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K243.01936-43
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30 JAN 1959

#10
83 pages
+ cover and table

SPACE SYSTEM DEVELOPMENT PLAN

SENTRY PROGRAM

AIR FORCE BALLISTIC MISSILE DIVISION
HEADQUARTERS, AIR RESEARCH AND
DEVELOPMENT COMMAND

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HEADQUARTERS
AIR RESEARCH AND DEVELOPMENT COMMAND

(UNCLASSIFIED TITLE)
SENTRY
SPACE SYSTEM DEVELOPMENT PLAN

30 January 1959

REVIEW ON 31 Dec 2008

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AIR FORCE BALLISTIC MISSILE DIVISION
HEADQUARTERS
AIR RESEARCH AND DEVELOPMENT COMMAND

30 January 1959

FOREWORD

This volume presents the planning for the Advanced Reconnaissance System, Sentry. The plan reflects the reorientation of the Sentry Program under the management of the Advanced Research Projects Agency (ARPA). The planning described in this volume provides for the earliest possible development of the requirements stated in GOR No. 80, dated 16 March 1955, revised 26 September 1958, with one exception: the requirement of GOR No. 80 for an infrared reconnaissance capability have been withdrawn from the Sentry Program and made a separate Program, Missile Defense Alarm System (MIDAS).

This volume covers the capability of the Sentry System by summarizing its physical characteristics and by explaining the techniques for its operation. It also provides a brief explanation of the various subsystems that comprise the whole, the testing program being used in developing the system, and other significant areas that bear directly on the task of meeting the designated requirements. In addition, this volume covers the facility program requirements, including (1) test facilities at ARDC centers, and (2)the military construction required in support of the development system. Lastly, a summary of the funding requirements is included to reflect the revised FY 1959 financial plan and a new FY 1960 budget plan of dollars necessary to support the program included herein.

O. J. Ritland, Brig. Gen.

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Major General, USAF
Commander

for

AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)

SENTRY

DEVELOPMENT PLAN

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BACKGROUND

The concept for using a satellite as a platform for reconnaissance equipment was a natural outgrowth of the requirement for obtaining intelligence information of a potential enemy whose area and security precludes the effective collection of this information by ordinary aerial reconnaissance or other usual means. The need for timely and continuous intelligence information, to assess a potential enemy's capabilities and probable intent, has become more critical as the advancement of technology has produced offensive weapons with intercontinental range and greater destructive powers. The impetus which motivated the military establishment to foster work on new methods for collection of intelligence information came from the realization that current, reliable, prehostilities intelligence information is required to insure proper direction of national planning in the development of effective counterforce weapons and counterforce strategy.

The results of the numerous studies conducted since 1946, at the direction of the Department of Defense, established that a Satellite Intelligence System was feasible and would satisfy to a great extent the requirements for intelligence information to aid the national planners in making decisions.

The concept of the Advanced Reconnaissance System is a result of studies conducted at the Rand Corporation. A study completed in 1947, together with similar investigations by other contractors, concluded that a satellite vehicle was feasible as a reconnaissance vehicle but not as a weapons carrier. In 1950, the Research and Development Board vested satellite custody in the Air Force, and Rand was directed to explore its possible military utility.

Recommendations for an expanded study of reconnaissance applications were made to the Air Staff in late 1950, and a formal report (Rand-217) followed in April 1951. Feasibility studies for critical subsystems initiated at that time were television (RCA), attitude control (North American Aviation), and nuclear auxiliary power units (Bendix Aviation, Frederick Flader, Allis-Chalmers and Virtoo Corporation).

Recommendations for the ARS development were made by Rand in November 1953, and these were followed by a final report (Rand-262) in February 1954. Subsequently, the Air Force issued System Requirement No. 5 dated 27 November 1954, later revised on 17 October 1955, and General Operational Requirement No. 80 (SA-2C) dated 16 March 1955. In the spring of 1955, design study proposals were solicited by the Air Force from selected contractors.

The number of sources solicited was limited by the government's desire to maintain a secure program throughout the design and development phase. The WS 117L is a reconnaissance system involving the launching of a vehicle into orbit for the ultimate purpose of collection and dissemination of intelligence information. Therefore, the problem of providing an airframe and engines did not need to be the sole guide to the type of contractors solicited. Those solicited were the Lockheed Aircraft Corporation, the Radio Corporation of America, Glenn L. Martin Company, and Bell Telephone Laboratories. Bell Telephone Laboratories declined to submit a proposal.

The three contractors conducted their design studies between June 1955 and March 1956. These design studies culminated in three separate and distinct development plans. The Lockheed proposal was considered to meet the requirements most satisfactorily.

An ARDC System Development Directive No. 117L was issued on 17 August 1956. The development and test of WS 117L was awarded the Lockheed Aircraft Corporation on Contract AF 04(647)-97 in October 1956. The Massachusetts Institute of Technology was awarded the contract for research and development of the WS 117L Guidance and Orbital Attitude Control Equipment on Contract AF 04(647)-103 in November 1956. Executive management of the project is the responsibility of AFBMD.

By decision of the Secretary of Defense, 1 November 1957, the directive was issued to proceed with the WS 117L at the maximum rate consistent with good management.

The primary objective, established by the USAF's General Operational Requirement for WS 117L, was to "provide continuous (visual, electronic or other) coverage of the U.S.S.R. and satellite nations for surveillance purposes." In its capacity as Prime Weapon System Contractor, operating under the direction of AFBMD, Lockheed initiated a broad program of research and development to meet this objective; the program included both visual and electronic reconnaissance systems.

In January 1958, in order to accelerate the program, it was decided to augment the WS 117L program by making an interim use of the Thor booster for nine (9) flights. This would permit an early achievement of orbital capability. Subsequently, approval was granted for the use of five (5) additional Thor-boosted satellites to conduct biomedical experiments.

On 30 June 1958, the Advanced Research Projects Agency (ARPA) Order No. 9-58 was issued confirming previous Department of Defense directives for the assumption of responsibility by ARPA for the Advanced Reconnaissance Satellite Development Program. This directive established the Director, ARPA, as the source of policy and technical guidance for future WS 117L development

General Operational Requirement No. 80 was revised on 26 September 1958, placing additional requirements upon the Weapon System. Two (2) significant additions included in the revised GOR 80 were the requirements for a recoverable satellite for intelligence use and a mapping and charting addendum to the GOR.

On 5 November 1958 the ARPA published Order No. 38-59 which separated the Infrared Reconnaissance Development (Subsystem "G") from the basic Sentry Program and established the Infrared Development as the Missile Defense Alarm System (MIDAS).

On 1 December 1958 the ARPA proposed, in a memorandum report, a reorientation of the WS 117L Program. This proposal was directed to The Under Secretary of the Air Force in a memorandum on 5 December 1958.

As the result of the reorientation directives of early December, AFBMD presented a briefing to the ARPA on 15 December which included an analysis of the ARPA proposed program and an AFBMD counter proposal. The results of the briefing and subsequent negotiations culminated in an ARPA memorandum to The Under Secretary of the Air Force dated 17 December 1958. The following Development Plan reflects the instructions of the 17 .December 1958 memorandum with regard to program structure and technical objectives.

ARPA Order No. 48-59 dated 16 September 1958, confirming previous instructions directed that the Thor-boosted portion of the WS 117L development be separated from that program and continue as an independent project identified as DISCOVERER.

DESIGN CHARACTERISTICS

I. INTRODUCTION

A. Program Objectives

1. The Advanced Reconnaissance System, Sentry, described in this Development Plan, is designed to fulfill the military requirement outlined in GOR No. 80, 26 September 1958, and amendments thereto, ARDC SR No. 5, 17 October 1955, USAF DD No. 85, 3 August 1956, and ARDC SDD No. 117L, 17 August 1956.

2. A vital requirement for the defense of the United States is the earliest possible warning of a Soviet intention to attack. This system, employing an orbiting satellite, will provide at a reasonably early date, surveillance of the whole Soviet complex. The use of varied sensing devices in the satellite system will reveal Soviet preparations for a possible attack well in advance of the event.

3. Timeliness of receipt of the intelligence information is essential, with daily reconnaissance coverage at high resolution the ideal. In consideration of the requirement for earliest availability of the Sentry System, the engineering progression and Air Force acceptance will be from the lesser to the greater resolution.

4. The development objective will be to provide a satellite reconnaissance system capable of providing reconnaissance information which can be integrated into the USAF Intelligence Data Handling System and disseminated to operational military agencies. The research and development effort is directed toward providing reconnaissance equipment that will permit the following:

a. Terrain and mapping coverage.

b. Detection of new and hitherto unknown targets and verification of known targets.

c. Determination of electronic signal characteristics.

d. Location of targets and defenses.

e. Collection of data on technological improvements.

f. Evaluation of military and industrial strength.

g. Monitoring of electronic emissions.

h. Surveillance of enemy build-up indications.

i. Warning of attacks under way or pending.

j. Assessment of high-yield weapons' damage.

k. Reconnoitering of military movements.

l. Location of Naval forces throughout the world.

m. Collection of world-wide weather data (Primarily Cloud Cover).

II. SENTRY OVERALL OPERATIONAL CHARACTERISTICS

A. GENERAL

1. The Sentry System is composed of the satellite vehicle, the ICBM booster, launch facilities, tracking facilities, and a complex communication and data processing network with related facilities. The ICBM booster provides the primary propulsive power to the Sentry satellite vehicle. Separation occurs on attaining the proper altitude and attitude. As the booster falls away, the satellite vehicle continues in a self stabilized predetermined coast to a program altitude. Orbital altitudes will be varied according to mission requirements, vehicle on orbit weights, and similar technical considerations. At the termination of the coast phase, the internal satellite power plant activates, supplying the orbital velocity increment required to establish a substantially circular orbit. Subsequent platform motion and the internal controls will then erect the vehicle to the proper attitude. The most common reconnaissance orbits will pass within a few degrees of the poles. The vehicle will be programmed to initiate and terminate sensing equipment in the target area in accordance with a predetermined program.

2. The vehicle will continue around the earth, and when within range of a ground receiving station, upon command, read-out sensory equipment will begin to transmit the recorded data. These data will be received, processed, and transmitted to the using agencies. In case of a recovery payload, the vehicle will receive programming commands only from the tracking station.

3. The vehicle will then begin its next cycle. These revolutions will be repeated at approximately 90 minute intervals. Because the orbit is essentially fixed in space, while the earth rotates inside it, successive passes over the earth's surface will be displaced approximately 22-1/2 degrees at the equator. This offsetting will permit a single vehicle to view the entire earth in a total time period which depends on the width of swath observed. Useful operation will be terminated upon command at the exhaustion of the film supply in the case of a recoverable payload. In the case of a readout payload, termination will occur either when air drag slows the vehicle to point that it plunges into dense atmosphere, when the electrical power supply is exhausted or when a failure of equipment takes place. Expected useful life for early versions of the system is of the order of 10 to 30 days. Expected useful life for later versions of the system is in excess of a year.

4. The Sentry satellite vehicles will be equipped with devices for sensoring and relaying to the ground or storing for later recovery, reconnaissance information in the radio and visual regions of the electromagnetic spectrum.

5. The Weapon System will provide a reconnaissance capability of two modes, readout and recovery.

a. Readout Program

(1) Visual

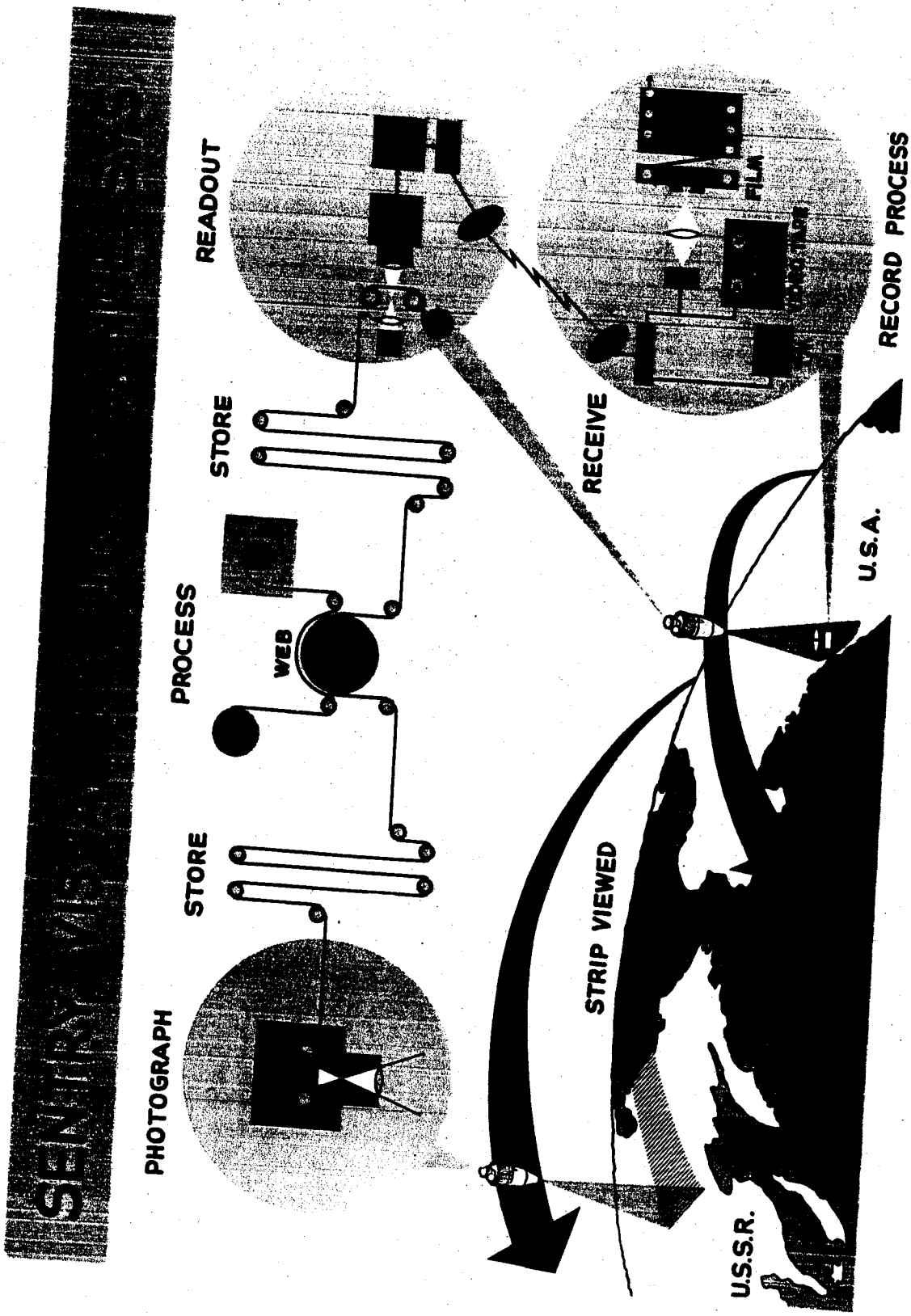
The reconnaissance equipment for the visual reconnaissance readout program consists of those satellite-borne equipments required to collect intelligence information in the visible spectrum, to process and store this information and on a command signal from the ground to convert stored images to appropriate signals for transmission to the ground. In addition to the satellite-borne equipment, related ground base equipment is required to take the out-put of the satellite-borne data link and reconstitute the signal into photographic form for further processing and intelligence use. Initially, the system will employ conventional photographic techniques with a special automatic film processing and television type data readout. Future consideration will be given to the development and use of electrostatic sensors and high resolution television in conjunction with magnetic tape storage. Initial visual equipment will be capable of resolving targets 20 feet in size and development will continue toward the goal of achieving resolutions of 5 ft or less.

(2) Ferret Reconnaissance

The Electronic Reconnaissance Subsystem (Ferret) consists of the satellite-borne equipment required to collect information from radiation in the region of the electromagnetic spectrum between 30 to 40,000 mc/sec, to store this information, to filter or index it as may be necessary, and, at the proper time, to reconvert the stored information into an appropriate electrical signal for transmission to the ground by the Ground-Space Communication Subsystem. The subsystem also includes the ground-based equipment required for in-flight calibration and vehicle equipment adjustment, engineering evaluation of equipment performance and decoding of reconnaissance data, time, and vehicle position for further data processing.

b. Recovery Program - Visual

The visual recovery program will provide, initially, for two separate payloads. The first of these payloads will be designed to obtain photographic coverage of mapping accuracy and the other payload will be designed to obtain high resolution reconnaissance information. In both cases, the data will be returned to the earth in the recovery capsule portion of the satellite vehicle. The advantage gained from a recoverable capsule is that it permits the collection of data over a large geographical area at a rate which would exceed the limits of a readout data link capability.



6. Sentry Data Processing will be oriented toward use of the data in order to assess imminency of immediate attacks. Equipment will be developed to integrate single isolated facts into an overall warning picture based on data from the reconnaissance satellites. With full system capability, control of reconnaissance coverage of the satellites becomes increasingly important. Thus, the programming of intelligence requirements into the system and feed back of the resulting reconnaissance data will require careful consideration and planning. Since the satellite reconnaissance data will be useful in long term analysis of change and activity, transcriptions will be made of the original records into formats suitable for use without special equipments by military operating agencies.

III. DESIGN SPECIFICATIONS AND GENERAL OPERATING DATA

A. SENTRY

1. The Sentry System is being developed over a period of years and it will include a variety of configurations, capabilities and useful satellite life spans. The development of the system will proceed from relatively simple design of limited capability to more refined versions capable of meeting stated system requirements. The original design and subsequent development work will endeavor to keep the basic system design as flexible as possible to provide a relatively rapid reaction to changing requirements. The present design objectives include two basic programs - readout and recovery.

a. Readout

(1) General

The Readout Program is divided into two reconnaissance modes; Visual and Ferret. To support these two reconnaissance modes, the ground space communications system will be provided as a means for communicating with the vehicle from ground stations and for receiving, monitoring and encoding environmental, vehicle, functional, and all reconnaissance data from the vehicle subsystems. The ground space communications system ground equipment will provide for the acquisition and tracking, reception of data, and the transmission of specific commands to the satellite vehicle. The communications system will include the equipment which will provide for interstation ground communications including the transmission of reconnaissance data and command and control instructions throughout the system. The readout development program will provide daily visual and electronic surveillance of potential enemy military installations. This system will provide the United States Air Force with intelligence data, the evaluation of which will constantly indicate the enemy's military position. It will indicate the imminence of hostilities and the buildup of activities having military significance. This will allow the initiation of retaliatory planning and enhance the capability of both active and passive defenses. Peacetime operation of the system permits the detection and identification of enemy radar and other electronics devices, and of enemy military activities in the preparation, training, and firing of ICBM's IRBM's and satellites.

(2) Visual

(a) The purpose of this program is to develop a reconnaissance satellite using a 36 inch focal length camera configuration capable of resolving 20 feet ground objects. With this system it will be possible to locate objects with an accuracy of approximately 1 mile of the true location.

(b) Ultimately, the visual readout program will incorporate a long focal length high resolution camera system (5 feet ground resolution). While the initial work in the long focal length high resolution area will be conducted in the Recovery Program, a great deal of this work will be directly applicable to the Readout Program.

(c) The visual reconnaissance satellite will consist of a stabilized vehicle and a visual reconnaissance payload operating with three data acquisition stations and an intelligence data processing center. The visual photographic payload will be employed with an electronic readout and transmission over the ZI. Auxiliary power will be supplied by batteries initially and later by solar or nuclear power supplies. The 36 inch system will cover a 17 mile width in the vertical position but will be programmed across the line of flight to intercept areas of definite interest. In later versions of this system the camera system will have the capability of program movement in the vehicle to provide stero photography when desired.

(d) The major activity of this program is concerned with the design, fabrication, and laboratory evaluation of experimental and prototype models of photographic visual payloads. Such work includes extensive environmental testing of the prototype, determining compatibility with the data link and command links, and flight testing. An important part of this program will be the achievement of sufficient reliability of the visual subsystem on orbit. Extensive testing on the ground and on orbit will have to be performed to obtain the reliability required for long life unattended operation.

(3) Ferret

The Electronic Reconnaissance System (Ferret) will be designed to provide a logically developed capability to satisfy the National Intelligence objectives in the area of electronic reconnaissance. It will progress from a basic package with limited capability to an eventual sophisticated surveillance system. This system is logically divided into capabilities consistent with the development time scale. These capabilities have been labelled Ferret-1, Ferret-2, Ferret-3 (F-1, F-2, F-3). The eventual Ferret Surveillance System will combine features of both F-2 and F-3 to provide continuous coverage of the desired portions of the electromagnetic spectrum over the area of interest. Ferret-2 and later equipments will be of modular construction to provide a maximum flexibility, making possible a variety of mission capabilities, dependent upon information gained in earlier flights and changes in National Intelligence objectives.

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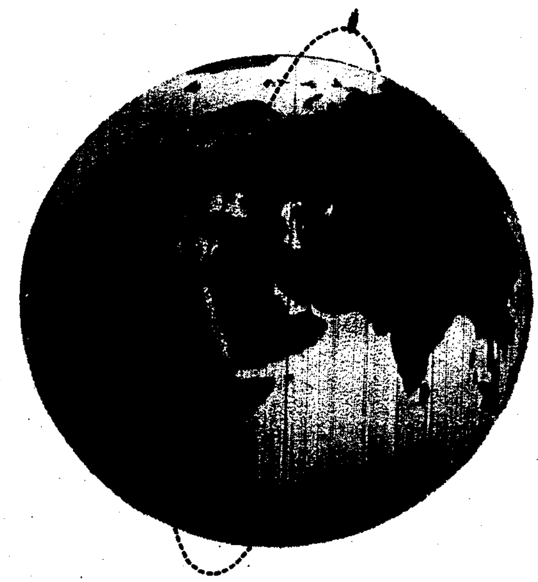
SENTRY ELECTRONIC RECONNAISANCE

OBJECTIVE

THE OBJECTIVE OF ELECTRONIC RECONNAISSANCE IS TO DETECT AND OBTAIN INFORMATION ON ELECTRONIC EMITTERS IN AREAS WHERE SUCH INFORMATION DOES NOT NOW EXIST.

ADVANTAGES OF SATELLITE FERRET SYSTEM OVER CONVENTIONAL FERRET TECHNIQUES:

1. COMPLETE WORLD COVERAGE
2. CONTINUOUS UNATTENDED SURVEILLANCE
3. ALL WEATHER OPERATION
4. RELATIVE FREEDOM FROM CAMOUFLAGE
5. ABILITY TO IDENTIFY HIGH PRIORITY INSTALLATIONS BY ELECTRONIC SIGNATURES
6. RAPID RECOVERY AND DISSEMINATION OF ELINT INFORMATION



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(a) Ferret-1 Equipment

This equipment will demonstrate the feasibility of the satellite ferret concept within the limitations imposed by equipment development time. It will consist of antennas, receivers, a data handling system, a recorder, and a programmer in the vehicle within in-flight calibration vans and a data handling system on the ground. [redacted]

data handling system performs error-checking and word counting operations and converts the coded word received from the vehicle via the ground space communications system into a format compatible with an IBM 704 or 709 computer. The in-flight calibration equipment will transmit signals with accurately known characteristics from the ground to the vehicle receiving equipment. When read-out at the tracking stations, signals received, by comparison with those transmitted, will provide a high degree of system calibration.

(b) Ferret-2 Equipment

This equipment will be designed to intercept, measure, store, and readout to a ground station pulsed emission in the electromagnetic spectrum from 50 to 18,000 mc/s. [redacted]

sist of antennas, receivers, a data handling system, a recorder, and a programmer in the vehicle with in-flight calibration vans and a data handling system on the ground. [redacted]