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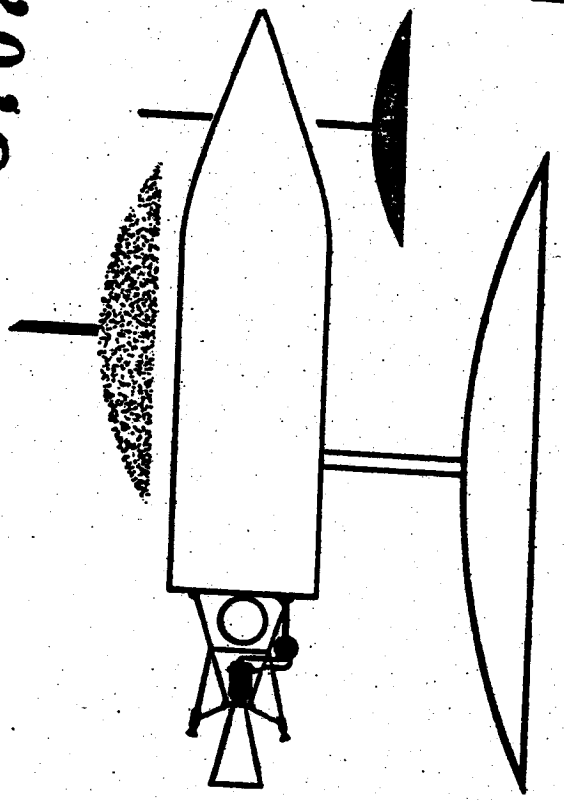

Pied Piper DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

E. Visual Reconnaissance

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
VAN NUYS, CALIFORNIA

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1 MARCH 1956

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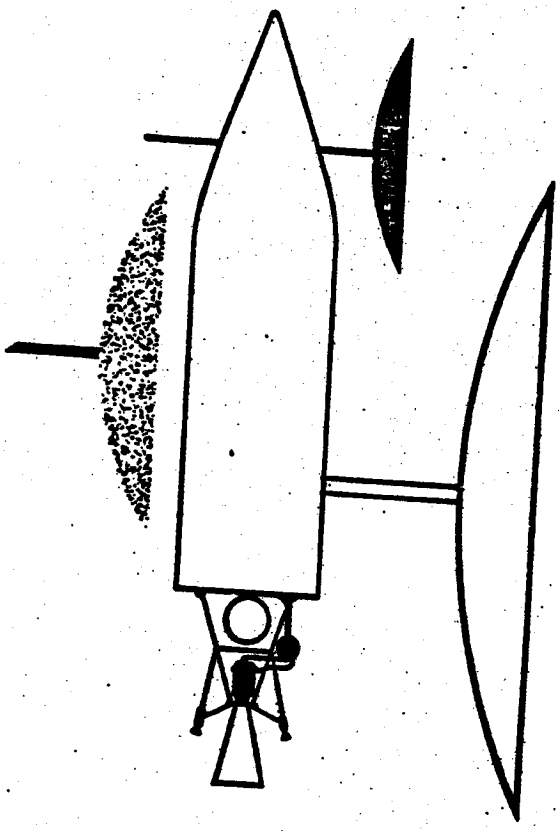

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FOREWORD

The Advanced Reconnaissance System (ARS) consists of a satellite vehicle containing equipment to perform visual, ferret, and infrared reconnaissance, together with the necessary system of ground stations and data processing centers.

This Development Plan for the accomplishment of the ARS was prepared by the Missile Systems Division, Lockheed Aircraft Corporation and its subcontractors, CBS Laboratories and Eastman Kodak Company. The specifications for the system were determined in the course of a one-year study now being conducted for the United States Air Force under contract AF 33(616)-3105. The plan is presented in two parts; Volume I, System Plan, and Volume II, Subsystem Plan. The subsystems are described in separate books, Volume II-A through II-L.

PIED PIPER DEVELOPMENT PLAN

VOLUME I. SYSTEM PLAN

VOLUME II. SUBSYSTEM PLAN

- A. Airframe
- B. Propulsion
- C. Auxiliary Power
- D. Guidance and Control
- E. Visual Reconnaissance
- F. Electronic Reconnaissance
- G. Infrared Reconnaissance
- H. Vehicle Electronics
- I. Airborne Test Systems
- J. Vehicle Intercept and Control Ground Station
- K. Ground Data Processing
- L. Vehicle Ground Support

CONTENTS

Subsystem E Visual Reconnaissance

SECRET
SECURITY CLASSIFICATION

RDB PROJECT CARD	TYPE OF REPORT: New System-Development Plan		REPORTS CONTROL SYMBOL DD-RDB(A)48: MSD 1536
1. PROJECT TITLE: VISUAL RECONNAISSANCE SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (UNCLASSIFIED) (PIED PIPER)	2. SECURITY: Secret	3. PROJECT NUMBER: 1115	
	4. INDEX NUMBER:	5. REPORT DATE: 1 March 1956	
6. BASIC FIELD OR SUBJECT	7. SUBFIELD OR SUBJECT SUBGROUP	7A. TECH. OBJ.	
8. COGNIZANT AGENCY	12. CONTRACTOR AND/OR LABORATORY: Lockheed Aircraft Corporation Missile Systems Division	CONTRACT/W.O. NO.: AF33(616)-3105	
9. DIRECTING AGENCY			
OFFICE SYMBOL / TELEPHONE NO.			
10. REQUESTING AGENCY	13. RELATED PROJECTS	17. EST. COMPL. DATES: RES. / DEV. / TEST / OP. EVAL.	
11. PARTICIPATION, COORDINATION, INTEREST	14. DATE APPROVED	18. FY / FISCAL ESTS. (M.$)	
	15. PRIORITY: Maximum / 16.		
19.			

20. REQUIREMENT AND/OR JUSTIFICATION

a. The satellite visual reconnaissance subsystem is a logical extension of the principles of aerial photography from the present state of the art. All prior effort involves manned aircraft and is concerned with problems of vibration, resolution, and angular movement at orders of magnitude different from those of the satellite environment.

b. The particular applications of interest to the Air Force will be the possibilities of mapping and examining inaccessible regions with a choice of resolution.

c. The successful culmination of the development program in an operational ARS will vastly increase Air Force capability in aerial reconnaissance and surveillance work.

22. RDB	SN	CN	PC & P	X.	L.	C.

DD, FORM AND 613 MISSILE SYSTEMS DIVISION

SECRET
SECURITY CLASSIFICATION

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LOCKHEED AIRCRAFT CORPORATION

RSD PROJECT CARD
CONTINUATION SHEET

SECURITY CLASSIFICATION SECRET

1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NUMBER
VISUAL RECONNAISSANCE SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (UNCLASSIFIED)	Secret	1115
(PIED PIPER)	4.	5. REPORT DATE: 1 March 1956

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21 a. Brief and Operational Characteristics

This subsystem provides photographic, electric image, and/or phototape recording for a satellite missile system. It includes programming of (1) recording, (2) storage, and (3) readout for transmission of raw data to appropriate ground intercept stations. This subsystem will function at orbital altitudes in the 300-mile region and resolve ground objects down to 20 feet in length or width. It thus delivers reconnaissance data for use by intelligence groups. Higher altitude systems can also be made available.

21 b. Approach

Visual data acquisition in this system does not differ significantly from long-range high-altitude aerial photography as practiced at the present state of the art wherein airborne rapid-processing has been used. TV camera investigation parallels the photo-film approach to exploit its possibilities with the aim of having a satisfactory system within the required time scale.

The major difficulties to be overcome include: (1) the hazards of high level radiation when nuclear power sources may be used; (2) those aspects of a gravitationless environment which interfere with the handling of photographic chemicals, (3) the determination of acceptable tolerances in balancing the desired wide-angle lens-coverage with desired ground resolution; and (4) the determination of interrelationships among vehicle stability, exposure time, and image motion compensation.

21 c. Subsystem Tasks

1. a. Photo Recording

b. Contractor: Eastman Kodak Company

c. Characteristics: Continuous-strip "Aerial" photography from an orbiting satellite will be carried out with operation programmed and/or ground commanded from intercept stations. Film processing will be automatic and the subsystem will encompass the flexibility of operating parallel units in the same vehicles for extra coverage or different magnifications.

2. a. Photo Readout

b. Contractor: CBS Laboratories

c. Characteristics: In principle, photo readout will be somewhat similar to the technique of televising film in commercial broadcasting. Specialized electronic components will be incorporated as the terminus of the program/command part of the information link to ground intercept.

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Performance limits are described in terms of approximately 5 megacycles video output bandwidth as the lower limit required to avoid any information-limiting aperture of the subsystem.

3. a. Information Link Component

b. Contractor: Columbia Broadcasting System

c. Characteristics: Video readout information will modulate an FM transmitter for relay to ground intercept on a programmed and/or command basis.

Range and performance limits are those which are characteristic of transmitters of this type and power level used. Performance will be maximized by means of a servo-controlled scanning antenna for ground-intercept-station tracking purposes.

21 d. Other Information

1. General

Although all work involving long-focus lenses, camera designs, and new films for aerial photography above 30,000 feet may be considered collateral activities, the unusual environmental conditions within the satellite present problems which are not met by presently available equipment. Nor has film-televising equipment been called upon to meet the exacting demands of recovering such amounts of information in aerial reconnaissance missions.

2. Alternate Recommendations

As an alternate subsystem, the direct pickup and instantaneous transmission by standard television techniques will be considered. This imposes the requirement of a multiplicity of vehicles and/or ground intercept stations for simultaneous operation.

The possibilities of the development of phototape as a storage medium to parallel the use of photographic film will be considered also.

3. Statement of Effects

All equipment will be contractor maintained and operating personnel will be contractor trained.

21 e. Background History

Study contracts such as Pied Piper under AF 33(616)-3105 established that adequate military reconnaissance and warning of enemy attack could be obtained only with satellite missiles.

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Study under this contract has determined that the subsystem visual reconnaissance system of this Development Plan can be produced in time to phase properly into the missile time scale.

21 f. Future Plans

It is planned to continue the studies already initiated and to develop components suitable for test purposes, and to insure compatibility with military intelligence requirements.

21 g. References

1. Appendix to this volume
2. Pied Piper Monthly and Quarterly Reports

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Pied Piper

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LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

TABS

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Subsystem E - VISUAL RECONNAISSANCE

Tab 1. General Design Specifications

I. GENERAL

A. Statement of the Problem

The basic objective may be stated as automatic aerial photo-reconnaissance from a vehicle whose orbital region is at an altitude of approximately 300 nautical miles and whose orbital velocity is in the order of 25,000 feet per second.

B. Approach

The objective will be approached through the development of a photo film and/or photo tape camera chain and/or a television camera chain coupled to a readout system.

The pioneer visual system development will carry through orderly stages:

a. Readout of prefabricated film.

b. Processing of latent images followed by readout.

c. Acquisition of visual images by means of a simplified camera followed by processing and readout.

d. Modifications to arrive at design forms of a universal camera.

The large scale or advanced visual system development will follow through stages which arrive at a semi-production prototype of

universal camera to yield the complete film system envisioned in the study program and which could be a surveillance system.

For a television surveillance system, two parallel approaches will be followed. One will utilize direct pickup and simultaneous transmission to ground (or other vehicle) employing a suitable TV Camera chain. The other will make use of a phototape (electrostatic image) strip camera offering choice in the matter of storage for delayed transmission. The developmental stages will include:

a. Design of a television camera chain to operate in the missile environment as programmed and/or ground commanded.

b. Design of repeater equipment for the Satellite terminus of the communication network.

c. Acquisition of visual images by direct TV pickup and instantaneous transmission to ground stations through a satellite communications network.

d. Modifications to arrive at a refined system.

e. Research and development to evolve a reusable phototape for electrostatic image recording.

f. Development of suitable strip-type camera, readout and erasure equipment.

g. Application and refinement of phototape data acquisition.

C. Solution

(1) Operational Ranges or Limitations

(a) Film Camera Chain

1. Typical ranges and limitations of lenses and film supplies are summarized in Tables I and II of the Appendix.
2. 70-mm film at 100 lines/mm resolution will be exposed and processed for a length of 30 inches for each pass within a continuous strip.
3. Equivalent exposure time will be in the order of 0.01 second using a one-mil slit.
4. Film camera chains in parallel operation will cover cases where width of desired ground coverage exceeds the capability of the individual lens chosen on the basis of ground resolution.
5. Flexibility in the above type of operation will permit observation of a part of the area covered by one at a different magnification by another. Particular variants are defined and fixed as a particular mission intent is established at some pre-flight time.
6. The film processor will have design variants by way of balancing chemistry with flight duration

and amounts of film involved. Basically it is expected to be a roller-applicator type.

(b) Photo Readout

1. In readout, high scanning line density (7000/inch) imposes the requirement of extensive optical minification of the flying spot cathode ray tube raster. Hence departure is made from the standard approach of sweeping the full film width with each scanning line by orienting this line along the length of film and making its image traverse the film by a combination of electronic and optico-mechanical scanning actions to complete a transverse "frame". The film is stepped along at the end of each frame.
2. The flying spot cathode ray tube will operate at anode voltage (approx. 27 KV) consistent with tube rating and environmental conditions to maximize resolution capability.
3. Cathode ray tube and photomultiplier parameters will be established to optimize readout resolution and signal-to-noise ratio.
4. The 70 mm x 30 inch film strip for each pass will be be read out in approximately 5 minutes time and with a minimum bandwidth of approximately 5 megacycles.

5. An Fm Data Transmitter, modulated by readout, center frequency of 7.5 KMC, frequency deviation of ± 5 MC, power output 10 watts, will employ tube types to optimize life, high efficiency, and FM linearity.

6. A parabolic data antenna, linearly polarized, will be approximately 3½ feet in diameter, having 35 db. gain.

(c) Television Camera Chain and Photo Tape Storage

The operational ranges for the televison camera chain and phototape strip-camera will be expected to parallel the general capabilities of the combined film camera chain and readout.

II. DESCRIPTION

A. Subsystem State of Art

Film Camera Chain

1. The immediate requirements by way of lens/film resolution and exposure time are within the scope of available lens and film types.

2. Film processing equipment study indicates the availability

of a processor when needed. No technical break-through is required.

Photo Readout

1. The flying spot cathode ray tube scanner is an extension of proved-in techniques. Commercially available components will be used in early stages.
2. Ruggedized components required for vehicle use are considered to be within the state of the art.
3. The data transmitter and antenna apply known techniques and improved transmitter tubes will be available in the near future.

TV Camera Chain and Phototape Strip Camera

1. Optical and electronic elements of the TV camera chain are within the present state of the art. Component ruggedization is needed. Improvements will extend the operational ranges of camera tube and its associated optics.
2. The phototape system is not within the immediate state of the art. Its principles have been demonstrated within the laboratory but an extensive research and development program will be required to bring it to reality.

B. Environmental Conditions Required for Operation

Film Camera Chain

1. The need for a sealed housing for the entire camera chain seems evident. This will include the photo-readout equipment of mechano-optical nature but excludes power supplies and amplifiers.
2. An upper limit on relative humidity is essential to raw film storage and transport through the camera proper.
3. Temperature control within a tolerance of $\pm 1^{\circ}$ F. probably will be required in the processing operation although the particular absolute level may be chosen over a wider range.
4. Pressurization will be required to avoid frothing or undue evaporation in the processor. Possibly a source of heat will be needed for film drying.

Television Camera Chain and Phototape Camera

1. A sealed housing will be required for cleanliness of optics. Certain types of camera tubes also require that some of the envelope be kept at an optimum temperature with a tolerance of 5°F.
2. Requirements imposed by the phototape system can be determined only through its own R&D program.

C. Special Tests Required

It is expected that nearly all aspects of this subsystem's design problems can be studied in the laboratory. Prior to the actual

installation considerations of a nuclear power source, some radiation tests, both with photographic films and electronic components, may be required. Actual flight tests in aircraft may be required for functional compatibility prove-in when combining components of the subsystem.

D. Other Subsystems Affected

Subsystem J (Ground Intercept Station) is closely interrelated with this subsystem and close liaison must be maintained.

Subsystem K (Ground Data Processing) is also affected but to a very minor degree.

E. Reliability Estimates

Film Camera Chain

A very high degree of performance reliability may be expected in the photorecording function as a whole. However, some difficulty lies in the component area of automatic exposure control wherein action at the focal plane in terms of "instantaneous" measure of brightness must be one of unusually low period in view of the vehicle's velocity.

Photo Readout

In general a high degree of performance reliability may be expected in this area. However, reliability limits will be established in terms of the electron tubes in this part of the system, the transmitter power output tube being the least reliable element.

TV Camera Chain

Because of the electronic nature of this subsystem component,

the same general remarks of (b) above apply here also, the TV camera tube being the most vulnerable.

F. Special Installation Considerations

Film Camera Chain

The particular considerations to be noted involve the determination of number of film camera chains needed along with the choice of lens and film magazine for each in terms of the mission intent as established at some pre-flight time. Choice of processing chemicals will be made on the same basis.

Obviously multiple chains will not be employed in the early development program.

Photo Readout

When the above mentioned development stages are reached, a similar situation by way of last-minute flexibility in installing parallel subsystem components applies. This includes parallel transmitters which then feed into a common antenna system.

G. Logistics Considerations

It will be advisable to have photo darkroom and storage facilities at launching sites on a GFE basis since mission intent may be determined at a very late hour in the flight schedule. Such facilities would be contractor maintained and personnel would be contractor trained.

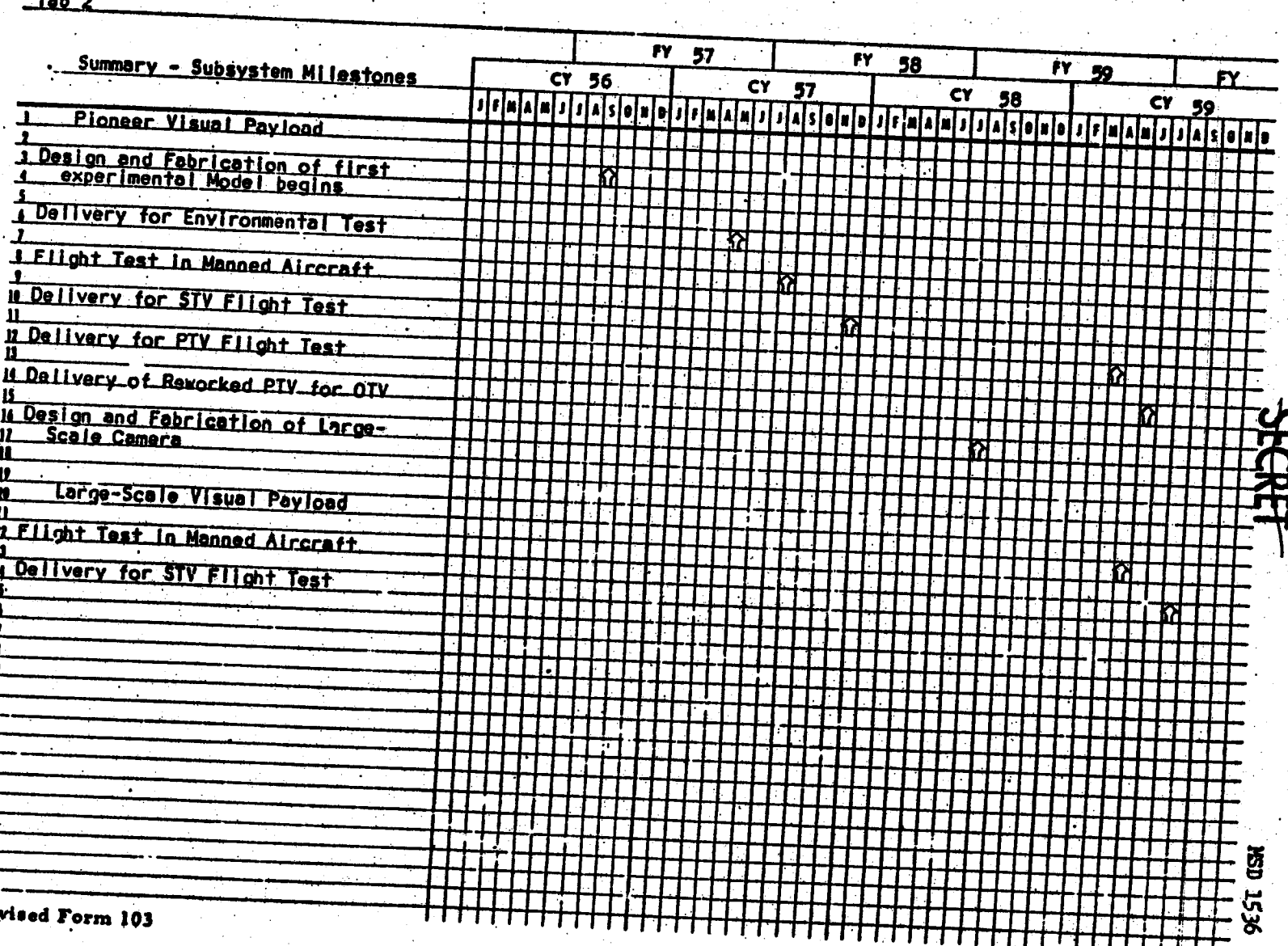
Optical and electronic test equipment will also be required on a GFE basis. This also will be contractor maintained and personnel will be contractor trained.

H. Compatibility

The various sections of these general design specifications summarily indicate the method of establishing compatibility wi h all phases of the program.

Subsystem E - VISUAL RECONNAISSANCE

Tab 2



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MISSILE SYSTEMS DIVISION

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Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - Subsystem Milestones

Large-Scale Visual Payload

Delivery for PTV Flight Test

Delivery of Reworked for First OTV

Visual Surveillance Payload

A. Photographic

Compatibility Prove-in with Radioisotope APU

Delivery for PTV

B. Television

Compatibility Prove-in with Nuclear APU

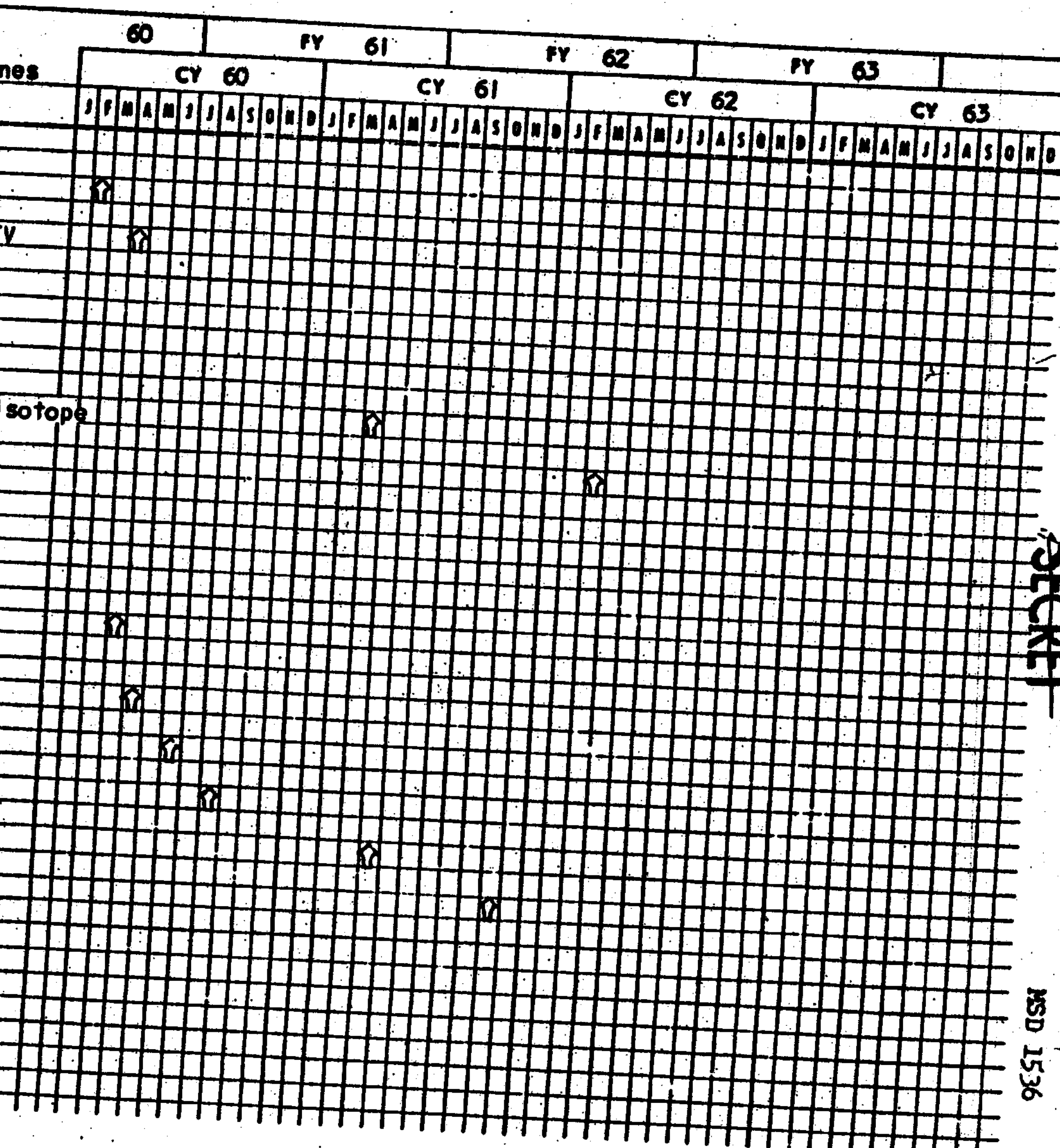
Delivery for Environmental Test

Flight Test in Manned Aircraft

Delivery for STV Flight Test

Delivery for PTV Flight Test

Delivery of Reworked for OTV Flight Test



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