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HEXAGON

~~(S)~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

THE DIRECTOR

29 APR 1966

MEMORANDUM FOR: DIRECTOR OF SPECIAL PROJECTS, S&W ←
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
Alexander H. Flax

Attachment

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

March 1966

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GENERAL SYSTEM OPERATIONAL REQUIREMENTS

The stated intelligence 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 5,000 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] 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.

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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 IID. The TITAN IID 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 IID is capable of placing a payload in excess of 16,000 pounds into a 100 NM circular 96° orbit from PMR and is capable of orbital inclinations from 75° to 140° . (Current range safety restrictions require a waiver below 83°). The TITAN IID 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.

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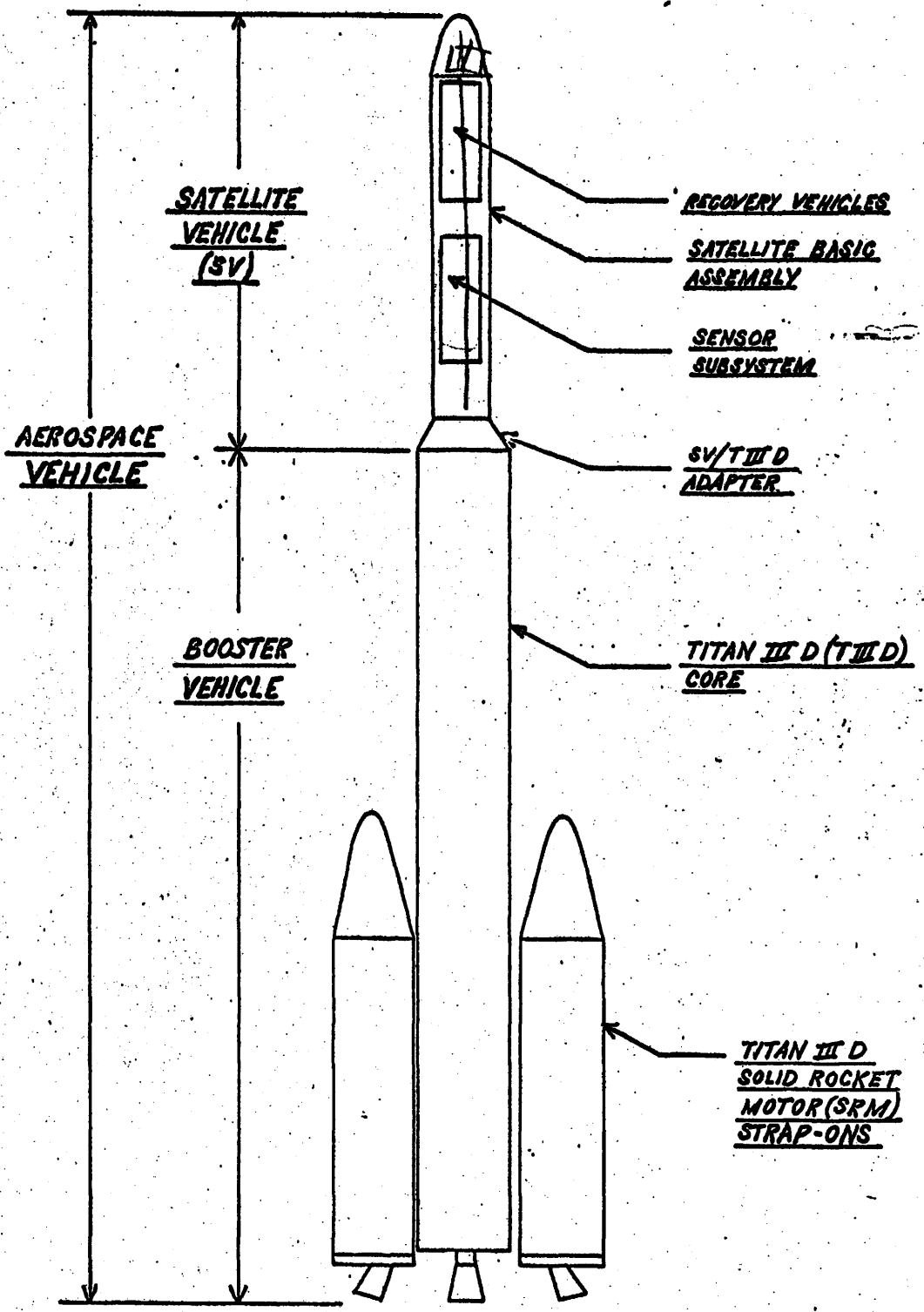


FIG.1 - AEROSPACE VEHICLE OUTBOARD PROFILE

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.

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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

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240 nautical miles, and at synchronous periods of three days and greater.

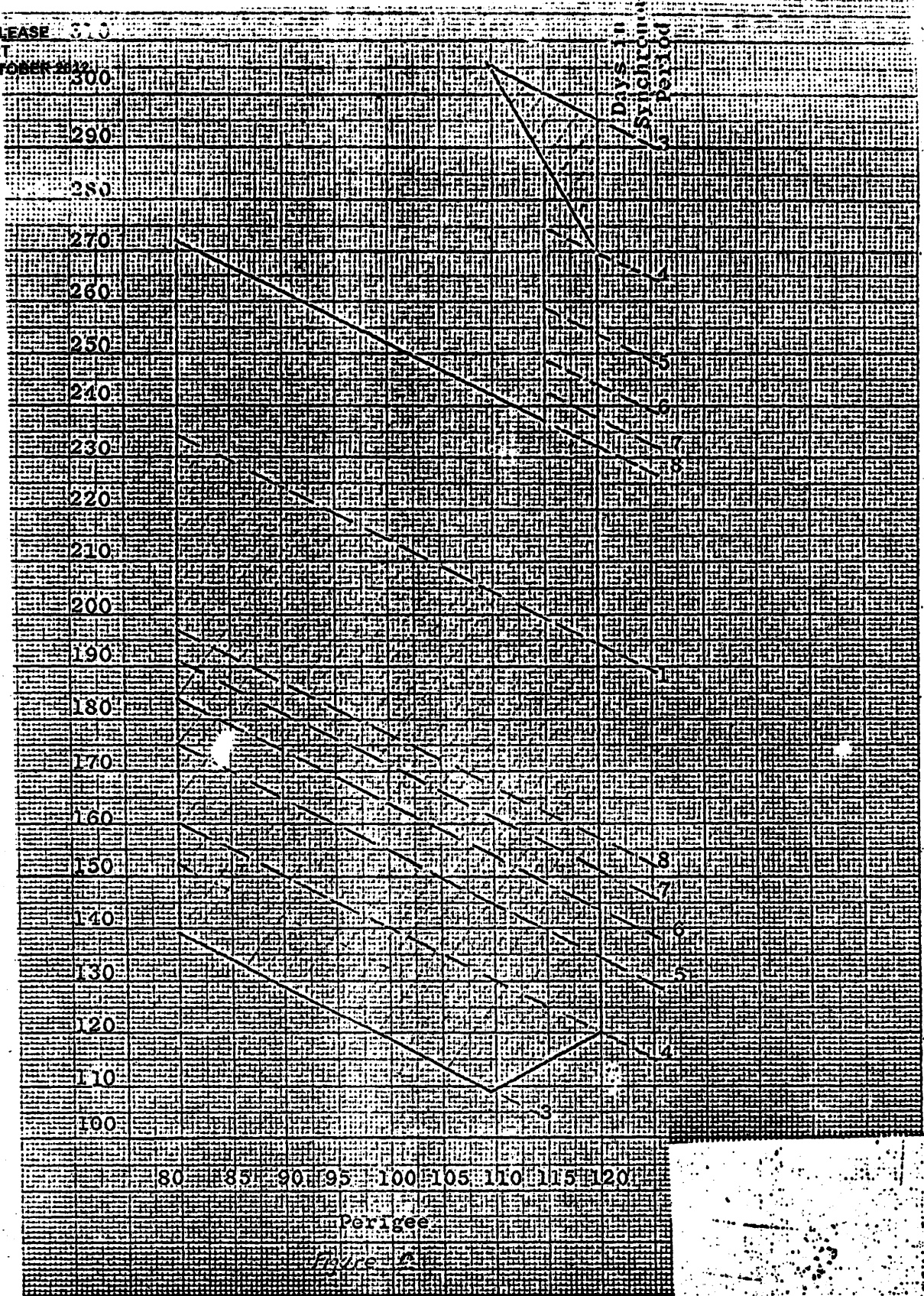
(A three-day synchronous period repeats ground traces beginning on the fourth day.) Orbits with earth synchronous periods of three days or greater and sun-synchronous inclination are shown by the cross-hatched portion of Figure 2. The additional orbits shown in Figure 2 would provide the added flexibility 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.

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Perigee

Days in Station

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 ± 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

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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.

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**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 10:1 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 resolution 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

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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 and must also be capable of selected coverage of non-Sino-Soviet Bloc territory. The imagery acquired depends upon the swath width (scan angle) provided by the system. This system shall carry sufficient film per day for camera to photograph *20 million nm²*

~~730,000 (design scan angle)
scan angle to achieve 140 NM swath from design perigee~~ NM²

This formula takes account of the effects of cloud cover, season of the year, typical target spread for search, surveillance, mapping and carting, 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.

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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.

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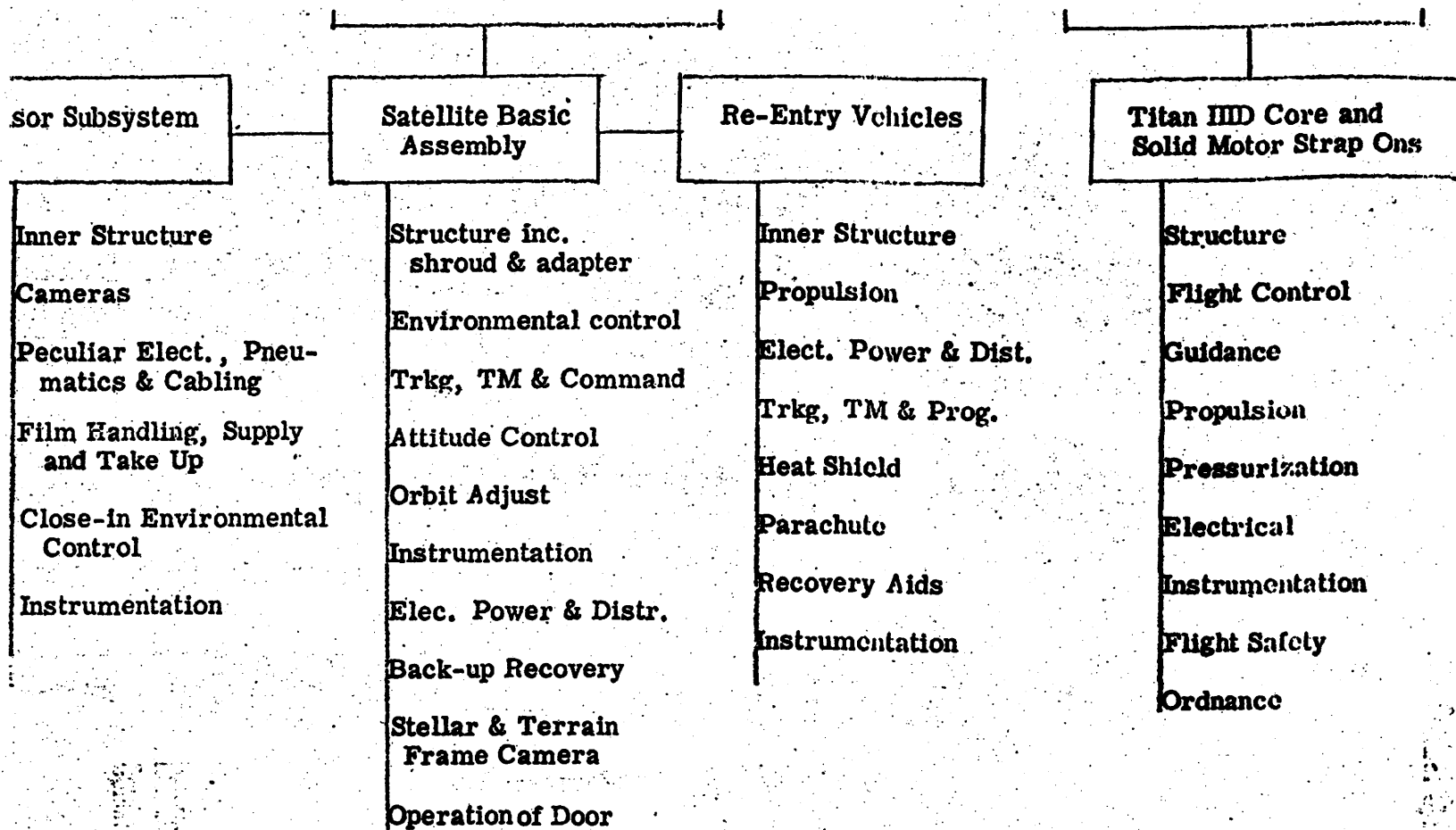


Figure 3

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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 $3\frac{1}{2}$ inches.

Sensor Subsystem Electronics and Pneumatics: All electronic and pneumatic components required for the operation of the sensor subsystem may be 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 ± 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 may be 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

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.



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 ΔV 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 IID. 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.

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Attachment 4-1

April 1966

REQUIREMENTS

1. INTRODUCTION:

Requirements for the New General Search System have evolved or have been derived from several sources by the NRO. The USIB establishes all formal requirements of the national intelligence community in terms of areas and targets to be covered, desired frequencies of coverage, and the quality of intelligence information desired (which translates into resolution). The Secretary of Defense, as Executive Agent for the NRP, occasionally establishes requirements in the form of operational capabilities which must be available in support of the JCS contingency plans. Additionally, guidance of an informal nature is provided to the NRO by agencies who participate directly in the national reconnaissance activities (for example, COMOR, NPIC, etc.). Finally, requirements in the form of operational/technical characteristics are established by the DNRO on the basis of experience with present systems, and the need to conduct the NRP on a cost-effective basis responsive to present and future needs. The sections which follow summarize pertinent requirements and guidance from all of these sources.

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2. USIB AND SECRETARY OF DEFENSE REQUIREMENTS

a. The formal USIB requirement for the General Search System is contained in USIB-D-41.13/1 dated July 27 and July 30, 1964. A summary statement of this requirement is as follows: "The development of work should proceed urgently toward the achievement of a single capability for search and surveillance with continuous stereoscopic ground coverage equivalent to KH-4 and a resolution equivalent to KH-7."

b. In subsequent informal discussions the above statement of requirements has generally been interpreted to mean that the new search system should have a swath width no less than CORONA and contain at least an equivalent amount of film (in square mile coverage of the earth), and should achieve ground resolution at least equivalent to KH-7 at nadir and at comparable obliquities.

c. USIB-D-41.14/7, dated February 11, 1963, established a requirement that the NRO maintain a continuous standby capability of satellites which could be launched on short notice for the purpose of acquiring indications intelligence during periods of international crisis. Although this document actually concerned itself with the KH-4, it is considered applicable to the new search system. This interpretation has been reaffirmed several times in

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informal discussions with the USIB and the COMOR, and also is contained in all draft versions by the COMOR of the forthcoming USIB long-range requirements paper.

d. USIB-D-41.14/167, dated August 14, 1964, directed that the NRO consider and include appropriate protective measures in reconnaissance satellites against current and postulated Soviet anti-satellite capabilities. Such actions have been taken in the CORONA and GAMBIT programs, and a variety of vulnerability reduction devices are available if needed. Although this document was concerned with CORONA and GAMBIT, its provisions are considered applicable to the new search system. This interpretation has been verified in informal discussions with the COMOR.

e. USIB-D-41.14/229, dated March 19, 1965, established search, surveillance, and mapping, charting, and geodesy requirements for present image-forming satellite reconnaissance systems (CORONA and GAMBIT). Although it was recognized by all concerned that specific targets and land masses and required frequencies of coverage would change in the future, this document has been generally used as a guide for planning the new search system. It is noteworthy that a situation not unlike the present may exist when the new search system is developed, for it will be complemented with high resolution coverage by the advanced GAMBIT (G-3)

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in the same manner that the present CORONA is complemented GAMBIT coverage.

f. A November 21, 1964, memorandum from the Secretary Defense to the JCS (also to the DNRO for appropriate action advised that any new search and surveillance system developed by the NRO, as a follow-on and successor to the KH-4/KH-7, include quick reaction capability provisions for the rapid acquisition of intelligence information in international or situations.

3. COMOR GUIDANCE:

The COMOR, in informal discussions with the NRO, has provided very helpful advice and guidance on desirable operational characteristics of the new system. Much of the Committee's informal guidance is reflected in the stated requirements of the new system. Examples of the informal guidance provided the COMOR with regard to the new search and surveillance system are as follows: the system should have an on-orbit program for maximum flexibility and operational effectiveness; it should have greatly reduced response times (vis-a-vis CORONA and G from launch decision to product recovery; it should have a range of orbit selection for operational flexibility; the time required to change orbits during the countdown process should be reduced if possible; it probably should possess a [REDACTED]

Handed to [REDACTED]
[REDACTED]

it should have a crisis reconnaissance capability, e

4. DNRO/NRP CONSIDERATIONS:

a. In the design of the New General Search System, maximum possible utilization must be made of existing launch facilities, on-orbit tracking/command/control facilities, capsule recovery forces, processing and production facilities and interpretation facilities. The reason for this requirement is simply one of economy--to use the hundreds of millions of dollars already invested in ground facilities and equipment acquired to support on-going satellite operations. Analyses indicate that the use of these facilities and equipments will not degrade the operating effectiveness of the New General Search System. With regard to re-entry vehicles, the Hawaii area should continue to be the primary area for capsule recovery. (Although it is quite feasible to recover capsule over land, the problems of interference with commercial air traffic in the United States, and poorer weather over the mainland almost dictate that a ZI mode of recovery be used only in emergency situations.)

b. The design of the new search system should feature state-of-the-art technology or, at most, reasonable predicted

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extensions thereof. It is desired that the new system become operational as soon as possible and a long development period fraught with unsolved technology problems must be avoided if possible.

c. The overall system must be designed around the three camera concepts now on contract (namely, the Perkin-Elmer design, plus the Eastman Kodak and Pancake designs at Itek). These three designs are all technically feasible and all represent reasonable projections of the state-of-the-art in satellite camera technology. Several [REDACTED] have been invested to bring them to the point where they are at this date. Both time and money would be lost if camera concepts other than these were introduced into the new search system.

d. The new search system must use either an existing standard space booster, or one in which only minimum and modest modifications are included. Any appropriate DoD or NASA booster may be considered; however, it is desired that the booster lift capability be appropriately matched to the required on-orbit weight (with provisions for some subsequent growth). The rationale is that a new booster development could cost from a few hundred million to a billion dollars or more; and such an expenditure is not necessary.

e. The new system should have the capability to be launched from the Western Test Range into 75° to 140°

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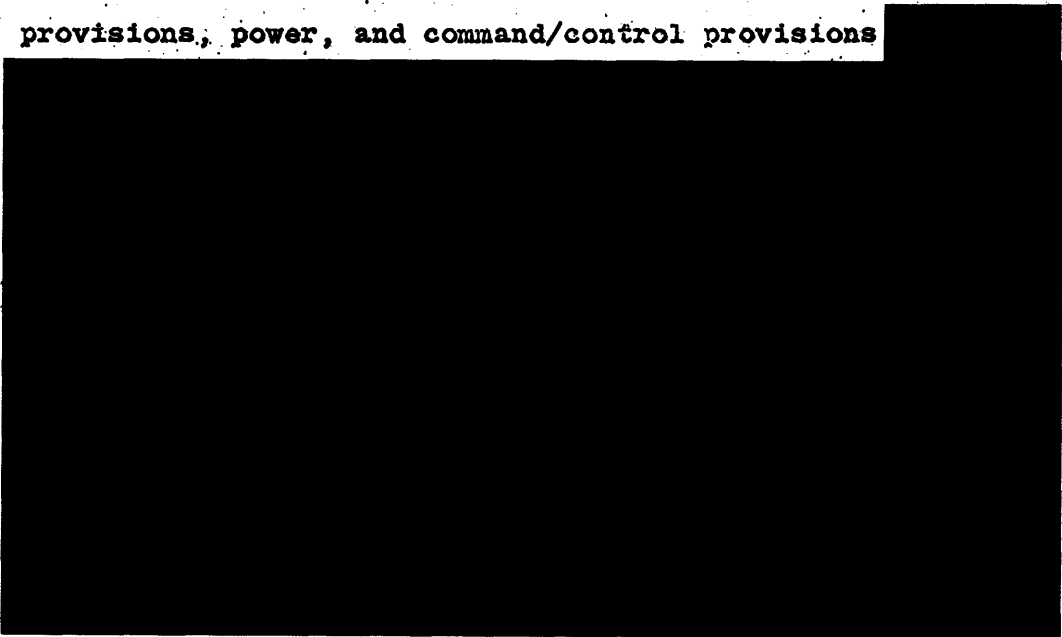
inclinations. The booster and spacecraft/sensor combination should have the capability to be launched at any time between 1700Z and 2300Z. Operational experience with the CORONA and GAMBIT systems indicates that this degree of flexibility is needed for the wide variety of search, surveillance, and MC&G missions undertaken.

f. The New General Search System should possess the inherent capability to hold in a ready-to-launch condition at T-1 hour, or less, for periods up to 30 days. The booster should have the inherent capability to accept new orbital parameters (these may be pre-computed so-called "library cases" as utilized in current systems) in T-24 hours or less. This requirement stems from NRO operational experience with CORONA and GAMBIT, plus NRO/COMOR analyses of quick-reaction needs in changing international situations.

g. The sensor and spacecraft should have the capability to photograph at any altitude between normal design perigee (normal design perigee will be not less than 80 miles for reasons of atmospheric drag and thermal heating penalties) and 240 miles. NRO analyses of current systems indicate that this is a desirable flexibility to possess, and that it is achievable at only minor cost in weight and complexity. An example of the value of high altitude photography follows. Whereas a typical camera system under consideration might

have access to the entire Sino-Soviet Bloc in six or seven days at GAMBIT resolutions when operating at design perigee. If operated at higher perigees, it would provide access to the entire Sino-Soviet Bloc in two or three days at nadir resolutions on the order of six to eight feet. This capability could be very valuable in certain crisis situations.

h. The spacecraft should include the volume, structural provisions, power, and command/control provisions



is a highly desirable characteristic if the NRP is to be as cost-effective as possible.

1. Redundant critical sub-systems (command, stabilization, recovery, etc.) are mandatory in the new system.

It is acceptable for a redundant (i.e., back-up) sub-system to possess less capability than the primary system, if thi

General System

is a desirable trade-off in terms of cost, complexity, weight, etc. The need for redundant critical sub-systems has been demonstrated many times in CORONA and GAMBIT systems.

j. The command sub-system in the new general search must be highly flexible. In particular, a programmer that is loadable on orbit (in a manner perhaps akin to GAMBIT) is absolutely essential. NRO experience with CORONA and GAMBIT indicates that this flexibility is needed in relatively short-life systems, and that in the case of a long-life general search and surveillance system, it would provide greatly increased cost-effectiveness in the utilization of film (i.e., more cloud-free photography).

k. The half scan angle for the sensor sub-system shall be not less than 45° nor more than 60° . The 45° minimum limitation insures that all sensors under consideration will be comparable to or better than CORONA and GAMBIT in swath width and resolution, as specified in the appropriate USIB documents. An on-orbit programmable swath width to obliquities less than 45° , in suitable steps down to about 15° scan angle is a desired feature as a film conservation measure (i.e., less weight). An even more desirable programmable swath is one in which small swath angles may be selected anywhere throughout the camera pan (for example a 15° swath off vertical, to either side of the nadir position, up to the maximum design obliquity).

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Attachment 4-2

March 1966

SYSTEM LIFE CONSIDERATIONS
and
BOOSTER SELECTION

The TITAN III-D (3-segment, 120-inch diameter solid str on rocket motors) has been tentatively identified as the mo cost-effective booster for the new general search and surve lance system.

Studies of probable results of 1969 search and surveill missions (against projections of present requirements) have been conducted independently by SAFSP, CIA-OSP, the NRO Sta and systems engineering organizations (STL and Aerospace), with findings in reasonably close agreement. Specifically, it was agreed that either search or surveillance mission results depended primarily on a given number of active days of camera operations during a specific time period, and depended very little on the distribution of those days durin that period (i.e., random and consistent weather pattern distributions). In other words, to accomplish given search or surveillance goals during a specified period (for example search 90% of the Sino-Soviet Bloc in cloud-free photography in six months) requires a given number of active days on ort It does not matter, for all practical purposes, whether thes days are consecutive or spread-out across the period.

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The studies all generally concluded that for maximum cost-effectiveness of a system which incorporated the camera system under consideration, and in view of the state-of-the art of technology in terms of reliability in unmanned spacecraft, the total spacecraft weight on orbit would require a booster of the TITAN III D class.

Various boosters, including TITAN II, TITAN III-X/AGENA, and TITAN III-D have been considered for this mission.

Approximate data for comparable orbit conditions are:

<u>Booster</u>	<u>Approximate booster cost (launched)</u>	<u>Effective weight in orbit</u>	<u>Cost/lb</u>
TITAN II		6,400 lb	
TITAN III-X/ AGENA		8,000 lb	
TITAN III-D		14,000 lb	

* The exact value to be used here is open to some question based on how much of the AGENA capability might also be used for on-orbit operations.

These data, while very approximate, show that in general the cost per pound in orbit is relatively independent of the booster selected; the cost-effectiveness depends almost completely on how effectively the total orbited weight can be utilized.

Increased on-orbit weight is of interest to the degree that it can result in increased film load and/or increased mission duration. Since some elements of a space vehicle increase in weight only slightly (or not at all) when the

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mission duration or film load is increased, it is reasonable to expect that duration and film load can be increased more rapidly than spacecraft weight increases as any specific design is "stretched." Additionally, the nature of the weight increases required for longer duration missions and additional film is such that the cost-per-pound of space vehicle decreases somewhat as weight increases. Thus, as vehicle on-orbit weight increases, cost per pound tends to decrease, while effectiveness per pound increases. Therefore a general conclusion is that the cost per unit of mission effectiveness decreases in a monotonic fashion with increase booster performance capability over the entire region of capability examined.

In support of these general conclusions, evaluations have been conducted of the relative total program costs using several potential booster vehicles. Two cases examined included:

- a. A 62-inch focal length camera with an 86° scan operated at an altitude of 120 n. mi.
- b. A 60-inch focal length camera with a 120° scan operated at an altitude of 80 n. mi.

For case (a) above, three possible boosters were examined against a postulated requirement to cover 70% of the present 60-day surveillance target requirements in each 60-day period. Total program costs for a four-year operational program were estimated as:

<u>Booster</u>	<u>Program Cost (Relative to T-IIID)</u>
T-IIIX/AGENA	[REDACTED]
T-IIIX/AGENA (plus MINUTEMAN strap-ons)	[REDACTED]
T-IIID	[REDACTED]

For case (b) above, two boosters were examined for the case of covering 85 percent of the present 60-day surveillance target requirements in each 60 day period. Only costs directly associated with booster and space vehicle development, procurement and launch were considered for a three-year program. Results were:

<u>Booster</u>	<u>Program Cost (Relative to T-IIID)</u>
TITAN II	[REDACTED]
TITAN IIID (3-seg)	[REDACTED]

Comparable data were developed for a hypothetical search mission (based on present search requirements).

These relative cost data are presented to support the general conclusions that the larger booster is more cost-effective for the system under consideration. Calculations indicate that the TITAN III-D booster should permit the new search and surveillance satellite to be placed on orbit with sufficient expendibles for considerably more than a 25-day mission.

In theory, then, using the above rationale, the cost-effectiveness would increase continually along with increased mission life, with no upper limit--all other factors being equal. Thus, it might be assumed that a much larger booster

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than TITAN III-D should be used to permit the carrying of additional expendibles for even longer mission life. However the reliability of Sub-Systems in an unmanned spacecraft do have a practical upper limit based on the state-of-the-art of technology. The judgment of experienced spacecraft engineers is that approximately 30 days is a reasonable lifetime goal for the type of system under consideration; at that point, multi-redundancy in Sub-Systems to insure reliability begins to consume the extra lift capability of the larger boosters and cost-effectiveness begins to level off.

As a matter of interest, unsolicited proposals from several manufacturers tend to confirm that about a 30-day lifetime goal for unmanned reconnaissance systems of the general type under consideration appears to be a reasonable goal from a reliability standpoint.

The Air Force TITAN III System Program Office has propose that the new search and surveillance system be launched by a modified TITAN III-C rather than the TITAN III-D (3-segment). Over a three year program period, the total booster program costs (launch facilities, engineering and modifications, propellents, production, launch, etc.) appear reasonably comparable. Over a longer term period, however, or with an increased frequency of launches over that now contemplated, the TITAN III-D appears more cost effective.

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Since there appears to be ample margin for later growth and operational flexibility, it is intended to designate the TITAN III-D as the standard launch vehicle for the new generation search system.

During the spacecraft and sensor competition periods, it is intended to compete the 3-segment strap-on solids to the TITAN III core among the solid rocket motor industry. The solid rocket motor industry is somewhat "starved" for new business. When it was learned that the Air Force (NRO) was considering the use of the TITAN III-D (3-segment) as the booster for a new system, the Air Force was deluged with demands that this was a "new" motor and that a "new" competition should be held rather than sole source the contract to United Technology Corporation (developer of the 5-segment solid). In the interests of acquiring these motors at the lowest cost, it is proposed to hold an open competition

It is recognized, of course, that United Technology Corporation is in a most favorable position to win, by virtue of their experience and available facilities.

A brief solid rocket motor competition will not delay the first launch date of the new system since both the spacecraft and sensor developments require longer acquisition times than does the booster and its launch facilities.

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Attachment 4-3

April 1966

RECOVERY VEHICLE CONSIDERATIONS

In the course of preparing characteristics for the New Photographic Search and Surveillance System, previous analyses bearing on the selection of the number of recovery vehicles were again reviewed. The important factors considered included:

- a. Recovery Force Constraints
- b. System Efficiency
- c. Development Risk
- d. Operational Considerations

The overall system analyses which established the desirability of relatively long-lived missions have correspondingly led to large quantities of film per mission. For the various camera designs under consideration, from approximately 1000 to 2100 pounds of film will be required per mission.

A new RV development will have to be undertaken as existing recovery vehicles cannot be used in view of the large quantities of film to be recovered.

RECOVERY FORCE CONSTRAINTS

The recovery vehicles for the New Search and Surveillance System should be compatible, if possible, for economy reasons with the capabilities of the existing C-130 Recovery Force. This constraint leads to the conclusion that a configuration with a single recovery vehicle is undesirable. Although a single RV with 1000 pounds of film could certainly be handled, the suspended weight of one RV containing approximately 2000 pounds of film probably would exceed the maximum capability of existing aerial recovery equipment (approximately 3200 pounds is the maximum which has been demonstrated with current recovery equipment). In the event of a heat shield jettison failure, that weight limit would be exceeded; and even in the normal situation, there would remain virtually no safety margin. However, in the case of a two-RV configuration for approximately 2000 pounds of film, the catch weight of each capsule would be reduced to about 1600 pounds--well within the weights which can be handled routinely. In general, any configuration with two or more RVs falls within the Recovery Force capability.

EFFICIENCY

For the search and surveillance mission where relatively massive amounts of recovered film are required, two key design

considerations are the minimization of the ratio of total recovery system weight to film weight, and maximization of the percent of the total launched film that is ultimately successfully recovered (a reliability consideration).

For the ranges of film weights under consideration, it is clear that there is a considerable increase in the weight of the recovery vehicle sub-system and associated spacecraft structure, per pound of film recovered, as the number of RVs increase and their size decreases.

On the other hand, decreasing system efficiency with an increasing number of RVs tends to be counteracted somewhat by an increase in successful mission accomplishment--up to a point--through the use of multiple RVs. For example, on a 30-day mission, total vehicle failure on day 16 (or later) would result in total mission failure for a one-RV configuration but probably would result in a fifty percent successful mission for a two-RV configuration (assuming recovery of RV #1 on day 15).

More than two RVs, however, might result in a somewhat lower system reliability. It is evident that a two-RV configuration can employ a film path similar to that used in the present

CORONA, while more than two RVs probably would require film and splice operations for which there is no flight experience (however, this approach is not considered a serious technical problem).

If the system under consideration were severely weight limited because of the booster selected, the use of multiple RVs could impose significant limitations on the amount of film carried and/or system lifetime; reduced lifetimes, in turn, would require more launches and thus increase program cost by a proportionate amount. However, the booster tentatively identified for this system has sufficient on-orbit payload weight margin to carry as many as four RVs without reducing the lifetime goal for the normal mission.

DEVELOPMENT RISK

A review of several detailed RV designs which have been completed, covering a range of vehicle sizes up to a 1000-pb film capacity, has identified no fundamental development problems.

OPERATIONAL CONSIDERATIONS

There are several potential advantages of an operations character which favor multiple RVs. For example, multiple

RVs are needed in crisis reconnaissance situations wherein it may be necessary to return film on a daily basis. Multiple RVs are desirable from an operations viewpoint in that later stages of a mission could be influenced by the actual results achieved in the early stages.

It is unquestionable that a four-RV configuration would be more useful and cost-effective in a crisis situation than a two-RV configuration. Further, all other factors being reasonably equal, an eight-RV configuration would probably be better than one with six. However, a very large number of RV may not be practical for various technical reasons. Whether or not three or four RVs will reasonably satisfy the crisis requirement (and thus eliminate the necessity for an optional recovery configuration with even more RVs) must be the subject of further study.

OPTIONAL RV CONFIGURATION

In view of the factors discussed earlier, no further consideration has been given to a one-RV configuration for the contemplated 25-plus day system. The first configuration considered has been two RVs, returning one at the midpoint and one at the termination of the mission. The gross weight of

each recovery vehicle (maximum of about 2000 pounds) would be well within the capability of the recovery forces. The ratio of film weight versus capsule weight would be reasonably efficient. A quick processing, production, and readout of the results of the first half of the mission could be made available in time to influence camera operations for the last week of mission. Reliability of the two-RV configuration should be high (high reliability has been demonstrated in the CORONA system).

Another configuration considered has been either three or four recovery vehicles. The gross weight of each capsule would be well within the aerial retrieval capability of the recovery forces. The use of additional RVs does cause some penalty in terms of increased structural weight in the spacecraft to mount and carry them. Further, this arrangement is less efficient in terms of film weight per capsule. Additionally, the probability of capsule recovery decreases slightly with succeeding capsule; however, this is not a significant amount. Otherwise, a three or four recovery vehicle configuration appears more desirable and operationally efficient than a two configuration. For example, the results obtained in the first two RV film loads could be used as a basis for operational decisions in the latter stages of the mission.

Another configuration considered has been six or more recovery vehicles. This configuration, of course, is less efficient in terms of spacecraft/recovery vehicle weight versus weight of film recovered than any of the preceding options. It also would be less reliable due to the complexity of feeding film into six or more recovery capsules. On the other hand, it would be a highly cost-effective arrangement for periods of international crisis and in terms of operational effectiveness (in that the operator could more efficiently operate the cameras in subsequent mission stages on the basis of results actually achieved and verified on the film of the recovered RVs).

The New General Search System will also include a still index camera sub-system to enhance its usefulness for mapping and charting purposes. Whether or not to feed the SI film into one or all of the RVs used for the film from the main cameras is a technical trade-off of weight vs complexity. If three or more recovery vehicles are used for the main camera film, it appears that it may be more efficient to employ a small, separate recovery vehicle for the SI and recover all film at the end of the mission.

SUMMARY

In view of the uncertainty as to the precise number of recovery vehicles which should be incorporated in the new system, it appears desirable to request the spacecraft bidders to design for either a two- or four-capsule configuration. In the meantime, all previous analyses should be resynthesized and a final judgment made at the end of the spacecraft competition, comparing the re-evaluations of previous studies against the trade-offs in the new system of weight, cost, and complexity.

Later, and simultaneous with the development of the standard RV configuration (either two or four recovery vehicle with or without an additional small recovery vehicle for SI film), design studies will be undertaken toward an alternate RV configuration which would be used exclusively for crisis reconnaissance situations. This alternative RV configuration should include not less than six recovery vehicles (perhaps, as many as sixteen). The operational purpose of such a configuration would be solely the acquisition of indications intelligence, with the objective being to return a significant amount of film daily, for a maximum number of consecutive days within the overall weight and/or structural limitations of the system.

Attachment 4-4

March 1966

SYSTEM EFFECTIVENESS

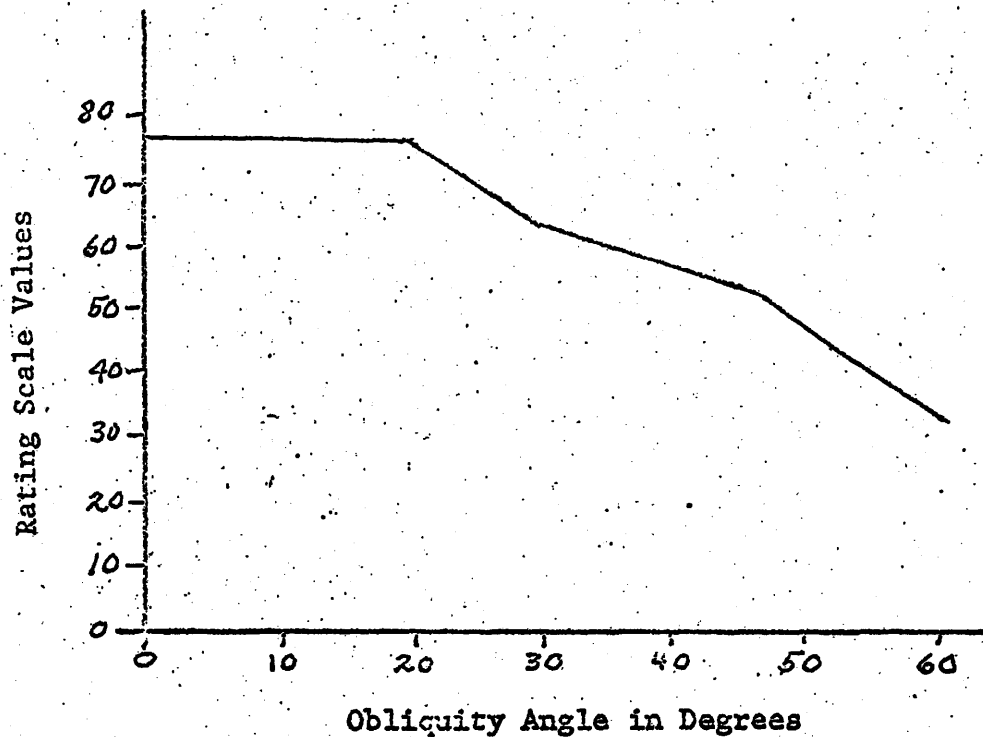
Since the three camera sub-systems under consideration were not all designed against precisely the same technical/operational requirements and criteria, there are significant differences among them in characteristics such as design per altitudes, scan angles, f-numbers, minimum spacecraft diameter required, power consumption, etc. And although each should equal or better the basic USIB requirement (i.e., resolution at least equivalent to KH-7, and coverage at least equivalent to KH-4), there are considerable variances in ground access, resolution across the format, etc.

Because the amount of intelligence information which can be derived from overhead photography varies considerably between differing obliquities and resolutions (for example, COMOR D-13/56 on the meaning of and need for higher resolution in overhead photography indicates that 3' resolution provides at least twice the information of 8-10' resolution), an evaluation technique had to be developed which assigns appropriate weighting factors to the variables.

The above-mentioned COMOR D-13/56 included the following table as a summary of the value of resolution in providing intelligence elements of information from photography of varying resolutions:

<u>Improvement in Ground Resolution</u>		<u>Changes the Cumulative Percent of Information</u>		<u>Gain</u>
<u>From</u>	<u>To</u>	<u>From about</u>	<u>To about</u>	
No photos	10' resolution	0	38	38
10	9	38	40	2
9	8	40	43	3
8	7	43	46	3
7	6	46	49	3
6	5	49	54	5
5	4	54	65	11
4	3	65	76	11
3	2	76	85	9
2	1	85	94	9
1	~0	94	~100	6

In another vein a Human Factors Research Inc./Perkin-E study on the effects of stereo convergence and obliquity on intelligence information which can be gained from overhead photography indicated that the usefulness fell off significantly at obliquities from 20 to 60 degrees. The following general graph from the study depicts their findings on the effect of obliquity:



The cited reports admittedly are subjective opinions; however, the relative value of resolution is a very subjective matter between extremes of photographic quality--as a matter of fact, no precise mathematical measurement technique has been devised and accepted as a standard. Nevertheless, it should be noted that most of these "subjective" reports were compiled by recognized experts in the field and thus, considerable weight must be given to their findings and opinions.

A Performance Evaluation Team Report of a recent KH-7 mission (the PET Report on Mission 4022) seemed to bear out the findings of the Human Factors Research Inc./Perkin-Elmer sponsored study on the effect of obliquity. The PET report noted that although the performance was good, the high obliquity of many photographs down-graded their value. At this point, the report was referring to obliquities between 30 and 42°.

Recently, in still another vein, in providing guidance to the NRO as a basis for selecting the orbit for GAMBIT mission #4027, the COMOR specified that the primary targets for which coverage was desired should be photographed at 30° or less obliquities. At the same meeting, considerable discussion was had on the desirability of limiting photograph obliquities in this manner for future missions of both GAMBIT and the forthcoming Advanced GAMBIT.

Additionally, a measure of the value of resolution is indirectly contained in COMOR D-25/211 (re the requirement for high resolution photography of South China [REDACTED]). The report stated that "KH-4...has yielded some intelligence, but its resolution is not sufficient to provide the required details concerning Chinese ground forces." It

also stated that "KH-7 has adequate resolution for ground force targets...." Thus, it indicates that 10' or worse resolutions have very little value in determining ground order of battle, but that resolutions on the order of three feet are quite useful.

From all of the above, it generally appears that about 5 resolution may be near the maximum at which very much useful information of a true surveillance nature can be obtained from overhead photography. This also appears to apply to many new targets photographed for the first time in search missions. It also appears that the value of information obtained decreases rapidly at obliquities above 30-40° from vertical. (There are of course, certain exceptions to both of these generalizations)

From the above, plus evaluations of KH-4 and KH-7 mission analyses, the following relative resolution values were arrived at for the purpose of comparing different systems

.85 for 2-3' resolution
.70 for 3-5' resolution
.50 for 5-8' resolution
2.5 for >8' resolution
resolution

Thus, the potential intelligence value of a single day operation for a satellite search and surveillance system may be calculated by summing up the values of resolution for all of the territory to which photographic access is obtained. To obtain the best and worst potential performance which may be expected, this summation should be done for both a mid-winter and mid-summer situation, taking into account the varying sun angles as the satellite traverses the area of interest. This technique will be utilized in the sensor source selection evaluation and is set forth in the RFP.

In evaluating the potential performance value of a photographic satellite, the weight of film which should be carried is a significant matter and a difficult answer to determine precisely. Both SAFSP and CIA contractors have made comprehensive analyses of projected current KH-4 and KH-7 search and surveillance requirements against climatology, actual weather for given intervals, etc., in estimating the amount of film which should be carried.

The amount of film carried is, of course, quite significant in that an increase in film results in increased RV weight.

which in turn results in increased spacecraft weight, etc. Thus, it is important that the amount of film carried per day of operation be as minimal as possible.

The long-term NRO experience with CORONA provides an excellent baseline for the determination of film requirements of the new search and surveillance system, so long as suitable adjustments are made for variances in design altitudes, design scan angles, etc. The pragmatic solution to this problem is rather simple--namely, that the pounds of film required per day, per camera, is that necessary to record 730,000 square miles of imagery (calculated as a sum of individual frames design perigee altitude, and ignoring frame-to-frame duplicate coverage), multiplied by the designated design scan angle of proposed system, and divided by the scan angle required by proposed system to achieve a 140 mile swath width at design perigee altitude.

This formula is based on more than two years of actual CORONA operations, and takes into account the average mix of a single mission of search and surveillance both within and without the Sino Soviet Bloc, mapping and charting operations, engineering test and validation operations, the ability to

forecast weather, operational techniques employed, etc. In this respect, as an example of the typical use of a search and surveillance system, it is of interest to note the projected allocation of film for a forthcoming CORONA mission (15% for mapping and charting outside the Sino-Soviet Bloc; 15% for search and surveillance outside the Bloc; 66% for search and surveillance inside the Bloc; and 4% for miscellaneous purposes). The formula also recognizes the CORONA/GAMBIT relationship in the surveillance role and generally assumes a similar relationship in the future for the Advanced GAMBIT (G-3) and the new search and surveillance system.

The formula has proved valid under a variety of tests. Both CIA-OSP and SAFSP have carried out studies on the number of days on orbit required to achieve varying degrees of coverage of Sino-Soviet search and surveillance targets as a function of swath width. These analyses have employed weather models of different kinds but the results are in substantial agreement with each other. The simple formula derived from CORONA experience gives results which are also reasonably close to these analyses. This is to some degree fortuitous since, as has been pointed out, actual CORONA operations (and as far

ahead as can be projected at this time--i.e., operations by analogy) do not entirely conform to the missions assumed in the CIA and SAFSP analyses.

As a further check on formula validity, film weight requirements for the proposed new system were computed using the CORONA-derived formula and then compared with previous CIA, SAFSP, and contractor estimates for two of the three sensor sub-systems under consideration. In one case, for a 25-day mission for a specific sensor, the CORONA-derived formula indicated a requirement for 1,000 lbs of thin-base film and compared favorably with the 960 lbs in the contractor's analysis. In another case, for a 30-day mission for a specific sensor, the CORONA-derived formula and the contractor analysis agreed that approximately 2,100 lbs of ultra-thin-base film would be required.

As a final item, it is also of interest to note that the decision to extend the CORONA mission life from 11 to 14 days thus necessitating the larger THORAD booster, without an increase in film capacity, was made on the basis of such experience and predictions.

The CORONA, of course, does not have an adjustable swath width and the NRO often must photograph a 140-mile swath on the ground to cover a much smaller target area (conversely, it not infrequently would be desirable to have a wider swath than CORONA provides). However, if the CORONA were capable of on-orbit control of the scan angle (i.e., swath width) from its maximum down to approximately a 15-20° scan angle, the system should consume from 5 to 10 percent less film per day. Thus, the RFP will indicate that the formula constant of 730,000 may be reduced to 680,000 if an on-orbit programmable swath is a characteristic of the design.

From the preceding, the sensor contractor can calculate a mission value for various design optimum points for scan angles and perigee altitudes. A potential total mission value may be calculated by multiplying the possible days on orbit by the potential value of an average day's operation (discussed earlier in this paper). The possible days on orbit are arranged, with due consideration of reliability, by computing the weight of film and other expendables required daily, plus the basic weights of the sensors and spacecraft (adjusted from base-line weights depending on total film weight, operating altitudes, etc) and equating these against the possible total

on-orbit weight provided by the selected booster.

By working back and forth among such formulae, the sensor contractor can determine an optimum scan angle (between the upper and lower limits established in the RFP) and optimum design perigee altitude (at or above a lower limit imposed for reasons of atmospheric drag and thermal heating considerations) for his system. These formulae also completely eliminate the task for the contractor of attempting to estimate how well his system would perform in a search or surveillance role against 1965/66 requirements postulated into the 1969 time period. Thus, a comparative measure of mission value will not be prejudiced by the ability of a sensor contractor to plan operations (when such is not his responsibility, nor are the potential sensor contractors experienced in this area of endeavor).

The exact formulae and conditions under which the potential value of a day's operations will be calculated and value of an entire mission (based on the most efficient use of the total poundage which may be placed on orbit) are set forth in the RFP.

It should be emphasized that these value computations for daily and total mission effectiveness are neither sole nor overriding factors which will determine the winner of the sensor competition. Rather, they represent an equitable basis on which to compare the system performance of cameras designed against slightly different requirements and thus constitute one of the many factors which must be evaluated during the source selection process.

Attachment 4-5

April 1966

SYSTEM MANAGEMENT AND RESPONSIBILITIES

A Management Task Group of NRO, SAFSP, and CIA-OSP members was convened by the DNRO in late 1965 to assess alternative means of managing and assigning organizational responsibility for the development, production, and operation of the new photographic satellite search and surveillance system. Their report assessed four possible management arrangements (spanning a broad spectrum of possibilities) three optional assignments of system responsibilities. It recognized that, subject to the application of sound management procedures, many variants in the assignment of system responsibilities would be possible and workable.

The recommended arrangements represent a combination of the features of several of the various alternatives for management arrangements and assignments of system and sub-responsibility. The proposed management plan and assigned responsibilities are based on experience in the acquisition complex and costly systems both in the DoD generally and in

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CONTROL SYSTEM ONLY

NRO experience in the field of reconnaissance satellite systems, and the requirements of the August 11, 1965 DoD-CI NRP Agreement, both generally and specifically in regard to this system.

The purpose of this paper is to explain the basis for more significant features of the management/responsibility which is included elsewhere as a separate document.

First, it is essential that a single authoritative and responsible System Project Director be designated for the overall system. Involved is the development of an entirely new system which, if past experience is any guide, will not mature (in an engineering sense) for a considerable period after the first launch. Experience also indicates that a satellite project of any duration involves a continuing progression of technical improvements. In any event, but particularly in the development phase, a single person responsible for overall system engineering and integration is virtually a management essential if an early and reliable operational capability is to be achieved. A single System Project Director is also important to efficient and effective overall system planning, programming, and budgeting.

During mission operations, it is important to have a single, authoritative overall project director in the field -- particularly when difficulties are encountered.

Taking into account all phases of system life including the acquisition process, the transition to operational status and the continuing conduct of operations has led to the conclusion that the Director of Special Projects (SAFSP) should be designated as the System Project Director for the new general search and surveillance satellite system. SAFSP appears to be the NRO component best suited for this responsibility in terms of available personnel, facilities, equipment, and overall experience in the acquisition and operation of space systems. In addition to assigned personnel, the Director, SAFSP (acting in his additional capacity as Deputy Commander of the Air Force Space Systems Division), has immediately available to him all of the resources of SSD. Further, under existing DOD arrangements wherein the Air Force assigns space organizations either wholly to the NRO (as in the case of SAFSP and SAFSS) or to the operational control of the NRO during a mission (as in the case of SSD's launch, on-orbit command and control, and capsule recovery forces), the Director, SAFSP, is the only field authority who can direct all elements involved in a space operation from launch through recovery.

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The SPD will be responsible for overall system engineering (includes master system specifications) and integration, preparation of the system for launch, the launch itself, on-orbit command and control, recovery of the RV's, delivery of film to processing facilities, and overall planning, programming, and budgeting. In recognition of the joint agency nature of the program, there will, of course, be restraints on the scope of SPD authority in certain of these areas. For example, the overall system engineering and integration responsibilities of the SPD would include all interfaces with the sensor subsystem, but not system engineering or technical direction for the sensor subsystem itself. On the other hand, the SPD in the exercise of interface responsibility would be required to meet the basic structural, dynamic, and thermal, power, etc., requirements of the sensor subsystem.

In addition to the role of SPD, it is proposed to assign responsibility to SA FSP for the booster, launch facilities, spacecraft (identified in the RFP as the Satellite Basic Assembly), stellar-index camera, and recovery vehicles. These assignments of responsibility are consistent with optimum utilization of available resources and capabilities, and with the 1965 NRP Agreement.

Some of the technical rationale supporting the above assignments of responsibility is set forth in the next few paragraphs.

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Control System

The Satellite Basic Assembly (i.e., spacecraft) will support and house the primary sensor and provide the basic structural strength and stiffness required for support of re-entry vehicles and all satellite vehicle components including attitude control, orbit-adjust propulsion, telemetry, tracking aids, command and control equipment, stellar index and terrain camera, and instrumentation. Although it would be possible to designate a particular section of the satellite basic assembly structure as the sensor housing, it appears that better packaging and design integration as well as achievement of electromagnetic compatibility for the system as a whole will be achieved if the configuration is not constrained in this way. Also, the structural, thermal and dynamic characteristics affecting the sensor will necessarily depend on the disposition of the total satellite vehicle mass, stiffness and strength, as well as stabilization and control arrangements; problems in these areas can, in general, best be solved by dealing with the satellite vehicle as a whole rather than with a vehicle having a separately engineered sensor section. Further, the design of the entire vehicle for the launch environmental conditions is also best served by this approach.

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In particular, close scrutiny has been given to the possibility of unusual thermal interface problems between the satellite basic assembly and the sensor sub-system under the proposed management arrangement. DoD, NASA, and NRO experience with a wide variety of space systems indicates that no serious problems should be encountered so long as close-in and fine thermal control is a responsibility of the payload sub-system contractor (and such an assignment of responsibilities is recommended for the sensor sub-system). The System Project Director will, in any case, be charged with meeting the environment requirements for the sensor and associated equipment established by the Sensor Sub-System Project Office. The achievement of optimum thermal balance within the spacecraft shell will be facilitated by an integrated approach (exercised by the SPD) to the design and packaging of components structure considering the totality of heat sources and available heat sinks in relation to heat dissipation capabilities. Experience in other programs has verified the feasibility of assuring adequate thermal control with this division of responsibility between contractors. It is not questioned that isolation of the sensor sub-system in its own section of the spacecraft in some instances, results in a better thermal arrangement for this section alone; however, this would be achieved at the

Control System

does not appear to offer advantages sufficient to offset the disadvantage in structural and dynamic design and packaging which would result.

Finally, flexibility to meet changing requirements, such as the need to incorporate vulnerability reduction devices or modifications in the number of re-entry vehicles for crisis situations can most easily be met by an integrated approach to the satellite vehicle.

Thus, the assignment of overall responsibility for an integrated satellite basic assembly to SA FSP, in accordance with the normal assignments designated in the 1965 NRP Agreement, is considered to be the best management arrangement.

It is proposed that responsibility for the stellar index camera (or index camera only, if attitude data is provided by some means other than stellar photography) be assigned to SA FSP. Since the SI camera is not closely related to the primary sensor (in a technical sense), much more flexibility is afforded the SPD in the configuration and location of this subsystem; however, it is recognized that overall system considerations may dictate the technical characteristics and location of the SI camera.

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The re-entry vehicles must provide for film take-up but otherwise they are completely independent of the sensor sub-system. Development and production of re-entry vehicles must be managed in such a way as to take maximum advantage of the common requirements of the NRP. (In the past it has proved possible basically to utilize the same re-entry vehicle on three different operational systems.) The re-entry vehicle system must be closely compatible with recovery operations which are conducted by the Air Force. The technology of re-vehicles is closely related to Air Force ballistic missile re-entry vehicle technology; basic and applied research as well as test facilities for both research and development are generally applicable to both ballistic and orbital recovery vehicles. The assignment of responsibility for the re-entry vehicles to SAFSP therefore recognizes the organizational responsibilities and capabilities discussed above and is in complete accord with the DoD-CIA Agreement of 21 August 1965.

It is proposed to assign responsibility for the complete Sensor Sub-System to the CIA. The Sensor Sub-System is defined as including the major camera assemblies, close-in environment control, any close-in and camera-peculiar electronics and pneumatics associated with sensor operation, the source of supply (reels), the film transport mechanism, and the film

take-up spools. In addition, CIA will be responsible for supervising the physical installation of the sensor sub-system in the spacecraft during preparations for launch (this may be accomplished either at the spacecraft or sensor sub-system facility, or at the launch facility; this will be determined later), participating in the pre-launch system check-out, and certifying prior to launch that the sensor sub-system is operationally ready. During on-orbit operations, the CIA-C sensor/contractor team will be the principal advisors to the System Project Director for sensor sub-system operation. In the case of technical difficulties and when in the judgment of the SPD that mission failure may be imminent, there being insufficient time to solicit other technical counsel, the operational decisions of the SPD shall always be overriding. This assignment of responsibility will utilize the capabilities, experience and competence of CIA-OSP in sensor development and acquisition and is also consistent with the 1965 NRP Agreement.

It is believed that these assignments of system responsibility will provide the highest possible degree of system integrity--particularly, during the acquisition phase. They will insure maximum utilization of experience and resources available. They should insure the highest degree of flexibility in the engineering trade-offs which will inevitably

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made during the development phase. Experience in on-going satellite system projects indicates that such assignments of responsibility are both feasible and reasonable.

It has been noted previously that the System Project Director would not be responsible for the sensor subsystem. The SPD will have no authority to engineer or direct technical matters purely internal to the sensor subsystem, nor will he have the authority to revise sensor subsystem program and budget matters coordinated with him (he must insure that the latter are consistent with the overall master schedule). However, the SPD must concur in and approve all interface matters between the sensor subsystem and the other elements of the system. Both the SPD and the CIA Sensor Subsystem Project Director (and their SE/TD contractors, if utilized) must have free and full access to desired information and data on all elements of the system, including direct access to contractor engineering staffs, plants, and test facilities. However, supervision and direction of contractor activities will be solely by CIA for the sensor subsystem and by SAFSP for other system elements. If either SAFSP or CIA-OSP determines that an action of the other involves interface consultation and resolution of the problem is in order (the DNRO will r

problems where diverse positions cannot be reconciled). On matters where interface clearly is involved, the SPD shall normally possess the resolving authority. Such procedures, implemented fully in the event of a major system, are absolutely essential if the development of a complex system, with major sub-systems assigned to different organizations, is to proceed in an orderly and efficient manner.

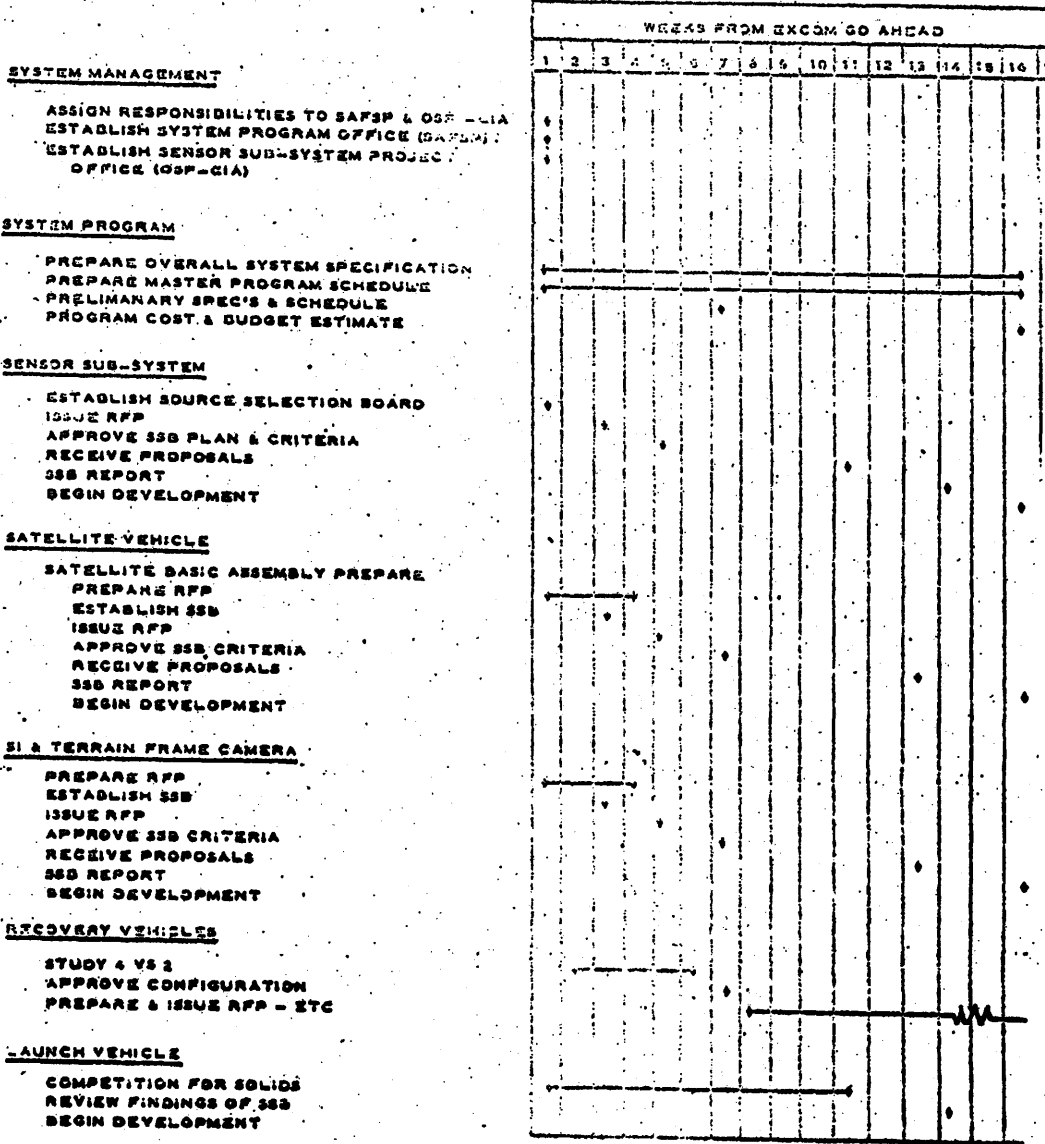
It is assumed that CIA will follow past practice and manage the acquisition of the sensor sub-system from a project office located at CIA Headquarters. On the other hand, the System Project Director will be located in Los Angeles. To facilitate communications over this distance, it is believed desirable that the Sensor Sub-System Project Office assign a liaison officer to the SPD and locate this individual in the offices. His function would be to keep the SPD informed of sensor sub-system activities, to obtain desired information on the sensor sub-system for the SPD, and to serve as a general information catalyst between both locations.

At the option of the CIA, a resident representative of SPD will be located at Langley in a similar capacity.

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SCHEDULE OF EARLY EVENTS



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1. Film width should not exceed 9 1/2 inches. An increase beyond this maximum would require the modification and/or procurement of significant quantities of equipment in the processing/production/interpretation community. Since film widths greater than nine inches are not required for the efficient operation of any of the sensor sub-systems, this arbitrary judgment can be imposed without penalty to any particular system.

[REDACTED] is a desirable but not an essential characteristic. NRO experience with CCORONA indicates that this feature is not used nearly as often as was first anticipated; and it therefore should be included in the new general search system only if the increase in weight, complexity, or dollars is relatively modest.

2. For the perigee altitudes and mission durations contemplated for the new search system, a drag make-up system will be required in the spacecraft. In addition, this secondary propulsion system should have the capability to perform modest orbit adjustments either for the purpose of refining achieved orbits to the planned nominals (this feature is important for sun synchronous long duration missions) and/or to change perigees for intelligence requirements or vulnerability reduction measures. It is not

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contemplated that cross-track orbit adjustments of any significance will be attempted, and the secondary propulsion system should be sized accordingly. Lastly, the secondary propulsion system should have the capability to de-orbit the spacecraft in a pre-determined area after completion of the operational mission.

o. As is standard practice in the recovery capsules used in the CORONA and GAMBIT programs, the RVs for the new search system must include a form of self-destruct capability if they are not recovered in a reasonable period (i.e., a dissolvable plug in the capsule which would cause it to sink into the sea approximately 48 hours after the immersion).

p. The ground resolution at nadir at the contractor designated normal design altitude will be not worse than 2 feet in the center of the format (this resolution will be computed as described in the Request for Proposal). This need directly reflects the USIB requirement for GAMBIT-comparable performance in resolution. When the USIB requirement was stated, the GAMBIT program, although in its early stage was expected to obtain nadir ground resolutions of three feet or better at 95-mile perigee altitudes. Subsequently, in operation, the GAMBIT system has been regularly flown at 81 miles' perigee; the expected ground resolution at this altitude is 2.7 feet or better. The GAMBIT photography has consistently demonstrated the expected resolution.