MSD 1536
Vol. II
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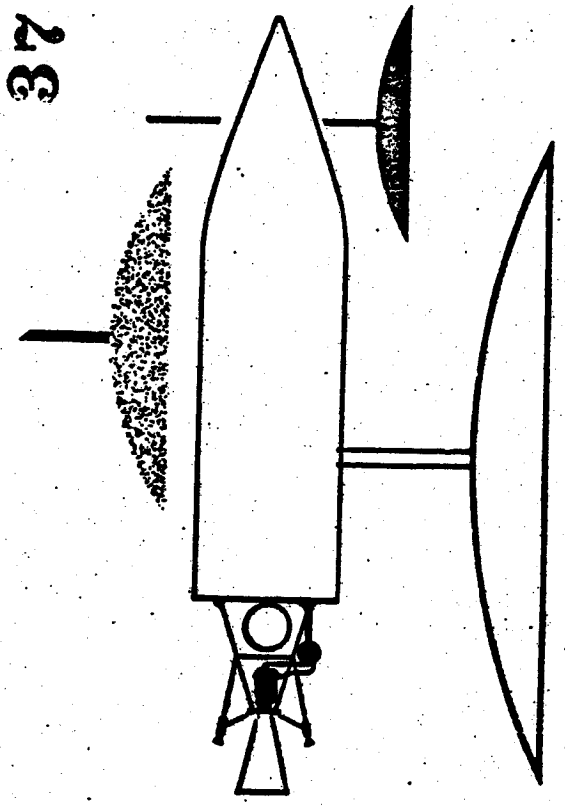

Pied Piper DEVELOPMENT PLAN (S)

VOL II SUB-SYSTEM PLAN

G. Infrared Reconnaissance

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
VAN NUYS, CALIFORNIA

SECRET
SECURITY CLASSIFICATION

MSD 1536

RDB PROJECT CARD	TYPE OF REPORT	REPORTS CONTROL SYMBOL DD-RDB(A)498

1. PROJECT TITLE	2. SECURITY	3. PROJECT NUMBER
INFRARED RECONNAISSANCE SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Uncl.) (PIED PIPER)	Secret	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	CONTRACT/W.O. NO.
	Lockheed Missile Systems Division	AF 33(616)-3105
9. DIRECTING AGENCY		
OFFICE SYMBOL / TELEPHONE NO.		

10. REQUESTING AGENCY	13. RELATED PROJECTS	17. EST. COMPL. DATES
		RES.
11. PARTICIPATION, COORDINATION, INTEREST		DEV.
		TEST
		OP. EVAL.
	14. DATE APPROVED	18. FY / FISCAL ESTS. (M $)
	15. PRIORITY: Maximum / 16.	

19.

20. REQUIREMENT AND/OR JUSTIFICATION

a. This subsystem will provide early warning, observation of military aircraft patterns, and ground detection of targets. No comparable subsystem is currently available or under development. All previous infrared systems have been developed for manned aircraft. For satellite application, the resolution, sensitivity, scanning, and data processing requirements are of different magnitudes because of the altitude and environment (nuclear radiation from the APU for example). Extremely high reliability is required for unmanned operation, and other operational considerations.

b. Air Force interest will center about surveillance possibilities, particularly of inaccessible regions as related to early warning systems.

c. This subsystem should increase Air Force capability in the direction of greatly increased warning time of attack by manned aircraft, air-breathing missiles, and ICBM launchings. It will also increase the Air Force capability to provide surveillance of military air traffic patterns as an indicator of imminence of hostilities.

22. RDB	SN	CN	IC & P	X	L	C

R&D PROJECT CARD
CONTINUATION SHEET

~~SECRET~~
SECURITY CLASSIFICATION

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

21 a. Characteristics

This subsystem will acquire infrared radiation data for the tracking of manned bombers and air-breathing missiles. It will include equipment for information storage and relay to ground intercept stations. Variants will provide for detecting and tracking of ICBMs, for instantaneous data transmission through a multi-satellite communication network. Reconnaissance and surveillance data is thus delivered for intelligence groups.

21 b. Approach

Two models of infrared equipment employing detectors of the PbTe type are considered: one for operations against manned bombers and air-breathing missiles and the other against ICBMs. Although the basic concepts will be the same for both, there are two major differences: the type of scan and method of transmitting the data to the ground. For ICBM detection-tracking the information is relayed to the ground via an intersatellite radio network, and a satellite-to-ground link. In the case of the manned bomber detection system, the information is recorded prior to transmission to the ground. The type and quantity of information that is transmitted and recorded is such as to permit the use of very narrow bandwidths (on the order of kilocycles). Sensitivity, resolution, and reliability will be the major problems which will be encountered during the subsystem development program.

21 c. Subsystems Tasks

1. a. IR Scanner for Bomber Tracking

b. Contractor: Eastman Kodak Co., and Lockheed, MSD.

c. The optical system for the manned bomber and the air-breathing missile will be designed in accordance with conventional infrared collector systems. The reflector will be capable of scanning around a vertical axis covering a solid angle of 90 degrees, making it possible to determine orientation of the target with respect to the satellite. The subsystem will be capable of detecting the exhaust plumes of manned aircraft as well as air-breathing missiles in the radiation region of 4.2 microns. The range of detection of a high-altitude intercontinental bomber or missile will be in the order of 420 n. miles. (Ref. 1, p. A-1)

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INFRARED RECONNAISSANCE SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Uncl.) (PIED PIPER)	Secret	1115
	4.	5. REPORT DATE 1 March 1956

2. a. IR Scanner for ICBM Tracking

b. Contractor: Eastman Kodak Co., and Lockheed, MSD.

c. The optical system to be utilized for the ICBM detection will be similar in general features to those used for bomber detection. However, due to the nature of the detection problem (high trajectory ballistic missiles) it will be necessary to provide two reflectors mounted back-to-back creating two essentially horizontal fan beams which scan up and down in a nodding motion. The detection range of the system will be a minimum of 3000 n. miles against ICBMs. The altitude of operation of the satellites is in the order of 1000 n. miles. (Ref. 1, p A-13)

3. a. Airborne Data Processing

b. Contractor: CBS and Lockheed, MSD.

c. The detected electronic information as received by the scanner which was described in task 1 above is appropriately processed by means of a data processing coder in a form suitable for recording. This data processing equipment will be very similar to that being developed for the Electronic Reconnaissance subsystem.

4. a. Data Recording

b. Contractor: CBS and Lockheed, MSD.

c. The data as received from the data processing unit of task 3, is stored on a suitable narrow band magnetic tape recorder. The recording equipment will be quite similar to that being developed for the Electronic Reconnaissance subsystem.

5. a. Data Transmission

b. Contractor: CBS and Lockheed, MSD.

c. The data as recorded for subsequent transmission (task 4) provides the input to the data transmission equipment. This equipment consists of a transmitter and associated equipment and will be similar to equipment being developed for the Electronic Reconnaissance subsystem.

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INFRARED RECONNAISSANCE SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Uncl.) (PIED PIPER)	Secret	1115
	4.	5. REPORT DATE: 1 March 1956

6. a. Data Link Network for ICBM Tracking

b. Contractor: CBS and Lockheed, MSD.

c. To provide for immediate transmission of ICBM track data, an inter-satellite network is required. This network is composed of an omnidirectional transmitter and receiver in each satellite. This equipment will not impose a serious weight problem. As targets are detected, the inter-satellite network is activated and all pertinent information is instantaneously put into the network. The number of satellites in this system is chosen such that detection requirements as well as inter-satellite network requirements are met. (Ref. 1, p A-13)

21 d. Other Information

Design techniques as developed by other companies in the I-R field will be monitored in order to assure the completion of a satisfactory subsystem in time for the planned system. There is no available adequate equipment.

21 e. Background History

Study contracts such as Pied Piper under AF 33(616)-3105 have determined that reconnaissance data to be obtained with a satellite can be obtained in no other way. Study has determined that important data could be obtained by an Infra red Satellite Reconnaissance System.

21 f. Future Plans

It is planned to continue the studies already initiated and to develop equipment suitable for testing.

21 g. References

1. 2d Quarterly Report, Project Pied Piper.

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MSD 1536

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

TABS

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Subsystem G - INFRARED RECONNAISSANCE

Tab 1 - General Design Specifications

I. GENERAL

A. Statement of the Problem

The basic objective in this subsystem is the solution of the problem of detecting and monitoring infrared images of minute size relative to the large field of view involved. Another aspect of the problem involves the urgency of extracting the data for immediate conversion to military usefulness in counter force activities and to preserve it for use in military intelligence. As in the case of the visual reconnaissance subsystem, the problem is further complicated by the satellite's orbital altitude and velocity.

B. Approach

The approach which will be followed in solving the problem of developing the infrared subsystem is as follows: Two models of infrared equipment, employing detectors of the PbTe type are considered, one for operation against manned bombers and air breathing missiles and the other against ICBM's. Although the basic concepts will be the same for both, there are two major differences, namely, the type of scan and, in the case of the ICBM detection tracking system, the information being relayed to the ground via an intersatellite radio network and satellite-to-ground link. In the case of the manned bomber detection system, the information is recorded prior to transmission to the ground. The type and quantity of information that is transmitted and recorded is such as to permit the use of very narrow bandwidths (on the order of kilocycles per second). The specific equipment to be developed is described in Sec. 2.

C. Solution

Tentative measurements on the infrared radiation emanating from high thrust rocket engines have indicated the feasibility for detecting and tracking aircraft and ICBM's from satellites. However, it will be necessary to carry out a continuing research and testing program aimed at determining radiation values from rocket engines, sensitivity required of infrared detector cells, and means of increasing their capabilities.

Simultaneous with the research program will be the preparation of the design specifications for the first experimental laboratory model of infrared scanner. This will be followed by design, fabrication and testing of environmental components for flight test, an aircraft test model, a payload test vehicle model and later, an operational test vehicle model of the overall subsystem equipment.

The elements of the infrared air surveillance subsystem for the satellite are all within the state-of-art and can be developed with a normal amount of effort. It is anticipated that the major problems which will be encountered in obtaining an operational infrared subsystem will be those associated with achieving required sensitivity and resolution of the optical system. Another major problem which must be faced will be that of achieving a satisfactory reliability for an automatic unattended system operating in the extreme environment which will exist in a satellite (nuclear radiation fields due to A.P.U., extreme variations in temperatures, etc.).

One of the most difficult problems will be that of providing near 100% reliability during the required military useful life. One specific example is the problem of operating the infrared scanner in the extreme temperature environment and low pressures. This is considered to be primarily a design problem in materials, bearing seals, etc. Shielding design requirements, due to nuclear radiation fields, must be determined in order to prevent deleterious effects on the operation of the PbTe infrared cells, if in fact such effects exist. Ground and flight tests will be required over long periods of time to determine the cumulative effects of these radiation fields.

Information must be derived concerning the spatial and spectral characteristics of rocket engines at various altitudes and using various fuel combinations. It is planned to carry out these tests on test missiles currently in the overall ICBM program. Radiation measurements from the exhaust of turbojets in the region of 4.2 microns will be obtained from current programs.

As a part of the development program it will be necessary to design and fabricate models of experimental laboratory equipment. This equipment will be given extensive laboratory tests to determine feasibility of the concepts and to determine performance parameters primarily of the optical portion of the system.

It is planned to carry out high altitude aircraft tests with the first development model of the infrared subsystem. This development model of the infrared equipment will be modified from the satellite

configuration by scaling down and calibrating the major components in order to simulate the operation from a satellite. Other laboratory bench models will also be fabricated.

Simultaneous with the aircraft flight test program, critical components of the complete subsystem will be fabricated for testing in the systems test vehicle flight program. These tests will provide certain environmental conditions for components such as infrared detectors, scanner bearings, amplifiers, instrumentation, etc.

The next step is the design and fabrication of several models of the complete IR equipment including all components to be utilized in complete subsystem tests in the Payload Test Vehicle (PTV). These tests will allow the first opportunity to carry out development tests of the equipment in the full scale orbiting vehicle. There will be two variations of the equipment for the first time which will allow tracking of both manned aircraft, and air breathing missiles as well as the ICBM's.

The series of models for complete infrared tracking equipment will be flight tested in the Operations Test Vehicle (OTV). Here there will be six complete subsystems fabricated for each mission; i.e., manned bomber tracking and ICBM tracking. These flight tests will provide the final checks on complete systems performance under operational satellite conditions. It is planned in the case of the ICBM tracking equipment to test out the inter-satellite communications network through the use of two satellites in orbit simultaneously.

In the case of the airborne data processing, recording and transmission equipment, it is intended to take full advantage of the development program which will exist as a part of the Electronic Reconnaissance Subsystem. For this purpose, specifications for these equipments will be prepared based upon the electronic reconnaissance development program and incorporating the minimum number of changes as necessary to fulfil special requirements of the infrared subsystem.

There are no components in the subsystem which are inherently unreliable except for some portions of the electronic circuitry. The electronic unreliability will be treated by the use of redundancy of components and good circuit design.

There are no special installation considerations necessary in connection with the infrared subsystem except for the removable nose cone.

No major GFE is required.

II. DESCRIPTION OF SUBSYSTEM TASKS

A. IR Scanner for Bomber Tracking

The optical system for the manned bomber and air breathing missile will be designed in accordance with conventional infrared collector systems. The following represents a general guide to how the problem amy be solved. The collector would consist of a line array of 40 cooled PbTe detecting cells contained at the focal plane of a 56 in. diameter reflector. Each element would cover a 1° elemental field of view. The reflector would be capable of scanning around a vertical axis and thus cover a solid angle of 90° in 40 concentric 1° circles. The azimuthal orientation of the optical system would be determined and by electronically scanning each individual detecting element in the line array, it would be possible to determine the orientation of the target with respect to the satellite. The detecting elements are capable of detecting the exhaust plumes of manned aircraft as well as air breathing missiles in the radiation region of 4.2 microns. The range of detection on a high altitude intercontinental bomber or missile shall not be less than 420 n. miles. A typical installation of this type of equipment in an orbiting vehicle is shown in Fig. 1. Additional information concerning the operational and hardware studies which support the proposed solution to this task appears in the second quarterly report, MSD-1481, pages 8, 17 and 41.

B. IR Scanner for ICBM Tracking

The optical system to be utilized for the ICBM detection would be similar in general features to that for the detection of manned bombers. However, due to the nature of the detection problem (high trajectory ballistic missiles) it will be necessary to provide two reflectors mounted back-to-back which create two essentially horizontal fan beams which scan up and down in a nodding motion. The optical system would consist of upwards of 70 cooled PbTe detecting elements arranged in a line array at the focal plane of a 56 in. reflector. The incremental field of view will be in order of 0.25° and the overall detection cone will be around 18°. The detection range of the system would be a minimum of 3000 n. miles against ICBM's. The altitude of operation of the satellites is in the order of 1000 n. miles. Additional details covering the operational studies which support the proposed solution of this task appear in report No. MSD-1481, pages 9, 18, and A-13.

C. Airborne Data Processing

The detected electronic information as received by the scanner which was described in para. IIA is appropriately processed by

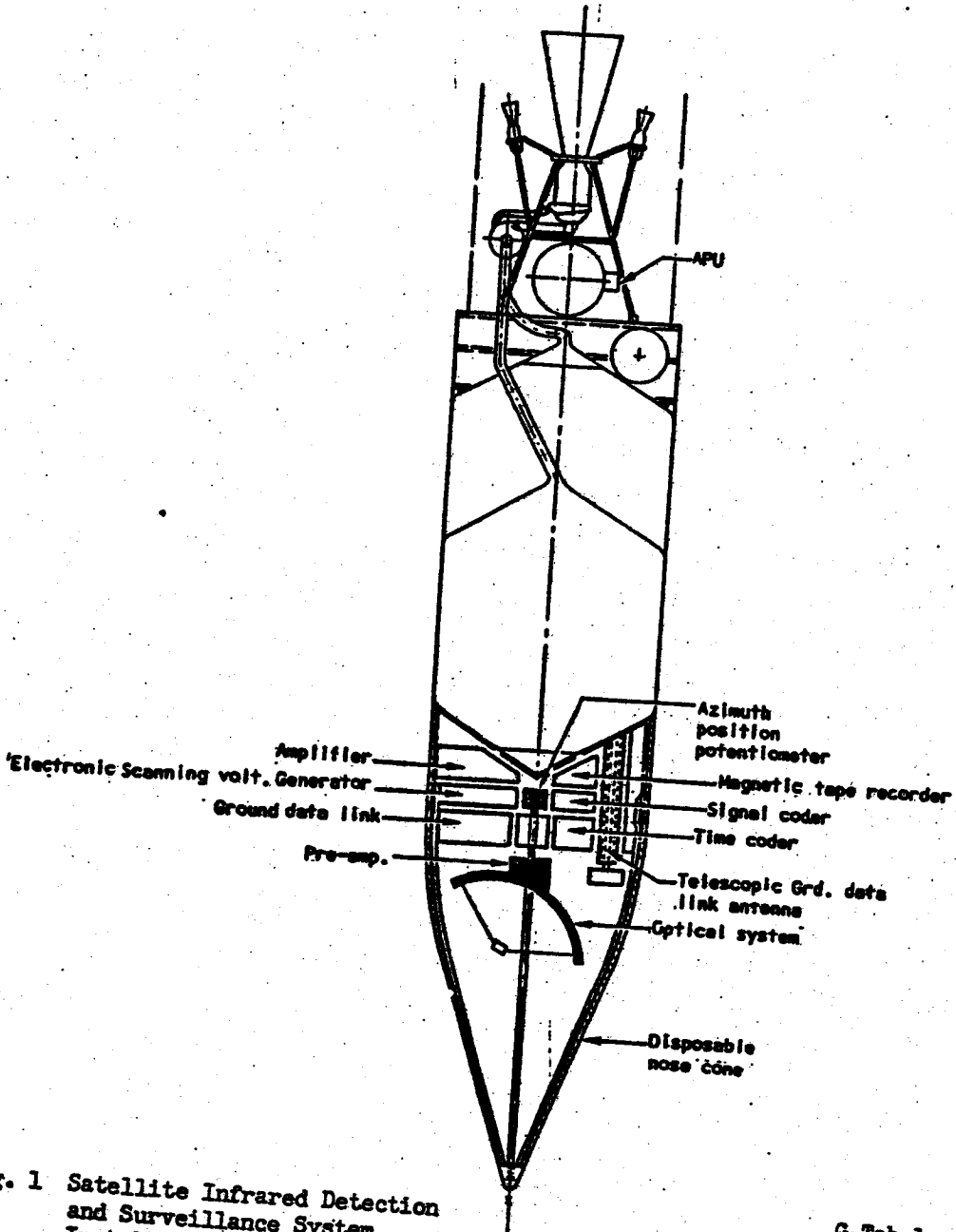

Fig. 1 Satellite Infrared Detection and Surveillance System Installation

MISSILE SYSTEMS DIVISION

means of a data processing coder in a form suitable for recording. This data processing equipment will be similar to that being developed for the Electronic Reconnaissance Subsystem F.

D. Data Recording

The data as received from the data processing unit of para. IIC in this tab is stored on a suitable narrow band magnetic tape recorder. This data recording equipment will be similar to that being developed for the Electronic Reconnaissance Subsystem.

E. Data Transmission

The data as recorded by the data recording equipment described in para. IC of this tab is fed into the data transmission equipment. This equipment consists of a transmitter and associated equipment and will be similar to the equipment being developed for the Electronic Reconnaissance Subsystem.

F. Data Link Network for ICBM Tracking

To provide for immediate transmission of ICBM tracking data, an intersatellite network is required. This network is composed of an omnidirectional transmitter and receiver in each satellite and would operate on a frequency of about 30 mc.in order to minimize the radiation which reaches the ground. As the targets are detected by the optical system, the data is transmitted instantaneously into the inter-satellite network. The ground station will be capable of "tapping" off the data from the inter-satellite communication network. This ground to satellite data link will operate in the frequency band of 200-300 mc. Operational considerations which dictate the use of the proposed inter-satellite network are contained in report No. MSD-1481, page A-13.

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Subsystem G - INFRA RED SUBSYSTEM

Tab 2 Summary - Subsystem Milestones

Line	Milestone	Milestone marker
1–2	Research Program Begins (continuing study)	CY 57 J
5–6	Preparation of Design Specifications for first experimental model	CY 57 F
9–10	Design and Fabrication of first experimental laboratory model	CY 58 M
13–14	Testing of first experimental laboratory model	CY 58 D
17–19	Design and fabrication of two models of PTV (Payload Test Vehicle) for manned Bomber started	CY 58 D
22–23	Design and fabrication of two models of PTV for ICBM started	CY 58 D
26–27	Design and fabrication of first aircraft test model	CY 59 M
30–31	Non-operating Mock-up for PTV completed	CY 59 M
34	Begin Aircraft Tests	CY 59 A
37–38	[illegible] for PTV flights [illegible]	CY 60 M

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MSD 1536

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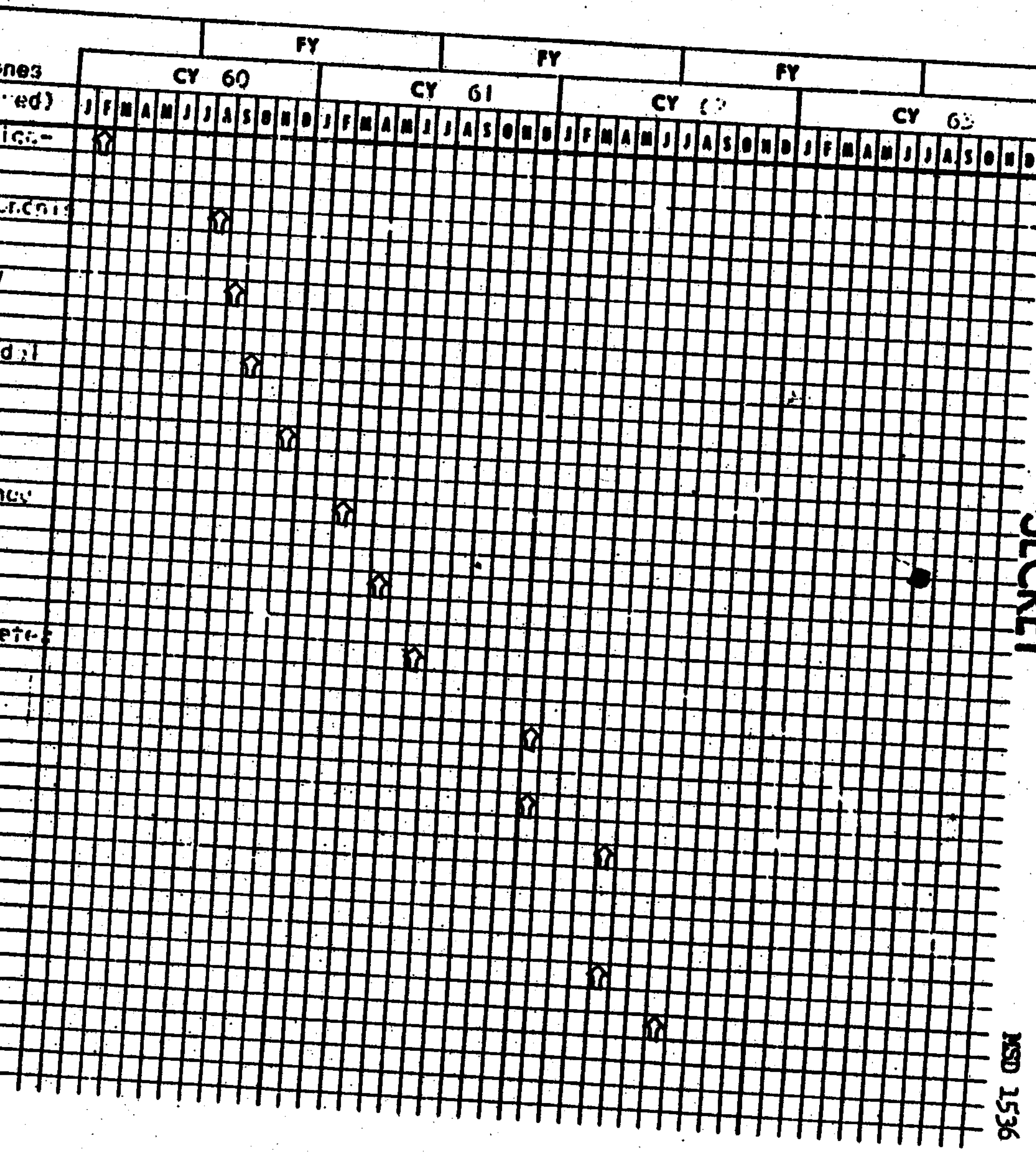
Subsystem 3 - INFRA RED SUBSYSTEM

Tab 2 Summary - Subsystem Milestones (Continued)

1 Begin Production Design and Fabrication of CTV Models
4 Flight Tests of Environment components in STV
7 Fabrication of first model of PTV test model completed
10 Testing of first aircraft test model completed
13 First PTV Laboratory Test Model completed for Manned Bomber
16 Flight Test of PTV Models for Manned Bomber
19 Testing of Second Aircraft Test Model (ICBM)
22 Second PTV Flight Test Model completed for ICBM
25 Completion of Fabrication of First OTV model for Manned Bomber
28 Flight Test of PTV Model for ICBM
30 Completion of Fabrication of first OTV Model for ICBM
33 Flight Testing of First OTV Model
35 First Manned Bomber Model
37 First ICBM Model



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Subsystem G - INFRA RED SYBSYSTEM

Tab 2 Summary - Hardware Delivery

FY 58 | FY 59 | FY 60 | 61

CY 58 | CY 59 | CY 60 | CY 61

J F M A M J J A S O N D (each calendar year)

1 Experimental Laboratory Model

2 Aircraft Test Model

STV Environmental Components

PTV Test Model

2 Manned Bomber Model

2 ICBM Model

OTV Test Model (cont'd on next page)

Revised Form 133

Subsystem G - INFRA RED SUBSYSTEM

Tab 2 Summary - Hardware Delivery (Continued)

	FY / CY 60	FY / CY 61	FY / CY 62	CY 63
	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	J F M A M J J A S O N D
OTV Test Model (cont'd)				
6 Manned Bomber Models				
6 ICBM Models				

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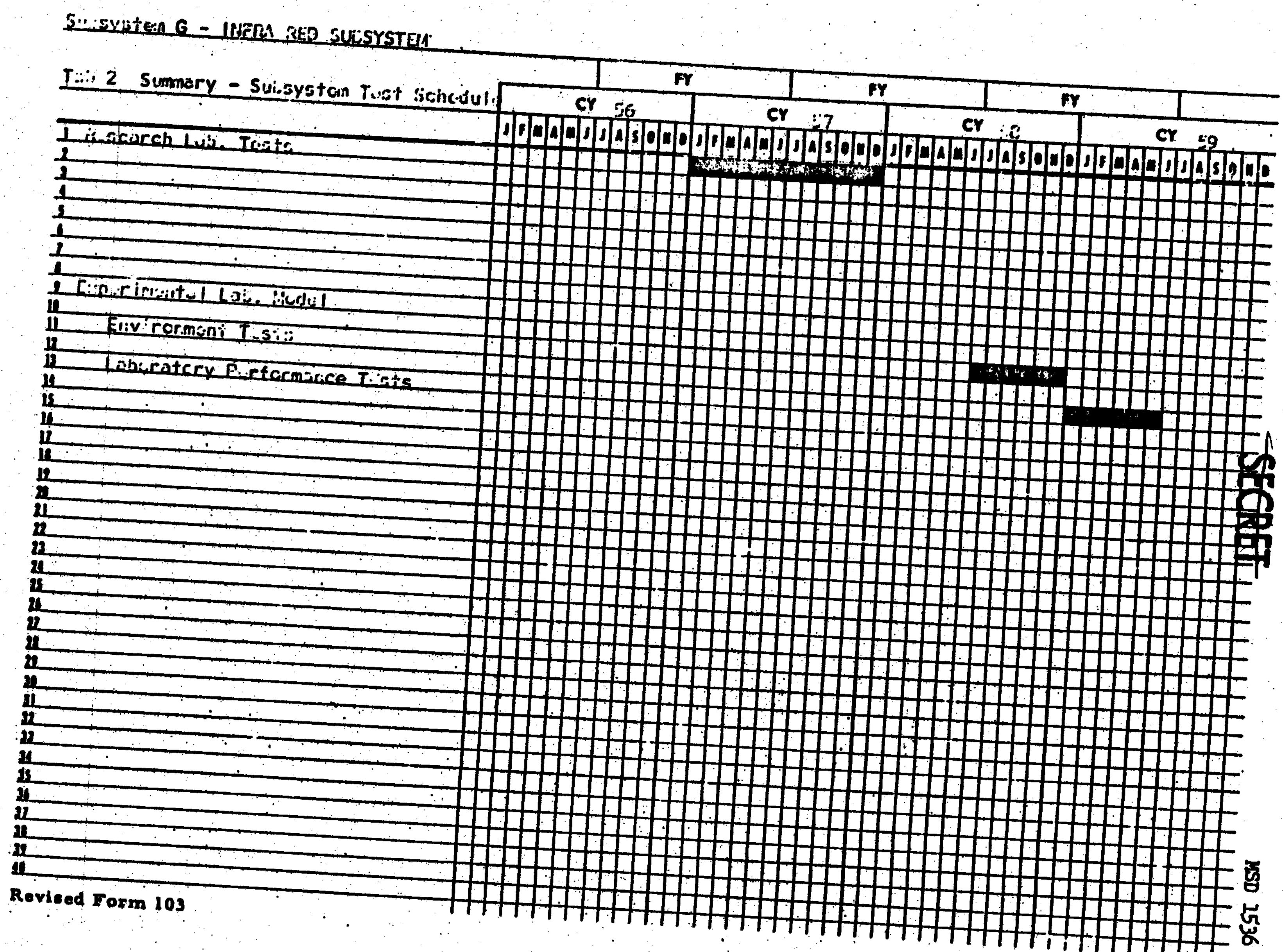

Subsystem G - INFRA RED SUBSYSTEM
Task 2 Summary - Subsystem Test Schedule
FY
FY
FY
CY 56
CY 57
CY 58
CY 59
J F M A M J J A S O N D
1 Research Lab. Tests
9 Experimental Lab. Model
11 Environment Tests
13 Laboratory Performance Tests
Revised Form 103
MSD 1536