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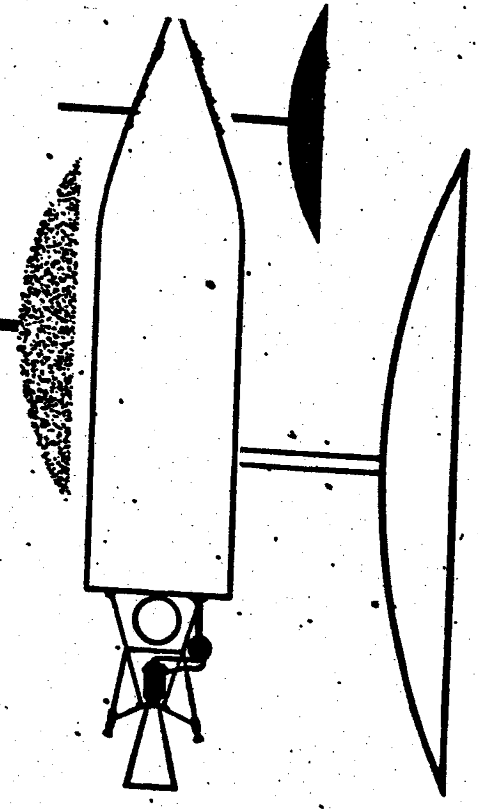

Pied Piper
DEVELOPMENT PLAN

RESTRICTED DISTRIBUTION
Approval for release must be obtained from WDTR

VOL. II SUB-SYSTEM PLAN

H. Vehicle Electronics

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LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
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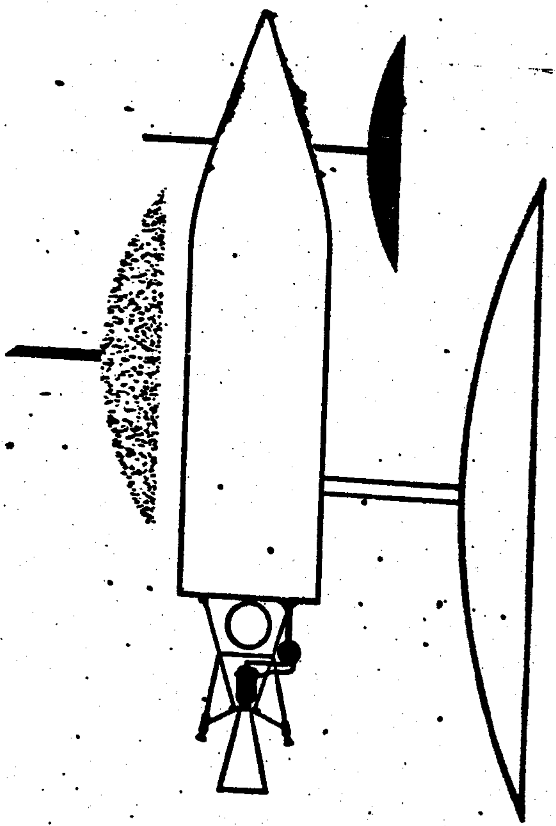

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H. Vehicle Electronics [U]

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LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
VAN NUYS, CALIFORNIA

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56WCLR 5471

~~SECRET~~

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 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:

9. DIRECTING AGENCY:

OFFICE SYMBOL:

TELEPHONE NO.:

10. REQUESTING AGENCY:

11. PARTICIPATION, COORDINATION, INTEREST:

12. CONTRACTOR AND/OR LABORATORY: Lockheed 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. 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

RSD PROJECT CARD
CONTINUATION SHEET

~~SECRET~~
SECURITY CLASSIFICATION

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

21 a. Brief Characteristics

The Vehicle Electronics subsystem provides the means for ground control of the ABS 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.

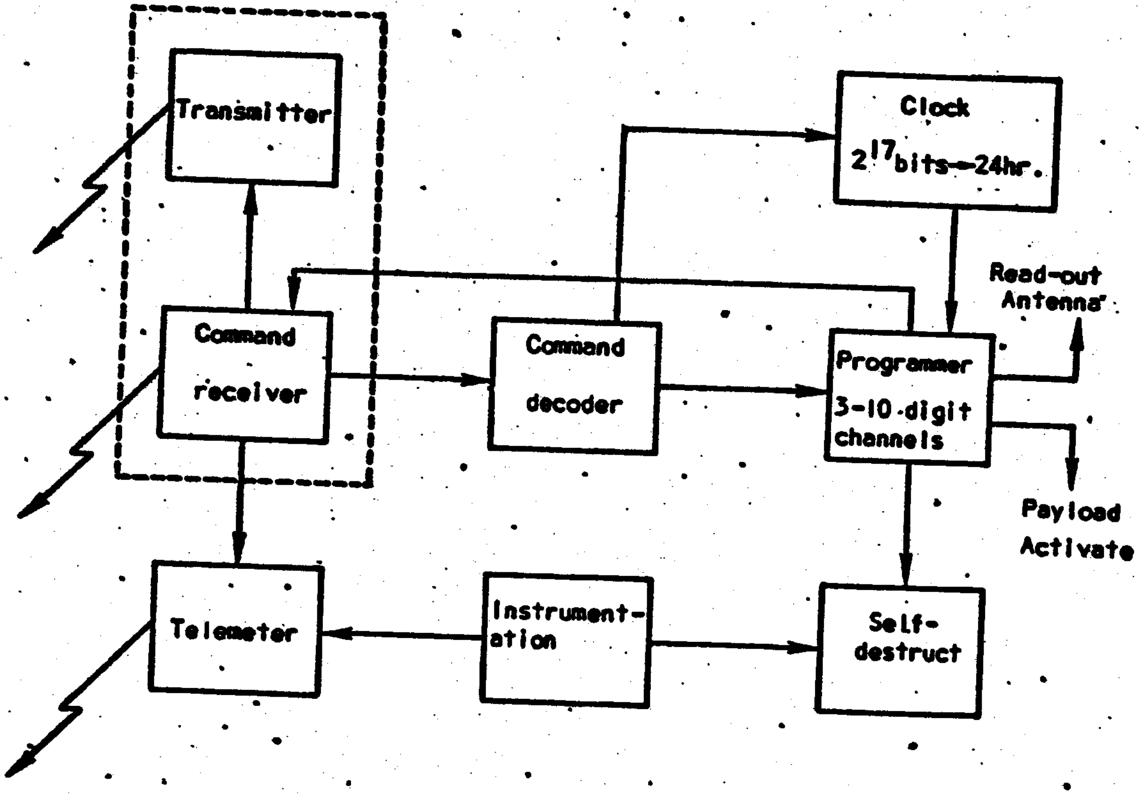
(6) Reliability

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

1. Summary Program Milestones

Radar Beacon - Transponder

S-Band (250 w)

S-Band (2 kw)

C-Band

Command Receiver

Programmer

Telemeter

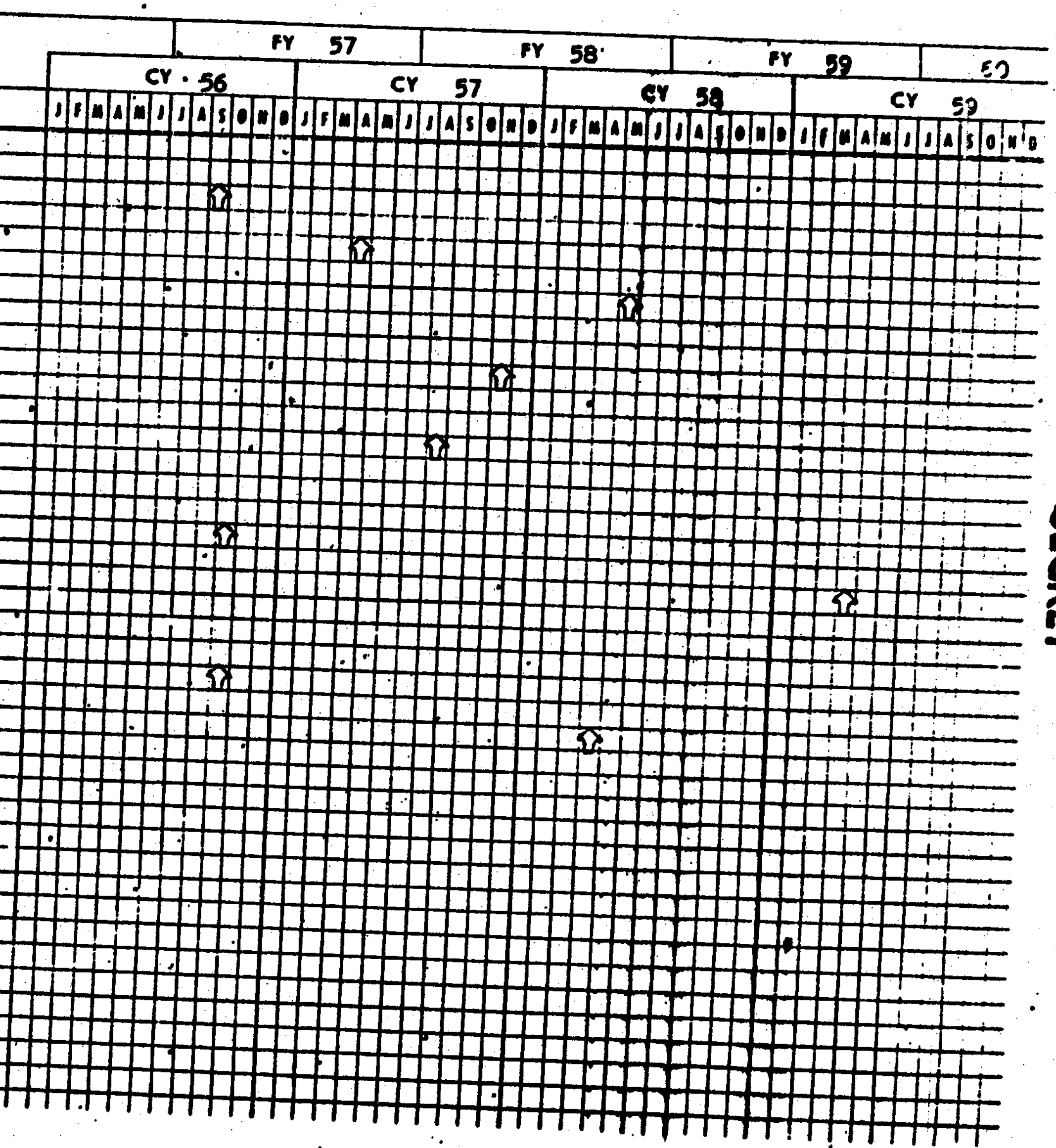
FM/FM

PAM/FM

Destruct System

Range Safety

Orbital



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Subsystem H - VEHICLE ELECTRONICS

Tab 2

II. Summary, Hardware Deliveries

Task	Item	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
								FY 57												FY 58					
		CY 56												CY 57											
Task 1	Radar Beacon - Transponder																								
	S-Band (250 w) (9)									1	1	1	1	1	1	1	1	1							
	S-Band (2 kw) (17)																1	1	1	2	2	2	2	2	1
	C-Band (94)																								
Task 2	Command Receiver (104)																				1	1	2	2	2
Task 3	Programmer (104)																				1	1	2	2	2
Task 4	Telemeter																								
	LAC FM/FM (45)									1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
	PAM/FM (75)																								
Task 5	Destruct System																								
	Range Safety (35)									1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Orbital Destruct (80)																								

Task	Item	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
								FY 59																	
		CY 58												CY 59											
Task 1	Radar Beacon - Transponder																								
	S-Band (250 w) (9)																								
	S-Band (2 kw) (17)	1	1	1																					
	C-Band (94)				1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	1	1			*	
Task 2	Command Receiver (104)	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			*	
Task 3	Programmer (104)	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			*	
Task 4	Telemeter																								
	LAC FM/FM (45)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
	PAM/FM (75)																	2	2	3	2			*	
Task 5	Destruct System																								
	Range Safety (35)	2	1	1	1																				
	Orbital Destruct (80)				1	1	1	1	1	1	1	1	1	1	1	1	1	1						*	

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

Revised Form 103

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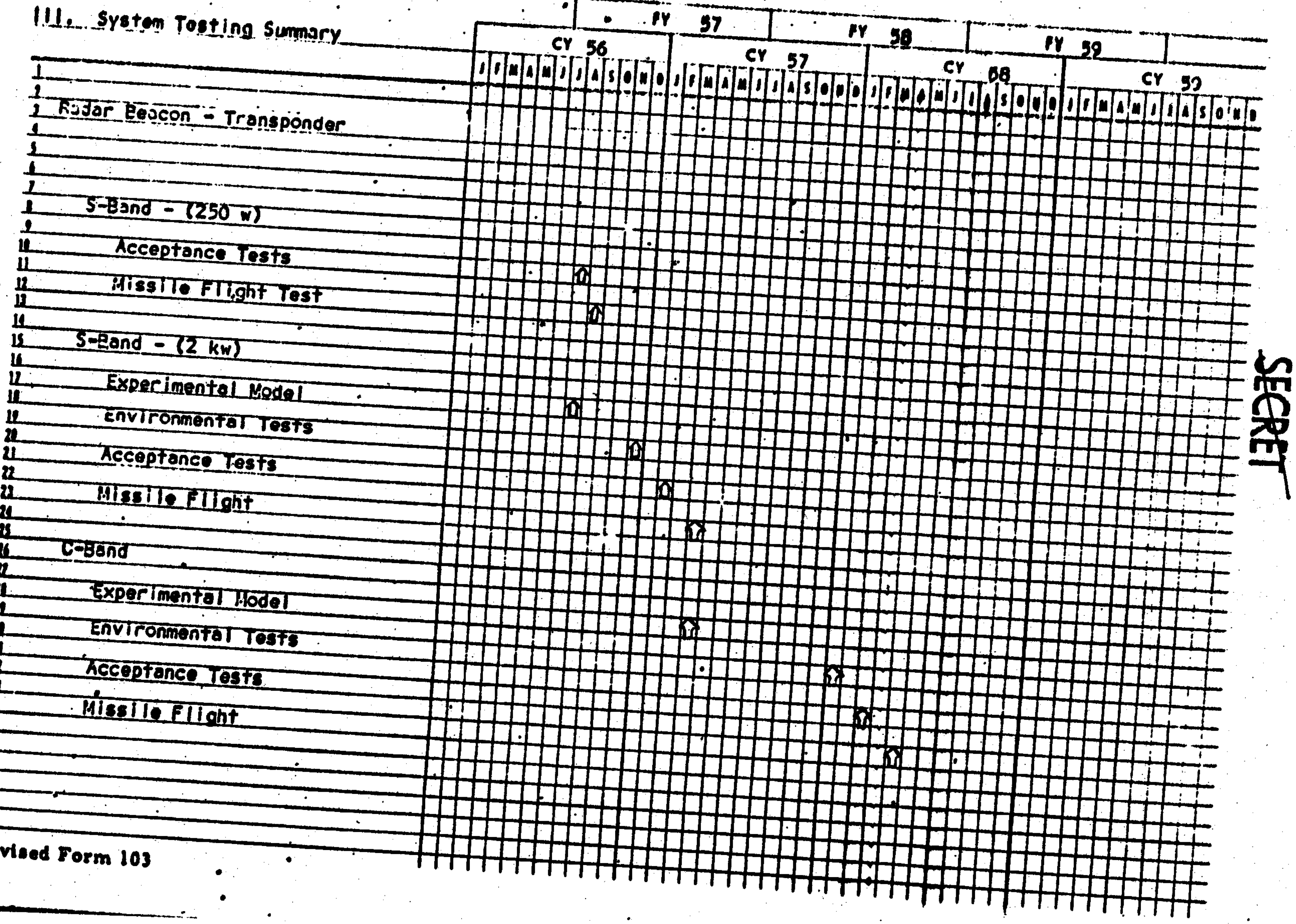
Subsystem H - VEHICLE ELECTRONICS

Tab 2

III. System Testing Summary



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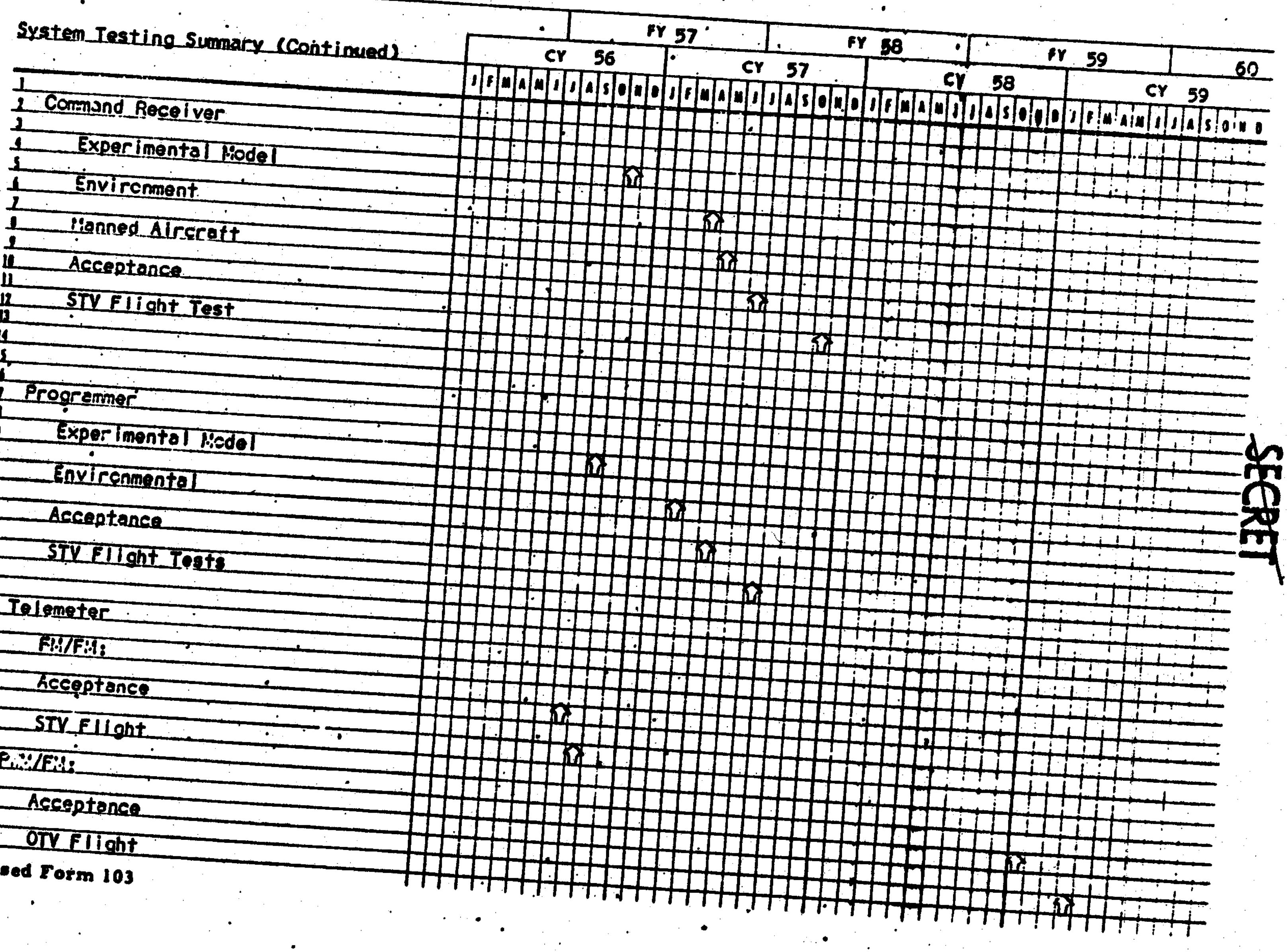
Tab 2

System Testing Summary (Continued)

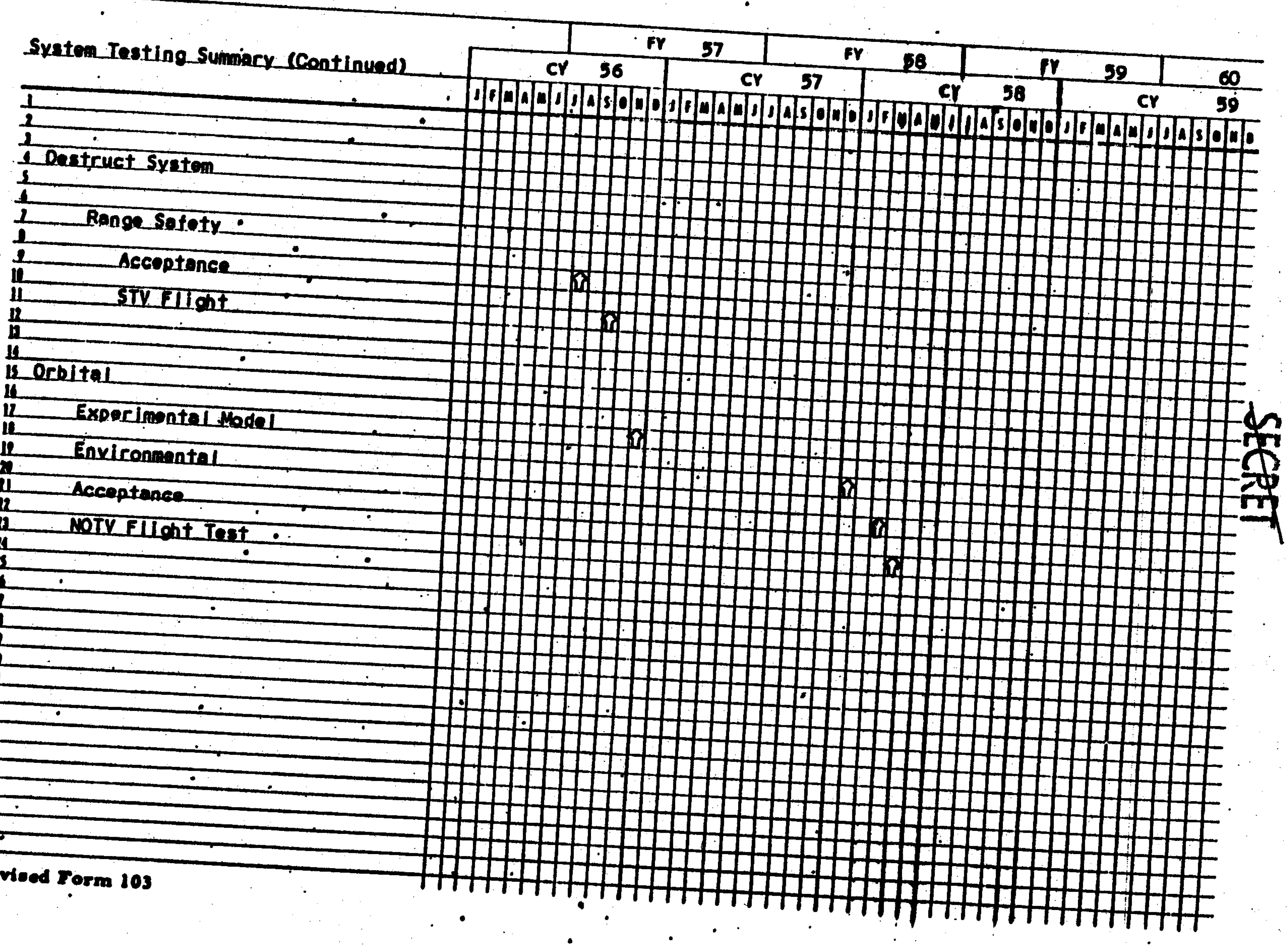


Revised Form 103

Subsystem H - VEHICLE ELECTRONICS

Tab 2

System Testing Summary (Continued)



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1\.

R & D TEST ANNEX

☐ SYSTEM ☐ PROJECT ☒ TASK ☐ OTHER

2\. REPORTS CONTROL SYMBOL

PAGE 1 OF 5 PAGES

3\. DATE 1 March 1956

4\. TITLE BEACON TRANSPONDER

5\. INITIAL ☒ CHANGE

6\. NUMBER

7\. RESP CENTER

8\. PROJECT OFFICER

9\. SUPPORTS (Sys or Proj) ARS

10\. CONTRACTOR LOCKHEED MSD

11\. CONTR NO

12\. PRIORITY AND PREC

13\. SECURITY ~~SECRET~~

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
1.	MSD S-Band Beacon (250 w)	Acceptance Missile Flight Tests	MSD Research Labs. AFMTC	July 1956 Sept, 1956	Sept. 1956 Jan. 1957
2.	MSD S-Band Beacon (2 kw)	Experimental Tests Environmental Tests Acceptance Test Missile Flight Tests	MSD Research Labs. " " " " " " AFMTC	July 1956 Sept, 1956 Jan. 1957 April 1957	Aug. 1956 Dec. 1956 Feb. 1957 July 1957
3.	C-Band Beacon (Type to be determined)	Experimental Tests Environmental Tests Acceptance Tests Missile Flight Tests	MSD Labs. " " " " AFMTC	Feb. 1957 Nov. 1957 Apr. 1958 May 1958	April 1957 Jan. 1958 Mar. 1958 Aug. 1958

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 2 OF 5 PAGES

3. DATE: 1 March 1956

4. TITLE: COMMAND RECEIVER

5. INITIAL ☒ CHANGE

6. NUMBER: 1

7. RESP CENTER:

8. PROJECT OFFICER:

9. SUPPORTS (Sys or Proj): ARS

10. CONTRACTOR: LOCKHEED MSD

11. CONTR. NO:

12. PRIORITY AND PREC:

13. SECURITY: ~~SECRET~~

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
1.	Command Receiver	Experimental Tests	CBC Labr.	Sept, 1956	Nov. 1956
		Environmental Tests	MSD Research Lab.	Feb, 1957	Apr. 1957
		Manned A/C Test	AFMTC	May 1957	July 1957
		Acceptance	"	July 1957	Aug. 1957
		STV	"	Aug, 1957	Nov. 1957

TEST CENTER APPROVAL

20. NAME: ORGANIZATION:

21. NAME: ORGANIZATION: DATE

DATE

RESPONSIBLE CENTER APPROVAL

22. NAME: ORGANIZATION: DATE

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1.

R & D TEST ANNEX

☐ SYSTEM ☐ PROJECT. ☒ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 3 OF 5 PAGES

3. DATE 1 March 1956

4. TITLE PROGRAMMER

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj) ARS

10. CONTRACTOR LOCKHEED MSD

11. CONTR NR

12. PRIORITY AND PREC

13. SECURITY ~~SECRET~~

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
1.	Programmer - MSD Design	Experimental Tests	MSD Research Lab	Aug. 1956	Oct. 1955
		Environmental Tests	" "	Feb. 1957	Mar. 1957
		Acceptance Test	AFMTC	Apr. 1957	May 1957
		STV Flights	"	Aug. 1957	Oct. 1957

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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II-Tab 3, p 3

1. **R & D TEST ANNEX** ☐ SYSTEM ☐ PROJECT ☒ TASK ☐ OTHER		2. REPORTS CONTROL SYMBOL PAGE 4 OF 5 PAGES
		3. DATE 1 March 1956
4. TITLE AIRBORNE TELEMETER	5. INITIAL ☒ CHANGE ☐	6. NUMBER

7. RESP CENTER	8. PROJECT OFFICER	9. SUPPORTS (Sys or Proj)	10. CONTRACTOR	11. CONTR NO	12. PRIORITY AND PREC	13. SECURITY
		ARS	LOCKHEED MSD			~~SECRET~~

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. REQ TEST COMPL DATE
1.	MSD Telemeter LAC-FM/FM	Acceptance Tests STV Flight	AFMTC "	Aug, 1956 Sept, 1956	Sept. 1956 Oct. 1956
2.	Telemeter Advanced PWM/FM	Acceptance Tests OTV Flight	AFMTC "	Nov, 1958 Apr, 1959	Jan. 1959 June 1959

TEST CENTER APPROVAL

20. NAME	ORGANIZATION	DATE
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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1.

R & D TEST ANNEX

☐ SYSTEM ☐ PROJECT ☒ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 5 OF 5 PAGES

3. DATE 1 March 1956

4. TITLE DESTRUCT SYSTEM

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj) ARS

10. CONTRACTOR LOCKHEED MSD

11. CONTR NO

12. PRIORITY AND PREC

13. SECURITY ~~SECRET~~

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
1.	Range Safety Destruct	Acceptance STV Flight	MSD Research Lab AFMTC	July 1956 Oct. 1956	Aug. 1956 Dec. 1956
2.	Orbit Vehicle Destruct	Experimental Test Environmental Test Acceptance Test NOTV Flight Test	MSD Research Lab " " " AFMTC "	Dec. 1956 Nov. 1957 Jan. 1958 Apr. 1958	Aug. 1957 Jan. 1958 March 1958 July 1958

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.

~~SECRET~~

~~SECRET~~

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 March 1956

4\. TITLE VEHICLE ELECTRONICS SUBSYSTEM - ARS

5\. INITIAL ☒ CHANGE

6\. NUMBER

7. ITEM NUMBER	8. AIRCRAFT REQUIRED QTY	TYPE, MODEL AND SERIES	SERIAL NUMBER	9. [illegible] CODE	10. [illegible]	11. [illegible] AND LOCATION	12. [illegible] RELEASE DATE	13. RECOMMENDED DISPOSITION	14. [illegible]	15. [illegible]
1	1	[illegible]				* Jan. 1957 Sunnyvale Calif. Then — → Patrick AFB., Fla.	July 1958		[illegible]5 hours every 3 months	

* Aircraft to be used to Flight Test Beacon, Programmer, Data Link, and other airborne components. Extent of modification to be determined and indicated in bailment agreement.

Aircraft to be shared with other ARS subsystem development, e.g. Visual and Ferret Reconnaissance Test Programs.

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

~~SECRET~~

1.

R & D MATERIEL ANNEX

☒ SUB-SYSTEM ☐ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE OF PAGES

3. DATE 1 March 1956

4. TITLE VEHICLE ELECTRONICS SUBSYSTEM - ARS

5. INITIAL ☒ CHANGE ☐

6. NUMBER [illegible]

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

No special materiel required at this time. Development program review may result in specialized equipment requirements at a later date.

ARDC FORM 1 JUL 55 107 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

~~SECRET~~

SUBSYSTEM ARS - VEHICLE ELECTRONICS

DATE 1 March 1956

ITEM:

LOCATION: AFMTC

USING AGENCY:

BUDGET CONTROL ESTIMATE:

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:

The facilities for Vehicle Electronics Research and Development and Pre-Flight check-out will employ existing MSD Facilities and the AFMTC ARS facilities shown in the Facilities Annex of the Vehicle Ground Support Subsystem Plan.

REMARKS:

Revised Form 108

Tab 7

R & D Contracts Funds

Subsystem H - Vehicle Electronics

Subsystem N. VEHICLE ELECTRONICS

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

		FY 57				FY 58				FY 69			FY 60	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LAC														
(1) Research and Engineering	45	76	100	131	168	199	234	260	280	295	324	358	339	353
(2) Fabrication	110	110	113	190	190	211	265	297	297	218	214	214	159	223
Purchased Components	42	42	42	72	72	72	87	94	94	64	64	64	39	62
Sub Total	198	228	255	393	430	483	587	652	673	580	603	638	537	646
CRS	42	42	42	46	58	62	72	84	97	109	122	115	137	172
Total excluding Fee	240	271	297	440	488	546	659	737	777	680	726	753	674	818
Fee	24	27	29	44	48	54	65	73	77	68	72	75	67	82
TOTAL* including Fee	265	299	328	485	538	601	726	811	855	731	799	829	741	900
Total Fiscal Year			1,377				2,676				3,834			
*Differences in totals due to rounding														

Subsystem E. VEHICLE ELECTRONICS

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

	FY 60		FY 61				FY 62				FY 63			TOTALS
	15	16	17	18	19	20	21	22	23	24	25	26	27	
LAC														
*(1) Research and Engineering	429	444	469	449	454	409	354	359	372	352	357	292	218	8,200
(2) Fabrication	187	312	347	295	305	332	242	266	247	355	449	108	-0-	6,272
Purchased Components	53	91	99	86	89	96	59	66	63	87	110	86	-0-	1,855
Sub Total	670	849	917	832	850	840	658	693	683	796	918	486	219	16,324
CUE	229	284	362	359	359	342	302	240	312	317	394	394	207	5,308
Total excluding Fee	900	1134	1279	1192	1210	1182	960	933	995	1113	1313	880	426	21,633
Fee	90	113	128	119	121	118	96	93	100	111	131	88	43	2,162
TOTAL* including Fee	990	1247	1407	1311	1331	1300	1056	1026	1095	1224	1444	969	469	23,797
Total Fiscal Year	3878				5349				4401				2082	

*Difference in totals due to rounding

Tab 8

Estimate of Manpower Requirements

Subsystem H - Vehicle Electronics

Subsystem E VEHICLE ELECTRONICS

Tab 8 Estimate of Manpower Requirements

WORK ITEM	Type of Manpower	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		- QUARTERS -													
LAC - Research and Development	1-2-3 *	9	15	19	25	32	38	46	51	55	58	65	72	68	72
LAC - Fabrication and Assembly	4	31	31	31	52	52	58	75	84	84	62	62	62	46	65
Sub-total		40	46	50	77	84	96	121	135	139	120	127	134	114	137
CBS - Scientific and Engineering	1	6	6	6	6	6	6	6	7	7	7	8	8	9	11
CBS - Engineering Support	2	0	0	0	1	3	4	6	7	9	10	11	11	14	18
CBS - Manufacturing	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total		6	6	6	7	9	10	12	14	16	17	20	19	23	29
Total		46	52	56	84	93	106	133	149	155	137	147	153	137	166

*Average

40% Type 1 Scientific and Technical

50% Type 2 Engineering Support

10% Type 3 Management and Administration

MSD 1536

Subsystem E VEHICLE ELECTRONICS

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		
LAC - Research and Development	1-2-3 *	86	89	94	90	91	82	71	72	74	80	71	70	41		1628
LAC - Fabrication and Assembly	4	54	90	100	85	88	96	70	77	71	108	129	31	0		1788
Sub-total		140	179	194	175	179	178	141	149	145	178	200	101	41		3416
CBS - Scientific and Engineering	1	14	16	21	20	20	19	17	16	17	17	22	22	11		332
CBS - Engineering Support	2	25	33	41	42	42	40	35	24	37	38	46	46	25		568
CBS - Manufacturing	4	0	0	0	0	0	0	0	0	0	0	0	0	0		
Sub-total		39	49	62	62	62	59	52	40	54	55	68	68	36		900
Total		179	228	256	237	241	237	193	189	199	237	268	169	79		4316
*Average																
40% Type 1 Scientific and Technical																
50% Type 2 Engineering Support																
10% Type 3 Management and Administration																

~~SECRET~~

Pied Piper

MSD 1536

Military Only

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

APPENDIX

~~SECRET~~

Subsystem H - VEHICLE ELECTRONICS

APPENDIX

The following tasks, comprising the Vehicle Electronics Subsystem, are discussed in this appendix:

1. Radar Beacon-Transponder
2. Command Receiver
3. Programmer
4. Instrumentation and Telemeter
5. Destruct System

These tasks, together with the tasks discussed in other subsystems on Visual and Electronic Reconnaissance, cover the major electronic and electro-mechanical portions in the vehicles.

1. RADAR BEACON - TRANSPONDER

The S band SCR-584 type, AFMTC Mod. II tracking radar equipment[1] operates with a variety of available crystal video beacons. These beacons developed initially during World War II and subsequently modified and redesigned, provide receiver sensitivities of the order of -45 dbm and transmitter peak powers in the 250 watt region. One beacon, the AN/DPW-1, uses a transmitter having a 2 kw peak power, and employs a superheterodyne receiver with a sensitivity of approximately -70 dbm. This unit is not packaged for missile use, however.

Lockheed, with the subcontracting assistance of Stewart-Warner, is developing a new S band beacon for use in the Lockheed MSD X-7B missile test program. This development, now well advanced, will provide a superheterodyne plus a 250 watt transmitter. The new MSD beacon will be used in the initial phases of Pied Piper.

Beacon antennas initially will have to be designed for maximum coverage and very little, if any, gain. As the program advances, up to 10 db gain can be picked up in beacon antenna design, assuming predictable vehicle attitude control. This, plus added attention to maintenance, and the selection of components, will compensate for the somewhat marginal beacon capability. Later, higher powered versions of the MSD beacon will be developed if suitable 1-2 kw tubes become available.

---

[1] See Appendix to Subsystem Plan J.

As the program continues and the C-band AN/FPS-16 (XN-2) tracking radar is used, beacons developed by Canoga Corp. or by RCA in connection with TALOS will be investigated.

2. COMMAND RECEIVER

2.1 General

The command receiver is perhaps the most vital single piece of ~~equipment to be carried in the satellite. The command receiver keeps~~ the satellite from responding to random radar interrogations by keeping the beacon transponder turned off except when the proper command signal is sent on the command frequency. In addition, the command receiver controls the programmer and resets the vehicle clock every 90 minutes to keep timing errors from accumulating from orbital pass to orbital pass. In the event of station difficulties this may go as long as 5 or 6 hours. The command receiver also controls the vehicle data transmitter keeping it off except during the few minutes of contact time (6-12 minutes) with a friendly ground station.

Possible failure of the programmer makes it desirable to have the command receiver on continuously during the early flights relying on secrecy of command frequency and control tones to prevent the enemy from interrogating the vehicle. On later flights after the programmer has proved itself, the command receiver can be so programmed as to be on only while over friendly territory. The requirement for continuous operation of the receiver makes low power consumption a matter of primary importance. It would be desirable to use transistors; however, the uncertainty of the cosmic ray environment plus the lack of data concerning transistor tolerances to cosmic rays rules them out for the early vehicles. In addition, while high temperature silicon transistors are available there are still no transistors known which will function at very low temperatures. The use of an electric heater to keep the transistors at an operating temperature level would probably take more power than the filaments of the tubes replaced by the transistors.

2.2 Receiver Specifications

2.2.1 R. F. Circuitry

The command receiver will be a crystal controlled superheterodyne operating in the 100-250 mc region. The receiver will be sensitive to FM, incorporating double limiters to remove extraneous AM. The IF band width will be ± 100 kc, and the limiter discriminator band width will be ± 500 kc to allow operation under severe multiple path interference as may exist when the satellite is near the horizon. A one microvolt signal across the 70 ohm antenna input should produce 20 db of quieting on a 0-15 kc noisemeter measurement made at the discriminator output terminals. An RF amplifier will be used ahead of the mixer, both to achieve the required sensitivity and to reduce the image response. The final choice of IF frequency will be a compromise between gain available with standard subminiature filamentary type tubes and image attenuation which should be at least 60 db.

The receiver tube line-up required to meet the above specifications is as follows: 1 RF amplifier, 1 crystal oscillator, 2 IF amplifiers, 2 limiters, 1 discriminator, 2 audio amplifiers.

A common filamentary tube type such as the 1 AD 4 can be used for all positions. Allowing 0.5 watt per tube the receiver will require less than 5 watts of power.

2.2.2 Command Circuitry

The command functions of the receiver will be handled by frequency selective reed relays driven by the audio output amplifier of the receiver. These relays have Q's of better than 100 in the range of 60 - 400 cps and have the advantage of requiring no standby power. The tuned relays in pairs will control mechanical latching relays, one tone to actuate the latching relay, another to deactuate it. These latching relays will in turn control the tape recorders, film read-out, etc. One tuned relay, however, will function as a master relay and will directly control the power supplied to the vehicle beacon and data transmitters preventing them from operating unless a continuous command time is being received. The high Q of the relay will prevent rapid signal fades from turning off the satellite transmitters unintentionally.

The frequency band from 400 cps to 15 kc will be separated by a filter and sent to the visual antenna servo system as it is in this frequency band that the servo loop subcarriers will be transmitted.

The total continuous power requirement for the command receiver and relays will be 10 watts or less.

3. PROGRAMMER

3.1 General

Many different systems of programming the electronic portions of the vehicle are possible. Almost any of the various memory devices already developed for computers, such as punched paper tape, magnetic tape, magnetic drums, ferrite cores, and electrostatic storage tubes, could be used. In general, these devices can be assembled into systems with far greater information storage capacity than will be required in the beginning.

For the earlier vehicles, reliability of the programmer is certainly of the utmost importance. The programmer should control the very minimum of functions since another possibility of failure is introduced with each additional function. The probability of failure for the programmer must be far less than that for any of the individual units controlled. It should be designed in such a manner that possible environmental extremes, namely, cosmic rays, magnetic fields, and extreme heat, are unlikely to cause failure.

In view of the above, it would seem that the best solution would be a mechanical device which uses a minimum of electronic components. Clock-type devices can be made very reliable and extremely rugged as shown by their use in artillery shells. In the event of failure, the programmer should fail safe; i.e., fail in the condition that gives the most useful output from the vehicle.

3.2 Pioneer Vehicle Programming

For the earlier vehicles, at least, the problems which the programmer must solve are quite simple. It must turn on the reconnaissance system and disable its command circuits when the vehicle is over enemy territory. Then, when the vehicle is over the United States, it must turn on the command circuit and allow the ground station to take over. If several orbital circuits should take place without ground contact being established, the beacon transmitter will be activated in the vehicle to allow easier location from the ground.

Under normal conditions the programmer clock will be reset on each orbital circuit to prevent the accumulation of timing errors. Since the vehicle will fly at about five miles per second, a one-second error in the clock would result in a five-mile positional error for the reconnaissance data. Taking the average orbital time to be about 90 minutes, the accuracy required is 1 part in 5,400. Since the clock will not be subjected to high vibrations or high g loads during operation, a simple mechanical escapement should suffice.

Fig. 3-1 shows in block form the system as presently envisaged. The output cam is driven at a rate of one revolution per 80 minutes; the shaft driving it contains a solenoid-actuated reset which is controlled in turn by a tone F from the command receiver. The time between leaving U. S. territory and arriving over enemy territory would nominally be less than 80 minutes and would vary with each orbital circuit. To allow

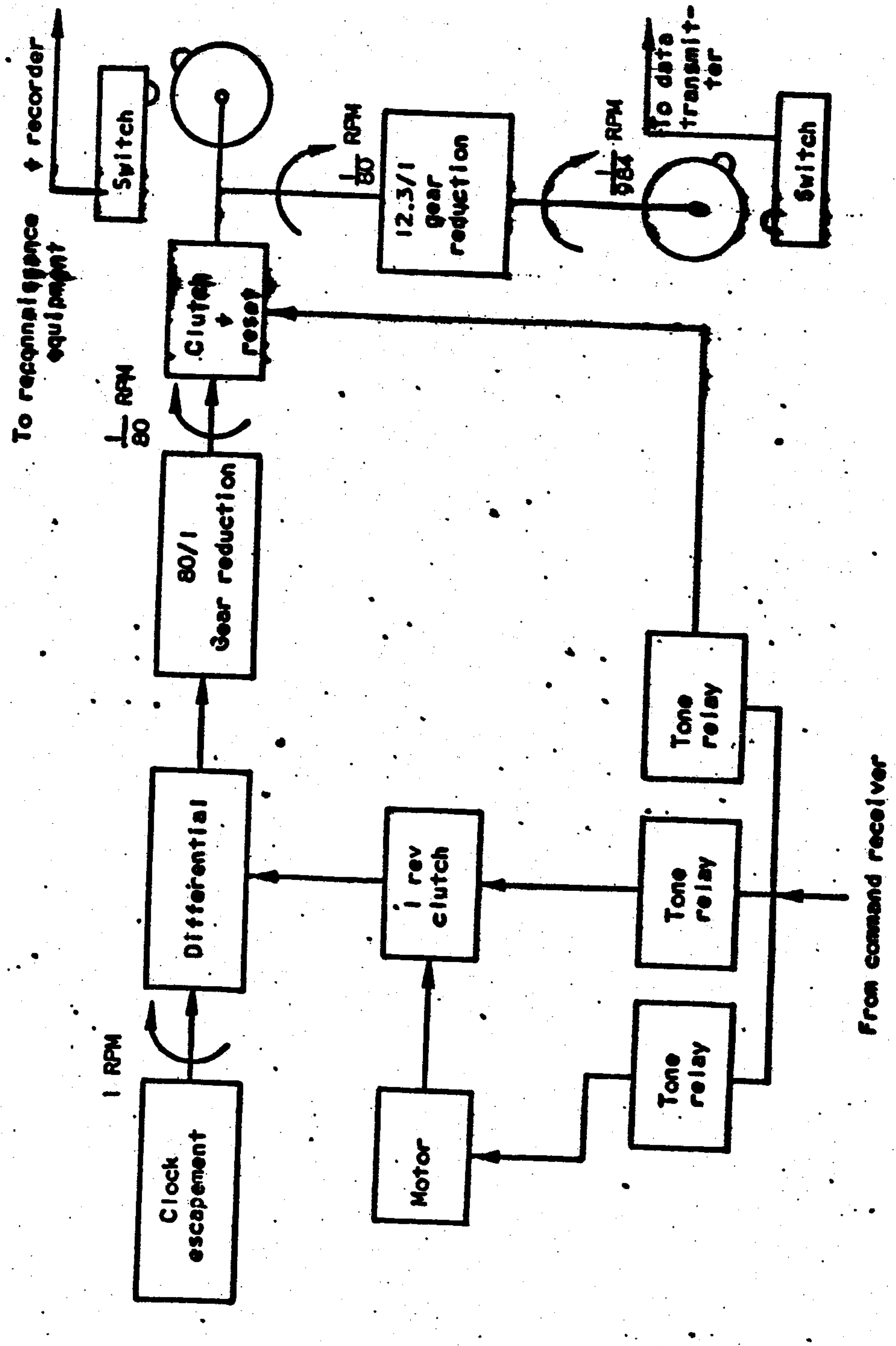

Fig. 3-1 Programmer

for this time variation, a differential unit can insert discrete numbers of revolutions into the 1 rpm shaft upon the receipt of a different tone F_2 from the command receiver. Thus, it is possible for the ground station to advance the time of closing of the output switch to coincide with the entry of the vehicle over enemy territory.

A signal from the ground station turns on the data transmitter in the vehicle. After ground recognition is established, an additional tone turns on the data read-out. Just before contact time ends, the proper tones are sent to reset the clock mechanism. An additional tone turns off the command receiver to prevent the enemy from assuming control of the programmer while the vehicle is over enemy territory. If several orbital circuits are made with no ground contact, the overtime cam closes and turns on the data transmitter which serves as a permanent beacon until contact is regained.

For more complex operations, a programmed sequencing system will be required to provide for initiation of the data read-in cycle, for pointing the read-out antenna, and for alerting the microwave transponder-command receiver.

The detailed nature of the ARS operating cycle, i.e., short periods of contact followed by long periods without contact, makes it desirable that the programmer be capable of accepting several commands at the time when they are first conceived. In this way an interruption in operations would not prevent the vehicle from receiving a command which has been held for transmission until the time of data contact which immediately precedes the scheduled command execution. On the other hand, a random access memory capable of handling all of the commands for several days operation would be undesirably complex. For this reason, a sequential storage system will be employed.

This proposed programmer is a punched tape system in which commands are stored as a function of the time for execution, Fig. 3-2. The commands are transmitted in the sequence for execution. At each data contact, the program stored in the vehicle is canceled out and a new program (consisting of (1) the unused program still required and (2) any new commands in proper sequence) is transmitted.

The program provided is simple in its initial form. Reconnaissance read-in is commanded on a time signal. The data link antenna is commanded to its acquisition azimuth and the transponder-command receiver is activated from a single time signal.

The information required from the command link and programmer may be estimated for a single orbit (90 min) period as follows:

Functions	Modes
1. Camera Stop and Start	2
2. Transponder Activation	1
3. Antenna Acquisition Azimuth	1
	4

These commands may be given for a 0.35 degree resolution in azimuth with 10 binary digits and a 1.6 mile resolution in position with 14 binary

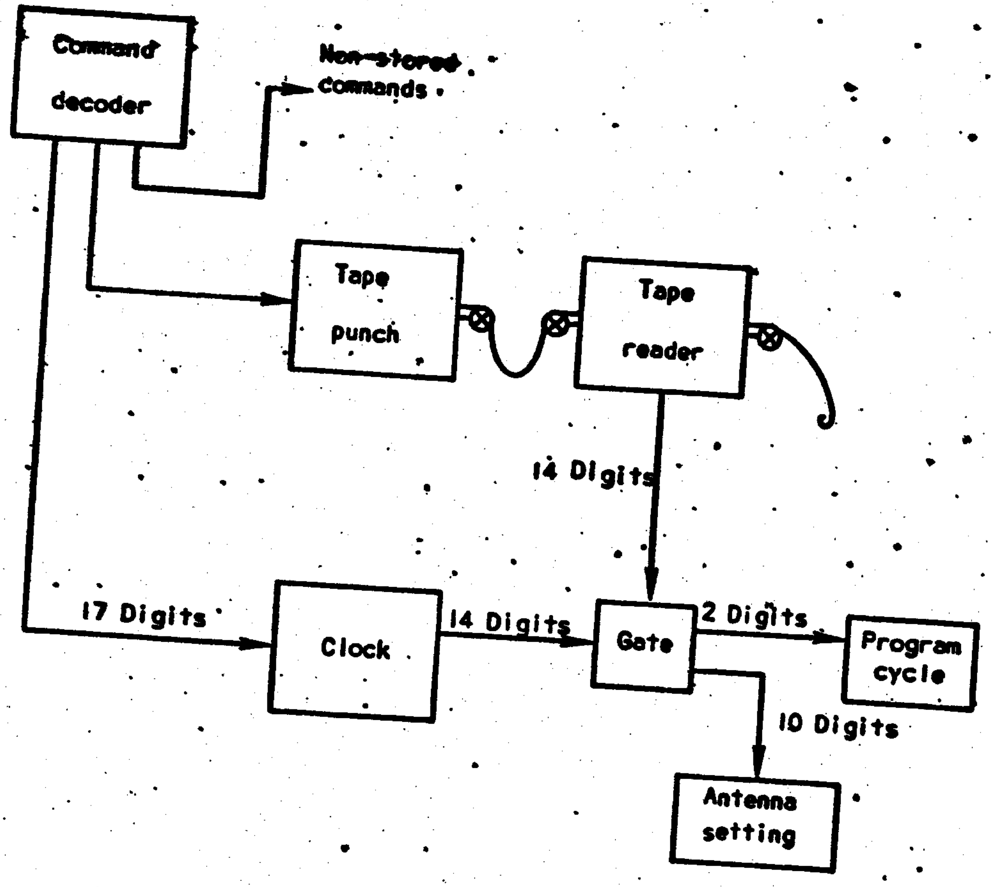

Fig. 3-2 Programmer, Storage System

digits. Time corrections of one second accuracy with 24 hour unambiguous notation require 17 binary digits. Storage requirements may be estimated if commands are transmitted for the next five passes together with a time signal accurate to one second, about 300 digits must be transmitted to the vehicle for storage on each contact.

A standard teletype roll of 2500 ft length has seven data holes per row and may store as much as two million bits of data. Accordingly, a 10 row tape of the same length would store nearly 3 million bits. If these are used at the rate of 400 bits for each data contact, this storage would be adequate for about two years of operation.

A lost vehicle search mode will be activated if the programmer is ever exhausted of stored instructions. In this mode the transponder will be activated continuously.

3.3 Advanced Programmer for Later Vehicles

Economic and security considerations make it undesirable to operate payload components at all times; advanced payload configurations may include several mode changes together with some high resolution directional properties. Therefore, data read-in and read-out functions should be programmed to function only during those periods when useful data are expected. In this way, power consumption can be maintained at a minimum and the amount of useful data being received and transmitted is kept at a high level.

This section will examine the payload programming problems and suggest several considerations to be treated.

The variables which can serve as the basis for a payload program are:

1. Geographic location and time
2. Receipt and recognition of coded signals
3. Receipt and recognition of specific kinds of data
4. Ambient conditions of heat, light, etc.

For many data read-in functions satisfactory programming requires only start and stop signals according to geographic location. From a knowledge of the orbit parameters, geographic location can be related directly to these parameters; time programming will therefore be satisfactory.

In addition to straight read-in, read-out and stop-start programming, special commands for detailed examination of specific areas at high resolution can be issued from time to time. Since these commands will be generated as a result of military requirements or as the result of data gained in previous passes of the vehicle, it is unlikely that they will be originated in such a way that a sequential read-in and sequential read-out system will be feasible without some means of intermediate storage.

If, for example, a picture received of the Leningrad area, reveals data which indicates that small portions of this area should be examined in more detail as soon as possible, a command might be prepared to shift to longer focal length lenses and to point the camera in the appropriate direction the next time this area is photographed. This command cannot be transmitted to the missile immediately after preparation unless it can be received and stored in such a way as to be read-out in the same sequential order that it should be executed. If this storage capacity is not available in the vehicle, the command cannot be transmitted until it can be placed in proper sequence during the read-out pass immediately preceding the desired execution. A minor command link failure might require that execution be delayed for another full cycle of the reconnaissance system. Consequently, a random, or rapid access, storage system is very desirable in the vehicle programmer.

Some functions will be programmed for performance only upon receipt of a coded signal; e.g., the data read-out; specialized reconnaissance in the neighborhood of radio signals of known properties, whether enemy or friendly; and general changes of payload cycling. This type of programming might be used to economize on power consumed and also to reduce the quantity of uninteresting data which must be processed by the ground data system. A modification of this programming function might be applied to the actual reconnaissance data received. In such a system the reconnaissance data can be compared against special recognition masks or filters to generate the coded signal. Changes in ambient conditions of heat and light can be used as a basis for commanding changes in the payload functioning, film processing, etc.

Examples of the many functions to be programmed and the corresponding number of settings are given in the following tabulation:

Payload Functions	No. of Stations
1. Camera stop and start	2
2. Change camera orientation	6
3. Corrections to attitude control system	10
4. Position data read-out antenna for future contacts	12
5. Functional emphasis of ferret	(derived from functions 2 and 3)
6. Data read-out stop and start	2
TOTAL	$32 = 2^5$

In order to store commands for these various functions to be executed at the proper minute, i.e., within 300 miles of a designated point and within the succeeding $2\frac{1}{2}$ days (60 hours), it would be necessary to divide the time interval into 3600 parts. Such a program of 32 different functions (see above) could be stored in a memory matrix of capacity of $32 \times 64 \times 64 = 2^{17}$ bits. Nearly 500 coded signals and ambient conditions would be available and could be set up to activate the program to perform any of these changes in payload state. A vehicle-borne memory of this capacity could be built, say, of magnetic cores, so that random or immediate data access and read-in could be employed. Memories of this kind have been described in MSD 1336 (Ref. 1).

4. INSTRUMENTATION AND TELEMETERING

Instrumentation of the Pied Piper in the early phases of the program will be used to determine subsystem performance, environmental conditions and geophysical data required for design information. An FM/FM telemetering system consisting of 15 channels, including three commutated channels will be utilized for transmission of this information to the ground receiving stations. In later phases when the system is operational the telemetering will be simplified to handle quantities which would monitor environment and reasons for failures. The limitations imposed on the amount of instrumentation to be utilized are the space and power available.

4.1 Design Philosophy

The Proposed Flight Test Program for the Pied Piper vehicle requires a telemetering system capable of monitoring vehicular functions in both the booster and orbital stages in order to guarantee, as nearly as possible, satisfactory performance of these vehicles. In the event of failure of a vehicle the telemeter will provide data to determine the nature of the difficulties.

For the orbit test vehicle program, the telemeter must be capable of transmitting the specialized geophysical and environmental conditions associated with the varied Pied Piper Flight Program. A high degree of accuracy and versatility is required in the early phases of the program to furnish design information for the final vehicle. It is further planned, by judicious location of ground equipment, and the use of on-board recording techniques to provide telemeter information over the non-orbiting flight paths, and in the case of the orbiting vehicles, to the maximum extent possible. Separate telemetering equipment in both the booster and orbiting stages is planned.

The instrumentation requirements dictate a combination of telemetering channels, some continuous and some commutated. Vibration, acceleration, pressure, and other items practically dictate the use of an FM/FM system with 1000-5000 cps response on two or three channels, at least in the early test program and up to the point where the vehicles perform as planned. In later phases of the program a PWM/FM system is recommended from the standpoint of overall system efficiency.

4.2 Equipment

The initial FM/FM system is planned on the basis of Lockheed developed equipment which is used successfully in the various X-7 vehicles as well as in modified form in the Lockheed RTV program. Performance records of the systems operation show the following characteristics:

HIGH ACCURACY. Telemetered data reproducible within an accuracy of ± 1%.

VERSATILITY. Extremely flexible and adaptable to a wide variety of information quantities.

HIGH RELIABILITY. Accuracy and failure-free operation, maintained to a high degree by extensive use of in-flight calibration, redundant circuits, and other techniques designed to increase reliability.

OPERATION UNDER SEVERE ENVIRONMENTAL CONDITIONS. Designed with rugged components with low microphonic sensitivity to withstand high amplitude shock and vibration.

RAPIDITY. Rapid presentation of data by means of complete automatic data reduction equipment.

By means of the telemetering system described, information on temperature, pressure, acceleration and other quantities of interest is transmitted by radio to the ground. Radio receivers in a ground station detect and amplify the signals from the airborne telemeter transmitter. The output of the radio receiver consists of a number of frequency modulated tones. This is also the case with the radio frequency carrier used to convey the signal to the ground. The tones from the receiver are applied to magnetic tape recorders which make permanent recordings, used as a data source in all subsequent data-reduction operations. Each of the tones is called a subcarrier and the radio frequency operating range for each tone is called a subcarrier channel.

The FM/FM system is flexible and versatile in the amount and type of information that can be telemetered and is relatively insensitive to atmospheric and man-made interference.

The automatic data reduction system permits quick, accurate processing of large quantities of telemetered data. The frequency modulated data signals on magnetic tape are converted to a digital count by a special electronic method. This method has several advantages over the more commonly used analog methods which convert the frequency modulation into an analogous voltage output. The electronic digital process utilizes the ratio between the data signals and a reference frequency recorded on the magnetic tape to obtain digital data, which are then punched on cards with the exact time at which data samples were taken. Because the data signal and the reference frequency are recorded on the same magnetic tape, the accuracy of the data reduction process is not affected by variations in the speed of the magnetic tape transport mechanism, and a simple playback device can be used.

The ground equipment will consist initially of existing and presently operated facilities at AFMTC. The receiver sensitivity (including preamplifier and multicoupler) of -100 dbm, the helical antenna gain of 18 db, and the proposed transmitted power of 15 Watts will result in good telemeter signals up to a transmission range of 300 miles, which is adequate for the STV flight tests. However, for later phases which include OTV flight tests, where 1500 mile transmission range is required, certain modifications of existing station equipment are required. These modifications include: (1) the use of larger, high gain, steerable, receiving antennas of either the helical or parabolic type; and (2) the use of tie-in techniques with associated radar and optical tracking equipment in order to obtain an antenna gain of 28 db.

The following calculations describe the air-to-ground telemetering link for STV flights and OTV flights in terms of the parameters selected:

RF Frequency (Telemetry Band)	220 mc
Receiver RF Band Width	300 kc
Receiver Noise Figure (including Preamp and Multicoupler)	4 db
Minimum Signal Required at Receiver	-100 dbm
STV Flights	
Antenna Gain (Receiver)	18 db
Transmitter Power	15 (42 dbm)
Space Attenuation for 300-mile path	133 db
Estimated Safety Factor	

42 db + 18 db - 133 db + 100 db = 27 db

OTV Flights	
Antenna Gain (Receiver)	28 db
Transmitted Power	50 (47 dbm)

Space Attenuation for 2000-mile path 150 db

Estimated Safety Factor

47 db + 28 db - 150 db + 100 db = 25 db

The airborne telemetering system planned for the STV flights will consist of a maximum of 15 subcarrier channels with 3 channels commutated on a 30 point commutator at 5 rps. Transmission of approximately 100 information quantities can be made with this system. Standard RDB channels are contemplated with total RF deviation of ± 125 kc. Lockheed subcarrier oscillators, modulation amplifiers, and transmitter will be used in conjunction with a Rheem RF power amplifier capable of 15 watts power output at 220 mc. A block diagram of the system is shown in Fig. 4-1

Lockheed subcarrier oscillators can be used with a wide variety of transducers such as variable reluctance pressure, acceleration, and vibration pick-ups; strain gages; thermocouples; and voltage inputs. Performance data have shown long-term stability with wide variations in supply voltages and environmental conditions which is the result of a design incorporating adequate degenerative feedback, amplitude stabilization, careful selection of components, and independence between oscillator and the input circuit. Automatic in-flight calibration checks of the oscillator zero frequency and sensitivity are made to improve accuracy and determine reliability of data. Band

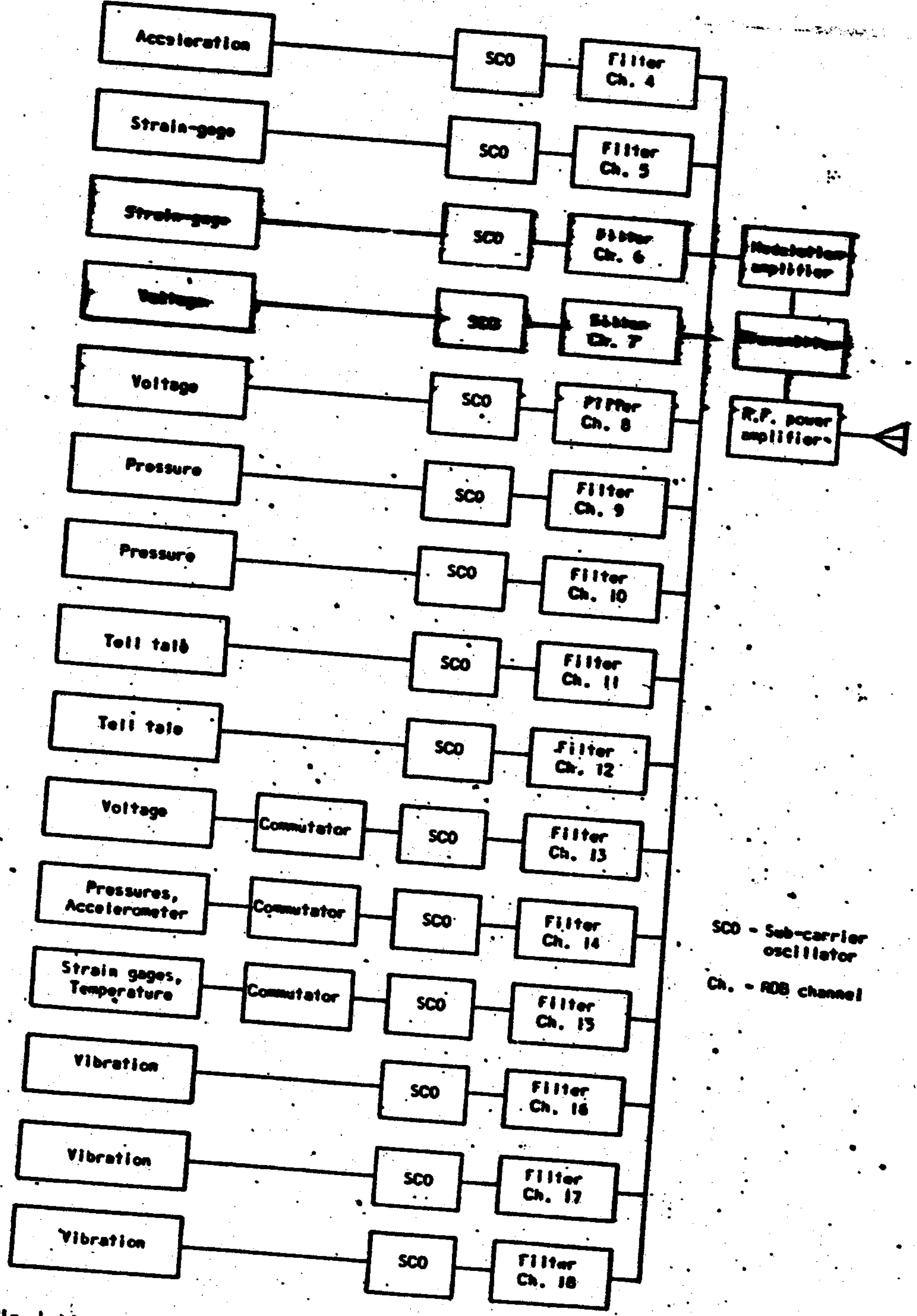

Fig. 4-1 Airborne FM/FM Telemetering System Block Diagram

pass filters are used in the output circuit of each subcarrier oscillator to reduce possible intermodulation between oscillators.

The modulation amplifier is a summing amplifier which combines the outputs of the sub-carrier oscillators and matches their impedance to the transmitter. RF deviation of the transmitter is controlled by a feedback adjustment on the modulation amplifier which varies the summing gain.

The Lockheed transmitter generates the radio frequency carrier which is frequency modulated by the sub-carrier oscillator signals. It is relatively free from distortion and noise under the most severe environmental conditions encountered during flight. These features are possible by the use of self-excitation and crystal control. The self-excited oscillator is a multivibrator type which can be frequency modulated over a wide range at a low carrier frequency. The multivibrator output is mixed with a crystal oscillator output to translate the signal to the high frequency region which is again mixed with the quadruple of the crystal oscillator frequency to translate the signal to the VHF region for further amplification in a two-stage amplifier.

The Rheem RF power amplifier is a ruggedized radio frequency amplifier capable of increasing the power output from the 2-watt transmitter to a level of 15 to 20 watts to be fed into the antenna. This output power level will be adequate for the STV flights with a transmission path of approximately 300 miles; however, for the OTV flights requiring a 1500 mile path, a power output of 50 watts will be required. Lockheed's X-7 RF power amplifier will be used to supply this added power to the antenna.

The approximate size, weight and power requirements for the 15 channel airborne telemeter system described above are as follows:

Size	1300 cu. in.
Weight	80 lb.
Power Requirements	250 w

As the flight program progresses many of the original environmental and geophysical information channels will not be required and the telemetering system size and power requirements can be reduced, considerably. For the OTV flights a second telemetering system as a part of the Atlas will be operated in the booster stage of the vehicle to measure quantities and operational sequences such as booster ignition, burn-out, and separation.

An airborne tape recorder of the type selected for the ferret recorder will be used for the OTV flights to record telemeter data during the portions of the flight when the vehicle is outside the range of the ground receiving stations. Recording time will be determined by a programmer which will select equal or critical segments of the orbit to monitor.

It is planned that the telemeter antenna will consist of four radiators located in a trough around the circumference of the vehicle, Fig. 4-2. 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 connecting 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.

If space, weight and fpower are available during the flight test program, dual RF systems will be utilized to increase the reliability.

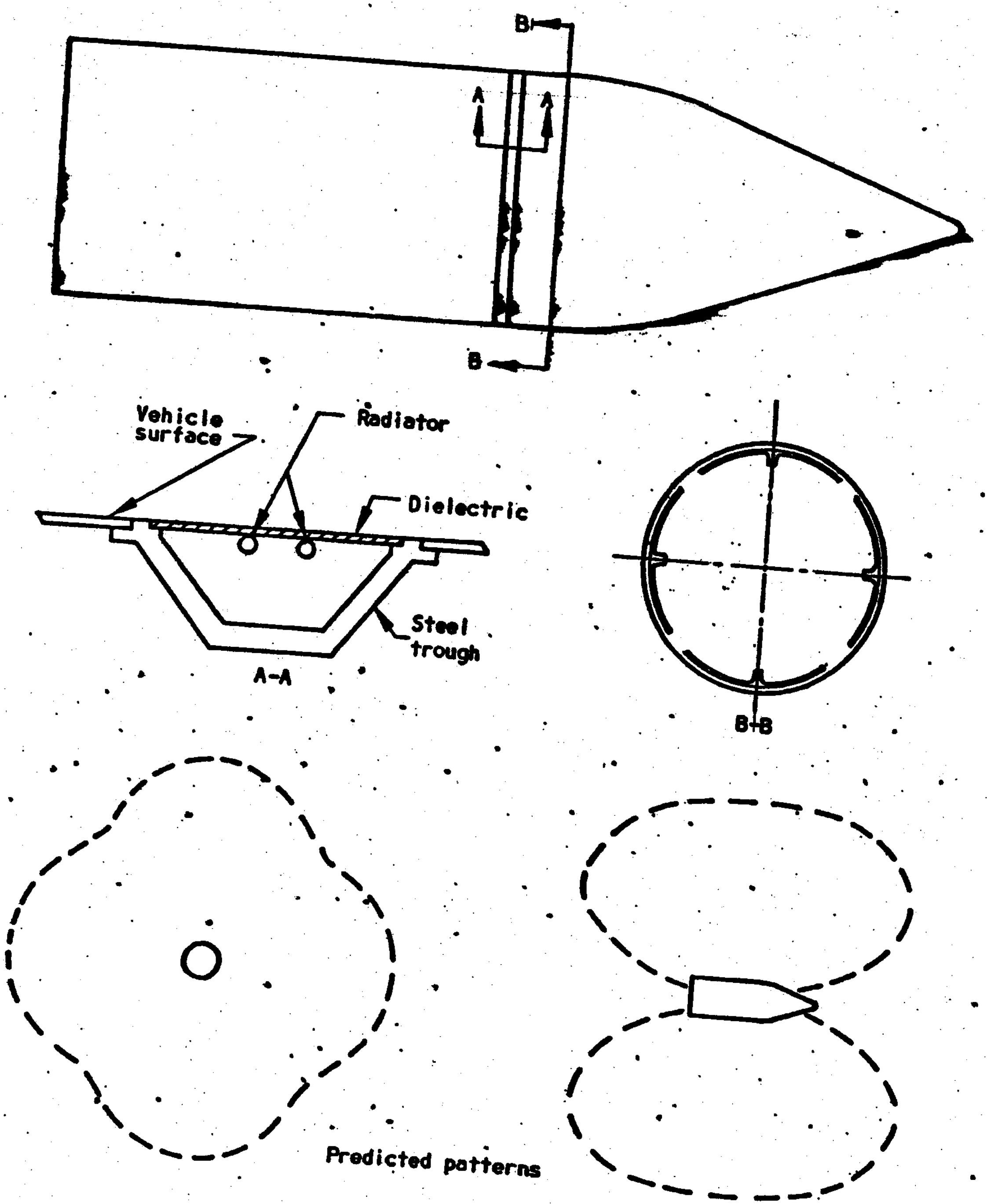

Fig. 4-2 Proposed Telemeter Antenna

5. DESTRUCT SYSTEM

Reference (2) specifies that a mechanism, suitable for the destruction of the system after it has passed its useful life, be incorporated into the system.

At the very first launching, the sovereignty of other nations will be invaded. In the event that no treaties exist (as would probably be the case with the USSR) it would be desirable to minimize damage and/or make identification impossible.

Diplomatic or military considerations may apply to the matter of destruction of an ARS vehicle and as a result it appears desirable to provide for a command control of the destruct system. This provision will cover the requirements of range safety when coupled with the booster destruct system and will also provide for compliance with possible diplomatic requirements.

Reference (3) discusses the problem of re-entry heating and suggests the degree to which a vehicle may be destroyed when it re-enters the dense atmosphere. Some of the results of this and earlier studies will be delineated in the following, but the differences between the ARS problem and others will be mentioned.

The velocity at which the ARS re-enters the atmosphere is approximately twice that of earlier studies on other programs. Moreover, the re-entry will be at a "glancing" angle (less than 10° with the horizontal) whereas other studies treated considerably steeper angles. Since the heat transfer function is nonlinear with respect to velocity and re-entry angle, we must be cautious in extrapolating to such different initial conditions.

The present design is such that the outer shell will come off fairly soon after re-entry, exposing internal mechanisms to the air-stream. At first glance, this would seem to insure that pieces would disintegrate and burn up. However, the high value of the drag-weight parameter is not conducive to higher temperature. When the outer shell comes off, it is not clear that the components will disintegrate. In fact, it can be assumed that components such as the helium sphere and the rocket nozzle will not burn up. Analysis of this problem would require much time and would have doubtful value; the kind of test program required would assume the proportions of the ARS program itself. Consequently, an explosive destruct system is considered necessary for insurance against dangerous and recoverable pieces falling on foreign territory.

Several items of interest need to be specified at this point as they will affect future discussion. There are differences exceeding 2000° F and 100 g acceleration during the re-entry portion of the falling trajectory and any phase of the ascent or orbit, that is, temperatures of less than 1000° F going up or in orbit (except for combustion chambers) and temperatures exceeding 3000° F coming down; and similarly for accelerations. This is particularly important with respect to the destruct system. Since the conditions of flight are reasonably uniform until the atmosphere is re-entered, at which time the environment is quite severe, these phenomena may be employed to actuate a destruction system.

Consideration must be given to three general areas: first, in the pre-launch and boost phase, second, in the orbit of the vehicle, third, counter-intelligence with respect to recovered pieces. Each of these contributes to the design of a destruct system for the ARS.

The system must be shock-proof, vibration-proof, tamper-proof, and it must not be subject to premature actuation by noise, temperature, or extraneous currents. Moreover, because of the lead time in assembly before firing, the destruct system may be required to remain inert for a considerable time before launching.

The possibility of premature or overriding destruct-by-radio signals from the ground must also be considered. Since this is a problem common to other areas in the ARS program, a uniform solution will probably be derived if necessary.

Much discussion may take place with respect to the fragmentation problem, particularly as it concerns the synthesis of components from recovered parts by intelligence agents. It is believed that, if adequate provision is made to protect life and property, the counter-intelligence aspects can be adequately provided for.

Use of temperature as intelligence is one means considered for the actuation of the destruct system. Fuzes would be electrically actuated, deriving their power from thermocouples. Preliminary estimates of iron-constantan and chromel-alumel thermocouples show that they would supply enough power. Both materials would be used, and connected in parallel since they hit peak power at different temperatures. In addition to supplying the power, a bi-metal temperature switch, set for a high temperature, would complete the fuze circuit. The problem of adequate shielding and proper wiring design would require some care in its solution. With electrical units in nearby operation, the possibility of extraneous generated currents must be minimized.

Finally, since it is planned to vent the LOX and JP-4 tanks after the main rocket motor is turned off, a normally closed, pressure actuated relay, tied in with the LOX or JP-4 tanks would insure (to a high degree of reliability) that premature actuation of the destruct system would not take place as long as these tanks were pressurized. Including ten pounds of explosives, it is estimated that the weight of thermocouples, switches, leads and support brackets would be about 18 pounds.

The use of the direction and magnitude of acceleration loads is an alternate means considered to actuate the destruct system. The sequencing is fairly simple in that the fuze may be armed during the boost phase or during the vehicle main rocket engine phase. Acceleration during all phases of the boost, transition, and final boost to adjust in orbit is a maximum of 5-7 g positive, and a minimum of 1 g negative. Negative accelerations will be of nominal value until the vehicle falls

REFERENCES

1. MSD 1336 Progress Report on Pied Piper, 4 Oct. 1955 (Secret)
2. Pied Piper Work Statement (Secret)
3. MSD Report 1399 dated 1 Nov. 1955 (Secret)
4. "Elements of Ordnance", T. J. Hayes, John Wiley & Sons, New York, 1938.
5. "Explosives & Demolitions", War Department Technical Manual FM5-25, U. S. Government Printing Office, Washington, D. C. 1945.