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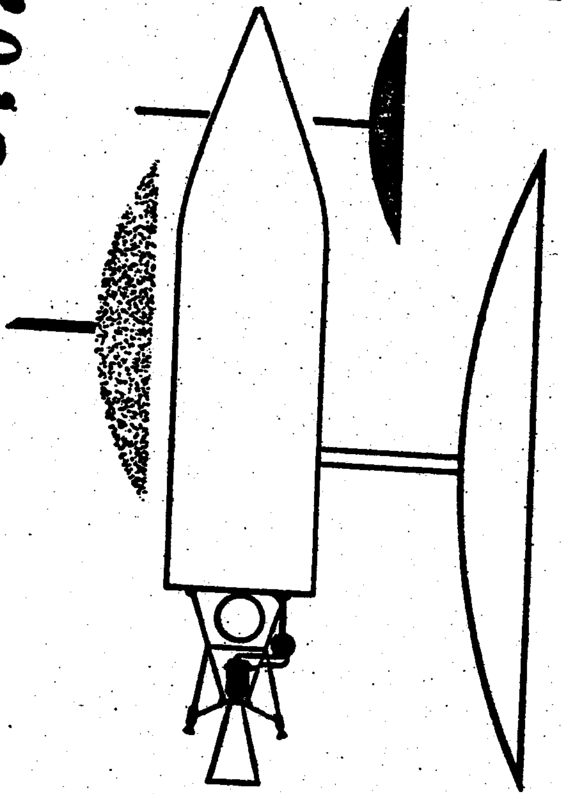

Pied Piper
DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

E. Visual Reconnaissance

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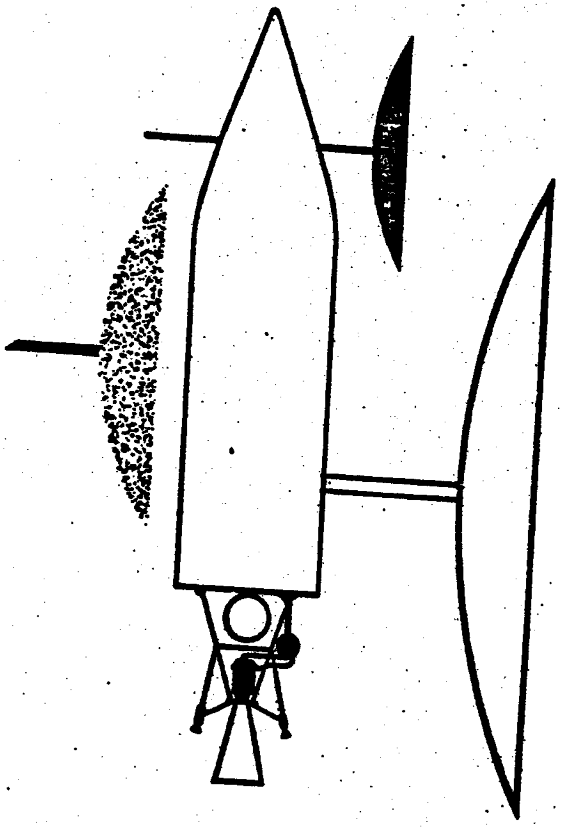

Pied Piper
DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

E. Visual Reconnaissance

DOWNGRADED AT 12 YEAR INTERVALS;
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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

CONTENTS

Subsystem E Visual Reconnaissance

SECRET
SECURITY CLASSIFICATION

MSD 1536

RDB PROJECT CARD

TYPE OF REPORT New System-Development Plan

REPORTS CONTROL SYMBOL DD-RDB(A)48

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

9. DIRECTING AGENCY

OFFICE SYMBOL

TELEPHONE NO.

10. REQUESTING AGENCY

11. PARTICIPATION, COORDINATION, INTEREST

12. CONTRACTOR AND/OR LABORATORY
Lockheed Aircraft Corporation
Missile Systems Division

CONTRACT/W.O. NO. AF33(616)-3105

13. RELATED PROJECTS

14. DATE APPROVED

15. PRIORITY Maximum

16.

17. EST. COMPL. DATES
RES.
DEV.
TEST
OP. EVAL.

18. FY	FISCAL ESTS. (M $)

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** **IC & P** **X.** **I.** **C.**

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R&D PROJECT CARD
CONTINUATION SHEET

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MSD 1536

1. PROJECT TITLE
VISUAL RECONNAISSANCE SUBSYSTEM
FOR ADVANCED RECONNAISSANCE SYSTEM
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(PIED PIPER)

2. SECURITY OF PROJECT ~~Secret~~

3. PROJECT NUMBER 1115

4.

5. REPORT DATE 1 March 1956

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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5. REPORT DATE 1 March 1956

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 serial 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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MSD 1536

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

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

MSD 1536

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

TABS

~~SECRET~~

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 ± 1° 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.

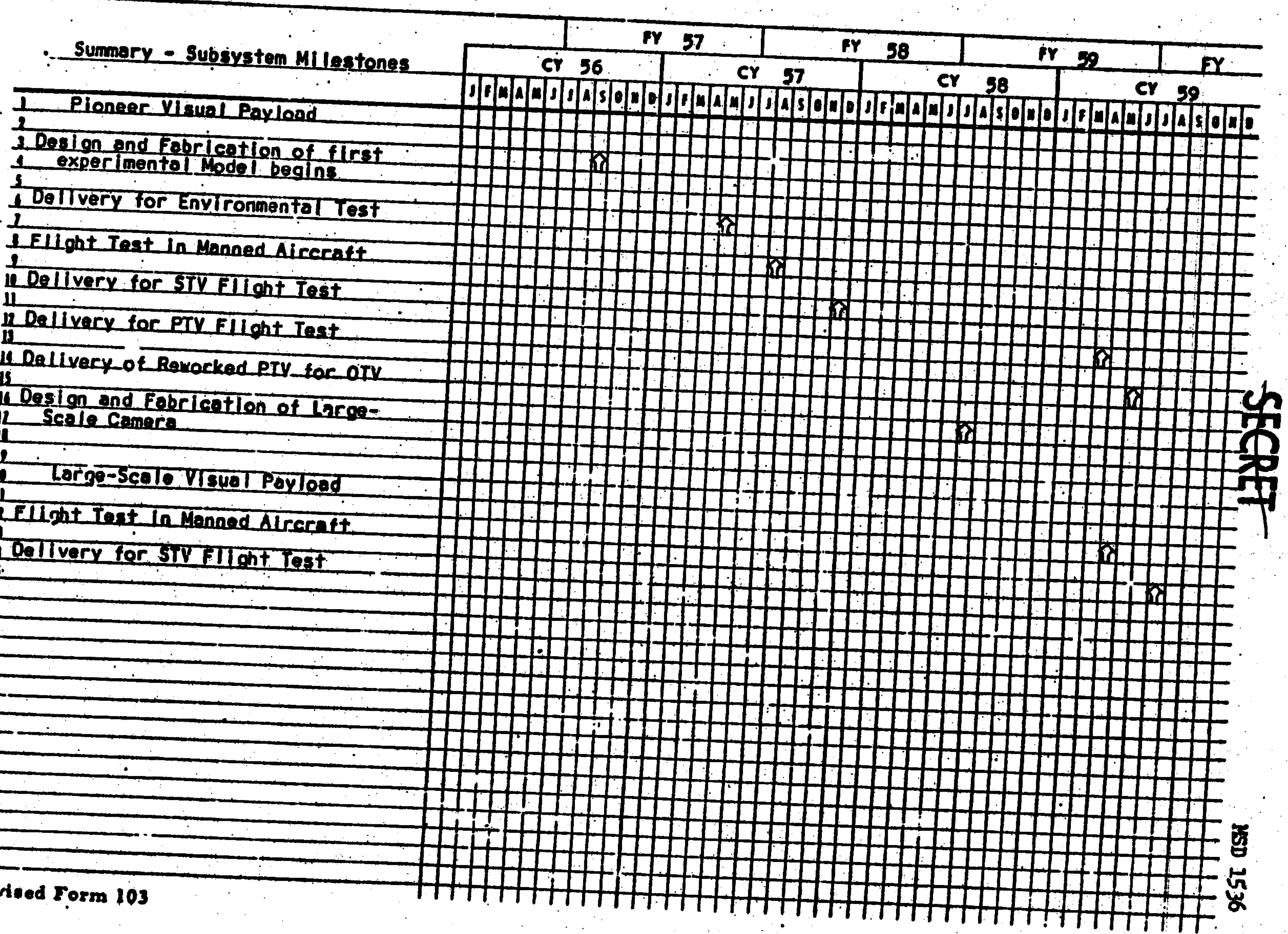
Optical and electronic test equipment will also be required on a GFE basis. This also will be contractor maintained and personnel will be contractor trained.

H. Compatibility

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

Subsystem E - VISUAL RECONNAISSANCE

Tab 2



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Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - Subsystem Milestones

1 Large-Scale Visual Payload
2
3 Delivery for PTV Flight Test
4
5 Delivery of Reworked for First OTV
6
7
8 Visual Surveillance Payload
9
10 A. Photographic
11
12 Compatibility Prove-in with Radioisotope
13
14 APU
15
16 Delivery for PTV
17
18
19 B. Television
20
21 Compatibility Prove-in with
22 Nuclear APU
23
24 Delivery for Environmental Test
25
26 Flight Test in Manned Aircraft
27
28 Delivery for STV Flight Test
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30 Delivery for PTV Flight Test
31
32 Delivery of Reworked for OTV Flight
33 Test
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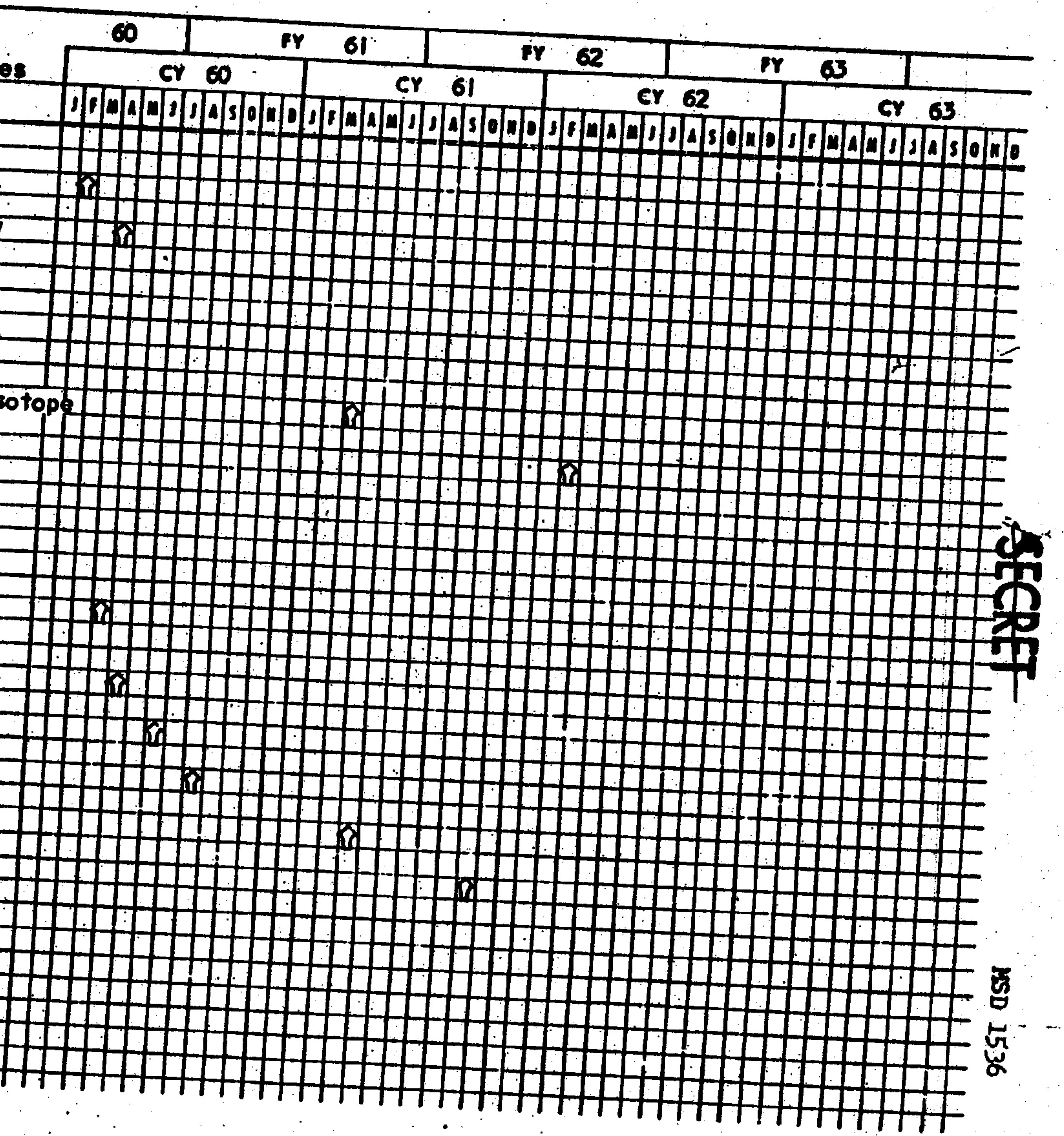

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Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - Hardware Delivery

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		CY 57											
		J	F	M	A	M	J	J	A	S	O	N	D
1	Pioneer Visual Recon. Payload												
2													
3	Experimental Model				2								
4													
5	Aircraft Test Model							1					
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9	PTV												2
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13	Large-Scale Visual Recon. Payload												
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25	Photo Surveillance Recon. Payload												
26													
27	Experimental Model												
28													
29	PTV												
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31	TV Surveillance Recon Payload												
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33	Experimental Model												
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35	Aircraft Test Model												
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40	OTV												

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39	PTV												
40	OTV												

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15	Experimental Model												
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17	Aircraft Test Model												
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19	STV				1								
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39	PTV								2				1
40	OTV												2

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Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - Hardware Delivery (Cont)

		61						FY 62												FY 63												FY																	
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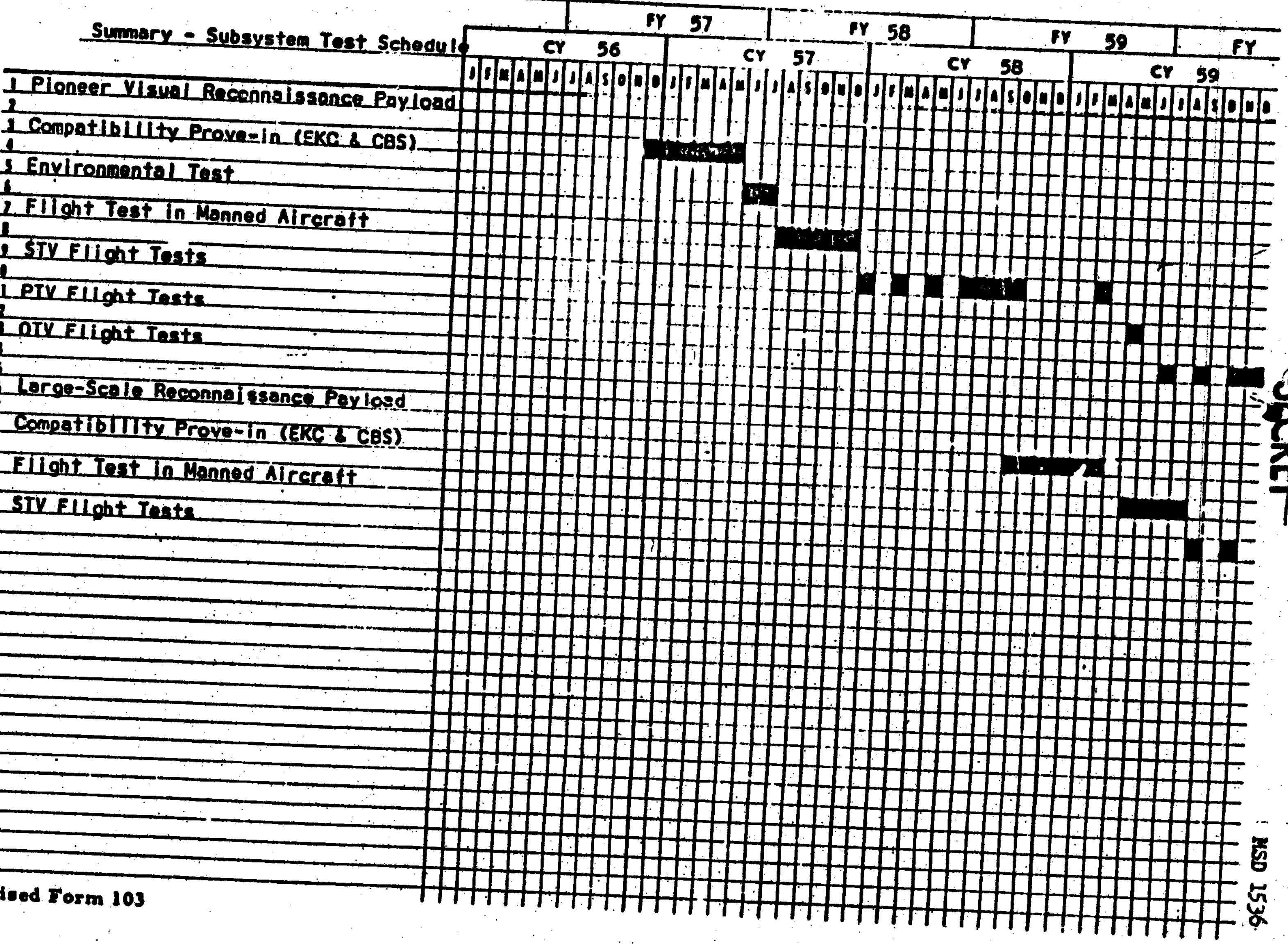
Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - Subsystem Test Schedule



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MISSILE SYSTEMS DIVISION

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LOCKHEED AIRCRAFT CORPORATION

Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - Subsystem Test Schedule

1 Pioneer Visual Reconnaissance Payload
2 OTV Flight Tests'
3
4 Large Scale Reconnaissance Payload
5 PTV Flight Tests
6 OTV Flight Tests
7
8 Visual Surveillance Recon. Payload
9
10 A. Photo
11 Compatibility Prove-in with
12 Radioisotope APU
13 STV Flight Tests
14 PTV Flight Tests
15 OTV Flight Tests
16
17 B. Television
18 Compatibility Prove-in with
19 Nuclear APU
20 Environmental Test
21 Flight in Manned Aircraft
22 STV Flight Tests
23 PTV Flight Tests
24 OTV Flight Tests
25
26 C. Phototape
27 Environmental Test
28 Flight Test in Manned Aircraft
29 STV Flight Tests
30 PTV Flight Tests
31 OTV Flight Tests
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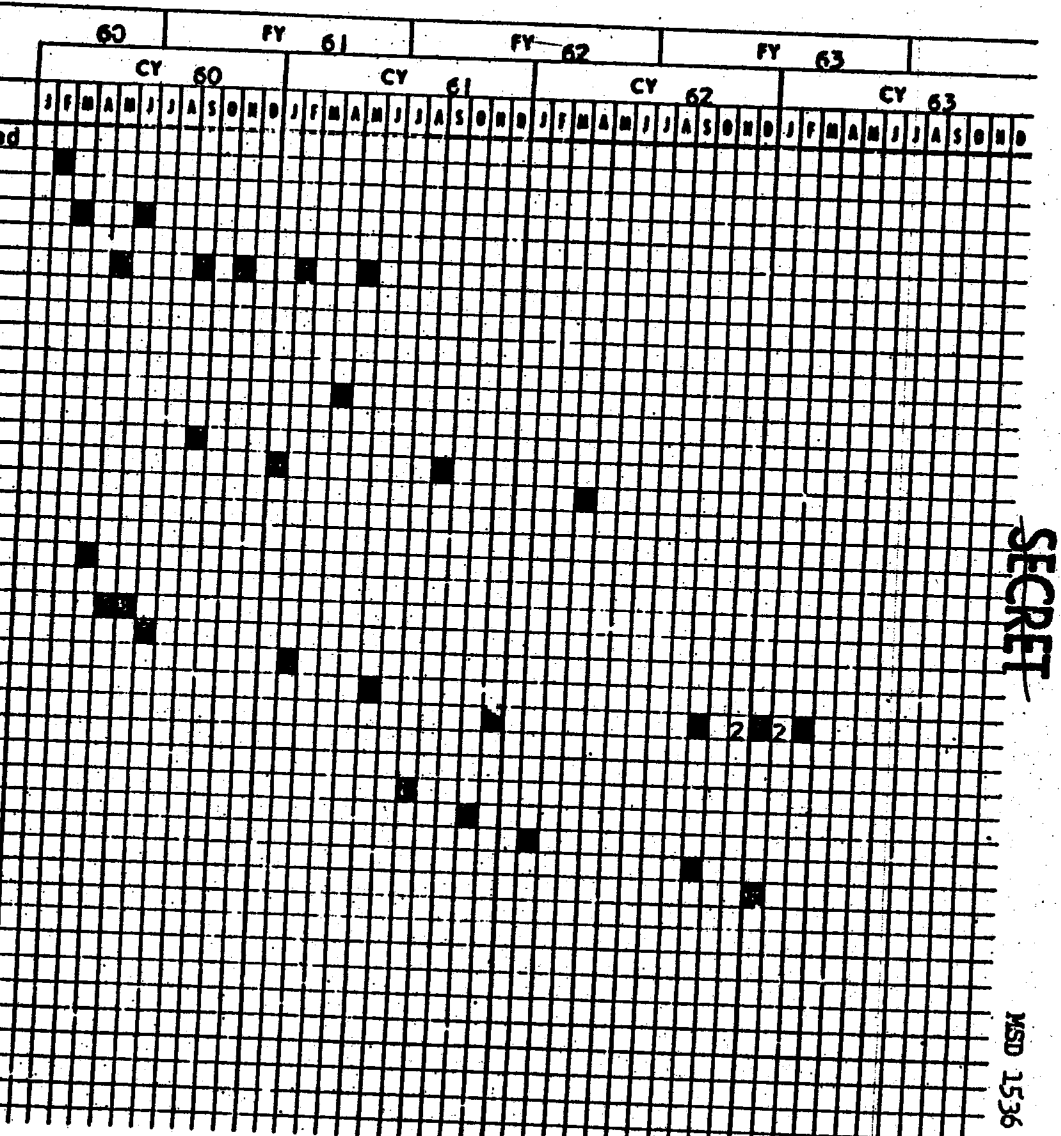

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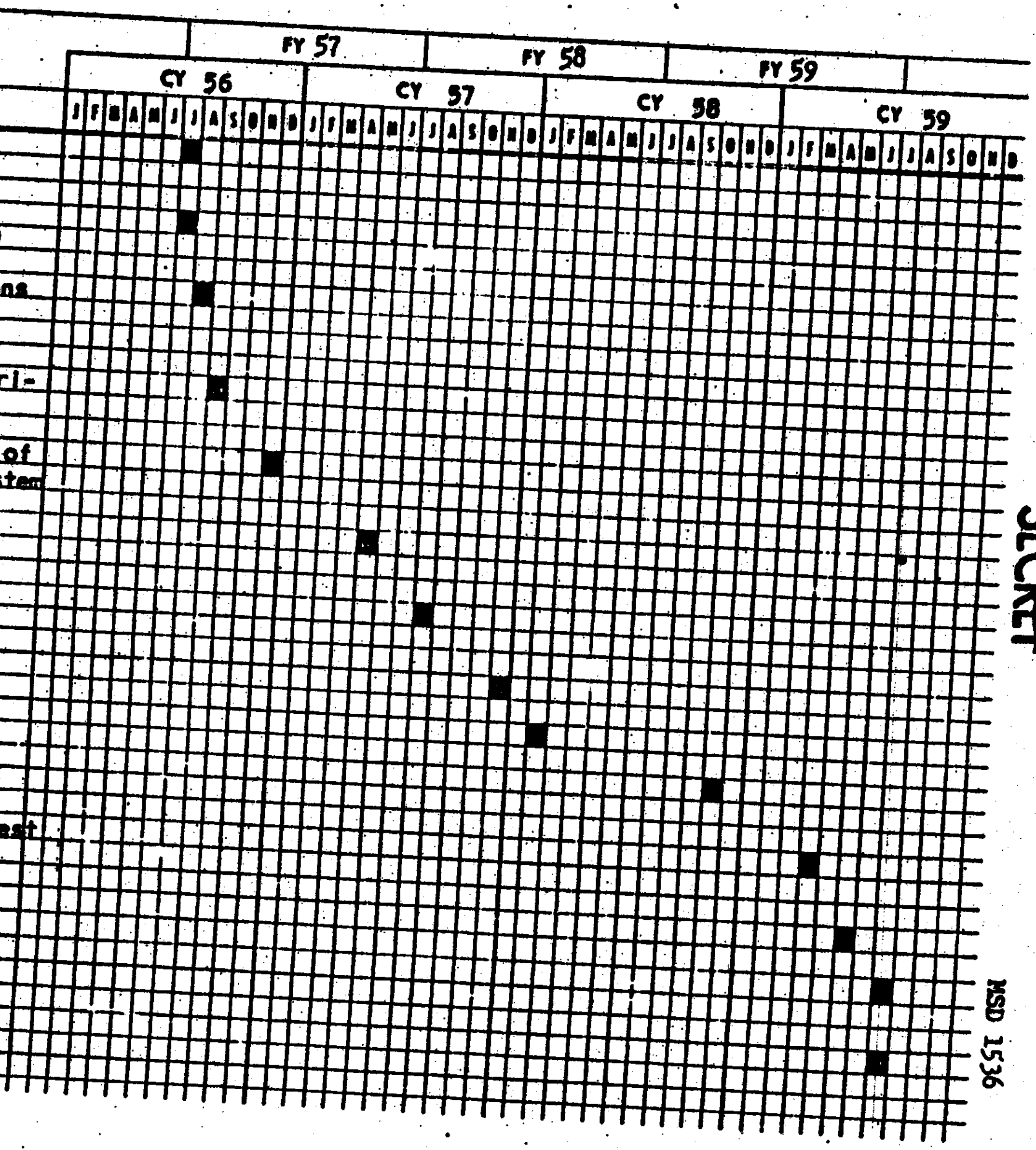
Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - R&D Schedule

System

1 System Engineering Begins
2 (Continuing Study)
3
4 Research and Development Begins
5 (Continuing Study for All Tasks)
6 Pioneer Visual Recon Payload:
7 Preparation of Design Specifications
8 for First Experimental Model of
9 Pioneer System
10
11 Design & Fabrication of first experi-
12 mental model of Pioneer System
13
14 Compatibility Prove-in (EKC & CBS) of
15 experimental model of Pioneer System
16
17 Delivery for Environmental Test
18 (Tiedown 1 and 2)
19
20 Flight Test in Manned Aircraft
21 of Pioneer System
22
23 STV Flight Test of Pioneer System
24
25 Redesign of Pioneer System for PTV
26
27 Fabrication of Pioneer System for
28 PTV and OTV (4)
29
30 Delivery of Pioneer System for PTV Test
31
32 Delivery of Reworked Pioneer System
33 for OTV #1
34
35 Redesign of Pioneer System for
36 Operational
37
38 Design & Fabrication of Large-Scale
39 Camera
40

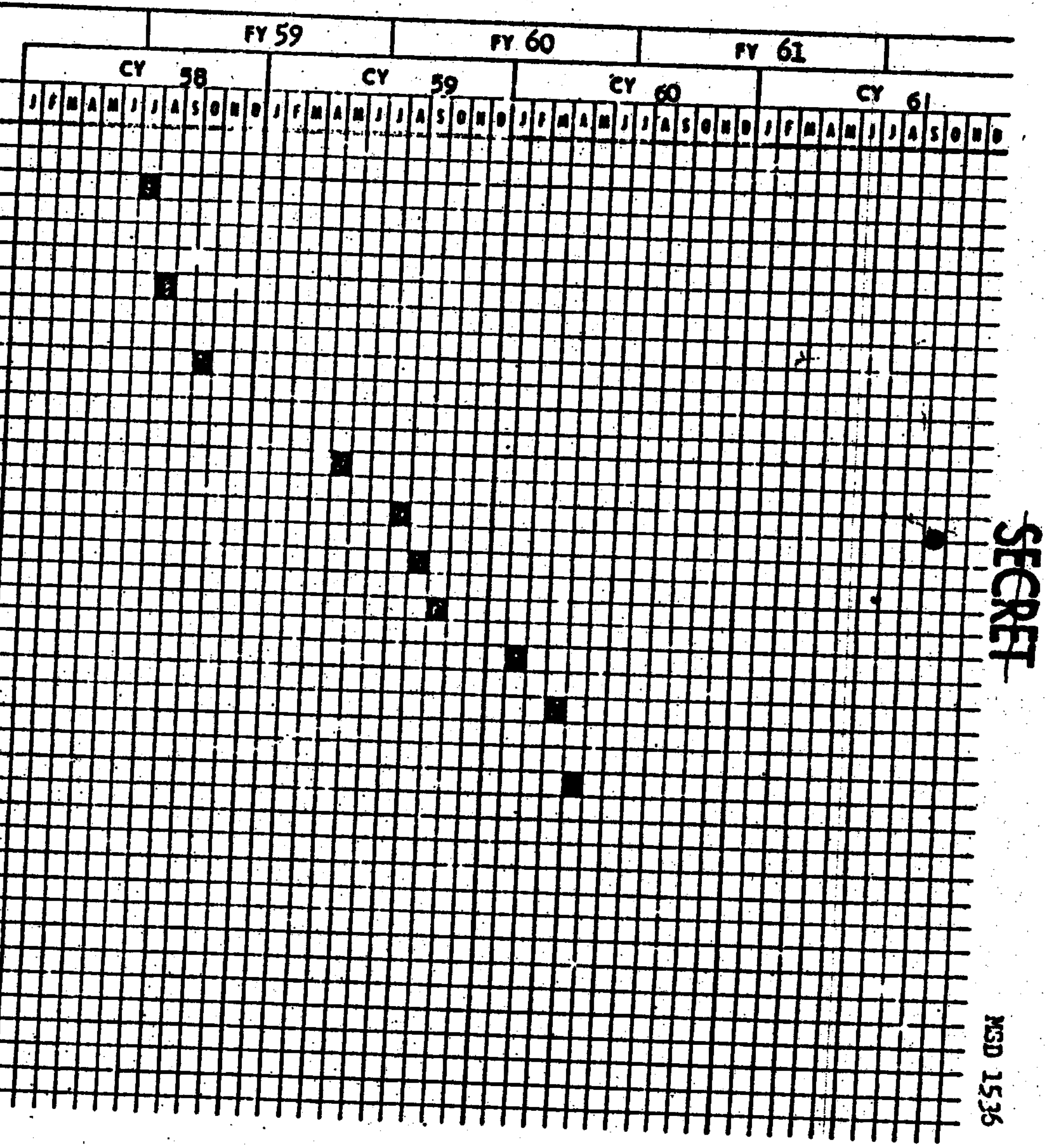


Revised Form 103

Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - R&D Schedule



Large-Scale Visual Recon Payload

Preparation of Design Specifications for first experimental model of Large-Scale System

Design & Fabrication of first experimental model of Large-Scale System

Compatibility Prove-in (EKC & CBS) of experimental model of Large-Scale System

Flight Test in Manned Aircraft

Delivery for STV Flight Test

Redesign for PTV

Fabrication for PTV & OTV (7)

Delivery for PTV Test

Delivery of Reworked Large-Scale System for OTV #1

Redesign of Pioneer System for Operational

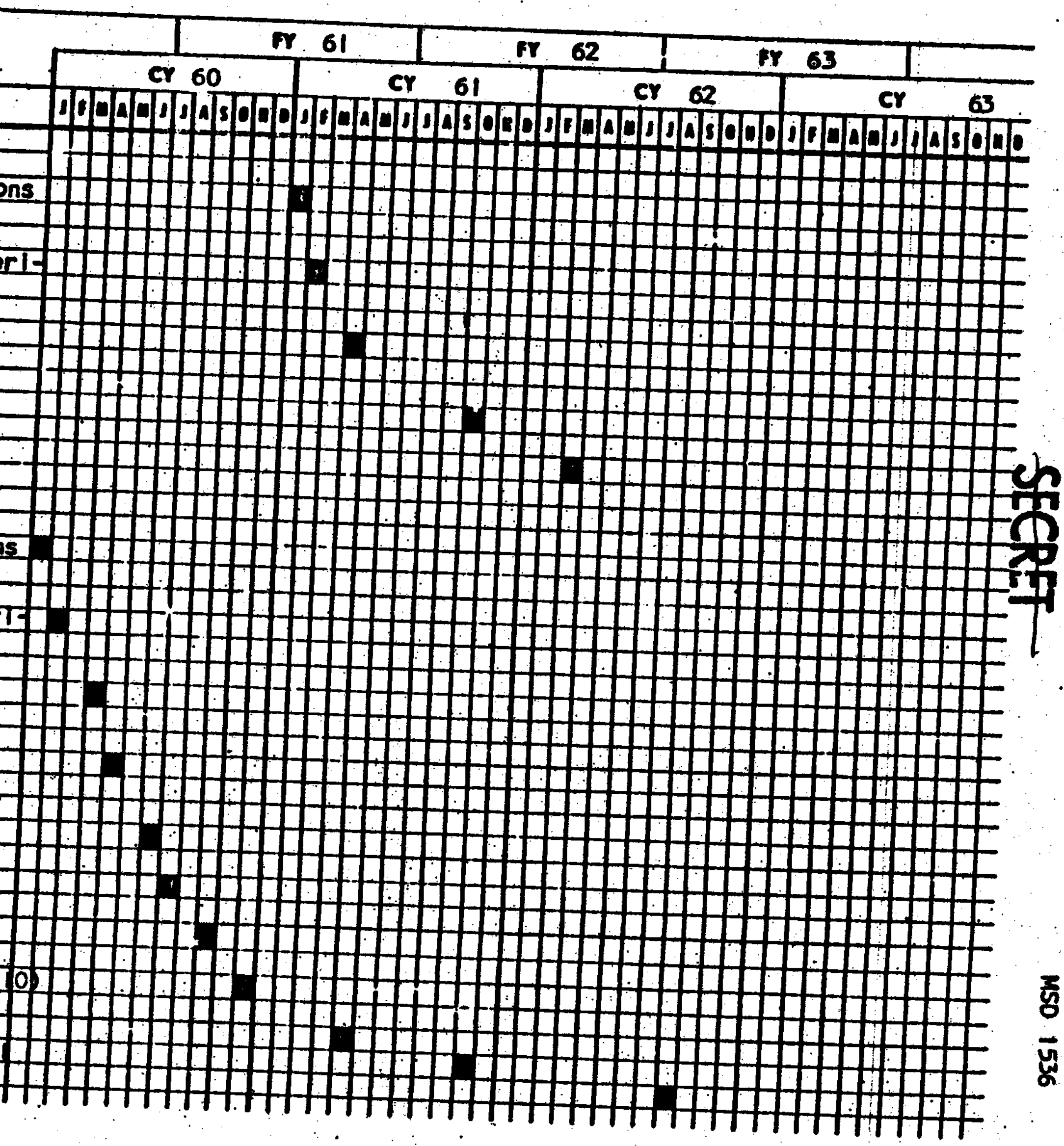
Revised Form 103

Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - R & D Schedule

Visual Surveillance Recon Payload
  (A) Photographic
Preparation of Design Specifications for first experimental model
Design & Fabrication of first experimental model
Compatibility Prove-in with Radioisotope APU
Fabrication for PTV
Delivery for PTV Test
  (B) Television
Preparation of Design Specifications for first experimental model
Design & Fabrication of first experimental model
Compatibility Prove-in with Nuclear APU
Delivery for Environmental Test (Tiedown 1 and 2)
Flight Test in Manned Aircraft
Delivery for STV Flight Test
Redesign for PTV
Fabrication of System for PTV & OTV(10)
Delivery for PTV
Delivery of Reworked System for OTV #
Redesign for Operational



Revised Form 103

Subsystem E - VISUAL RECONNAISSANCE

Tab 2

Summary - R&D Schedule

Phototape

Preparation of Design Specifications

Design & Fabrication of first experimental model

Delivery for Environmental Test (Tiedown 1 and 2)

Flight Test in Manned Aircraft

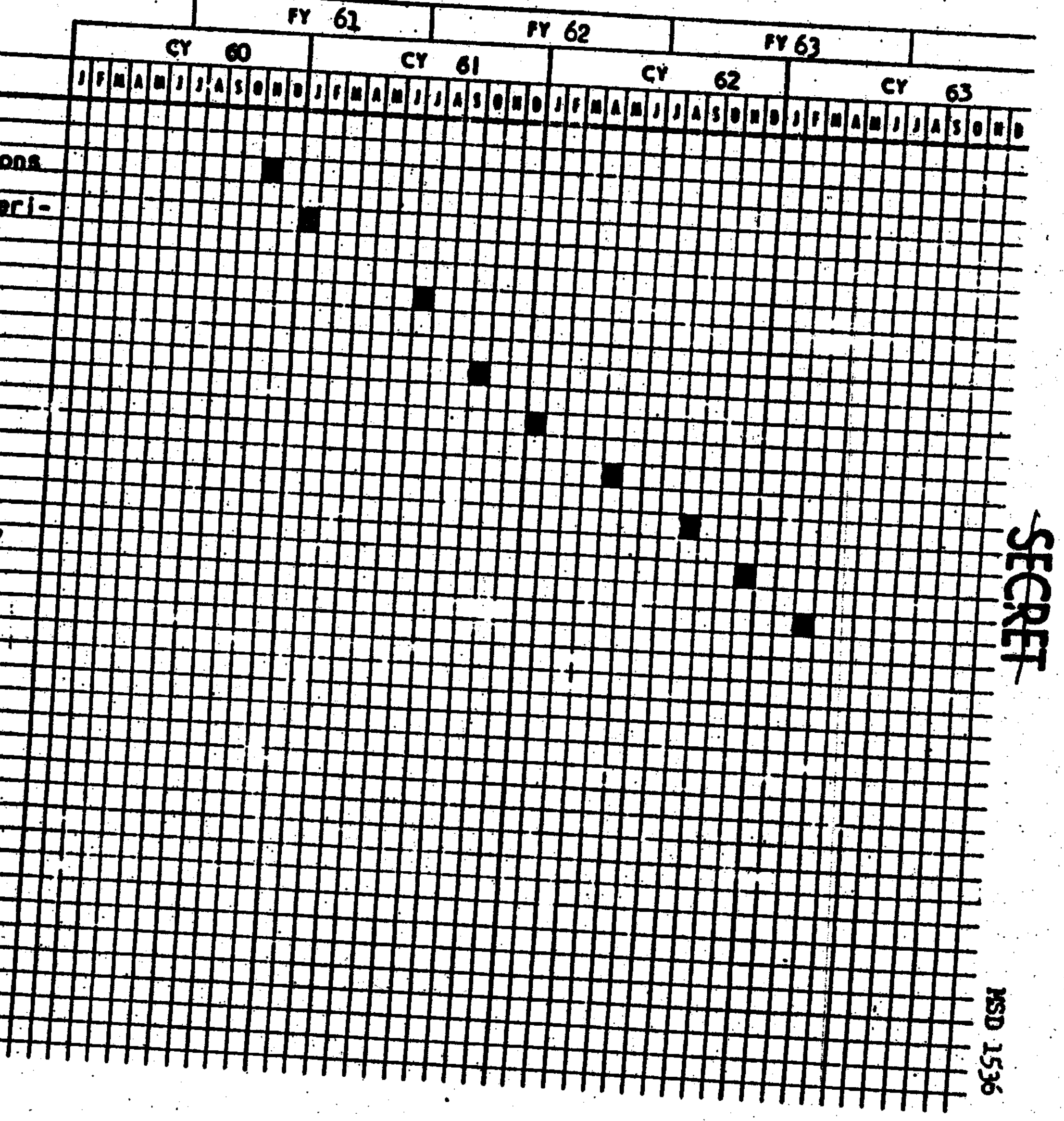
Delivery for STV Test

Redesign for PTV

Delivery for PTV test

Delivery of Reworked System for OTV

Redesign for Operational



Revised Form 103

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MSD 1536

1.

R & D TEST ANNEX

☐ SYSTEM ☑ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE | OF | PAGES

3. DATE 1 Mar. 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
1	Pioneer Visual Recon TV-Film Readout System	STV Flight Test Using Fixed Transmitting Antenna	AFMTC	Dec 1957	Feb 1958
2	Pioneer Visual Recon Photographic Processor	STV Flight Test Using Fixed Transmitting Antenna	AFMTC	Feb 1958	Mar 1958
3	Pioneer Visual Recon Payload	STV Flight Test Using Fixed Transmitting Antenna	AFMTC	Apr 1958	Jun 1958
4	Pioneer Visual Recon System (Model I)	1st STV Flight Test of Complete System Using Portional Antenna	AFMTC	Jun 1958	Aug 1958
5	Pioneer Visual Recon System (Model I)	2nd STV Flight Test	AFMTC	Jul 1958	Sep 1958

TEST CENTER APPROVAL

20. NAME | ORGANIZATION

21. NAME | ORGANIZATION | DATE

22. NAME | ORGANIZATION | DATE

RESPONSIBLE CENTER APPROVAL

NAME | ORGANIZATION | DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

MISSILE SYSTEMS DIVISION

~~SECRET~~

LOCKHEED AIRCRAFT CORPORATION

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 2 OF PAGES

3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
6	Pioneer Visual Recon System (Model 1 - Mod 1)	1st STV Flight Test	AFMTC	Aug 1958	Oct 1958
7	Pioneer Visual Recon System (Model 1 - Mod. 1)	2nd STV Flight Test	AFMTC	Sep 1958	Nov 1958
8	Pioneer Visual Recon System (Model 2)	1st STV Flight Test	AFMTC	Feb 1959	Apr 1959
9	Pioneer Visual Recon System (Model 2)	1st PTV Flight Test	AFMTC	Apr 1959	Jun 1959
10	Pioneer Visual Recon System (Model 2)	1st OTV Flight Tast	GFF *	Jun 1959	**
11	Pioneer Visual Recon System	2nd OTV Flight Test	GFF *	Aug 1959	**

* To be determined at a later date.

** For useful life of vehicle and payload

TEST CENTER APPROVAL

20. NAME

ORGANIZATION

21. NAME

ORGANIZATION

DATE

RESPONSIBLE CENTER APPROVAL

22. NAME

ORGANIZATION

DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 4 OF PAGES

3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RDD TEST COMPL DATE
18	Large Scale Visual Recon. System (One Camera)	1st OTV Flight Test	GFF *	April 1960	**
19	Large Scale Visual Recon. (Four Camera System)(Model I)	1st PTV Flight Test Plus Test of High Performance Booster	AFMTC	March 1960	July 1960
20	Large Scale Visual Recon. System (Model I)	1st OTV Flight Test	GFF *	Aug. 1960	**
21	Large Scale Visual Recon. System (Model I)	2nd OTV Flight Test	GFF *	Oct. 1960	**
22	Large Scale Visual Recon. System (Model I)	3rd OTV Flight Test	GFF *	Jan. 1960	**
23	Large Scale Visual Recon. System (Model I)	4th OTV Flight Test	GFF *	April 1960	**

* To be determined at a later date.

** For useful life of vehicle and payload.

TEST CENTER APPROVAL

20. NAME ORGANIZATION

21. NAME ORGANIZATION DATE

DATE

RESPONSIBLE CENTER APPROVAL

22. NAME ORGANIZATION

DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 3 OF PAGES

3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
12	Pioneer Visual Recon. System (Model 2)	3rd OTV Flight Test	GFF *	Oct. 1959	##
13	Pioneer Visual Recon. System (Model 2)	4th OTV Flight Test	GFF *	Dec. 1959	##
14	Pioneer Visual Recon. System (Model 2)	5th OTV Flight Test	GFF *	Jan. 1960	##
15	Large Scale Recon. Camera	1st STV Flight Test of Long Focal Length Camera	AFMTC	Aug. 1959	Oct. 1959
16	Large Scale Visual Recon. System (Model 1)	1st STV Flight Test	AFMTC	Oct. 1959	Dec. 1959
17	Large Scale Visual Recon. System (One Camera)	1st PTV Flight Test of Payload Plus Test of High Performance Booster	AFMTC	Feb. 1960	April 1960

* To be determined at a later date.

\## For useful life of vehicle and payload.

TEST CENTER APPROVAL

20. NAME ORGANIZATION

21. NAME ORGANIZATION DATE

RESPONSIBLE CENTER APPROVAL

22. NAME ORGANIZATION DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 5 OF PAGES

3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys. or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
24	Visual Surveillance Photo. Recon. System	1st STV Flight Test	AFMTC	Aug. 1961	Oct. 1961
25	Visual Surveillance Photo. Recon. System	1st PTV Flight Test of Payload and Bola Configuration Test	AFMTC	Dec. 1960	Feb. 1961
26	Visual Surveillance Photo. Recon, System	1st PTV Flight Test of Bola Configuration with Nuclear APU	AFMTC	Aug. 1961	Oct. 1961
27	Visual Surveillance Photo. Recon. System	1st OTV Flight Test of Photo. Payload with Radioisotope APU	GFF *	March 1962	**
28	Visual Surveillance Television Payload	Compatibility Test with Nuclear APU	AFMTC	March 1960	May 1960
29	Visual Surveillance Television Payload (Model I)	1st STV Flight Test	AFMTC	Jan. 1961	March 1961

* To be determined at a later date.

** For useful life of vehicle and payload.

TEST CENTER APPROVAL

20. NAME ORGANIZATION

21. NAME ORGANIZATION DATE

RESPONSIBLE CENTER APPROVAL

22. NAME ORGANIZATION DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

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3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
30	Visual Surveillance Television Payload (Model I)	1st PTV Flight Test	AFMTC	May 1961	July 1961
31	Visual Surveillance Television Payload (Model I)	1st OTV Flight Test with Nuclear APU	GFF *	Nov. 1961	**
32	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Sept. 1962	**
33	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Nov. 1962	**
34	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Nov. 1962	**

* To be determined at a later date.

** For useful life of vehicle and payload.

TEST CENTER APPROVAL

20. NAME ORGANIZATION DATE

21. NAME ORGANIZATION DATE

RESPONSIBLE CENTER APPROVAL

22. NAME ORGANIZATION DATE

ARDC FORM 1 JUL 56 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 7 OF PAGES

3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RDD TEST COMPL DATE
35	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Dec. 1962	**
36	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Jen. 1963	**
37	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Jan. 1963	**
38	Visual Surveillance Television Payload (Model I)	Test of Operational Prototype and Test of Inter-satellite Type System	GFF *	Feb. 1963	**

* To be determined at a later date.

** For useful life of vehicle and payload.

TEST CENTER APPROVAL

20. NAME ORGANIZATION

21. NAME ORGANIZATION DATE

RESPONSIBLE CENTER APPROVAL

22. NAME ORGANIZATION DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

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MSD 1536

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

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3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
39	Phototape Visual Surveillance Recon. Payload	1st STV Flight Test	AFMTC	Jan. 1962	March 1962
40	Phototape Visual Surveillance Recon. Payload	1st PTV Flight Test	AFMTC	Sept. 1962	Nov. 1962
41	Phototape Visual Surveillance Recon. Payload	1st OTV Flight Test	GFF *	Dec. 1962	**
42	Pioneer Visual Recon. Payload	Tests in Captive Test Vehicle	LAC MSD Sunnyvale	May 1957	June 1957
43	Pioneer Visual Recon. Payload	Flight Test in Manned Aircraft	LAC MSD Sunnyvale	July 1957	Dec. 1957
44	Large Scale Recon. Payload	Flight Tests in Manned Aircraft	LAC MSD Sunnyvale	April 1959	Aug. 1959

* To be determined at a later date.

** For useful life of vehicle and payload.

TEST CENTER APPROVAL

20. NAME

ORGANIZATION

21. NAME

ORGANIZATION

DATE

RESPONSIBLE CENTER APPROVAL

22. NAME

ORGANIZATION

DATE

ARDC FORM 1 JUL 56 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

MISSILE SYSTEMS DIVISION

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E-Tab 3, p 8

LOCKHEED AIRCRAFT CORPORATION

1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 9 OF PAGES

3. DATE 1 Mar 56

4. TITLE E - VISUAL RECONNIASSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
45	Visual Surveillance Photo. Recon. Payload	Compatibility Test with Radioisotope APU	LAC MSD. Sunnyvale	March 1961	March 1962
46	Visual Surveillance Television Payload	Environmental Test in Captive Test Vehicle	LAC MSD Sunnyvale	April 1960	June 1960
47	Visual Surveillance Television Payload (Model I)	Flight Test in Manned Aircraft	LAC MSD Sunnyvale	June 1960	Aug. 1960
48	Phototape Payload	Environmental Test in Captive Test Vehicle	LAC MSD Sunnyvale	July 1961	Dec. 1961
49	Phototape Visual Surveillance Recon. Payload	Flight Test in Manned Aircraft	LAC MSD Sunnyvale	Oct. 1961	Dec. 1961

TEST CENTER APPROVAL

20. NAME

ORGANIZATION

21. NAME

ORGANIZATION

DATE

DATE

RESPONSIBLE CENTER APPROVAL

22. NAME

ORGANIZATION

DATE

ARDC FORM 1 JUL 55 105 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

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MSD 1536

1\. **R & D TEST AND TEST SUPPORT AIRCRAFT ANNEX**

☐ SYSTEM ☐ PROJECT ☐ TASK ☐ OTHER

2\. REPORTS CONTROL SYMBOL

PAGE 1 OF 1 PAGES

3\. DATE 1 Mar 56

4\. TITLE Subsystem E - VISUAL RECONNAISSANCE

5\. INITIAL ☒ CHANGE

6\. NUMBER

7. ITEM NUMBER	8. AIRCRAFT REQUIRED QTY	TYPE, MODEL AND SERIES	SERIAL NUMBER	9. ASG CODE	10. MOD REQD	11. DATE REQD AND LOCATION	12. ESTIMATED RELEASE DATE	13. RECOMMENDED DISPOSITION	14. F HRS F CST	15. EST COST
1	1	B-50*								

The Aircraft for Visual Reconnaissance Subsystem is the same as that request in Subsystem H - Vehicle Electronics

* The extent of modification required is not known now, but will be indicated in the bailment agreement.

ARDC FORM 1 JUL 55 106 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

1.

R & D MATERIEL ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 1 OF 1 PAGES

3. DATE 1 March 1956

4. TITLE

Subsystem E - VISUAL RECONNAISSANCE

5. INITIAL ☒ CHANGE

6. NUMBER

7. MATERIEL REQUIREMENTS (Indicate Items in Columnar Form using Columns as cited in Examples)

R & D material requirements are listed as part of Tab 5 - Subsystem J - Vehicle Intercept and Control Ground Station. Other specialized equipment will be listed at a later date.

ARDC FORM 1 JUL 53 107 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

SUBSYSTEM E - VISUAL RECONNAISSANCE

DATE 1 March 1956

LOCATION:

ITEM: SYSTEM TEST FACILITY*, INTERCEPT, CONTROL AND DATA ACQUISITION STATION * AFMTC *

BUDGET CONTROL ESTIMATE:

USING AGENCY: LOCKHEED MSD, CBS LABORATORIES
EASTMAN KODAK CO.

NEED DATE:

SCHEDULE:	1956						1957												1958												1959											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D

DESCRIPTION AND UTILIZATION:

* Complete description of these facilities are given in Tab 6 - Subsystem L - Vehicle Ground Support

REMARKS:

Revised Form 108

Tab 7

R & D Contract Funds

Subsystem E - Visual Reconnaissance

SECRET

Subsystem E. VISUAL RECONNAISSANCE

Tab 7. R & D Contract Funds (in thousands of dollars) (Cont'd)

	FY 60		FY 61	FY 61 FY 62 FY 63
	15	16	17	[redacted]
LAC				
(1) Research and Engineering	725	695	[redacted]	
EASTMAN KODAK	269	269	269	[redacted]
CBS	869	674	[redacted]	
Sub Total	1863	1638	[redacted]	
Fee	186	164	[redacted]	
Totals*	2049	1802	[redacted]	
Total Fiscal Year		8033		[redacted]
*Difference in totals due to rounding				

Subsystem H. VISUAL RECONNAISSANCE

Tab 7. R & D Contract Funds (in thousands of dollars)

	FY 57				FY 58				FY 59				FY 60		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTALS
LAC															
(1) Research and Engineering	56	71	79	121	158	221	270	337	408	469	534	588	638	588	11,318
EASTMAN KODAK	53	79	159	234	344	370	370	370	370	370	370	327	305	294	6,439
CBS	163	224	273	367	534	709	872	983	1109	1126	1169	1139	979	997	22,067
Sub Total	272	374	541	721	1036	1299	1512	1690	1888	1966	2073	2054	1922	1879	39,824
Fee	27	37	54	72	104	130	151	169	189	197	207	205	192	188	1,982
TOTALS	299	412	595	793	1140	1429	1664	1860	2077	2163	2280	2259	2115	2067	41,806
Total Fiscal Year				2099				6093				8779			43,806

*Difference in totals due to rounding

E-Tab 7, p 3

Tab 8

Estimate of Manpower Requirements

Subsystem E - Visual Reconnaissance

Subsystem E. VISUAL RECONNAISSANCE

Tab 8. Estimate of Manpower Requirements

WORK ITEM	Type of Manpower	QUARTERS													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
LAC Research and Engineering	1-2-3*	11	14	15	23	30	42	53	66	80	92	107	118	128	139
LAC Fabrication and Assembly	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub Total		11	14	15	23	30	42	53	66	80	92	107	118	128	139
CBS Scientific and Engineering	1	7	10	12	16	23	30	37	42	44	41	42	44	36	33
CBS Engineering Support	2	15	21	27	36	48	63	75	84	90	94	96	90	74	67
CBS Manufacturing	4	11	14	16	22	30	41	53	60	66	70	75	72	68	63
Sub Total		33	45	55	74	101	134	165	186	200	205	213	206	178	163
EK Scientific and Technical	1	4	5	11	11	16	28	28	28	28	28	28	28	28	28
EK Engineering Support	2	2	4	11	14	20	16	16	16	16	16	16	16	17	17
EK Shop and Fabrication	4	4	6	14	19	30	28	28	26	28	28	28	20	15	13
Sub Total		10	15	36	44	66	72	72	72	72	72	72	64	60	58
TOTAL		54	74	106	141	197	248	290	324	352	369	392	388	366	359
* Average															
40% Type 1 Scientific & Technical															
50% Type 2 Engineering Support															
10% Type 3 Management & Administration															

Subsystem E. VISUAL RECONNAISSANCE

Tab 8. Estimate of Manpower Requirements (Cont'd)

WORK ITEM	Type of Manpower	QUARTERS														Total Man Quarters
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	
LAC Research and Engineering	1-2-3*	145	139	139	126	120	107	89	86	86	74	74	74	74		2251
LAC Fabrication and Assembly	4	-	-	-	-	-	-	-	-	-	-	-	-	-		
Sub Total		145	139	139	126	120	107	89	86	86	74	74	74	74		2251
CBS Scientific and Engineering	1	32	24	28	32	32	32	32	32	32	32	32	32	32		521
CBS Engineering Support	2	63	49	56	66	66	66	66	66	66	66	66	66	66		1703
CBS Manufacturing	4	63	50	60	70	70	70	70	70	70	70	70	70	70		1534
Sub Total		158	123	144	168	168	168	168	168	168	168	168	168	168		4063
IX Scientific and Technical	1	28	28	28	28	28	28	15	13	12	10	6	2	2		527
IX Engineering Support	2	17	17	17	17	17	15	15	15	12	10	6	2	2		155
IX Shop and Fabrication	4	13	13	13	13	13	13	10	12	10	8	8	8	8		431
Sub Total		58	58	58	58	58	56	40	40	34	28	20	12	12		1317
TOTAL		361	320	341	352	346	331	297	294	288	270	262	254	254		[illegible]
* Average																
40% Type 1 Scientific & Technical																
50% Type 2 Engineering Support																
10% Type 3 Management & Administration																

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Pied Piper

MSD 1536

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

APPENDIX

~~SECRET~~

SUBSYSTEM E - VISUAL RECONNAISSANCE
APPENDIX I

TABLE I

Focal Length (in.)	Lens-Film Resolution (lines/mm)	Ground Coverage/Camera Chain		Ground Resolution
		Angle	Width (miles)	
6	100	19.0°	100	100 ft
18	100	6.3°	33	33 ft
24	100	4.8°	25	25 ft

TABLE II

Duration	Ground Coverage Miles of Width/Camera Chain	Ground Resolution (ft.)	Film Capacity	
			(ft)	(lb)
1 Month	100	100	600	3.3
	33	33	1,800	9.7
	25	25	2,400	13.0
1 Year	100	100	7,200	39.0
	33	33	18,600	100.0
	25	25	24,800	134.0

SUBSYSTEM E

VISUAL RECONNAISSANCE

APPENDIX II

VISUAL RECONNAISSANCE DATA LINK

Earlier subsystem proposals for the visual data link called for a servo-receiver in the vehicle to lock in with a 10,000 mc ground transmitter. Its purpose was to provide signals for orienting the visual transmitting antenna. A high signal-to-noise ratio in the visual link combined with the use of FM for video modulation makes it possible to obviate the airborne servo-receiver at the cost of some additional ground equipment. A method for accomplishing this is described.

TRANSMITTER

The data link for visual reconnaissance will be essentially similar to the ferret data link except that in order to realize the required range and video band width, the vehicle and ground antennas must be high gain and the vehicle antenna must perform a tracking function. The Visual Data Link will be at a frequency of 7.5 kmc.

The minimum usable signal, S_{min}, is given by

$$S_{min} = \frac{S}{N} \overline{KT} \, \overline{NF} \beta$$

$$S_{min} = 55 \text{ dbm}$$

where

S/N = 40 db = minimum signal to noise ratio (power)

KT = -204 db w/cycle

NF = 9 db

β = 10 mc - 70 db cycles

The Electronics Components Laboratory (Wright - Patterson Field) has issued a purchase request (PR 3608) for an ARS klystron having the following characteristics suitable for this requirement:

Klystron Characteristics (PR 3608)

Power Output	10w
Frequency	7.45 - 7.70 kmc
FM	Linear
Life, efficiency, etc.	Suitable for ARS

It is expected that this klystron will be available. Although magnetrons are generally inferior to klystrons from the point of view of life expectancy, other tube types, such as interdigital TWT's (M-type Carcinotrons) have indicated such desirable characteristics as long life and efficiency comparable to a magnetron (30%) and good fm linearity. These tubes may be operated with permanent, lightweight magnet assemblies, in lieu of the klystron, and will be investigated as possible alternate transmitting tubes.

The transmitter, then, will consist of a modulator, transmitting tube, and power supply, as shown in Fig. II-1. Approximately 100 volts are required to modulate the transmitting tube, and the total power consumption will be in the order of 100 watts.

The parabolic antenna (of the vehicle) will have a 1.7 ft radius with a gain of 35 db. To assure ground tracking, it will be conically scanned at a 30 cycle rate.

The ground terminus of this link is described in Subsystem J Vehicle Intercept and Control Ground Station.

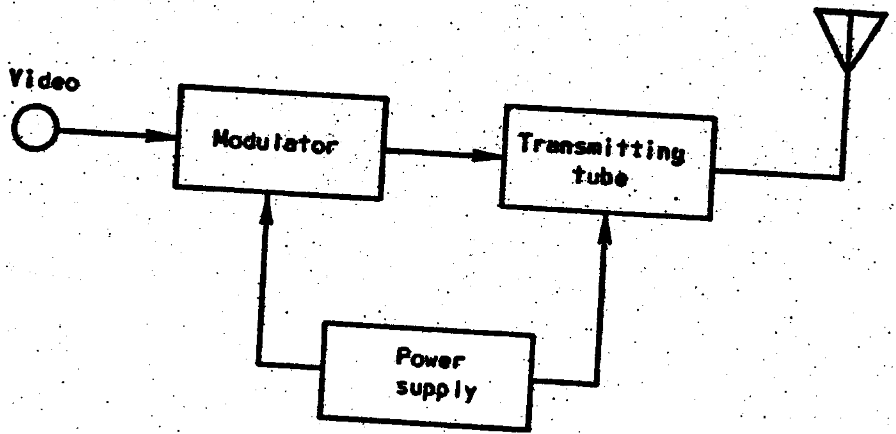

Fig. II-1 Visual Reconnaissance Transmitter

Calculating the necessary transmitted power to complete this link, we have:

$$P_T = \frac{P_r \; (4\pi)^2 \; R^2}{G_R \; G_T \; (\lambda)^2 \; L}$$

P_r = Receiver Usable Signal = -85 dbw

R = 1400 mi

G_r = Receiver Antenna Gain = 50 db

G_T = Transmitter Antenna Gain = 35 db

λ = 4 cm

L = Transmission Loss Coeff. = 3 db

SUBSYSTEM E

VISUAL RECONNAISSANCE

APPENDIX III

COMPARISON TEST OF O^1 FILM-ELECTRONIC AND IMAGE ORTHICON ADVANCED RECONNAISSANCE SYSTEMS

The O^1 Film-Electronic Advanced Reconnaissance System, and the Image Orthicon-Magnetic Tape Recorder System have been simulated for comparison in the laboratory. Photographs were taken to represent the picture quality and resolution at equivalent places in each system.

The photographs show clearly that the O^1 Film-Electronic System can produce useful picture quality and detail. Furthermore, comparison of the photographs representing the final picture through each system shows that the quality and detail of the Film-Electronic System can be equal to, or better than, that of the Image Orthicon-Magnetic Tape Recorder System.

The Film-Electronic System by-passes the tape recorder, and the limited useful life of the Image Orthicon, and thereby greatly enhances the possibility of achieving the desired objective of creating a useful satellite reconnaissance vehicle capable of being launched in the near future.

Fig. E-1

IMAGE ORTHICON, 38" LENS

Kinescope Display of Direct Pickup

Without Magnetic Tape Storage

Actual Negative Size

Fig. E-2 EASTMAN F5740-6 FILM (Microfile Type), 6" LENS

50X Enlargement of Image

Stored by Vehicle Camera

Fig. E-3

IMAGE ORTHICON, 38" LENS.

Delayed Transmission With Simulated Magnetic Tape Storage

(Kinescope Display at Ground Receiving Station)

Fig. E-4 EASTMAN F5740-6 FILM (Microfile Type), 6" LENS

Delayed Transmission Using Flying Spot Film Scanner

(Kinescope Display at Ground Receiving Station)

Actual Negative Size

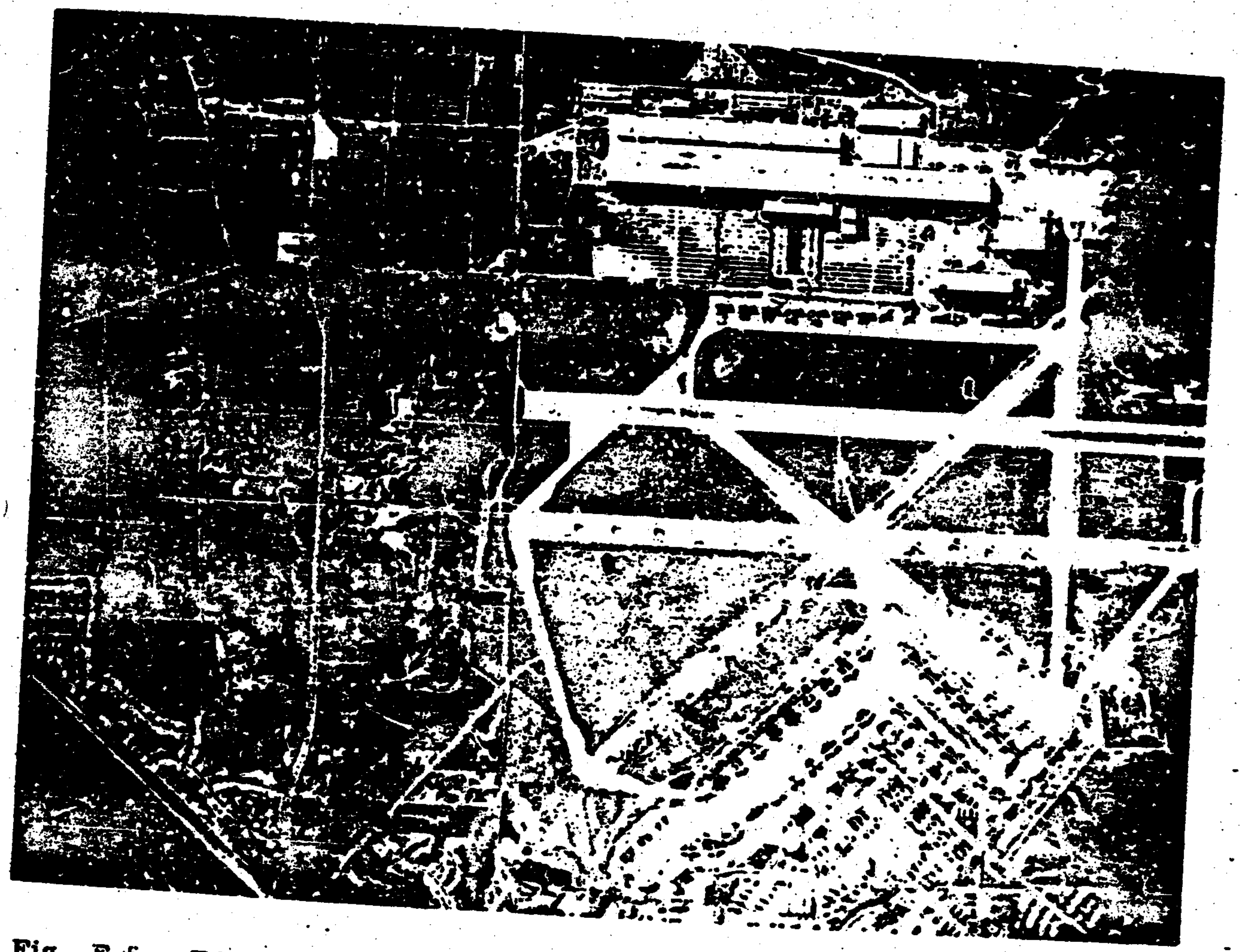

Fig. E-5 EASTMAN F5740-6 FILM (Microfile Type), 18" LENS

50X Enlargement of Image

Stored by Vehicle Camera

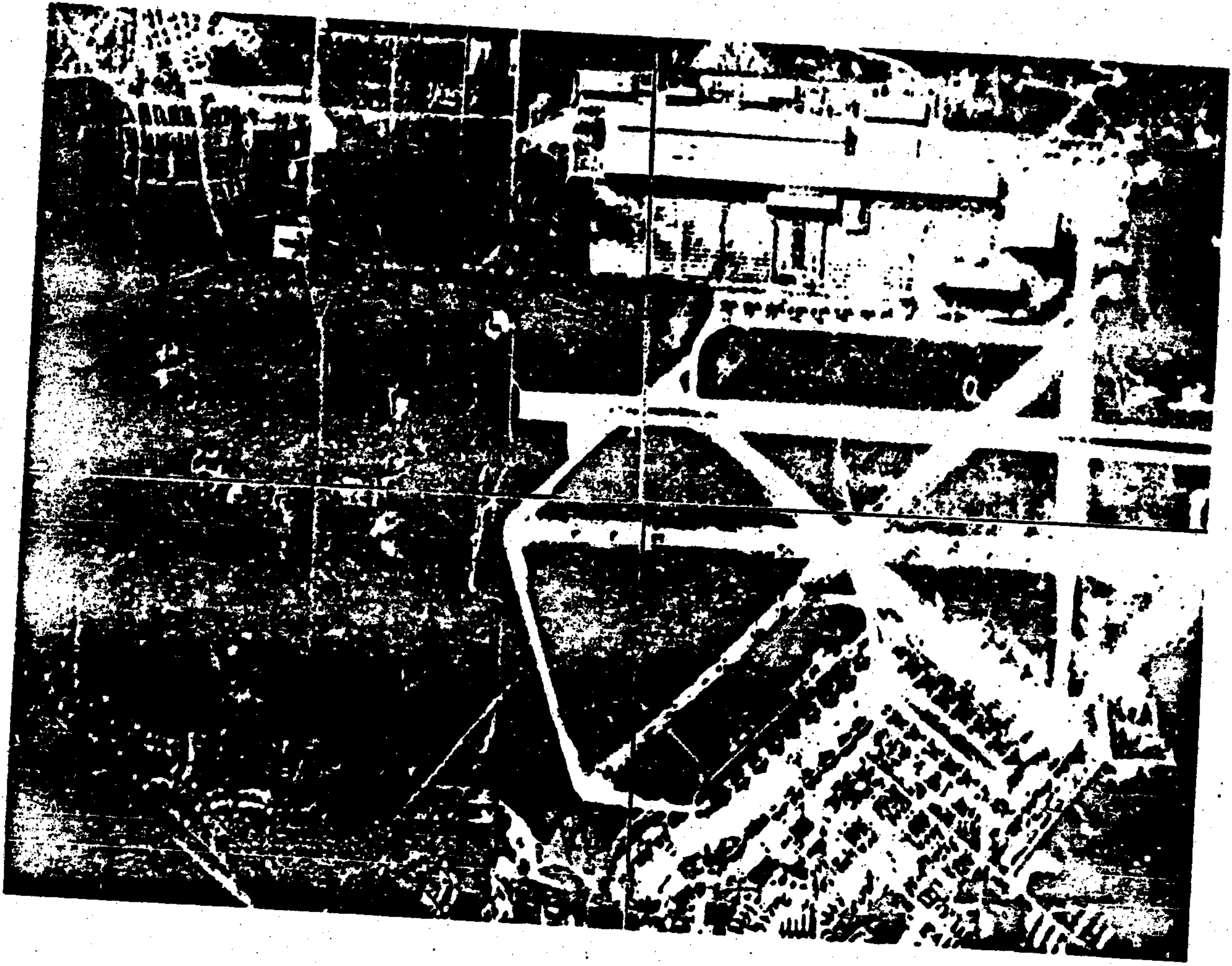

Fig. E-6 EASTMAN F5740-6 FILM (Microfile Type), 18" LENS

Delayed Transmission Using Flying Spot Film Scanner

(Kinescope Display at Ground Receiving Station)

Fig. E-7

Print of Aerial Photograph

Used as Original Scene

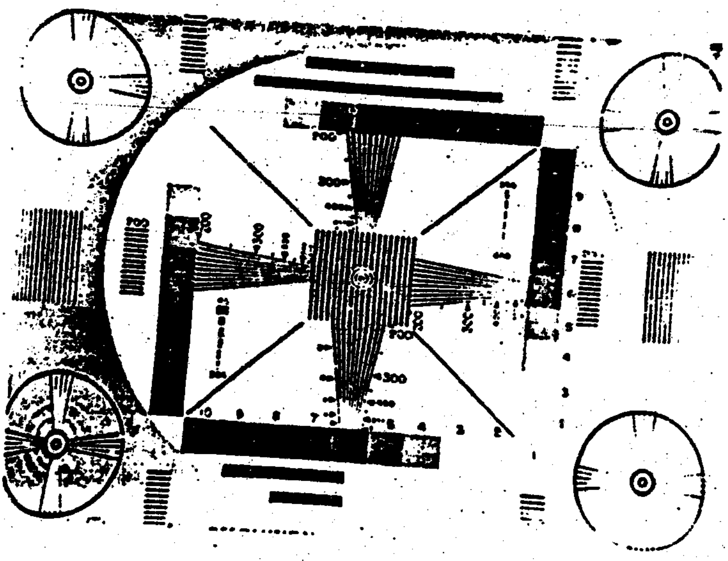

Fig. E-8A IMAGE ORTHICON - RETMA RESOLUTION CHART

Kinescope Display of Direct Pickup Without Magnetic Tape Storage

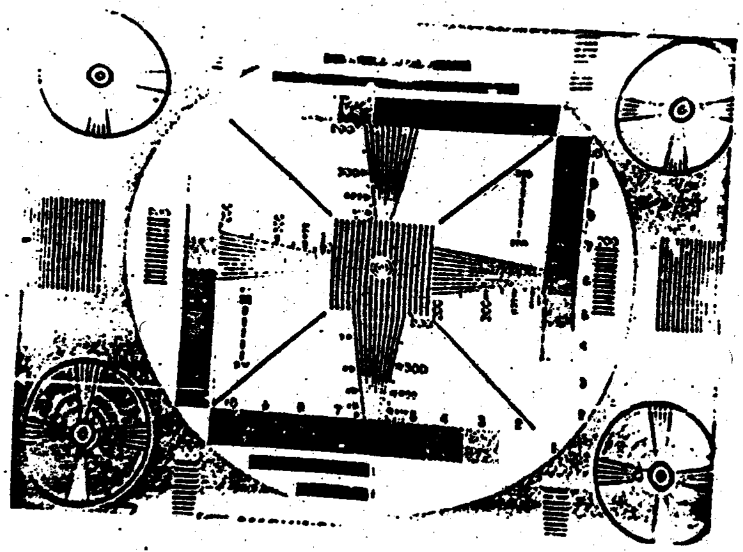

Fig. E-8B IMAGE ORTHICON - RETMA RESOLUTION CHART

Kinescope Display With Simulated Magnetic Tape Storage

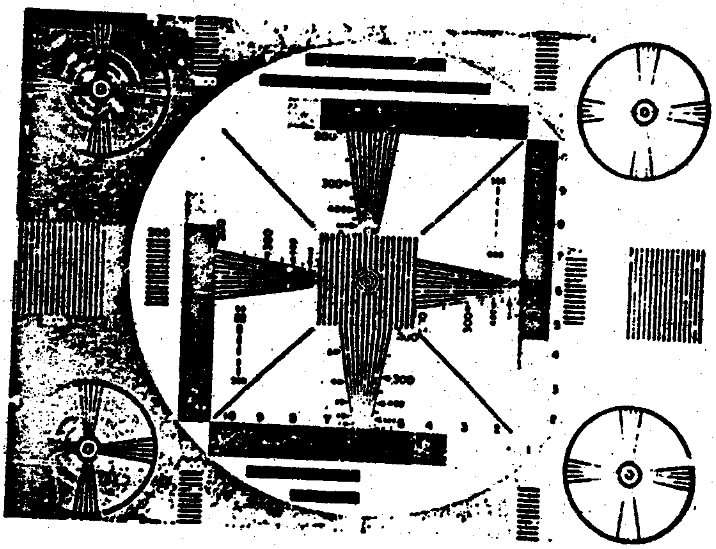

Fig. E-9

FLYING SPOT FILM SCANNER

Kinescope Display of RETMA Resolution Chart on 35 mm. Slide

Fig. E-10

FLYING SPOT FILM SCANNER

Kinescope Display of Pickup

From 35 mm. Slide

1. BACKGROUND

Pioneer visual reconnaissance systems assume the use of present "state-of-the-art" techniques to permit early attainability. Refinements and heretofore undeveloped methods are reserved for later, surveillance type, applications.

With these aims as a guide, a review of available and proposed systems was made. The most serious problem encountered was that of recording visual data at wide band widths. Present day video recording techniques on a reusable material, such as magnetic tape, appear to require extensive development before successful application to the ARS would be possible.

Another important problem encountered was the limited useful life of the Image Orthicon Camera tube. Signal currents carried deteriorate the glass target and the resulting changes in target resistivity cause a latent image to remain (known as "sticking") in a frame time by leakage through the glass. The tendency to stick increases with tube life and statistics show that in 90% of the cases "sticking" limits the useful tube life to less than 1000 hours. Sticking eventually becomes intolerable for both the wide-spaced target types, like the 5820, and the close-spaced types, like the 1854. The close-spaced types have an advantage in that they are capable of a slightly higher resolution and signal-to-noise ratio, but because of the heavier signal currents through the target become sticky sooner. The problem of limited useful life will require extensive research.

To record visual reconnaissance, the use of a photograph film system with electronic read-out was considered best for the pioneer ARS systems. This Film-Electronic system has been discussed fully in past Pied Piper progress reports, and only pertinent details will be repeated below.

The film consumption for the Pioneer system has been estimated by Eastman Kodak to be less than five pounds per month. The result of relative sensitivity studies of the Image Orthicon and film was presented in Pied Piper Progress Report for November 1955. For convenience, the tabulated results are included in Table III-1.

The remaining question of picture quality and resolution is difficult to evaluate numerically. At a joint CBS-EKC meeting it was decided to set up equipment to simulate the Image Orthicon System of the Rand Report and the Pioneer Film-Electronic system, and to compare visually the results attainable. This section of the appendix describes the equipment, procedures and techniques, and results of the comparison test.

TABLE III-1

SENSITIVITY AND RESOLUTION CAPABILITIES FOR FILM AND FOR IMAGE ORTHICON SYSTEMS

	IMAGE ORTHICON "FEEDBACK" SYSTEM	SUPER XX FILM	MICROFILM
<u>Basic light sensitivity in Shadows</u> (meter-candle-seconds). Includes 2:1 loss for No. 12 filter and 4:1 contrast ratio.	.007	.01	.3
Actual system illumination requirements (meter-candle-seconds) for I.O. - F/16; for Film - F/2.8	.007	.00033	.01
Relative Sensitivity	1	21	.7
Resolution of Sensitive Surface	10 opt. lines/mm	75 opt. lines/mm	130 opt. lines/mm
Ground Resolution 300 mi. altitude for both. 38" focal length for I.O. 6" focal length for Film	200 ft/ opt. line	140 ft/ opt. line	80 ft/ opt. line

2. DESCRIPTION OF APPARATUS

The apparatus and techniques of the comparison test are described below.

2.1 Subject Matter

A positive transparency was contract-printed by EKC from a high quality (8" wide by 6" high) aerial reconnaissance negative with a scale factor of 1:60,000. The exposure and development of the positive were controlled to give a contrast range of 5:1 and a gamma of unity. The positive transparency was considered to be the scene viewed at an altitude of 300 miles by either the Film or Image Orthicon System.

The positive transparency was photographed on Eastman F5740-6 film (microfile type) by EKC and reduced to a size of 0.152" x 0.114". The negative thus obtained then represents the stored scene of the 0^1 system using a 6" focal length lens at an altitude of 300 miles. A portion of the transparency, was also photographed by EKC on Eastman F5740-6 film (microfile type) to a reduced size of 0.152" x 0.114" with a demagnification corresponding to that of an 18" lens at an altitude of 300 miles. The negatives were mounted for electronic read-out by a flying-spot scanner to be described below.

The 8" x 6" master positive transparency was mounted on a light box for uniform rear illumination. The master was then viewed by an Image Orthicon camera with additional optical demagnification, such that the scale factor at the photocathode was very nearly that corresponding to a 38" focal length lens at altitude of 300 miles.

2.2 Choice of Scanning Rate

The scanning rates of the Image Orthicon System described in the Rand Report are as follows:

1. 600 total scan lines
2. 558 active scan lines
3. 4:3 aspect ratio
4. 23.1 frames per sec
5. 13.87 kc line ratio
6. 6.52 mc over-all system bandwidth

For security reasons, as well as for the practical advantage of locking the sync. generator to the 60 cycle power line, a high quality commercial Image Orthicon Camera Chain, and sync. generator were modified to operate as above but with a 4% increase in frame rate (24/sec) and band width.

The Image Orthicon system of the Rand Report takes and records 4 x 3 aspect ratio frames sequentially in a direction transverse to the motion of the vehicle. In the 0^1 (or Pioneer) system the film is read out by a line-scan flying-spot cathode-ray tube in frames that cover the width of the film. A single frame of the 0^1 system is a transverse strip with an aspect ratio of about 20 to 1, containing many more picture elements than a single frame from the Image Orthicon.

Since the aspect ratio and number of picture elements per frame for the Image Orthicon and 0^1 systems are different, it is not possible in a comparison test, to show the same ground area in a single frame through both systems. The frame size of one system or the other must be modified to reproduce the same area in a minimum number of frames.

For this comparison test the frame covered by the Image Orthicon system was kept the same as that described in the Rand Reports, with one frame covering the area in the original transparency. The frame size of the 0^1 Film-Electronic System was altered to cover the same area with a minimum integral number of 4 x 3 aspect ratio frames for which the density of flying spot cathode-ray tube picture elements imaged on the film was the same as the 0^1 system capability.

The film for the 0^1 system is rated at better than 100 optical lines/mm. For the tentative value of 130 optical lines/mm, the 0.152" x 0.114" negative contains 0.114 x 25.4 x 2 x 130 = 753 TV elements in the 0.114" height.

For a vertical resolution factor of 0.7, the number of active scanning lines required is

$$\frac{753}{0.7} = 1076 \text{ active lines}$$

By reading out the negative in four frames each covering 1/4 (0.152" x 0.114"), only $\frac{1076}{2}$ = 538 active scan lines are required per frame. This value is so very close to that required by The Image Orthicon System, that it was decided, for equipment simplification reasons, to operate all of the electronic equipment for the comparison test at the scanning rates and band widths given as above.

In addition to simplifying the electronic equipment required for the tests, the common scan rate approach provided one other very important advantage. Direct comparison of the Image Orthicon and Film Flying-spot cathode-ray, tube television pick-up devices, with respect to resolution and picture quality, was possible for identical scanning conditions.

2.3 Flying-Spot Film Scanner

A block diagram of the Flying-Spot Film Scanner system is shown in Fig. III-1. The P16 phosphor has a spectral energy characteristic with a peak in the near ultraviolet, extremely short persistence, and very fine grain. The 5ZP16 flying-spot cathode-ray tube was chosen for the film scanner, because of the advantageous persistence and grain characteristics and because of the desirable flat optical face plate. The cathode-ray tube was operated at the maximum rated anode voltage of 27 kv to obtain high resolution and high radiant power outputs. Vertical dynamic focusing voltage, derived from the scanning circuitry was applied to the focus electrode to improve the beam focus at the corners of the raster. Time did not permit the installation of horizontal dynamic focus circuitry.

A special 13 mm f/1.5 lens was used to image the flying-spot raster onto the Eastman F5740-6 negatives. The light transmitted through the negatives was collected and applied to the photocathode of a type K1234, high sensitivity, photomultiplier tube. The video signal was then corrected for phosphor decay and output capacitance of the photomultiplier. Gamma correction for proper reproduction of gray scales was also applied. Aperture equalization was inserted to "crispen" the video information.

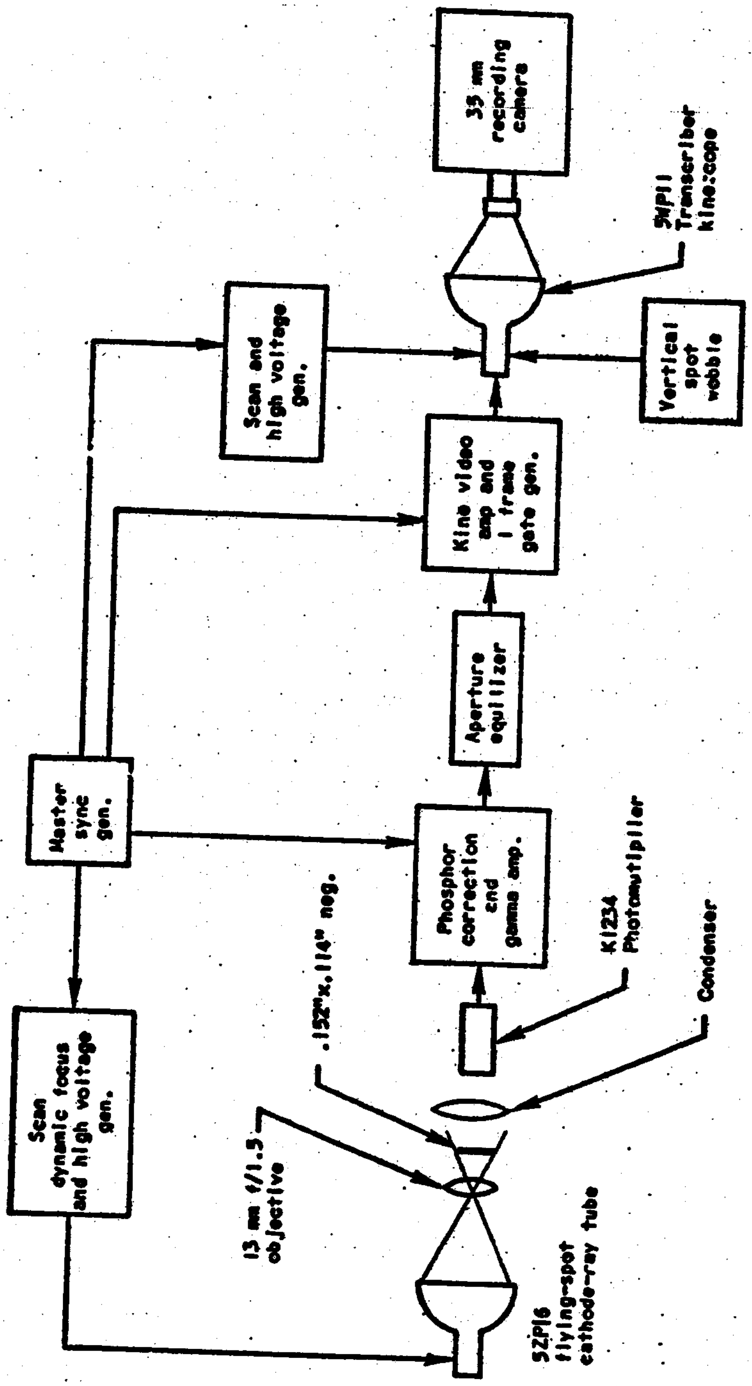

Fig. III-1 Flying-Spot Film Scanner Block Diagram

The video information was applied to a 5WP11 transcriber kinescope. The P11 phosphor emits a highly actinic blue radiation that is desirable for photography with blue-sensitive, fine-grain film.

A one-frame gate was applied to the 5WP11 cathode. Type 5374 film in a 35 mm copying camera was used to record single frames of video information displayed on the 5WP11. Vertical spot wobble was employed to minimize the scanning line structure in the display.

2.4 Image Orthicon System

A block diagram of the Image Orthicon System is shown in Fig. III-2.

The 8" x 6" master transparency mounted on a light box was imaged on the photocathode of a type 1854 Image Orthicon. The Image Orthicon was operated over the "knee" of the transfer characteristic for best resolution and signal-to-noise ratio. Several Image Orthicons, both new and used (with a variety in numbers of hours of operation) were tested in the system. The 1854 Image Orthicon with the best resolution, least noise, and most uniform response (freedom from shading) was chosen for the comparison tests.

Both vertical and horizontal dynamic focus voltages were applied to the Image Orthicon to improve the corner resolution. During the tests, the Image Orthicon was exposed to the scene continuously; that is, to simplify the equipment, the photocathode was not pulsed "on" 1.5 milliseconds per frame as described in the Rand report. The test thus gives a slight advantage to the Image Orthicon System in that the burden

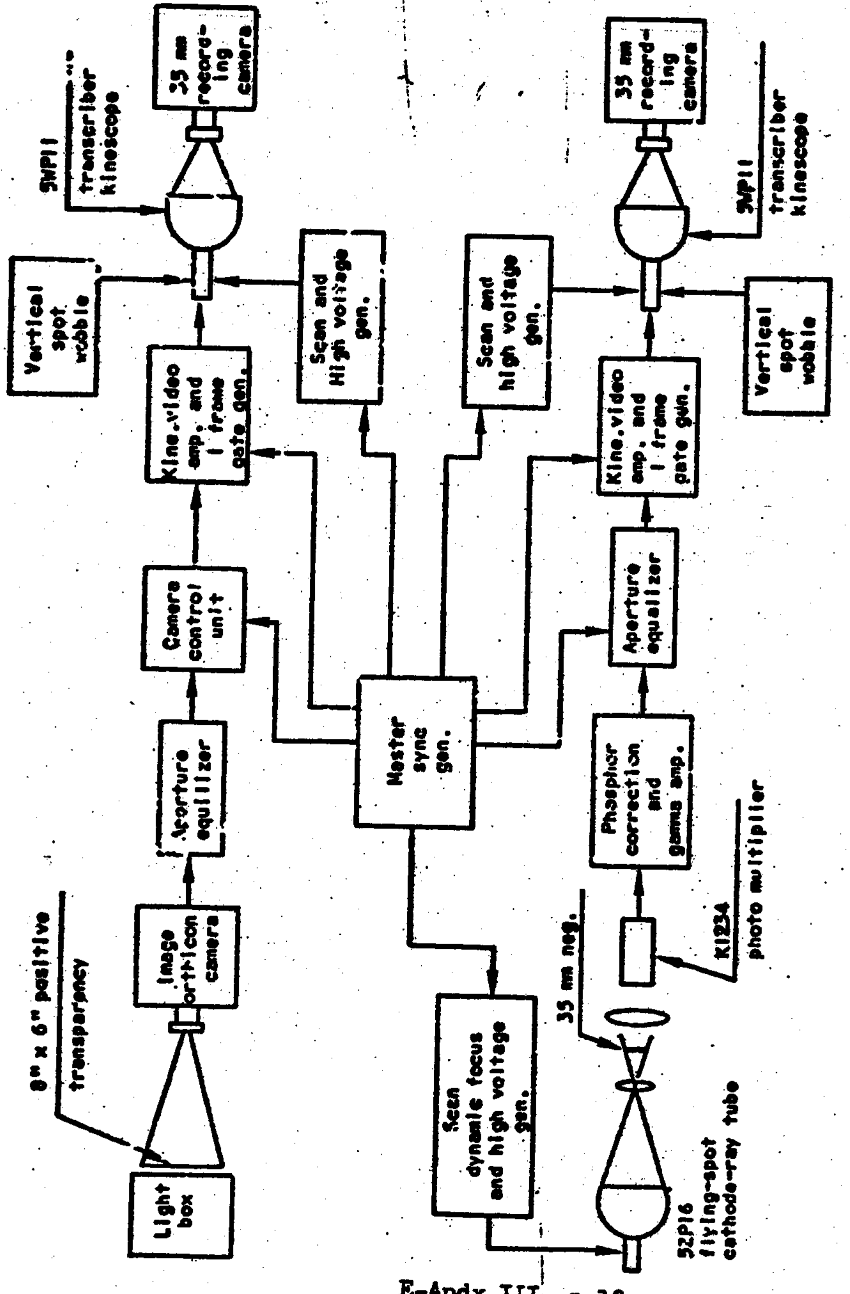

Fig. III-2 Image Orthicon System Block Diagram on the circuitry to provide and maintain the required photocathode in the pulsed "on" condition is eliminated. Although noise in the photocathode current imaged on the target is integrated over a full frame time (1/24 sec) for continuous operation, the signal-to-noise ratio at the output of the Image Orthicon is very probably the same for both conditions of operation, since noise in the Image Orthicon output is almost entirely that of the scanning beam.

The video signal from the Image Orthicon camera was "crispened" by an aperture equalizer. The output of the camera chain was displayed on a 5WP11 transcriber kinescope. Vertical spot wobble was employed to minimize the line structure in the display. A one-frame gate was applied to the cathode of the 5WP11 so that only single frames were photographed on 35 mm type 5374 film by the recording camera.

Since a video tape recorder with the band width specified in the Rand reports does not exist, it is difficult to evaluate the deterioration in picture quality that will result from the tape recording process.

The magnetic tape recorder will degrade the video information in several ways. The finite gap of the recording head represents a finite aperture that will cause a "roll-off" of the recording frequency response characteristic. The "roll-off" will reduce the fine detail contrast in the recorded information. Similarly the pick-off, or playback head, represents a finite aperture that will further reduce the fine detail contrast in the output of the tape recorder. It is possible to compensate partially for these apertures by means of aperture equalizer amplifiers. However, the high frequency noise will be boosted proportionally. Furthermore, the magnetic tape is not a perfectly homogeneous material. It does have grain, which adds to the apparent noise in the recorder output. Any aperture equalization applied to the recorder output increases the high frequency grain noise. The magnetic tape recorder is supposedly a linear process. However, in practice, the range of linearity is limited, and compression is possible. In magnetic tape recording the synchronizing information is stored along with the picture information. On play back, the tape and display devices must be synchronized. Any non-uniformity in the tape speed during recording, or playback makes the synchronizing problem difficult, and may result in horizontal jitter and loss of horizontal resolution in the final display.

Present-day quality broadcast practice of video recording consists of photographing the picture on the face of a kinescope. Since the wide-band tape recorder described in the Rand reports does not exist, the tape recording process was simulated for the comparison test by recording from a 5WP11 kinescope onto 35 mm type 5374 film, with readout by a 5ZP16 flying-spot cathode-ray tube. Such a process has finite recording and play-back apertures in the line scan direction due to the recording kinescope and flying-spot scanner beam sizes. Such a process also has grain due to the P11 and P16 phosphor particle sizes, and to a much smaller degree, to the film emulsion. Since this process represents quality boradcast practice, it is reasonable to state that to a first order approximation, the horizontal resolution and signal-to-noise ratio for the kinescope film recording system are comparable to those of the non-existent magnetic tape recorder of the Rand report.

The kinescope-film recording process may possibly give a loss of vertical resolution, depending on the techniques used, that does not exist for the magnetic tape recorder. To minimize the possible loss of vertical resolution, the following procedure was employed.

The video signal from the Image Orthicon camera was displayed on a kinescope whose aspect ratio was purposely distorted to 3 x 4 (width-to-height), that is the kinescope raster was stretched vertically. Vertical spot wobble was employed to minimize the line structure in the display. A single frame of information was photographed on 35 mm type 5374 film. The information was thus essentially recorded in almost contiguous horizontal strips (instead of fine horizontal lines) on the film. The 5WP11 transcriber kinescope was replaced by a 5ZP16 flying-spot cathode-ray tube. The same distorted aspect ratio was maintained. The 35 mm negative representing the recording was then read out by the flying-spot cathode-ray tube operating at the same scan rates, and displayed on a 5WP11 transcriber kinescope with spot wobble. Again only one frame of video was photographed to represent the output of the system. The process of recording and read out with a stretched aspect ratio was self-rectifying so that the output picture was undistorted.

In the simulation it was intended to register the fine line structure of the 5ZP16 raster imaged on the film, with the centers of the strip structure of the negative. For the ideal case, then, the information would be recorded in horizontal strips, and read out along the center lines of the strips. There would then be no loss in vertical resolution, but only loss of horizontal resolution due to the recording and play-back apertures. The ideal case was not achieved in this comparison test, but the fact that the ideal was closely approached is verified by the photographs in this report.

The kinescope recording process contains elements, the kinescope and the film, that are nonlinear. For this comparison test the film gamma was controlled, and compensating gamma amplifiers were adjusted to reproduce gray scales satisfactorily.

3. DISCUSSION OF RESULTS

The results of the Comparison Test are illustrated in Fig. 1 through 10.* The various photographs have been grouped to show the quality of visual data at equivalent plac s in both systems. Thus, direct pick-up of the aerial scene by a 38" focal length Image Orthicon camera is illustrated in Fig. 1, while direct pick-up by the 6" focal length photographic camera of the O^1 system is shown in Fig. 2. The aerial scene output of the simulated tape recorder of the Image Orthicon System is shown in Fig. 3, while the film scanner output of the O^1 system is shown in Fig. 4. These two illustrations represent the visual data at the output of the storage process required for delayed transmission. The photographs in general speak for themselves. They show the picture quality representing direct pick-up to be about comparable for both systems. At the output of the storage process, however, the picture quality of the Image Orthicon-simulated tape recorder system is inferior to that of the O^1 Film-Electronic system.

Figures 5 and 6 illustrate the picture quality and resolution that can be obtained with the Film-Electronic system using an 18" focal length lens (still less than one-half the 38" focal length lens of the Image Orthicon System) as planned for O^1 Special Purpose system and for higher order systems. These photographs compared to Figs. 1 and 3 show the resolution and picture quality of the Film-Electronic system to be superior to that of the Image Orthicon system.

The RETMA Resolution chart was substituted for the aerial scene to

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*Sec Apdx. III, pl ff.

to show the resolution capabilities at various places in both systems. Fig. 8A illustrates direct pick-up by the Image Orthicon camera. The picture shows horizontal resolution capabilities (vertical wedge) of better than 600 TV lines (in a frame height) with the contrast ratio falling off gradually beyond 350 TV lines. The vertical resolution (horizontal wedge) is off course limited by the active number of scanning lines (558) in the frame, and the Kell factor (approximately 0.7). The vertical resolution cuts off at about 390 TV lines.

The output of the simulated tape recorder is illustrated in Fig.8B. Here horizontal resolution begins to fall off at about 400 TV lines, with complete cut-off at ab ut 500 TV lines, which for the scanning rates used is equivalent to complete cut-off at 5.75 mc. The vertical resolution cuts off at about 325 lines. There is therefore some loss in vertical resolution going through the simulated magnetic tape recorder that would not exist in an actual tape recorder.

A 35 mm negative of the RETMA Resolution Chart was read out in one frame through the flying-spot film scanner. The output is shown in Fig. 9. Here the horizontal resolution is better than 600 TV lines with no fall-off in contrast ratio. The vertical resolution is again limited by the number of active scan lines and Kell factor, and is equal to about 425 lines, since the beam spot size of the flying-spot cathode-ray tube is finer than for the Image Orthicon. Direct comparison of Figs. 8A and 9 shows that the flying-spot film scanner, in one frame, has better resolution and signal-to-noise ratio than one frame from an Image

Orthicon camera.

A 35 mm negative on commercial microfile film, was made by photographing the original aerial scene transparency. The 35 mm negative was read out in one frame through the flying-spot film scanner. The output is illustrated in Fig. 10. By comparison with Fig. 1, the conclusion is unequivocal. The Film-Electronic System is capable of producing better picture detail and quality than an Image Orthicon for the same scanning conditions. This conclusion is contrary to that reached on pages 96-99 of Rand Report R262, Vol. 1.

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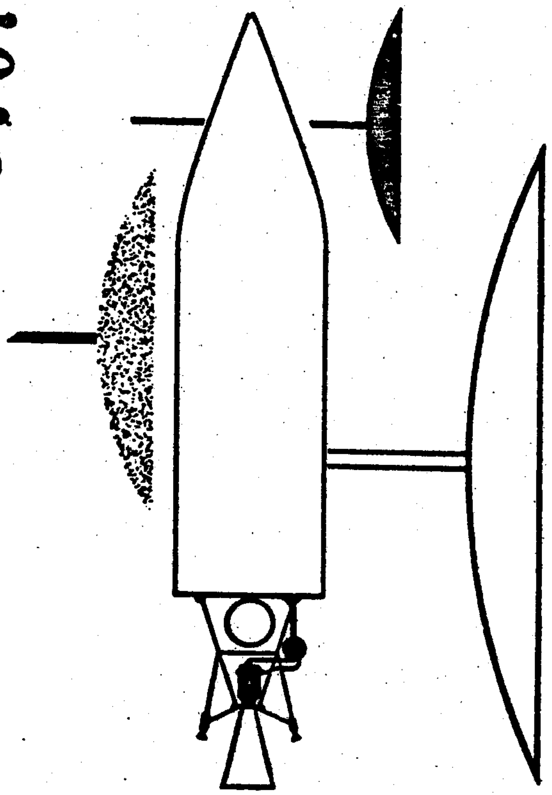

Pied Piper
DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

E. Visual Reconnaissance

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