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HANDLE VIA BYEMAN CONTROL SYSTEM ONLY - GAMBIT

Program Summary Report

VOLUME 1

DIRECTORATE OF SPECIAL PROJECTS
OFFICE OF THE SECRETARY OF THE AIR FORCE

GROUP I
Excluded from automatic
downgrading and declassification.

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 1ST STRATEGIC AEROSPACE DIVISION (SAC)
VANDENBERG AIR FORCE BASE, CALIFORNIA 93437

22 July 1981

REPLY TO ATTN OF: CC

SUBJECT: Facility Access

TO: To Whom It May Concern

[redacted] are authorized unaccompanied access to Bldg 1538. They are allowed to vouch entry to said building for the personnel listed below. Vehicles and equipment which they deem necessary for performance of official duties will be allowed into the area. [redacted] are responsible for the actions of their personnel.

[redacted]

JACK L. WATKINS, Maj Gen, USAF
Commander

[redacted]
Colonel, USAF
Vice Commander, WSMC

Peace . . . . is our Profession

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VOLUME	APPENDIX	DATA PACKAGE (CONTAINER #1	CONTAINER #2)
1	--	x	
2	1		x
3	2		x
4	3 & 4		x
5	5		x
6	6 thru 8		x
7	9 thru 11		x
8 (Tube)	12 thru 14	x	
9	15		x
10	16		x
11	17 thru 19		x
12	20		x
13	21 thru 23		x
14	24		x
15	25 thru 27		x
16	28 thru 31		x
17	32 thru 33	x	
18	34 thru 36		x
19	37		x
20	38 and 39	x	
21	40 and 41	x	
22	42	x	
23 (Can)	43	x	
23 (Can)	43	x	
24 (Tube)	44 - 46	x	
24 (Tube)	44 - 46	x	

CAN (MICROFILM) CONTAINS: ROLL 2 (Appendixes 1 thru 8), ROLL 3 (Appendixes 8 thru 16), ROLL 4 (Appendixes 17 thru 25), ROLL 5 (Appendixes 26 thru 37), ROLL 6 (Appendixes 38 thru 41), ROLL 7 (Appendixes 44 thru 46).
(NOTE: ROLL 1 (206 Program Report) was not in container when opened 22 July 1981.)

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DEPARTMENT OF THE AIR FORCE
6595TH SATELLITE TEST GROUP (AFSC)
VANDENBERG AIR FORCE BASE, CALIFORNIA 93437

26 August 1981

REPLY TO ATTN OF: CC

SUBJECT: Removal of "Van Winkle" Documentation

TO: Whom It May Concern

1. On 22 Jul 81, special equipment container #978 was opened upon direction of Maj Gen J. Kulpa, Director, SAFSP. Microfilm and film were removed for reproduction in support of documenting the history of Program 206.

2. Upon opening the container the contents were checked against the manifest: it was noted that one item was missing. The missing item was microfilm roll #1.

3. Following study and duplication, the removed documents were returned on 26 Aug 81. The container was purged with dry nitrogen and resealed.

[redacted]

Program Security Officer

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~~TOP SECRET~~ — GAMBIT

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GAMBIT PROGRAM SUMMARY REPORT

1960 - 1967

BYE-16625/68 1 9

APPROVED:

JOHN L. MARTIN, JR.
Brigadier General, USAF
Director

ROY O. SMITH, JR.
Colonel, USAF
Deputy Director

DIRECTORATE OF SPECIAL PROJECTS

OFFICE OF THE SECRETARY OF THE AIR FORCE

This report contains 122 pages.

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~~TOP SECRET~~ — GAMBIT

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FOREWORD

In August 1967, following completion of the 206 Program -- a highly classified Air Force satellite reconnaissance project known covertly as "GAMBIT" -- the Assistant Secretary of the Air Force for Research and Development approved the preparation of two sets of surplus GAMBIT hardware and associated documentation for long term storage at Vandenberg Air Force Base, California, under the code name "Project Van Winkle." It is intended that this satellite hardware and accompanying data package be released at some future date to the Smithsonian Institute and Air Force Museum for display purposes when national security considerations permit.

The express purpose of this report is to summarize the GAMBIT history; briefly describe its hardware; provide some insight into the operational aspects of the program; and record the salient results achieved therefrom.

Since the exchange of correspondence which led to the establishment of this long term storage project may be of some interest to the reader, copies of that correspondence have been provided on the pages which immediately follow.

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C O P Y

BYE-16625-68

DEPARTMENT OF THE AIR FORCE
DIRECTORATE OF SPECIAL PROJECTS (OSAF)
AF UNIT POST OFFICE, LOS ANGELES, CALIFORNIA 90045

SP-1 4 Aug 1967

SUBJ: Long Term Storage of GAMBIT Hardware at Vandenberg AFB

TO: SAFRD (Dr. Flax)

1. The GAMBIT Program was initiated immediately following the loss of the U-2 reconnaissance aircraft over the Soviet Union in May 1960. The mission of the Program was to obtain aircraft-quality photography via satellite. While it was not the first project to obtain satellite photography, it was the first to obtain satellite photography of aircraft-quality, and substantially exceeded the actual technical specifications set out at its inception. Based on our earlier discussion to preserve certain GAMBIT hardware for historical purposes, I have established appropriate plans and have been proceeding with necessary actions to prepare this equipment and associated documentation for long term historical storage for eventual release to the Air Force Museum and the Smithsonian Institute. It is my intent to take advantage of available contractor manpower still assigned to subject program to carry out this task during program phase-out.

2. Both GE and EKC have submitted proposals for the accomplishment of this work. Total cost related thereto has been estimated at approximately $100,000 which is considerably less than the eventual savings expected from program termination action. I believe it appropriate that a portion of these savings be utilized to accomplish this work in connection with required hardware disposition actions.

3. Details concerning the hardware to be stored and the method for carrying out this task are contained in the attached plan. In addition, I have also included a proposed letter for your signature to CINCSAC directing the long term storage of this equipment.

4. All effort associated with preparing this hardware and documentation for long term storage should be complete by about 30 Sep 1967, assuming we receive your approval now to proceed.

/s/
JOHN L. MARTIN, JR.
Brigadier General, USAF
Director

2 Atch
1. Long Term Storage Plan
2. Prop Ltr to CINCSAC

C O P Y

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COPY

DEPARTMENT OF THE AIR FORCE

WASHINGTON

Office of the Assistant Secretary

August 25, 1967

MEMORANDUM FOR THE CHIEF OF STAFF, USAF

SUBJECT: Long Term Storage of GAMBIT Hardware at Vandenberg AFB (Project Van Winkle)

1. The last GAMBIT satellite was launched on June 4, 1967 and we are now in the process of closing out the program.

2. The GAMBIT Program was initiated immediately after the loss of the U-2 reconnaissance aircraft over the Soviet Union in May 1960. The mission of the program was to obtain aircraft quality photography via satellite. While it was not the first project to obtain satellite photography, it was the first to obtain satellite photography of aircraft quality and it has provided a significant portion of the country's intelligence during the period it was operational from July 1963 to June 1967. Therefore, it is considered desirable to preserve existing examples of this hardware for release to the Air Force Museum and the Smithsonian at a future date to be determined by the Secretary of the Air Force.

3. In view of the present sensitive nature of this equipment, positive security control must be maintained and written approval of the Secretary of the Air Force will be required to move or open the containers once the storage site is selected and the containers placed.

4. The storage at Vandenberg AFB appears to be most logical. Therefore, I am sending the attached letter to the Commander, SAC, requesting him to provide and maintain appropriate storage.

/s/
ALEXANDER H. FLAX

COPY

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C O P Y

SAF-1625-68

DEPARTMENT OF THE AIR FORCE
WASHINGTON

Office of the Assistant Secretary

August 25, 1967

SUBJ: Long Term Storage of Program 206 Equipment at Vandenberg AFB (Project Van Winkle)

TO: Commander
Strategic Air Command
Offutt Air Force Base
Omaha, Nebraska

1. Two sets of certain classified satellite hardware from Program 206 are being readied for long term storage at Vandenberg AFB. It is intended that this hardware be released to the Air Force Museum and the Smithsonian Institute for display purposes at some future date to be determined by the Secretary of the Air Force.

2. In order to facilitate storing this hardware for an indefinite period, it is requested that a suitable storage site be arranged at Vandenberg AFB which will provide approximately 750 sq. ft. of secure storage space at minimal cost. Once the storage site has been selected and approved by the Director of Special Projects, OSAF, and the hardware containers put in place, the storage site must not be changed without prior written approval from the Secretary of the Air Force.

3. Due to the sensitive nature of this equipment, it is mandatory that positive security control be established and maintained to preclude forceable or accidental opening of the containers. The external view of the storage containers will be unclassified. Two plaques will be placed on each container indicating the contents are non-explosive and non-hazardous and that Secretary of the Air Force approval is required to move or open the containers.

4. Request you advise the Director of Special Projects, OSAF, Los Angeles, California, of the storage site selected so that appropriate arrangements can be made to have this hardware delivered for storage. You are also requested to take necessary action to insure that each succeeding commander of Strategic Air Command, and commander of Vandenberg Air Force Base are made aware of this storage and all restrictions related thereto.

/s/
ALEXANDER H. FLAX

C O P Y

LIST OF FIGURES AND TABLES

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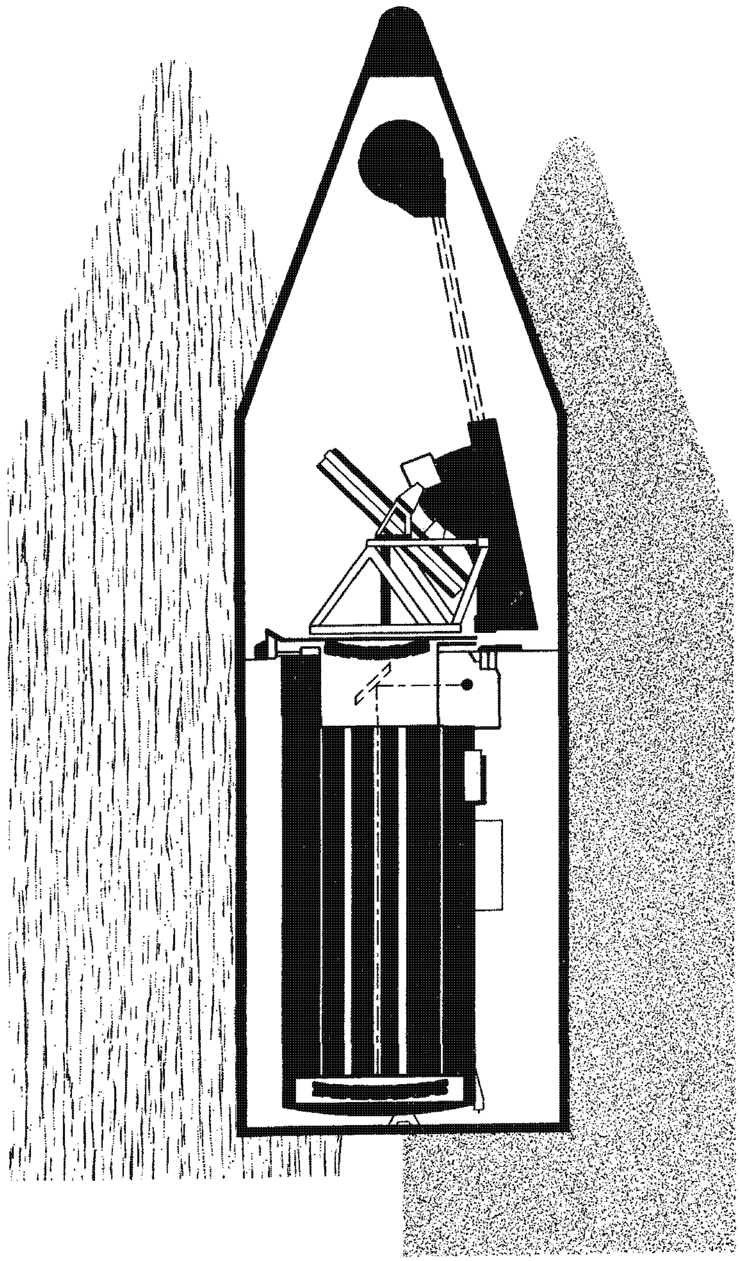
GAMBIT PROGRAM SUMMARY



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SECTION 1

GAMBIT PROGRAM SUMMARY*

1.1 INTRODUCTION

The GAMBIT Program, concealed under various numerical designators, was a satellite reconnaissance development program of the early 1960's. It was a camera-in-orbit activity carried on in those years when very little was known and less was publicly said about the subject.

Under the auspices of the United States Air Force, the GAMBIT system was developed and used as a national resource of the United States in the years from 1960 to 1967. Due to the political and military circumstances of the time and to the nature of the technology involved, GAMBIT went from conception to completion amidst the tightest of secrecy wraps. During the period when GAMBIT was being developed and operated, the United States never conceded its existence, although both the foreign and domestic press sometimes made near-accurate guesses about what was occurring in military space programs, and foreign intelligence agencies certainly were aware that information acquired through orbital reconnaissance was playing a significant role in shaping national policy in the United States.

*This summary history was prepared by Mr. Robert L. Perry of the RAND Corporation who, by special arrangement, served as historian for the Special Projects Directorate (SAFSP).

At the conclusion of the GAMBIT Program, in mid-1967, when the program had been superseded by more advanced developments, the Secretary of the Air Force agreed that the public interest would be well served by preserving two GAMBIT satellite vehicles that had not been flown. It seemed probable that at some future time, when revelation of what had been done, and how, no longer offended the interests of national security, the nation might want to display these vehicles in its national museums. Because the vehicles and their contents cannot speak fully for themselves, it seemed appropriate to include with them a description of the course of the program, its major events, its technological ingredients, and the details of its operation. The pages that follow provide that information.

To those who are encapsulating these documents and artifacts, it appears that this preservation process may insure the survival of knowledge that might easily be lost if no precautions were taken. Some of the events of the GAMBIT Program were uniquely important. In many respects, the specific achievements of GAMBIT anticipated by several years some widely heralded results of other space programs that could be conducted openly, and that thus became generally known. But it is not merely pride of achievement that calls for the preservation of these items of hardware and the account of their use. Here is the record, and the product of an exciting technology in its formative years, of management practices and development procedures and space operations that seem certain to be of great interest to a later generation. Although circumstances prevented the general release of such information at the time the GAMBIT Program was concluded, the people of the United States should be able, someday, to learn of what was, in its time, a most remarkable achievement.

1.2 RECONNAISSANCE FROM SPACE: PRELUDE

Although an American satellite reconnaissance system had been advocated as early as 1946, very little was done to further the notion for nearly a decade. The justification for inaction was the lack of rocket boosters powerful enough to place relatively heavy photographic payloads in orbit -- but even had suitable boosters and payloads been available, it is doubtful that much progress would have resulted. Disinterest in satellite technology was pronounced in the 10 years following World War II. That advocates were unable to concoct a convincing requirement for satellite operations certainly contributed to administrative apathy, but the lack of evidence that space operations were really feasible probably had equally as much effect. Until 1955 there was almost no serious consideration of how a reconnaissance satellite might fit into the national force structure, and except for some abstract studies that were given more amused tolerance than real attention, there was no effort to define a national policy on the use of space for military purposes.

Nevertheless, by 1951 the United States Air Force had formally established a satellite reconnaissance development project that was later called "SAMOS" or Weapon System 117L (WS-117L). Funding was scant and other resources few, so no appreciable progress was made before 1955. With the creation of a national ballistic missile program in that year some additional interest and a bit more money came to WS-117L. The excuse for development was that an observation satellite might be able to detect troop concentrations or air fleet movements and thus could provide advance warning of a pending attack. The Strategic Air Command was mildly interested in the possibility that the use of satellite reconnaissance would improve targeting techniques. But, the era was dominated by concepts of massive retaliation, and as long as national strategy was based on bombing large cities, reconnaissance from space represented a capability that was scarcely essential. Finally, within the defense establishments there was apprehension that the "space for peace" policy enunciated by President Dwight Eisenhower in 1955 was too narrow to accommodate a military reconnaissance satellite.

The first significant change in these conditions followed immediately on the Soviet Union's launch of Sputnik I in October 1957. A Russian proclamation of success in ballistic missile development had appeared the previous August, and had caused some alarm in military circles, but Sputnik I was an undisguisable event that touched off a public and political furor over relative American and Soviet missile and space achievements. Reaction to Sputniks I and II brought substantial increases in funding for both the established missile development programs and the embryonic satellite developments.

Unfortunately for the prospects of WS-117L, a new national awareness of space operations caused an enormous expansion of the entire space research field, military as well as civil, and although total resources were appreciably increased they had to cover a multitude of projects rather than support the earlier two (SAMOS and Vanguard). And although the Air Force retained at least nominal control of what had been WS-117L, custody of virtually all military space programs was given to the newly created Advanced Research Projects Agency of the Department of Defense. Partly for that reason, partly because WS-117L still was oriented toward technical goals defined somewhat imprecisely early in the decade, and partly because unanticipated difficulties in the development of a reconnaissance satellite were slowing progress, WS-117L staggered through a succession of delays, reprogramming decisions, and program redirections or expansions during the next two years. When the Air Force recovered custody of the satellite reconnaissance program in early 1960, neither progress nor prospects for progress could be viewed optimistically. The early program had been built around readout concepts involving on-orbit film development and electronic transmission of images to ground stations. By 1960 it had become apparent to much of the Air Force that the quality of the information so retrieved was unlikely to be particularly high and that the cost of the complete system, which included an elaborate complex of readout and data processing stations, was certain to be exorbitant.

An interesting alternative had been conceived as early as 1957: recovery of exposed film from orbit. The concept emerged from studies conducted by the RAND Corporation and by Thompson-Ramo-Wooldridge Corporation, was taken up by the Lockheed Missiles and Space Division and General Electric Corporation, and eventually led to a modest research and development program built around the DISCOVERER project established in 1958. But a succession of technical failures had marked early attempts to demonstrate a capsule recovery technique, and by 1960 much of the Air Staff was convinced that recovery was not a feasible option for satellite reconnaissance operations. Nevertheless, the recovery technique was embodied in a WS-117L variant that entered development during the period of early DISCOVERER experimentation. It was, on the whole, not highly regarded by either the policy making people in Washington or the project managers responsible for its development, but in the absence of anything more promising it limped along haltingly.

An incidental reason for the striking lack of real progress in satellite reconnaissance before 1960 was the existence of a perfectly satisfactory alternative technique -- the use of special high-altitude aircraft for overflight of areas denied to the United States. In May 1960, with the capture of Gary Powers and a U-2 aircraft well inside the boundaries of the Soviet Union, that alternative became politically unacceptable. The international squabbling that followed the U-2 episode proved unexpectedly important to the satellite program because one of its by-products was an order from the President cancelling further aircraft overflights.

The timing of the cancellation was singularly unfortunate. In May 1960, the Soviet Union was starting to deploy intercontinental ballistic missiles in some numbers; without information acquired by overflight, the United States was in no position to determine the rate of deployment or the location of launch sites, pieces of information crucial to the effective functioning of the strategic forces and to the maintenance of a convincing nuclear deterrent. Satellite reconnaissance suddenly represented the only real opportunity for obtaining information the United States felt it must have. But obvious deficiencies of the ongoing SAMOS Program and the apparent inability of the Air Force to decide whether readout or recovery of film should be emphasized combined to make the whole matter of a future program an item of concern of the National Security Council. There were suggestions from several quarters that the responsibility for satellite reconnaissance should be taken away from the Air Force and given to some special agency of government. Simultaneously, two new and attractive proposals for the development of recovery-style reconnaissance systems appeared, each more promising than the original readout systems (handicapped by poor resolution, high cost, and technical complexities) and the cumbersome camera and film recovery system then in early development.

In August 1960, in the course of the DISCOVERER Program, the Air Force for the first time demonstrated that data capsules could be recovered from orbit. Late that month the National Security Council completed its review of the satellite reconnaissance program and recommended that responsibility for its conduct be assigned directly to the Secretary of the Air Force, thus taking its administration out of the environment of military routine in which it had been embedded. In practice, the Under Secretary of the Air Force, Dr. Joseph V. Charyk, became the administrative head of an activity now redefined to include responsibility for operational as well as developmental functions. On the advice of General Thomas D. White, Air Force Chief of Staff, and Lieutenant General Bernard A. Schriever, Commander of the Air Research and Development Command, Under Secretary Charyk had earlier approved the appointment of Brigadier General Robert E. Greer to head a reorganized Air Force satellite program. That program and all of the orbital reconnaissance projects then being considered by the Air Force were thereafter handled as a national resource independent of other Air Force activities. Under Secretary Charyk became, in practice, administratively responsible for the total program.

In the course of the next two years the earlier SAMOS reconnaissance satellite projects were either phased out or cancelled. In their stead the GAMBIT system was created. It was generally known outside project circles as Program 206; other designators were used from time to time but were changed for reasons of project security. Due to the increasingly sensitive nature of satellite reconnaissance and the rather extreme Soviet reaction to earlier American statements on the matter, the development was conducted in great secrecy. Apart from those immediately involved either in the development or operational phases of the program, few in government and virtually none outside (except participating contractors) had any knowledge of the undertaking. It had been plain from the beginning that actual launches could not be concealed and that their purpose probably would be obvious to the Soviet Union, but by conducting the program under tight security wraps the United States hoped to avoid most of the problems that would arise if purpose, capability, and achievements were widely known. The Soviets apparently had much the same thought. By the mid-1960's both the United States and the Soviet Union were operating observation satellites and both carefully abstained from calling attention to the situation.

The reconnaissance system itself -- launch booster, second stage, orbiting vehicle, photographic subsystem and recovery capsule --

was a combination of elements taken from the earlier SAMOS Program and unique equipment developed solely for the GAMBIT Project. Its core was a high-resolution camera proposed, designed, and ultimately built by the Eastman Kodak Company. Having a focal length of 77 inches, roughly twice the focal length of instruments earlier intended for use in satellites, the GAMBIT camera was capable under ideal conditions of capturing an image that permitted identification of ground objects measuring only two feet across. In practice, this meant obtaining from a satellite platform photographs equal to or better in quality than those taken by the U-2 reconnaissance aircraft. The camera was to be operated from a satellite vehicle in polar orbit, most pictures being taken from an altitude of about 95 miles. The orbital vehicle that encased the camera was developed by the General Electric Company. In its own right it would embody several striking advances over earlier satellites. In particular, it would be able to change both orbital attitude and orbital period on command through the use of gas jets and small rocket motors. The combination of camera and orbital vehicle was to be capable of producing stereo pairs, lateral pairs or strip photographs as the occasion required. It could also be precisely aimed at sites offset from the orbit track. Vehicle and camera were to be put into orbit by a combination of an Atlas booster (a decendent of the first American intercontinental ballistic missile) and an Agena spacecraft, a product of the original WS-117L project.

In 1960, when there was limited experience with the recovery of capsules from orbit, there were fears that a Soviet submarine or surface vessel might abscond with a capsule that was inadvertently dropped into the ocean in the recovery area instead of being caught in the air by the special aircraft assigned to that task. One of the objectives of GAMBIT as originally conceived was to provide for a soft landing of the recovery capsule somewhere in the wastelands of the western United States.

The various ingredients of what became the GAMBIT system were independently conceived, the camera by Eastman, a system concept by RAND and Space Technology Laboratories of Thompson-Ramo-Wooldridge, and the orbital and re-entry vehicles by the General Electric Company. What became a package was worked out mostly by Colonel Paul J. Heran and other members of General Greer's immediate staff. Both Dr. Charyk and General Greer were personally and intimately involved in the refining process, as were members of the Space Systems Office which Dr. Charyk established to handle the Washington end of the reconnaissance program. The project office was continued in its original location in the complex of buildings chiefly occupied by the Air Force Ballistic Missiles Division in the Inglewood and El Segundo areas of Los Angeles.

Owing to the very sensitive nature of the program, it was essential to conceal the existence of GAMBIT not only from the Soviet Union, and hence from the American public, but also from other military and civil departments of the government. Reaction to an open acknowledgement that the project existed might be enough to doom it. The inconspicuous purchase of Atlas and Agena vehicles could be arranged easily enough and excused on the ground of their use in other projects, but to avoid drawing attention to the sizeable funds that were needed to transact what was essentially a new and prospectively very expensive satellite development, money for the project was allocated to a budget item identified as "advanced systems development." For the first 18 months of GAMBIT's existence, project office personnel were physically separated from the group General Greer headed because it seemed desirable to avoid any suggestion that reconnaissance -- with which General Greer had been publicly associated -- was the purpose of Program 206. The camera payload was never identified in reports or correspondence circulated openly, but still in classified form, even within the Air Force. Nothing was ever said outside project circles that specifically identified the objective of Program 206, so most of those who knew of its existence assumed that it involved either new munitions of some sort or an Air Force man-in-orbit program. The passage of time and the continuing absence of anything obviously interesting in the visible part of the project eventually provided their own cloak of obscurity. Boosters, upper stages, and launch services were purchased rather routinely, through "normal" channels, and there were surprisingly few occasions when it became necessary to provide any explanation other than that of "classified payload."

The development phase of the GAMBIT Project extended from December 1960, when the first contracts were let, to first launch, on 12 July 1963. In all, 38 GAMBIT launches were attempted from pads at Vandenberg Air Force Base; 36 space vehicles achieved orbit; 35 capsules were recovered; and of these, 27 contained fully useful photographic negatives. Nearly 110,000 feet of film were sent aloft; approximately 36,000 feet of film containing images useful to the United States were recovered and processed. The area covered by the cameras of GAMBIT vehicles and recorded for photo interpreters exceeded 7,000,000 square miles, virtually all of it selected because it contained items of particular interest to one or another of the American intelligence organizations. Maximum ground resolution occasionally went as low as 18 inches (that is, an article 18 inches on a side could be detected, or all ground details larger than 18 inches could be plainly identified). In essence, GAMBIT was able to provide "airplane quality" reconnaissance photographs of virtually any desired point on earth, on order, repeatedly, and over a period of four consecutive years.

1.3 THE INITIAL DEVELOPMENT PROGRAM

Formal contracts covering the development of the GAMBIT system as it was originally conceived were signed between November 1960 and January 1961.

One of the peculiar characteristics of satellite programs was that development costs tended to extend through the entire period of operational use rather than being concentrated in pre-operational phases, as was normally true in weapons development. In all, $150.5 million was spent on GAMBIT development in the period from late 1960 through July 1967. Of this total, the satellite vehicle and reentry vehicle accounted for $105.7 million and the camera payload for $28.7 million. Eastman Kodak Company was the payload contractor; General Electric developed and produced the satellite and recovery vehicles and their associated subsystems; Lockheed Missiles and Space Company provided the modified Agena second stage; General Dynamics/Astronautics supplied the Atlas booster; and Itek Corporation furnished the stellar-index camera. The horizon sensor, originally a General Electric responsibility, was in the end obtained from Barnes. In all, with procurement and operational funds included, GAMBIT cost approximately $650 million.

Although none of the satellite reconnaissance systems developed as a part of the earlier SAMOS project had actually flown successfully at the time GAMBIT requirements were laid down, it was clear that a level of performance considerably higher than earlier believed feasible would be required of GAMBIT. Thus the specification of a ground resolution of two to three feet (as against the 10 feet to 100 feet of earlier systems), a capability of photographing targets somewhat off the direct orbital track (a precision pointing ability not incorporated in earlier systems), and land recovery (all earlier systems had incorporated either readout or air-catch provisions of some sort, although variants of sea recovery had been extensively studied). The 90 to 95 mile flight altitude represented a lowering of orbital heights from the 105 to 150-mile altitudes planned for previous satellites. Together, the orbit and resolution requirements imposed a need for highly accurate orbits over periods of several days (the nominal design objective was a five-day mission), for extremely precise attitude and altitude control, and for an ability to roll the vehicle about its main axis so the camera would be precisely pointed at a specific target area. Land recovery implied extremely precise deboost velocities and re-entry programming.

The attitude control system consisted of a two-axis gimballed platform on which were mounted infrared horizon scanners and an integrating gyroscope. The horizon sensors were designed to measure pitch and roll error; the gyro, yaw error. Attitude was controlled by exhausting cold gas (freon) through several jet nozzles in response to amplified signals from the gyro error outputs. A hot gas stabilization system was considered but never adopted because of excessive development lead time.

A set of two restartable rocket engines, each capable of producing 50 pounds of thrust, provided an orbit maintenance capability. This system was also used to deboost the Orbital Control Vehicle after the reentry vehicle was separated for recovery.

The basic design of the camera system was completed on 1 August 1961, 10 months after the date of the contract and about 14 months after Eastman Kodak had first proposed the 77-inch camera. Design of the orbital vehicle was not quite as far advanced. The initial program goal had been a first launch by January 1963, and for the moment there seemed no reason to question the reasonableness of the schedule. On that assumption, the procurement of operational articles was authorized in September 1961 and the program entered its system development phase.

The inevitable unpredictables of development began to have their effect by late 1961. The anticipated weight of the GAMBIT system overtook the payload weight potential of the Atlas-Agena launch combination in January 1962, and in order to reduce poundage the six forward-firing rockets earlier designed into the orbital vehicle had to be deleted. Thereafter, in order to reduce velocity and put the vehicle in a lower orbit, it was necessary to turn the vehicle about (end to end) by using yaw controls, thus making the two "rear" rockets serve the functions of the six that had been removed.

At the same time, difficulties with the development of vehicle stability subsystems were beginning to cause schedule slippages. The infrared horizon sensors being developed by General Electric seemed incapable of providing the required pointing accuracy and extensive re-engineering would delay a first launch well past the time the National Security Council had specified as "essential."

Immediate corrective measures included the provision of additional test facilities and test items, a costly and not fully satisfying remedy. The alternative was to rely on devices that stabilized the vehicle rather than the camera system, an expedient that was expected to cause degradation of the photographic image. In any case, a schedule slippage could not be avoided. May 1963 rather than January became the new target for first launch. The original estimates on the cost of the vehicle subsystem, which had been considered optimistic all along, were essentially doubled at the same time.

In considerable part the increasing cost of the GAMBIT Program stemmed from the difficulty being encountered in satisfying the requirement that the film capsule be recovered within the continental United States. General Greer had distrusted that requirement from the time of its imposition, even though the reasoning behind it seemed sound enough. By July 1962, however, there were excellent reasons for reconsidering the original decision. Weight was dominant. Notwithstanding determined efforts by the contractors and the project managers, GAMBIT was once more some 500 pounds heavier than its design limit, an overweight that could be traced to the complex subsystems needed for land recovery. Moreover, what had seemed in 1960 to be compelling reasons for mistrusting air-catch over the sea no longer had much force. Continued successes with the DISCOVERER system had dispelled doubts about the general feasibility of making air-catch a routine operation, while experience in recovery operations had all but demolished the apprehension that a Soviet trawler or submarine might abscond with a recovery capsule.

One of the problems that had been lightly passed over when the land recovery concept was adopted for GAMBIT in 1960 was the impracticality of relying on jettisoning as a device for reducing the catch weight of a recovery capsule. Over the sea a parachute-suspended re-entry device could freely shed such bulky encumberances as hatch covers and an ablative shield. They could injure nothing in their fall, and the bits and pieces would vanish into the emptiness of the Pacific without alerting anyone to the secret of a satellite reconnaissance operation. Over land, nothing could be cast loose, first because of the danger to buildings and people, and second because of the possibility of a security breach.

As experience with DISCOVERER had shown, the danger of overshooting or undershooting the recovery area could never be dismissed. That was an important consideration, because in a land-recovery operation any appreciable error in de-orbit sequencing could cause a film capsule to come down in Mexico or Canada, a prospect that nobody wanted to think about. Because of such factors the possibility of applying air-catch techniques to the GAMBIT re-entry vehicle was examined as early as January 1962, but the weight of the vehicle made it seem all but impossible.

Uneasily conscious of the need to reduce weight and of objections to land recovery, General Greer in the early summer of 1962 thought of an alternative. He informally mentioned his idea to Dr. Charyk, who thought it worth investigating. So General Greer in July 1962 wrote a longhand memo authorizing General Electric to do a quick study of the feasibility of "gluing the DISCOVERER capsule on the front end of GAMBIT." While the contractor began the inquiry, General Greer sought the advice of Colonel John L. Martin, Jr. of the Washington-area project group. Together they analyzed the pro and con factors. In August 1962, General Greer incorporated their arguments in a study in which he formally urged abandonment of land recovery concepts for the GAMBIT Program.

After mulling over the complex options, Under Secretary Charyk concluded that the arguments against relying on a recovery-over-land were formidable and that an excellent case could be made for air-catch. Launch schedules probably would slip somewhat if air-catch techniques were adopted, but program costs would be reduced and -- most important -- adoption of the DISCOVERER recovery technique meant that program risks would be substantially lessened. It seemed improbable that land recovery could be developed in time to satisfy GAMBIT program schedules in any case. On such grounds a change to air-catch procedures was approved. Partly because so extreme a shift in concept and configuration offered an opportunity for making other desirable changes, partly because of the increasing pressure of several other GAMBIT problems, General Greer used the occasion of the shift from land recovery to air-catch as the occasion for a general program overhaul. Colonel W. G. King, who had been associated with satellite reconnaissance in one role or another almost from the year of its conception, was named program manager. Proposals for a new recovery capsule lying midway between the original GAMBIT design and the proven DISCOVERER design were squelched in favor of the simplest possible adaptation of the DISCOVERER capsule. The vehicle stability problem, still not satisfactorily resolved, was attacked directly: General Greer and Colonel King proposed leaving the

General Electric Orbital Control Vehicle attached to the Agena second stage through the whole of early missions rather than separating it once orbital velocities had been achieved, as the development plan specified. The Agena had a well tried stabilization system of its own, though one that was generally believed to be insufficiently precise for the sort of pointing accuracy GAMBIT ultimately would require. To provide insurance against the ultimate failure of stabilization system development in the GAMBIT vehicle, the decision was made to employ a coupling device developed as an offshoot of an earlier space program: the interconnect joint would allow the conjoined vehicle and its camera section to be rotated about the longitudinal axis of the Agena, thus providing the independent camera pointing capability that was so important to GAMBIT. If the original subsystems went through development on schedule and without more trouble, so much the better. If they did not, at least there was an acceptable alternative. The ultimate option, which most program people preferred not to think about, was to cancel the program because of its technological inadequacies.

Another safeguard was introduced during the period of program overhaul that came late in 1962. A Backup Stabilization Subsystem (BUSS), also known as "Lifeboat," was incorporated. It essentially consisted of independent re-entry command circuitry, a separate magnetometer, and an independent supply of stabilization gas. If the primary systems for any reason became inactive or ineffective, "Lifeboat" could be actuated. The magnetometer used lines of magnetic force for longitudinal stabilization reference, thus permitting accurate and automatic determination of the proper vehicle attitude for the start of de-boost operations. Having its own gas supply and being dependent only on a separate command sequence for the recovery process, "Lifeboat" was capable of insuring re-entry under conditions that otherwise might be fatal to the mission.

The several additions and changes to GAMBIT during the fall of 1962 were uniformly intended to simplify the total system and increase chances of its operating as intended. Their effect was to improve -- substantially -- the prospect of program success. Putting them into effect had another consequence: it permitted the deletion of some rather elaborate test sequences that had earlier been scheduled, and in turn that action restored credibility to launch schedules -- which had become increasingly unreal as troubles mounted late in 1962.

On the strength of experience in the mostly abortive satellite reconnaissance programs of earlier years, one other change was introduced early in 1963. At the insistence of General Greer, who had a well developed respect for the unforeseeable, the objective of the first GAMBIT launch was formally and plainly stated: "Get one good picture." No attempt was to be made to operate GAMBIT in all its modes during initial flights. That could come later, as the inevitable problems of total system operation were met and subdued.

A stellar-index camera, a device for insuring that photographs of individual ground sites could be precisely located by reference to celestial bodies, was made a firm requirement of GAMBIT early in 1963. Until that time it had been treated as an auxiliary package. Because of the late certification of the requirement, however, there was no possibility of adding the stellar-index camera to the first four GAMBIT systems to be flown.

By the time the stellar-index camera had been incorporated into the system specification, the first lot of GAMBIT equipment -- launch and orbital vehicles, camera, and subsystems -- had passed through the manufacturing stage and was in final assembly and testing. Force of circumstances made the fourth GAMBIT vehicle the first in what was very nearly a new "mark" of the system. "Hitchup," the interlock of General Electric's Orbital Control Vehicle (or OCV) with the Agena, was a provision of the first six launch combinations, but "Lifeboat" was installed in the Agena in the first three and in the separate GAMBIT Satellite Vehicles thereafter, while both the roll-joint and the stellar-indexing camera were scheduled to be installed starting with the fourth article.

Early in March 1963, the initial order for six GAMBIT systems was enlarged to provide for a total of 10, and still later that month six more were ordered. In one respect the expansion reflected increased confidence in the prospects of program success, but the central reason for buying additional systems at that time was a change in national requirements for satellite reconnaissance. Its source was the Cuban missile crisis of October 1962. On the strength of experience during that episode the intelligence community had concluded that a substantial assurance of obtaining "on order" photographs of denied areas had to be provided, and one of the obvious ways was to provide "standby" reconnaissance satellites that could be called into use if a primary mission failed for some reason, or that could be put into orbit on short notice should the occasion arise. GAMBIT launches had originally been scheduled at approximately 40-day intervals; if more frequent launches proved desirable, or if backup systems had to be kept in readiness while scheduled operations continued, more GAMBIT systems would have to be obtained and provisions for acquiring additional GAMBIT-capable launch pads would have to be made. The objective was to provide a short-notice capability of inspecting, in detail, activities at various points over the Earth. To satisfy it, a modest stockpile of GAMBIT systems and boosters had to be acquired.

While decisions on these matters were in process, the first GAMBIT system was proceeding through final assembly and check-out. Incorporation of the "hitchup" safeguards slowed the progress of the booster-payload assembly early in the year, but by February it was back on a schedule compatible with a first launch in June 1963. Problems of electromagnetic interference appeared and were brought under control in February, and in mid-March the Agena selected for the first flight passed its final acceptance tests at Lockheed's Sunnyvale (California) plant. Early in April, Eastman Kodak located and corrected three elusive causes of focus error in the camera subsystem. Later that month static tests of the assembled camera section indicated that image resolution would be somewhat better than specified when GAMBIT development had been authorized, some 18 months earlier.

By early May 1963 the Atlas, the Agena, and an entire GAMBIT section had been combined on the launch pad and system checkout tests had begun. On the 11th of that month a valve failure and a faulty propellant loading sequence caused a leak in the boosters' pressurization system and the thin-skin Atlas collapsed on its stand -- sending a full load of fuel and 13,000 gallons of liquid oxygen shooting over the launch pad. The Agena and its GAMBIT payload were roughly dumped on the concrete hardstand. The General Electric vehicle and its contents were severely damaged; the Agena sustained injuries that though superficial, were serious enough to force the substitution of another second stage. The Camera Payload and Satellite Vehicle were each test items, not slated for the first launch, but the Agena and the Atlas were those intended for use on 27 June. Obtaining a replacement Atlas was no problem, though the project officer who abruptly lost a booster to a program that he could learn nothing about may have thought otherwise, but the Agenas were not that plentiful and in any case the Agena had to be modified in several respects to accept the special "hitchup" items. Launch stand damage was relatively slight, but so were the prospects of repairing it in time to support the 27 June launch.

Difficulties in the final calibration of the Orbital Control Vehicle occurred shortly after the launch pad accident and the fault-correction process set back delivery schedules by about two weeks -- during which period stand repairs and the Agena modifications were completed. By 12 July all the preliminaries had been disposed of, the first GAMBIT system was in final countdown, and all that remained was to discover whether the system would live up to its advance notices.

During the countdown there were three "holds" for technical reasons. After carefully considering the risk involved in resuming the countdown, General Greer ordered the launch to proceed. Lift-off came at 1344 hours, Pacific Daylight Time, on 12 July 1963.

Both the Atlas and the Agena operated normally. Returns from the first orbit indicated that vehicle apogee was 116 nautical miles and perigee 107. The orbital period was 88.51 minutes with an inclination of 95.34°. All parameters were well within the desired ephemeris. During the dumping of propellants from the Agena engine, vehicle motions were generated which depleted the Agena's control gas supply; however, enough was left for Agena stabilization during nine orbits.

All telemetry and command and control elements operated correctly during the early portion of the mission. On the fifth orbit, the camera was turned on for eight strip exposures of 20 seconds each. An identical maneuver was performed on each of the next two orbits. On the eighth and ninth revolutions, two stereo pairs and five 20-second strips were exposed. At that point it was necessary to discontinue prime photography because of the premature exhaustion of Agena stabilization gas.

The wisdom of "Lifeboat" incorporation was all too evident. The OCV/Agena was allowed to coast through the balance of 17 orbits, stabilization having become ineffective after the eighth. "Lifeboat" was actuated by a signal from the ground control station during the 17th pass and during the 18th orbit the "execute" command was transmitted to "Lifeboat". A routine separation and recovery followed, entirely unmarked by drama.

After the re-entry capsule had been safely recovered by C-119 aircraft circling near Hawaii, the Oribtal Control Vehicle was separated from the Agena for solo tests in a research and development mode. The OCV maintained its stability through revolutions 18-25 and it was successfully restored again on revolution 34 after a period of "coasting." Thereafter spurious commands caused instability, but on the whole, the operation was thoroughly satisfactory. General Greer's expectation of the unpredictable had proved sound in that not only had the OCV's mistrusted stabilization system been affected by the spurious commands, but the performance of the proven Agena had also been unexpectedly degraded when large quantities of engine propellants were dumped. In the end, the successful operation of the "Lifeboat" or "back up stabilization system" (BUSS) provided a successful conclusion to the initial operational mission.

Evaluation of the recovered film indicated that the image had been slightly out of focus, apparently because of uncompensated temperature changes affecting the face of the primary mirror and also because of incorrect image motion compensation settings. Nevertheless, on some portions of the film linear measurements of ground objects five feet across could be made, while average resolution was in the neighborhood of 10 feet. Among other things, this meant that single large objects could be detected on the processed

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photographs. On the whole, performance was quite good, exceeding expectations for an initial trial of GAMBIT.

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1.4 SUBSEQUENT DEVELOPMENT AND OPERATION

Although weapons acquisition processes of the early 1960's hinged on the promise that elaborate pre-planning would offset the usual consequences of working among the many uncertainties of development, virtually all development programs were troubled to some extent by unforeseen shortcomings of technology and by simple errors of design and fabrication. Frequent technical changes brought on either by efforts to overcome late-discovered deficiencies or by attempts to improve system performance marked most developments of the time. The frequency of change was particularly pronounced in space programs. Nothing resembling an operational space vehicle which could be produced in lots of near-identical items ever emerged from the space programs of the early 1960's. Boosters were largely standardized, and to a lesser degree the upper stages. But the orbital vehicles, the sensors subsystems, the various secondary systems and components continued to be subject to modification through most of their operational lives. During the period when the last 20 Orbital Control Vehicles were produced for GAMBIT, for example, necessary technical changes of one sort or another accounted for 73 percent of total contract costs. None of the changes was frivolous; most were essential either to correct defects that had been identified as operational experience with GAMBIT accumulated, or to improve in some way the performance of the orbiting elements of the total system. For that matter, the first several launches of GAMBIT were oriented more toward research and development than operational utility, although the ratio of emphasis between research and development on the one hand and operations on the other tended to shift toward the latter as time passed.

Of the 38 GAMBIT systems launched, only three were entirely trouble free. Most missions satisfied the principal flight objectives, but in almost every case during the first two years of operation something in the way of a change, a correction, or an addition to the system was prompted by the flight experience. Both the first and the second launches were affected by defects in the gas stabilization system. On the fourth flight the rate gyro system failed, causing almost immediate exhaustion of the OCV pneumatic gas supply, and there was a random short in the mirror control circuitry. Missions 10 and 11 were marked by focus adjust problems of considerable magnitude. The Agena engine failed before orbit was attained on mission 12. The direct current power converter malfunctioned on mission 21, and on the next two missions high stabilization gas comsumption forced an early shutdown of camera operations. An outside hatch cover stuck on mission 34, preventing use of the camera. During mission 36, the command subsystem sent improper signals to the camera circuitry, adversely affecting some exposures.

At the same time, GAMBIT was regularly producing excellent photography. On its seventh flight, in April 1964, the system returned images of 209 individual areas singled out in advance and registered a "best ground resolution" of 2.5 feet. The average "best" ground resolution for the first six flights during which photography was recovered (that is, through mission 8 but excepting 4 and 5) was 2.7 feet, and 421 individual locations were photographed. As a result of mission 15, photo interpreters acquired pictures of 688 locations and were able to work with a "best resolution" of 2.0 feet, while on flight 27, on 19 April 1966, more than 2000 locations were photographed and "best resolution" was again 2.0 feet. Flight 17 was the first of the five-day missions; by flight 26 the mission duration had reached six days; and on mission 30, begun on 12 July 1966, the orbital vehicle remained aloft and operational for more than eight days. Except for the one instance of disabling malfunction during flight 34, each of the last 15 missions returned in excess of 1000 individual location photographs; all had a "best resolution" of 2.5 feet or lower; and three had "best resolution" figures in the 1.6 to 1.9-foot range.

Some of the problems encountered by GAMBIT vehicles could scarcely have been foreseen by the most astute forecaster. During

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missions 8 and 9, in May and July 1964, the horizon sensor became inoperative either intermittently or for periods of several orbits. Analyses of flight behavior finally suggested that as the vehicle passed over the south polar cap the temperature-sensitive infrared sensor lost its ability to discriminate between earth and extra-terrestial space. At that time of year, deepest winter in the southern hemisphere, the temperature differential was insignificant. The development of a more discriminating sensor was undertaken as soon as the source of the trouble was located, but it subsequently became clear that some cheaper, simpler, and more quickly available alternative was preferable. The remedy ultimately adopted was to turn off the horizon sensors and let the vehicle "coast" while over the Antarctic, an expedient that proved fully effective.

Only the first three GAMBIT missions were flown in the "hitchup" configuration. Starting with flight four, the entire satellite vehicle composed of the Orbital Control Vehicle and the re-entry vehicle, was separated from the Agena immediately upon reaching orbit and operated essentially as conceived when the GAMBIT Program was defined early in 1961.* The first flights were clearly and plainly intended to be "developmental" in nature, a precaution that seemed necessary in light of experience with earlier and generally disappointing recon-

*Thus the roll joint connection was not needed, though had matters developed less favorably, it might well have been the savior of the program.

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naissance satellite programs. Neither the quantity of film exposed nor the amount of ground coverage provided per mission was considered a suitable criterion for judging mission success. Dr. Brockway McMillan, who had succeeded Under Secretary Charyk in March 1963, when Dr. Charyk left government service to head the new ComSat Corporation, defined GAMBIT's objectives as being limited to the acquisition of high resolution stereo photographs of designated areas of the earth. System effectiveness, he reasoned, would be measured by the results of efforts to satisfy that requirement and by no other standards.

Although so deliberate an approach to full GAMBIT operational utility had not been specified when the program was established in 1960, Dr. McMillan and General Greer were in complete agreement that the careful, gradual demonstration of the full capabilities of GAMBIT could be extended over the first ten missions without unduly handicapping the program. All of the previously unsuccessful photographic satellite programs had been marked by premature attempts to operate complete systems in all their modes, and in virtually every instance misfortune had been the outcome. The wisdom of a deliberate approach therefore seemed apparent. Not all of the problems that would arise in the course of operating GAMBIT could be identified by the time the tenth mission was completed, but many had been, and the extent of technical change brought on by the experience of those developmental flights validated the concept under which they were conducted.*

One of the projects of early experimentation was a demonstration that the satellite vehicle could be directed into a surprisingly low orbit and kept there for an appreciable period. Three orbit adjust maneuvers and a controlled de-orbit maneuver during mission five (launched 25 February 1964) showed that the orbit could be adjusted as comprehensively as planned and that it would be feasible to operate GAMBIT at a perigee of 70 nautical miles -- 20 miles lower than originally thought possible. (The fifth flight, incidentally, was one of three in the first set of ten that ended without returning usable photography due to a yaw anomaly caused by personnel error in the command generation process. Nevertheless, the success of the orbit maneuver demonstration justified, in its own right, the entire flight trial.)

In the course of the four-day seventh mission (launched 23 April 1964), the satellite vehicle spent two days at a perigee of 72 miles.

*As has earlier been noted, the fourth GAMBIT vehicle differed in several major respects from the first three; although no gross changes or additions of the sort that emerged from the program review of early 1963 were incorporated in GAMBIT vehicles four through ten, the tenth vehicle differed from the fourth about as greatly as the fourth had differed from the first. Nevertheless, for the purposes of program accounting, the fifth GAMBIT mission was counted as the first operational mission, and in terms of results achieved, it deserved that designation.

All photographic systems worked perfectly -- permitting designers to establish, among other items, that the stellar camera had to be shielded from earth light if its photograghs were not to be degraded. On the next mission (launched on 19 May 1964) an Agena malfunction placed the Satellite Vehicle in an orbit with a perigee of only 57 nautical miles. For two orbits it experienced atmospheric densities 17 times greater than any previously encountered by a satellite. The vehicle had stabilized itself by the time it passed over the first control station and in response to commands the orbit adjust rockets promptly sent the vehicle into a higher orbit. Again, the photographic equipment suffered no serious injury and the remainder of the mission was carried out routinely -- even though the infrared sensors became partially inoperative late in the first day of operation and the payload had to be recovered earlier than planned. The 57-mile transit provided incidental confirmation of the existence of significant atmospheric drag force, even at that altitude, and before the mission was ended the GAMBIT vehicle had returned better data on the density attributes of the atmosphere between 52 and 90 miles than had been available previously from any source. A serendipitous benefit of the infrared sensor problem was the discovery of the difficulties of relying on such stabilization indicators over the polar regions.

Most of the many technical changes incorporated into GAMBIT as a result of flight experience and deficiency analysis were introduced in 1964 and 1965. Effective with the 30th GAMBIT mission, the battery complex was enlarged to provide additional electrical power and the quantity of stored gas for the stabilization system was increased, but otherwise the experience of the final 15 missions (flown between January 1966 and June 1967) brought about no major alteration or modification of either the space vehicle or its photographic subsystem.

1.5 PROGRAM STRUCTURE AND MANAGEMENT

Through the life of the GAMBIT Program, its administrative overseers, in Washington, were Dr. Charyk (through March 1963), Dr. McMillan (March 1963 to September 1965), and Dr. Alexander H. Flax, Assistant Secretary of the Air Force. Each was personally, continually, and intimately involved in program affairs. Major General Greer served as Director of Special Projects, the title of the West Coast manager, until his retirement in June 1965 -- precisely halfway through the schedule of 38 GAMBIT launches. Brigadier General John L. Martin, Jr., who had served as chief of the Washington contingent from July 1962 to August 1964, and subsequently as Vice Director of Special Projects under General Greer, became Director of Special Projects upon General Greer's retirement in June 1965 and continued in this capacity for the remainder of the GAMBIT Program. Colonel Paul J. Heran acted as primary project director during the formative stage of GAMBIT, until September 1961, although he had a primary assignment elsewhere. In September 1961 Colonel Quentin Riepe was named project director; he was succeeded, in December 1962, by Colonel William G. King, who remained in charge of program affairs through the period of the first 31 flights. Colonel R. O. Smith, Jr., formerly Chief of the program's Engineering Division, was project director for the last seven GAMBIT missions.

Brigadier General Martin and Colonels King, Heran, and Riepe had experience with Air Force space programs that extended, in some cases, as far back as the creation of a satellite program in 1951. Brigadier General (then Colonel) Martin and Colonel King had been very closely associated with the various Air Force space projects which were established after Sputnik I propelled the Air Force fully into space program activity in late 1957.*

*Throughout the period of GAMBIT development and operation, the various military and civil organizations involved in the program were ordinarily referred to by acronyms or organizational symbols. The principal abbreviations were:

SAFUS	Office of the Under Secretary of the Air Force (Drs. Charyk and McMillan).
SAFSS	Office of the Secretary of the Air Force, Space Systems (the Washington contingent of the satellite reconnaissance organization).
SAFSP	Office of the Secretary of the Air Force, Directorate of Special Projects (originally, in 1960-61, "Director of the SAMOS Project"). This group was located in Inglewood/ El Segundo, California.
SAFRD	Office of the Assistant Secretary of the Air Force for Research and Development (Dr. Flax).
SSD	Space Systems Division of the Air Force Systems Command
SAMSO	Space and Missiles Systems Organization of the Air Force Systems Command (successor to SSD).
GE	General Electric Company
EKC	Eastman Kodak Company
LMSC	Lockheed Missiles and Space Company (also LMSD-Lockheed Missiles and Space Division) of Lockheed Aircraft Corporation.

For administrative purposes, many of the GAMBIT Program participants were nominally assigned to SSD (or SAMSO) although in actuality they were responsible to the Director of Special Projects (SAFSP).
(Continued on next page.)

Program management of GAMBIT was an Air Force responsibility. It extended from the broad area of general guidance to the specific responsibility for launch, on-orbit, and retrieval operations. The Aerospace Corporation, a "not-for-profit" company, provided general systems engineering and technical direction services to the Air Force. In essence, the Aerospace Corporation furnished technical specialists who served, individually and in teams, as technical advisors to the Air Force group. In the usual way of space and missile development programs, the Aerospace function was labeled "technical direction," but for GAMBIT the "directive" aspect of the assignment carried somewhat less weight than was customary.

There was no "prime contractor" for GAMBIT. Instead, services and materials were purchased by Air Force contracting officers from separate concerns functioning as associate contractors (see Figure 1-1). Eastman Kodak and General Electric were the most important of the associates because they had development

(Continued from previous page)
That SAFSS and SAFSP existed was common knowledge. They were openly listed in telephone directories and on organizational charts. Within a relatively small group of government people their general interest in space reconnaissance was also known. But only those people who had some contributory role in the reconnaissance program were aware of precise responsibilities, and only constant and active program participants in the programs had access to the details of program structure. Much the same arrangement prevailed for those elements of contractor establishments involved in developing or operating parts of the system; what the sub-groups did, and what their products might be, was concealed not only from outsiders but also from virtually all but senior executives of their parent corporations.

responsibility and subsequent production responsibility for the principal elements of the GAMBIT system, respectively the camera and its associated elements, and the satellite and recovery vehicles. General Electric served as the integrating contractor for the combination of orbiting vehicle and camera system. Lockheed Missiles and Space Company and General Dynamics/Astronautics provided, respectively, the Agena and the Atlas booster vehicles and services associated with their use. The Burroughs Corporation supported ground station operations at Vandenberg Air Force Base, the launch site, and supplied the guidance software used with the Atlas booster. Space Technology Laboratories, a division of Thompson-Ramo-Wooldridge Corporation, developed both the computer procedures and the computer programs for targeting operations and provided such technical support as these operations required; while General Electric provided vehicle commanding computer programs and support.

Of the several government organizations associated directly or indirectly with GAMBIT, the Air Force's 6595 Aerospace Test Wing (at Vandenberg) and 6594 Aerospace Test Wing (Sunnyvale, California, and Hawaii) were most directly and continually involved. The 6594 ATW (later renamed Detachment 1) operated the Satellite Control Facility at Sunnyvale and exercised operational control of the retrieval activity, based in Hawaii. The 6595 ATW provided all of the military services associated with vehicle and launch readiness at Vandenberg.

Due largely to the exceptional secrecy restrictions which were imposed on the GAMBIT Program, the various organizations and individuals involved in its development and operation interacted less formally and more effectively than was true with most R&D programs. There was a great deal of personal contact at all levels. Seminar-style management meetings between major contractors and the program managers were often and effectively substituted for the elaborate and formalized reports that characterized most other military development programs of the era. The direct interface between the Air Force project managers and the various contractors insured the prompt and accurate movement of information in one direction and decisions in the other. In much the same way, the constant availability of the program director (General Greer or General Martin) to the project manager (Colonel Riepe, Colonel King or Colonel Smith) was a guarantee that senior management became quickly aware of any problems that arose. Similarly, the easy interaction of the directorate staff on the West Coast with the Washington staff and the readiness of communication between the program directors and the program executives (Drs. Charyk, McMillan, and Flax) provided additional assurancy of problem awareness.

The structure thus created was a variant of what is often called "management by exception." The project managers had exceptional authority in their own right; the program directors functioned, for most matters, independent of report and review requirements imposed by some higher headquarters. For GAMBIT, there were but three basic echelons. And at the apex of the relatively simple structure, the program executives had ready access to the highest levels of government.

At the operating level of project management, all of the functions essential to the effective control of program affairs were concentrated in the project office itself. Specialists responsible to the program director were charged with such responsibilities as procurement, programming, and security, while routine matters of administration were the responsibility of a small cadre of directorate people who levied requirements on the far larger body of Air Force personnel assigned to the Air Force Space Systems Division. Matters that could be handled routinely, that did not require special priority or unusual attention, were merely routed into "normal" Air Force channels. In that respect, the relatively small size of the directorate and of the project office and the efficiencies that resulted from that smallness depended in some degree on the zealous performance of unexciting responsibilities by large numbers of Space Systems

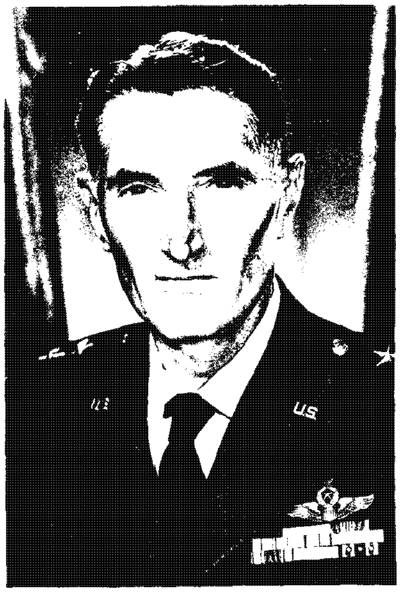
Division personnel who were usually unaware of the true purposes of the actions they had been instructed to take. Thus, Agena vehicles and Atlas boosters were obtained through so-called "normal" channels, although from time to time the project office had to intervene to secure special equipment or to push matters along more quickly than was customary. For a time relatively early in his tenure, General Greer served (as an additional duty) as Vice Commander of the Space Systems Division, a device designed to insure that the Division provided all the support the Special Projects Directorate needed to perform its assignment. Later, when a full-time SSD Vice Commander was required to handle the rapidly expanding administrative workload associated with that job, General Greer's title was changed to Deputy Commander for Satellite Programs, an additional duty which he, and later, General Martin retained through completion of the GAMBIT Program.

Sections 2, 3 and 4 of this document provide additional details concerning system description, operational considerations and program accomplishments which, together with this narrative summary and the various reports, specifications and drawings that are included as appendices, constitute the basic record of the GAMBIT Program. Its specific achievements are recorded in the classified intelligence archives of the Nation, in the form of high-resolution photography which was provided during its lifetime, and in the intelligence which was derived therefrom.

PRODUCT/FUNCTION	ORGANIZATION
OVERALL PROGRAM MANAGEMENT	[redacted]
GAMBIT SYSTEM HARDWARE	
Atlas (D and SLV-3)	General Dynamics
Agena-D Booster	Lockheed Missiles & Space Co.
Satellite Vehicle (SV)	General Electric Co.
Camera Payload	Eastman Kodak Co.
Satellite Re-entry Vehicle (SRV)	General Electric Co.
SOFTWARE	
Orbit Selection, Mission Profile	Space Technology Laboratories
Command Generation	General Electric Co.
Tracking	Data Dynamics
Utility Program	Lockheed Missiles & Space Co.
Integration	System Development Corp.
LAUNCH OPERATIONS	
Standard Launch Complex 4 Vandenberg AFB, Calif.	6595th Aerospace Test Wing
ON-ORBIT OPERATIONS AND RECOVERY	
Satellite Test Center (STC) Sunnyvale, Calif.	AFSCF Detachment 1 (Was 6594th Aerospace Test Wing)
Tracking Stations - Worldwide	Air Force Satellite Control Facility
Recovery Aircraft & Ships	Air Force Satellite Control Facility

Figure 1-1 GAMBIT Products/Functions by Organization

SAFSP DIRECTORS



ROBERT E. GREER
Major General, USAF

JOHN L. MARTIN, JR.
Brigadier General, USAF

DEPUTY DIRECTORS FOR GAMBIT PROGRAM

WILLIAM G. KING, JR.
Colonel, USAF

ROY O. SMITH, JR.
Colonel, USAF

Figure 1-2 SAFSP Directors and GAMBIT Deputy Directors

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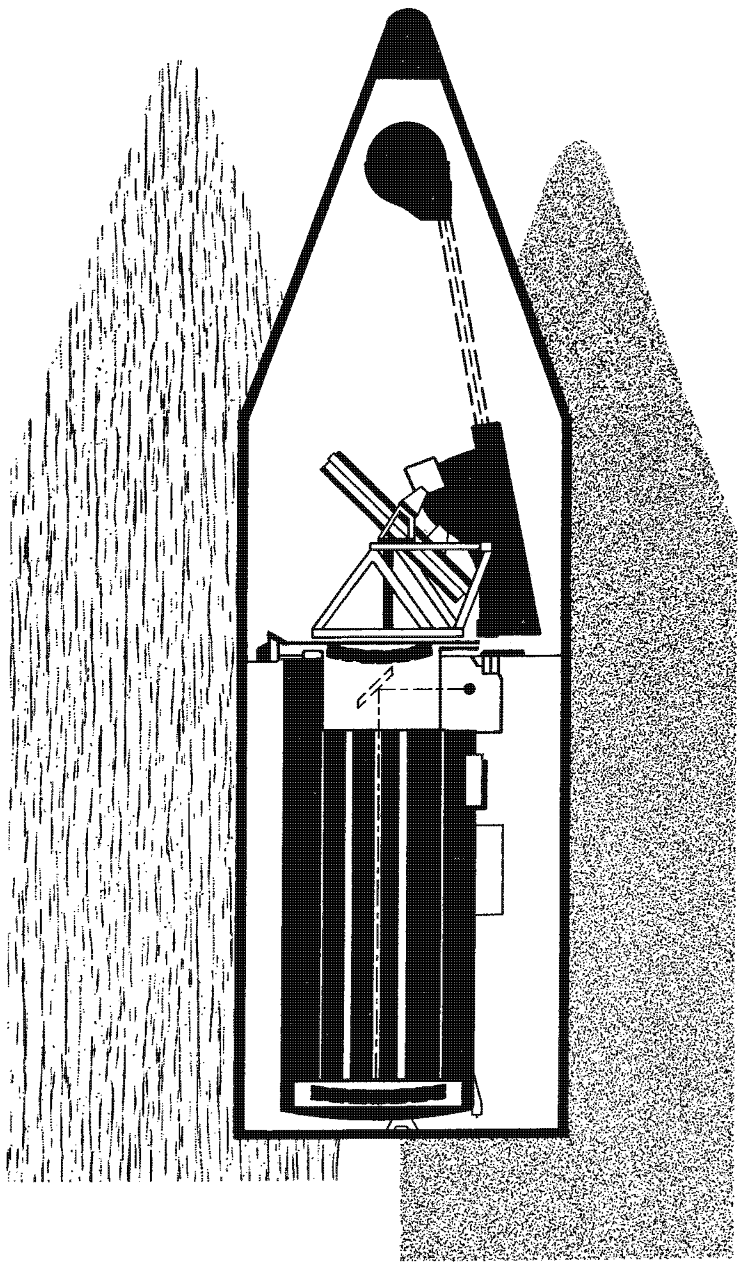
SYSTEM DESCRIPTION



SECTION II

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SECTION 2

SYSTEM DESCRIPTION

2.1 CAMERA PAYLOAD

The basic design of the Camera Payload was dictated primarily by GAMBIT mission objectives which were defined by the 1960 analysis of what levels of reconnaissance could be attained without over stressing the existent state-of-the-art in optics, mechanics, photographic film, various space sciences, and electronics. The prime requisite was an optical system capable of recording on film specific ground details that appeared within relatively small geographical areas of interest. A total system resolution of about two to three feet was basic.* The Maksutov optical system was adapted to a strip type camera to fulfill this requirement. This system, in conjunction with the stereo mirror, provided a flexible mode of operation which could yield, on command, either vertical or oblique photographic stereo pairs or continuous strip photographs.

The complete optical assembly, shown in Figure 4-2 of Appendix 9, was composed of three mirrors and two lenses, of which the primary mirror was the basic component. Each of the other elements

*This meant, for all practical purposes, that the total system had to resolve a two-to-one contrast ground object three feet square or smaller.

was simply an auxiliary component the function of which was to alter the direction of the entering light rays or to make the required corrections to the inherent aberrations of the spherical primary. Each of the assembly components is described below.

The primary mirror was a first-surface spherical mirror with a radius of curvature of approximately 168 inches. The working surface of the mirror was figured to about a $1/10\lambda$ quality and coated with a high-reflectance material which was protected by a silicon oxide hard overcoat. The primary mirror was the image-forming component of the system.

The meniscus lens was a negative optical element which corrected the inherent spherical aberration contributed by the primary mirror. Although the lens introduced very little optical power into the system, the high level of performance demanded of the system necessitated the utmost in quality and material uniformity in the meniscus lens.

The stereo mirror was a first-surface plano mirror whose working surface was figured to a $1/10\lambda$ quality. The mirror received the same reflectance coating and protective overcoat as the primary mirror. By rotating the stereo mirror forward or aft on its trunnions, it became possible to provide a capability for stereo pairs and vertical strip photography.

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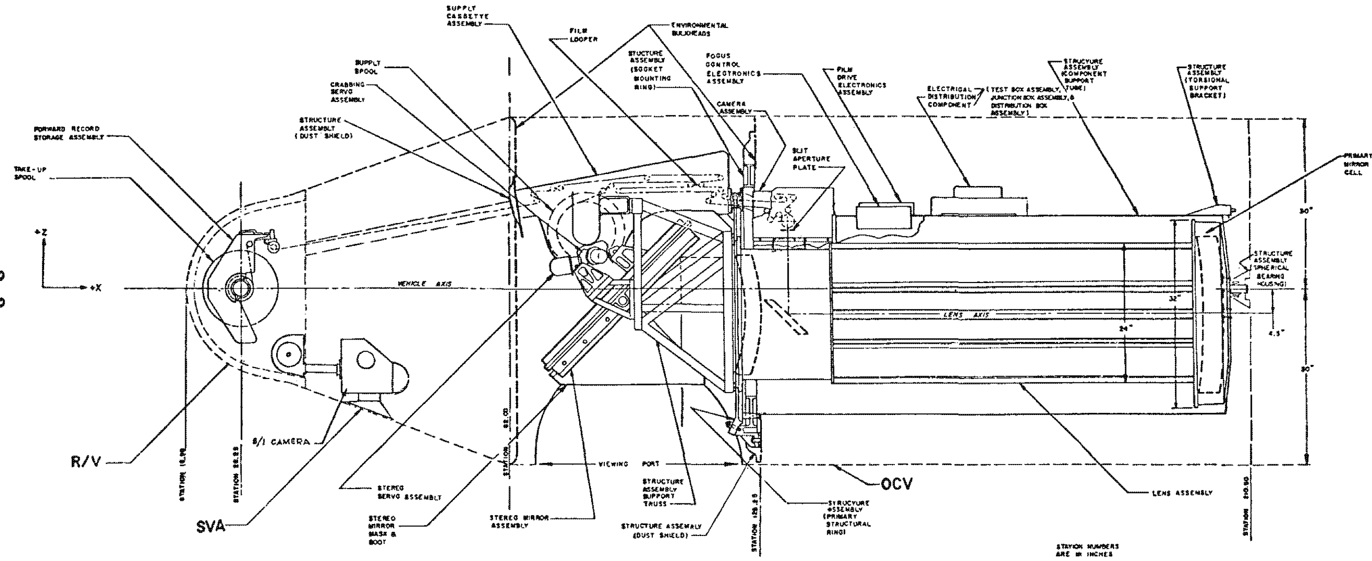

Figure 2-1 Camera Payload Schematic

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The diagonal mirror was a first-surface plano mirror coated as were the primary mirror and the stereo mirror. A relatively small rectangle mounted in the center of the lens barrel, the diagonal mirror reflected the light rays from the primary mirror through a 90-degree angle into the camera.

The field flattener consisted of two lens elements mounted in a cell near the focal plane. The primary function of the flattener was to correct the inherent field curvature produced by the primary mirror. The flattener was also designed for the additional responsibility of reducing the chromatic aberrations in the system.

As an integrated unit, the components described above formed a lens system whose basic optical characteristics were as follows:

Effective focal length	77-inch nominal
Relative aperture	f/3.95
T-number	6.4
Transmittance	38 percent
Veiling glare	1 percent maximum

The film handling system, shown schematically in Figure 3-7 of Appendix 9, consisted of the following major components:

Film supply assembly

Camera

Film take-up assembly

Film handling electronics

The film supply assembly included the housing for the unexposed film and the looper portion on the film supply side of the camera. The looper was a device composed of rollers fixed to a movable truck. These rollers were arranged so that a decrease in the quantity of film on the take-up looper was accompanied by an increase in quantity in the supply looper. Thus, film could be transported past the exposure slit without actuating the supply and take-up portions of the film handling system, thereby greatly reducing any degradation caused by velocity transients. The film take-up assembly consisted primarily of the looper, on the take-up side of the camera, the take-up motor, and spool.

The camera consisted of four major functional subassemblies described below:

Film Platen and Drive. Film was driven by an hysteresis-synchronous motor which could be programmed to run at 64 different speeds. This motor pulled the film out of the supply side of the looper and around the platen, which was a free-running roller.

Slit Aperture Plate. This plate controlled exposure by providing, on command, one of the three operational slits. (A fourth test slit was sometimes used for flight experiments.)

Focus Control Assembly. The focus control electronics package was mounted on the component support tube which enclosed the lens. This unit sensed an out-of-focus condition and would correct this by moving the film plane with respect to the image plane until the two coincided within ±0.0005 inch. This correction could be accomplished by ground commands or by direct feedback from the focus control electronics.

Focus Detector Assembly. In the focus detector assembly, a portion of the ground scene from the payload optical system passed through a focus shifter disc which alternately shifted the plane of best focus ±0.006 inch and was then directed to a reticle. Movement of the ground scene image across the reticle produced a "chopped" (modulated) light signal. Condensing optics imaged this signal onto a photocell which converted it to an alternating current electrical signal called the focus signal. The rotating shifter disc sequentially introduced two thicknesses of parallel-sided glass into the light path which caused the ground scene image to form at two planes, one on each side of the reticle. When the optics were in focus the two image planes were displaced from the reticle by equal amounts, indicated by the amplitude of the focus signal. If the images were displaced from the reticle by unequal amounts, the amplitude of the focus signal was different for each and the system sensed that it was out of focus. It would then automatically adjust the optics until equivalently equal amplitude signals were being generated for each of the two induced images.

Acceptance Level Resolution. The original specification on photo-optical dynamic resolution for acceptance of the camera payload was 105 lines per millimeter using a two-to-one contrast tri-bar target. All GAMBIT payloads delivered by EKC exceeded this specification.

As an added incentive to the contractor to improve payload performance, the specification objective was increased to 130 lines per millimeter by payload FM-21. The remaining payloads were accepted at an average level of 150 lines per millimeter. This remarkable progress in improvement of resolution considerably exceeded the initial design estimate on ultimate limits of photo-optical performance.

2.2 SATELLITE VEHICLE

An inboard profile of the basic Satellite Vehicle (SV) is shown in Figure 2-2. This assembly was comprised of the Satellite Re-entry Vehicle (SRV), the adapter, and the Orbital Control Vehicle (OCV). A detailed drawing of the SV is included in Appendix 45 (GE drawing 2052002).

2.2.1 Satellite Re-entry Vehicle.

The Satellite Re-entry Vehicle (SRV) consisted of the forebody, capsule, parachute and thermal cover, and thrust cone, each of which are described below.

Forebody. The forebody was composed of a phenolic glass structural liner on which was bonded a phenolic nylon char and ablative heat shield. The thickness of the phenolic nylon char and ablation heat shield varied from 0.8 inch at the nose to 0.25 inch at its aft edge. The forebody was reinforced internally by three rings with the midring serving as the capsule mounting surface. The capsule was constrained to the midring by four explosive piston devices and was freed when the explosive pistons were activated to release the parachute thermal cover. Inertial forces maintained contact between the capsule and forebody until parachute deployment caused sufficient deceleration to extract the capsule from the forebody.

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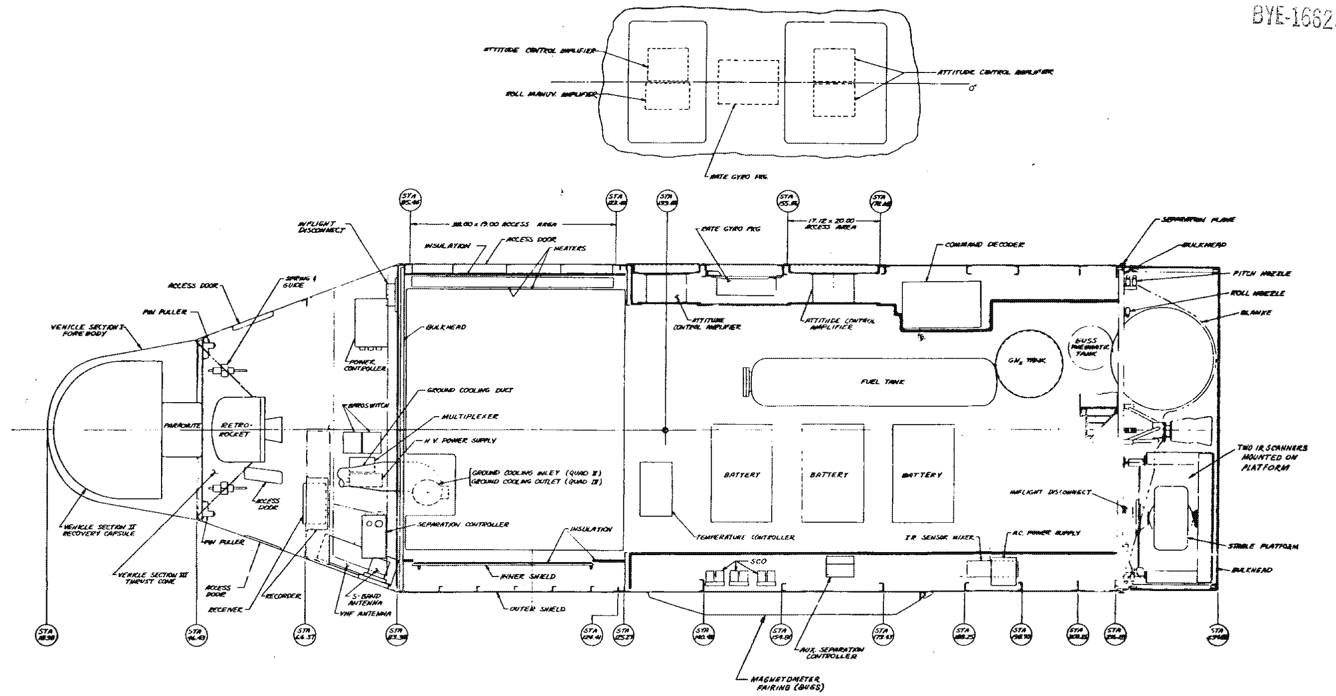

Figure 2-2 Satellite Vehicle Inboard Profile

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Capsule. The capsule was constructed of aluminum spun into a hemispherical shape with a brazed-on "tee" ring for mating with the forebody ring. Assembly of these two units was accomplished by means of four explosive pistons. A phenolic glass rear cover provided environmental sealing. The capsule contained the telemetry subsystem, the recovery subsystem (except for the parachutes), most elements of the environmental subsystem, the auxiliary timer, and the telemetry and recovery batteries. This unit provided the mounting for both the primary camera payload and the Stellar Index Camera (SIC) payload film take-up cassettes.

Parachutes and Thermal Cover. A deceleration parachute and the main canopy were housed in a "C" shaped pack which was positioned in two wells in the capsule cover. The pack was enclosed by a thermal cover to protect the contents from wake heating. The same explosive pistons that fasten the forebody and capsule also fastened the cover to the capsule. When fired, these explosive pistons separated the capsule and the forebody and propelled the thermal cover rearward with sufficient velocity to overcome wake flow. The force of the rearward-moving thermal cover deployed the deceleration parachute which, in turn, deployed the reefed main canopy after a dwell period. The deceleration parachute continued to provide deceleration and stabilization during the 10-second interval before the reefed main canopy was deployed.

Thrust Cone. The thrust cone had a truncated cone shape and was fastened by two explosive bolts to the forebody. The unit contained the retrorocket, the spin-up and despin nozzles, valves, tanks, and the ejection programmer. After completion of its functions, the thrust cone (released by the firing of the two explosive bolts) was separated by compressed springs. The thrust cone provided hard-mounting points for the film encapsulation or tunnel sections between the guillotine cutter sealers on the capsule and the camera systems in the OCV. In both the primary and Stellar Index Camera (SIC) systems, a separation plane was defined when the recovery vehicle separated from the adapter and again when the thrust cone separated from the forebody. The SIC film-transport tunnel sections were connected by lap-joints which were sealed by the compression of open-cell foam. The primary film transport tunnel was joined by two wire cables which were secured to the capsule cover and which passed through the thrust cone and into a flange of the adapter tunnel. Tension applied to the cables pulled the respective tunnel sections together and compressed O-rings between the flanges. Redundant pyrotechnic guillotine devices were employed on each wire cable to free the tunnel sections prior to separation events.

2.2.2 Vehicle Adapter.

The adapter formed a structural transition between the SRV and the Orbital Control Vehicle. The adapter skin and stringers were fabricated from titanium to accept powered flight heating withour recourse to some form of additional shielding. The secondary structure was made up of equipment or component mounting racks at two axial station locations. The adapter contained the majority of the telemetry, tracking and command equipment such as transmitters, receivers, VHF- and S-band antennas and recorder. Also located in this area were the Stellar Index Camera (SIC), separation programmer, and baroswitches.

2.2.3 Orbital Control Vehicle (OCV).

The Orbital Control Vehicle was of semimonocoque aluminum construction which was basically divided into the five sections described below:

Forward-bay, Section 5. This bay extended from stations 84 to 125 and contained items of the environmental control subsystem, outer and inner shields, environmental heaters, blankets, controllers, and the inner shield actuation mechanisms.

Mid-bay, Section 6. This bay contained the majority of the on-board components. These included the eight (maximum) batteries, BUSS separation backup battery, and the necessary power regulation and distribution equipment to support all on-board systems with the exception of the SRV retrieval equipment which was supplied from the SRV batteries. The command, guidance and control, and portions of the environmental control subsystems were also installed in Section 6.

Primary Camera System. Sections 5 and 6 of the Orbital Control Vehicle contained the primary camera system which was described in paragraph 2.1. An environmental control system maintained the camera payload temperature limits.

Section 5 housed, but did not support, the earth-oriented reflective mirror and mirror support structure. It also provided access for loading film into the supply cassette. Section 5 was maintained to very exacting cleanliness requirements by means of filters located in the station 84 and station 125 bulkheads. A dust shield which was attached to the camera mounting plate provided an isolated clean bay during powered flight. The inner shield provided a viewport for the photographic payload and also provided certain environmental control.

Section 6 contained the mounting points for the primary camera system, and access doors to the primary camera and the distribution box which was mounted on the lens tube. The primary camera had two axial mounting stations consisting of three pads, 120 degrees apart at station 125 and a single mounting point at approximately station 210.

Structural Adapter, Section 7. This section formed the vehicle interface to the Agena vehicle via a conventional inside radial leg flange and eight longitudinal bolts. Immediately aft of this ring was the Agena aluminum honeycomb structure which attached to Section 7 by means of 24 bolts. The primary structural joint to the Agena was accomplished at the time of pad-mating through the installation of the eight 0.5 inch steel bolts from the Agena side of the interface as shown on General Electric Drawing 238R802 (see Appendix 46). The forward end of Section 7 attached to Section 8 via a "vee"-band which was disconnected by means of four explosive bolts. The SV separation springs, vehicle-powered flight vent ports, and two-axis stable platform stimulators were also located in this section.

BUSS Bay, Section 8. This section enclosed the components comprising the backup deboost subsystem. It was of semimonocoque construction with access doors. The forward tie to Section 6 was riveted while the aft tie to Section 7 was accomplished through the "vee"-band previously described.

2.2.4 Stellar Index Camera (SIC)

The Stellar Index Camera was produced by Itek Corporation and provided as GFE to General Electric for installation in the Adapter Section of the SV. This unit consisted of an integral stellar and terrain camera which provided the following:

a. A framework for correlating and locating the photographic coverage obtained by the primary camera system.

b. Geometric data which was used in determination of the primary camera's photographic distortion.

c. Photogrammetric information which provided ground control point extension over long distances and position determination when this information was combined with orbital data.

d. Stellar information which was used in determining vehicle attitude and rate of change of attitude during photographic operations.

The Stellar Index Camera system consisted of an earth-looking frame camera of one-and-a-half-inch focal length and an integral stellar field-looking frame camera of about three-inch focal length. This system had two modes of operation. In the dependent mode, this system would expose a stellar frame on 35mm film and a terrain frame on 70mm film each time the primary camera system began its strip frame. In the independent mode, the stellar-terrain camera could be commanded apart from the primary system. This mode was utilized when mapping coverage was desired. The dependent mode was used when attitude information was needed to establish the primary camera's photographic scale.

The Stellar Camera incorporated an 85mm f/1.8 Canon lens and had a shutter speed of two seconds. This camera used 35mm film (3401 emulsion) and provided 2000 frames on the usual flight load of 250 feet. The frame length was 1 3/16 inches and the exposure format was circular with a 15/16 inch diameter. The full field angle of the lens was about 18 degrees. Radial distortion of this lens was less than 45 microns at the maximum field angle.

The Terrain or Index Camera incorporated a 38mm f/4.5 Biogon lens. The shutter speed of this system was preset to 1/500th second. The camera used 70mm film (3400 emulsion) and provided 2000 frames on the usual flight load of 500 feet. The camera frame length was 2 3/8 inches and the exposure format was 2.25 inches square. The field angle of the camera was about 70 degrees side to side and 90 degrees from one corner to diagonal corner. The linear and tangential distortion associated with this camera was less than 100 microns over the format area within 25 degrees of the optical axis and less than 200 microns outside of the 25 degrees. The camera average weighted area resolution (AWAR) was a minimum of 70 lines per millimeter on 3400 film at high contrast.

The film output of the SIC was passed through a closed film chute into a takeup area in the Re-entry Vehicle. This takeup area was separated from the primary takeup area by a metal enclosure. The camera, control electronics box, cables, chutes, film, and takeup assembly weighed less than 55 pounds. Other than occasional stellar shutter malfunctions experienced at the outset, the unit afforded highly reliable performance.

In order to assure precision of the photogrammetric data which this unit provided, an extensive calibration was made on each unit to determine its internal geometry. On installation in the Satellite Vehicle, the relative orientation of the SIC and primary camera systems was measured. A digital control of photographic exposure provided relative time accuracies of such exposures to a standard error of one millisecond. This extremely accurate timing together with the satellite tracking data enabled use of the orbit as a datum plane.

2.3 BOOSTER STAGES

2.3.1 Atlas D (SLV-3). The standard 62-foot-long, 10-foot-diameter Atlas launch vehicle was used in boosting the Agena D/Satellite Vehicle out of the earth's atmosphere to a specified point in space. Its engines, which burned RP-1 and liquid oxygen, developed a total of 387,000 pounds of thrust (330,000 pounds by the main engines and 57,000 pounds by the sustainer engine).

The General Electric Mark II radio guidance system was employed to calculate the required vehicle position and velocity and to command the flight correction necessary to satisfy mission trajectory objectives.

2.3.2 Agena D (SS-01B). The Lockheed Agena D space vehicle was used as the second stage booster to provide the necessary additional velocity increment to place the Satellite Vehicle in the desired near-polar orbit. This 20-foot-long booster vehicle was powered by a Bell rocket engine (Model 8096) which developed a rated thrust of 15,800 pounds for a total duration of approximately 240 seconds.

The Agena guidance and flight control system provided the capabilities required to compute velocity, sense attitude deviations about prescribed axes, position the engine for thrust deflection, and operate the attitude control gas valves. The velocity meter measured the velocity gained and transmitted the engine cutoff signals when the necessary velocity had been attained. A horizon sensor and an inertial reference package provided the earth and inertial attitude references to the flight control electronics. The flight control electronics operated the hydraulic actuators as necessary to deflect the engine thrust during the period of engine operation and operated the gas valves to provide roll, yaw and pitch control when the main propulsion system was inactive.

A command system was used to facilitate control of the vehicle during the ascent phase. This system was comprised of an S-band beacon transponder and decoder system, and a computer programmer.

2.4 SOFTWARE SYSTEM

The development of GAMBIT computer programs required the combined efforts of several contractors as depicted in Figure 2-3. All software programs were developed for the Control Data Corporation 1604 computer. These programs were in machine language which made possible the exchange of necessary data from one software subsystem to the other by use of the reset tape.

Basically, there were five major types of software programs as follows:

a. Tracking and Orbit Prediction

b. Event Selection

c. Event Generation

d. Command and Control

e. Mission Correlation

The tracking computer program developed for GAMBIT made use of maximum likelihood techniques to reduce the data received from multiple radar stations. The orbit prediction model associated with this program used a numerical integration technique which could accommodate a completely general potential function. Prediction accuracies obtained were on the order of several hundreds of feet.

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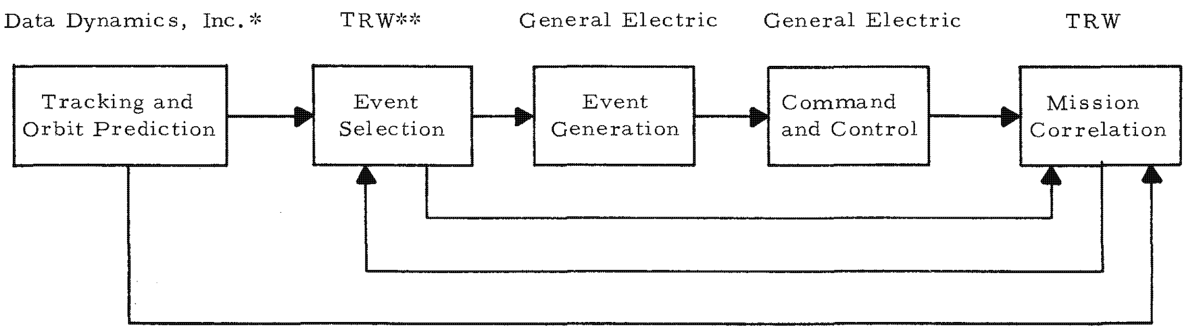

*Formerly Laboratory for Electronics

**Formerly Space Technology Laboratories

Figure 2-3 GAMBIT Program Software System

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Event selection computer programs developed for GAMBIT were designed to select the subset of areas of interest from the total requirements that were to be photographed on any specific mission. These programs made use of priorities, resolution, and total number of areas of interest as decision parameters for selection of those specific areas to be photographed.

The GAMBIT event generation program provided the interface between Event Selection and Command and Control. It computed and permitted modification of vehicle parameters and events such as crab angle, film speed, and door opening and closing times which were necessary to accomplish each photographic operation.

Operational Command and Control computer programs were developed to provide the Satellite Test Center (STC) with a semi-automatic means for operational control of the Satellite Vehicle while on orbit. This computer program provided mathematical computation, command message generation, and checks to assure that no vehicle malfunction would be created by the command message generated. Operation of the program and selection of all input parameters were controlled by the Command Generation Section at the STC.

Mission correlation programs computed the titling and framing information for each photographic operation. This program made use of the post-pass or post-flight ephemeris prediction and the commanded event list to perform these computations. These programs also accomplished the verification of operations which were used as a feedback to the mission planning programs to indicate that a specific area had been photographed and could be devalued (for selection logic purposes) on subsequent passes.

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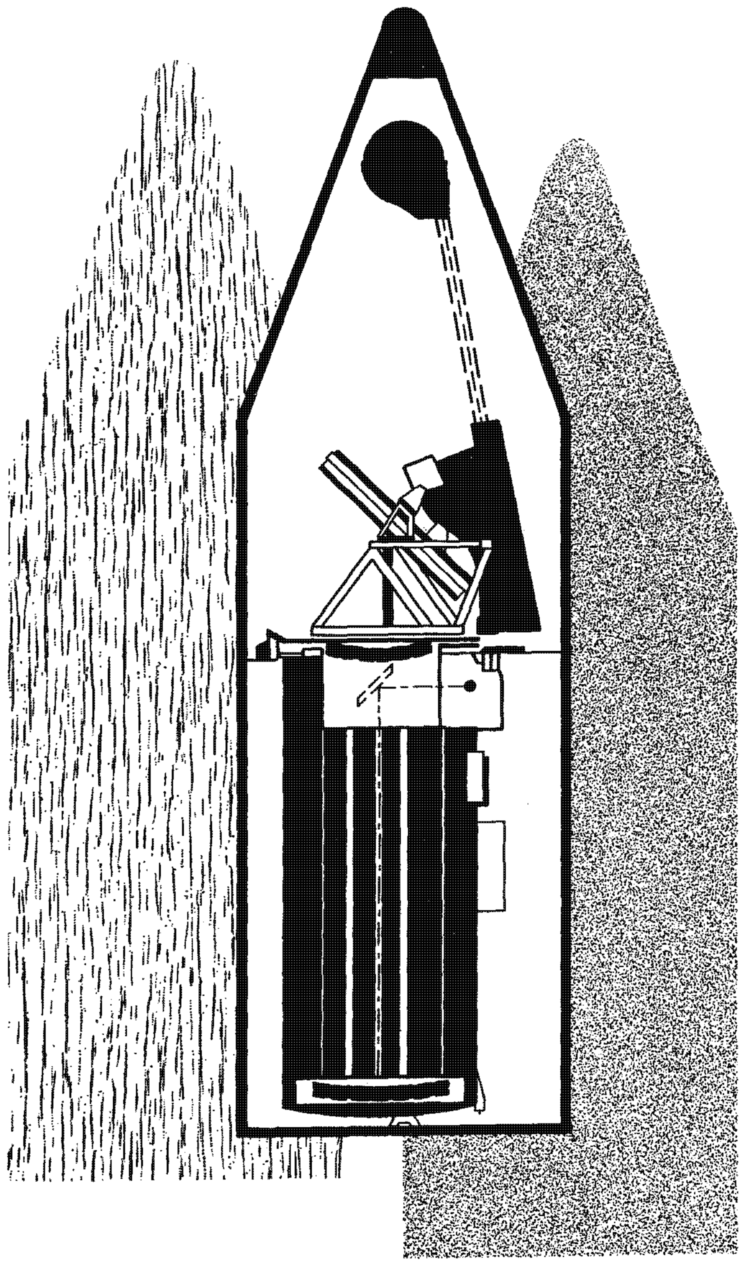
GAMBIT OPERATIONS



SECTION III

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SECTION 3

GAMBIT OPERATIONS

3.1 Launch

Final countdown prior to launch took approximately eight hours and consisted of checking all subsystems of the Atlas, Agena and Satellite Vehicle; loading propellants in the Agena and pressurizing them; topping off the Agena and Satellite Vehicle gas tanks; heating the SV attitude control gas; completing range RF checks; transferring to internal power; loading Atlas liquid oxygen; final SV command loading; and finally lift-off of the Atlas/Agena/Satellite Vehicle when all launch/abort criteria had been met.

Ascent tracking was accomplished by the Vandenberg Tracking Station and a downrange tracking ship. During the launch and ascent phases, the Launch and Operation Control Center (LOCC) and the Vandenberg Tracking Station maintained continuous contact with the Satellite Test Center (STC) located in Sunnyvale, California. The following events were reported in system time as they occurred:

a. Lift-off

b. Booster engine cutoff (BECO-Atlas)

c. Booster engine separation (Atlas)

d. Sustainer engine cutoff (SECO-Atlas)

e. Vernier engine cutoff (VECO-Atlas)

f. Atlas separation

g. Agena engine ignition

h. Agena engine cutoff

Since the orbit injection point was over the horizon from the Vandenberg Tracking Station, orbit injection and separation of the Agena from the Satellite Vehicle were monitored by the downrange ship. These data were transmitted to the STC via single-sideband radio. All telemetry and tracking data obtained by VTS and the downrange ship were put on magnetic tape and sent to the STC for use in post flight data analysis.

All GAMBIT launch operations were conducted under the direction of the 6595 Aerospace Test Wing, Vandenberg Air Force Base, California

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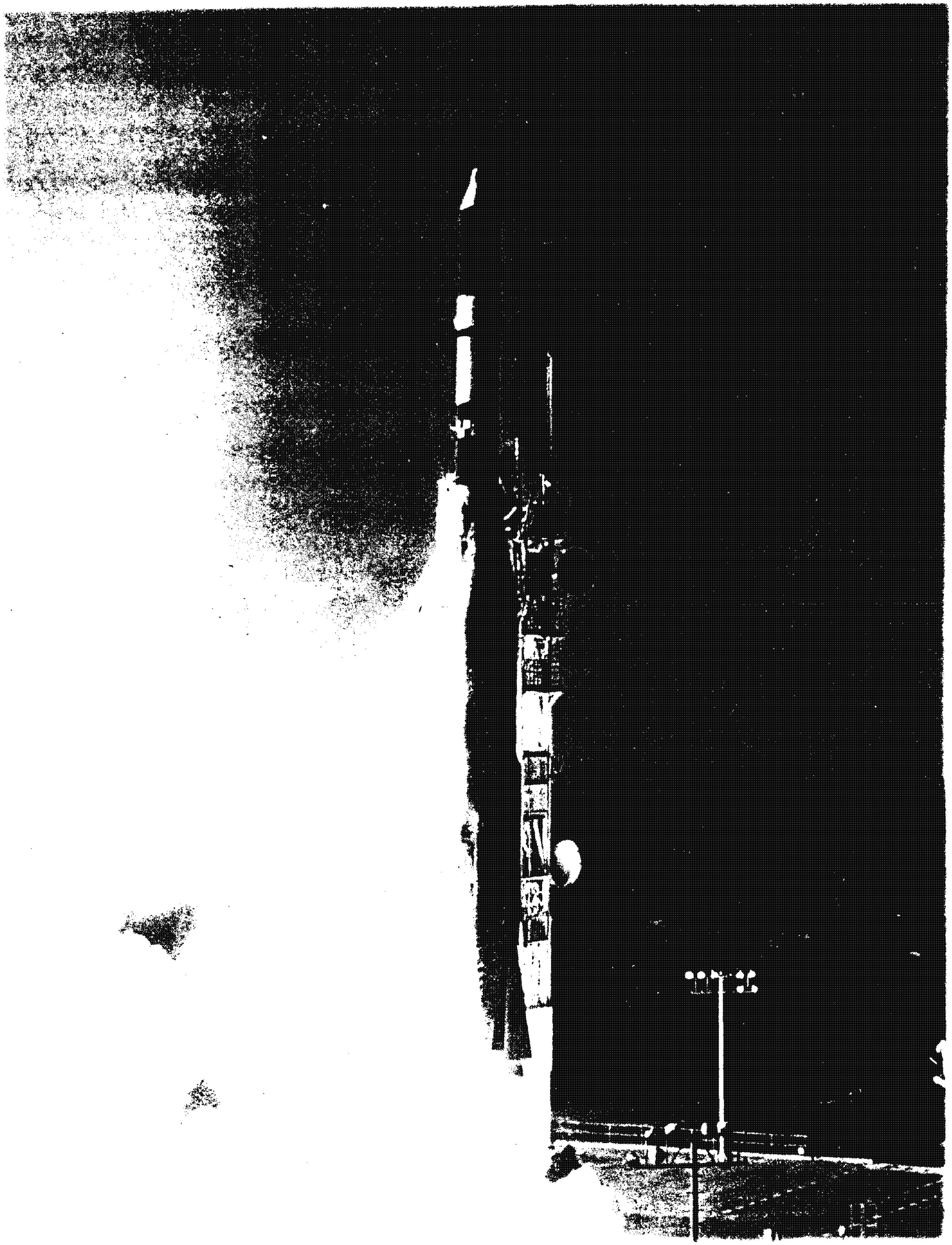

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3.2 ON-ORBIT OPERATIONS

GAMBIT on-orbit operations were the primary responsibility of the 6594th Aerospace Test Wing -- which was later redesignated Detachment 1, Air Force Satellite Control Facility (AFSCF) -- located at the Satellite Test Center (STC) in Sunnyvale, California.

Prior to each flight, mission direction was provided to this group by the GAMBIT Program Office in the form of a System Test Objective (STO). Based upon this direction, the AFSCF Field Test Force Director (FTFD) issued a Test Operations Order (TOO) which provided specific direction regarding the on-orbit operations for that particular flight. The Field Test Force Director provided all necessary flight plans and coordinated the activities of the Test Controller, computer operations, the vehicle analysis group, and the Technical Advisor (an Aerospace Corporation employee) and his staff.

Real time operational control of the vehicle was vested in the Test Controller who was briefed on both the progress of the mission and vehicle status prior to each active tracking station pass. These briefings were coordinated by the FTFD (or his designated representative) and required inputs from the various analytical groups supporting the operation. Vehicle status was maintained by the vehicle analysis group and was monitored by the Technical Advisor (or his designated representative). Personnel from each contributing contractor were assigned to the Technical Advisor's staff and provided specialized support for analyzing vehicle status and performance.

The Air Force Satellite Control Facility (AFSCF) provided a complex and sophisticated communications and control network with its operation nerve center located at the Satellite Test Center (STC) in Sunnyvale, California. This facility included six remote satellite tracking stations located at Vandenberg Air Force Base, California; New Boston, New Hampshire; Kodiak, Alaska; Kaena Point, Hawaii; Guam; and Thule, Greenland. The STC contained a computer complex of four CDC 1604's (later updated to four CDC 3600's) for handling telemetry and tracking data and for preparing command messages. All tracking stations were tied into the STC by 1200 bit-per-second data lines.

Activity associated with commanding and controlling the GAMBIT Satellite Vehicle was a continuous process from lift-off to recovery. Tracing and telemetry data had to be continuously evaluated, the next group of vehicle activities scheduled, command messages prepared and station passes planned.

Tracking and telemetry data were received during every tracking station pass. Orbital parameters were recomputed after each pass and the ephemeris tables used in generation of commands were updated. Vehicle and payload status and performance were evaluated after each station pass and a careful surveillance was maintained to detect any system anomalies. The rates of depletion of expendables (control gas, electrical power and film) were carefully watched and factored into subsequent event planning.

A calibration book such as that included in Appendix 3 was prepared for each Camera Payload prior to launch. This book contained constants (obtained through measurements of each payload during acceptance test), various curves, and tabular lists relating quantities being measured via telemetry for all flight instrumentation points. During orbital operations the calibration book was used by the Technical Advisor's Staff to evaluate the response of the Camera Payload to programmed commands and environmental conditions.

Active tracking station passes (during which data were received and/or command messages transmitted) were scheduled every time the Satellite Vehicle was within the 5 degree cone (i. e., more than 5 degrees above the horizon at the tracking station) for a period of more than two minutes. On occasion, when the need was urgent, active passes of shorter duration were scheduled. A typical 24-hour period averaged 22 to 24 active station passes with only one occasion during the day when the time between passes exceeded 3 hours.

Planning of Satellite Vehicle events for the next command message required a considerable amount of time. Normal command messages contained detailed instructions for two or three revolutions (3 to 4-1/2 hours) plus some contingent instructions for longer periods.

Planning involved the scheduling of Satellite Vehicle and Camera Payload events (roll maneuvers and camera operation) based upon specific direction regarding photographic areas of special interest. Computer programs were employed to select the optimum sequences of events for best utilization of the camera to obtain the greatest number of selected target areas on a priority basis.

In addition to scheduling payload events, the event planning activity also included tracking station pass activities (i.e., tracking beacon on, telemetry readout, command loading, etc.) and any other special activities related to that particular pass.

Special purpose computer programs were used to predict tracking station contact times and durations, the impulses required to sustain the orbital parameters, and the terminal event sequence timing.

After the various events were planned, all commands were formatted into the proper bit structure, checked for constraints, and listed in a printer. The command sequence was then checked by hand to assure that all desired activities were scheduled and to detect any undesired events. Subsequent to this check, the command messages were sent to the selected tracking station and verified.

Tracking station passes averaged about 5 minutes duration. During these passes, the Test Controller at the Satellite Test Center maintained responsibility for pass activities. The Satellite Vehicle transmitter was turned on by stored command just prior to acquisition time. The tracking station reported acquisition of signal, lock on of the tracking equipment, signal strength, and the receipt of suitable data. The Test Controller verbally gave the instruction for the tracking station to transmit commands to the Satellite Vehicle, both the previously prepared messages for command storage and any necessary additional real time commands (for immediate execution). On those occasions when everything did not go according to plan (e.g., noisy reception, failure of commands to be accepted by the Satellite Vehicle, etc.), the Test Controller exercised the authority provided for contingent actions. Time was so critical during a normal pass that contingent actions were usually limited to retransmitting commands, changing Satellite Vehicle transmitters, or discontinuing pass activities.

Modes of Photographic Operation. The following basic modes of photography were employed in conducting GAMBIT operational missions: (a) stereo pairs; (b) lateral pairs; and (c) continuous-strip photographs.

In photographing stereo pairs, the primary camera stereo mirror was first aimed forward and an exposure made. The mirror was then aimed aft toward the same area and another exposure made from a later position in the orbit. With slight modifications in timing, stereo pairs could be taken at an obliquity angle to provide stereo photography of areas to the left and right of the ground track.

Lateral photographic pairs were obtained by an obliquity movement of the Satellite Vehicle between the time an exposure was made looking forward and the time the next exposure was made looking down or aft. This mode of operation made possible double swath widths for broader coverage (without stereo). This permitted photography of two separate targets laterally displaced along the same ground track. (Lateral triplet photographs were also taken using essentially this same technique, but only on an experimental basis.)

Conventional monoscopic strip photography was used to record a continuous ground track. This mode of operation was employed when it was necessary to cover a long target or several closely spaced areas lying within the obliquity capability ($\pm$ 42 degrees) of the Satellite Vehicle.

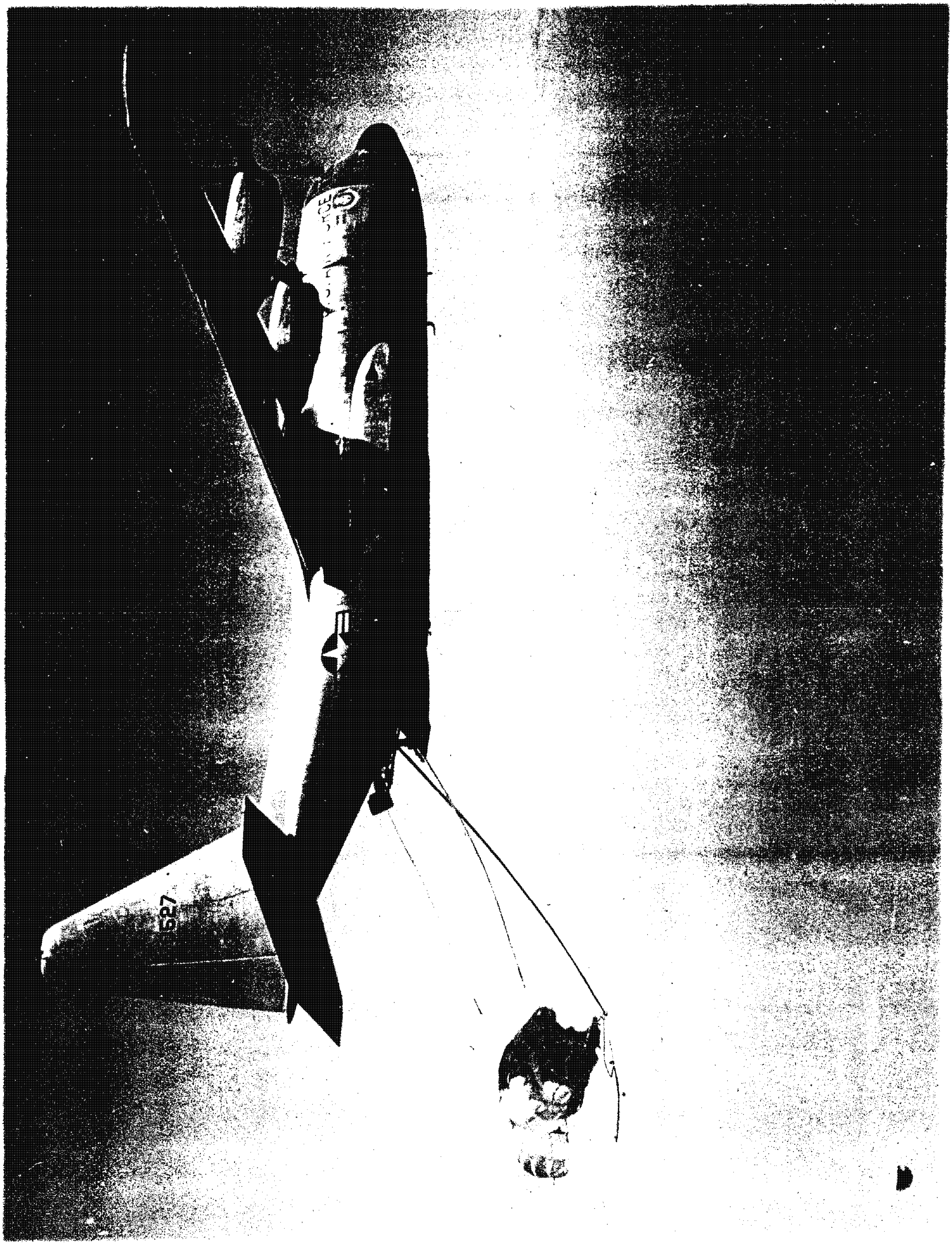
3.3 RECOVERY

GAMBIT recovery operations were the responsibility of the 6594th Test Group located at Hickam AFB, Hawaii. Recovery aircraft (C-119's initially and later JC-130's) were deployed along the ground track from the predicted point of impact near the Hawaiian Islands to another point approximately 700 miles downrange of the impact point. In all cases recoveries were made from a north-to-south pass although a backup capability existed to recover on a south-to-north pass.

Just prior to terminating each GAMBIT flight, the unexposed film from both the primary and secondary cameras was reeled onto the take-up spools located in the Satellite Re-entry Vehicle, after which the film was cut and the film chutes sealed. Normally on the second orbit prior to the recovery pass, the Satellite Vehicle was commanded to yaw 180 degrees to a fly-reverse attitude. At a prescribed time during the final orbit, the Satellite Vehicle pitched down to 60 degrees; the Satellite Re-entry Vehicle was separated from the Orbital Control Vehicle shortly thereafter, spun up for stabilization, deboosted and despun. After the re-entry vehicle had passed through the blackout region and had decelerated to about 900 feet per second, a drogue parachute was deployed at approximately 53,000 feet. The main parachute deployed some 10 seconds later at about 44, 000 feet. The capsule continued to descent until one of the recovery aircraft of the 6594th Test Group was able to intercept it using an air-recovery device specifically designed to catch the parachute as it descended (see photograph next page). The capsule was then reeled into the aircraft and flown to Hickam AFB.

Later, the Orbital Control Vehicle was deboosted from orbit so as to re-enter the atmosphere over the wide expanse of the Pacific Ocean where it was essentially destroyed by re-entry heating.

A C-135 aircraft flew the recovered capsule from Hickam AFB, Hawaii, to Niagara AFB, New York, where it was picked up by an Eastman Kodak representative for processing at Rochester, New York. After it was processed, the film was then flown to the Air Force Special Projects Production Facility (SPPF) at Westover AFB, Massachusetts for analysis of system performance. From there, it was delivered to the National Photographic Interpretation Center, Washington, D. C.



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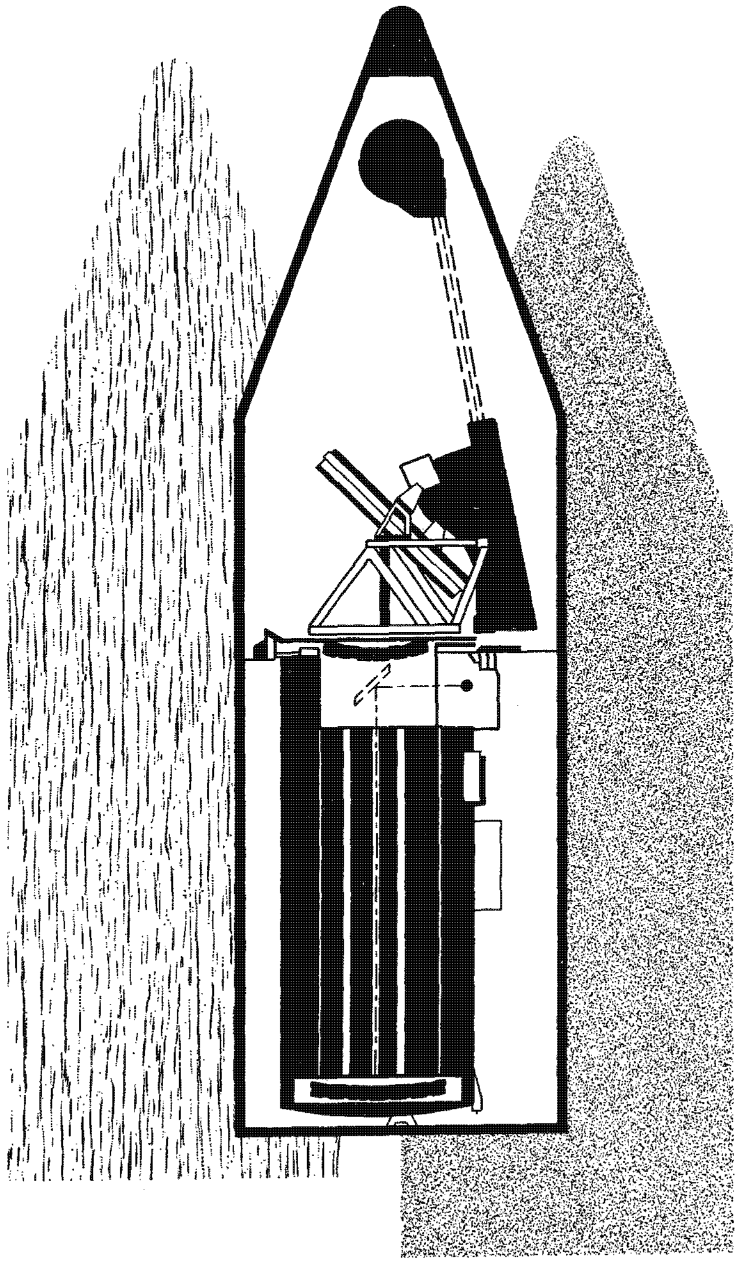
PROGRAM ACCOMPLISHMENTS



SECTION IV

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SECTION 4

PROGRAM ACCOMPLISHMENTS

4.1 MISSION PERFORMANCE SUMMARY BY FLIGHT

As previously stated, a total of 38 GAMBIT missions were flown during the lifetime of this program. The results achieved from these flights and the performance data related thereto are set forth in Table 4-1, "Mission Performance Summary by Flight." Orbital data shown are initial values which have been rounded to the nearest whole number. Blank spaces in the matrix indicate either unavailable or indeterminate data.

In the interest of simplicity and brevity, no attempt has been made to portray the many configuration changes made throughout the GAMBIT Program nor to describe specific vehicle deficiencies which were remedied during the course of this program. The primary purpose of the matrix which follows is to summarize what was accomplished on each of the 38 GAMBIT flights.

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SATELLITE VEHICLE NUMBER	DATE OF LAUNCH	TOTAL EXPOSED MAIN FRAMES	EXPOSED STEREO PAIRS	TOTAL FILM LOAD, FT.	PRE-LAUNCH FILM USAGE FT.	MISSION USAGE, FT.	R&D * USAGE, FT.	RECOVERED FILM FT.	BEST RESOLUTION IN FT.	AVERAGE RESOLUTION IN FT.	WORST RESOLUTION IN FT.	NUMBER OF STELLAR INDEX CAMERA FRAMES	PLANNED PRIME ORBITS	ACTUAL PRIME ORBITS FLOWN	PLANNED SOLO ORBITS	ACTUAL SOLO ORBITS FLOWN	INITIAL PERIGEE IN NAUTICAL MILES	INITIAL APOGEE IN NAUTICAL MILES	INITIAL INCLINATION IN DEGREES	INITIAL β ANGLE IN DEGREES **	SV WEIGHT IN POUNDS
951	12 July 63	74	9	1313	598	198	116	1313					18	18		7	107	119	95	-9	
952	6 Sept. 63	173	52	1930	380	782	112	1930					34	34	49	0	102	165	94	+10	
953	25 Oct. 63	242	84	1803	488	290	186	1803	1.9	3.0	10		34	34	49	31	78	183	99	+23	
954	18 Dec. 63	0	0	2430	448	112	0	2430					34	18	49	0	75	156	98	-15	4071
955	25 Feb. 64	124		2512	1041	267	67	2512	12.0		100		51	34	32	49	96	121	96	+20	4057
956	11 Mar. 64	436	117	2064	451	1091	164	2064					51	51	29	29	96	124	96	+2	4113
957	23 Apr. 64	572	162	2877	355	1663	285	2877				663	66	66	30	15	85	210	104	+24	4134
958	19 May 64	122	32	2932	223	551	75	2932	2.0	2.3		20	66	34	16	0	57	194	101	+13	4141
959	6 July 64	72	14	2838	233	184	0	2259	50.0		100		66	34	16	0	84	180	93	+17	4176
960	14 Aug. 64	131	39	2938	198	458	0	656	5		10		83	66	0	0	85	176	96	-26	4190
962	23 Sept. 64	555	232	2992	195	1403	0	2992	4	6.0	17	632	83	67	0	10	85	157	93	0	4207
961	8 Oct. 64			2969	198	0	0	0					83		0						4160
963	23 Oct. 64	0	0	2871	169	1045	357	0					67	67	16	15	82	174	96	+28	4212
964	4 Dec. 64	88	24	2977	266	205	24	2402	2.1	4.8	12	586	67	18	0	0	85	189	97	+22	4214
965	23 Jan. 65	535	128	2978	248	1086	122	2978	2.2	3.7	6.9		67	67	16	16	82	171	103	+11	4183
966	12 Mar. 65	471	45	2956	186	1211	383	2956	2.4	2.8	5.5		67	67	16	14	85	173	108	+22	4173
967	28 Apr. 65	747	180	2949	245	1284	413	2949	2.0	2.2			67	83	17	1	86	160	96	+ 1	4215
968	27 May 65	831	194	2965	209	1396	591	2965	2.0	2.2		2044	83	83	0	1	86	152	96	+ 9	4291
969	25 June 65	0	0	2833	178	0	0	2833					83	18	0	0	85	171	108	+11	4268
970	12 July 65	0	0	2963	181	0	0	2963					83		0						4266
971	3 Aug. 65	0	0	2969	241	199	1803	2969					83	67	0	0	84	176	107	+18	4234
972	30 Sept. 65	801	198	2955	272	1251	428	2955	1.8	2.0		1767	67	67	16	10	86	156	96	+13	4246
973	8 Nov. 65	15		2973	155	313	119	2973	2.0	2.5		278	67	18	0	0	84	163	94	+17	4258
974	19 Jan. 66	746	158	2972	131	1235	342	2972	1.9	2.2	2.6	2177	83	83	16	16	84	158	94	+ 6	4403
975	1 Feb. 66	860	194	2964	220	1422	331	2964	2.0	2.5	3.2	2171	83	83	16	16	84	167	97	+ 2	4401
976	18 Mar. 66	833	211	2972	163	1502	73	2972	1.9			1000	99	99	1	1	85	175	101	+ 4	4437
977	19 Apr. 66	1047	200	2964	217	1691	69	2964	1.8	2.0	2.4	2139	98	98	13	13	79	228	117	+25	4426
978	14 May 66	1058	282	2955	172	1831	184	2955	1.9	2.0	2.3	2031	99	99	15	15	77	211	111	+25	4420
979	3 June 66	725	197	2950	189	1344	33	2950	2.0	2.2	3.0	1885	99	99	1	1	82	167	87	+ 6	4454
980	12 July 66	959	245	3033	151	1510	13	3033		2.5		2128	131	131	0	0	81	163	96	+30	4467
981	16 Aug. 66	647	0	3442	183	1441	16	3442	1.8	2.0		1830	130	130	1	1	80	200	93	+23	4816
982	16 Sept. 66	717	176	2967	333	1138	4	2967		2.0		1697	131	115	1	1	80	192	94	+32	4807
983	12 Oct. 66	809	197	3386	160	1421	202	3386	1.5	1.9		2000	131	131	1	1	85	158	91	+10	4815
984	2 Nov. 66	0	0	3218	154	0	235	3218				2194	131	115	1	1	87	171	91	+ 6	4813
985	5 Dec. 66	859	203	3373	292	1482	0	3373		2.5		1800	131	131	1	1	79	219	105	- 2	4821
986	2 Feb. 67	821	174	3383	159	1498	87	2953		2.2		1876	131	131	1	(30)	80	214	103	+16	4796
987	22 May 67	887	194	3397	143	1653	0	3397	1.8	2.0	4	1882	131	131	1	1	79	194	92	+21	4793
988	4 June 67	1062	221	3359	344	1524	0	3359		2.0		1963	130	130	1	1	80	195	105	+28	4815

Table 4-1 Mission Performance Summary by Flight

*The term "R&D" as used here applies to that film which was employed for special experimental purposes such as exposure evaluation, night photography, color photography, and image degradation.

**The term "β angle" is defined as the solar incidence angle.

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4.2 PHOTOGRAPHIC RESULTS ACHIEVED

In order to portray the degree of detail which was made available by GAMBIT photography, several typical examples have been reproduced on the pages which follow. These black and white prints of various prominent landmarks have been enlarged by a factor of 20 from the basic 3404 thin-base film recovered from orbit. For reasons of propriety, only pictures taken over the continental United States have been included in this report.

The theoretical maximum resolution that could be obtained using this film (exposure index 3.6) was 325 lines per millimeter. The best resolution which was actually attained by the GAMBIT system was approximately 170 lines per millimeter (equivalent to a ground resolution of less that two feet at 2:1 contrast).

In addition to the standard 3404 thin-base film which was used in connection with the primary GAMBIT mission, certain other types of film were also used on a limited basis for experimental purposes. These were:

Type	Nomenclature	Thickness	Exposure Index
SO 380	Ultra thin base	.002"	3.6
SO 362	Thin base	.003"	6.0

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Type	Nomenclature	Thickness	Exposure Index
SO 121	Color film	.005"	20
3400	Night film	.003"	20

Only photographs developed from the primary 3404 thin-base film have been included in this report. They are listed on the following page.

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LIST OF PHOTOGRAPHS

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The Pentagon, Washington, D. C.

Altitude: 84.2 NM	Obliquity: +38.29°
Scale: 1:102,500	Stereo Triplet Photo

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[illegible] 18825

The White House, Washington, D. C.

Altitude: 84. 2 NM	Obliquity: + 38. 29°
Scale: 1:102, 500	Stereo Triplet Photo

United States Capitol Building
Washington, D. C.

Altitude: 84.0 NM
Scale: 1:106,100

Obliquity: +38.29°
Stereo Triplet Photo

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Portion of the Ramp and Runways
North Island Naval Air Station, San Diego, California

Altitude: 82.0 NM
Scale: 1:87,500

Obliquity: -23.0°
Stereo Photo

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Sky Harbor Municipal Airport, Phoenix, Arizona

Altitude: 81.7 NM	Obliquity: -8.3°
Scale: 1:78,200	Stereo Photo

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Name of City Displayed at Airport, Fort Worth, Texas

Altitude: 80.1 NM
Scale: 1:76,200

Obliquity: +4.42°
Strip Photo

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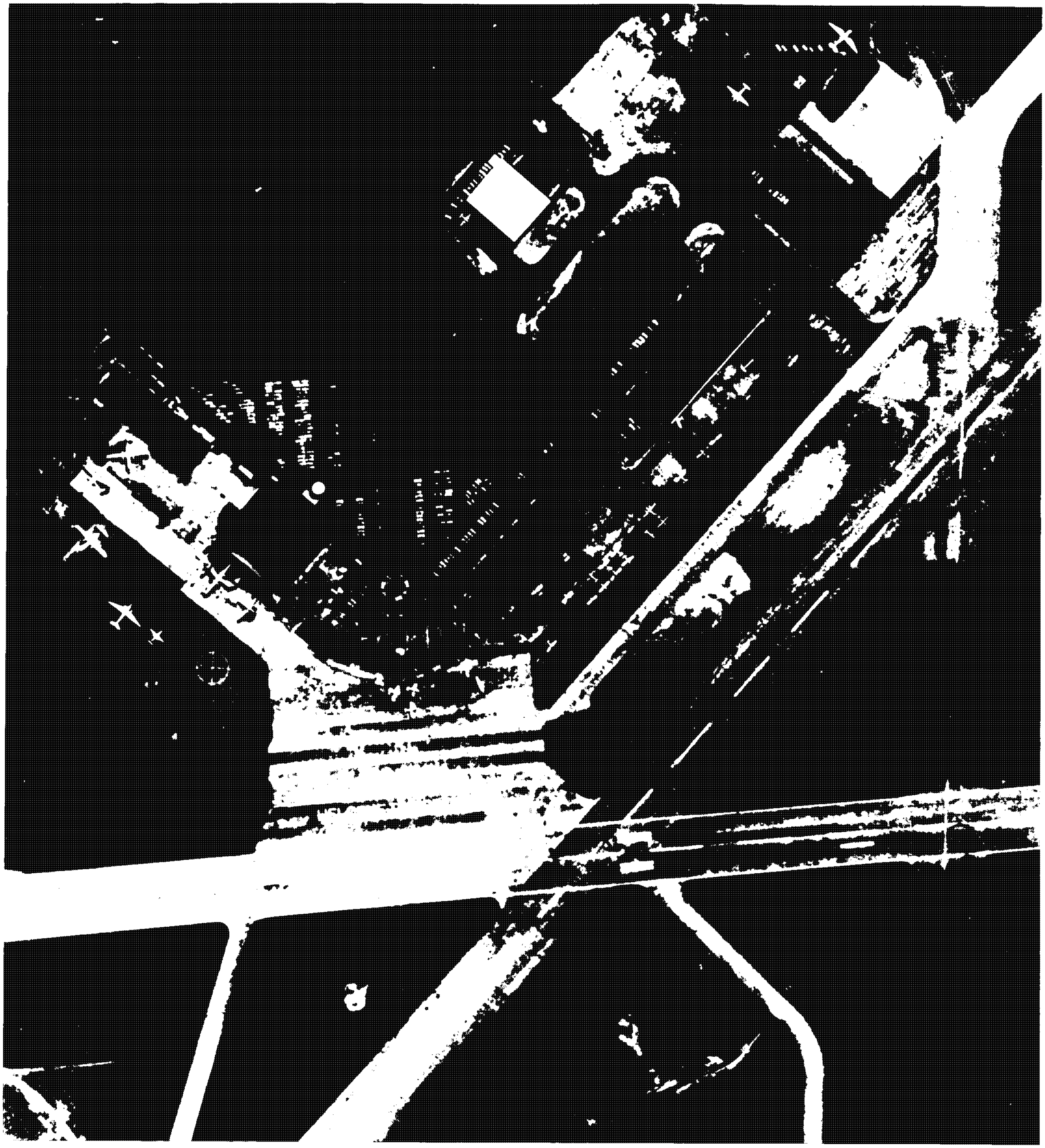

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Prudential Life Building, Boston, Massachusetts

Altitude: 80.6 NM   Obliquity: -12.33°
Scale: 1:78,500   Strip Photo

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Ocean Liners at Dock in Harbor
New York City, New York

Altitude: 82.0 NM
Scale: 1:77,900

Obliquity: +0.37°
Strip Photo

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Football Stadium, Great Falls, Montana

Altitude: 89.4 NM

Obliquity: +2.5°
Stereo Photo

40X

This photograph represents the first taken from outer space in which people can be specifically identified.

Note offensive player positioning ball prior to kick-off.

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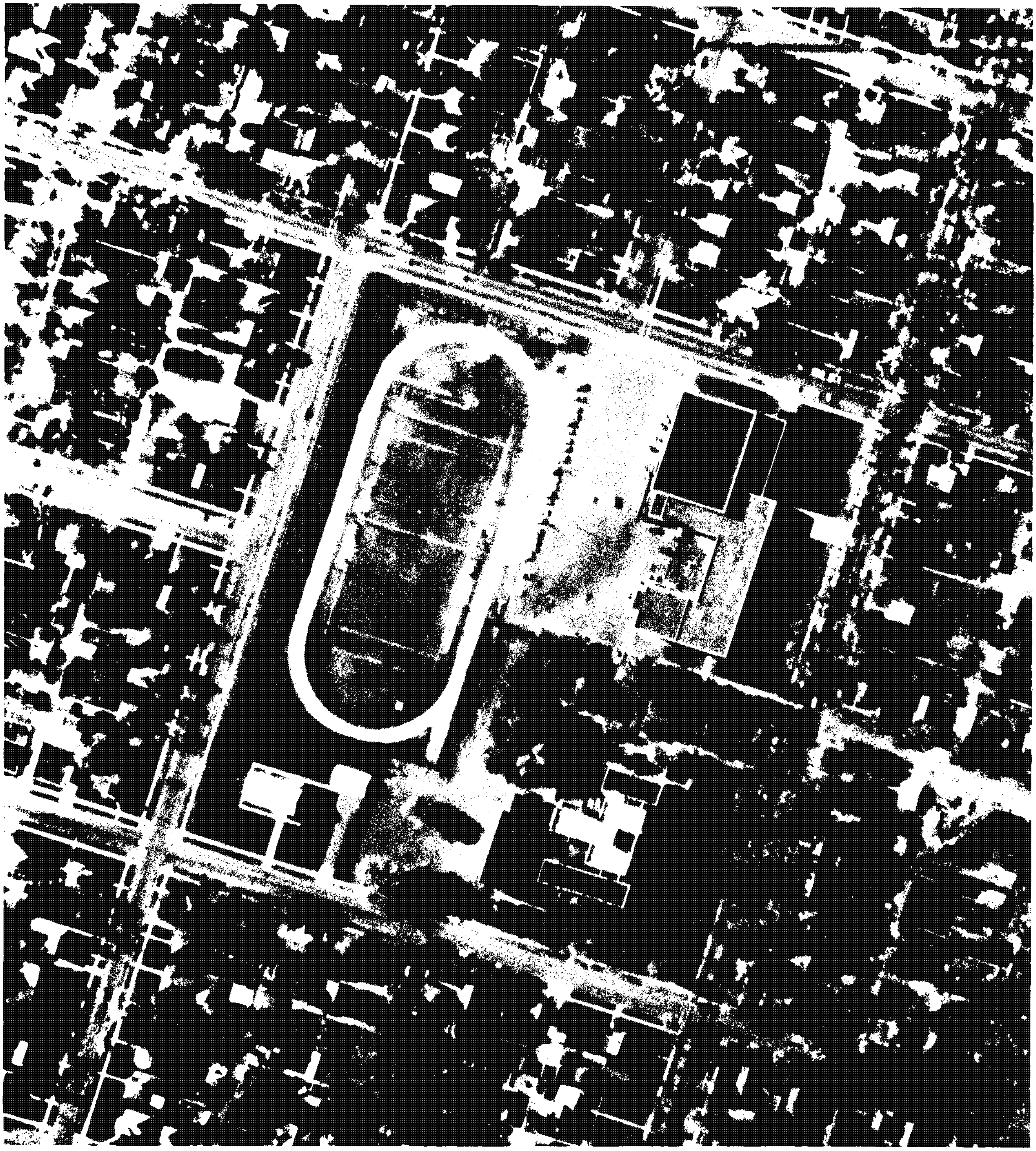

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Football Stadium, Great Falls, Montana

Altitude: 89.8 NM   Obliquity: +2.5°
Stereo Photo

40X

This photograph was taken approximately eight seconds after the preceding photograph.

Note that the offensive team has lined up for kick-off.

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