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THE FASTBACK B___ VEHICLE

A FAST RESPONSE, LOW COST PHOTO RECONNAISSANCE SYSTEM

26 MARCH 1971

[illegible] DENVER DIVISION

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FOREWORD

This report is a summary of studies of a version of the FASTBACK satellite which incorporates on-board film development and a laser scanner read-out system. We refer to this system as FASTBACK B. The incorporation of read out, coupled with other changes, provides the system with the capability of photographic coverage of selected areas on a daily basis for time periods up to 30 days.

In addition to the technical description of the system, cost and schedule data are included. In cases where FASTBACK systems are carried over into FASTBACK B, the schedule and cost data are firm. However, in areas where new systems are added or major revisions made, these data are more preliminary. As a consequence, the cost data is of a budgetary nature. Should you be desirous of receiving firm price and schedule data, we will be pleased to generate it.

CONTENTS

PART I -- TECHNICAL DISCUSSION

I. THE CONCEPT

FASTBACK B is a quick reaction crisis reconnaissance system that uses a low altitude satellite to provide hard copy photographs of selected target areas on a daily basis.

The satellite is launched from the Western Test Range into one of a number of generally polar orbits by means of a modified Minuteman I. The orbit has a nominal perigee and apogee of 95 and 205 nm., respectively, which causes the satellite to pass over the same spot on the earth once every 24 hours. The satellite remains in orbit at least 30 days. To maximize target area access flexibility, the orbit perigee occurs during ascending passes. For any given mission, the perigee is located at the latitude that will optimize coverage of the specified targets.

The nominal resolution of the photography is 3½ feet, including the near real time read out to ground stations located at New Boston, New Hampshire and Vandenberg Air Force Base, California. The daily target area coverage is 9000 square nm.

FASTBACK concepts and techniques are used in the FASTBACK B system whenever possible.

II. TARGET AREA COVERAGE

Although FASTBACK B can provide worldwide coverage, most areas requiring photo reconnaissance have been in the Northern Hemisphere and are located on the land mass extending from 20° N to 75° N latitude and from 10° E to 150° E longitude (see Figure II-1).

The FASTBACK B system can deliver hard copy photographic data covering 270,000 square nm. of the sensitive area to the user during its 30-day life. Normally, photos covering 9000 square nm. (equivalent to 90 pictures, 10 by 10 nm. in size) are taken and read out during each of the 30 days. Although the read-out schedule is fixed for a given 30-day mission, the photography schedule can be varied from day to day and also during a day's operation.

The use of the WTR launch site and orbit inclinations ranging from 81° to 102°, with data taken during ascending passes, provides the user with hard copy photos of target areas located in the western portion of the sensitive area within 12 hours after launch.

Hard copy photos of targets located in the remainder of the sensitive area are provided within 24 hours after launch.

Crisis areas are most likely to occur in areas outside the Sino-Soviet homelands. Korea, Indo-China, Suez, Hungary, and Czechoslovakia have been crisis areas. Reaction targets are most likely to occur within the borders of the USSR, the CPR, and within the Warsaw pact countries. Airfields, railroad yards, seaports, and troop bivouac areas are typical reaction targets. Individual targets could be military and naval units and tactical installations.

When a crisis situation arises, an orbit inclination is selected that causes the satellite to pass directly over the specified target. A series of contiguous photographs can be taken to detect and identify the movement of personnel and equipment and to locate fixed installations. Because of the effect on

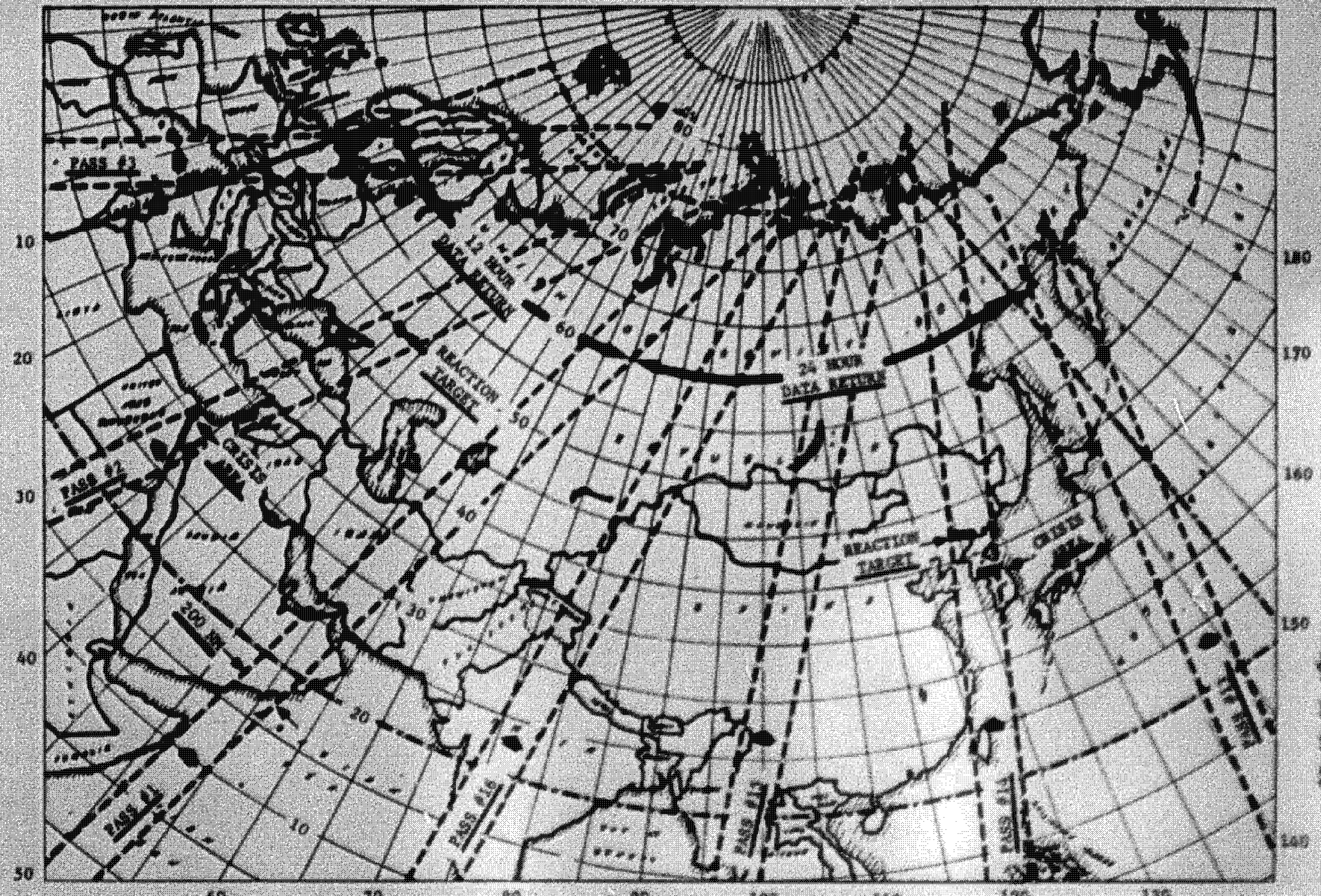

FIGURE II-1 NORTHERN HEMISPHERE SENSITIVE AREA AND 81° ORBIT picture resolution, the access width is limited to 100 nm. on each side of the satellite flight path. Film storage capacity limits the single target coverage to 4600 square nm. Read-out time limits the daily area coverage to 9000 square nm. Many combinations of coverage area width and length are possible, e.g., 200 x 20 + 100 x 45, 90 x 50 + 60 x 70, etc.

Other programming can schedule fewer photographs in the crisis area and provide greater coverage of reactive target areas. Large area search may be programmed at any time. If this option is exercised in conjunction with crisis area and reaction target monitoring, less coverage is available for these areas.

As an illustration of the potential coverage capability of a single mission, the ascending passes of an orbit having an inclination of 81° is shown in Figure II-1. Postulated crisis areas and reaction targets are located within the access boundaries. Note that the 1st pass lies near the Aral Sea and the 2nd pass lies near Suez. An increase in the orbit inclination will cause the pass pattern to move in a westerly direction until, at an inclination of about 102°, the 1st pass of a 102° inclined orbit overlaps the 2nd pass of an 81° inclined orbit. Hence, inclinations of from 81° to 102° provide 100 percent coverage of the sensitive area defined in Figure II-1. Should daily coverage be required of a target that does not lie within 100 nm. of the flight paths of the example 81° orbit, another 30-day satellite would be placed into an orbit with an inclination such that the satellite would pass directly over this target.

For all inclinations, the relationship of the orbital period and the earth's rotation is such to cause each subsequent pass to move 22.5° in a westerly direction. This creates a fixed pass pattern with respect to the earth's geography. However, due to the relative motion of the inclined orbital plane and the earth-sun line, the time of crossing a given latitude is not necessarily a constant. In the case of the 81° orbit, the time of crossing a given latitude advances about 10 minutes each day. For example, if the 1st ascending pass crosses 20° N latitude at 1430 local time on day #1, the 2nd and 3rd ascending passes will also cross 20° N latitude at approximately 1430 local time on day #1. The 14th, 15th, and 16th ascending passes will cross 20° N latitude at approximately 1420 local time on day #2. The cumulative effect of this continuously changing angle between the orbital plane and the earth-sun line is such to cause the 20° N latitude crossings to occur at approximately 0930 local time on the 30th day. This 5-hour time change corresponds to the maximum value experienced for inclinations between 81° and 102°, and, except for high latitudes during the winter, it is well within normal daylight time spans. During the winter, coverage of northern latitudes is limited to about 57° due to target illumination requirements. This corresponds to a solar elevation angle (eta) of 10° at local noon and results in degrading the photographic resolution with respect to its nominal value. Coverage can be extended to 75° N latitude between days 70 and 270, of each year. For sun synchronous orbits there is no relative motion between the orbit plane and the sun and therefore the time of day of target overflight remains constant during the entire mission. As discussed above, for non-sun synchronous orbits, the local time of target overflight becomes progressively earlier for inclinations less than about 96.3° and progressively later for higher inclined orbits. For such orbits, the time of launch is selected so that the average local time of target overflight is noon. In addition, any target is accessible via a sun synchronous orbit when an initial parking orbit is used and extended in time to provide the proper phasing between the target and the orbiting satellite.

Should the nature of the target be dynamic (such as the movement of an army), and if daily coverage is not required, another 30-day satellite would be launched with an inclination of 96.3° and a perigee and apogee of 95 and 163 nm., respectively. This would cause the satellite to pass over the same spot on the earth once every 7 days and would also provide 100 percent coverage of the sensitive area shown in Figure II-1.

Table II-1 shows the daily opportunities for data take over the sensitive area of Figure II-1 and the daily read-out schedule using the New Boston and Vandenberg AFB ground stations for orbit inclinations between 81° and 102°.

Table II-1 DATA TAKE AND READ OUT

ORBITAL INCLINATION	ORBITAL PASS NUMBER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
81°	Ⓣ	Ⓣ	Ⓣ				NB		V				Ⓣ NB	Ⓣ NB	Ⓣ	Ⓣ V
92°	Ⓣ	Ⓣ				NB		V				Ⓣ	Ⓣ	Ⓣ NB	Ⓣ	Ⓣ V
102°	Ⓣ				NB	NB		V			Ⓣ	Ⓣ	Ⓣ	Ⓣ NB	Ⓣ	Ⓣ V

Ⓣ = Data take opportunity
NB = New Boston ground station
V = Vandenberg AFB ground station

The total daily time over the sensitive area is approximately 165 minutes. The total daily read-out time to both ground stations

[redacted]

ranges from 20 to 22 minutes depending on the inclination during which time data on approximately 9000 square nm. is transmitted. The read-out time is based on a minimum elevation angle at the ground station of 5°. By adding another ground station such as Kodiak, the total daily read-out time is increased by approximately 16 minutes which increases the data capability by some 6500 square nm.

III. MISSION SUBSYSTEM ANALYSIS

A. Camera - The FASTBACK B camera is a modified FASTBACK camera. The objects of the modifications are to achieve maximum selectivity in picture taking to avoid waste of ground station transmission time and to permit use on a spinning spacecraft. A comprehensive analysis of this camera is in the FASTBACK document. The characteristics of the camera which affect its performance in the FASTBACK B are:

Focal length	45 in.
Film width	5 in. (4.6 in format)
Exposure time	1/700 sec.

The camera is arranged in the spacecraft with its optical axis perpendicular to the spin axis to maximize the moment of inertia about the spin axis, and to comply with internal satellite constraints. This results in rotating the direction of film motion 90° relative to the 45° mirror. Figure III.A-1 shows the orientation as it relates to the orbit direction.

Selective picture taking is achieved by the installation of a variable panoramic scan feature. For a point target, the 0.1 radian field of view in the track direction is permitted to pan for only 0.1 radian, making a 10 x 10 nm. picture. To accomplish a 50 x 85 nm. search mode, the camera is programmed to take 5 overlapping strips 10 nm. wide in track and to expose 8 equivalent pictures cross track. As shown in Figure III.A-1, these strips may be arranged to cover odd sized search areas. There is considerable flexibility in this concept, enabling the picture taking selection to be closely adapted to a particular crisis area and minimizing the amount of photography necessary for proper coverage.

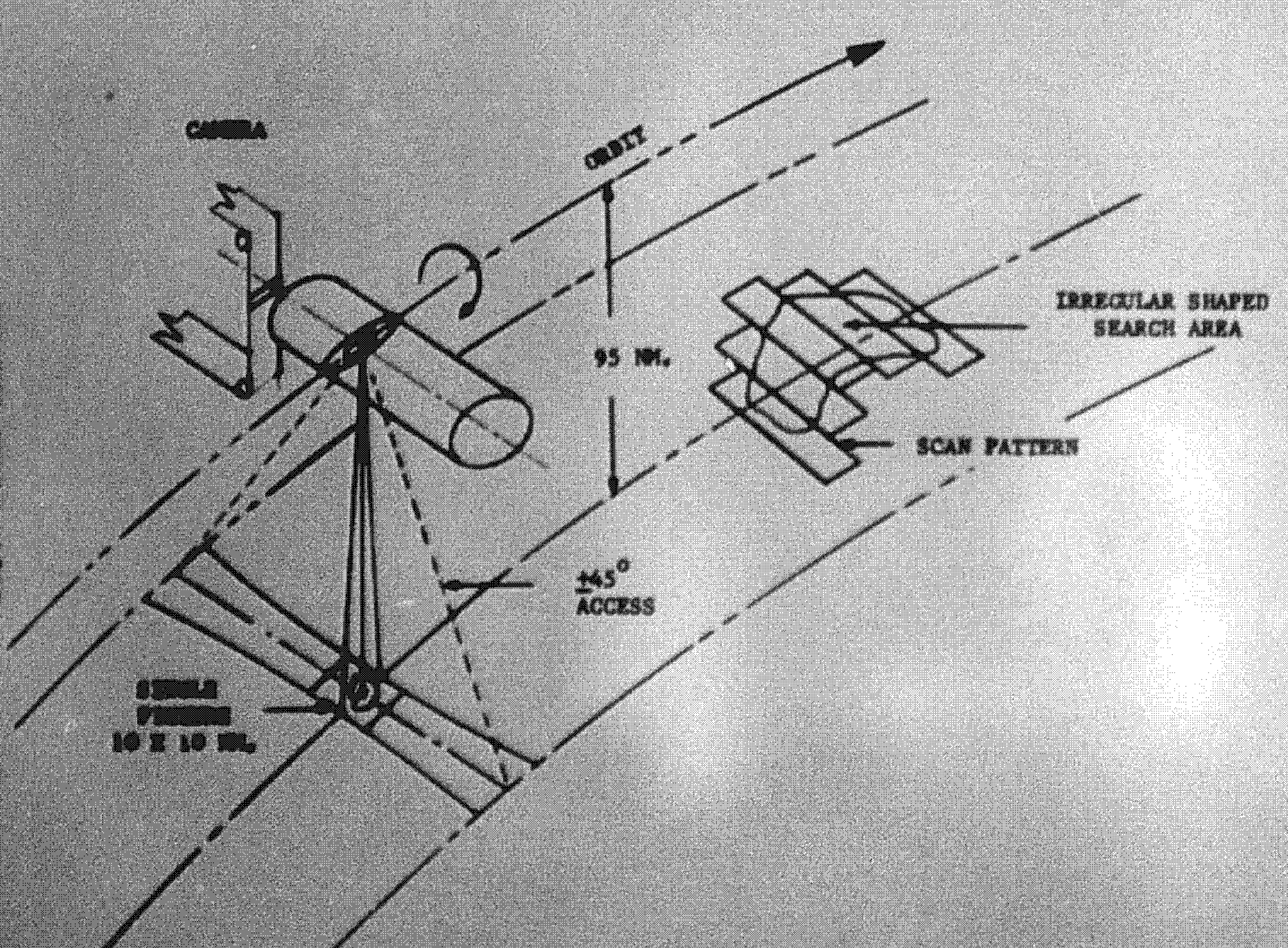

FIGURE III. A-1 CAMERA-ORBIT SCHEMATIC

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B. Image Motion Compensation - The major causes of image motion peculiar to a spinning satellite are as follows:

1. In track
    a. Coning
    b. Velocity/height ratio (V/H)
2. Cross range
    a. Nodal regression
    b. Earth rate
    c. Yaw error
    d. Vehicle spin speed

Causes of image motion, not peculiar to a spinning satellite, are included in the FASTBACK analysis.

The coning of the geometric axis about the actual spin axis requires very precise control and compensation for movement of masses during the mission. Experience shows that coning angles of spinning space vehicles can be held to one minute of arc.

This angle causes periodic pitch as well as yaw rate of the picture on the ground. Yaw rate at nadir may be neglected, but becomes important at significantly large look angles.

The pitch rate causes in-track image motion as shown in Figure III.B-1.

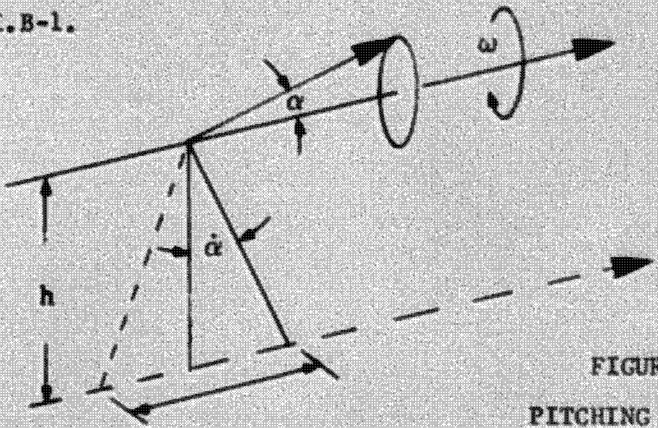


FIGURE III. B-1

PITCHING DUE TO CONING

The equivalent maximum angular pitch rate for 1 arc minute coning at 27 rpm is:

$$\dot{\alpha} = \omega \sin \alpha$$

where: $\dot{\alpha}$ is pitch rate
α is coning angle
ω = spin rate

$$\dot{\alpha} = (2.8)(2.9 \times 10^{-4})$$
$$= 8.1 \times 10^{-4} \text{ rad-sec}^{-1}$$

In the image motion analysis of FASTBACK, the pitching rate used was 7×10^{-4} radians per second. This suggests that a better coning angle capability is needed or some budget may be taken from the inherent precision of a V/H determination made from orbit parameters.

The allowable V/H permitted in the FASTBACK image motion error analysis is 4.5×10^{-4} radians per second. Once the spacecraft has been tracked, ephemeris data is known to a high degree of precision. The V/H in the crisis area on the first revolution is based on orbit injection parameters and will not be known with as high a degree of precision. On the basis of an estimate that the altitude will be within .5 nm. and the orbit velocity within 25 ft/sec, the error in V/H would be 2.7×10^{-4} rad-sec^{-1}. This compares to the value used in the analysis and indicates that some of the coning problem can be alleviated by the improved V/H accuracy based on injection accuracy and certainly based on ephemeris knowledge.

Cross-track image motion in the spinning system will be mainly due to yaw error and the precision with which the spin rate can be determined. The amount of yaw correction to be applied to the satellite in the crisis area can be derived from the ephemeris data. Similarly, the amount of yaw correction for earth rate can be derived from the knowledge of target location. The errors in these quantities, if significant, can be combined with the error in yaw determination of the attitude control subsystem and corrected in the planned manner. In any event, the total budget is $\pm 0.5^{\circ}$, which is what is allowed in FASTBACK.

The roll rate error allowed on FASTBACK is the same as pitch and is 7×10^{-4} radians per second. This becomes the precision with which the spin rate of the spacecraft must be known.

C. Photo Scanner - Photo scanning is based on the CBS Laboratories' approach. It consists of their wide bandwidth laser scanner and ground recorder processor. These are connected through a satellite-to-ground, wide-band, video communication link.

The video output bandwidth requirements are two 50 MHz channels with an S/N ratio high enough that no significant amount of noise is introduced during transmission to the ground. The resolution and bandwidth constraints result in a film scanning speed of approximately 14.7 sec. per picture at a 4.6 inch format. This results in 90 equivalent pictures per day when the total ground transmission time is 22 minutes per day.

The scanner is designed to index rapidly through the unused film due to inter-picture spacing to avoid wasting ground transmission time. To do this and provide film status information on the ground, each picture will be annotated at the time of exposure. This information will be utilized by the scanner to locate the start of each picture.

The photo scanner is the controlling element in picture resolution. The limiting resolution is 161 line pairs per millimeter in the scan direction and 128 lpm in the cross scan direction.

The reason for the difference is the sampling consideration of a raster scan imaging system. The pitch is 1/2 the diameter of the spot which is closer than normal TV practice.

The resulting system resolution is:

$$k = \sqrt{(k_{sc})(k_{cs})} = \sqrt{(161)(128)} = 143 \text{ lpm}$$

The ground resolution obtained at 95 nm. altitude with 45 in. focal length is 3.5 ft.

D. <u>Film Processing</u> - The film processing and drying is based on the Micromat process, a product of the Townley Chemical Corporation. The Micromat process makes use of a porous spongy web affixed to a film backing for strength. The web is approximately 8.25 mils thick with a thin backing to give it sufficient strength to permit reel handling. The weight is approximately 0.042 lb. per ft.^{2}. This compares with a 3404 film weight of 0.022 lb. per ft.^{2}. The web is squeezed against the exposed film between two carefully spaced rollers at the start of development. The film and mat proceed across a temperature controlled platen, curved so as to maintain contact, and are separated at the end of the development time. Under ambient conditions, development time is 3 minutes.

The processor film platen can be sized to provide varying film processing rates at a given development time and temperature. By raising the processing temperature to as high as 115^o F, the developing time may be shortened to 20 seconds. Thus there is considerable flexibility available in adapting the processor to film storage capacities, scanning rates and ground transmission time availability. Pressurization of 70^o F is about 1 psi.

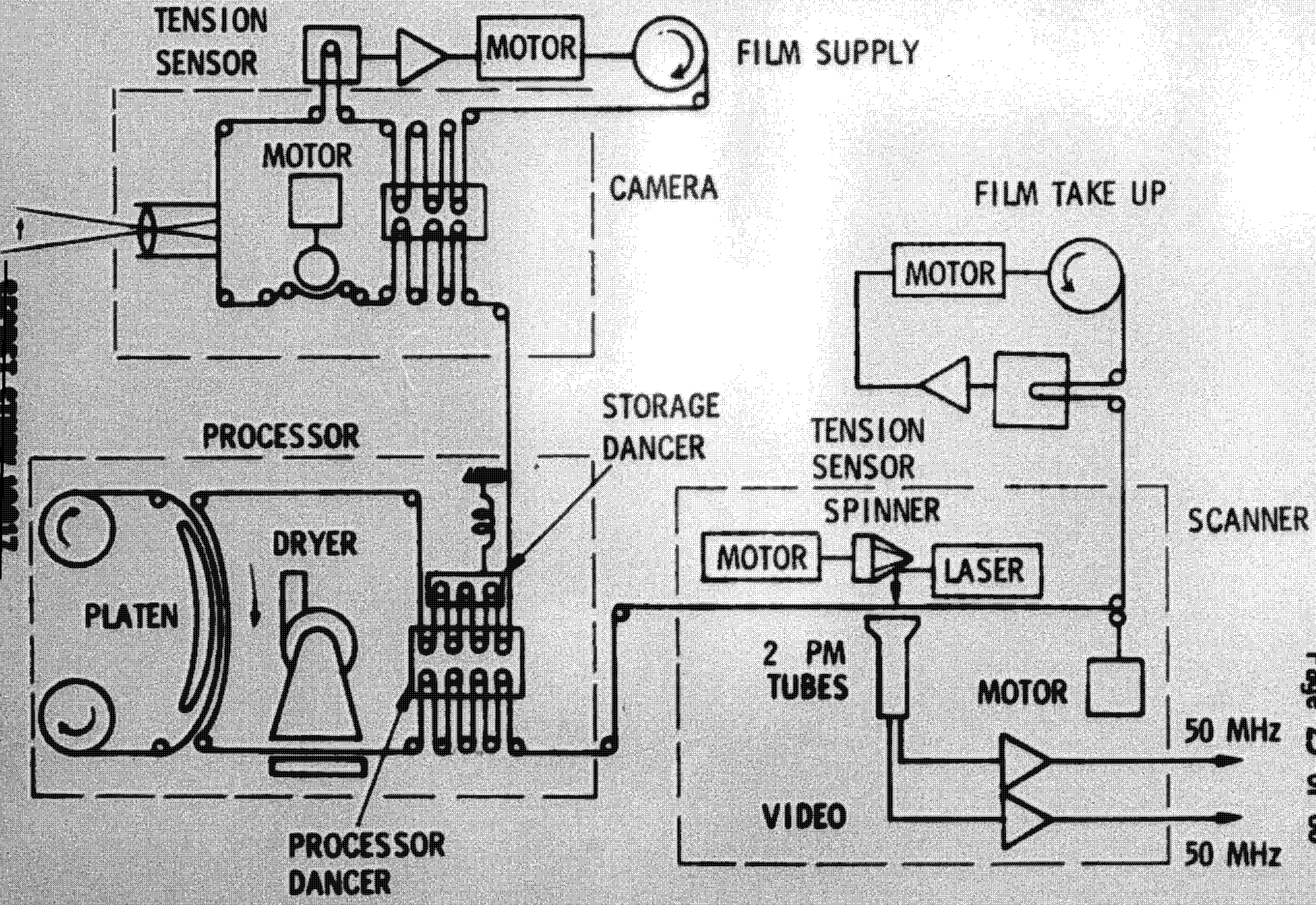
E. Film Transport - Film transport provides film at various speeds for the camera, processor and scanner. The film transport shown in Figure III.E-1 is designed to support a 30-day operation. 2000 ft. of film and Micromat processing web have been provided.

The looper box on the camera is provided to enable rapid feed of the film when the camera capstan drive is accelerating and rotating. Negligible "up-to-speed" time is required as compared with FASTBACK. The film speed during exposure is about 125 inches per second.

The maximum picture taking sequence provides for a total of 46 10 x 10 nm. pictures. This may be varied in cross-range field of view by the variable panoramic scan feature of the camera from 10 x 10 to 10 x 200 nm. for each panoramic strip. In terms of angular field of view, this corresponds to 0.1 x 0.1 radians to 0.1 x 1.6 radians. Ground coverage at greater aspect angles is, of course, greater than at nadir. The exposed length of film for the equivalent of 4.6 radians of coverage per burst, including an allowance for inter-picture spacing, will be approximately 25 ft. Each sequence of exposed film will be stored and processed at one time. After the 25 ft. has been exposed and admitted to the storage box, additional leader of film must be motored through the camera to insure that the last exposed picture will clear the scanner.

When all of this film is stored in the processor storage box, the storage dancer has moved toward the top of the box. When processing and drying takes place, the processing dancer also moves toward the top of the box responding to the transfer of the film from the exposed to the developed side (storage).

This compact arrangement enhances temperature control during the processing and drying. It also confines all of the shifting of the film mass to one place. This enables convenient



Film Transport and Processing Figure III E-I mass compensation as necessary.

The read-out system pulls the film on demand from the processor storage. The video output from the 2 photo multiplier channels goes to the communication link. The film leaving the read-out system is wound onto the take-up reel. The film tension throughout the system is 2.5 lb.

F. Mission Data Transmission - Mission data are transmitted over two X-band channels to two ground stations where the recorder/processor produces hard copy photographs.

The satellite provides two mission data transmission channels with 250 MHz bandwidths in the 7-8 GHz band. Transmission of 50 MHz video data to a 46-ft. ground antenna, having a 150° K system noise temperature, requires 100 watts of radiated power for either channel at the maximum range. Two despun transmitting antennas each have a fan beam which gives up to 14 db gain at maximum range and lower gain at shorter distances. This configuration allows the use of a traveling wave tube amplifier with as low as 10 watts output power to be used.

Each 50 MHz analogue data stream from the scanner is connected to its own data conditioner, X-band exciter and traveling wave tube amplifier (TWTA). Two sets of diplexers, despin drive assemblies, directional polyrod antennas and associated waveguides complete the subsystem equipment. Figure III.F-1 is the subsystem block diagram.

Conditioning of the input signals requires both amplification and filtering to achieve the proper input level for the exciter and to compensate for roll-off in the high frequency response of the payload film scanner. Compensation in the satellite instead of the ground station improves the quality and resolution of the video data as it is received. The transfer function of the pre-emphasis network counteracts the scanner frequency response by providing more attenuation at lower frequencies so that the output more closely approaches the actual film image characteristics. After filtering, the conditioner amplifies the video signal to the level for proper deviation of the exciter frequency.

The analogue data stream can be converted to a digital data stream at a time when encryption becomes a requirement. Each

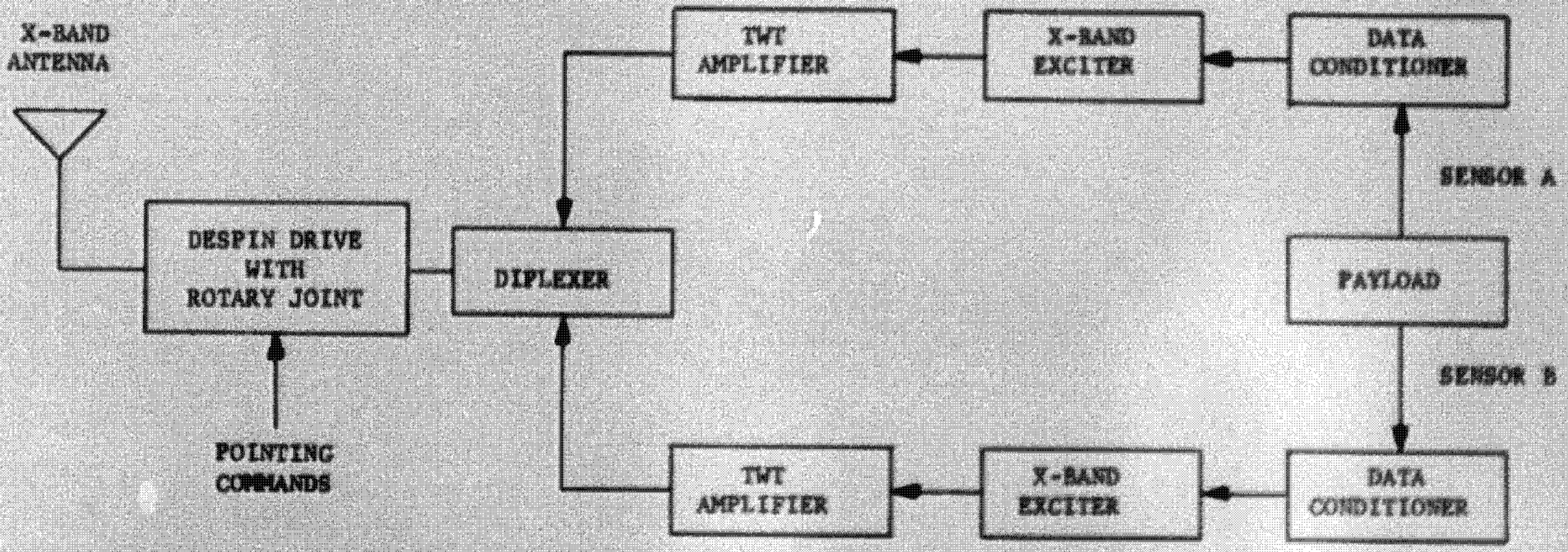


FIGURE III. F-1 MISSION DATA TRANSMISSION SUBSYSTEM half cycle would contain 5 bits, allowing 32 shades of grey contrast. The encryption device would be in series between the converter and the exciter.

The solid-state exciters in the two channels provide frequency deviation of ±100 MHz, so that their output bandwidths are 250 MHz each. The two carriers are approximately 500 MHz apart in the 7-8 GHz region so that there is a wide guard band between the two channel frequencies.

The TWTA amplifies the exciter output signal by about 30 db for an output power of 10 watts minimum. The space-qualified Hughes 12024, which has been considered for this application, can provide as high as 20 watts, if necessary, although d.c. power requirements are reduced for lower output levels.

Reliabilities of the TWTAs and exciters are very high, therefore there is no need for a cross-switching capability between the units for redundancy.

The diplexer contains filters to combine the two TWT outputs into a single channel and to prevent power from either TWT entering the other unit. Insertion loss of the diplexer is low because the wide separation between the two frequency bands permits use of relatively broad filters. The diplexer output is RG-68U waveguide to the rotary joint of the despin drive assembly.

Despin and pointing of each directional antenna is accomplished by a despin drive motor which drives the antenna oppositely to the direction of the satellite spin motion. Varying the motor speed by ground command provides a means of correcting for changes in spin rate and for moving the antenna to a new pointing direction. Antenna pointing control is accomplished in real time from SCF ground stations by commands over the S-band link. The despin drive mechanism also contains a rotary joint for transfer of rf power to the antenna.

Each antenna for the data transmission subsystem generates a fan beam approximately 20° wide and 80° long. The fan lies in the plane containing the spin axis with a maximum gain of 14 decibels between 70° and 90° from the spin axis, corresponding to the direction of the horizon at the read-out stations. This configuration enables antenna pointing with a single gimbal. A polyrod antenna appears to offer the best combination of beam shape and weight, with an offset parabolic reflector segment considered as an alternative.

IV. SATELLITE DESCRIPTION

A. General Description - The launch configuration of FASTBACK B (see Figure IV.A-1) and the guidance system through orbit injection are identical to FASTBACK with the following exceptions:

1. The payload envelope is extended 8.78 in. forward to accommodate packaging requirements, thus moving the satellite orbit injection motor (SOIM) forward within the existing fairing envelope. The fairing is the same.

2. The three axis stabilization system and the attitude control engines, used for control authority during SOIM burn, are mounted on the aft end of the satellite as in FASTBACK. The attitude control engines are also used for the SOIM vernier correction and for orbit sustenance propulsion during the 30-day orbital life of FASTBACK B.

The three axis stabilization system through SOIM burn is identical to FASTBACK. After orbit injection, spin stabilization provides satellite attitude orientation. X-band mission data read-out antennas and attitude control subsystem rate gyros are located on despun platforms on the forward and aft bulkheads of the satellite. The S-band command and status antenna is located on the aft bulkhead, but is not despun. A horizon crossing indicator and a solar aspect sensor are mounted adjacent to each other on the cylindrical surface. Precession torques, spin torques, SOIM ΔV error correction, and orbit sustenance propulsion are supplied by hydrazine mono-propellant engines. A body mounted silicon solar array supplies make-up power to the 6 ampere hour silver-cadmium secondary battery. This array is protected from aerodynamic heating during boost phase by an environmental cover, jettisoned after third stage burn. The four 75-lb. axial hydrazine engines, the inertial measurement unit, the

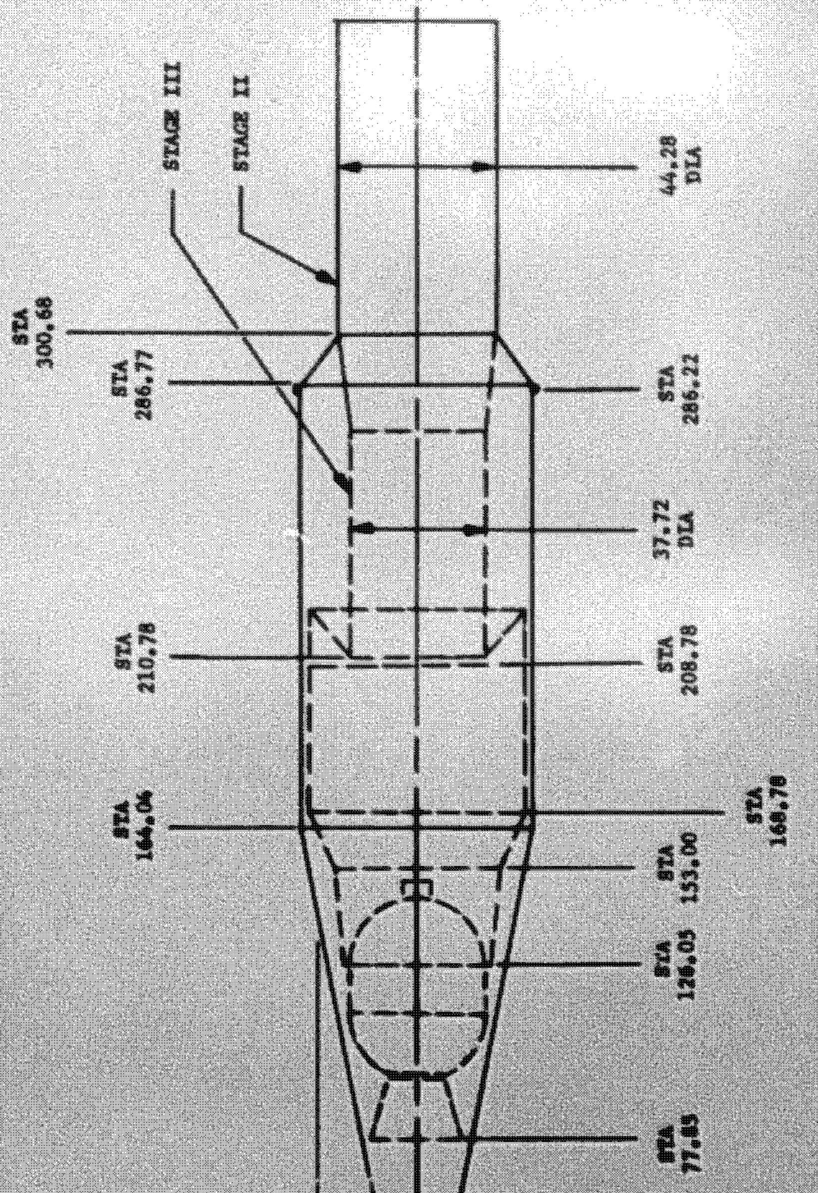


FIGURE IV. A-1 LAUNCH CONFIGURATION

on-board computer, and the booster mixer are identical to FASTBACK. There is no reentry or recovery hardware.

Dynamic balance is one of the most critical requirements of FASTBACK B. To achieve dynamic balance, it will be necessary to maintain a spin axis to principal axis deviation of not more than 1 arc minute. To minimize cross products of inertia, equipment items have been arranged in statically balanced wafers along the longitudinal axis where possible (see Figure IV.A-2). The hydrazine tanks are mounted symmetrically on the satellite longitudinal center of gravity and are pressurized from common manifolded helium pressure bottles. The film take-up and storage reels are mounted on the longitudinal (spin) axis to avoid perturbation of the angular momentum vector during the critical film exposure period.

Loop boxes will include provisions for mass transport compensation during film processing. The despun platform will be locked during data collection, and will be dynamically balanced to minimize satellite jitter during read out.

A preliminary weight summary is given in Table IV.A-1. The total weight of 1019 lb. represents the satellite as installed in the orbit injection stage, including fully loaded hydrazine and helium tanks. A typical daily power profile is shown in Figure IV.A-3.

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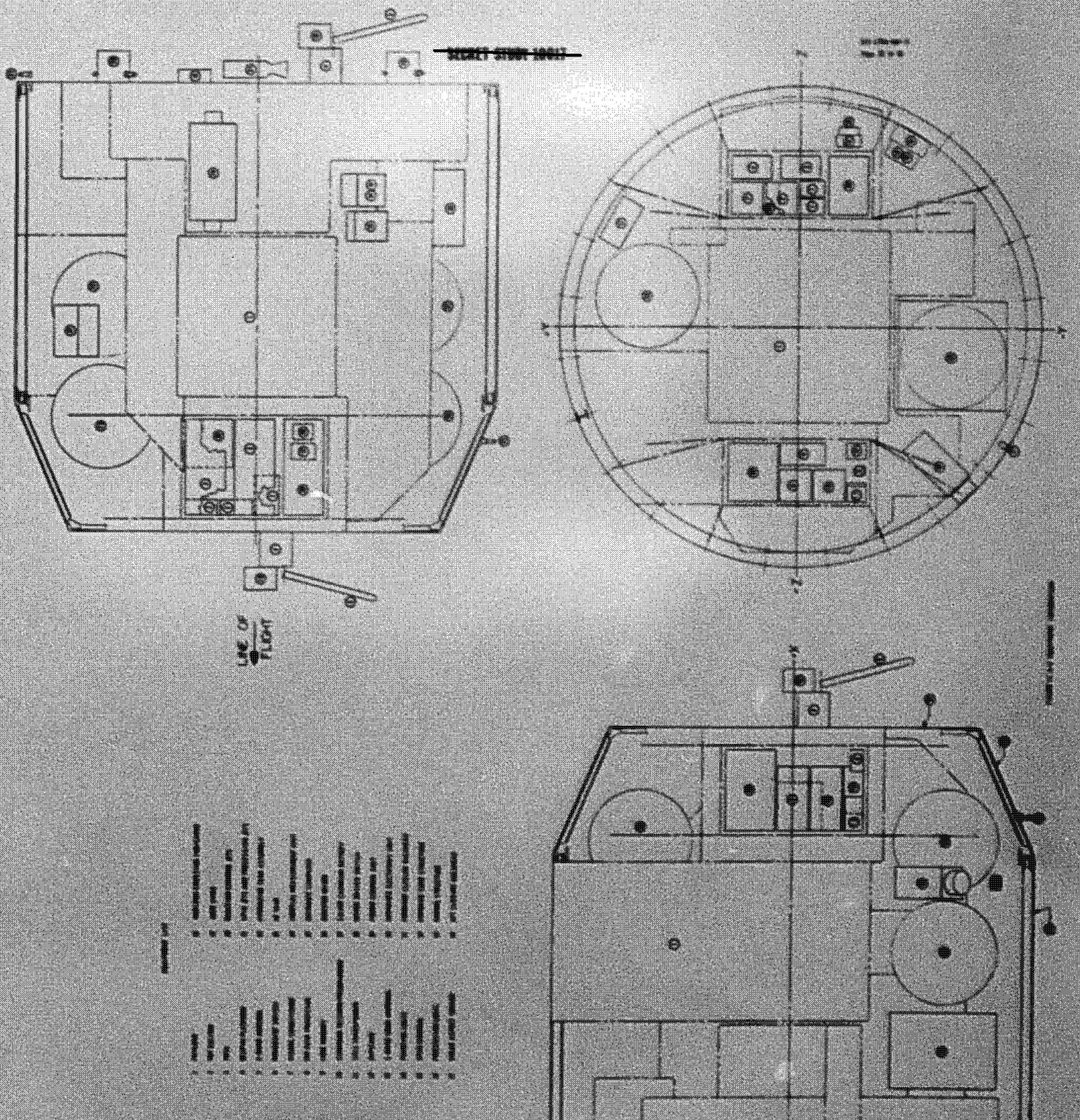

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TABLE IV. A-1 WEIGHT SUMMARY

SUBSYSTEM	ESTIMATED WEIGHT (LBS)
Mission	373.0
Data Transmission	100.5
Command and Status	21.4
Attitude Control	17.0
Attitude and Reaction Control Propulsion	151.6
Guidance	87.6
Electrical Power	86.7
Structure	103.4
Thermal Control	27.5
Range Safety	50.3
Total	1019.0

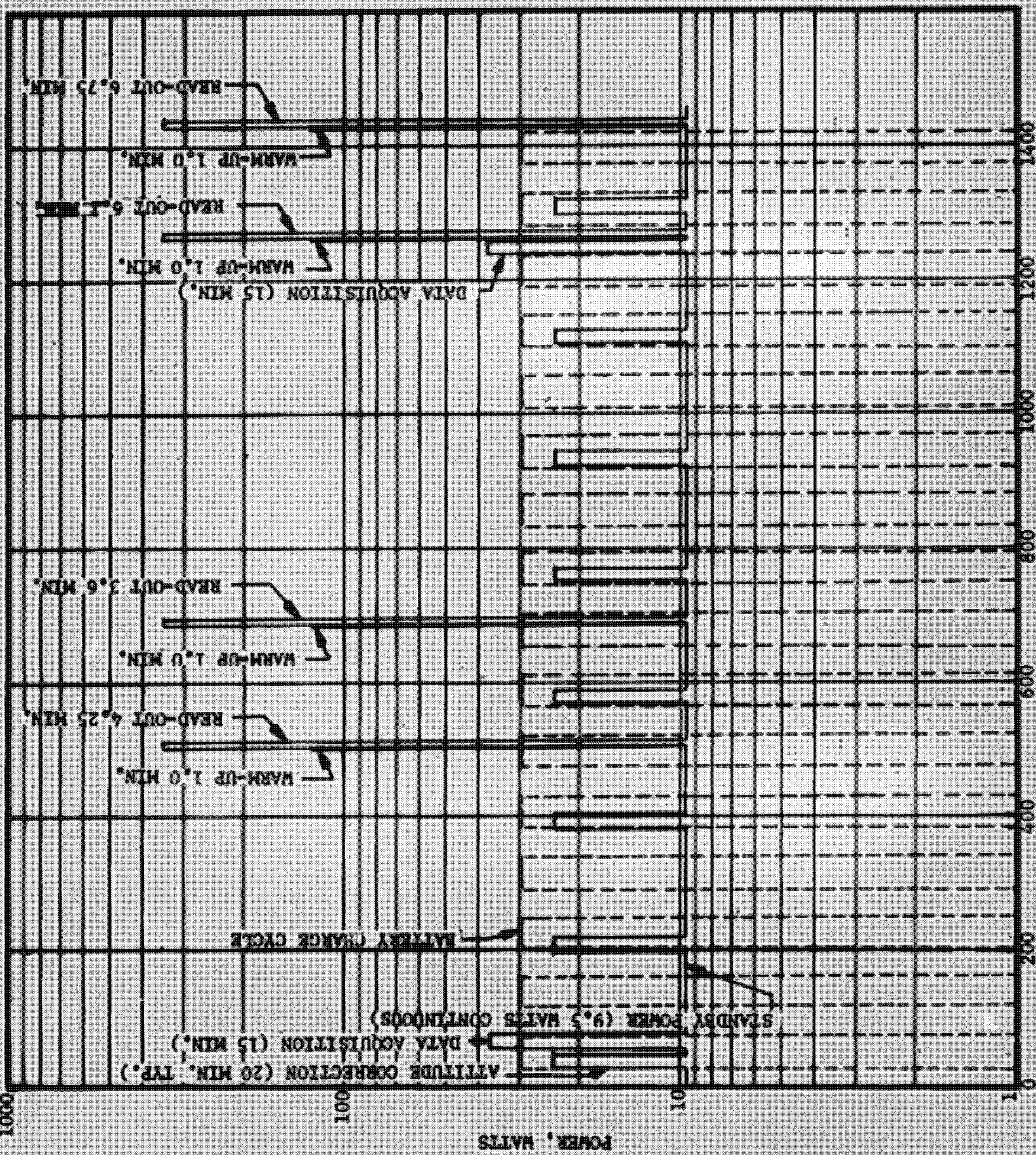

FIGURE IV. A-3 TYPICAL DAILY POWER PROFILE

B. Mission Subsystem - The mission subsystem consists of a modified FASTBACK camera, a processor to develop the exposed film, a CBS laser scanner to convert the picture into analogue electrical signals, a data conditioner to maintain constant output signal response over a range of photographic bandwidth, and a wide-band communication link to transmit the data to the ground stations. A film transport system supplies film, at various speeds, to the camera, processor and scanner. A CBS ground recorder/processor is used to convert the electrical signals to hard copy photographs.

Figure IV.B-1 shows the mission subsystem installed in the satellite.

1. Camera - The FASTBACK camera is modified to remove the film supply and take-up reels. A vari-scan feature is added to allow panoramic pictures to be taken during any portion of each $\pm 45^{\circ}$ access of each revolution of the satellite. Pictures may be taken during the entire 90° scan or at selected sectors. The trunnions are removed and the camera is fixed with respect to the satellite.

2. Processor - The processor develops the exposed film by the Micromat process. The film is mated with the Micromat processor, along a curved platen, for 3 minutes. The film is then dried with blowers and desiccants for 30 seconds. The processor is pressurized at 1 psi and maintained at 75° to 80° F.

3. Laser Scanner - The laser scanner scans the developed film with two spots approximately 5 microns in diameter. Each spot scans half the frame in the horizontal dimension and the total vertical dimension. Each channel has an output information bandwidth of 50 MHz.

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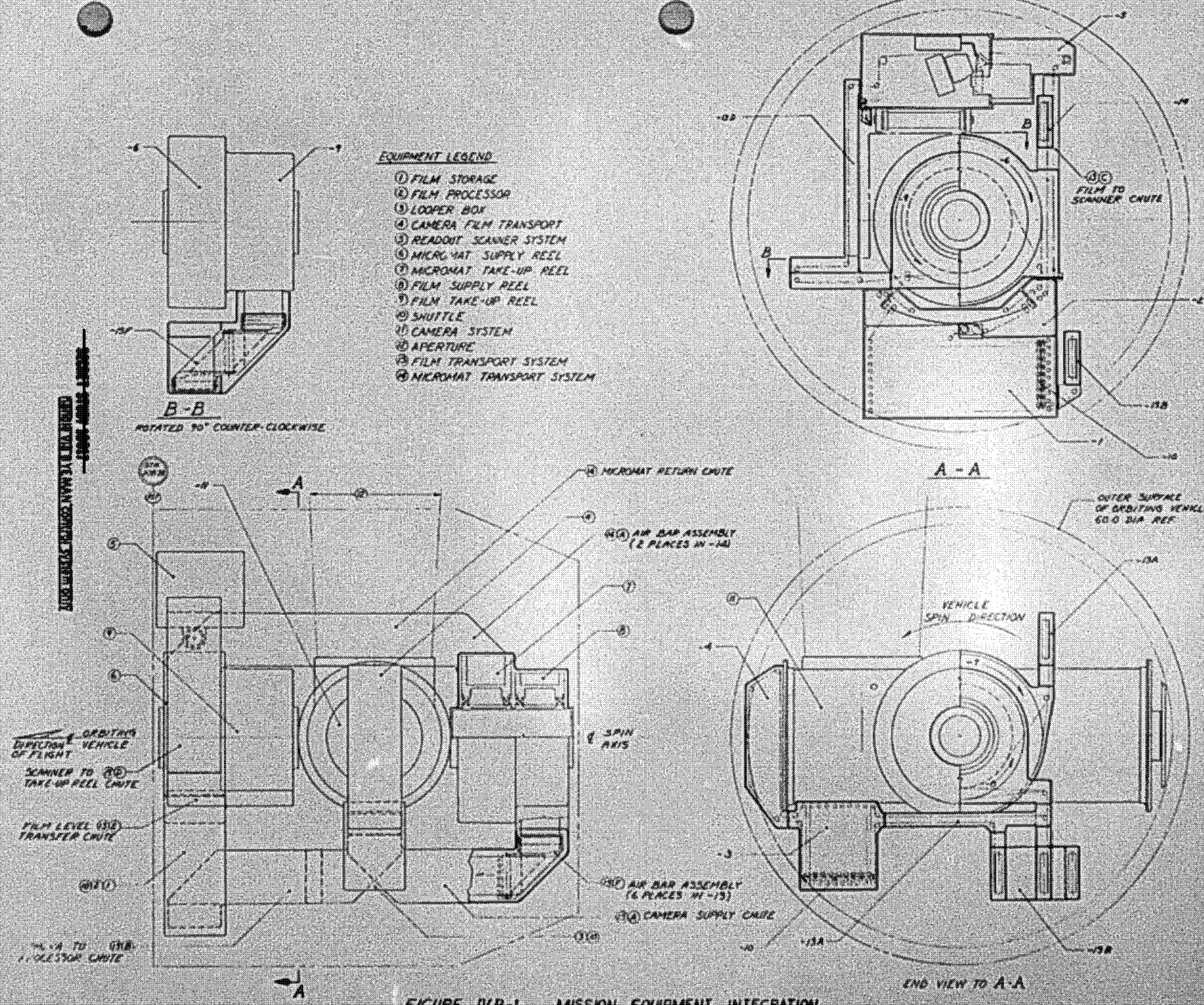

FIGURE IVB-1 MISSION EQUIPMENT INTEGRATION

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4. Data Conditioner - The data conditioner multiplies the scanner output by the reciprocal of the scanner's modulation transfer function.

5. Communication Link - The satellite portion of the communication link consists of two 10-watt traveling wave tube power amplifiers, their exciters, a diplexer, coaxial switch and two despun antennas. The links are frequency modulated on two carriers 500 MHz apart in the 7-8 GHz region with RF bandwidths of 250 MHz. The two amplifier outputs are combined by the diplexer and routed by the switch to either of two despun fan beam antennas. Each polyrod antenna has a circularly polarized fan beam of 14 db gain and 20° x 80° beamwidth with the long dimension along the spin axis.

C. Command and Status - The command and status subsystem provides the processing, storage and read out of status data, the execution of stored and real-time commands and the range and range rate determination.

1. Configuration - A block diagram of the command and status subsystem is given in Figure IV.C-1. The subsystem consists of an S-band omni-antenna, diplexer and SGLS transponder, a status data processor, command processor and a data memory. The data memory is under the control of the command processor and is used both for command program data storage and status data storage. The memory addressing function is mechanized such that no single failure will allow the command program data, residing in the memory, to be disturbed by status data memory functions. In addition, command program functions are given priority over status data functions.

2. Command - Following orbital injection, the launch/injection computer function is shut down and all control functions are performed by the command processor. The stored command program is altered as required during SGLS station passes via the command uplink. Closed loop command verification is accomplished automatically by means of the status downlink and the real-time processor on the ground. The command processor is nearly identical to the central command decoder/programmer unit described in the Martin Marietta Corporation development report titled "Spaceborne Signal and Data Processing Equipment - Command Decoder Programmer Set and Data Handling Telemetry Equipment", dated 10 January 1971.

A prototype of this equipment was developed and successfully tested during the calendar year 1970. The task included successful integration of the equipment with a procured

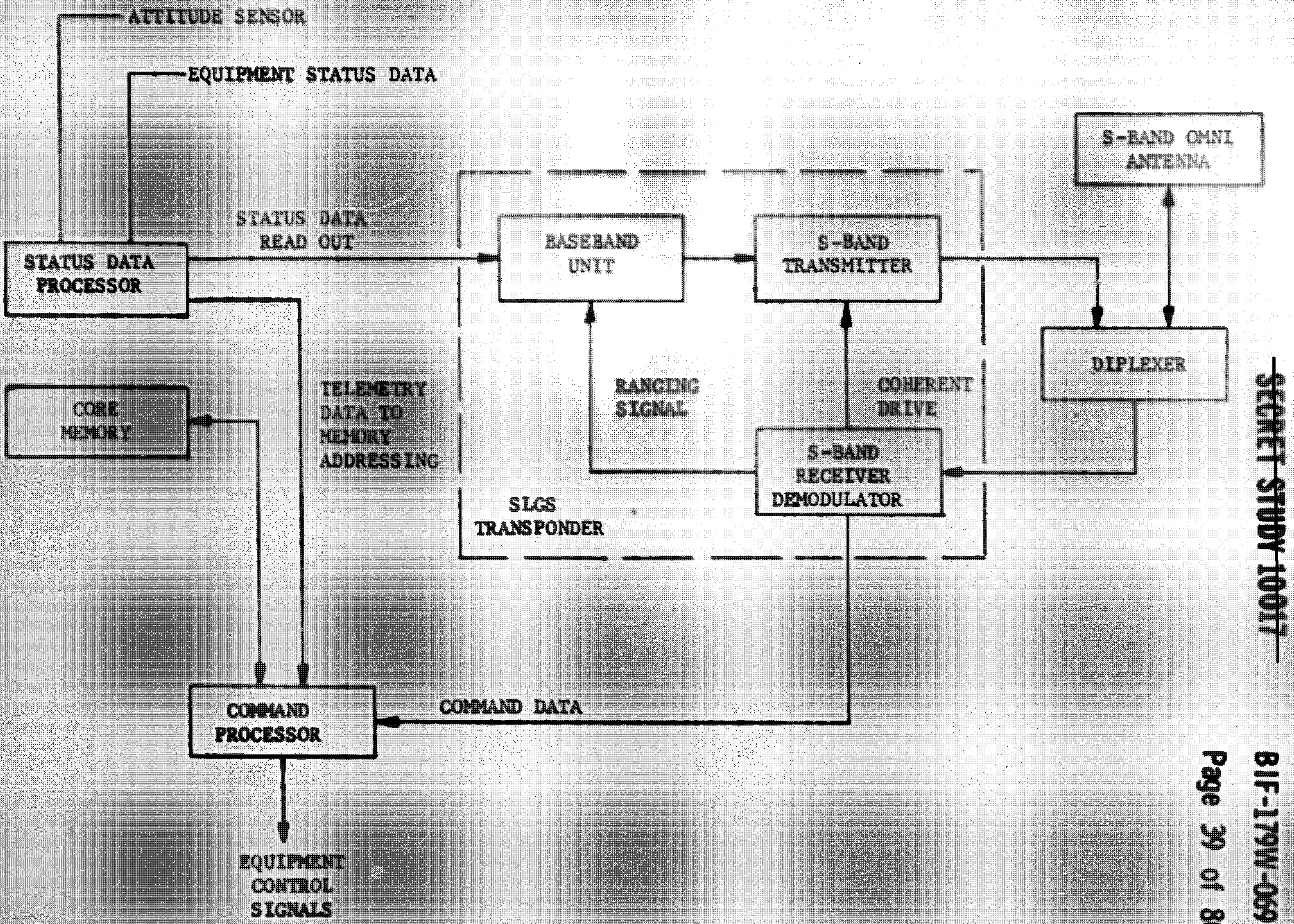

FIGURE IV. C-1 COMMAND AND STATUS SUBSYSTEM

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spaceborne memory and with AGE program load/verification equipment. On-orbit command verification was designed to be compatible with existing range tracking stations' processing capabilities. Application of the developed equipment to this configuration requires only the addition of memory sharing logic since separate core memories were employed for the command and status functions in the 1970 development configuration. By comparison, FASTBACK B does not require as much or as diverse a memory capacity as did the application for which the existing equipment was designed.

3. Status - The status data processor, when commanded, processes and stores equipment status data and attitude sensor data for transmittal to the ground during station passes. The downlink status data format then includes real-time status data, on-orbit status and attitude data, command verification data for command program loading, and real-time X-band telemetry pointing data for automatic closed loop command control of the satellite X-band antennas.

As in the case of the command processor, the status data processor is nearly identical to existing Martin Marietta Corporation prototype equipment. Specifically, it is nearly identical to the central multiplexer unit described in the classified Martin Marietta Corporation report referenced above.

4. RF Link - The coherent RF link is maintained by the SGLS transponder. This equipment is a repackaged version of an SGLS transponder for which the Martin Marietta Corporation has generated a formal procurement drawing. The S-band omni-antenna is similar to Martin Marietta Corporation designs which have been successful on previous programs.

D. Attitude Control Subsystem

1. Orbit Injection - To meet orbit injection requirements, the same guidance, navigation and control concept, employing the Hamilton Standard Delta Inertial Guidance System (DIGS) used on FASTBACK, will be used for FASTBACK B.

2. On-Orbit Attitude Determination - Figure IV.D-1 is a block diagram of the attitude control subsystem. Following orbit injection, the satellite is reoriented to its nominal on-orbit attitude. On-orbit stabilization for the 30-day FASTBACK B mission is provided by spinning the satellite at a nominal 27 rpm spin rate. The scanning motion required by the camera and the attitude sensors is also provided by the satellite rotation. Determination of the location of the spin axis vector in space is accomplished by measuring and storing horizon crossing times with a horizon crossing indicator (HCI), and the sun aspect angle with a sun aspect sensor (SAS). These data are transmitted to the ground stations. The received data are processed in a ground based computer, programmed with the necessary data processing software. Error data are transmitted to the satellite for vehicle correction. Attitude accuracy, using the SAS and HCI, is dependent upon proper sunline-nadir separation, and the data measurement times will be based on this separation.

3. Precession and Spin Control - The spin axis (angular momentum vector) is maintained in the proper inertial state by a precession control system using on-board logic and reaction control jets. Precession of the spin axis is required periodically due to external torques. The most significant torque is due to aerodynamics at perigee. Precession of the momentum vector is expected to be less than 0.1° per orbit assuming a 300 ft. lb. sec. momentum about the spin axis. A prototype of the precession electronics for a

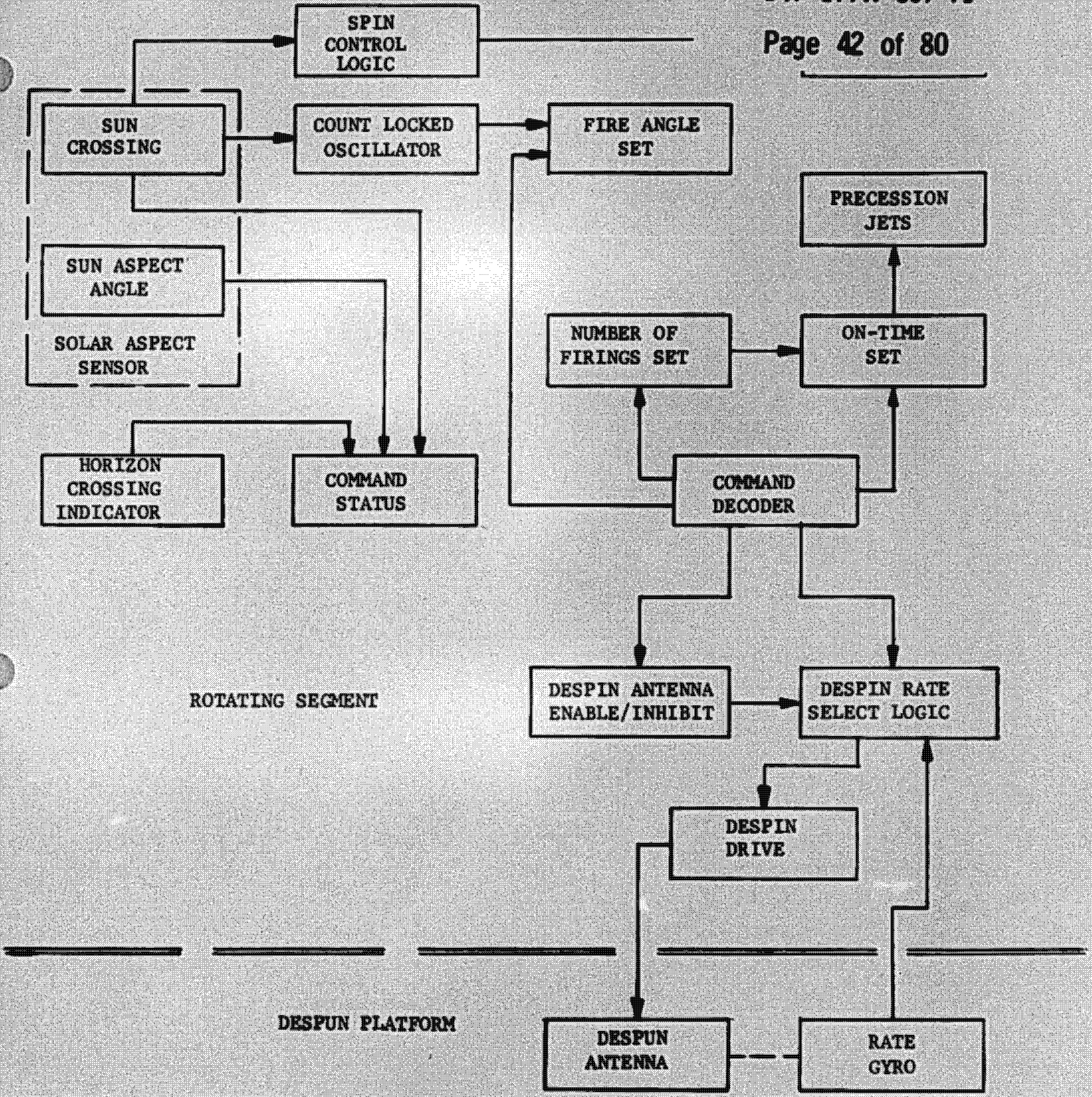


FIGURE IV. D-1 ATTITUDE CONTROL SUBSYSTEM similar vehicle was developed and successfully tested in 1970. This equipment is presently being used in tests employing a dual spin satellite on a 3-axis air bearing.

Spin control is an on-board closed-loop system and maintains the spin rate to 27 ± 6.7×10^{-3} rpm through use of the sun sensor, spin control logic and the reaction control subsystem. Due to external torques, the spin speed is slowly time varying. Internal torques can also significantly change spin speed. Camera and processor operation may cause significant spin transients during start up. The frequency response of the spin control system is low due to the accuracy requirements so that large transients require significant settling time or a pre-programmed correction.

4. Despun Antenna - A pointing capability is required for the X-band data transmission antennas. Two despun platforms are provided and are used only over ground station areas. Each antenna provides coverage over a hemisphere by positioning its fan beam around the spin axis. The antenna is acquired by providing a low scan rate on the antenna using a rate gyro. An autotrack signal, when received, overrides the rate command and points the antenna to the ground station. Upon command, the despun antenna control system is opened. The antenna spins up and eventually spins with the satellite.

5. Disturbance Torques - Internal torques in a spinning satellite are critical and must be controlled if nutational motion is to be kept at a minimum. If the internal transverse momentum is assumed cyclic, the body transverse rate is given by:

$$w_T(t) = \frac{IAw}{I_T(w^2-w_N^2)} \left[(w_3-w_N) \sin w_N t + \frac{(w^2-w_N w^3)}{w_N} \sin wt \right]$$

where:

w_3 = spin speed

w_N = nutation frequency

w = internal momentum frequency

IA = internal momentum amplitude (maximum)

I_T = transverse inertia

As w approaches the nutation frequency, the body rate, w_T, becomes large.

External torques are usually slowly time varying and do not cause significant transverse body rates. Energy dissipation limits the nutation, and momentum vector control is accomplished by the precession logic and ground command.

6. Performance - The performance of the mission subsystem, due to attitude control subsystem errors, is primarily dependent upon spin speed control, spin axis attitude and internal momentum control. In addition, payload alignment and spin axis dynamic unbalance must be controlled.

Spin speed control to $27 \pm 6.7 \times 10^{-3}$ rpm can be achieved if the transients can be kept small. This implies careful control of the payload disturbing torques. This assumes that several spin period measurements can be averaged for spin rate error detection.

The spin axis attitude with proper choice of measurement times can be kept to within 0.5° using the sensors as indicated. Ground computation is required.

The degree of internal momentum control necessary depends upon the maximum allowable body rates that can be tolerated. The momentum magnitude and frequency content determines the resulting spin axis motion.

Nutation damping is assumed and the performance required will dictate the damping mechanism. Passive damping, if adequate, is desirable from a power standpoint.

E. Attitude Control and Reaction Control Propulsion Subsystem - The attitude control (AC) and reaction control (RC) propulsion subsystem is shown schematically in Figure IV.E-1. The system is similar to FASTBACK in that it utilizes mono-propellant hydrazine (N_2H_4) in a blowdown mode (2:1) with helium gas as the pressurant for reaction control (high thrust) and attitude control (low thrust).

The proposed system utilizes two propellant tanks and two pressurant tanks unlike FASTBACK because of the on-orbit spin mode. The propellant tank will use a diaphragm or surface tension device for proper engine propellant feed prior to spin up.

Maximum thrust levels are 75 lbs. for the RC engines and 0.5 lbs. thrust for the AC engines. At the end of the mission the RC thrust is about 38 lbs. and AC thrust is about 0.3 lbs. The RC engines provide pitch and yaw control for the vehicle during solid motor burn and vernier velocity if required to achieve orbit and orbital velocity adjustment throughout the mission. The AC engines provide spin speed maintenance and pitch and yaw control on orbit. 119 lb. thrust solid rocket motors provide initial spin up.

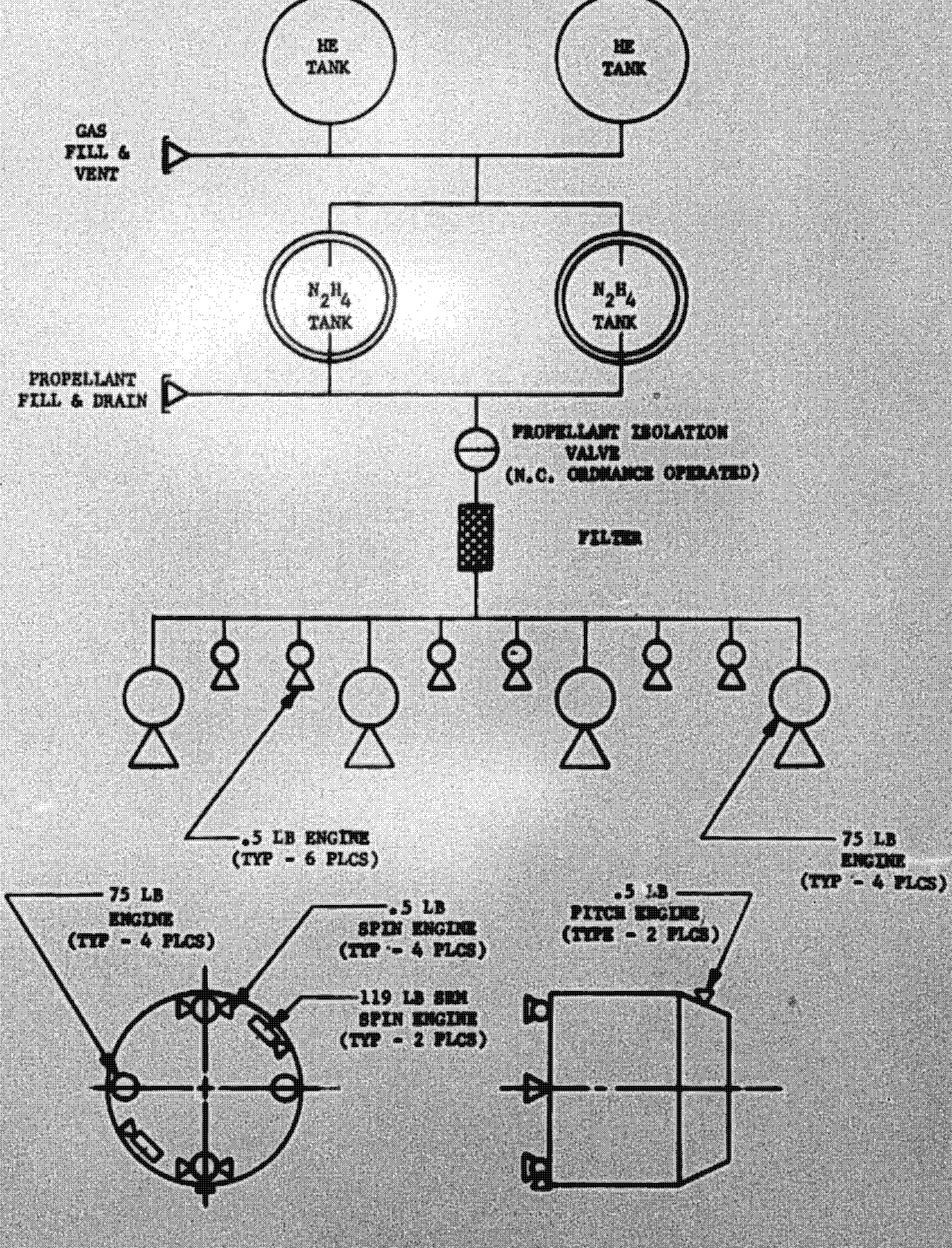


FIGURE IV. E-1 ATTITUDE CONTROL AND REACTION CONTROL PROPULSION SCHEMATIC

F. <u>Electrical Power Subsystem</u> - The electrical power subsystem consists of a silicon solar array (body mounted), a secondary silver-cadmium battery, a power control unit (PCU) to regulate battery charging, an ordnance and electronics unit (OEU) for firing pyrotechnic devices, a motor driven switch for transferring from ground to spacecraft power, a discrete conditioner located in the booster mixer, and wiring harnesses to provide power distribution. Ground power is supplied to the satellite via a flyaway umbilical until approximately 30 seconds prior to launch. At that time, the motor driven switch is actuated and transfers from ground power to satellite internal power.

A depth of discharge of at least 2.5 ampere hours is available for the boost and orbital inject period before the solar array starts recharging the battery. The body mounted solar array generates approximately 30.2 watt hours per orbit or 473 watt hours per day. Spacecraft equipment requires 403 watt hours per day which results in a maximum daily energy requirement of 473 watt hours at a battery charging efficiency of 85 percent. Therefore, energy balance is maintained each day under even worst case battery loading conditions. Throughout the duration of the mission, battery depth of discharge never exceeds 40 percent. A typical daily power profile is shown in Figure IV.A-3.

The solar array consists of silicon solar cells covered by 6 mil cover slides. The solar array is sized to be equivalent to a minimum of 4.42 square feet at normal solar incidence, consistent with seasonal variations in orbital parameters and sun position, during daylight periods of each orbit.

The battery is a 6 ampere hour secondary silver-cadmium battery capable of satisfying cycle life requirements and will weigh approximately 9 pounds.

The PCU, OEU and discrete conditioning are identical to FASTBACK.

G. Structural Subsystem - Figure IV.G-1 is an exploded view of the structural subsystem. The basic barrel structure of FASTBACK B is identical to FASTBACK, but is approximately 9 inches longer. The aft bulkhead of FASTBACK B supports the 75 lb. hydrazine engines, the despun antenna platform, the S-band omni-directional command and status antenna, the spin-up motors and a portion of the solar array.

The forward reentry cone of FASTBACK is deleted in FASTBACK B. The forward bulkhead of FASTBACK B is moved forward to Sta. 153 (see Figure IV.A-1) to accommodate equipment mounting requirements. The bulkhead itself functions only as a closure for the compartment and a radiating surface for internally generated heat.

The camera and associated mechanisms are supported on four longerons. The command and status transmission electronics are mounted on two trusses near the forward end of the satellite. The inertial measurement unit, battery, and computer are mounted on longerons near the skin surface at the aft end to facilitate installation, maintenance, and heat radiation. Range safety equipment is located in the SOIM adapter section.

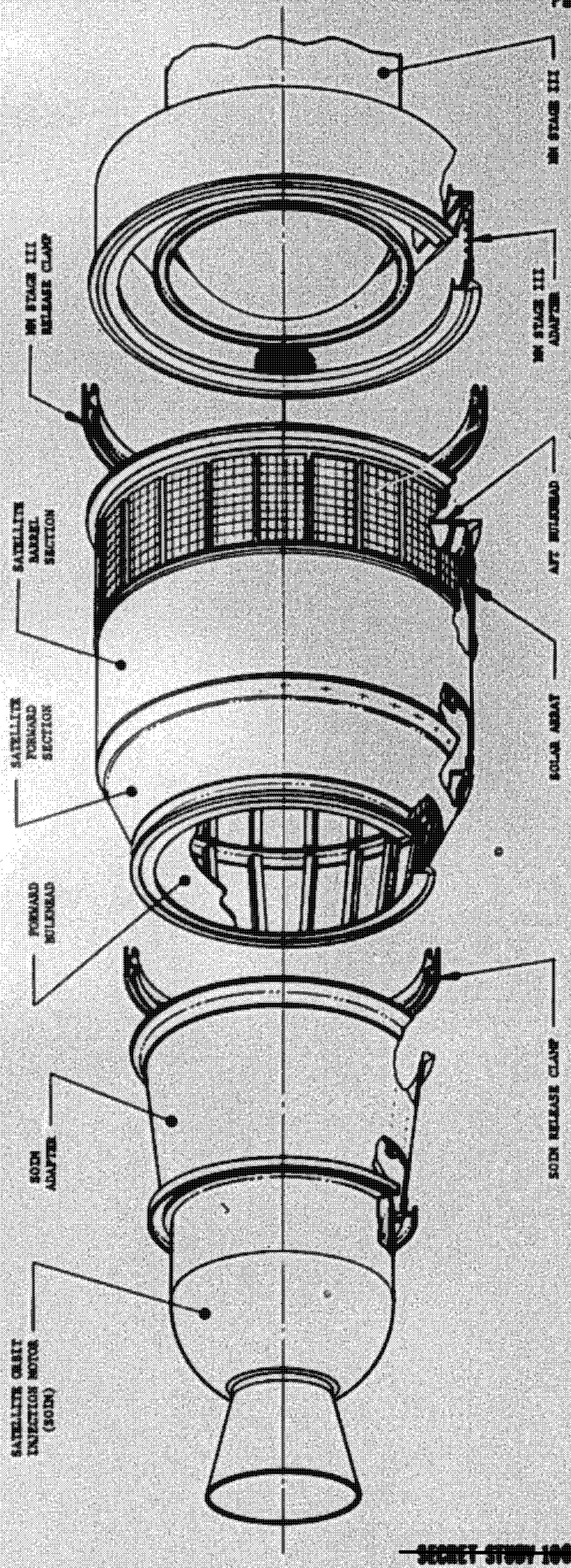


FIGURE IV. C-1 STRUCTURAL SUBSYSTEM

H. Thermal Control Subsystem - The thermal control subsystem utilizes semi-passive techniques rather than evaporative coolers as planned for FASTBACK. Component generated heat is radiated to the satellite skin at the bulkheads and rejected to space. Satellite skin temperatures are controlled by coatings.

Multilayer insulation and heaters may be required on selected components or areas such as propellant tanks or lines for protection because of relatively high minimum temperatures.

The camera is thermally controlled in a manner similar to FASTBACK.

I. Range Safety Subsystem - The range safety communications equipment (Figure IV.I-1) is mounted on the SOIM adapter. This configuration, in conjunction with the remaining flight safety equipment, provides the range safety capability required for launch at WTR.

As noted in the equipment block diagram of Figure IV.I-1, all communication links are implemented with two antennas for 95 percent of spherical coverage. The command function is parallel redundant.

Flight proven equipment will be employed throughout the subject configuration.

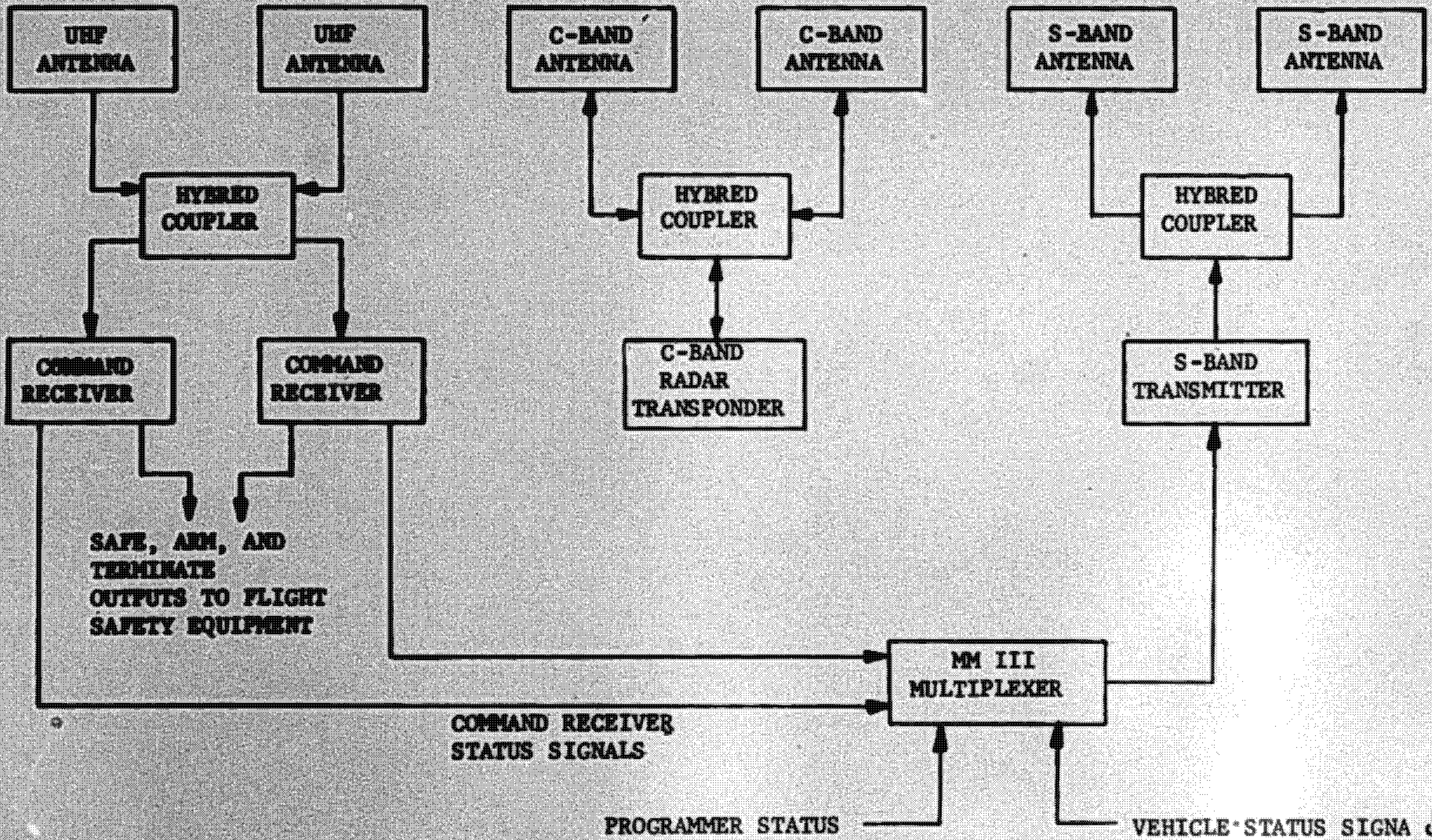
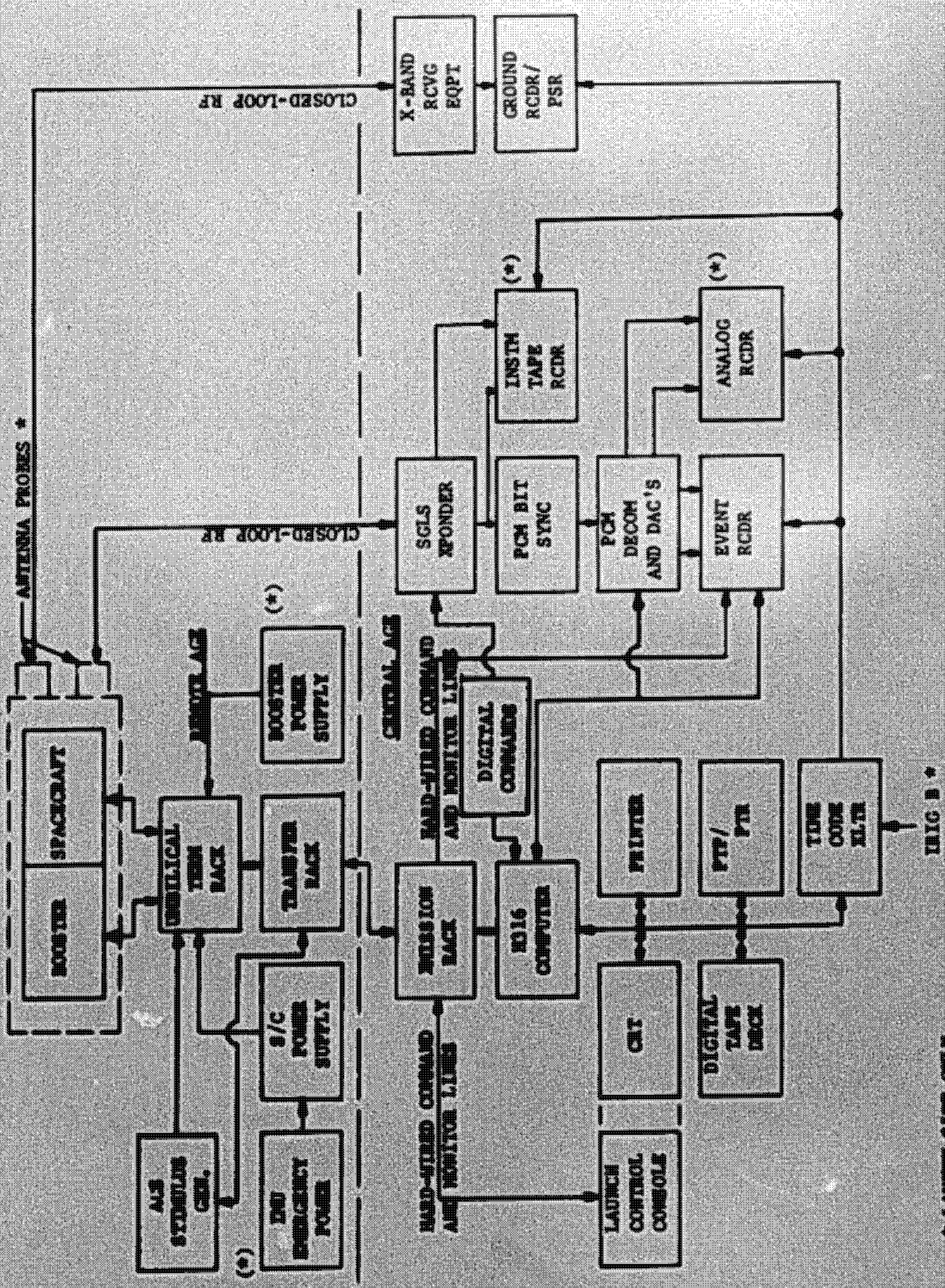


FIGURE IV. I-1 RANGE SAFETY SUBSYSTEM

V. SYSTEM OPERATION

A. Factory Operations - The mission subsystem, the command and status subsystem and the range safety subsystem are mated with the satellite and its subsystems in the factory. A combined system test (CST) is performed using the AGE shown in Figure V.A-1 to obtain factory acceptance. Dynamic balance of the satellite in the "on orbit" condition is performed. The first unit then undergoes a thermal-vacuum test followed by final CST. The satellite (including ordnance and battery) is placed in its shipping container and the unit is air lifted to Vandenberg AFB.



* LAUNCH SITE ONLY

FIGURE V. A-1 ELECTRICAL AGE

B. Prelaunch Operations - The satellite is removed from the shipping container, mated and aligned with the SOIM. A CST is performed using AGE identical to that used at the factory. This assembly is then mated with the Minuteman I booster which was modified at Hill AFB. The payload fairing is installed. A CST is performed prior to transfer to the launch pad. The all-up booster is maintained in a horizontal position. Periodic tests are performed to insure a ready condition.

If required, provisions are made to advance film and Micromat to insure their proper condition.

C. Launch Operations - When the mission directive is received, the booster is erected to the vertical launch position. The inertial monitoring unit is aligned. Guidance equations are computed and loaded. An inclination is selected that allows the orbit to pass over a specified target. This capability provides the basis for computing the 30-day mission subsystem program. Upon completion, the program is loaded into the satellite. The battery is energized and ordnance armed. The terminal countdown is completed, the booster launched, and the satellite is placed into a 95 nm. circular orbit. A Hohmann transfer is performed during the first revolution, just after passing the crisis area latitude, to place the satellite into a 95 x 205 nm. orbit. This flight plan provides a Minuteman I capability of placing a satellite weighing up to 994 lbs. in the 95 x 205 nm. orbit at an inclination of 102° as compared to only 934 lbs. via a direct injection technique. Higher weights can be orbited at lower inclinations. The relationship of the major steps required for final orbit achievement is shown in Figure V.C-1.

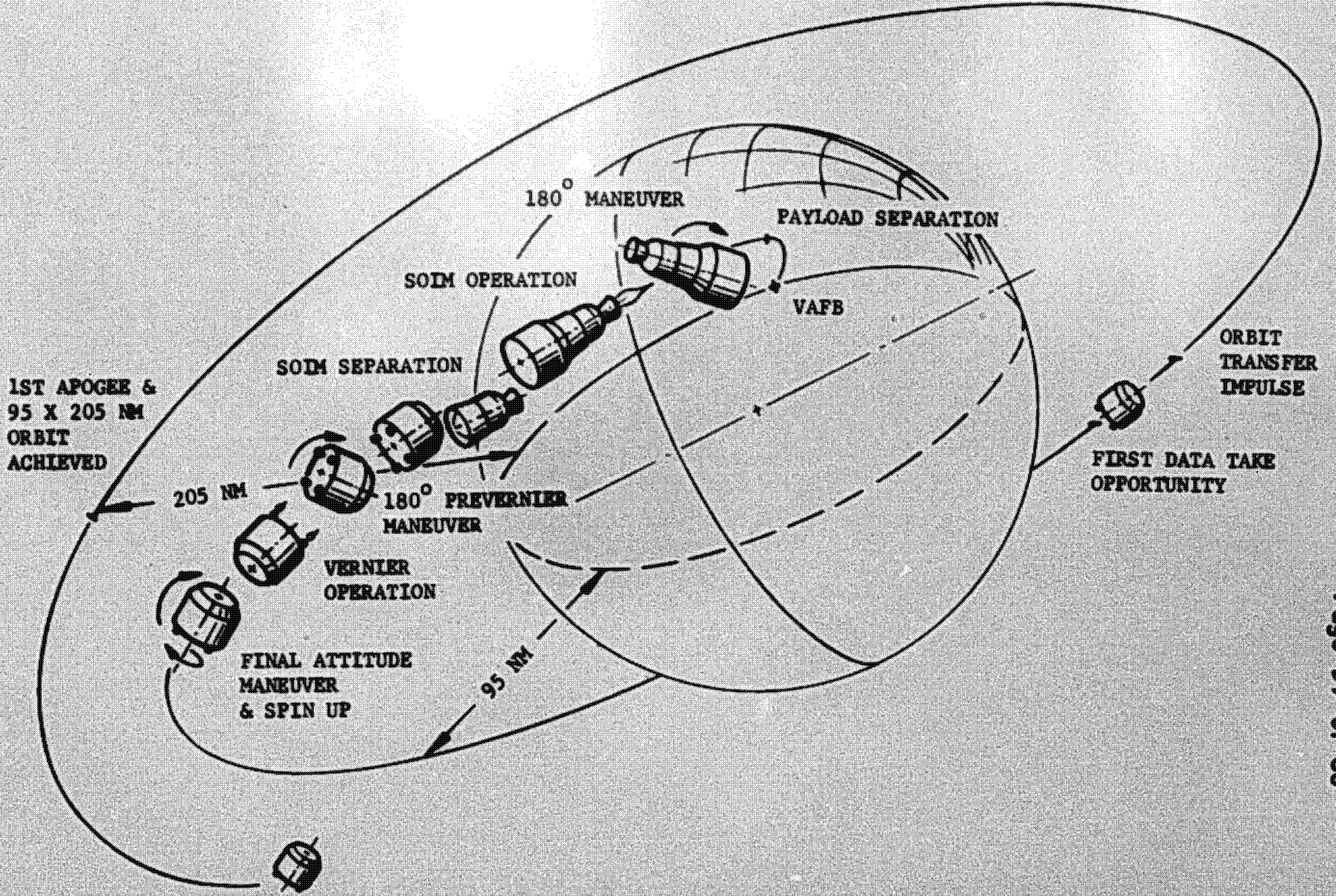


FIGURE V. C-1 ORBIT ACHIEVEMENT

D. Mission Operations - Table V.D-1 is a one-day scenario of a typical mission based on the postulated crisis area and reaction target locations shown in Figure II-1, and the data take opportunities and read-out schedule to New Boston and Vandenberg AFB of an 81° orbit, as shown in Table II-1.

For the 81° orbit, the total available read-out time is enough for 89 equivalent pictures. Because the read-out time occurs in increments, and film indexing problems limit the scanning process to whole pictures, 86 equivalent pictures were taken, developed, scanned, and transmitted. The 8600 square nm. data area is based on each picture covering 10 x 10 nm. Considering the larger coverage per picture, when the camera is pointed off nadir, and the location of the crisis areas and reaction targets with respect to the satellite flight path, a total data area in excess of 9000 square nm. was actually obtained.

TABLE V. D-1 ONE-DAY SCENARIO

PASS NUMBER	PICTURES TAKEN	PICTURES STORED	PICTURES READ OUT	CUMULATIVE DATA AREA (NM^2)
1	0	0	0	0
2	12 + 28*	40	0	↓
3	0	40	0	
4	0	40	0	
5	0	40	0	
6	0	40	0	
7	0	25	15	1500
8	0	25	0	↓
9	0	9	16	3100
10	0	9	0	↓
11	0	9	0	
12	0	9	0	
13	0	0	9	4000
14	16 + 30*	24	22	6200
15	0	0	0	↓
16	0	0	24	8600

* Crisis area + reaction target

Table V.D-2 is an illustrative event sequence covering the first day's operation of an 81° inclined orbit and is related to the map of Figure II-1 and the scenario of Table V.D-1. The need for the 180° maneuver of event 6 is dependent on the velocity achieved at SOIM burn out. If it is higher than nominal, the payload must be turned around before the SOIM is separated to prevent a collision between the satellite and the SOIM during vernier motor retro thrust. If the velocity achieved is lower than nominal, the 180° maneuver (event 8) occurs after the SOIM separates in order to place the vernier motors in a forward thrusting attitude. This serves to add the required velocity increment to the satellite and also moves the satellite away from the SOIM.

The final attitude maneuver of event 11 places the spin axis essentially perpendicular to nadir at the nominal latitude of the mission targets, and places the vernier motors in the position required for the orbit transfer impulse.

The first perigee (event 14) is biased somewhat north of the nominal target latitude in anticipation of the southward drift of the perigee caused by the precession of the line of apsides.

Satellite tracking (see events 18, 19, 24, and 26), to determine the ephemeris adjustments necessary to assure target coverage with a minimum of film processing and data transmission, will be accomplished daily during the mission. Satellite control functions are performed by the satellite and ground SGLS equipment, status data processors, command decoders, and computers at the STC and the tracking stations. Tracking and ephemeris determination are performed by the SCF with the aid of the coherent receiver and transmitter in the satellite. The SCF tracking stations (New Boston and Vandenberg AFB) are capable of measuring range, range rate, and angular coordinates as a function of time, and transmitting the data to the STC for computation of ephemerides. The stations receive

TABLE V. D-2 EVENT SEQUENCE

TL = Time from launch (hours:minutes:seconds)
D = Duration of event (hours:minutes:seconds)
EVNO = Event number
G & C = Guidance and Control Subsystem
SOIM = Satellite Orbit Injection Motor
ACS/ACP = Attitude Control Subsystem/Attitude Control Propulsion
CP = Command Processor

TIME	EVENT	SOURCE	PREREQUISITE	EVNO
	Phase 1 - Launch Preparation			
TL- 04:30:00 D= 04:30:00	Launch preparation and terminal countdown	Launch site AGE	Mission directive	1
	Phase 2 - Ascent to Circular Orbit			
TL+ 00:00:00 D= 02:58	Booster operation and payload fairing jettison	G & C	Launch preparation complete	2
TL+ 00:02:58 D= 01:46	Payload separation and coast	G & C	Booster 3rd stage burn out	3
TL+ 00:03:10 D= 00:30	180° maneuver to injection attitude	G & C	Payload to booster clearance = 20 ft.	4
TL+ 00:04:46 D= 00:44	SOIM operation	G & C	Injection altitude and attitude achieved	5
TL+ 00:05:30 D= 00:30	180° SOIM separation maneuver	G & C	SOIM burn out	6
NOTE: Event 6 only occurs if velocity imparted to payload exceeds nominal				
TL+ 00:06:00 D= 00:10	SOIM separation	G & C	SOIM burn out or SOIM separation maneuver complete	7
TL+ 00:06:10 D= 00:30	180° prevernier maneuver	G & C	Satellite to SOIM clearance = 20 ft.	8
TL+ 00:06:40 D= 00:08	Vernier motor operation	G & C	Prevernier maneuver complete	9
TL+ 00:06:48	95 nm. circular orbit achieved	---	Vernier operation complete	10

TABLE V. D-2 (Continued)

TIME	EVENT	SOURCE	PREREQUISITE	EVNO
	Phase 3 - Fractional Orbit Operation			
TL+ 00:06:50 D= 00:20	Final attitude maneuver	G & C	Vernier operation complete	11
TL+ 00:07:20 D= 00:02	Spin up to 27 rpm	ACS/ACP	Final attitude maneuver complete	12
TL+ 01:03:00 D= 13:45	1st data take opportunity	---	20°N to 75°N latitude dwell time	13
	Phase 4 - Orbital Transfer			
TL+ 01:13:00 D= 00:20	Orbit transfer impulse	ACS/ACP	1st perigee achieved at 50°N latitude	14
TL+ 01:58:00	1st apogee achieved 95 x 205 orbit achieved	---	Orbit transfer impulse achieved	15
	Phase 5 - 30-Day Mission Operation			
TL+ 02:33:00 D= 00:09	1st actual data take (12 pictures)	CP	Crisis area at 30°N latitude achieved (2nd pass)	16
TL+ 02:38:00 D= 00:09	2nd actual data take (28 pictures)	CP	Reaction target area at 50°N latitude achieved (2nd pass)	17
TL+ 10:09:00 D= 03:41	1st data read out and satellite tracking (15 pictures)	CP and transmitter	Within line of sight of New Boston (7th pass)	18
TL+ 13:06:00 D= 03:55	2nd data read out and satellite tracking (16 pictures)	CP and transmitter	Within line of sight of Vandenberg AFB (9th pass)	19

TABLE V. D-2 (Continued)

TIME	EVENT	SOURCE	PREREQUISITE	EVNO
	Phase 5 - 30-Day Mission Operation (Continued)			
TL+ 19:31:00 D= 02:12	3rd data read out and ephemeris update command (9 pictures)	CP and transmitter & receiver	Within line of sight of New Boston (13th pass)	20
TL+ 20:37:30 D= 00:05	3rd actual data take (16 pictures)	CP	Crisis area at 38°N latitude achieved (14th pass)	21
TL+ 20:38:30 D= 00:07	4th actual data take (30 pictures)	CP	Reaction target at 42°N latitude achieved (14th pass)	22
TL+ 20:43:00 D= 00:02	Ephemeris adjustment	ACS/ACP	Perigee achieved (14th pass)	23
TL+ 21:02:00 D= 05:24	4th data read out and satellite tracking (22 pictures)	CP and transmitter	Within line of sight of New Boston (14th pass)	24
TL+ 21:28:00 D= 00:01	Ephemeris adjustment	ACS/ACP	Apogee achieved (14th pass)	25
TL+ 23:55:00 D= 05:53	5th data read out and satellite tracking (24 pictures)	CP and transmitter	Within line of sight of Vandenberg AFB (16th pass)	26

and decommutate status data and transfer selected portions to the STC for real-time computation and analysis. For example, horizon crossing and sun sensor data are used in conjunction with position data for computing satellite attitude, attitude correction commands and mission control commands. Time-word corrections in stored program commands are made at the tracking stations to correct for changes in spin rate. Real-time commands are used to reorient the spin momentum vector while the status system monitors attitude sensors.

Data flow includes mission equipment control and antenna pointing commands, as well as data read out. Requests for mission control originates with the mission plan from the user and are formulated into command messages at the STC, based on correlation of ephemeris time and ground traces with target locations. Corrections in the commands can be made during a station contact if tracking or telemetry indicate time or attitude errors.

Pointing of either of the despun antennas for mission data read out is accomplished by commanding its despin motor rate slightly different than the rate indicated by the rate gyro, so that the antenna beam sweeps slowly across the ground. When the beam is aimed toward the ground station, so that an acceptable signal is received, another command changes the despin motor drive rate to hold the antenna aimed at the station.

Further drift commands are given to change the beam position whenever the beam moves off the station.

The tolerance in orbit injection velocities, due to booster guidance system errors, is such to cause the satellite flight path to be up to 10 nm. east or west of the planned flight path during the first few orbital passes. Although this is well within the access width capability of the camera subsystem, this distance will continually increase during the 30-day mission. The ephemeris adjustments of events 23 and 25 are primarily to eliminate the build-up of these orbit injection errors. After event 26 (the end of the first day), the sequence recycles back to event 13 and repeats for 30 days. During the 30-day mission, orbit sustenance maneuvers of approximately 70 ft. per sec. are required every 5 days to make up for the period decay due to atmospheric drag effects and to make up for the southward drift of the perigee due to the precession of the line of apsides which varies from 17.5° to 22° depending on the orbit inclination.

E. Ground Station Operation - At the New Boston and Vandenberg AFB ground read-out stations, the X-band receiver output is connected to a recorder/processor. This unit produces 9.2 x 9.2 inch hard copy photographs having a resolution corresponding to the 161 lpm of the 4.6 inch mission camera film format. Properly cleared personnel are present at each station during a mission to evaluate and select photographs of prime interest. These selected, priority photographs are inserted into a [redacted] type scanner, converted into electrical signals and immediately transmitted over television bandwidth links [redacted] at the appropriate rate. Another recorder/processor [redacted] produces hard copy photographs. The non-priority photographs can be transmitted at a later time or pouched [redacted]

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

When broadband military communication satellites become operational, data read out will not be limited to the times over ground stations but will occur as rapidly as the film development and scanner capability will permit.

PART II -- MANAGEMENT INFORMATION

VI. PROGRAM MANAGEMENT

The FASTBACK B Program is being proposed, as is the FASTBACK Program, to be accomplished in a relatively short span time and within an attractive dollar estimate. FASTBACK B will accomplish this through use of components and/or technologies from previous successful programs; and by use of a program management structured such that all decisions which impact upon program cost, schedule or technical integrity will be made exclusively by the program management team. Therefore, we will create a consolidated team of qualified and experienced personnel to implement the program. The structure of the team is shown in Figure VI-1.

For FASTBACK B, the actual structure has changed somewhat from FASTBACK to fit the areas of emphasis required peculiarly for FASTBACK B. However, the criteria and philosophy of management remains the same. Each major hardware element, headed by a key individual reporting directly to the Program Director, is subdivided into functional subsystems. These subsystems are of a size that permits each of them to be managed as a closely coordinated operation. Each is staffed with a comprehensive team of personnel having the management, design, procurement, fabrication, and quality skills necessary to perform the assigned task. The manager of each subsystem is empowered with the authority, and carries the responsibility for his subsystem. Satellite assembly and systems tests, including AGE, are performed as one functional subsystem to ensure the integrity of the final product prior to acceptance of the end items.

Mission subsystem is a separate organization to emphasize the most sensitive area of FASTBACK B. A dedicated organization can 1) focus its attention on coordinating the work of the two or three hardware Contractors, 2) expedite and enhance the critical marriage tests, and 3) objectively review satellite design elements which may affect the performance of the mission subsystem.

To develop and maintain total program criteria, integrate the total requirements, provide systems engineering, and perform software analysis, a third major element, Systems Analysis and Integration has been created.

Program level management functions, contract administrattion, central estimating, and master planning and cost management will report directly to the Program Director. The major elements, as well as the subsystems, will have lower tier planning, scheduling, and cost control responsibilities within their organizations. All such effort will complement the master schedule and program budgeting/cost control system.

This organization structure produces a program management concept of relating personnel to a complete sense of personnel responsibility and pride for the successful performance of the FASTBACK B Program tasks.

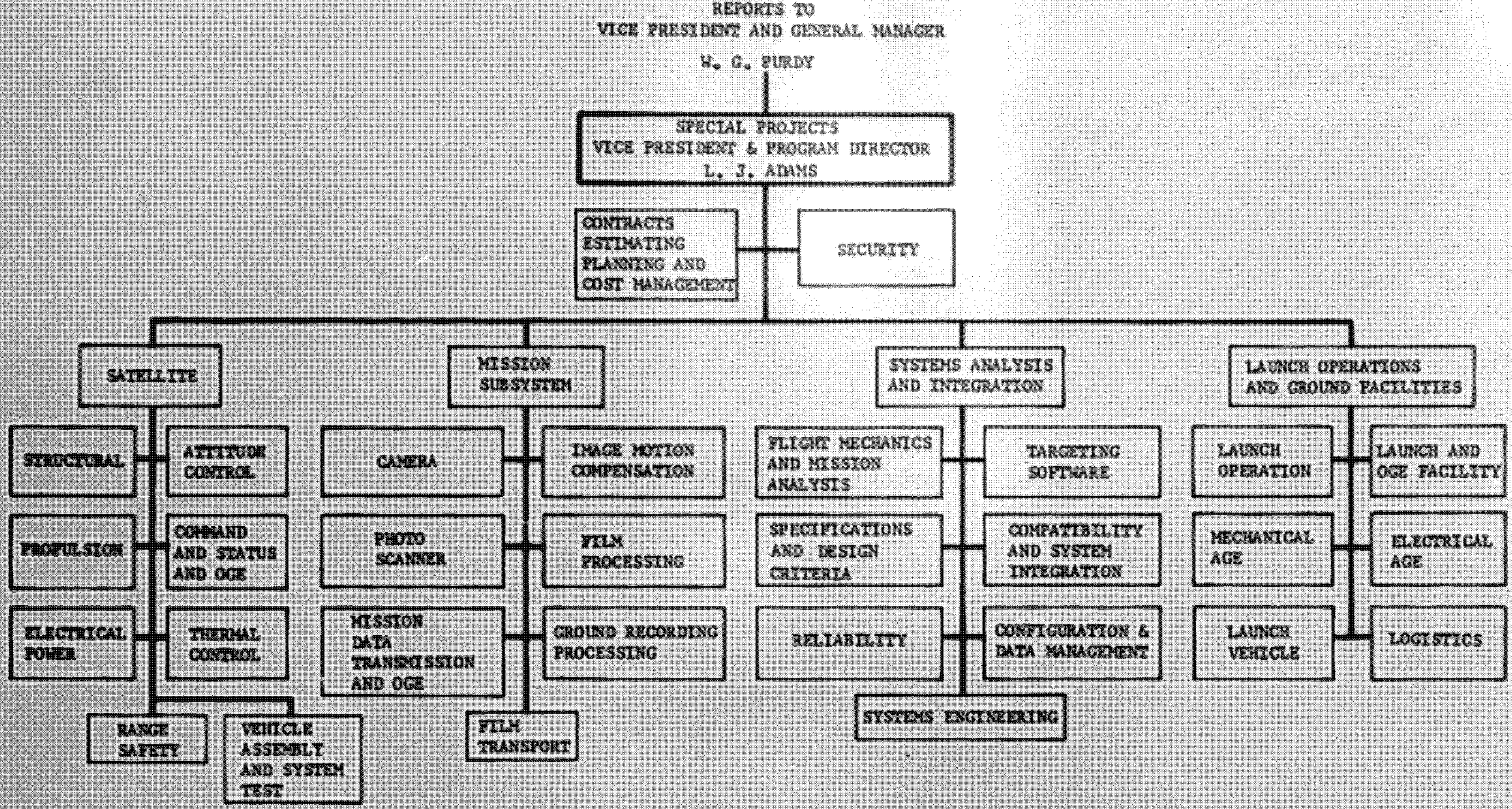


FIGURE VI-1 ORGANIZATION STRUCTURE

VII. PROGRAM SCHEDULE

The Program Master Schedule for FASTBACK B, Figure VII-1 reflects a twenty-two month development phase and a fifty-two month operational program. The development phase is essentially the same plan as for FASTBACK, with consideration given to an alternate hardware configuration.

A. Development Phase - The twenty-two month development phase starts with program go-ahead at the beginning of month one and anticipates having the specifications and criteria completed by month three. The system analysis effort will continue through the development phase to support testing and design problem solution. A Critical Design Review (CDR) is scheduled in the seventh month just prior to satellite final engineering release at the end of month eight.

In the meantime, the procurement orders will have been placed with the major subcontractors and parts suppliers for the breadboarding, mockup, prototype, qualification test articles and for long lead flight components. The test program, starting with development testing at month four, proceeds uniformly into prototype testing and component qualification testing concurrently with elements of the controls mockup (CMU) testing followed by the electronic/controls mockup (ECMU) testing. The structures development test program will be conducted on the prototype structure, starting in month ten, and continuing through month seventeen.

Software requirements will be fully identified by the end of month five. All coding and supplier equipment deliveries will be completed in time to start the software verification program at end of month eight.

Verification and validation of the airborne/ground tape are planned to be complete in month twelve to support vehicle verification testing and acceptance. The flight software

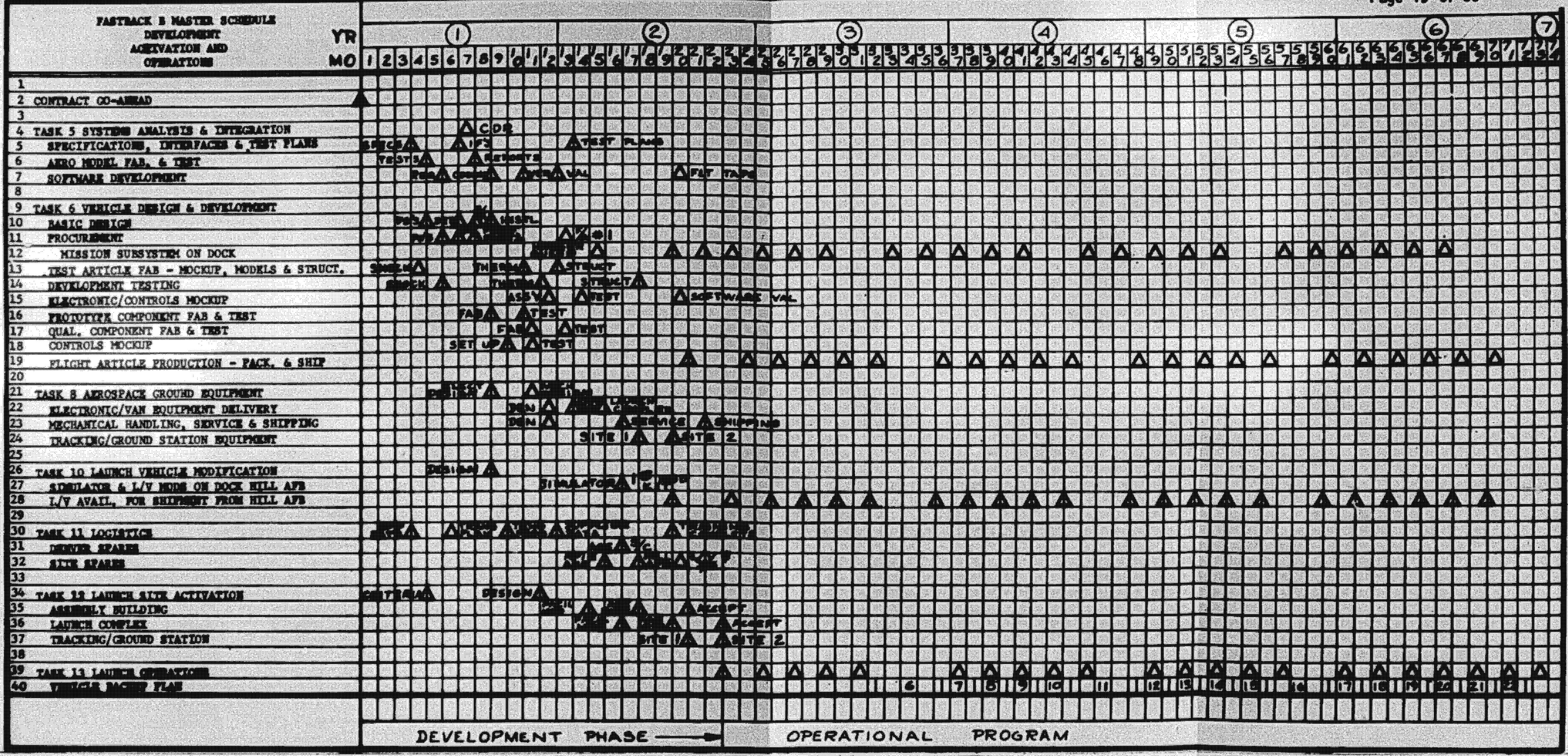


FIGURE VII.- 1 MASTER SCHEDULE

verification and validation effort is planned to be complete in month twenty to support launch complex acceptance.

The ground equipment (AGE) design release is scheduled at eight months for electronic equipment and eleven months for mechanical equipment. The launch site AGE requirements will be duplicated at Denver for satellite acceptance, augmented with a Minuteman I (launch vehicle) simulator. The ground equipment for the launch vehicle modification center, at Hill Air Force Base, will be existing Minuteman I AGE hardware, modified, and a satellite simulator.

Ground recorders and data processors will be delivered to the Remote Tracking Stations at Vandenberg Air Force Base, California and New Boston, New Hampshire for satellite control and data collection. The AGE will be delivered in month seventeen for the first site modification and month nineteen for the second site modification.

Criteria for the launch site activation will be established by the end of month four. Final installation engineering will be released by month eleven. Facility modifications to the assembly building will be completed in month fourteen, ground equipment installed by month seventeen, and the installation accepted in time to receive the first launch vehicle in month twenty. Concurrently, the launch pad construction and modification to the launch operations building are scheduled to be complete by the end of month sixteen, and all ground equipment installed by month nineteen, with full acceptance demonstrated in month twenty-two.

The logistics program requirements include obtaining the launch vehicle Government furnished data in the first three months in order to support the design release of the launch vehicle modification in the eighth month. The comprehensive transportation plan will be completed by the end of month six. Contractor personnel, supporting Denver and the launch site, will begin training by month ten and will be trained by month nineteen. Simultaneously, the program spares inventories will be to operational levels by month twenty.

The first launch is scheduled to occur at the end of month twenty-two and will demonstrate completion of the development program.

B. <u>Operational Program</u> - The operational program is sized to support five launches per year and provides a total of twenty-two complete satellites. After initial delivery of the first two flight articles, the delivery rate is one every sixty days assuming a single production line capability at the Contractor and Subcontractor facilities. A vehicle back-up capability has been provided starting at ten months in the operational program by providing six flight articles during the first year to support five planned flights. In addition to vehicle lot production, a capability is planned to allow some adjustment to take care of a variable vehicle usage.

Concurrently with the satellite delivery program, the launch vehicle modification kits will be delivered to Hill Air Force Base from Denver to meet the launch vehicle modification schedule imposed upon Hill Air Force Base. The schedule for delivery of launch vehicles to the launch site is coincident with the satellite deliveries. The modification line capability is scheduled to support the planned launch and back-up rate.

VIII. PROGRAM PRICE

This budgetary estimate is based on the following considerations:

A. The FASTBACK B schedule.

B. The quantity of satellites is 5 per year (non-recoverable).

C. The FASTBACK B satellite is similar to FASTBACK except for the deletion of:

1. the recovery subsystem,
2. the reentry heat shield,
3. electrical subsystem, and
4. camera trunnions

and the addition of:

1. the film processor scanner and data transmission subsystem,
2. the 30-day attitude control, thermal control, and solar cell electrical power subsystems,
3. the command and status subsystem, and
4. mission data transmission.

D. A WTR range safety subsystem is included.

E. The FASTBACK B ground equipment is similar to FASTBACK with the following additions:

1. Two sets of command and status AGE.
2. Four film scanner exercisers.
3. Two sets of recorder/processor OGE.

F. A minimum launch crew with capability of performing 5 launches per year.

G. Existing Martin Marietta Corporation facilities will be used for fabrication and test of satellites and AGE/OGE.

Vendor information has been applied for the mission subsystem and other significant cost items.

Table VIII-1 shows the contribution of each task to the budgetary estimate.

TABLE VIII-1 BUDGETARY ESTIMATE

Task No.	Task Description	Non-Recurring Price (Thousands)	Recurring Price (Thousands)	Total Price (Thousands)
04.XX	Program Management	$ 1,804.2	$ 2,610.8	$ 4,415.0
05.XX	Systems Analysis and Integration	6,210.0	482.7	6,692.7
06.XX	Vehicle Design and Development			
06.01	Mission	16,763.2	58,191.0	74,954.2
06.02	Command and Status	1,475.0	12,400.0	13,875.0
06.03	Attitude Control	5,500.0	18,359.4	23,859.4
06.04	Attitude Control & Reaction Control	2,804.9	12,113.3	14,918.2
06.05	Electrical Power	3,164.3	5,114.2	8,278.5
06.06	Structure	6,996.0	14,480.0	21,476.0
06.07	Thermal Control	396.8	1,687.8	2,084.6
06.08	Range Safety	739.4	4,452.6	5,192.0
06.09	Vehicle Assembly, Test, Pack and Ship	1,728.5	5,662.3	7,390.8
08.XX	Aerospace Ground Equipment			
08.01	Electrical AGE/OGE	7,299.4		7,299.4
08.02	Mechanical AGE/OGE	2,450.7		2,450.7
08.03 & 04	Electrical & Mechanical AGE/OGE Maintenance		151.2	151.2
08.05	Mission OGE	4,000.4		4,000.4
08.06	Command and Status AGE		(Included in 08.01 Price)	
08.07	Exerciser	1,760.0		1,760.0
08.08	AGE/OGE Pack and Ship	85.9		85.9
10.XX	Launch Vehicle Modification		776.4	776.4
11.XX	Logistics	787.9	14,523.1	15,311.0
12.XX	Launch Site Activation	3,334.0		3,334.0
13.XX	Launch Operations		6,027.4	6,027.4
	Total Program Price	$67,300.6	$157,032.2	$224,332.8

Unit Recurring Spacecraft Price (Task 06.XX) = $6,020,936