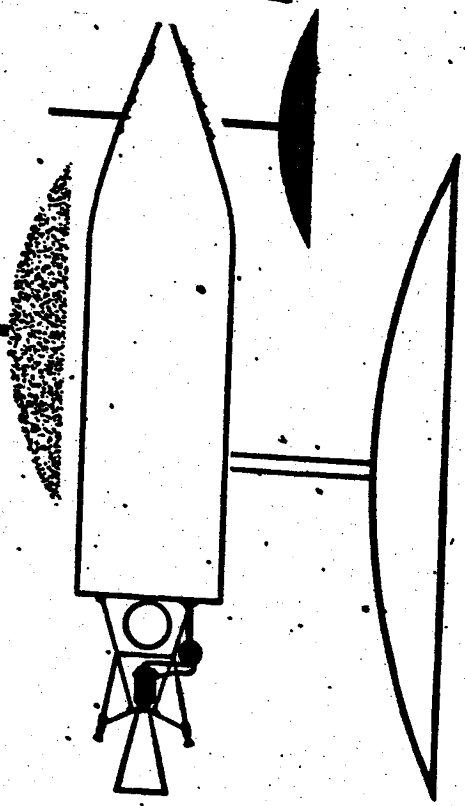

Pied Piper DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

H. Vehicle Electronics

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
VAN NUYS, CALIFORNIA

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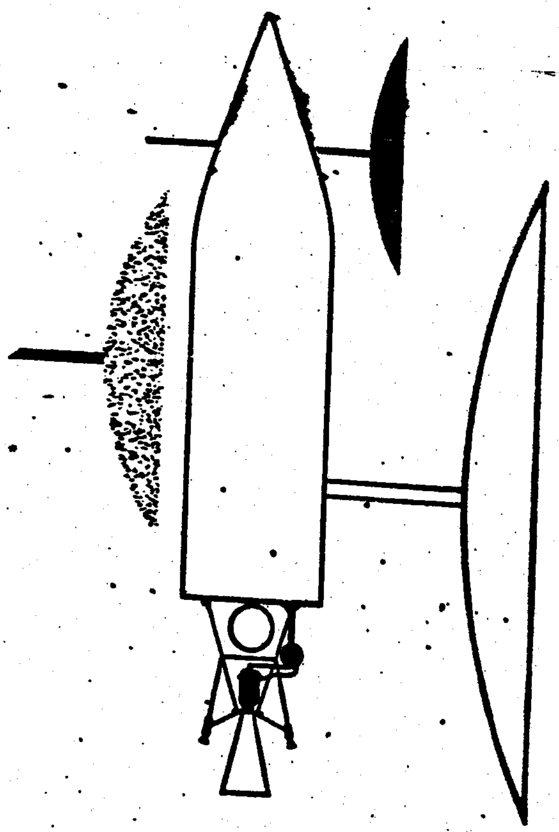

Pied Piper DEVELOPMENT PLAN

RESTRICTED DISTRIBUTION
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VOL. II SUB-SYSTEM PLAN

H. Vehicle Electronics [U]

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DECLASSIFIED AFTER 12 YEARS.
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MISSILE SYSTEMS DIVISION
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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.

SECRET MSD 1536

PIED PIPER DEVELOPMENT PLAN

VOLUME I. SYSTEM PLAN

VOLUME II. SUBSYSTEM PLAN

A. Airframe

B. Propulsion

C. Auxiliary Power

D. Guidance and Control

E. Visual Reconnaissance

F. Electronic Reconnaissance

G. Infrared Reconnaissance

H. Vehicle Electronics

I. Airborne Test Systems

J. Vehicle Intercept and Control Ground Station

K. Ground Data Processing

L. Vehicle Ground Support

CONTENTS

Subsystem H Vehicle Electronics

SECRET
SECURITY CLASSIFICATION

RDB PROJECT CARD

TYPE OF REPORT: New System Development Plan		REPORTS CONTROL SYMBOL DD-RDB(A)48
1. PROJECT TITLE: SUBSYSTEM DEVELOPMENT PLAN - VEHICLE ELECTRONICS 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	CONTRACTOR AND/OR LABORATORY: Lockheed Missile Systems Division	CONTRACT/W.O. NO.: AF33(616)-3105
9. DIRECTING AGENCY		
OFFICE SYMBOL	TELEPHONE NO.	
10. REQUESTING AGENCY	13. RELATED PROJECTS	17. EST. COMPL. DATES: RES. / DEV. / TEST / OP. EVAL.
11. PARTICIPATION, COORDINATION, INTEREST	14. DATE APPROVED	18. FY / FISCAL ESTS. (M $)
	15. PRIORITY: Maximum	16.
19.		

20. REQUIREMENT AND/OR JUSTIFICATION

a. In the collection of reconnaissance data by the ARS Vehicle, a Vehicle Electronics function must be performed. This requires equipment to assist in the ground control of the vehicle, equipment to collect and telemeter environmental data to the ground, and a vehicle destruct system for safety and security purposes.

b. This Vehicle Electronics subsystem forms a basic part of the overall ARS program since this subsystem is necessary to maintain vehicle operations.

c. A satellite has not been used heretofore in a reconnaissance mission. A major increase in the coverage available will result, thereby providing a greatly increased Air Defense capability.

H, p 1

22. RDB	SN	CN	IC & P	X.	I.	C.

DD FORM 613 MISSILE SYSTEMS DIVISION

SECRET
SECURITY CLASSIFICATION

LOCKHEED AIRCRAFT CORPORATION

1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NUMBER
SUBSYSTEM DEVELOPMENT PLAN - VEHICLE ELECTRONICS FOR ADVANCED RECONNAISSANCE SYSTEM (UNCLASSIFIED) (PIED PIPER)	S	1115
	4.	5. REPORT DATE 1 March 1956

21 a. Brief Characteristics

The Vehicle Electronics subsystem provides the means for ground control of the ARS Vehicle Payload. A beacon transponder and a separate command link aids in ground radar tracking and provides for receipt of commands in the vehicle. A decoder and programmer in the vehicle stores the commands and feeds them into equipment as required. A telemetry system will be provided to collect and transmit environmental data to a ground receiving station. A vehicle destruct system will be provided for range safety, security, and international requirements.

21 b. Approach

The beacon-transponder and command decoder are integrated to decrease complexity and an entirely independent command control link based on the use of high powered FM radio techniques will be supplied, permitting commands independent of the radar link. The independent FM command link makes possible closed loop tracking control of the data link antenna.

All equipment will be designed to emphasize long life, and reliable operation in the specialized environment. Antenna design integration and radio noise reduction considerations will be directed toward elimination of interference in the superheterodyne beacon as a result of proximity to the other electronic equipment. The instrumentation and telemetry tasks will make use of standard techniques but having relatively large information capacity.

1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NUMBER
SUBSYSTEM DEVELOPMENT PLAN - VEHICLE ELECTRONICS FOR ADVANCED RECONNAISSANCE SYSTEM (UNCLASSIFIED) (PIED PIPER)	S	1115
	4.	5. REPORT DATE: 1 March 1956

21 c. Tasks of the Subsystem

The Vehicle Electronics subsystem is divided into the following tasks:

1. Beacon Transponder - MSD

A microwave beacon capable of receiving pulsed radar signals from specific vehicle intercept and control ground stations, and replying with suitable transmitted pulses to be received by the interrogating ground radar will be used. This capability will be available up to 1500 miles line-of-sight to the ground radar. A command decoder will operate in conjunction with the beacon transponder to sort out discrete commands received from the ground radar.

2. Programmer - MSD

This unit accepts the commands received over the command links, stores the commands, and emits them at the proper time for execution.

3. Command Receiver - CBS

The command receiver operates in a manner such that the beacon transponder is turned on or off by command. Numerous other commands are handled by this receiver including the important function of data link transmitter control. This receiver operates in conjunction with a high powered FM ground command transmitter, which is independent of the tracking radar equipment.

4. Telemeter - MSD

The on-board instrumentation and telemeter continuously monitor and transmit to ground receivers environmental conditions within the vehicle.

SECRET

Pied Piper

MSD 1536

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

TABS

SECRET

Subsystem H - VEHICLE ELECTRONICS

Tab 1 - General Design Specifications

I. GENERAL

A. Statement of the Problem

The Vehicle Electronics System includes the electronics, exclusive of payload, necessary to maintain vehicle operations. A microwave beacon-transponder is employed to aid in acquisition and tracking from the ground. A command receiver operating in the 100-250 mc region will permit command transmissions to the vehicle. In addition, the command link is employed to transmit data link tracking error signals.

A programmer and clock will be used to store commands and to release them at the proper time for execution. A Lockheed FM/FM telemeter will be used in the flight test and early operational vehicles to monitor flight conditions. This telemeter is different from the Ferret and Visual Reconnaissance data links and will be phased out after the O^1 system (Program II) has been initiated.

A destruct system is required for safety and for diplomatic reasons. It will operate on command signals with a high security code and also from an internally initiated indication of re-entry, e.g., thermal or acceleration shock.

B. Approach

To establish and maintain control over the ARS vehicle, and permit useful interpretation of reconnaissance data collected, it is essential that the orbit parameters be determined with sufficient accuracy to permit a one-to-one correlation of time with geographical location. If this is done, power conservation may be obtained through payload programming, and directional equipment may be oriented with respect to the vehicle attitude to obtain geographical reference of observations. In addition, programming permits deactivation of electronic command control links during periods when commands may be transmitted from unfriendly territory.

The position correlation is obtained from orbit computations based on a ground tracking system. To aid this tracking system, the vehicle carries a beacon-transponder which is integral with the command decoder. When the beacon is obtaining transmission from the ground, the transponder provides slant range data and aids in radar angle tracking out to 1500 miles.

An additional independent command receiver, operating in the 100-260 mc region, receives FM transmission from high powered (50 kw) ground transmitters modulated in a manner permitting up to 100 discrete commands. This equipment makes possible orientation of the data link antenna and in addition simplifies the "lost-bird" acquisition problem.

The commands received are decoded and used to correct the vehicle time reference and to program future payload functions, e.g., data read-out, antenna azimuth, transponder activation.

To permit monitoring of the vehicle operation and provide a means for studying ambient conditions and their effect on system operation, a telemetered monitoring system will be used. Environmental data will be collected by on-board instrumentation. These data will be transmitted to the ground over a telemeter link and will also be employed as an input to a self-destruction system.

In the ARS application, the design of vehicle electronics components must provide for long life in the specialized environment, and power consumption compatible with APU design.

Special consideration must be given to the selection of operating frequencies to avoid interference, and to permit the design and use of high gain antennas (at both ground station and vehicle) which would provide for maximum security and minimum power dissipation.

C. Solution and Recommendations

(1) Operational Ranges or Limitations

(a) The beacon transponder will be used with the SCR-584, AFMTC-Mod 2 radar equipment in the initial phases of this program. This beacon will provide return signals at line-of-sight ranges out to 1500 miles. In addition, it will be able to handle up to 10 discrete commands. These commands will be used as the back-up system.

Existing beacons used on RTV and other missile programs today are inadequate because of their limited power output and marginal receiver sensitivity. A new beacon is being developed by Lockheed MSD which will use a superheterodyne receiver and a newly developed transmitter with a peak power output of 250 watts. This equipment will be used on the MSD X-7B program and will also be used in the early test phases of Pied Piper. To further improve the radar beacon performance, a circularly polarized antenna will be developed for the vehicle to overcome cross polarization effects encountered at low elevation angles near the horizon. In addition, trained personnel will be used to maintain and operate this equipment and additional system improvement can be obtained by individual component selection. A higher powered version of this MSD beacon will also be developed to improve this performance as the program approaches the orbital test phase.

As the program progresses, a more advanced tracking radar, the FPS-16 system operating at C band, will be employed. In this case, another beacon will be required. A beacon which might be usable in modified form for this purpose is currently under development for the Talos program.

(b) Command Receiver

The command receiver which forms part of the airborne electronic subsystem operates independently of the beacon transponder. This receiver operates in the 100-250 mc region in conjunction with a high powered FM ground transmitter and is capable of handling up to 100 commands. In this capacity it will function as the primary command control system in the vehicle.

The receiver will be capable of receiving signals from the ground transmitter at all times within line-of-sight range of the ground control station. Receiver outputs will tie into the programmer, will be used to activate the beacon, and will supply other useful commands to the vehicle subsystem.

The receiver will be a crystal controlled superheterodyne requiring very nominal power for its operation. It will incorporate the latest FM receiver techniques and will feed a number of high Q frequency selective reed relays.

The command receiver antenna design is important in that coverage must be obtained for different orientations to provide a reliable ground-to-air command channel. It is planned that the vehicle antenna will consist of radiators located in a trough around the circumference of the vehicle. The trough will be covered with a high temperature, low loss dielectric material to provide a zero drag surface and a transparent window for the radiators. The radiators will consist of folded dipoles spaced evenly around the circumference and fed in phase. A nearly uniform field will be produced around the vehicle with nulls fore and aft. Balanced to unbalanced matching transformers will be provided to permit the use of standard coaxial cable for connection to the transmitter. The trough will be v-shaped and will be designed to carry the entire stress load around the antenna cavity. Silver plating will reduce the surface losses and raise the radiation efficiency of the antennas. Gaskets will be provided to allow for differential expansion to protect the dielectric from breakage.

(c) Programmer

A programmer is supplied as part of the vehicle electronics subsystem incorporating a mechanical clock which provides an overall accuracy of one second. This programmed sequencing system provides for initiation of the data read-in cycle, for pointing the data link (read-out) antenna and for alerting the microwave beacon transponder. The purpose of the clock is to operate the gate which permits stored commands to be read out of the programmer. A constant speed motor driving a contactor and counter make possible the timing accuracy indicated.

(d) Telemeter

A Lockheed designed FM/FM telemetering system which has a capacity of 15 continuous channels plus 3 commutated channels operating in the standard 220 mc band will be provided. A newly developed 15 watt RF transmitter which is currently being used on the RTV program will be used. Initially, this transmitter will read out data concerning vehicle performance and, in particular, environmental characteristics of the test situation. As the program progresses, it is anticipated that the telemeter will monitor the operation of ferret and visual reconnaissance equipment which will form part of the payload subsystem. It will eventually phase out as the system becomes operational.

(e) Destruct Equipment

Range safety, operational and diplomatic requirements indicate the need for a destruct system. The destruct equipment will be capable of destroying the vehicle either by programmed on-board commands, by commands transmitted to the vehicle over the radar or radio command links, or from internal indications of need for destruction.

(2) State-of-Art Feasibility

The airborne equipment is within the state of the art although special consideration must be given to the difficult antenna design problems, the problem of obtaining adequate beacon performance, and the radio noise effects on high sensitivity beacon receivers. Long service life and operation within primary power limitations will be the major developmental problems.

(3) Environmental Factors

The temperature extremes and other environmental factors encountered are no more severe than in the case of other missile programs where similar electronic equipment is used. The beacon and telemeter in particular are presently operational, at least in part, in other programs. No unusual difficulties are anticipated. Overall vehicle environment is discussed in the Appendix to Vehicle Electronics.

(4) Special Development Tests

Standard development test techniques are required in developing the beacon transponder and portions of the other equipment. Limited aircraft flight tests are required for the development of the command receiver, airborne beaconry, and some antenna evaluations, particularly in regard to low-angle propagation effects through the troposphere.

The STV and OTV programs will supply valuable test data applicable to the various development tasks. Environmental factors and propagation effects in particular will be investigated in these tests.

(5) Related Equipment Affected by Development Tests

The Vehicle Intercept and Control Ground Station equipment tests and the Air-to-Ground Data Link are intimately associated with the Vehicle Electronics equipment test program.

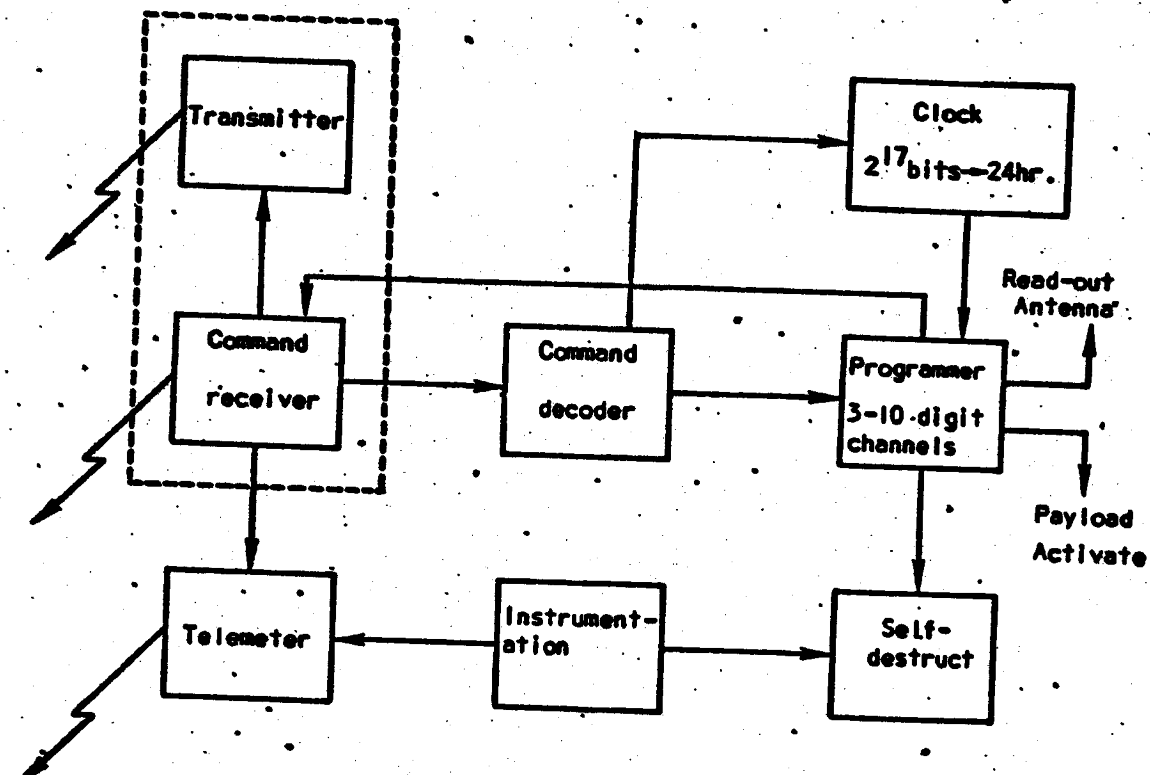
(6) Reliability

The telemeter has been used in several other Lockheed programs including the RTV. Other equipment will employ standard "good design practice" plus top-level engineering type maintenance.

(7) Special Installation Considerations

Vehicle Electronic equipment will be installed in the vehicle to permit adequate air-conditioning and maintainability.

The antenna installation will be unique, particularly when one considers the multiplicity of Ferret antennas in addition to beacon, command receiver, telemeter, and data link antennas involved. An integrated design including extensive model tests will be utilized in the antenna program.



Vehicle Electronics, Simplified Block Diagram

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Subsystem H - VEHICLE ELECTRONICS

Tab 2

I. Summary Program Milestones

1 Radar Beacon - Transponder
2
3 S-Band (250 w)
4
5 S-Band (2 kw)
6
7 C-Band
8
9
10 Command Receiver
11
12
13 Programmer
14
15 Telemeter
16
17 FM/FM
18
19 PAM/FM
20
21 Destruct System
22
23 Range Safety
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25 Orbital
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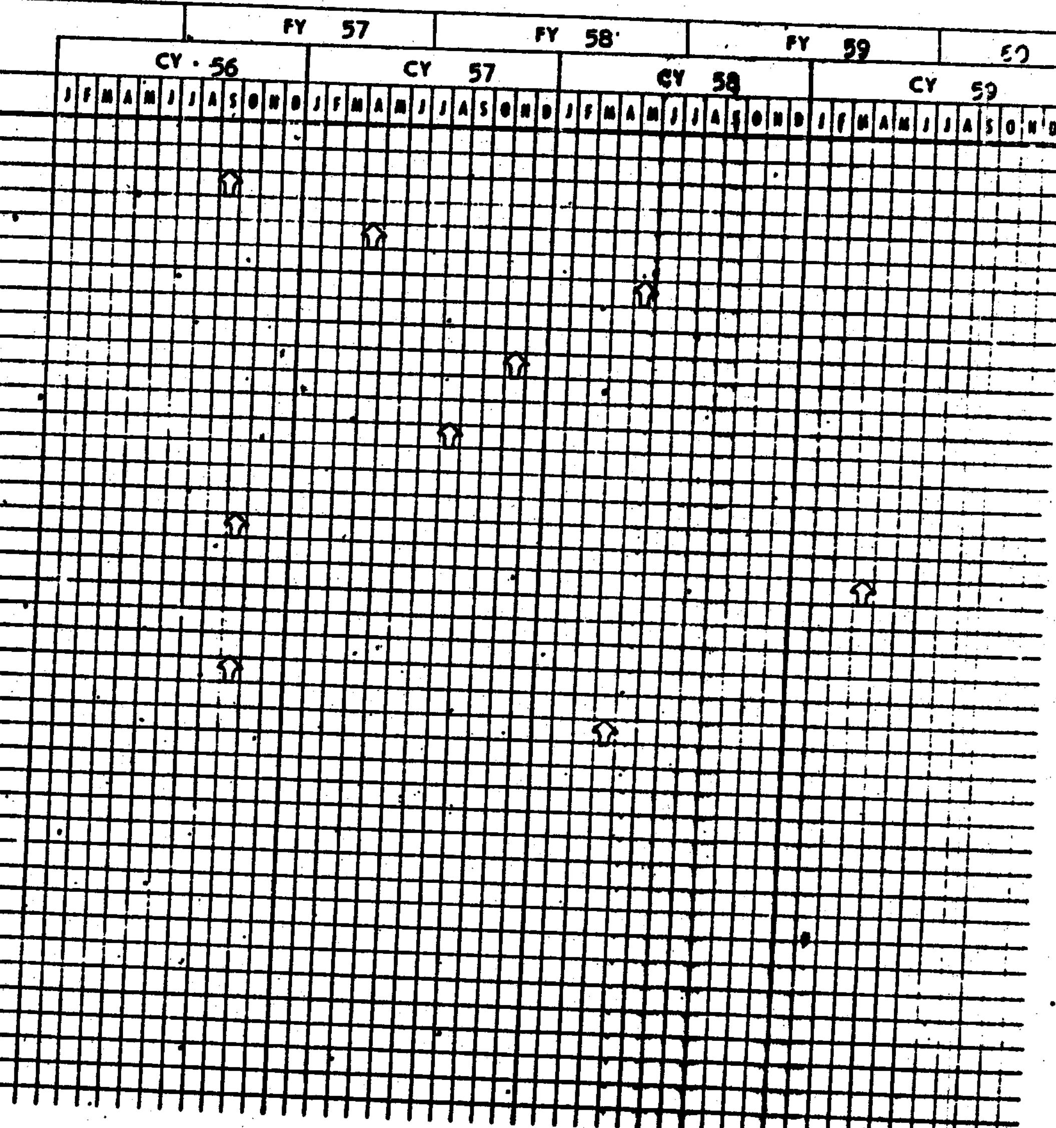

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Subsystem H - VEHICLE ELECTRONICS

Tab 2

II. Summary, Hardware Deliveries

(FY 57: Jul 1956 – Jun 1957; FY 58: Jul 1957 – Jun 1958; FY 59: Jul 1958 – Jun 1959)

CY 56

			J	F	M	A	M	J	J	A	S	O	N	D
1	Task 1	Radar Beacon - Transponder												
2		S-Band (250 w) (9)												
3		S-Band (2 kw) (17)									1	1	1	1
4		C-Band (94)												
5														
6														
7	Task 2	Command Receiver (104)												
8														
9														
10														
11	Task 3	Programmer (104)												
12														
13														
14														
15	Task 4	Telemeter												
16														
17		LAC FM/FM (45)												
18													1	2
19		PAM/FM (75)												
20														
21														
22	Task 5	Destruct System												
23														
24		Range Safety (35)												
25														
26		Orbital Destruct (80)										1	1	2
27–39														

CY 57

			J	F	M	A	M	J	J	A	S	O	N	D
1	Task 1	Radar Beacon - Transponder												
2		S-Band (250 w) (9)												
3		S-Band (2 kw) (17)	1	1	1	1	1							
4		C-Band (94)												
5						1	1	1	2	2	2	2	2	1
6														
7	Task 2	Command Receiver (104)												
8														
9									1	1	2	2	2	3
10														
11	Task 3	Programmer (104)												
12														
13									1	1	2	2	2	3
14														
15	Task 4	Telemeter												
16														
17		LAC FM/FM (45)												
18			2	2	2	2	2	2	2	2	2	2	2	2
19		PAM/FM (75)												
20														
21														
22	Task 5	Destruct System												
23														
24		Range Safety (35)												
25														
26		Orbital Destruct (80)	2	2	2	2	2	2	2	2	2	2	2	2
27–39														

CY 58

			J	F	M	A	M	J	J	A	S	O	N	D
1	Task 1	Radar Beacon - Transponder												
2		S-Band (250 w) (9)												
3		S-Band (2 kw) (17)												
4		C-Band (94)												
5			1	1	1									
6														
7	Task 2	Command Receiver (104)				1	1	1	1	2	2	2	2	2
8														
9			3	3	3	3	1	1	1	1	1	1	1	1
10														
11	Task 3	Programmer (104)												
12														
13			3	3	3	3	1	1	1	1	1	1	1	1
14														
15	Task 4	Telemeter												
16														
17		LAC FM/FM (45)												
18			2	1	1	1	1	1	1	1	1	1	1	1
19		PAM/FM (75)												
20														
21														
22	Task 5	Destruct System												
23														
24		Range Safety (35)												
25														
26		Orbital Destruct (80)	2	2	1	1	1							
27														
28														
29						1	1	1	1	1	1	1	1	1
30–39														

CY 59

			J	F	M	A	M	J	J	A	S	O	N	D
1	Task 1	Radar Beacon - Transponder												
2		S-Band (250 w) (9)												
3		S-Band (2 kw) (17)												
4		C-Band (94)												
5														
6														
7	Task 2	Command Receiver (104)	2	2	2	2	2	2	1	1		*		
8														
9			1	1	1	1	1	1	1			*		
10														
11	Task 3	Programmer (104)												
12														
13			1	1	1	1	1	1	1			*		
14														
15	Task 4	Telemeter												
16														
17		LAC FM/FM (45)												
18			1	1	1	1	1	1	1					
19		PAM/FM (75)												
20														
21														
22	Task 5	Destruct System				2	2	3	2			*		
23														
24		Range Safety (35)												
25														
26		Orbital Destruct (80)												
27														
28														
29			1	1	1	1	1					*		
30–39														

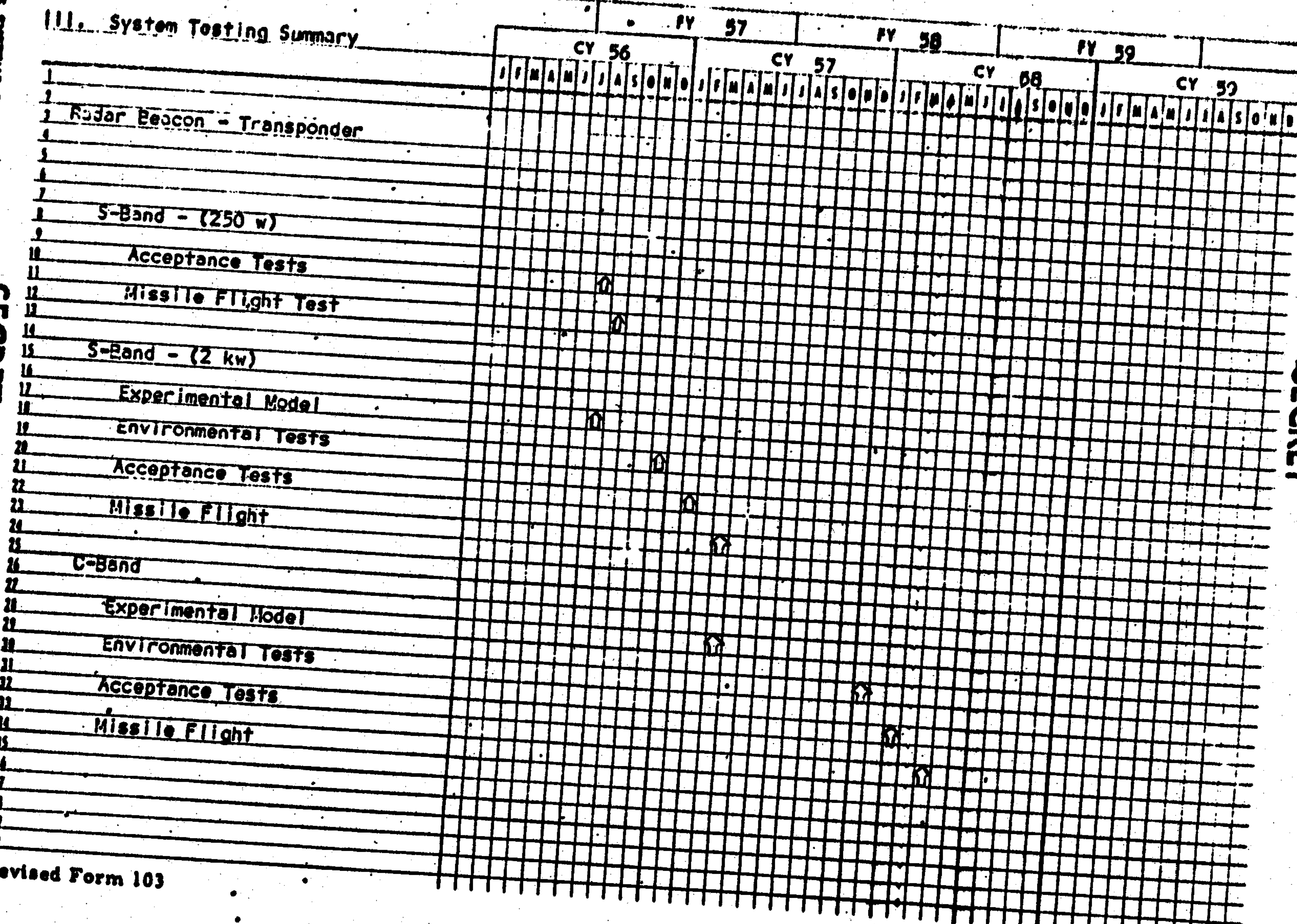
* Continuing program requirement: 66 units delivered at rate of 1½ per month

Revised Form 103

Subsystem H - VEHICLE ELECTRONICS

Tab 2

III. System Testing Summary



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