing a design which is essentially diffraction limited, fully color corrected and is free of any obstruction, which in ordinary reflective lenses causes a loss of modulation. Since Schmidt systems use a perfectly spherical primary, the "segment" of the primary is spherical too, making its fabrication and alignment fairly simple.

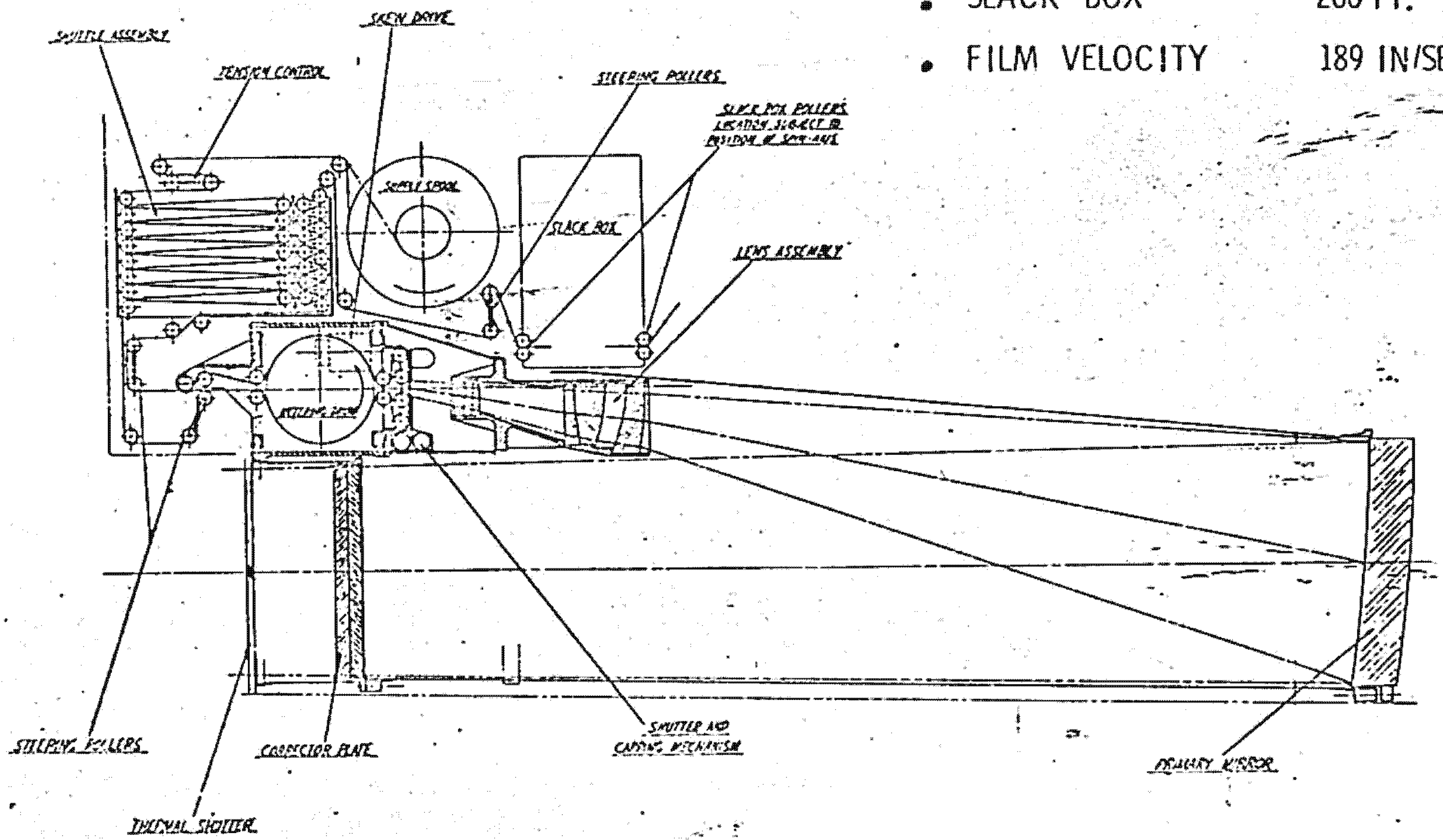
The corrector plates are truly off-axis, however, and must be cut after final polish from full size corrector plates of 43 inches diameter. Similarly the five-element correctors lens assembly is cut from full-size lenses after fabrication. However the alignment of these lenses is also simplified since every surface is spherical. Only the two Schmidt corrector plates must be carefully aligned in six dimensions to obtain the full performance of the system.

The film transport and platen are also shown in this drawing. The shuttle has about 50% more film capacity than that required for a single panoramic exposure from plus to minus 45° in roll. Thus only the shuttle and platen servo must handle film at the 189 inches/second required during exposure; that is, the supply spool and the feed to the slack box operate at slower speeds as required by average film usage over several panning swaths.

In order to conserve film, the film is stopped and reversed between exposures. A metering servo and capping shutter permit successive exposures to be spaced closely, thus also minimizing the time wasted by the laser scanner in reading unused film. The capping shutter is also used to control the length and location of shorter frames. Swath segments as short as 6° can be programmed anywhere in the 90° panoramic scan -- one such segment per scan.

CONFIGURATION STUDY A

- SHUTTLE CAPACITY 140 IN.
- SLACK BOX 200 FT.
- FILM VELOCITY 189 IN/SEC



This chart summarizes the preceding study. It is believed that there is no engineering or technological difficulty in fabricating the recommended optics.

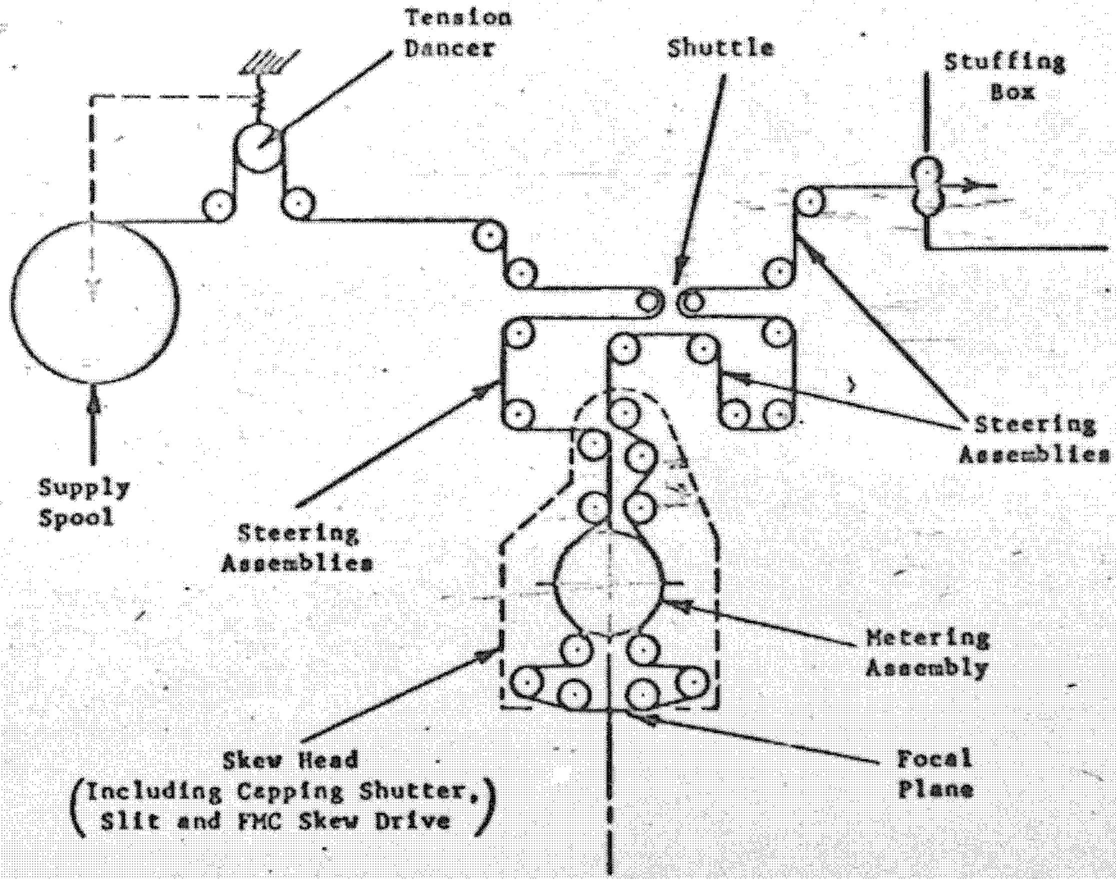
OPTICAL FABRICATION EXPERIENCE

- SYSTEM "CORED" FROM LARGER SYMMETRIC DESIGN; NO NEW FABRICATION TECHNIQUES NECESSARY
- PRIMARY MIRROR AND ALL FIELD CORRECTION LENSES ARE SPHERICAL
- SCHMIDT CORRECTOR PLATES FABRICATION FEASIBILITY PROVEN UP TO 48 INCH DIAMETER
- SCHMIDT PLATE CORING FEASIBILITY PROVEN ON OFF-AXIS PARABOLIC MIRRORS BETTER THAN $\lambda/17$ PEAK TO PEAK

This schematic shows more detail on the camera film handling system.

The primary control of film speed is the metering assembly, which must be controlled in its speed to better than 0.02%. The only other servos involved in film speed are those driving the supply spool, and the pinch rollers into the stuffing box. Both these servos are driven to maintain proper film tension into and out of the shuttle. The shuttle (which actually stores 140" of film) then absorbs the high speed forward and reverse motions of the film during and between exposures.

The entire platen assembly, called the skew head in the figure, must be rotated slightly (about $\pm$0.1 degree motion centered about 0.6 degrees from normal to the film motion). A separate servo provides this slight rotational motion which compensates for the combined effects of the satellite forward motion and earth rotation.



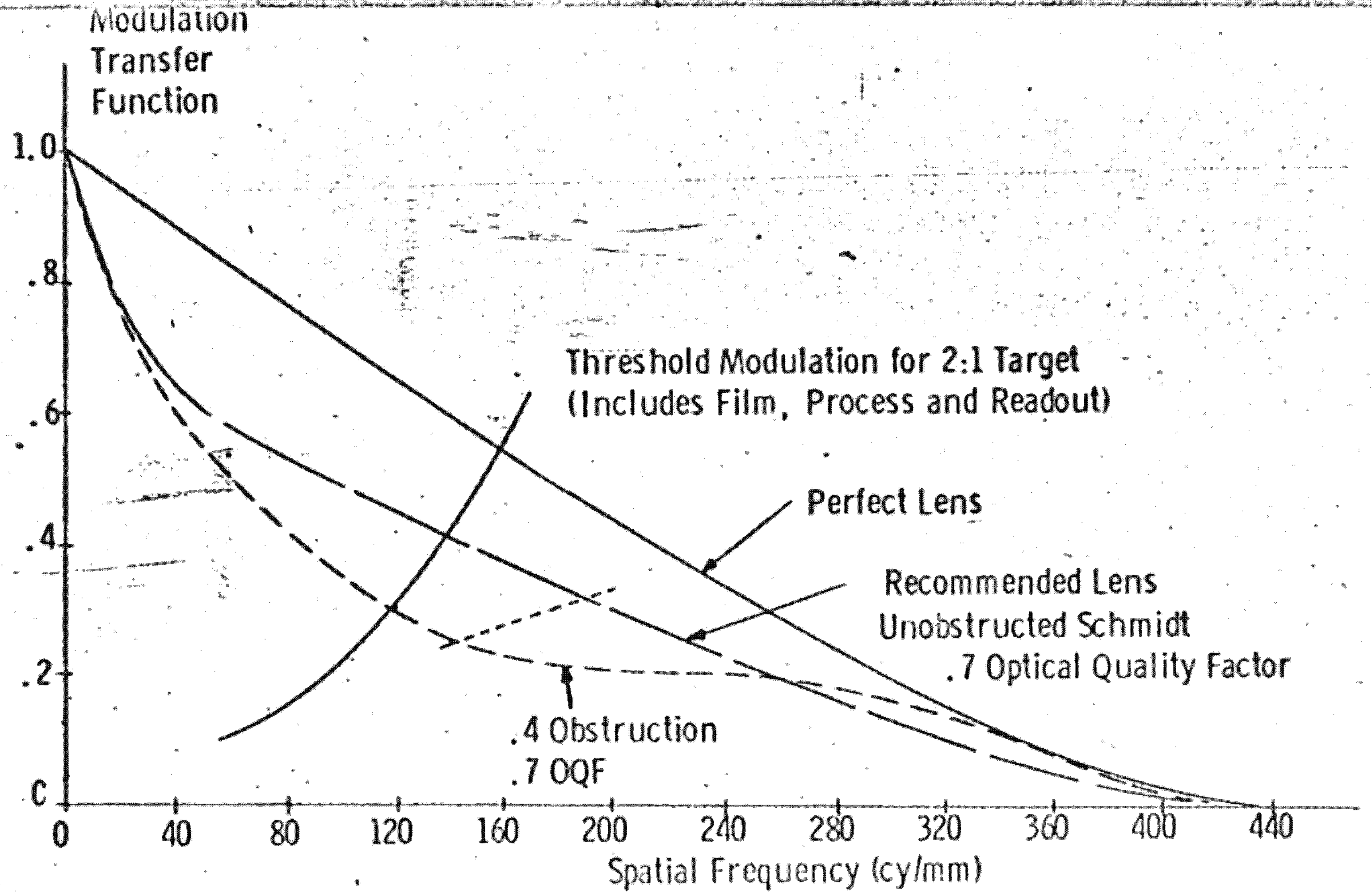
FILM PATH SCHEMATIC

This graph illustrates one of the advantages of the optical system design selected. Shown are the MTF of a perfect unobscured lens, the MTF of the lens design selected (based on an optical quality factor of 70%), and the MTF of a similarly well manufactured lens with a 40% diameter obscuration (such as might be the case if a Ross or other more conventional design were used to cover this large field angle of 6 degrees).

The curves show that there is a substantial advantage to the use of an unobscured aperture in the mid-frequency range which is particularly critical to picture quality. Also the threshold modulation curve for the Spin-Scan system, including readout and losses due to imperfect reconstruction of the picture on the ground is shown for reference. It can be seen that the improvement in resolution is 15 - 20% -- a gain similar to that obtainable if a perfect lens (rather than one with 70% OQF) could be constructed.

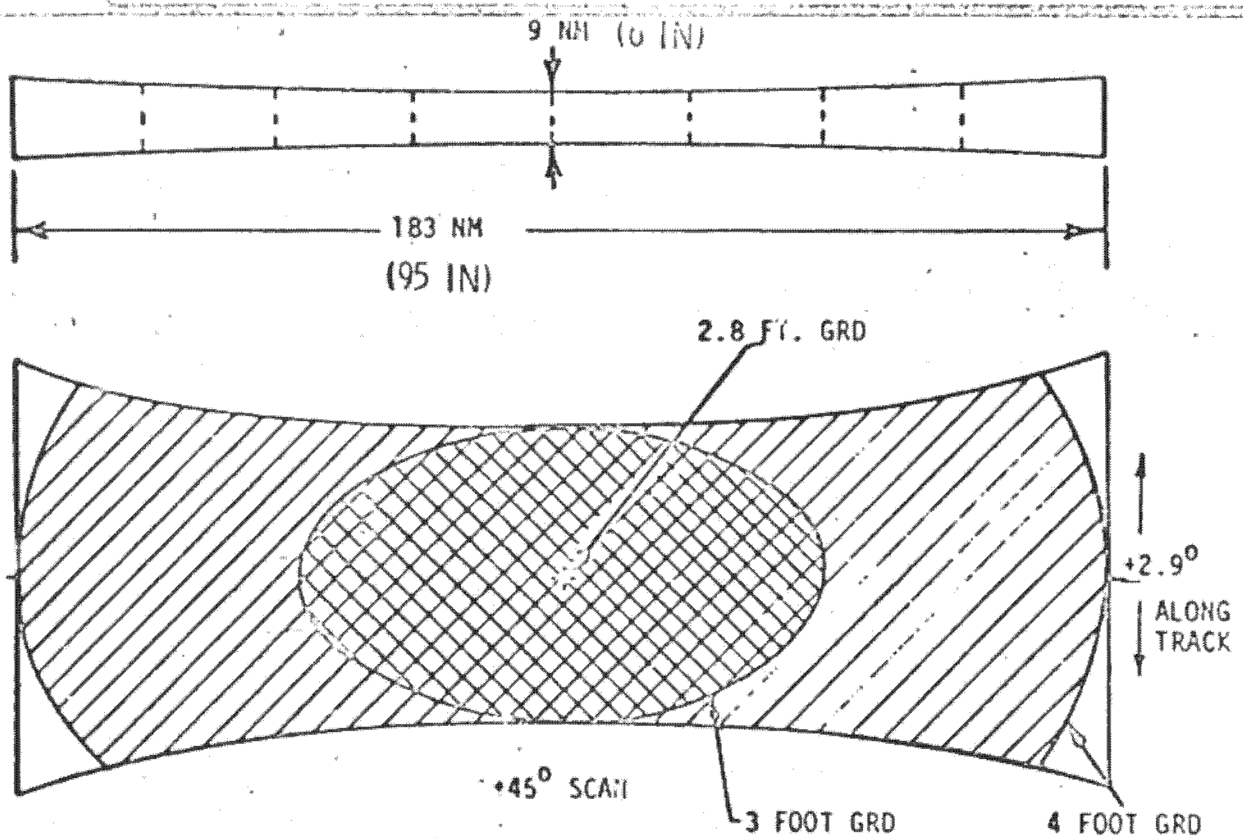
Another advantage of the unobstructed aperture design is the added transmissivity (approximately an additional 15%).

MODULATION TRANSFER FUNCTION ADVANTAGE OF UNOBSTRUCTED DESIGN (f/4.3)



The upper of the two figures on this chart shows the dimensions of a single full panoramic scan. 95" of film are required for a $\pm 45^0$ scan, covering a cross-track distance of 183 n mi at the nominal perigee of 90 n mi. For this camera, the six-inch format of the image provides 9 n mi coverage in-track. The system has been so designed that successive scans will provide about 10% overlap at nadir, and of course almost 50% overlap at 45 degrees obliquity. The lower figure shows the resolution that is available over the entire format. It is clear from this figure that a substantial portion of the overall format will provide better than 3 ft resolution under standard conditions.

GROUND RESOLVED DISTANCE AND COVERAGE



1650 NM² GROUND COVERAGE FROM 90 NM ALTITUDE

The next few charts will discuss the spacecraft configuration briefly. Actually the configuration is to some degree a melding of the designs of the two study contractors; TRW Systems, and General Electric Company. These two independent studies naturally differ in many details, but are surprisingly similar in overall concept.

SPACECRAFT CONFIGURATION

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This sketch shows one way in which the Itek camera can be mounted into a spinning satellite.

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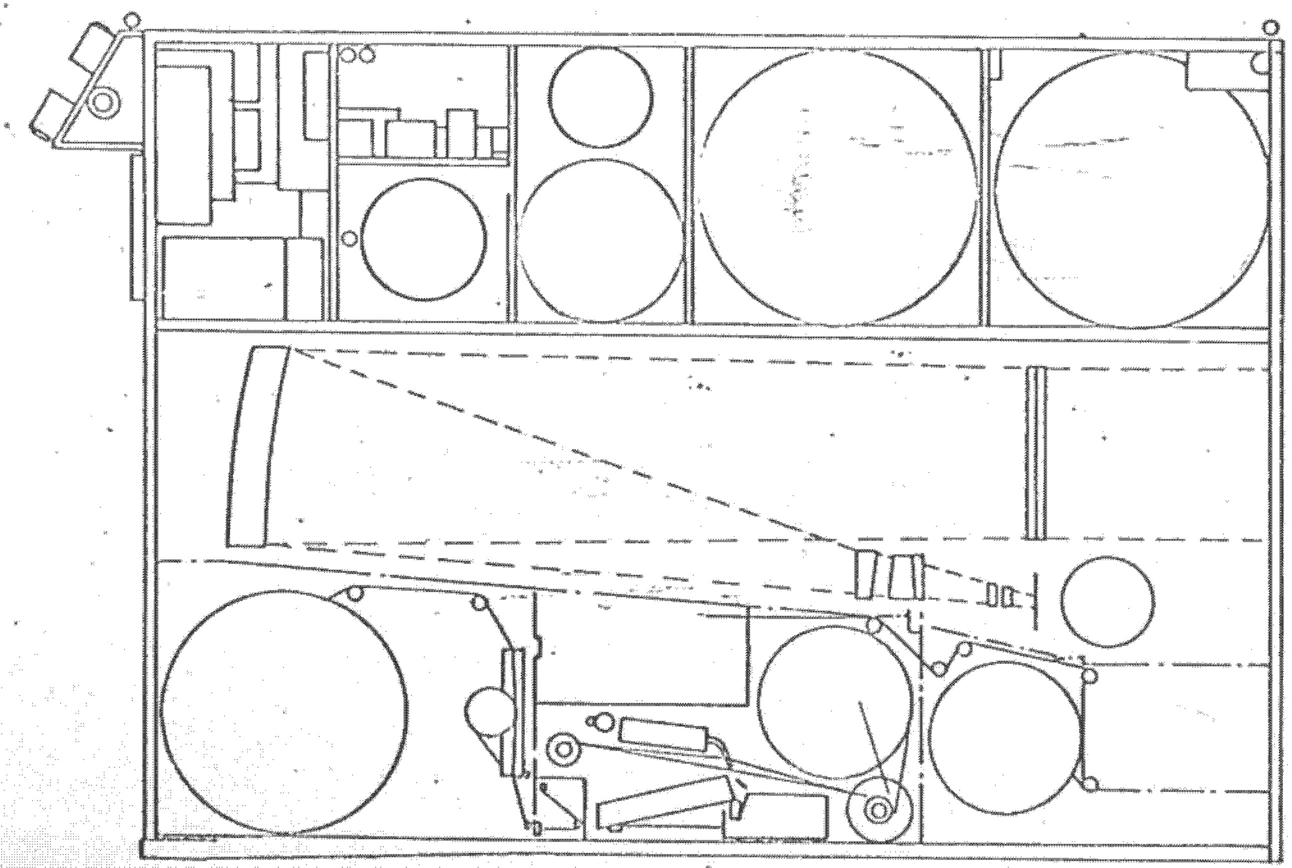

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This figure indicates the locations of the principal components of the attitude control and propulsion subsystems. The two hydrazine fuel tanks are pressurized by nitrogen from a high-pressure tank. A unique feature of this configuration is the location of all rocket thrusters at one corner of the spacecraft. By appropriately timing the pulses, a second set of thrusters (characteristic of most designs) is eliminated.

Other electronics packages are mounted in the remaining volume of the compartment occupied by the attitude control electronics.

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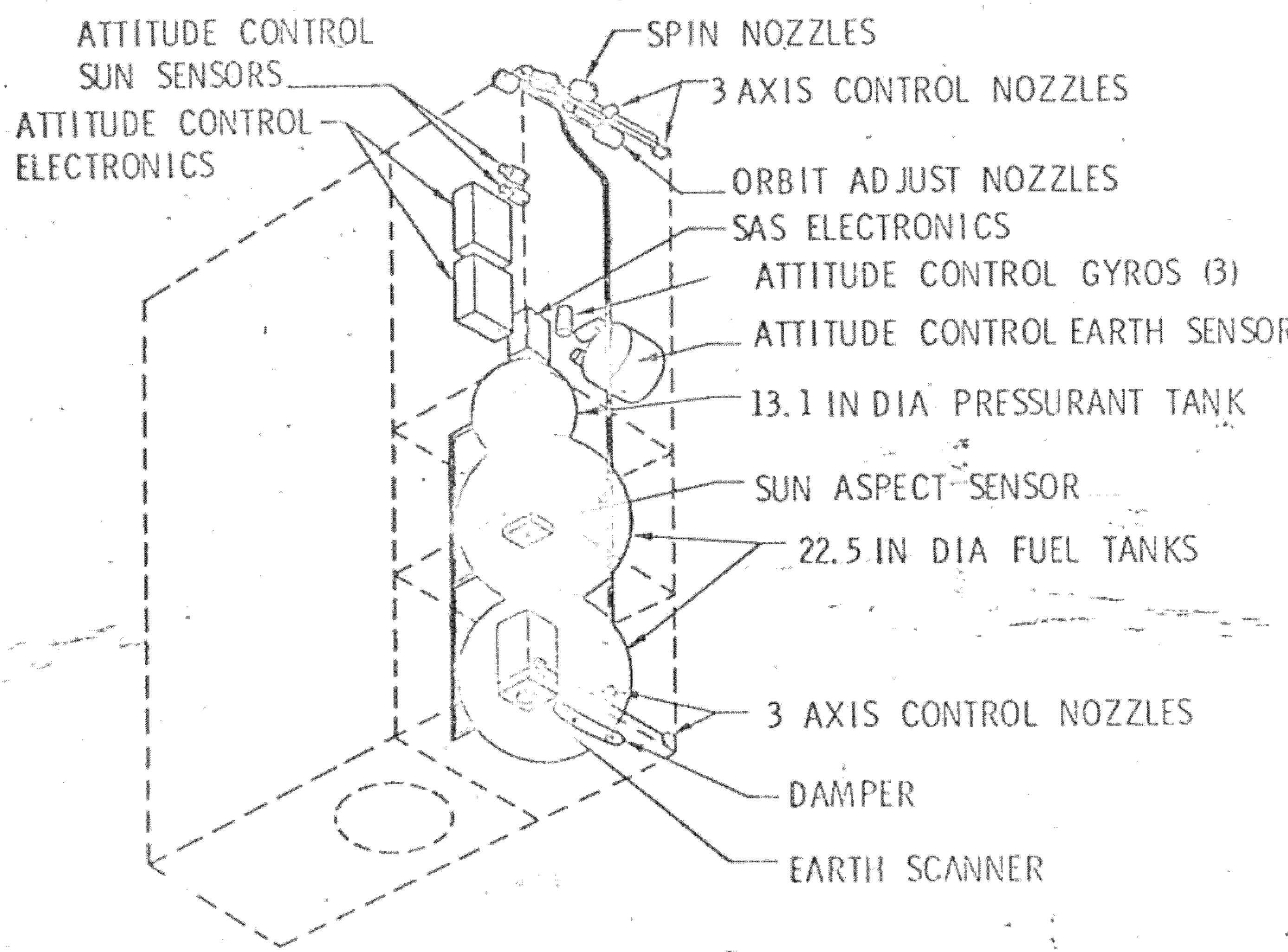
ATTITUDE CONTROL SUN SENSORS
ATTITUDE CONTROL ELECTRONICS
SPIN NOZZLES
3 AXIS CONTROL NOZZLES
ORBIT ADJUST NOZZLES
SAS ELECTRONICS
ATTITUDE CONTROL GYROS (3)
ATTITUDE CONTROL EARTH SENSOR
13.1 IN DIA PRESSURANT TANK
SUN ASPECT SENSOR
22.5 IN DIA FUEL TANKS
3 AXIS CONTROL NOZZLES
DAMPER
EARTH SCANNER

This table shows that attitude must be known very accurately if the ground-commanded film velocity and skew are to produce high quality pictures.

Basic three-dimensional vehicle attitude will be determined by using both sun and earth sensors as reference. Currently available sensors can provide the requisite accuracy.

ATTITUDE CONTROL REQUIREMENTS

ACS PERFORMANCE PARAMETER	MISSION REQUIREMENT	PREDICTED PERFORMANCE
SPIN ANGLE ATTITUDE KNOWLEDGE	0.2 DEGREES	0.036 DEGREES
PITCH ATTITUDE KNOWLEDGE	1.0 DEGREES	0.887 DEGREES
YAW ATTITUDE KNOWLEDGE	1.0 DEGREES	0.887 DEGREES
SPIN RATE KNOWLEDGE	0.02 PERCENT	0.015 PERCENT
MAXIMUM PAYLOAD CONING	0.01 DEGREES	0.01 DEGREES
DISTURBANCE DAMPING TIME	25 MINUTES	14.5 MINUTES
READOUT POINTING ERROR	3 DEGREES	3 DEGREES

This table lists a number of contributors to smear which must be carefully controlled. Both contractors have shown subsystem designs which should be able to provide the close controls which are necessary.

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RANDOM SMEAR BUDGET
2 σ CENTER OF FORMAT (μ RAD/SEC)

IN-TRACK

SKEW ANGLE SERVO (0.2 MIN)	174
INITIAL ALIGNMENT (0.2 MIN)	174
ROLLER AXIAL RUNOUT	67
VIBRATION	100
EARTH CURVATURE	585
SKEW ANGLE COMMAND	316
ALTITUDE KNOWLEDGE (0.2 NM)	100
TERRAIN VARIATION (0.5 NM)	250
SPIN AXIS ALIGNMENT (0.5 MIN)	[redacted]
ROLL ATTITUDE KNOWLEDGE (0.2°)	125
YAW ATTITUDE KNOWLEDGE (1°)	208
PITCH (NUTATION) RATE (θ_M 0.01°)	[redacted]
TOTAL RSS	1,150

CROSS-TRACK

CAPSTAN SERVO ERROR (0.02%)	[redacted]
CAPSTAN THERMAL (± 2°F)	50
CAPSTAN RUNOUT	20
CAPSTAN MEASUREMENT	20
FILM THICKNESS VARIATION (0.2 MIL)	151
CREEP VELOCITY	50
ROLLER RUNOUT	352
FOCAL LENGTH MEASUREMENT (0.008%)	282
VIBRATION	200
SPEED COMMAND	100
MODULATION COMMAND	27
OPTICAL AXIS DISPLACEMENT	27
SPIN KNOWLEDGE (0.02%)	[redacted]
PITCH ATTITUDE KNOWLEDGE (1°)	[redacted]
YAW ATTITUDE KNOWLEDGE (1°)	[redacted]
TOTAL RSS	1,318

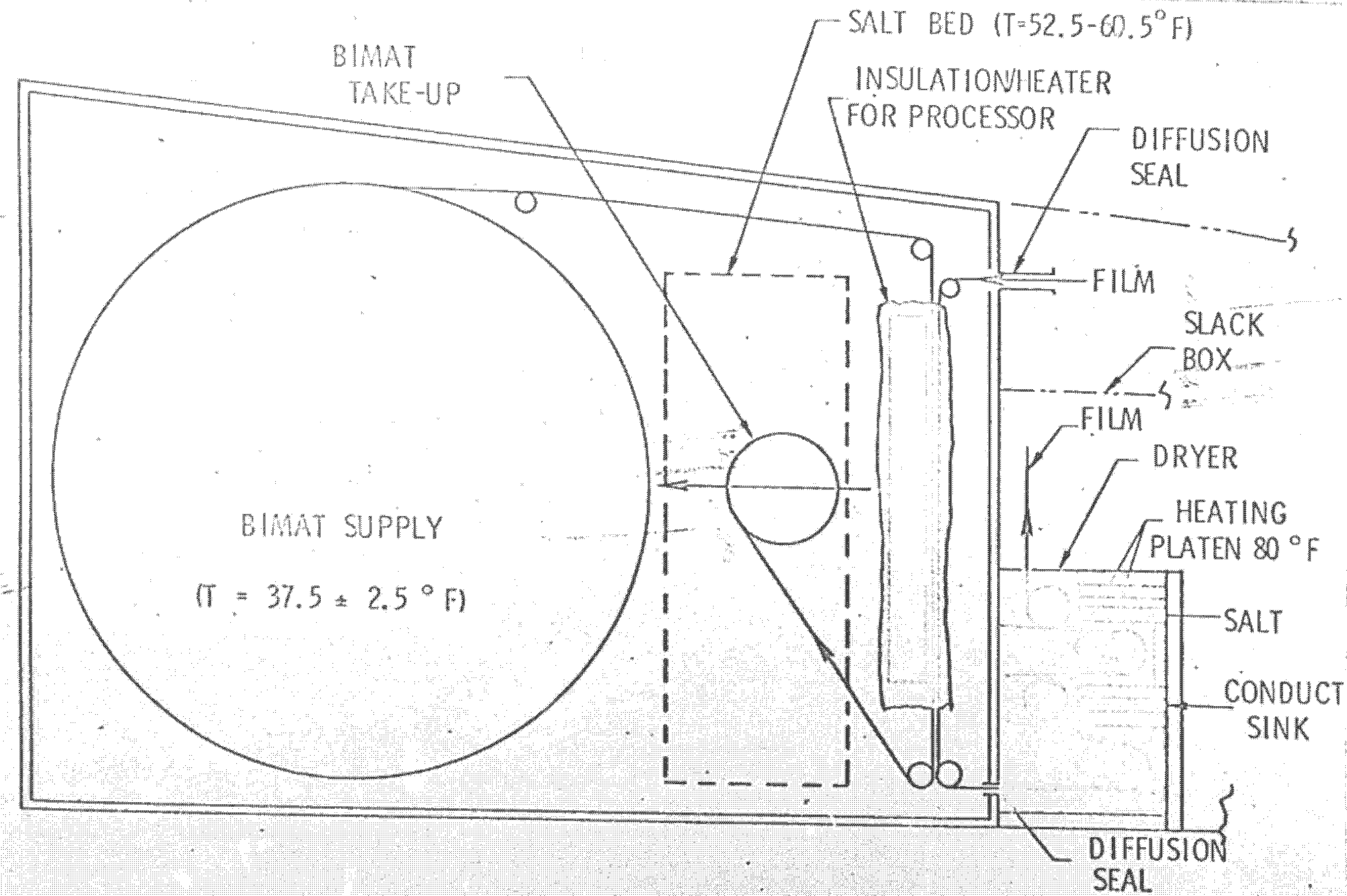
This sketch illustrates one way in which Bimat can be stored and used.

As indicated on the sketch, Bimat can be stored for months or years at a temperature of about 37 degrees Fahrenheit, in an atmosphere of saturated water vapor. On the other hand, the film must be about 70 degrees F to be developed properly.

In the concept shown, the exposed film is introduced into the Bimat storage box through a vapor seal to prevent loss of water vapor. The film and Bimat are pressed together, and heated to 70 degrees electrically. The film is moving continuously, but slowly, and is developed to completion by the Bimat process. The film is then separated, led out of the box, and thoroughly dried by further heating in an enclosed space with dessicant also present. The Bimat meanwhile is simply wrapped up and stored, being of no further use.

A concept similar to this has also been developed at Eastman Kodak.

BIMAT PROCESSOR



This chart suggests that there has been considerable experience in the use of Bimat, both in space (for lunar orbiter) and in various military programs on the ground. In addition Eastman Kodak Company has successfully demonstrated storage of Bimat in the cold wet environment indicated, for periods of a year or more.

BIMAT PROCESS

EXPERIENCE	OVER 10 YEARS
KEEPING QUALITY	EK 18 - 24 MONTHS DEMONSTRATED
CHEMISTRY	ESTABLISHED
RESULTS	RELIABLY REPEATABLE
SPACE TESTED	LUNAR ORBITER
FIELD TESTED	AIR FORCE / SIGNAL CORPS / ARMY
HUMIDITY AND TEMPERATURE CONTROL	STATE-OF-THE-ART
HARDWARE	MARK SYSTEMS

This sketch illustrates the design of the laser scanner for the film.

The helium-neon laser emits monochromatic red light, in an extremely well-collimated beam. This light beam is expanded, and then focused on the film by a lens as shown. The light from the lens is reflected from a rotating 12-faceted prism, so that the focused spot of light moves across the film as the prism is rotated. The film is curved very precisely so that the spot of light stays in focus as it traverses the film.

Actually the lens and rotating prism are so designed that two facets are reflecting light simultaneously; thus two separate spots will be moving across the film. By providing two light pipes behind the film, the film is essentially split in half optically. One of the two laser spots will in general be illuminating each of the two light pipes. The actual amount of light gathered by one light pipe, and thereupon converted to an electronic video signal by the photomultiplier tube associated with that light pipe, is of course proportional to the density of the film at the focused laser spot. The film moves slowly past the scanning light beam. A resolution of better than 200 line pairs per millimeter for this process has been demonstrated by CBS Laboratories, Inc.

Using the spinner speed shown, the output video signal from each of the photomultiplier tubes has an information bandwidth of 38 MHz. The dual-channel scanner can read about two feet of six-inch film per minute at the necessary resolution.

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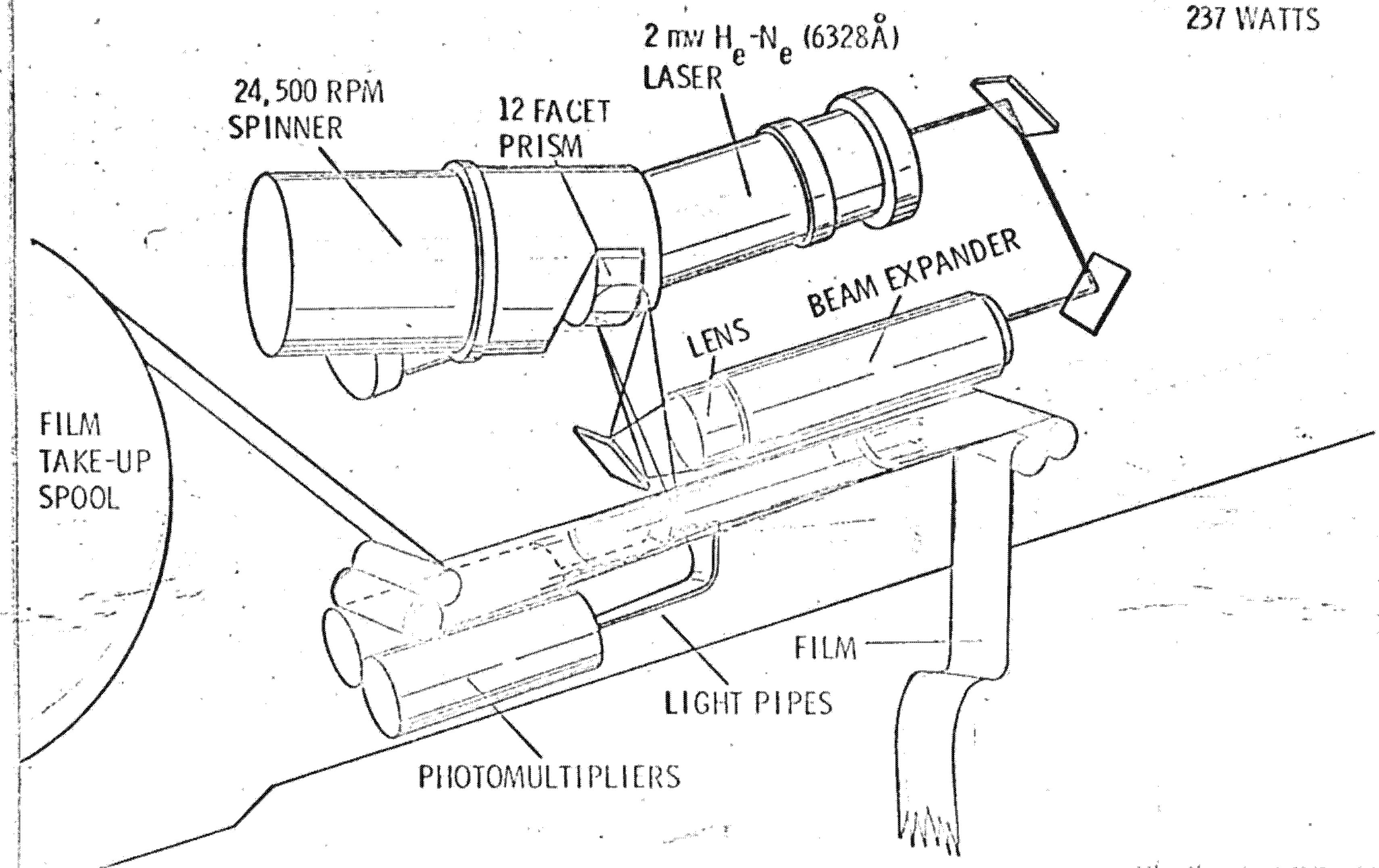
LASER SCANNER CONFIGURATION

57 LB
237 WATTS



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Handle via BYEMAN
Control System Only

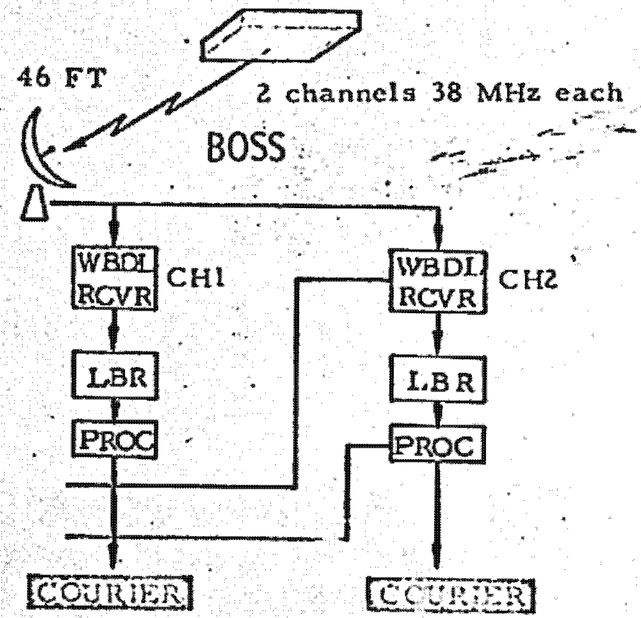
This chart suggests the very simple modifications to the Boss and Cook Tracking Stations at New Boston, New Hampshire, and at Vandenberg Air Force Base, California, respectively. This modification consists essentially of adding a feed to receive the 12 GHz signal on existing 46-foot parabolic antennas at each of the stations. Ground laser recorders must then be provided to reconstruct the pictures. It is intended that each of the video signals be recorded on a separate recorder at 2X scale to minimize further degradation of the picture by film grain on the recording film.

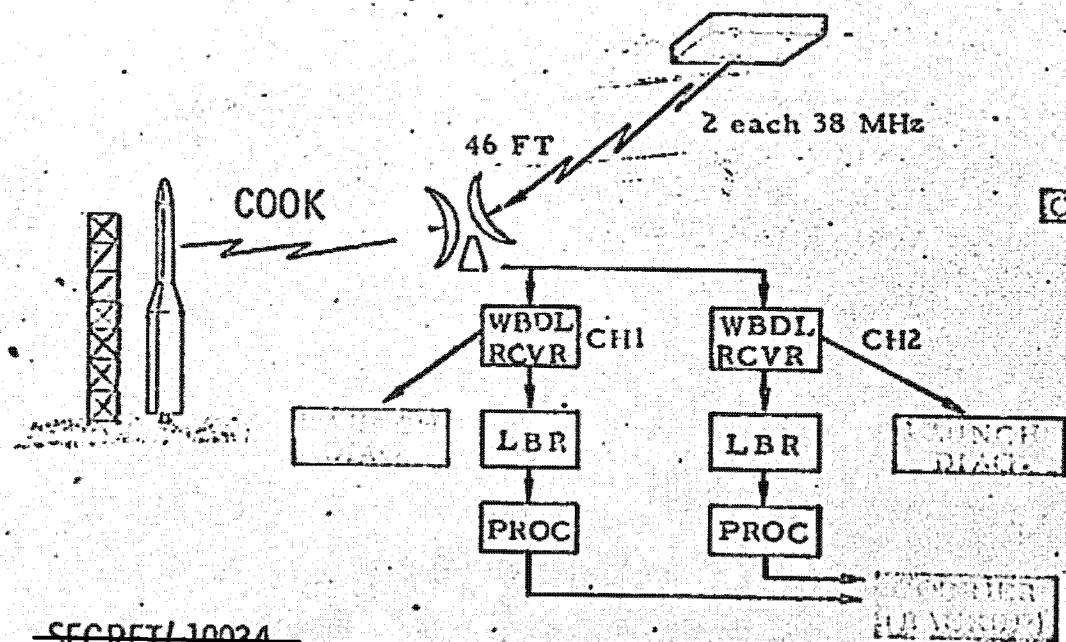
Cook has been chosen as one of the two stations to be implemented with readout equipment in order that this same equipment can be used for pad checkout of the Spin Scan Satellite before launch. The reconstructed photography will then be transported by courier to Washington.

The diagram does not show the TT&C concept, since that is the standard SCF SGLS equipment, operated in its usual way. Any of the six SCF ground stations will be able to provide telemetry, tracking, and command for this satellite.

DIFFERENCE BETWEEN A-7X AND K-9

- BANDWIDTH: 40 MHZ VS 38 MHZ
- CARRIER / NOISE 34 DB VS 24 DB
- FIXED BANDWIDTH FOR K-9





Handle via BYEMAN
control system only

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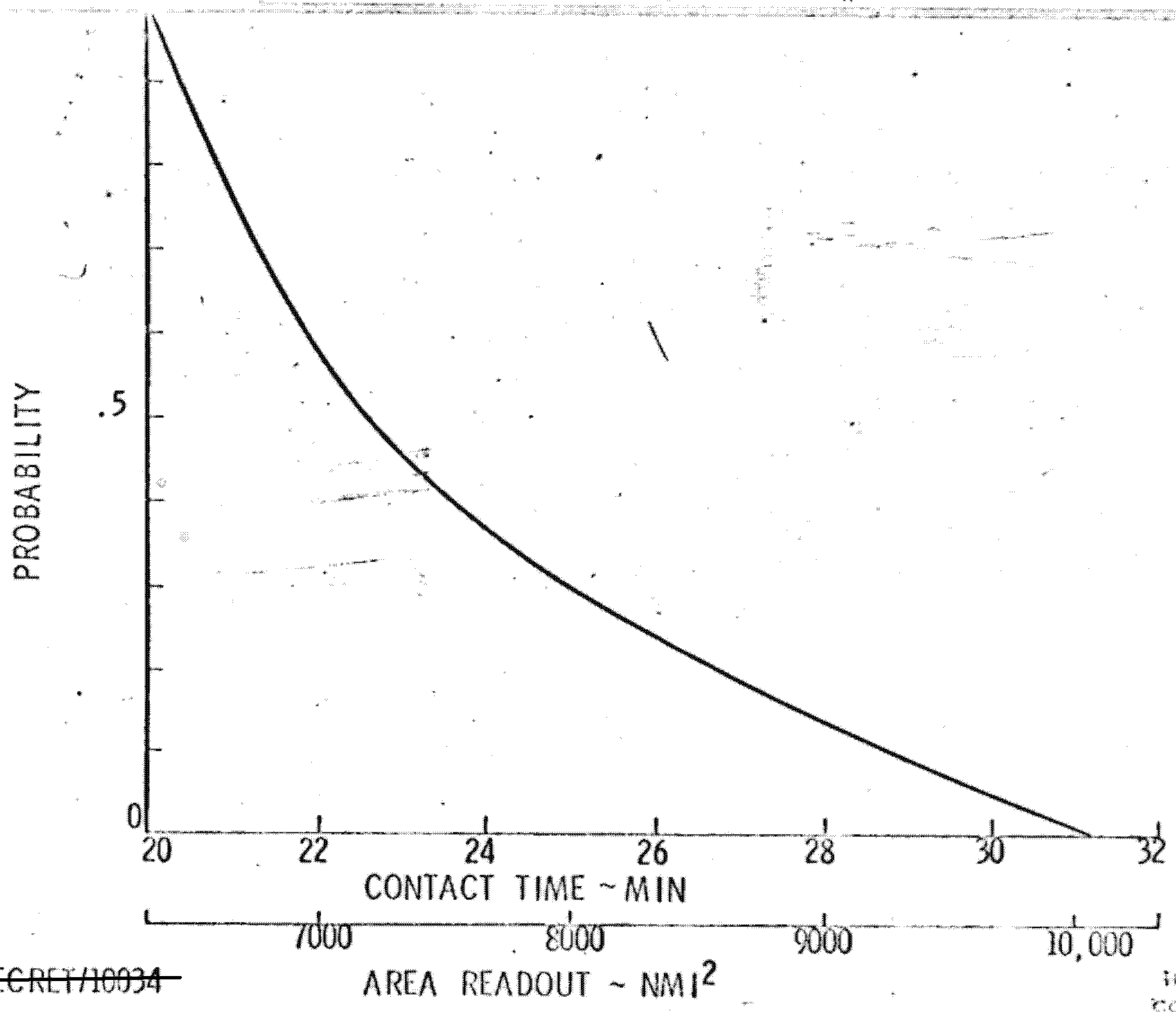
The Spin Scan Satellite is required to read out at least 4,000 square nautical miles per day. This much area can be read out in about 13 minutes of station contact time, with the two data links described previously.

This chart shows that the use of Cook and Boss will together provide at least 20 minutes of readout time per day; on those days for which the orbit phasing is advantageous, over thirty minutes are available. This suggests that on many occasions the Boss Station can read out the entire daily take, with the short delivery time implied by proximity of Boss to the Washington, D. C. area. Alternatively, 8,000 to 10,000 square n mi of area can be read out if the station pass times are favorable; even in the most unfavorable relationship between ground traces and station locations, over 6,000 square n mi per day can be read out if the priority of targets justifies use of film at this higher rate.

STATION CONTACT TIME
(VTS + NHS, 24 HRS)



This chart shows current weight estimates for the principal subsystems. It is interesting to note that over 25% of the weight of the spacecraft is hydrazine. This results from the desire to sustain a highly elliptical orbit with low perigee of 90 n mi for eight weeks, in addition [redacted] (b)(1) (b)(3)

The system can alternately be used for discrete targeting at somewhat poorer resolution by operating at a higher altitude (where the drag make-up penalty for taking photographs on many orbits per day is within the hydrazine allowance).

WEIGHT SUMMARY

CAMERA	298 LB
PROCESSOR/ SCANNER	170
ATTITUDE CONTROL	30
PROPULSION	104
PROPELLANT	425
ELECTRICAL POWER	181
TT&C	51
STRUCTURE	210
ORBITAL WEIGHT	1,469
CONTINGENCY	126
TOTAL	1,595 LB

The refurbished Atlas E/ F booster has been tentatively selected for placing the Spin Scan Satellite into its initial orbit of 100 x 100 n mi. Since the satellite weights 1600 pounds, the graph shows that there is a restricted range of orbit inclinations which are available using this booster.

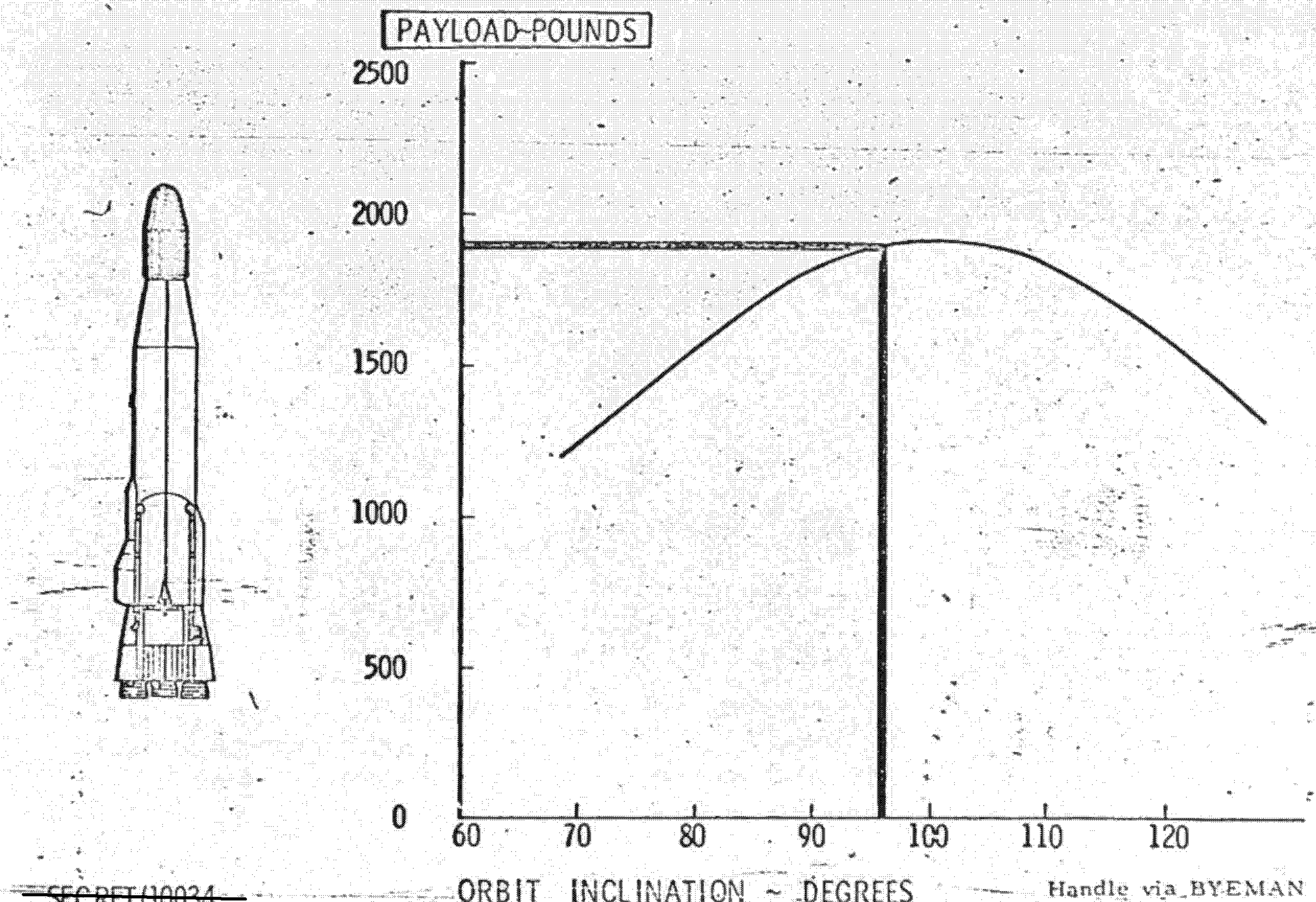
The rather surprising reduction in payload capability for this booster for posigrade orbits results from a range safety restriction at VAFB which requires a dog-leg maneuver for all launch azimuths less than 202.5 degrees.

The Atlas booster will be launched from launch complex BMRS-A, which is equipped with operational AGE. This hardware permits an indefinite hold (up to at least 6 months) for the booster at T-2 hours. In this state the booster is dry, but pressurized. Programmer, gyros, batteries, and pyrotechnics are not installed. The gantry is around the missile. Thus a very rapid response to the launch-on-demand concept is possible. The major limitation to quick launches is probably the range safety problem in controlling traffic, trains, and ships at sea.

At T-2 hours, the Atlas would be readied for launch by installing all the missing hardware. The guidance site would load in the appropriate roll program for the selected launch azimuth; the pitch program need not be changed. The radio guidance system -- GERTS -- would have to have constants for its targeting software computed at the base for such a short response time. However, the GERTS computer has the necessary capacity, and it could be programmed for this task.

The reliability of the Atlas E/ F is about 90% now; 34 out of a total of 38 refurbished Atlases have functioned properly since 1966. If near-100% reliability is desired, with essentially doubled payload capacity, the SLV-3A Atlas should be selected at about $3.5M extra per launch.

ATLAS E/F LAUNCH



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The next few charts summarize the capability of the proposed Spin Scan Satellite.

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This table lists some of the important characteristics of the concept.

PERFORMANCE AT 90 NMI

RESOLUTION	< 3 FT TO 25° OBLIQUITY
	< 4 FT TO 45° OBLIQUITY
ACCESS SWATH	183 NMI
CONTIGUOUS SCANS	9 NMI
TOTAL AREA (1 REV)	> 6500 NMI^2
TOTAL FILM LOAD	3000 FT (530,000 NMI^2 ; 15% WASTE)
FIRST PICTURES	24 TO 48 HOURS
OPERATING LIFE	~ 8 WEEKS

[redacted]

(b)(1)
(b)(3)

This chart presents the predicted resolution for the Spin Scan System operating at 90 n mi. To obtain the data used to prepare this chart a Monte Carlo analysis was performed varying all system and operational parameters of significance. The prediction is general in the sense that it is intended to include possible crises that may occur between 20^0 and 50^0N latitude [redacted] (b)(1) (b)(3) For a particular crisis, say the seven-day war, the lighting conditions would be far more favorable than the average assumed here, and the distributed performance curves would be considerably more favorable. Typical resolution for such a situation can be estimated from these curves by considering the lower portions of the distributions. The curve labelled "Distributed Roll" is simply a composite of all of the cases shown in the other three curves. Target contrast was held fixed in this analysis at 3:1. The atmospheric haze was accounted for by the use of the Aerospace Photometric Atmosphere Model which attenuated target contrast to about 2:1 in the best case to below 1.2:1, with an average of approximately 1.6:1. All system transfer functions, gain terms, and noise effects of significance were modelled and accounted for. The film, Bimat processing, laser scanner readout, data link, and reconstruction are accounted for by the Pierson Threshold Modulation Model which is consistent with the most pessimistic contractor estimates. Note that the median value on the distributed roll case is 38 inches and the best point occurs at 31 inches.

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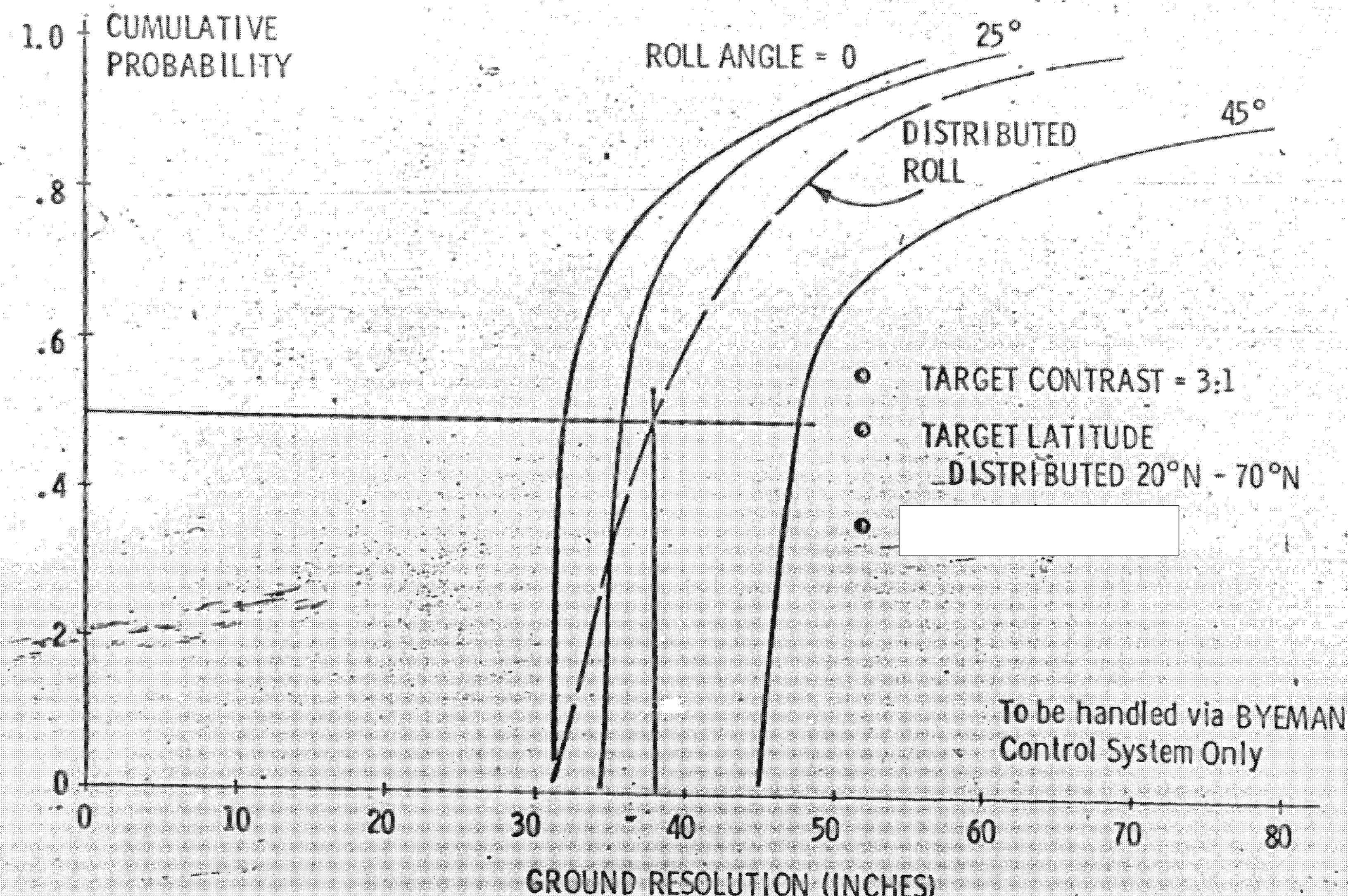
GROUND RESOLUTION

90 N MI



(b)(1)
(b)(3)

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The satellite carries 425 pounds of propellant to give the operator a wide range of flexibility in performing the crisis reconnaissance functions. Propellant utilization and orbital velocity requirements for various orbital maneuvers are listed in the table.

The Atlas injects the satellite into a 100 x 100 n mi circular orbit. [redacted] If he transfers directly to the operating orbit (90 x 210 n mi), 42 pounds of propellant are required. [redacted] (b)(1) (b)(3)

Spin/despin and precessing (reorienting) the spin axis consume about 37 pounds of propellant per month in the operating orbit.

[redacted] (b)(1) (b)(3)

[redacted] the ground trace shifts west 0.5 degrees/rev relative to the Q = 16 (repeating ground trace) orbit. An immediate transfer to a 300 x 300 n mi orbit, will shift the trace westward at 1.0 degree/rev relative to [redacted] Alternatively, a transfer to a 100 x 100 n mi orbit shifts the trace eastward at 1.0 degree/rev relative [redacted] The logic selected for the trace shift is a function of both the distance of the shift and the time available to perform the maneuver. (b)(1) (b)(3) (b)(1) (b)(3)

PROPELLANT USE

	FT/ SEC	LB
ORBIT TRANSFER:		
[redacted]	360	70
INJECTION [redacted] OPERATION (90 X 210)	215	42
DRAG MAKEUP (PER MONTH)	833	163
TRACK SHIFT AT 30° N, FOR EACH REV:		
BY DELAYING ORBIT TRANSFER (27 NMI WEST)	0	0
BY TRANSFERRING TO 300 X 300 (52 NMI WEST)	720	140
BY TRANSFERRING TO 100 X 100 (52 NMI EAST)	360	70
SPIN/ DESPIN AND PRECESS (PER MONTH)	-	37
TOTAL AVAILABLE		425

(b)(1)
(b)(3)
(b)(1)
(b)(3)

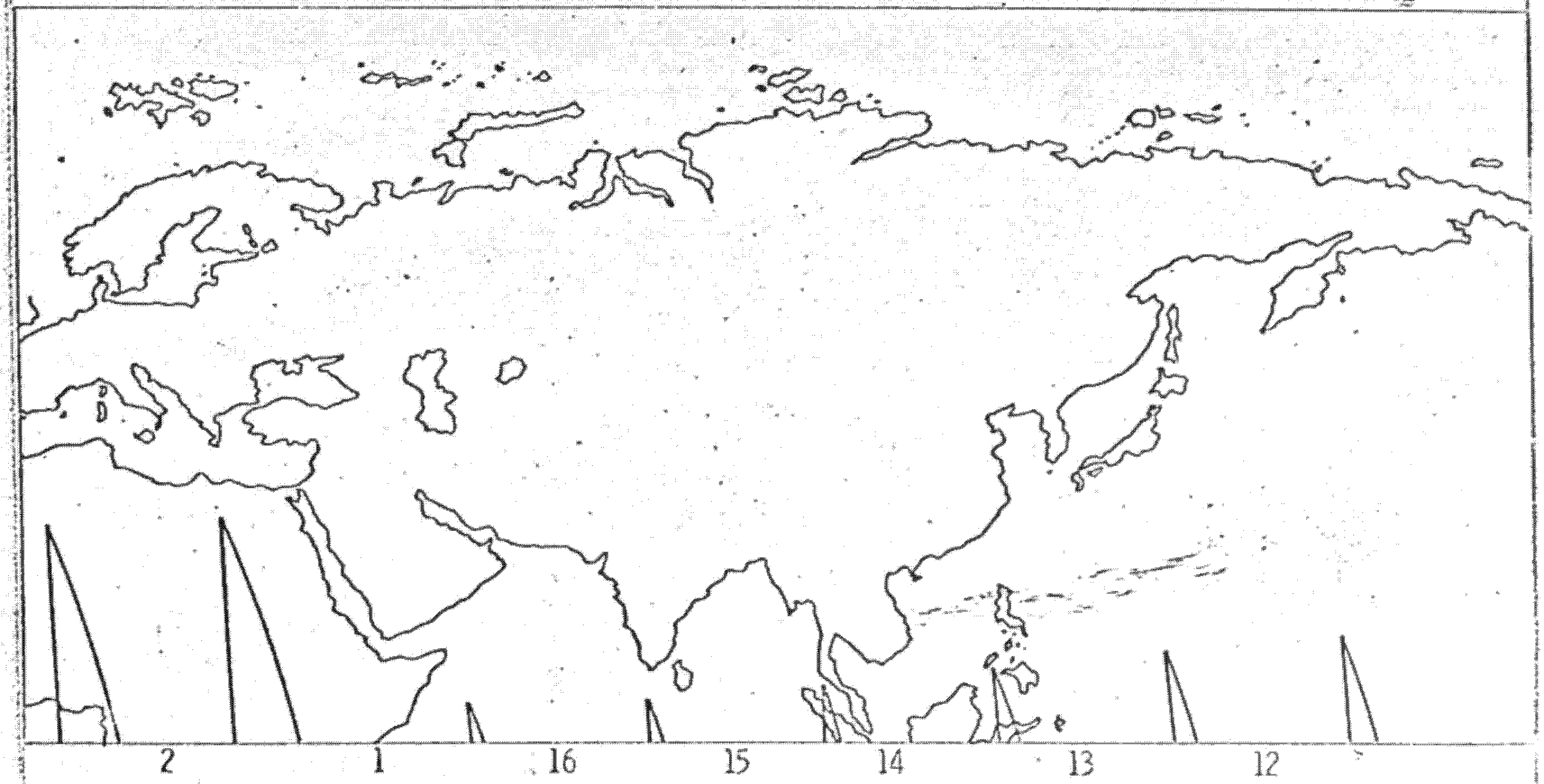
The figure illustrates that all of Asia and Europe--and nearly all of Africa-- is accessible to the Spin Scan Satellite during its first day of operation. Only the small triangular areas cannot be seen during the first day; however, they are accessible on the second day, if desired.

In preparing this illustration, it is assumed that the satellite will cross the area from south-to-north (near midnight launches from WTR). A range of inclinations--89.5^{0} to 103.9^{0}--is permissible since the sun angle can be maintained above 30^{0} throughout the eight-week period. This accounts for most of the longitudinal coverage flexibility. Added capability in shifting the ground trace is obtained by permitting the orbit Q to vary between 16.0 (90 x 210 n mi) and 16.4 (100 x 100 n mi). Q is defined as the number of orbits per day.

SAFSP

INACCESSIBLE AREAS DURING FIRST DAY (NORTHBOUND CROSSINGS)

- INCLINATION RANGE: 89.5° TO 103.9°
- Q RANGE: 16.0 TO 16.4



This figure was prepared using data similar to that for the previous figure. The only difference is this figure illustrates the first day accessibility of the area to the Spin Scan Satellite with north-to-south crossings (corresponding to near noon launches from WTR).

Combining data from the two charts indicates only two small areas in North Central Africa are inaccessible under these conditions during the first day.

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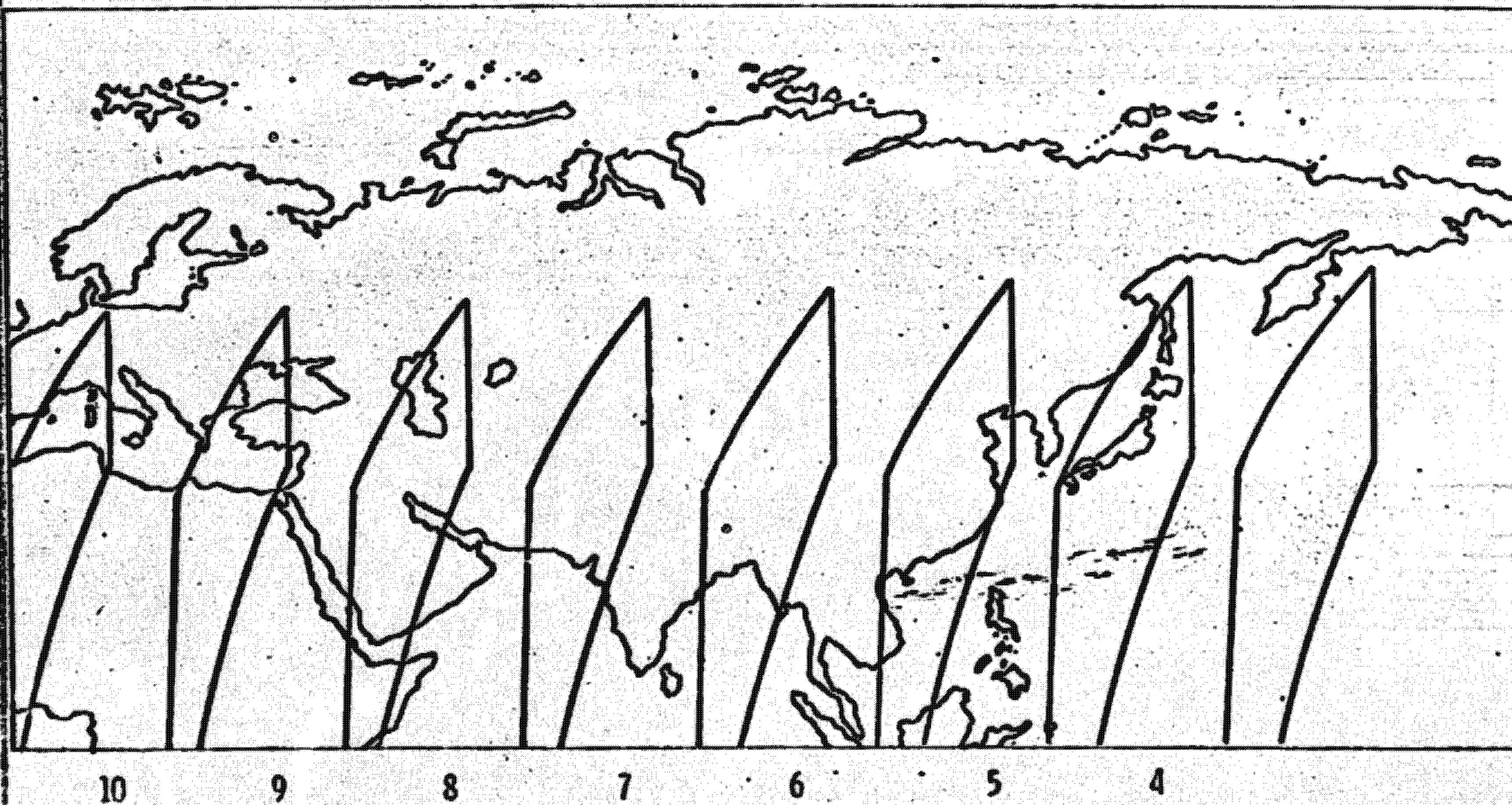
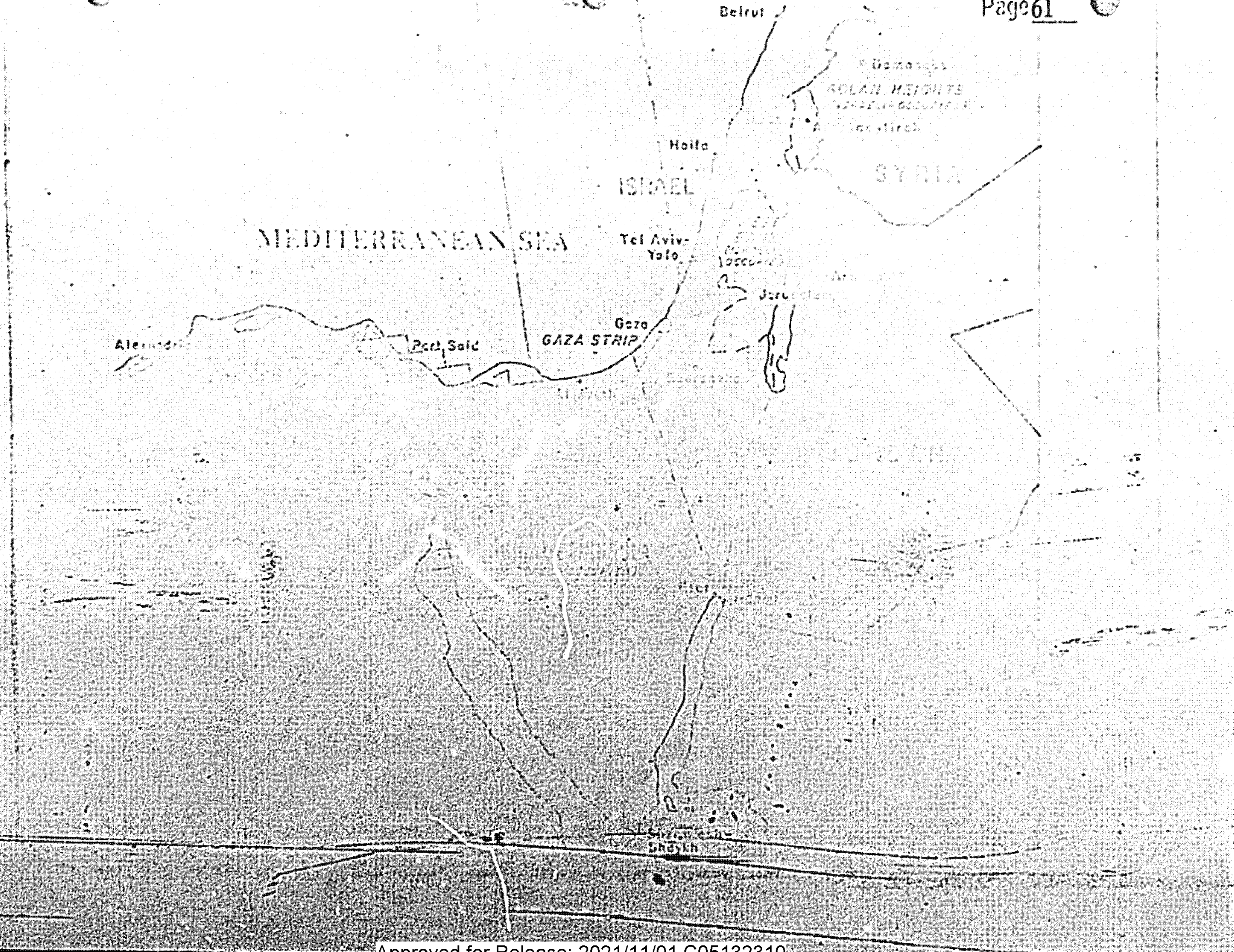
INACCESSIBLE AREAS DURING FIRST DAY (SOUTHBOUND CROSSINGS)

- INCLINATION RANGE: 89.5° TO 103.9°
- Q RANGE: 16.0 TO 16.4



The capability of the Spin Scan Satellite to cover local crisis areas is indicated on this map of the Middle East. Coverage of the complete Suez cease-fire area on one pass is possible. On a subsequent day, the Israel/Jordan border areas could be covered by allowing the ground trace to shift. The area coverage illustrated is 6500 n mi^2 for each pass.



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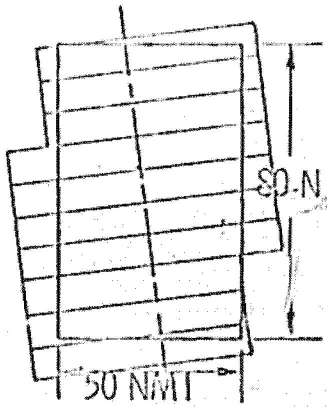
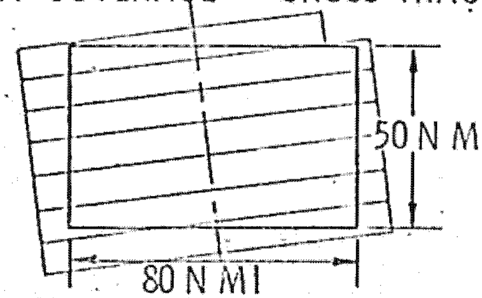
The satellite may be required to work against a variety of collection problems, such as these on the figure. The crisis area may be compact (top figures) and may have the long dimension oriented along-track or cross-track. Alternatively, the crisis may involve photographing communication lines (roads) or point installations scattered throughout a crisis area. It can be seen that the Spin Scan Satellite is quite effective in all of these four cases.

AREA COVERAGE - IN-TRACK

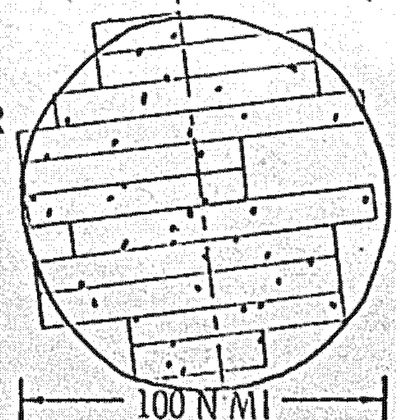


AREA COVERAGE - CROSS-TRACK

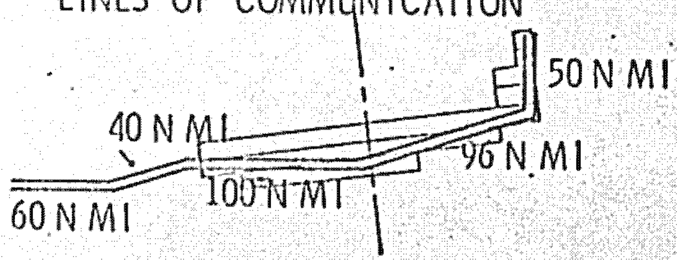


INSTALLATIONS

40 POINTS FROM RANDOM NUMBER TABLE



LINES OF COMMUNICATION



During the Spin Scan Studies, a number of alternate satellite configurations were examined.

ALTERNATE CONFIGURATIONS

Characteristics of the baseline configuration were discussed earlier in the presentation, but are repeated here to indicate differences between the baseline and the two primary alternate satellite configurations.

Configuration A is the satellite design resulting from the 1969 contractor studies, updated only by adding sufficient expendables for a 4-week mission life. It is launched piggyback on the Program 467 spacecraft.

Configuration B is the largest possible satellite that could be launched piggyback on the Program 467 spacecraft. It also is compatible with a dedicated launch by Atlas E/F. Resolution is good, but the weight limits force a shortening of the operational life.

SPACECRAFT FEATURES

	BASELINE	ALT. A	ALT. B
SPACECRAFT WEIGHT (LBS)	1600	875	1200
LAUNCH VEHICLE	ATLAS E/ F	467 P/ B	ATLAS E/ F 467 P/ B
RESOLUTION (FT.) (90 NM ORBIT) BEST MEDIAN	2.5/ 3.0	4.3/ 5.2	2.9/ 3.5
OPERATING LIFE (WEEKS)	8	4	3 [redacted] (b)(1) (b)(3)
CAMERA F.L. IN. AND F/ NO.	60-F/ 4.28	36-F/ 4.5	50-F/ 4
FILM WIDTH	6.6 INCHES	2.76 INCHES 70 MM	5 INCHES
SPIN RATES - PHOTO PASS	29.0	41.9	32.4
(RPM) - GENERAL OPERATION	0-3 AXIS STAB.	6.0	6.9
DATA LINK FREQUENCY	12 GHz	12 GHz	12 GHz
BANDWIDTH	76.4 MHz	27.4 MHz	62.8 MHz
NUMBER OF CHANNELS	2	1	2

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SYSTEM DEFINITION / SYSTEM ACQUISITION

COSTS AND SCHEDULES

The program planning has been done on the basis of a 1 May 1971 start date and four launches a year for five years. The summary schedule of activities leading to the first launch in 27 months (August 1973) is shown below and includes the following program phases:

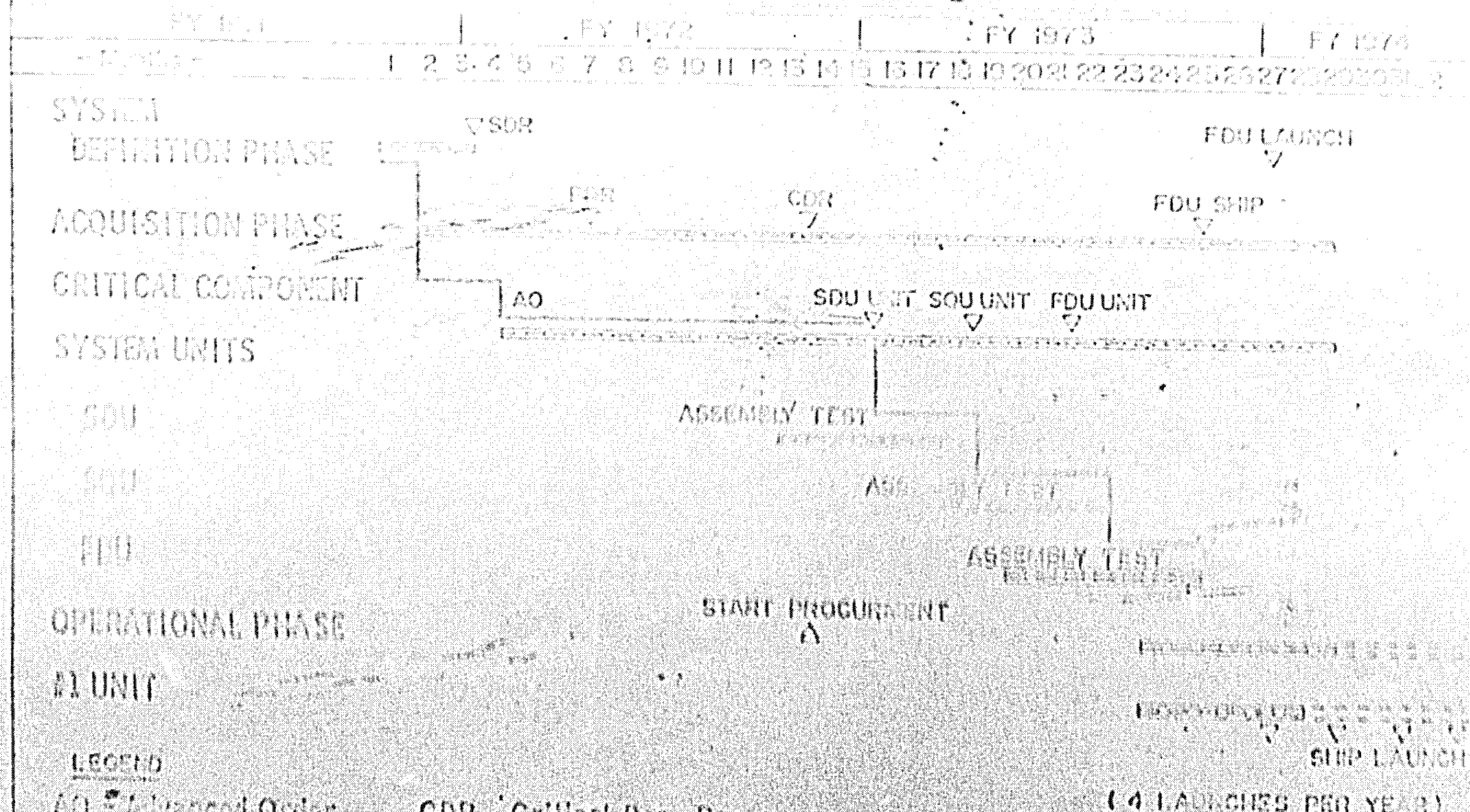
/ Program definition phase (3 months)

/ Acquisition phase (24 months)

/ Operational phase (5 years)

Procurement and development schedules are a critical factor in the program plan. During the program definition phase some long lead time procurement and critical development (camera subsystem) will be initiated to support the acquisition phase schedule. Other early procurement is planned in the acquisition phase to ensure availability of components. These actions and concurrent test scheduling at the qualification and acceptance level for systems and subsystems will realize the minimum schedule.

PROGRAM SCHEDULE (1 MAY 1971 START DATE)



LEGEND

AO - Advanced Order
SDU - Sys. Dev. Unit
SOU - Sys. Qual. Unit
FDU - Flight Demo. Unit

CDR - Critical Des. Rev.
PDR - Prel. Des. Rev.
SDR - Sys. Des. Rev.

~~SECRET / 1003A~~

Handle Via BYEMAN
Control System Only

The scheduled program has a development program which allows first launch 27 months after contract start. The first satellite launched is the heavily instrumented flight development unit (FDU). Additional diagnostic instrumentation is also carried on the second unit. Vehicles 3-17 are programmed on three month centers.

SAFSP

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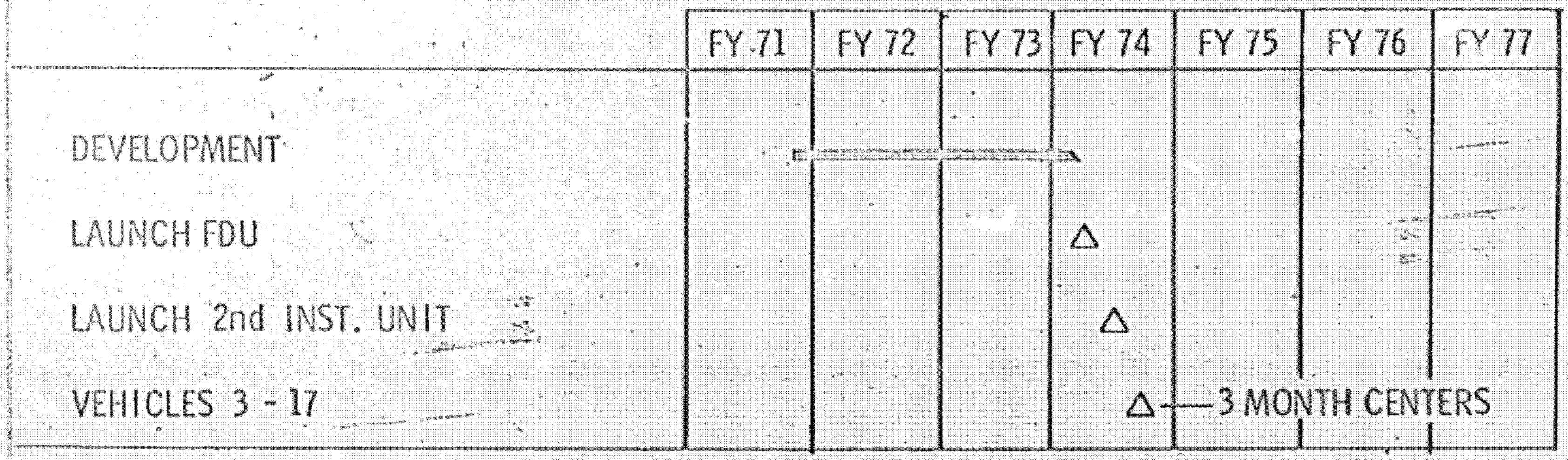
SCHEDULE: 1 MAY GO-AHEAD



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Handle via BYEMAN
Control System Only

This chart shows the price for the Spin Scan system through 1977. Fifteen percent fee is included on all contractor costs. The 1 May 1971 start date requires a directed sole source. If a competition is required, FY '71 costs can be moved to the FY '73 column. Costs are for the dedicated launch version using 60-inch focal length optics. Readout is to tracking stations at New Boston and Vandenberg. Seventeen launches are priced, and work in progress during FY '77 amounts to $14.5 million. Cost per vehicle launched is $9.7 million.

SPIN SCAN COSTS

(MILLIONS)

ATLAS E/ F LAUNCH

1 MAY GO-AHEAD

	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	TOTAL
NON-RECURRING	7.3	51.8	23.0	0.6	-0-	-0-	-0-	82.7
RECURRING	.3	3.6	26.0	38.1	37.1	36.9	36.7	178.7
TOTALS	7.6	55.4	49.0	38.7	37.1	36.9	36.7	261.4

WIP 14.5

17 VEHICLES

COST PER VEHICLE 9.7

Two alternate configurations were priced, a 1200 lb version and a 875 lb version both of which are launched piggyback on the 467 vehicle. The decreased capability (4 weeks life, poorer resolution and less flexibility) make these options relatively unattractive. The 1200 lb version costs are $43.3 M less over the life of the program. The cost per vehicle is $7.2 M or $2.5 M less than the 1600 lb version. The 875 lb satellite costs $61.2 million less over the program life of 17 vehicles. Per unit cost is $6.1 M or $3.6 M less per launch.

ALTERNATE CONFIGURATIONS

467 PIGGYBACK LAUNCH

	1200 LB VERSION	875 LB VERSION
DELTA PROGRAM COST 17 VEHICLES	MINUS 43.3	MINUS 61.2
DELTA COST PER VEHICLE	MINUS 2.5	MINUS 3.6

In summary the spin-scan system appears to be quite responsive to the crisis resolution requirement. It can provide the user pictures of the crisis area on a daily basis with adequate resolution (three feet or better) for most needs. The flexibility in manuvering the satellite ground track provides suitable coverage for most crisis situations.

Additionally the satellite has sufficient lifetime to survive the critical periods of the majority of crises. Additional satellites may be deployed for longer crisis periods.

The deployment flexibility inherent in the system is also valuable. The satellite may be [redacted] A combination of these deployment techniques could be employed to provide quickest return of the first pictures from the crisis area. (b)(1) (b)(3)

The satellite is now fairly complex to enable high resolution pictures to be obtained. Command and control requirements are also complicated because of the many manuvers required for the spinning satellite.

SUMMARY - SPIN-SCAN CONCEPT

- o RESPONSIVE TO CRISIS MANAGEMENT REQUIREMENT
  - DAILY PICTURES
  - ADEQUATE RESOLUTION FOR MOST NEEDS
  - ADEQUATE ACCESS AND COVERAGE
  - > 2 MONTHS LIFE
- o FLEXIBLE DEPLOYMENT; QUICK RETURN OF FIRST PICTURES
- o COMPLEX SATELLITE
- o COMPLEX COMMAND AND CONTROL REQUIREMENT