SYSTEM OPERATIONAL REQUIREMENTS FOR THE NEW SEARCH AND SURVEILLANCE SYSTEM.

(UNCONTROLLED WORK CY - 9 May 66)

Atch's 4-1 thru 5 - Extracts from: SYSTEM OPERATIONAL REQUIREMENT FOR A NEW PHOTOGRAPHIC GENERAL SEARCH AND SURVEILLANCE SATELLITE SYSTEM

(UNCONTROLLED WORK CY - 11 MAY 66)

~~(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

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Control System

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

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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.

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Control System

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 to carry small sub-satellites 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 planr d 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.

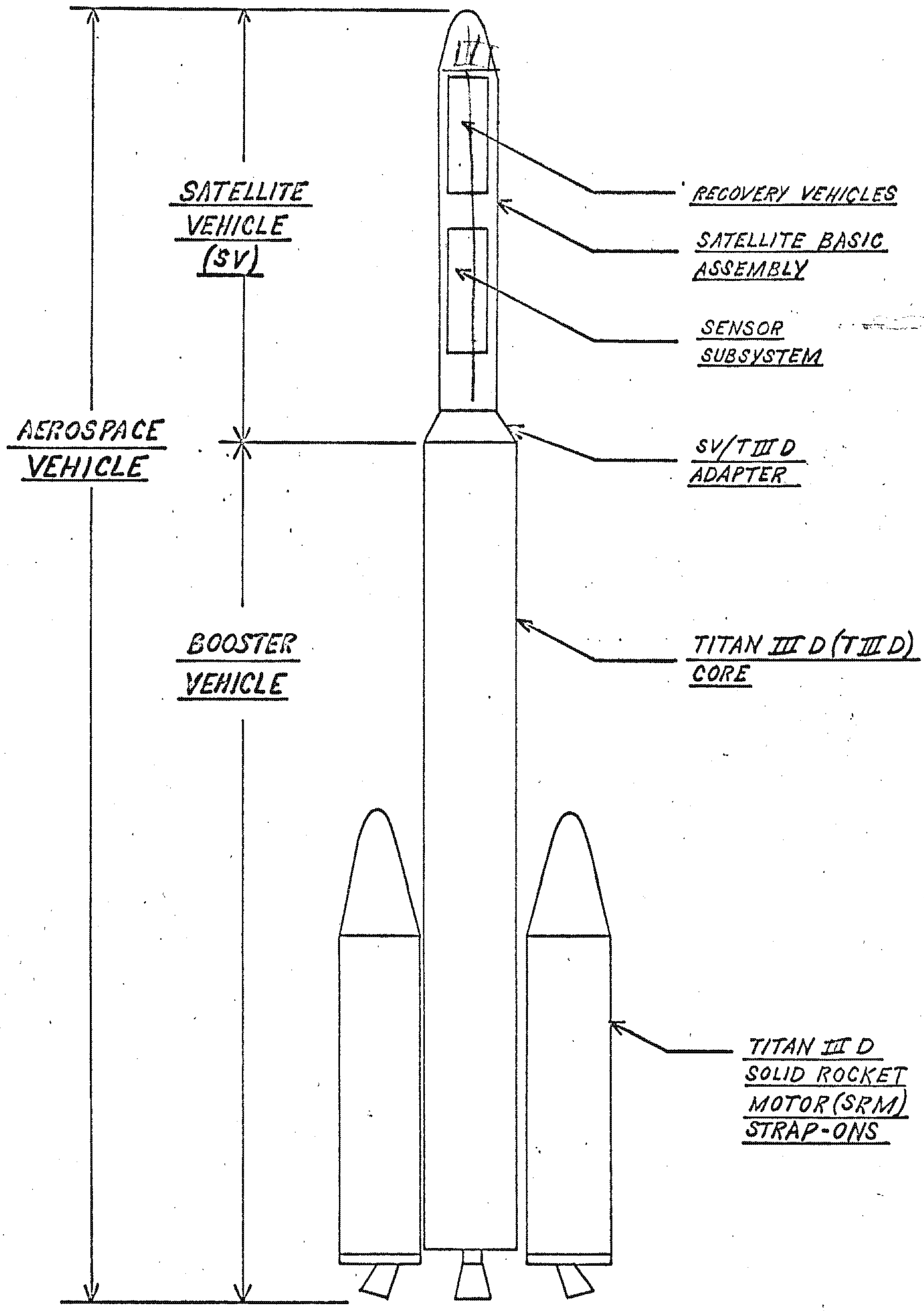

FIG.1 - AEROSPACE VEHICLE OUTBOARD PROFILE

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.

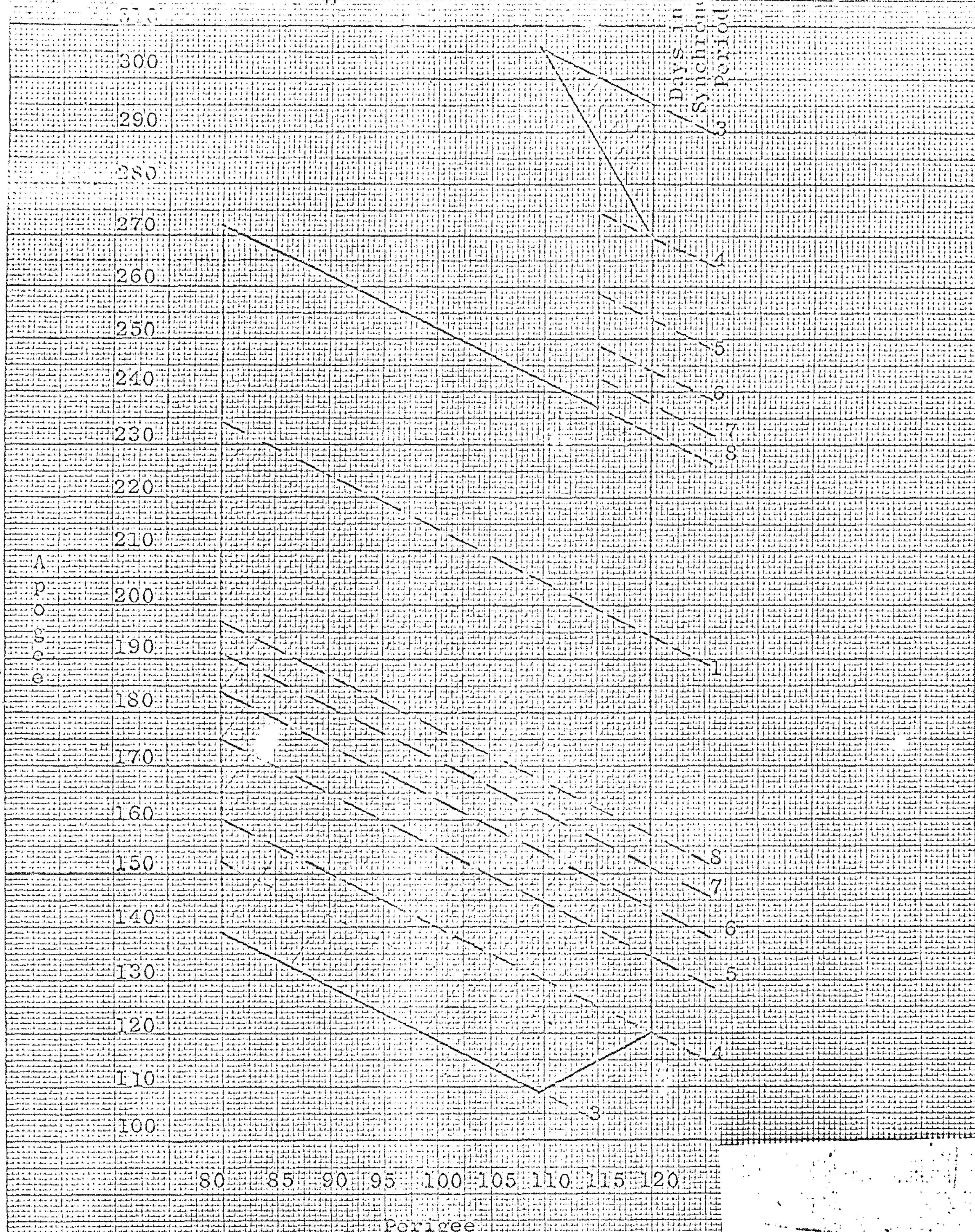
Days in Synchronous Period
Apogee
Perigee
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
80
85
90
95
100
105
110
115
120
3
4
5
6
7
8
1
8
7
6
5
4
3

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 $\leq$ 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 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 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.

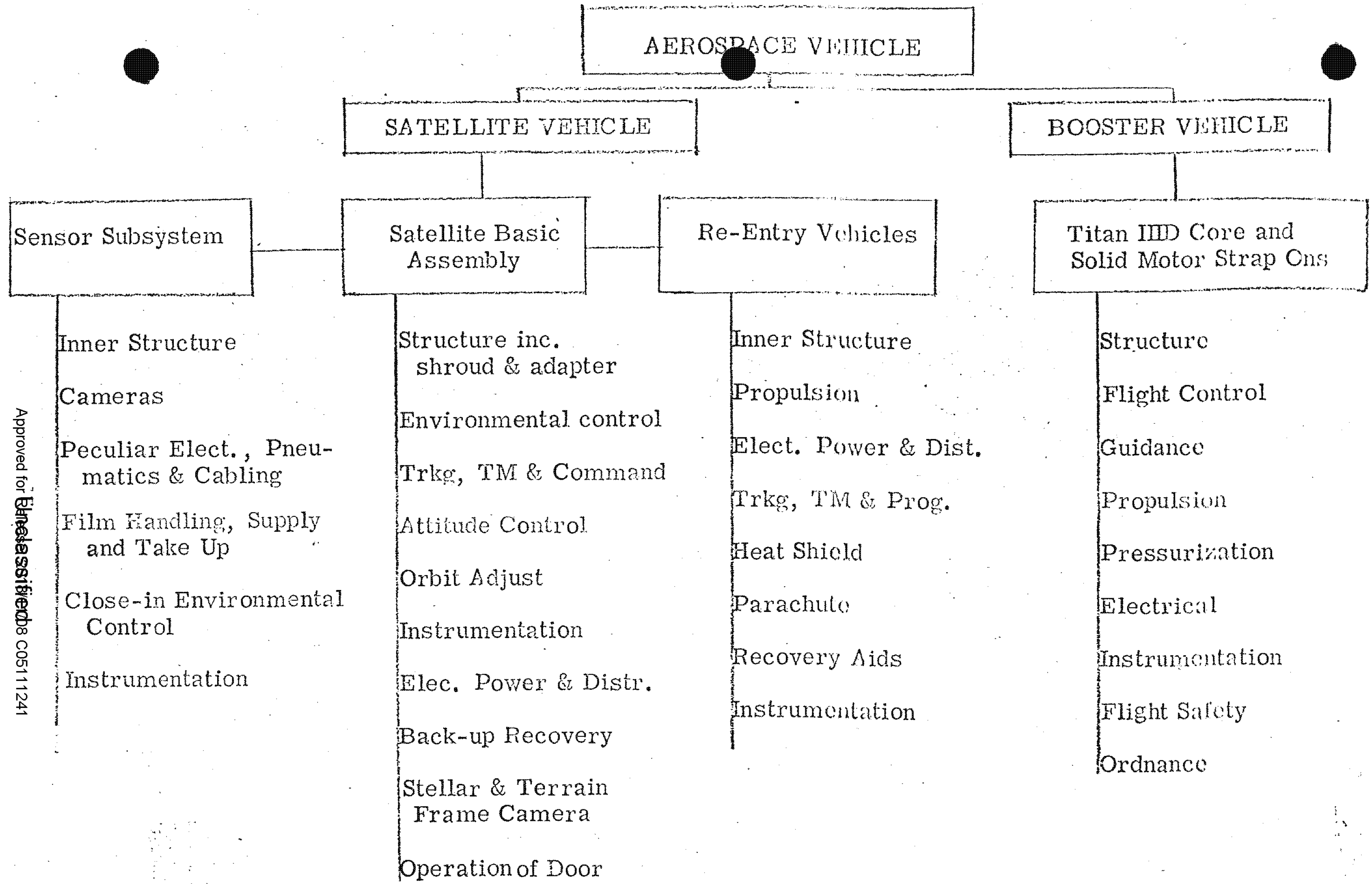
AEROSPACE VEHICLE
SATELLITE VEHICLE
BOOSTER VEHICLE
Sensor Subsystem
Inner Structure
Cameras
Peculiar Elect., Pneumatics & Cabling
Film Handling, Supply and Take Up
Close-in Environmental Control
Instrumentation
Satellite Basic Assembly
Structure inc. shroud & adapter
Environmental control
Trkg, TM &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

Sub-Satellite Housing: The Satellite Basic Assembly will provide the capability for carrying two small sub-satellites through powered flight and ejecting them upon command. The weight and cubage for each sub-satellite will be 300 pounds including attachments, and at least one foot by three feet by three feet. As an alternative, this volume, structure, power, etc., shall be applicable to carrying vulnerability reduction devices in lieu of the sub-satellites.

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 Vehi ies (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.

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Control System

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.

2. USIB AND SECRE RY OF DEFENS QUIREM

a. The formal SIB requirem for t General Search System is cont d in USIB .13/ dated July 27 and July 64. A mary ent of this requirement is as f s: "T evelo t work should proceed urgently toward the emen a single capability for search and surveillan ith continuous stereoscopic ground coverage equivale o KH-4 and a resolution equivalent to KH-7."

b. In subsequent informal discuss s 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 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/o postulated Soviet anti-satellite capabilities. Such action 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 CORON 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, establish 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 masse 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)

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

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

3. COMOR GUIDANCE:

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

[redacted] it should have a crisis reconnaissance capability, et

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 million of dollars already invested in ground facilities and equipmen 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 capsules 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 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 million dollars 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°

inclinations. The booster and spacecraft/sensor combinatic should have the capability to be launched at any time betwe 1700Z and 2300Z. Operational experience with the CORONA ar 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 ho or less. This requirement stems from NRO operational expe ence with CORONA and GAMBIT, plus NRO/COMOR analyses of quick-reaction needs in changing international situations.

g. The sensor and spacecraft should have the capabi to photograph at any altitude between normal design perige (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 indicates that this is a desirable flexibility to possess, and that it is achievable at only minor cost in weight and complex An example of the value of high altitude photography foll 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, structu provisions, power, and command/control provisions to carry either vulnerability reduction devices (decoys, chaff, etc. or sub-satellites of the so-called "super P-11" category. It is desirable that the booster have ample weight-lifting capability to carry either the anti-satellite countermeasur devices or sub-satellites without penalty to the normal mission design life. However, if excess weight capability is not available, it is acceptable to reduce expendibles (control gas, batteries, film, etc.) in order to carry auxi iary payloads. NRO experience with existing photographic and SIGINT satellites indicates that this inherent capabili is a highly desirable characteristic if the NRP is to be as cost-effective as possible.

i. 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 this is a desirable trade-off in terms of cost, complexity, wei 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 relati 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 consider tion will be comparable to or better than CORONA and GAMBI in swath width and resolution, as specified in the appropr ate 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 conser tion 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 exampl a 15° swath off vertical, to either side of the nadir posi tion, up to the maximum design obliquity).

TOP SECRET

Attachment 4-2

March 1966

SYSTEM LIFE CONSIDERATIONS
and
BOOSTER SELECTION

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

Studies of probable results of 1969 search and surveillance missions (against projections of present requirements) have been conducted independently by SAFSP, CIA-OSP, the NRO Staff, 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 during 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 orbit. It does not matter, for all practical purposes, whether these days are consecutive or spread-out across the period.

The studies all generally concluded that for maximum cost-effectiveness of a system which incorporated the camera systems 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:

Booster	Approximate booster cost (launched)	Effective weight in orbit	Cost/lb
TITAN II	$ 3.5 M	6,400 lb	$550/lb
TITAN III-X/ AGENA	$ 5.0 M*	8,000 lb	$625/lb
TITAN III-D	$ 8.0 M	14,000 lb	$570/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 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 increased 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:

Booster	Program Cost (Relative to T-IIID)
T-IIIX/AGENA	2.0
T-IIIX/AGENA (plus MINUTEMAN strap-ons)	1.27
T-IIID	1.0

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:

Booster	Program Cost (Relative to T-IIID)
TITAN II	1.23
TITAN IIID (3-seg)	1.0

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 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 proposed 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.

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 gener 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" competi tion 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.

* * * * * * *

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 quantity of film to be recovered.

Atch 4-3

RECOVERY FORCE CONSTRAINTS

The recovery vehicles for the New Search and Surveillanc 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 o 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 marg However, in the case of a two-RV configuration for approximat 2000 pounds of film, the catch weight of each capsule would b reduced to about 1600 pounds--well within the weights which c 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 desig considerations are the minimization of the ratio of total recovery system weight to film weight, and maximization of th percent of the total launched film that is ultimately success 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 configurat but probably would result in a fifty percent successful missi 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 confi tion can employ a film path similar to that used in the pres

CORONA, while more than two RVs probably would require film c 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 fil 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-pou film capacity, has identified no fundamental development problems.

OPERATIONAL CONSIDERATIONS

There are several potential advantages of an operational 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 RVs 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 1000 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 availa in time to influence camera operations for the last week of t 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 o 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 space-craft to mount and carry them. Further, this arrangement is less efficient in terms of film weight per capsule. Addition the probability of capsule recovery decreases slightly with e 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 complexit 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 operation 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 stella index camera sub-system to enhance its usefulness for mappin 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. I 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 vehicles 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 perigee altitudes, scan angles, f-numbers, minimum spacecraft diameters 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.

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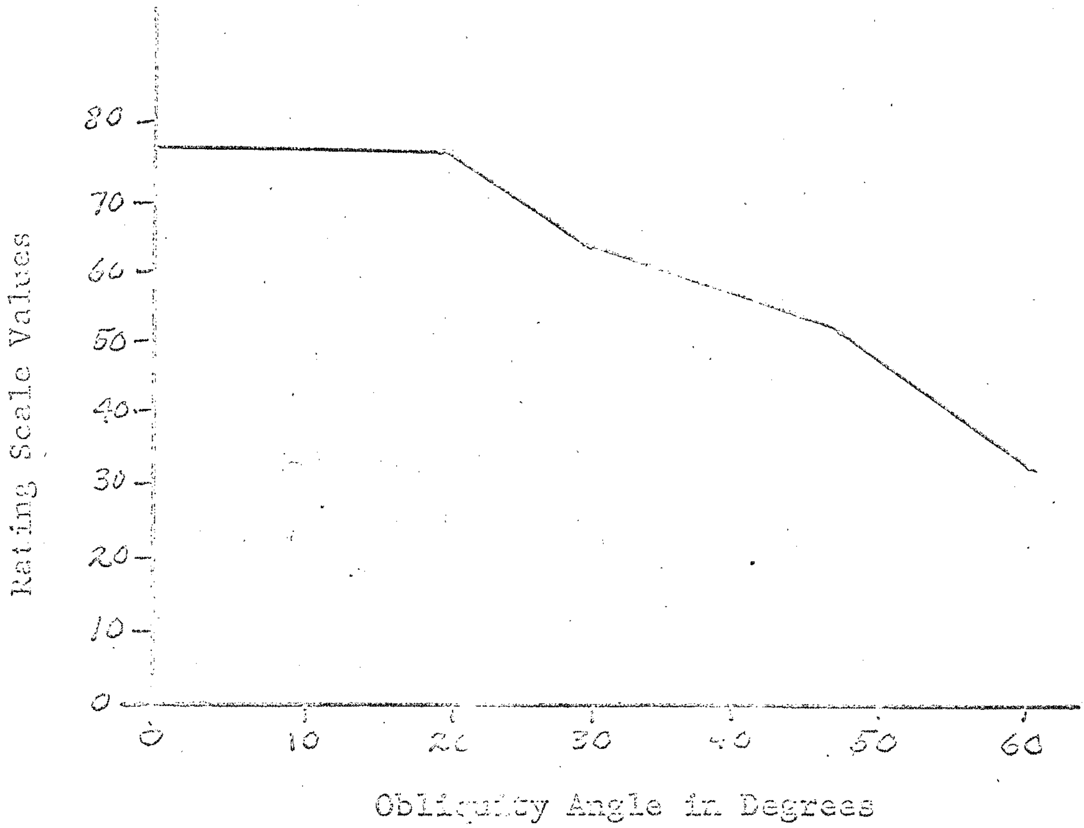
The above-mentioned COMOR D-13/56 included the following table as a summary of the value of resolution in providing intelligence elements of information from photography of varying resolutions:

Improvement in Ground Resolution		Changes the Cumulative Percent of Information		
From	To	From about	To about	Gain (
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 [illegible] Factors [illegible]search Inc./Perkin-El study on the effects of [illegible] convergence and obliquity ang on intelligence informa[illegible] which can be gained from overhea photography indicated [illegible] the usefulness fell off significa at obliquities from 20 [illegible] 30 degrees. The following general graph from the study depicts their findings on the effect o obliquity:

2



The cited reports admittedly are subjective opinions; however, the relative value of resolution is a very subjecti matter between extremes of photographic quality--as a matter of fact, no precise mathematical measurement technique has y 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, consid able 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 NRC 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 and North Vietnam). The report stated that "KH-4...has yielded some us 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 <u>potential intelligence value</u> of a single day' operation for a satellite search and surveillance system mig be calculated by summing up the value of resolution for all of the territory to which photographic access is obtained. To obtain the best and worst potential performance which mig be expected, this summation should be done for both a mid-wi and mid-summer situation, taking into account the varying su angles as the satellite traverses the area of interest. Thi 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 ma 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 signif cant in that an increase in film results in increased RV we

...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 at design perigee altitude, and ignoring frame-to-frame duplicate coverage), multiplied by the designated design scan angle of the proposed system, and divided by the scan angle required by the 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 [illegible]recast weather, operati[illegible] techn[illegible] employed, etc. In this respect, as an exampl[illegible] of the [illegible] use of a search an[d] surveillance system, it [illegible] of interest to note the projected allocation of film for a [for]thcoming [CORO]NA 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 purpo[ses]. The formula also recognizes the CORONA/GAMBIT relationship i[n] the surveillance role and generally assumes a similar relatio[n]ship in the future for the Advanced GAMBIT (G-3) and the new search and surveillance system.

The formula has prov[en] valid under a variety of tests. Both CIA-OSP and SAFSP ha[ve] carried out studies on the numbe[r of] days on orbit required to achieve varying degrees of coverag[e] 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 agreem[ent] 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 fi and compared favorably with the 960 lbs in the contractor's analysis. In another case, for a 30-day mission for a speci sensor, the CORONA-derived formula and the contractor analys 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 th decision to extend the CORONA mission life from 11 to 14 day thus necessitating the larger THORAD booster, <u>without an increase in film capacity</u>, was made on the basis of such experience and predictions.

The CORONA, of course, does not have an adjustable swat 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) fr 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 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 val may be calculated by multiplying the possible days on orbit by the potential value of an average day's operation (discus earlier in this paper). The possible days on orbit are arri at, with due consideration of reliability, by computing the weight of film and other expendibles required daily, plus th 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 tota on-orbit weight provided by the selected booster.

By working back and forth among such formulae, the sens contractor can determine an optimum view angle (between the upper and lower limits established in the RFP) and optimum [illegible] perigee altitude (at or above a lower limit imposed for reasons of atmospheric drag and thermal heating considera tions) for his system. These formulae also completely elimi the task for the contractor of attempting to estimate how we 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 n 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 c the total poundage which may be placed on orbit) are set for 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.

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In particular, clo[illegible] [illegible] [illegible] given to the possibility of unusual th[illegible] [illegible] problems between th[illegible] satellite basic assembly [illegible] the [illegible] sub-system under the proposed management arr[illegible]. [illegible], and [illegible] experie[illegible] with a wide variety of s[illegible] systems indicates that no serio[illegible] problems should be encoun[illegible] so long as close-in and fine thermal control is a res[illegible] of the payload sub-syste[illegible] contractor (and such an [illegible] of responsibilities is recommended for the sen[illegible] sub-system). The System Project Director will, in any ca[illegible] be charged with meeting the ther[illegible] environment requirements [illegible] the [illegible] and associated equi[illegible] established by the Sens[illegible] Sub-System Pro[illegible] Office. The achievement of optimum [illegible] balance within the spacecraft shell will be facilitat[illegible] by an integrated approach (exerci[illegible] by the SPD) to the desi[illegible] and packaging of components struc[illegible] considering the totalit[illegible] of heat sources and available heat sinks in relation to [illegible]. Experie[illegible] in other programs has ve[illegible] the [illegible] of assuring adequate thermal control [illegible] this [illegible] of responsibilit[illegible] between contractors. It [illegible] not [illegible] that isolation of the sensor sub-system in its own section of the spacecraft [illegible] in some instances, result in a better [illegible] arrangement f[illegible] this section alone; however, this [illegible] be achieved at the

[illegible] overall system [illegible]
does not appear to offer advan[illegible] sufficient [illegible] the disadvantages in structural and dynamic des[illegible] and [illegible]

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 S[illegible], in accordance with the normal assignments designated in the [illegible] NRP Agreement, is considered to be the best management arrangement.

It is proposed that respon[illegible] for the stellar index camera (or index camera only, if att[illegible] data is provided by some means other than stellar photograph[illegible] assigned to [illegible] FSP. Since the SI camera is not closely rel[illegible] to the primary sensor (in a technical sense), much more flexibility [illegible] in the configuration and location of this subsystem. However, it is recognized that overall system considerations [illegible] dictate the technical characteristics and location of the SI camera.

The re-entry vehicles must provide the 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-e vehicles is closely related to Air Force ballistic missile re entry vehicle technology; basic and applied research as well test facilities for both research and development are genera applicable to both ballistic and orbital recovery vehicles. The assignment of responsibility for the re-entry vehicles t SAFSP therefore recognizes the organizational responsibiliti and capabilities discussed above and is in complete accord w the DoD-CIA Agreement of [illegible] August 1965.

It is proposed to assign responsibility for the complet Sensor Sub-System to the CIA. The Sensor Sub-System is defi as including the major camera assemblies, close-in environm 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-sys in the spacecraft during preparations for launch (this may accomplished either at the spacecraft or sensor sub-system facility, or at the launch facility; this will be determine later), participating in the pre-launch system check-out, a certifying prior to launch that the sensor sub-system is operationally ready. During on-orbit operations, the CIA-O sensor/contractor team will be the principal advisors to th System Project Director for sensor sub-system operation. H in the case of technical difficulties and when in the judgm of the SPD that mission failure may be imminent, there bein insufficient time to seek other technical counsel, the operational decisions of the SPD shall always be overriding This assignment of responsibility will utilize the capabili experience and competence of CIA in sensor development acquisition and is also consistent with the 1965 NRP Agreem

It is believed that these assignments of system respon bility will provide the highest possible degree of system integrity--particularly during the acquisition phase. The will insure maximum utilization of experience and resources are available. They should insure the highest degree of fl bility in the engineering trade-offs which will inevitably made during the development phase. Experience in [illegible] satellite system projects indicates that such [illegible] of responsibili[illegible] 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 over-all 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 [illegible] information and data on all elements of the system, in[illegible] direct access to contractor engineering staffs, plants, and test [illegible]. However, supervision and direction of contractor acti[illegible] will be solely by CIA for the sensor subsystem and by SAFSP for [illegible] system elements. If either SAFSP or CIA-OSP determines that [illegible] of the other involves interface m[illegible] consultation and resolution of the problem is in order (the DNRC will re problems where diverse positions cannot be reconciled). On matters where interface clearly is involved, the SPD shall normally possess the res[illegible] [illegible] the [illegible] 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 [illegible], a [illegible] representative of the SPD will be located at Langley in a similar capacity.

[illegible]

[illegible]

[illegible] [illegible]

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

[redacted]

n. 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 capabilit 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 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's designated normal design altitude will be not worse than 2.7 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 stages 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 85 miles' perigee; the expected ground resolution at this altitude is 2.7 feet or better. The GAMBIT photography has consistently demonstrated the expected resolution.