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LMSD SATELLITE SYSTEMS BRIEFING

PART II

THE SAMOS PROGRAM

LMSD-445737X 14 SEPTEMBER 1959

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(6) LMSD

SATELLITE SYSTEMS BRIEFING.

PART II.

THE SAMOS PROGRAM

(14) LMSD-445737-Pt-2 (11) 14 SEP[redacted]59

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PREFACE

The Samos program is defined in the Air Force Space System Development Plan, WDPP-59-11, 30 January 1959. Lockheed Missiles and Space Division is the weapon system contractor responsible for implementation of this plan.

The material presented ~~herein~~ highlights some of the more significant aspects of the Samos development program, with particular emphasis on visual reconnaissance (Subsystem E), ferret reconnaissance (Subsystem F), and communications (Subsystem H).

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INTRODUCTION

SAMOS PROGRAM DEVELOPMENT OBJECTIVES

PROVIDE SATELLITE RECONNAISSANCE SYSTEM THAT WILL PERMIT:

- TERRAIN & MAPPING COVERAGE
- TARGET DETECTION, VERIFICATION & LOCATION
- MONITORING OF ELECTRONIC EMISSIONS
- DETERMINATION OF ELECTRONIC SIGNAL CHARACTERISTICS
- MILITARY SURVEILLANCE
  - EVALUATION OF MILITARY & INDUSTRIAL STRENGTH
  - BUILD-UP INDICATORS
  - SIGNIFICANT MILITARY MOVEMENTS INCL. NAVAL FORCES, WORLDWIDE
  - ATTACK WARNING
- BOMB DAMAGE ASSESSMENT
- COLLECTION OF DATA ON TECHNOLOGICAL IMPROVEMENTS

P1085 S 4/3/59
LMSD/427185

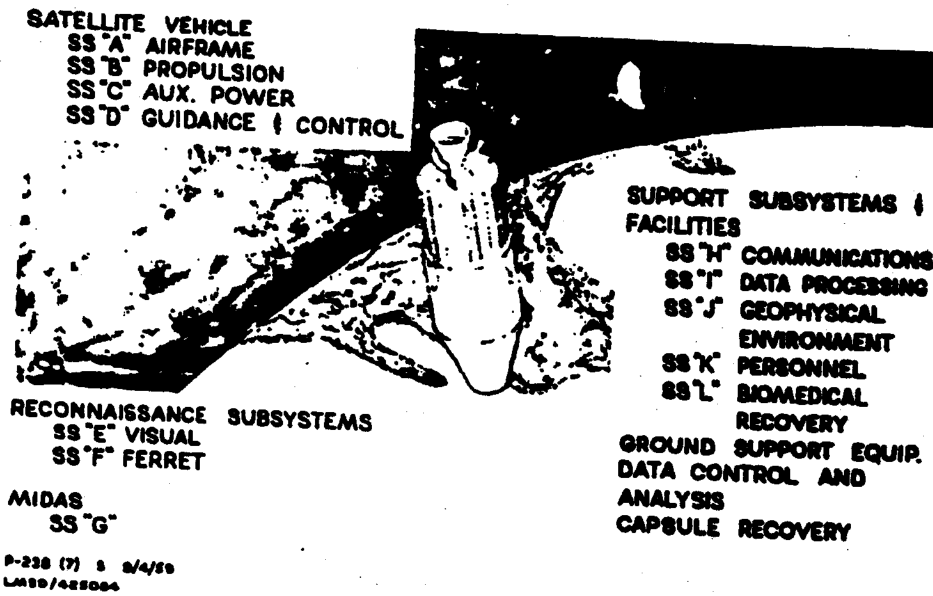
The great diversity of performance objectives for the Samos program requires the development of a system offering a high degree of flexibility in operational use and functional performance.

For example, terrain and mapping coverage implies a requirement for a visual reconnaissance system having moderate resolution with rather extensive area coverage capability to enable obtaining photographic coverage of large land masses in a reasonable period of time, and also to simplify the problem of converting the photographic coverage into maps.

On the other hand, detection and analysis of small enemy installations (such as radar equipment, aircraft, missiles, and their launch bases), while not requiring extensive area coverage, do require extremely high ground resolution capability. In addition, some of the objectives can be satisfied on a one-time basis while other objectives require daily observations.

In a similar manner, the requirements for electronic reconnaissance vary greatly, depending upon whether the objective is to merely monitor the level of activity at various locations within enemy areas, or to obtain sufficient detail on the electronic emissions to permit an accurate evaluation of the technical and functional capabilities and characteristics of the source of these emissions.

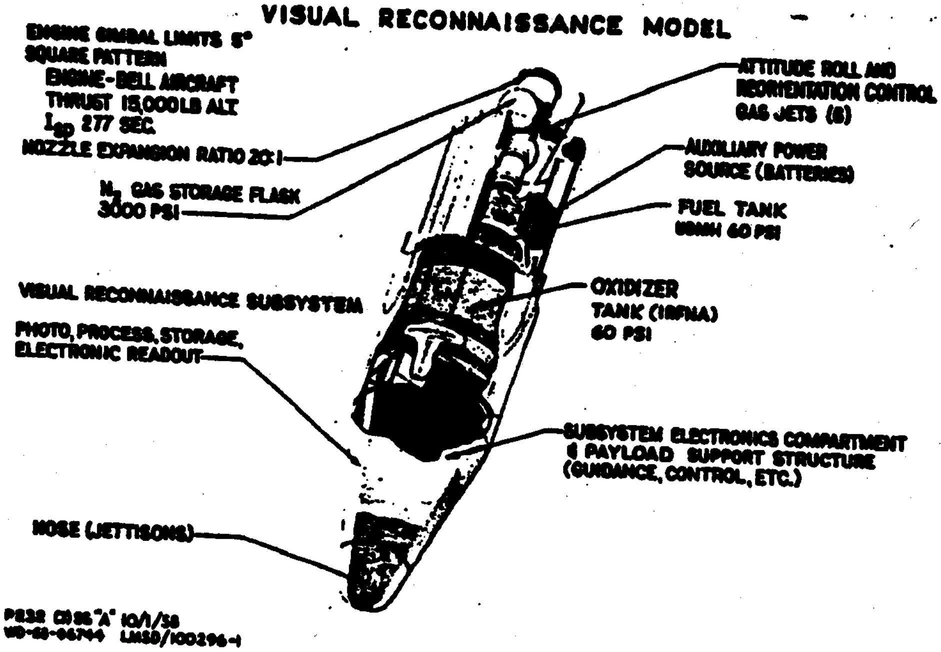
SUBSYSTEM STRUCTURE



The scope and complexity of the Samos program necessitates a subdivision into tasks of reasonable size for organizational and technical control purposes. As a result the program has evolved as a series of subsystems which represent a logical grouping of the various areas of effort on the program. In addition to the LMSD management and development responsibilities in the various subsystem areas, there is also the function of integrating all of the subsystems into one effective operational system. Although the MIDAS (Subsystem G) and the Subsystem L areas are now beyond the scope of the reoriented Samos program (and Subsystem I is not the responsibility of LMSD), cognizance of these areas of effort is required to insure the implementation of a technical program of maximum efficiency and economy.

SAMOS ORBITAL VEHICLE

VISUAL RECONNAISSANCE MODEL



The Samos reconnaissance program utilizes the basic Agena orbital vehicle. Minor variations in the detailed vehicle arrangement are required for the various payload configurations employed in implementing the variety of visual and electronic reconnaissance missions. The basic vehicle, however, remains essentially unchanged and affords a highly reliable means for orbit injection and controlled space platform operation of the intelligence sensing equipment.

The configuration shown provides a reconnaissance subsystem weight capacity on the order of 1,000 pounds. Through the use of dual burning during orbital boost, larger fuel and oxidizer tanks, and higher energy fuels, reconnaissance payloads of up to 5,000 pounds can be readily accommodated.

VISUAL RECONNAISSANCE MISSIONS

	PAYLOAD	PURPOSE	ALT. (S.M.)	PAYLOAD LIFE	COVERAGE	RESOL.
READOUT	E-1	R&D	300	1 MO.	100 MI. WIDE STRIP	100 FT.
	E-2	SURVEILL.	300	4 MO.	PROGRAMMED 17 MI. WIDE STRIP	20 FT.
	E-3	SURVEILL.	300	12 MO.	PROGRAMMED 5X5 MILES	5 FT.
RECOVERY	E-4	MAPPING	300	1 MO.	FRAME 460 X 460 MILES	200 FT.
	E-5	RECONN.	160-200	1 MO.	PROGRAMMED 60 MI. WIDE STRIP	5 FT.

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LMSD/436682

The visual reconnaissance program includes five basic payload configurations which provide:

a. Preliminary evaluation of the orbital operation of a readcut type payload (E-1)

b. Reconnaissance and surveillance capabilities at limited resolution (E-2)

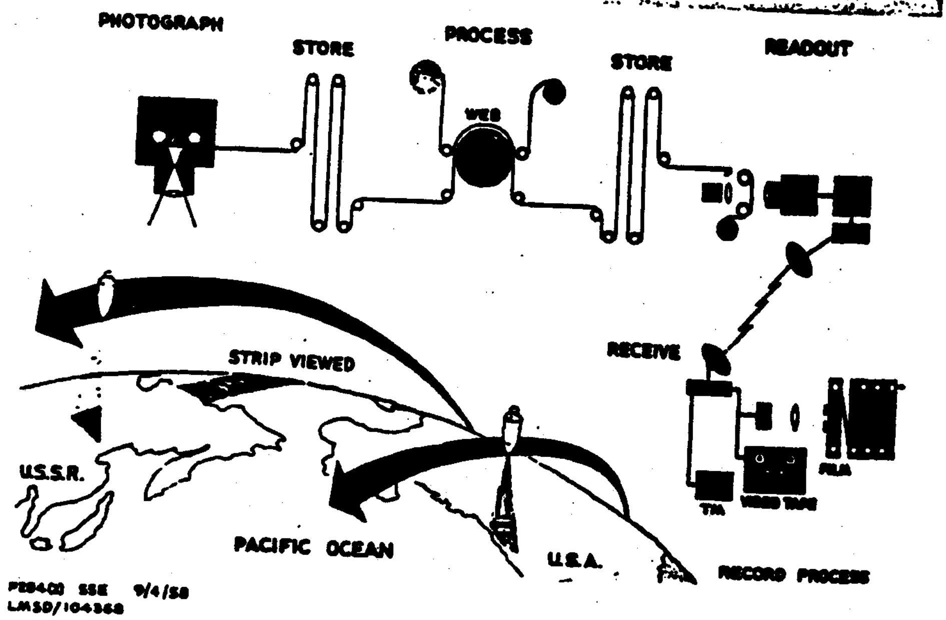
c. High resolution readout capabilities (E-3)

d. A highly accurate mapping capability (E-4)

e. A high resolution recoverable payload (E-5).

VISUAL RECONNAISSANCE
SUBSYSTEM E

E-2 PAYLOAD-FUNCTIONAL SCHEMATIC



The visual reconnaissance payload employs a slit-type camera to photograph, on command from the programmer, a strip of the earth's surface. The payload uses 70mm-wide film which, after exposure, is held in a variable capacity looper until processing by means of a pre-soaked "web" type material which is brought into contact with the film over a processing roller.

Upon contact with a ground readout station within the continental United States, the information on the film is read out by a high-resolution TV-type scanner and transmitted to the ground. At the station the video signal from the satellite is reconstructed into a film record for intelligence use.

SAMOS READOUT E-2 PAYLOAD DATA

GROUND RESOLUTION	20 FEET
GROUND WIDTH COVERAGE	17 MILES
MAXIMUM OBLIQUITY	26 DEGREES
STEREO CONVERGENCE ANGLE	34 DEGREES
GROUND COVERAGE AREA	55,000 SQ. MI./DAY
FILM CONSUMPTION	10 LB./MONTH
OPERATING LIFE	4 MONTHS
READOUT BANDWIDTH	6 MEGACYCLES
WEIGHT	919 LBS.
LENGTH	67 INCHES
BASE DIAMETER	55 INCHES
AVERAGE POWER CONSUMPTION	28 WATTS

P 1103 55 "E" 4/22/59
LMSD/427878

The basic parameters of the E-2 payload are listed in this chart. Obliquity steering involves 105 positions (plus or minus 26 degrees in half-degree steps). Stereo convergence angles of 0, 10, 20, and 34 degrees are available. The operating life listed assumes a readout-limited system with three readout stations and information being read out during every contact with a readout station.

SAMOS READOUT E-2 CAMERA DATA

FOCAL LENGTH	36 INCHES
FILM WIDTH	70 MM
PICTURE WIDTH	2 INCHES
LIMITING RESOLUTION	250 LINES/MM
APERTURE RATIO	F/4
APERTURE DIAMETER	9 INCHES
EXPOSURE TIME NOMINAL	1/100 SEC.
SPECTRAL RANGE	.500-.720 MICRONS
SLIT WIDTH	.0027 TO .085 INCH
WEIGHT	83 LB.

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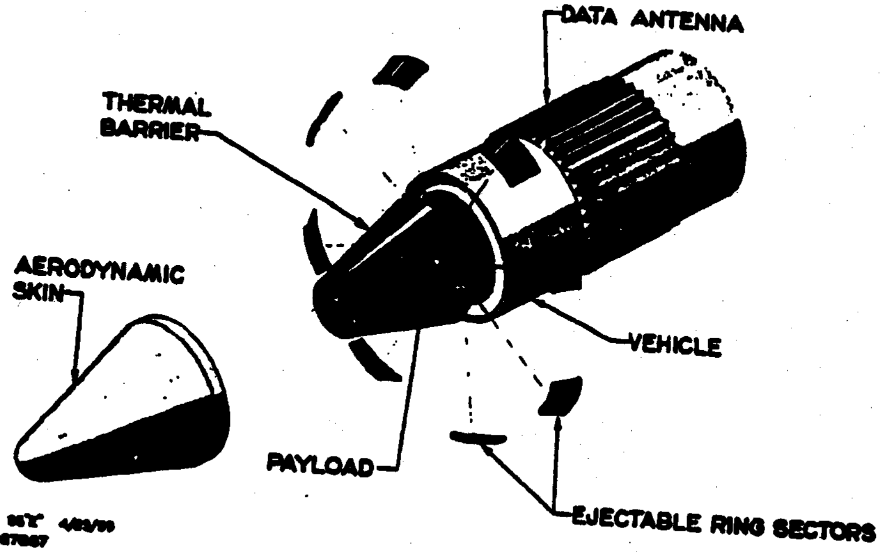
Data listed on the chart are those resulting when a slit camera is installed. A frame camera is being developed which can be used interchangeably to give a 2 x 2-inch square format. A comparable weight is expected for this model.

VISUAL RECONNAISSANCE PAYLOAD (E-2)

The largest single component of the E-2 payload is its 36-inch focal length lens, which occupies the central core of the payload package. All other components (including the film handling equipment, processor, readout packages, and environmental control equipment) are fitted around the lens but within the conical configuration imposed by the vehicle nose section.

SAMOS READOUT-EJECTION OF SUPPORTS

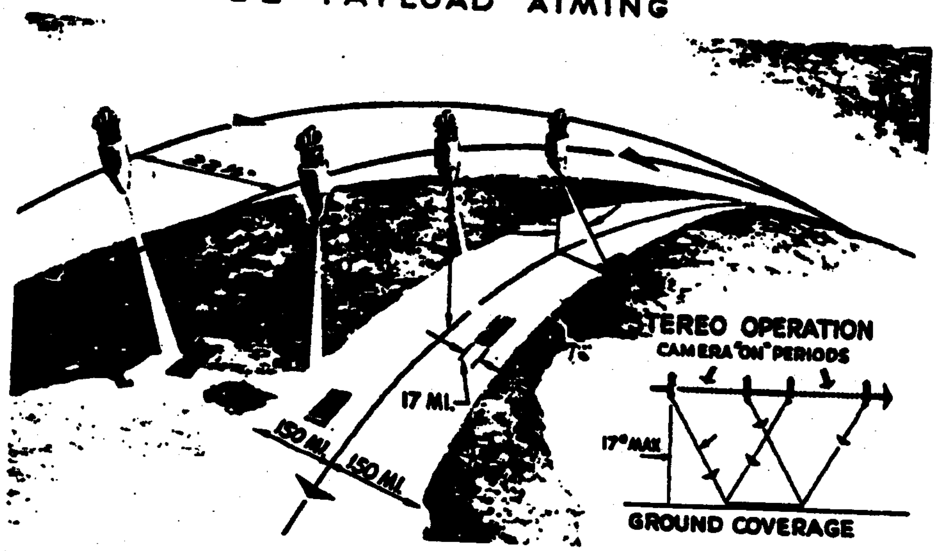
E-2 LAUNCH STABILIZING SUPPORTS



Upon attaining the proper nose-down orientation, the entire nose section of the aerodynamic skin is jettisoned, exposing the E-2 payload which is still locked rigidly in position. To prepare the payload for full operation, the trunnion support rings, which are necessary during the launch phase, are ejected and the payload is free to move as necessary to cover specific targets.

SAMOS READOUT-CAMERA PROGRAMMING

E-2 PAYLOAD AIMING

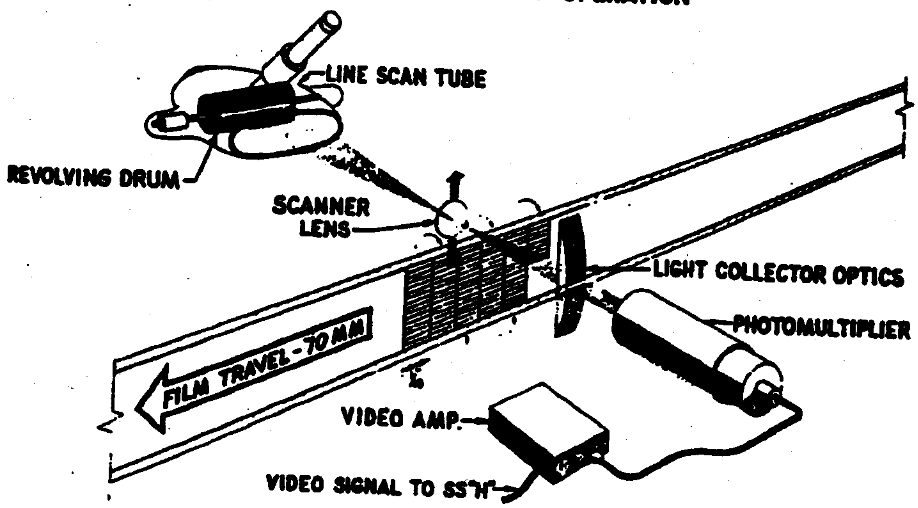


P 1220 SS 8/7/59
LMSD. 427011

With the long focal length employed in the E-2 payload, a relatively narrow ground swath (17 miles) is covered. Provision for covering targets up to 150 miles on either side of the ground track is included in the E-2 system. The entire payload can be programmed to point up to 26 degrees to either side. In addition, a stereo capability is provided by fore and aft aiming of the payload. A typical camera command, which must be stored in the vehicle programmer for execution over the territory of interest, includes exposure time and camera image-motion compensation data along with the obliquity, stereo, and crab orientations of the payload trunnion mount.

SAMOS READOUT SYSTEM

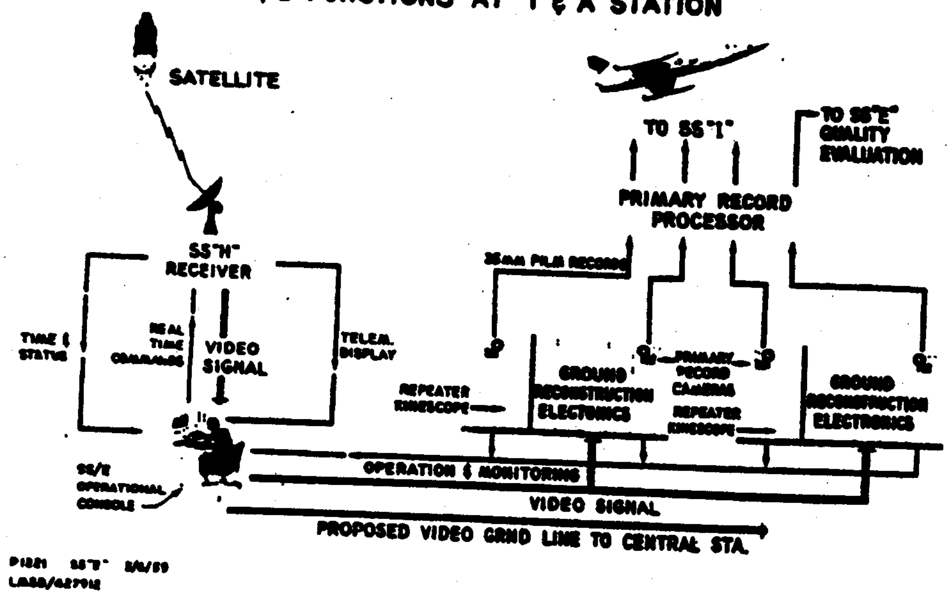
E-2 PAYLOAD READOUT OPERATION



The information is taken from the payload film ("read out") by scanning the film with a TV-like scanner. A mechanical drive is used to scan lateral strips of the 70mm film, with electronic sweep being used to cover the 0.10-inch strip. It is necessary to demagnify the scanning spot produced by the scanning tube to obtain a scanner resolution of 100 optical line pairs per millimeter. Light passing through the film is gathered by a collector optics system and photomultiplier tube in which the output is a video signal suitable for transmission to the ground.

SAMOS READOUT-GROUND RECONSTRUCTION

SS/E FUNCTIONS AT T & A STATION

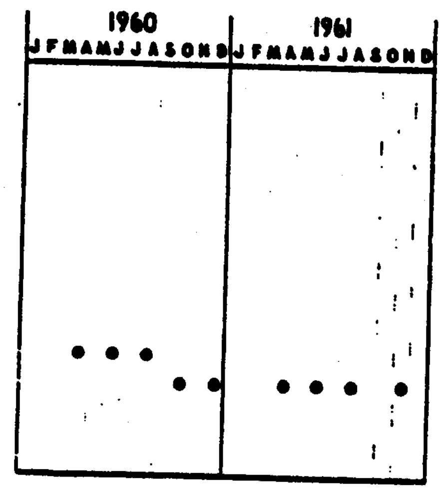


Upon reception at the ground station by the ground-space communications subsystem, the video signal is relayed to sets of ground reconstruction electronics whose function is the production of 35-millimeter primary ground records. Four duplicate records are produced at a typical tracking and acquisition station. The operator of the Subsystem E console can make adjustments in the payload scanner to optimize the video signal, and in addition acts as a nerve center for the subsystem area during a readout. Real-time transmission of the video signal to a central station is contemplated at a later date in the program, at which time a reduction in the number of records produced at a tracking and acquisition station will be possible.

SAMOS VISUAL READOUT FLIGHT DATES

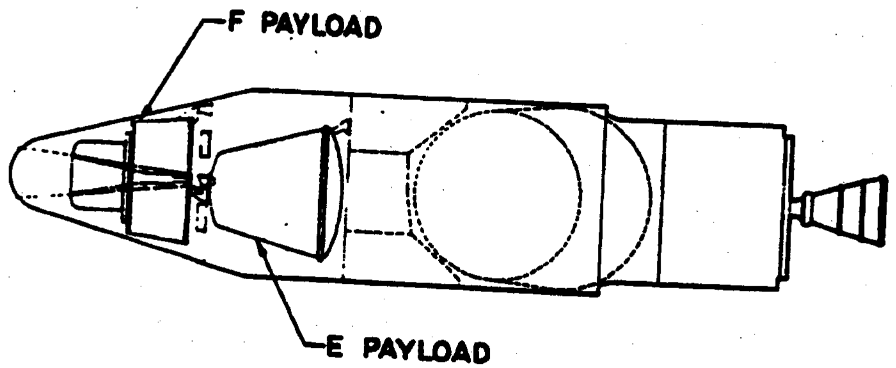
ARPA REORIENTED SCHED.

DUAL PAYLOAD (E-1,F)
(E-2 COMPONENT TEST)
E-2 VISUAL PAYLOAD



The primary effects of ARPA program reorientation included an advance of nine months in E-2 visual payload flight dates and de-emphasis of the former 6-inch focal length payload. Hardware from the 6-inch focal length program is being utilized in the E-1 component test flight configuration.

COMBINED E & F PAYLOAD



The E-1 components test payload will share the satellite vehicle with early ferret payloads. The E-1 payload is mounted behind the ferret equipment and, during the first few days of operation, will have a very limited view through a hole in the ferret antenna. After E-1 operation is proved, the ferret payload can be jettisoned, thus allowing the visual equipment an unrestricted view.

SAMOS READOUT ORBITAL OPERATIONS

DUAL PAYLOAD

CONCURRENT OPERATION

- SS/F FULLY OPERABLE
- SS/E FULLY OPERABLE BUT CAMERA FIELD RESTRICTED

CONSECUTIVE OPERATION

- SS/F JETTISONED AFTER EVALUATION & DETERMINATION OF SS/E OPERABILITY
- SS/E FULLY OPERABLE WITH UNRESTRICTED FIELD

8837 SST 4/21/59
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Operation of the dual payload configuration involves two distinct modes: concurrent operation of Subsystems E and F payloads to evaluate E-1 operation and to fully exercise the ferret system; and operation of the E-1 payload alone after jettisoning Subsystem F. Total payload lifetime is determined by battery exhaustion and is estimated at ten days.

SAMOS READOUT–E-2 GROWTH POTENTIAL

- RESOLUTION APPROACHING 5 FT. ON GROUND
- UTILIZE E-2 STRUCTURE & MAJOR COMPONENTS
- DEVELOP LONG FOCAL LENGTH LENS (120 IN. f/4)
- IMPROVE LENS-FILM RESOLUTION (250 LINES/MM)
- ADOPT LARGER FORMAT (5-IN. WIDE FILM)
- IMPROVE SCANNER RESOLUTION (100 LINES/MM)
- INCREASE DATA LINK BANDWIDTH (12 MC)
- IMPROVE ATTITUDE CONTROL (± 1/4°)
- CONSIDER FRAME TYPE CAMERA
- ADOPT AUTOMATIC IMAGE-MOTION COMPENSATION

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LMSD/427880

This chart represents the presently-estimated growth potential of the E-2 payload assuming: (1) maximum use of payload hardware being developed for E-2; (2) maximum compatibility with ground control and reconstruction equipment used in the E-2 program; and (3) logical extension of E-2 payload design, with no significant increase in scanner resolution.

E-3 VISUAL RECONNAISSANCE SYSTEM

CHARACTERISTICS & CAPABILITIES

- ACTIVE LIFE - 1 YEAR (300 S.MI. ORBIT ALTITUDE)
  POWER SUPPLY - SOLAR
- GROUND RESOLUTION - 5 FT. (2.5 FT. WITH 2X POWER CHANGER)
- OPTICS - 144" E.F.L. F/4.5
  SENSOR - ELECTROSTATIC STORAGE TAPE (60 FEET, REUSABLE)
- EXPOSURE - 1 MILLISECOND (REDUCED ATTITUDE CONTROL & IMC REQMTS)
  READOUT - ELECTRON BEAM DIRECT FROM TAPE
  DATA LINK - 12 MCS VIDEO BANDWIDTH
- GROUND RECONSTRUCTION - ELECTRON BEAM FILM RECORDER
  OPERATING MODES - VERTICAL, OBLIQUE, STEREO

8417 [illegible] 7/7/59
LMSD/436083

A nominal circular orbit altitude of 300 statute miles, together with the reusable electrostatic storage tape and a solar power supply, will permit the desired one-year active life on orbit.

An exposure period of only one millisecond, resulting from the high sensitivity of the photoconductive sensor, considerably simplifies the vehicle attitude control and the camera image-motion compensation problems.

System "optical" resolution capability is maximized through system simplifications achieved by the all-electronic visual reconnaissance equipment and the direct image reconstruction from the electron beam to film at ground bases.

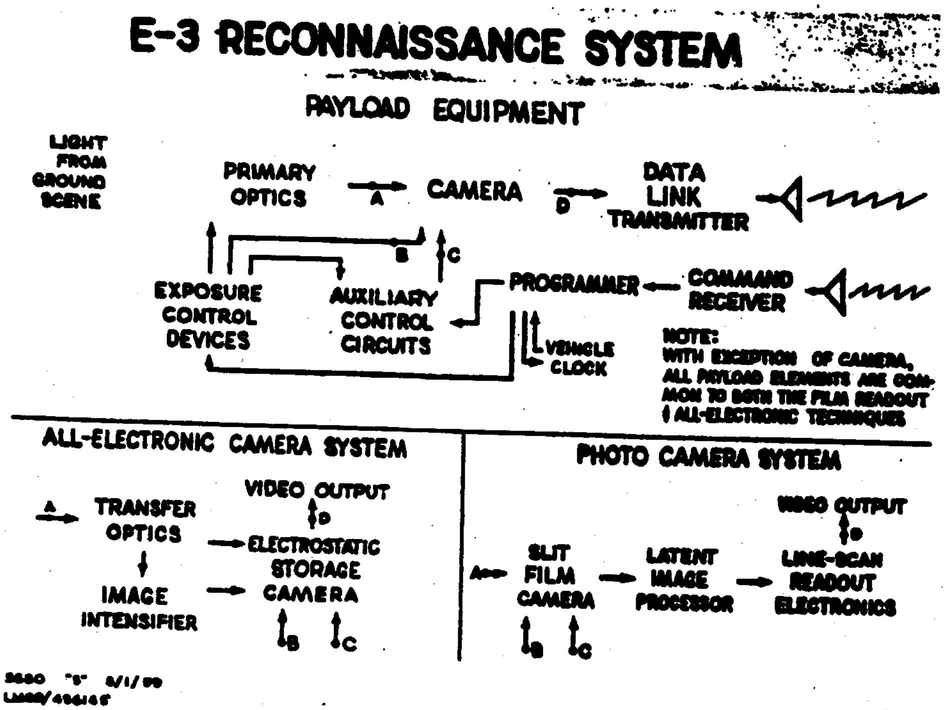
Use of the 12-mc video bandwidth data link permits doubling the readout capacity of high resolution video data without requiring additional ground stations.

OPN'L ADVANTAGES OF ALL-ELECTRONIC E-3 RECON. SYS.

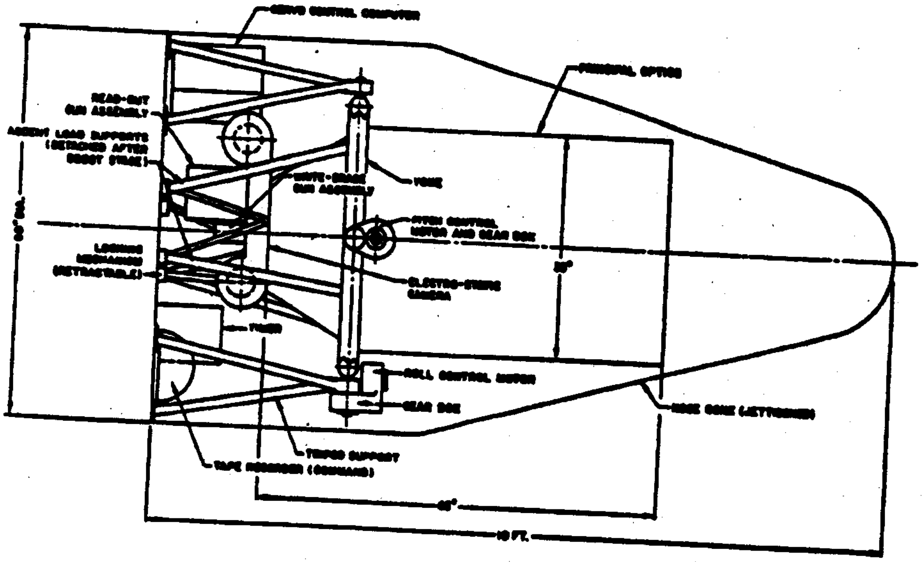
- RELIABILITY MORE READILY ATTAINED DUE TO DESIGN SIMPLICITY AND REDUNDANT EQUIPMENT POSSIBILITIES
- LOWER SENSITIVITY TO RADIATION
- IMAGE MOTION COMPENSATION REQUIREMENTS REDUCED (Ie., MORE SENSITIVE SENSOR ALLOWS A SHORTER EXPOSURE)
- REUSABLE IMAGING-STORAGE MEDIUM SIMPLIFIES ACHIEVING ONE-YEAR OPERATIONAL LIFE
- INCREASED SENSITIVITY PROVIDES CLOSER APPROACH TO 24-HOUR SURVEILLANCE CAPABILITY
- POSSIBILITY OF IMMEDIATE DATA TRANSMISSION (I.e., NO DELAY FOR FILM PROCESSING)
- FEASIBILITY OF PROVIDING REAL-TIME ADJUSTMENT OF PICTURE QUALITY DURING READOUT CONTACT

9678 "S" 8/1/59
LMSD/ 436140

The unique capabilities of the electrostatic storage camera, supplemented by optional use of the image intensifier section and relay lenses of additional magnification, offers a very high degree of flexibility in operational use and performance capability. This approach enables accomplishing functions within the broad area of visual reconnaissance requirements that would otherwise be technically unfeasible or economically prohibitive.



The relative simplicity of this technical approach is of particular interest. Even with the added functional capability provided by the transfer optics, image intensifier, and relay lenses for additional magnification, system simplicity is retained. This is largely due to the unique capability of the electrostatic storage camera to perform the imaging, image-motion compensation, temporary data storage, and data readout within the one self-contained unit, plus the additional factor that chemical processing attendant to operation with photographic film is no longer required.



The relative simplicity of the E-3 high resolution reconnaissance subsystem is illustrated above. Savings in space and weight resulting from use of the reusable electrostatic storage tape for video imaging and temporary data storage are apparent. While this initial preliminary layout is rather tentative with regard to specific detail, it does indicate the general payload hardware design concepts and requirements.

E-3 VISUAL RECONN. SUBSYSTEM

OPTICS

EFFECTIVE FOCAL LENGTH	44"
APERATURE & FOCAL RATIO	32"(F/4.5)
ANGULAR COVERAGE	APPROX 1°
FILTER	WRATTEN NO.12

CAMERA

IMAGING MEDIUM	ELECTROSTATIC STORAGE TAPE
IMAGE SURFACE	61MM (PRIM. IMAGE)+7.5MM (AUX. DATA)
SPECTRAL RANGE	0.5 TO 0.72 MICRONS
SENSITIVITY	EQUIVALENT ASA 145
EXPOSURE TIME	1-5 MILLISECONDS

STORAGE & READOUT

STORAGE CAPACITY	60 LIN. FT. OF 3.25" WIDE TAPE
SYSTEM RESOLUTION	100 OPTICAL LINE PAIRS/MM AT 10% SINE WAVE RESPONSE
READOUT BANDWIDTH	12 MC

GROUND RECORDING

ELECTRON BEAM FILM RECORDER

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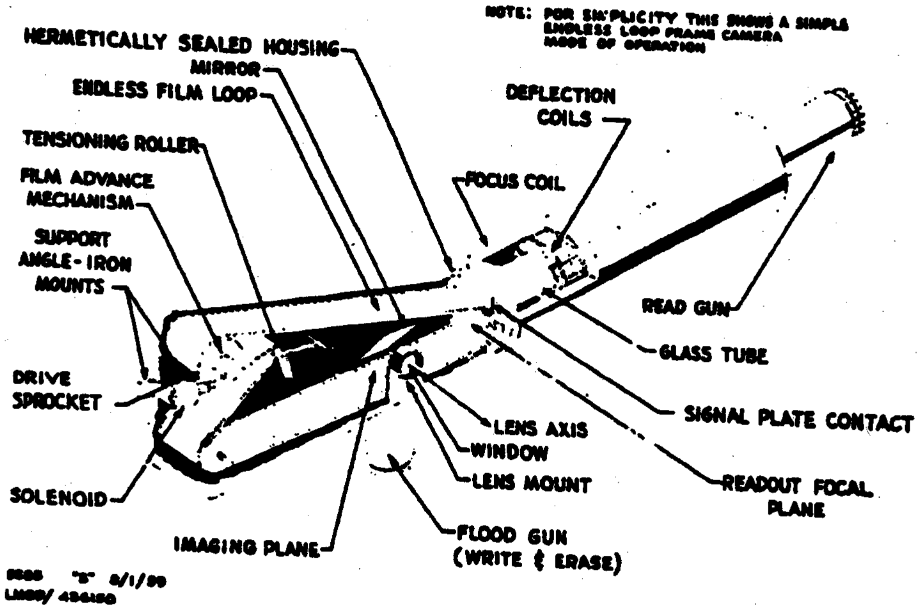
The characteristics of particular interest required for the performance of the high resolution readout surveillance missions include the relatively high sensitivity of the imaging medium which permits the employment of rather short exposure time, thus significantly reducing the attitude control and image-motion compensation problems. The system provides a very high resolution capability and, through the use of the reusable image storage medium, permits a payload design of minimum size and weight.

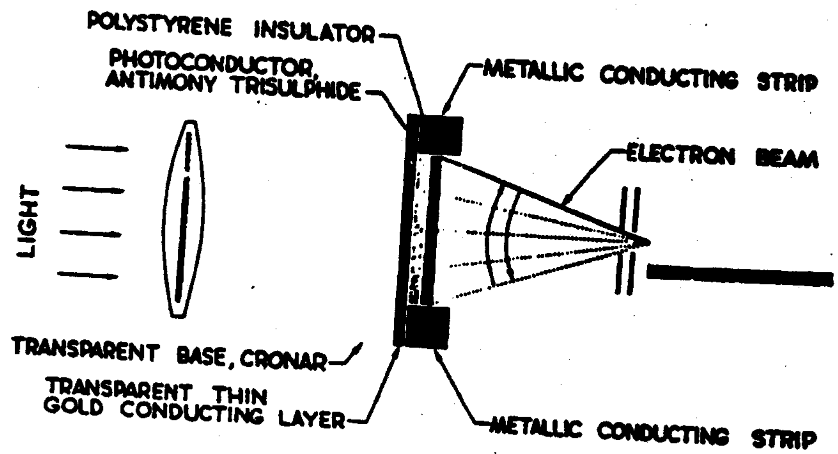
ELECTROSTATIC STORAGE CAMERA



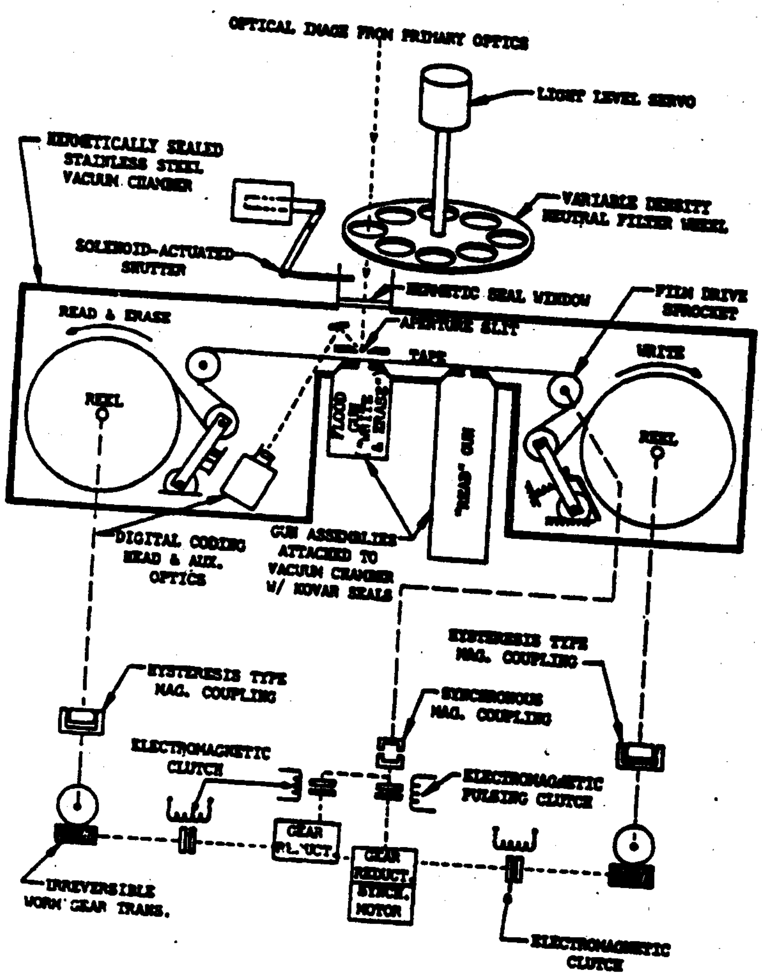
The above schematic representation of the electrostatic storage camera indicates the mechanization of such a camera for frame photography operation. Actually for applications where the ultimate in high resolution is desired and the metrical properties of the photography are not important, such as the E-3 reconnaissance mission, strip photography is preferable to frame camera operation.

The camera to be used in the E-3 system employs a slit before the image plane and a tape drive mechanism for image-motion compensation. The tape will be wound on rather conventional reels within a stainless steel evacuated chamber. Breadboard designs of this camera have already been built and tested by Radio Corporation of America, Astro-electronic Products Division. Technical feasibility of this approach is adequately demonstrated by currently available test data.

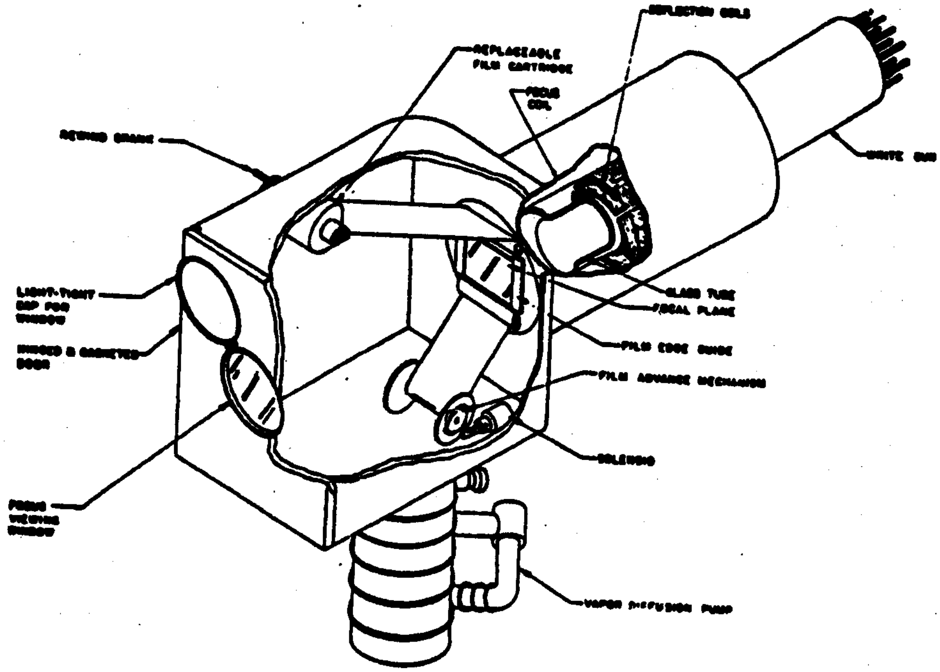
ELECTROSTATIC STORAGE TAPE



The electrostatic storage tape illustrated here is the heart of the E-3 reconnaissance system. Materials used in the construction of this tape were selected to meet the particular requirements for very high resolution, long storage time without image degradation, high resistance to radiation effects, and highly reliable reusability over a long active operating life.

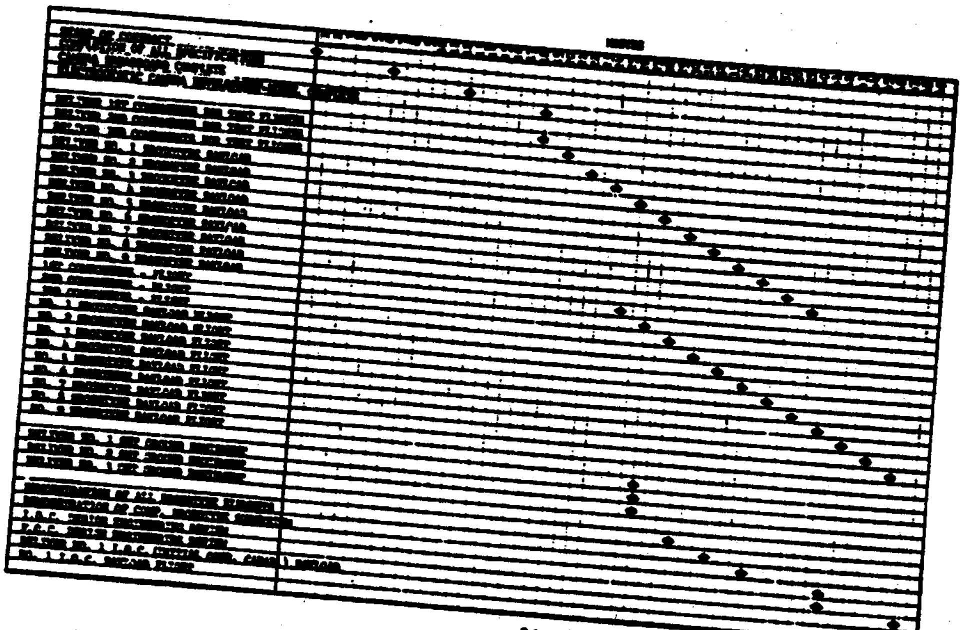


This chart illustrates schematically the salient features of the electrostatic camera. Items of particular design interest include the magnetic drive couplings and clutches that are employed to minimize the number of working parts that must be included within the evacuated chamber, and also the combination steel and glass design of the chamber wall. Partial breadboard models of this equipment have been built and tested at Radio Corporation of America, Astro-electronic Products Division.



The balanced design of a high resolution system for visual reconnaissance implies the need for high resolution capability in the reconstruction of the video image after reception at the ground readout station.

This electron-beam film recorder permits imaging the video data directly on photographic film without incurring the degradation in quality that normally would result from the use of an intermediate conversion medium, such as the phosphor of a cathode ray tube. By avoiding the degrading characteristics of the fluorescent phosphor and taking advantage of the finer electron beam diameters that are possible with a lower beam intensity, the electron-beam film recorder is capable of very high resolution.



Note: This schedule is included for planning purposes only and provides an indication of the timing that appears feasible for an adequately funded hardware development program.

As indicated in the included footnote, the above schedule is provided as a general indication of the timing that appears appropriate for the suggested E-3 development program.

SAMOS RECOVERY PROGRAM E-5 PAYLOAD

E-5 PAYLOAD OBJECTIVES

- 100% PHOTO POTENTIAL ABOVE 33° N LATITUDE
- 30 × 30 N. MI. PHOTOGRAPHS OF SPECIFIC TARGETS WITH 5 FOOT RESOLUTION
- 60 × 60 N. MI. PHOTOGRAPHS OF SPECIFIC TARGETS WITH 10 FOOT RESOLUTION
- STEREO CAPABILITY
- COMPATIBILITY WITH SENTRY READOUT
- LOCATION ACCURACY OF ONE N. MILE

PH35 [illegible]
LMSD/[illegible]

This chart outlines the objectives of the high resolution photographic reconnaissance program. The system should be capable of photographing any specified target area in the Eurasian land mass above 33 degrees north latitude.

The target area is defined as a 30 x 30-nautical mile area. In this area the photography should achieve 5-foot ground resolution. This 30 x 30-nautical mile area may be enclosed in a 60 x 60-nautical mile area which has 10-foot resolution at the edges.

It is required that the camera be capable of obtaining overlapping stereoscopic photography. This would permit maximum extraction of intelligence information from the photography.

A desirable, but not necessarily essential, objective is compatibility with the Samos readout system. This objective might permit use of the high resolution camera interchangeably with the cameras being specifically developed for the readout systems.

A necessary condition for the photography to be useful is that it be readily located. This objective would be fulfilled by recording the time of photography and correlating this information with the orbit ephemeris. It is required that the locational accuracy be one nautical mile or better.