(S) NATIONAL RECONNAISSANCE OFFICE

WASHINGTON, D.C.

OFFICE OF THE DIRECTOR

29 APR 1966

MEMORANDUM FOR: DIRECTOR OF SPECIAL PROJECTS, SAF
DIRECTOR OF RECONNAISSANCE, CIA

SUBJECT: System Operational Requirements for the New Search and Surveillance System

The approved System Operational Requirement for the New Search and Surveillance System is attached for your information and guidance.

In this regard, if desired, appropriate project personnel may be given the opportunity to familiarize themselves with the supplementary rationale contained in Attachments 4-1, 4-2, 4-3, and 4-4 to my April 23 memorandum to the Executive Committee.

Alexander H. Flax

Attachment

SYSTEM OPERATIONAL
REQUIREMENT
FOR A
NEW PHOTOGRAPHIC GENERAL SEARCH AND SURVEILLANCE
SATELLITE SYSTEM

March 1966

TABLE OF CONTENTS

GENERAL SYSTEM OPERATIONAL REQUIREMENTS

The stated in' .lligence requirements for a new photographic general search and surveillance satellite system are reflected in the following general system operational requirements. A description of the system, and the specific technical and operational criteria which this system must meet, are contained in the following sections of this report.

A continued requirement will exist for the United States to acquire satellite photographic reconnaissance of any designated part of the earth's surface as a primary source of information on the status, capability and threat posed by potentially hostile nations to the peace of the free world.

The new General Search and Surveillance System will be designed to provide an optimum capability for fulfilling the national search and surveillance objectives specified for the time period beginning in 1969 by the United States Intelligence Board through the Committee on Overhead Reconnaissance. These search and surveillance activities will be conducted in an environment similar to the current world situation ranging from a "normal" or cold war, through crisis situations during periods of international tension.

Priority will be given to photography of built-up areas of the USSR and China. The capability to cover other designated areas of the world is also required.

Systematic search of some 12 million square nautical miles may be required semi-annually, to detect activities associated with possible threats against the United States. Periodic surveillance is required of previously known specific objective targets at a ground resolution sufficient to detect and analyze changes in the status or capability of a target. Repetitive coverage of certain types of targets and target complexes is vitally important to permit a definitive analysis and to detect changes in status. Numerically, coverage approaching a total of [redacted] specific targets may be required, with coverages of various numbers required at intervals of two months, quarterly, semi-annually, and annually. Most primary targets are expected to be distributed throughout the Sino-Soviet land mass.

During periods of crisis, photographic coverage of any selected area of the world is desired. Crisis situation targets will be similar in character and require about the same ground resolution as those identified under search and surveillance. However, to prove effective, the satellite reconnaissance capability used for crisis situations must be flexible, i.e., capable of prolonged "standby" periods prior to launch, rapid response after the decision to launch is received, and responsive to on-orbit command and control. In addition, the overall system must be designed for minimal time between launch, recovery and delivery of photography to the user.

In meeting these requirements, the new system must be capable of providing a ground resolution from design perigee altitude of 2.7 feet or better at nadir. In addition, symmetrical stereo photography at appropriate convergent angles is required.

With a regard to anti-satellite defensive protection, the initial system design should consider precautionary features such as "passive" operation over area of interest, secure "activate-deactivate" and recovery command sequences, etc. Reasonable provisions will be included during design for volume, structural strength, power, etc., necessary for possible later incorporation of vulnerability reduction devices such as radiation shielding, shielding against pellet attack, decoys, electronic counter-measures (ECM), etc. These provisions may also be used [redacted] instead of the vulnerability reduction devices as appropriate. Since most of these vulnerability-reducing measures are threat dependent, initiation of development of specific devices should be deferred to as late in the system development period as possible to allow maximum use of timely threat intelligence.

Optimum use of existing or planned launching and on-orbit control equipments and facilities is desired with minimal modification where necessary, and the new system will be as nearly compatible with existing or planned command and control equipments and facilities as is practicable. Established recovery system equipments and methods will be utilized with minimal modification as necessary. The primary recovery zone will be the present Hawaiian recovery area. A contingency land recovery capability may be considered with no compromise to the primary mission or recovery method.

Existing photographic processing and data handling support facilities with equipment updated to the operational time period (and other modifications if required) will be used in exploitation of photography acquired by this new system.

SYSTEM DESCRIPTION

This section provides a general description, together with key operational constraints and requirements, of the new General Search and Surveillance System. A more detailed definition of the specific technical and operational criteria applicable to the various subsystems follows in the next section of this document.

The outboard profile of the entire aerospace vehicle is shown in Figure 1.

Launch Vehicle. The launch vehicle which has been selected for this system is the TITAN IIID. The TITAN IIID consists of stages 1 and 2 of the TITAN III, with two 120-inch diameter three-segment solid-propellant motors strapped on the sides of the first stage. This booster uses BTL radio guidance during powered flight and accomplishes a direct injection of the space vehicle into the desired orbit. The TITAN IIID is capable of placing a payload in excess of 16,000 pounds into a 100 NM circular 96^{o} orbit from PMR and is capable of orbital inclinations from 75^{o} to 140^{o}. (Current range safety restrictions require a waiver below 83^{o}). The TITAN IIID is capable of holding for launch at T-1 hour or less for 30 days.

No orbit control requirements are imposed on the booster. After stage 2 engine cut-off, the space vehicle is separated from the stage and a retro velocity is imparted to the stage.

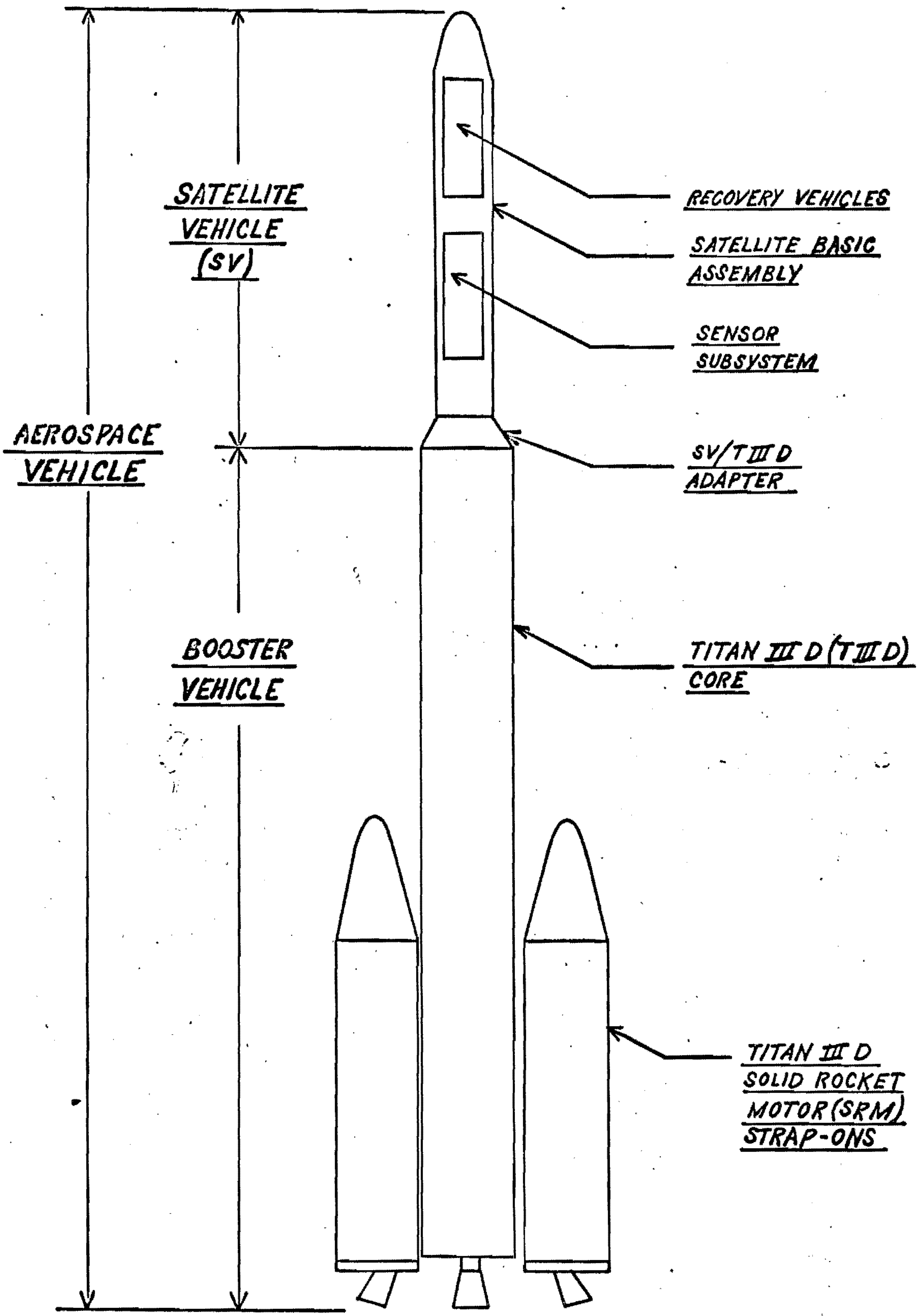

FIG. 1 - AEROSPACE VEHICLE OUTBOARD PROFILE

Satellite Vehicle. The Satellite Vehicle is the entire assemblage placed into orbit by the launch vehicle. It includes a Sensor Subsystem, a Satellite Basic Assembly, and the necessary Recovery Vehicles.

Sensor Subsystem: The Sensor Subsystem provides two panoramic cameras mounted for stereo imagery and includes all elements of the film path; all camera-peculiar electronics, and/or pneumatics necessary for operation of these elements in response to commands; power conversion components peculiar to the sensor subsystem; and a housing which establishes and controls the internal environment for the sensor and provides the structural support for all internal elements of the sensor subsystem.

Satellite Basic Assembly (SBA): The Satellite Basic Assembly provides the basic structure to support, house and protect all elements of the Satellite Vehicle and includes equipment necessary for on-orbit control, vehicle attitude control, orbit period control, and telemetry, tracking, command functions, all general electric power, and de-orbit control. It provides the controlled environment necessary for the proper operation of all subsystems and elements of the satellite vehicle during launch and in orbit. The Satellite Basic Assembly includes the Stellar Index and Terrain Frame Cameras (SI) and associated structure and power.

Recovery Vehicles: The Recovery Vehicles are mounted along the vehicle longitudinal axis and supported structurally by the SV. The primary recovery vehicles are identical in all respects except for the differences in film path imposed by the requirement to take-up of film sequentially. Each recovery vehicle consists of a heat shield; a spin-deboost-despin system, a parachute system; a watertight canister containing two film take-up reels (the reels are part of the film path); an events sequencer with appropriate electric power; and necessary telemetry, recovery aids, and security aids.

The spacecraft structure must be designed to accommodate the anticipated loads for either two or four Primary RV's. However, before final design is released, the system implications of each will be studied in detail and a specific configuration designated.

A separate recovery vehicle for the SI film will be provided and mounted appropriately within the Satellite Basic Assembly, or if more advantageous, one of the multiple RV's will be used for this purpose.

Operational Support. Launches will be conducted by the 6595th Test Wing from a launch pad such as PALC II Pad 4 at the Vandenberg Air Force Base complex. The system must meet all range safety requirements of the Air Force Western Test Range.

On-orbit operations will be controlled through the Satellite Test Center in response to direction from the Satellite Operations Center.

Recovery will be accomplished by air catch over the Pacific Ocean in the general area of Hawaii. RV dispersions, velocities, weights and diameters will be compatible with the capabilities of the USAF 6594th Recovery Wing operating with C-130 type aircraft.

Operational Constraints. The search and surveillance mission will be accomplished by relatively long-life vehicles (at least 25 days mission duration) launched at intervals of approximately 60 days. The Satellite Vehicle will include the option of increasing expendables to obtain increased life.

The typical mission will be conducted near the sun synchronous orbit inclination (orbit plane inclined slightly more than 96 degrees to the earth's equator). A sun synchronous orbit with period determined by perigee altitude for design camera performance and system resolution requirements will be identified as the reference orbit. In general, the reference orbit is defined as the least elliptic orbit which meets all these constraints at perigee altitudes not less than 80 NM. The mission duration must be satisfied specifically for the reference orbit conditions.

In order to provide flexibility, the system must be capable of being operated in a wide spectrum of orbits in addition to the reference orbit, although it is not a firm requirement that maximum duration requirements be met for those off reference orbits. It is required that the system be capable of operation (photography) at all orbital altitudes between 80 and

240 nautical miles and at synchronous periods of three days and greater. (A three-day synchronous period repeats ground traces beginning on the fourth day.) Orbits with earth synchronous periods of three days or greater and sun-synchronous inclination are shown by the cross-hatched portion of Figure 2. The additional orbits shown in Figure 2 would provide the added flexibility of a family of orbits with ground tracks on successive days lying west of the preceding day's.

Although no firm criteria for selecting an inclination other than sun-synchronous can be stated at this time, the capability to launch and operate in orbits with inclination from 75 to 140 degrees is required.

The overall system design must provide the capability to launch at any time commensurate with the desired latitude of photography, orbital inclinations, and environmental constraints as described herein.

There is no requirement to incorporate specific provisions in the initial operational system configuration to enhance survivability in a counter-measures environment. It is a requirement, however, to evaluate the potential threat and to define configuration options which could be employed in response to countermeasures activity. It is permissible to consider reduced mission life if required in order to employ these options, but it shall be an objective that provisions to incorporate them do not degrade the other capabilities of the operational configuration.

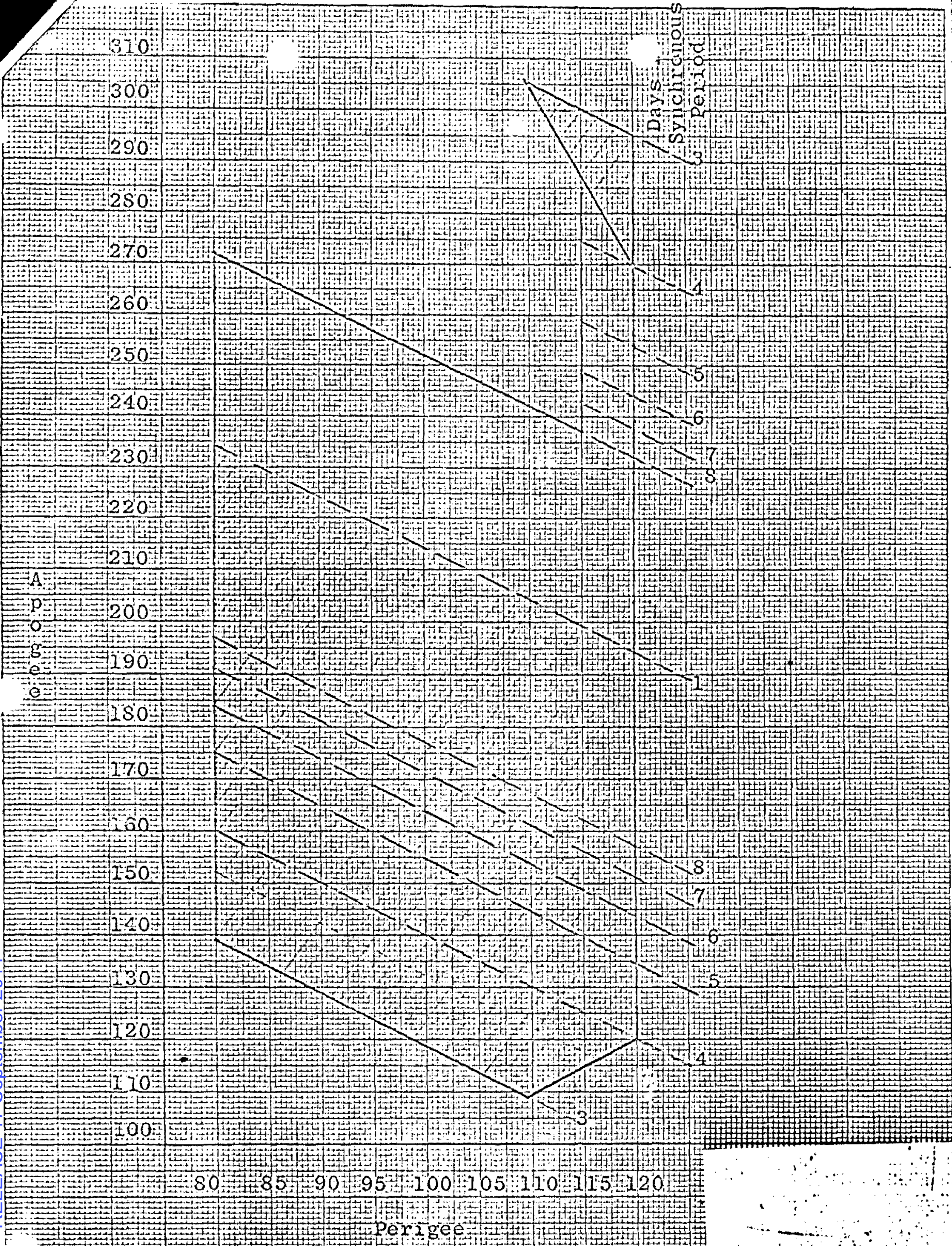
Apogee
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
Days Synchronous Period
3
4
5
6
7
8
1
8
7
6
5
4
3
80 85 90 95 100 105 110 115 120
Perigee

Figure 2

In normal operations, the booster will be targeted to accomplish a direct injection into orbit at perigee, thus fixing perigee initially at about 20 degrees North Latitude. Perigee location will move north as a result of the apsidal motion caused by oblateness of the earth. When perigee reaches 55 degrees North Latitude, the orbit adjust capability will be used to stabilize the apsidal orientation. For these perigee constraints, the camera must be capable of photography at true anomalies within $\pm$ 100 degrees. A capability is required to obtain photography on both south to north and north to south elements of the orbit.

Preliminary orbit determination will be based upon telemetered guidance conditions at separation of the space vehicle. More precise determination will be accomplished as tracking contacts are made by the Satellite Control Facility. The capability of the SV orbit adjust system will be used to establish the proper period. During the mission life, the orbit adjust system must also provide a period adjust capability to counteract the effects of atmospheric drag, and/or to adjust or maintain location of perigee and to deorbit the satellite vehicle after the mission is completed.

Recovery of the first RV will be accomplished when the nominal film weight has been loaded on the take-up reels. Camera operating decisions will normally be programmed to use the film throughout the nominal mission duration, so that recovery of subsequent RV's will be at specific times throughout the mission. In the event of a critical on-orbit failure, a back-up capability will be provided to recover any RV into which film has been spooled.

Subsequent to the recovery of the final RV, the space vehicle will be deorbited to impact in a water area.

TECHNICAL AND OPERATIONAL CRITERIA

SYSTEM PERFORMANCE REQUIREMENTS

Resolution - The required ground resolution for the system from design perigee altitude shall be 2.7 feet or better at scan nadir.

Ground resolution is to be stated as the geometric mean from design altitude for a Mil Std 150A three-bar target with 2:1 contrast at the entrance pupil and with 30 degrees sun angle. This resolution shall include the effects of manufacturing tolerances and is to be stated for dynamic conditions at 2 sigma focus and smear.

For purposes of standardization, resolution off nadir will be degraded with the scan angle by the secant of the scan angle to the 3/2 power and will be degraded further by any change in manufacturing tolerances, smear, focus, and other factors associated with the scan angle.

Stereo Coverage - Equal-scale convergent stereo coverage with an included angle of at least 20 degrees symmetrical to the vertical shall be provided. A capability to furnish monoscopic coverage with each camera shall also be provided.

Viewing Obliquity - The solution used for cross-track scanning shall produce a viewing obliquity of at least 45 degrees and shall not exceed 60 degrees. A capability to program total scan angle in 15° increments and to select any increment within the scan for photography is desired. However, the provision for varying scan angle or selecting any increment within the scan should not cause substantial degradation in system reliability or increase in system cost. If programmable scan angle is not provided then the amount of film required will be adjusted in accordance with the stipulations in paragraph 4, Coverage Requirements.

Coverage Requirements - The system must produce enough imagery to insure repeated coverage of the Sino-Soviet Bloc [redacted]

The imagery acquired depends upon the swath width (scan angle) provided by the system. This system shall carry sufficient film per day per camera to photograph

$$\frac{730,000\ (\text{design scan angle})}{\text{scan angle to achieve 140 NM swath from design perigee}}\ NM^2 .$$

This formula takes account of the effects of cloud cover, season of the year, typical target spread for search, surveillance, mapping and charting, and engineering test missions and duplicative frame to frame coverage. If programmable and selectable scan is provided, the constant in this formula may be decreased from 730,000 to 680,000.

Continuity - The overall system design shall provide a capability for continuous in-track coverage during system operation, and shall provide 3% overlap in-track at nadir.

Mensuration - A design goal for the GSS shall be the determination of the location of the nadir point of any frame relative to an established earth-datum within an error of 450 feet horizontally and 300 feet vertically, and determination of the relative position of points separated by not more than 20 miles ground distance to 40 feet horizontally and 10 feet vertically. The Sensor Subsystem should include provision for calibration with the other elements of the Satellite Vehicle as required to achieve this goal.

SATELLITE VEHICLE

General Definition - The Satellite Vehicle is the entire on-orbit configuration. It consists of the Sensor Subsystem (SS), the Satellite Basic Assembly (SBA), and the Recovery Vehicles (RV's). Figure 3 identifies the major components and functions of each subsystem.

The general design goal for the space vehicle shall be minimum weight consistent with the required performance and reliability specifications. The outside diameter of the entire space vehicle will not exceed 120 inches.

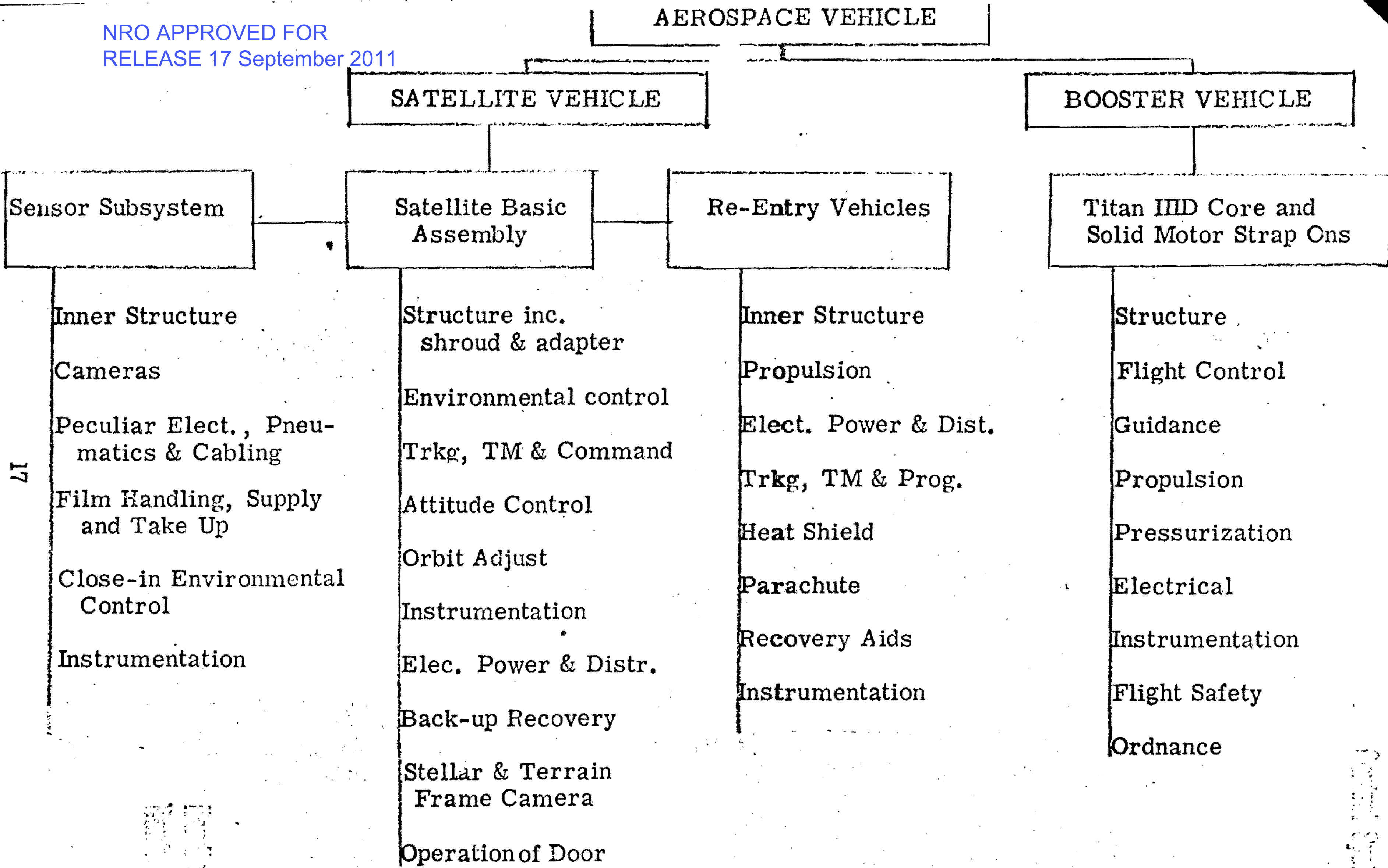
AEROSPACE VEHICLE
SATELLITE VEHICLE
BOOSTER VEHICLE
Sensor Subsystem
Satellite Basic Assembly
Re-Entry Vehicles
Titan IIID Core and Solid Motor Strap Ons
Inner Structure
Cameras
Peculiar Elect., Pneumatics & Cabling
Film Handling, Supply and Take Up
Close-in Environmental Control
Instrumentation
Structure inc. shroud & adapter
Environmental control
Trkg, TM & Command
Attitude Control
Orbit Adjust
Instrumentation
Elec. Power & Distr.
Back-up Recovery
Stellar & Terrain Frame Camera
Operation of Door
Inner Structure
Propulsion
Elect. Power & Dist.
Trkg, TM & Prog.
Heat Shield
Parachute
Recovery Aids
Instrumentation
Structure
Flight Control
Guidance
Propulsion
Pressurization
Electrical
Instrumentation
Flight Safety
Ordnance

Figure 3

Sensor Subsystem (SS)

Technical criteria for the major components of the sensor subsystem are as follows:

Panoramic Cameras: The SS will contain two panoramic cameras. Each camera includes an optical system and a film transport system for controlling the movement of film within the camera. The cameras will be mounted for stereo viewing at equal scale and equal angle. Maximum film width will be 9 1/2 inches.

Sensor Subsystem Electronics and Pneumatics: All electronic and pneumatic components required for the operation of the sensor subsystem maybe mounted with the sensor subsystem.

Environmental Control: The Sensor Subsystem will provide the environment dictated by the requirements of the panoramic cameras and film. This environment will include controlled temperature, pressure, and humidity. The Sensor Subsystem will operate within the environment provided by the Satellite Vehicle. The Satellite Vehicle must provide an environment acceptable to the Sensor Subsystem over the range of angles between the orbit plane and the earth sun line angles of $\leq$ 60 degrees.

Sensor-Peculiar Power Supply Components: Any power supply conversion components which are required solely for the operation of the panoramic cameras, and associated instrumentation maybe mounted with the Sensor Subsystem.

Film Handling System: The film handling system consists of the supply cassettes, the take-up cassettes, and provisions for cut or splice and wrap, and all other components which have to do with the guiding or supporting of the film path and its light-tight integrity external to the panoramic camera. With the exception of the take-up cassettes and their associated drives, all components of the film handling system may be mounted with the sensor subsystem. The take-up cassettes will be mounted internal to the RV's.

Satellite Basic Assembly (SBA)

The general function of the SBA is to provide the structure to mount and protect all elements of the satellite vehicle and to provide stabilization, propulsion, command and control, and power for the satellite vehicle. Provision shall be made to control the orbital decay and re-entry of the space vehicle upon completion of the mission so that the probability of land impact of any part of the space vehicle is less than 0.01. Technical criteria for the major components of the SBA are as follows:

Attitude Control: The attitude control system will provide 3 axis earth oriented stabilization for the entire space vehicle. The stability requirements must be consistent with the overall resolution performance goals of the system. Minimum tolerable attitude accuracies during photographic operations are:

Roll Error	0.7 degrees
Pitch Error	0.7 degrees
Yaw Error	0.8 degrees

The instantaneous SV rates about each of the three principal axes at any time during photographic operation will not exceed the following:

Roll	0.012 degrees/sec
Pitch	0.008 degrees/sec
Yaw	0.008 degrees/sec

A back-up stabilization capability to continue the mission will be provided at a reduced attitude accuracy if required.

Command and Control: The command and control system consists of a programmer and associated encoders, and an RF link with the Satellite Control Facility. Its main function is to provide discrete commands and other necessary data to the spacecraft. The command and control system must be compatible with the configuration of the Satellite Control Facility and include a capability for updating and revising the operating program on-orbit. Secure commands will be provided for those functions which could abort the mission. A back-up command and control capability to continue the mission will be provided at reduced capacity if required.

Tracking Transponder: The transponder is a beacon to assist tracking by the Satellite Control Facility and must be compatible with the requirements of this facility.

Telemetry: The telemetry system must meet the requirements of all equipment aboard the Satellite Vehicle. The telemetry system does not include transducers and signal conditioners peculiar to the Sensor Subsystem. A capability must be provided to store for later playback certain critical data relative to Sensor Subsystem operation, the Satellite Basic Assembly performance, and general health data of the Satellite

Vehicle. The telemetry system must be compatible with the Satellite Control Facility equipments.

Orbit Adjust: The orbit adjust system is a propulsion system integral with the Satellite Basic Assembly designed to insure that the required orbit is maintained for the duration of the mission. In particular, the orbit adjust system must be capable of adjusting and maintaining the desired period and location of perigee.

Power Supply: The power supply for the entire Satellite Vehicle will be an integral part of the Satellite Basic Assembly except for power conversion equipment peculiar to the Sensor Subsystem, and for the RV power requirements.

[redacted]

Back-Up Recovery: The Satellite Basic Assembly must include an independent subsystem to enable recovery in the event of a primary system failure. This back-up recovery system must provide a high probability of successful recovery in the primary recovery area in the event of a failure of the primary attitude control system, the command system, or the on-board programmer.

Structure: The Satellite Basic Assembly will provide the primary load carrying structure for the entire Satellite Vehicle and will be adequate to carry the acceleration and wind loads during powered flight. The Satellite Basic Assembly structure will also provide a mechanical interface with the RV's.

Stellar Index and Terrain Frame Camera: The Satellite Basic Assembly will contain a subsystem to record that data necessary for timely and accurate post-flight determination of the orientation of the panoramic camera optical axis during camera operations, and the calibration of the panoramic imagery with an accuracy consistent with the system performance requirements for mensuration.

Re-Entry Vehicles (RV's)

The Satellite Vehicle configuration will provide for mounting and protecting Recovery Vehicles. The RV's will be separated sequentially by command during the orbital operation. The RV's will be essentially identical. Each Recovery Vehicle will contain two take-up cassettes - one for each main panoramic camera. The re-entry vehicle design must permit a successful recovery in the primary recovery zone from all orbits described in the System Description Section of this document. In addition, the recovery vehicles must be capable of successful re-entry over the range of payload weights from both take-up cassettes empty to both full, and with any weight distribution between the two cassettes. A separate recovery vehicle will be carried for the SI film or one of the primary RV's may be used if found more advantageous. Technical criteria for the major components of the recovery vehicles are as follows:

Heat Shield: The ablative or other appropriate heat shield will provide for the protection of the film cassettes and other RV subsystems during the re-entry phase of the operation. The heat shield and its associated thermal coatings and insulation must be designed so that the internal time/temperature profile does not exceed the constraints specified for protecting the physical and chemical properties of the exposed film.

Retro Rocket: The retro rocket will provide for a Δ V large enough to insure that the re-entry dispersions do not exceed the requirements of the recovery force.

Spin-Despin System: The spin-despin system will impart a controlled angular velocity to the Recovery Vehicle after separation from the space vehicle. After firing the retro rocket, the RV will be despun to an accuracy as required by the re-entry dynamics of the vehicle.

Parachute System: The parachute system will insure that the sink rate of the package to be recovered does not exceed a specified velocity/altitude profile as determined by the capability of the recovery force.

The parachute configuration must also be consistent with the air-borne catch gear deployed with the recovery force.

Re-Entry Vehicle Electronics: The RV will contain electronic subsystems as required for sequencing events, tracking, and telemetry. The RV will also contain its own power supply for operation of these subsystems after separation from the Satellite Vehicle.

Structure: Each RV will contain a load carrying structure to integrate all RV components and to provide an internal mechanical interface for the take-up cassettes and associated components as well as an external mechanical interface for mating to the space vehicle. This structure will be adequate to carry the powered flight loads of the empty RV's and the re-entry loads of the RV's with both take-up cassettes full. The structure shall also guarantee structural integrity upon water impact and insure flotation. Provision will be made for destructive sinking after 48 hours as a security precaution.

Launch Vehicle

The Launch Vehicle for this system is the TITAN IIID. A capability to achieve a range of operational orbits from 75 to 140 degrees is required. Applicable specifications for this Launch Vehicle shall be used during system design and development.