LMSD
1536
10-2-P4-F
C-3-P(F-36)

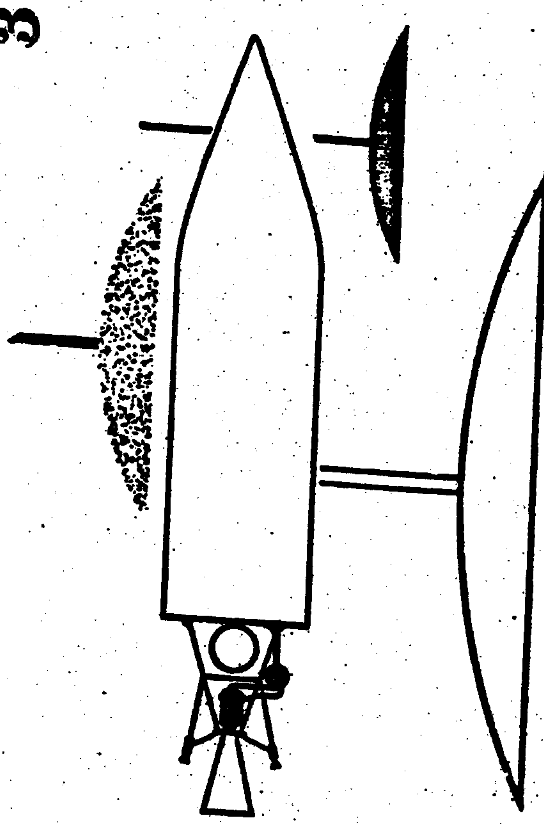
CONFIDENTIAL

Dnr 9-30-58
F158

LMSD 1536
Cy #36
83 sheets

LMSD 1536

370773



Pied Piper DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

F. Electronic Reconnaissance (S)

MSD-P LIBRARY
MAR 3 0 1966
TISIA - E

LMSC LIBRARY INVENTORY. Do not destroy. Return to L... or transmit to ... person or office.

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
VAN NUYS, CALIFORNIA

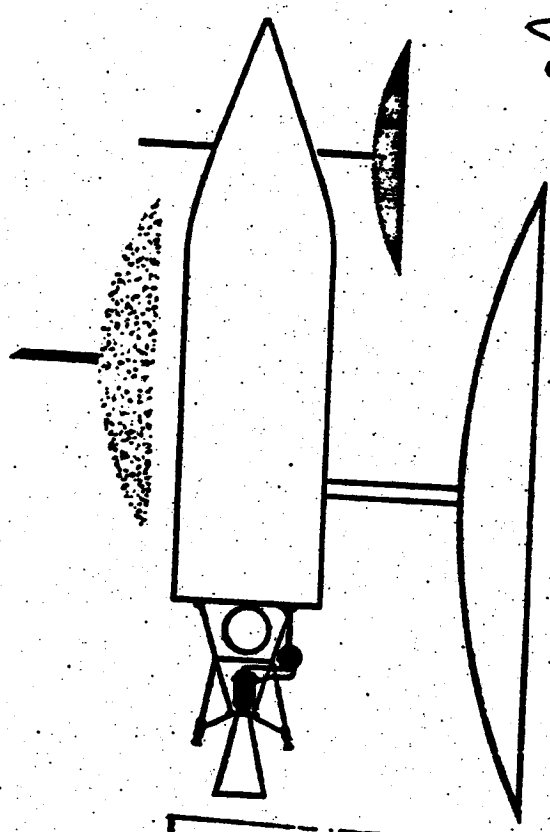
CONFIDENTIAL

DDC CONTROL
NO. 61213

CONFIDENTIAL

MSD 1536
1 MARCH 1956

COPY NO. 36
13 SHEETS



DOWNGRADED AT 12 YEAR INTERVALS;
NOT AUTOMATICALLY DECLASSIFIED
DOD DIR 5200.10

Pied Piper DEVELOPMENT PLAN

VOL II SUB-SYSTEM PLAN

F. Electronic Reconnaissance

TITLE CLASSIFICATION CHANGED TO SECRET IN ACCORDANCE WITH DOD DIR 5200.1 DATE: 6-13-61 INITIALS: [illegible]

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION
VAN NUYS, CALIFORNIA

CONFIDENTIAL

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18 U.S.C., SECTIONS 793 & 794. ITS TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

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)-3109. The plan is presented in two parts; Volume I, System Plan, and Volume II, Subsystem Plan. The subsystems are described in separate books, Volume II-A through II-L.

PIED PIPER DEVELOPMENT PLAN

VOLUME I. SYSTEM PLAN

VOLUME II. SUBSYSTEM PLAN

A. Airframe

B. Propulsion

C. Auxiliary Power

D. Guidance and Control

E. Visual Reconnaissance

F. Electronic Reconnaissance

G. Infrared Reconnaissance

H. Vehicle Electronics

I. Airborne Test Systems

J. Vehicle Intercept and Control Ground Station

K. Ground Data Processing

L. Vehicle Ground Support

CONTENTS

MSD 1536

~~SECRET~~
SECURITY CLASSIFICATION

RDB PROJECT CARD

TYPE OF REPORT

REPORTS CONTROL SYMBOL DD-RDB(A)48

1. PROJECT TITLE
ELECTRONIC RECONNAISSANCE SUBSYSTEM
~~FOR ADVANCED RECONNAISSANCE SYSTEM~~
(UNCLASSIFIED)

(PIED PIPER)

2. SECURITY ~~Secret~~

3. PROJECT NUMBER 1115

4. INDEX NUMBER

5. REPORT DATE 1 March 1956

6. BASIC FIELD OR SUBJECT

7. SUBFIELD OR SUBJECT SUBGROUP

7A. TECH. OBJ.

8. COGNIZANT AGENCY

9. DIRECTING AGENCY

OFFICE SYMBOL | TELEPHONE NO.

10. REQUESTING AGENCY

11. PARTICIPATION, COORDINATION, INTEREST

12. CONTRACTOR AND/OR LABORATORY
Lockheed 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. This subsystem is needed for the satellite since no comparable system is available, or in development. All prior systems involve reconnaissance from aircraft, and are concerned with problems of range, numbers of radars illuminated by and illuminating the vehicle, and physical environment, at orders of magnitude smaller than those of the satellite environment.

b. The reconnaissance capabilities will be of interest to SAC and ATIC. It also promises information of interest in the area of Electronic Countermeasures and strategic warning.

c. The ARS will provide knowledge of enemy military build-up, preparedness, capability, and possible intent. It will also provide a measure of enemy military and technolcgical progress.

22. RDB | SN | CN | RC & P | X | L | C

DD FORM 1 JAN 52 613

MISSILE SYSTEMS DIVISION

~~SECRET~~
SECURITY CLASSIFICATION

F - p 1

LOCKHEED AIRCRAFT CORPORATION

R3D PROJECT CARD
CONTINUATION SHEET

SECRET

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

21 a. Brief and Operational Characteristics

The Pioneer ferret equipment will provide a measure of electronic activity in the various enemy frequency bands. It identifies the approximate location, frequency, and prf of radar intercepts. It thereby delivers reconnaissance data on deployment of enemy radars (and associated military forces, airbases, weapons systems) for use by SAC, ATIC, and ECM people.

The Advanced reconnaissance equipment provides a measure or radar activity in greater detail than the pioneer system. It measures frequency, prf, and pulse width of each intercept with an order of magnitude greater accuracy, and provides a more accurate estimate of enemy electronic capabilities and deployment. The advanced system has greater resolving power, and can correctly classify radar intercepts with 75 to 90 per cent accuracy.

The continuous surveillance equipment has improved accuracy and resolution over the advance system, plus additional capability in the analysis of special signals, such as coded pulses. Wide band video signals can also be recorded directly for detailed study. It has great flexibility and can be programmed from the ground.

21 b. Approach

The ferret data acquisition in this system differs significantly from electromagnetic reconnaissance from aircraft. The latter is usually carried out at such an altitude and slant range that: (1) several orders of magnitude fewer radars are within line-of-sight from the vehicle, (2) the vehicle velocity is sufficiently slow to take several direction finding "cuts" which locate the radar within a small circle of confusion. In addition, ferret reconnaissance aircraft can have a much greater payload capability, a human operator to monitor the equipment, and frequent maintenance.

The major difficulties to be overcome in designing a satellite ferret system include: (1) obtaining long life and reliability, (2) the hazards of cosmic and nuclear radiation damage, (3) those aspects of gravitationless environment which effect operation of mechanical units, (4) reliable operation at extremes in temperature, and in the presence of occluded ionized gases, (5) shock and vibration during launch, and (6) the determination of interrelationships among vehicle stability, radar environment, antenna patterns, system bandwidths, and satellite-borne data reduction.

21 c. Subsystem Tasks

1. a. Pioneer Ferret Reconnaissance Equipment

b. Contractor: CBS

c. Characteristics

DD FORM 1 FEB 55 613-1 PREVIOUS EDITIONS OF THIS FORM MAY BE USED. SECURITY CLASSIFICATION

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

(1) Antennas from 50 to 18,000 mc, each antenna with approximately one octave coverage.

(2) 26 adjacent channel crystal video receivers to cover the above band; operation as programmed or commanded through communication channel.

(3) Data processing to identify the location, frequency, and prf of each signal. Integration-type of prf analysis.

(4) Narrow band magnetic tape recorder, to store the reconnaissance data.

(5) Playback and transmission of the data when commanded through the command link from a satellite control station.

(6) Flexibility of adding advanced reconnaissance receivers for "fine-tuning" in selected bands where detailed data is particularly desirable.

2. a. Advanced Ferret Reconnaissance Equipment

b. Contractor: CBS

c. Characteristics

(1) Antennas from 50 to 30,000 mc, with wider bandwidth antennas. Special antenna systems for accurate direction sensing from the satellite to improve directive resolution at long ranges.

(2) Scanning superhetrodyne receivers to cover approximately one octave each in frequency. Special receivers for pulse by pulse direction sensing from the satellite.

(3) Accurate prf, pulse width, and frequency analysis, and correlation with intercept location.

(4) Narrow band magnetic tape storage of processed data.

(5) Read-out to ground when commanded by satellite control station.

3. a. Continuous Surveillance Reconnaissance Equipment

b. Contractor: CBS

c. Characteristics

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

(1) Progression to super-broadband antennas.

(2) Flexibility in receiver programming, as commanded by satellite control station, to cover different frequency bands, or for parallel operation in a single band.

(3) Data analysis capability extended to special signals, frequency modulation, pulse width, or pulse code modulation, etc.

(4) Wide band data recording.

(5) Transmission of wide band video data to satellite control station aided by vehicle-borne high gain servo-controlled antenna, similar to visual reconnaissance data link antenna, for tracking satellite control station.

21 d. Other Information

Although all work involving airborne ferret reconnaissance may be considered collateral activities, the unusual environmental and operational conditions involved in reconnaissance from a satellite are not met by presently available equipment.

21 e. Statement of Effects

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

21 f. Background History

Project Beacon Hill* concluded that approximate frequency and location constitute up to 90% of the intelligence that can be derived from a signal intercept. Pied Piper Study Contract Af33(616)-3105 has shown the feasibility of obtaining this data (plus prf and pulse width) on radars in the USSR, China, and the satellite countries by means of electronic intercept equipment carried aboard an orbiting satellite.

21 g. References

1. Final Report, Project Beacon Hill, 15 June 1952

2. Appendix to this volume

3. Pied Piper Monthly and Quarterly Report

R&D PROJECT CARD
CONTINUATION SHEET

SECRET
SECURITY CLASSIFICATION

1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NUMBER
ELECTRONIC COUNTERMEASURE SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (UNCLASSIFIED) (PIED PIPER)	Direct	[illegible]
	4.	5. REPORT DATE 1 March 1[illegible]

21 h. Future Plans

It is planned to continue the studies already initiated and to develop equipment which will result in a military system at the earliest possible time commensurate with the intelligence needs and state-of-the-art, and with a logical progression from that point to more sophisticated equipments.

~~SECRET~~

Pied Piper

MSD 1536

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

TABS

~~SECRET~~

Subsystem F - ELECTRONIC RECONNAISSANCE

Tab 1 - General Design Specification

1. GENERAL

A. Statement of the Problem

The problem in Pied Piper ferret reconnaissance development is to design electromagnetic intercept equipment to be carried in an orbiting satellite vehicle, which will gather radar intercept data, process and record the data, and retransmit the information when the satellite is in communication with friendly satellite control stations.

The ARS requirements which establish the objectives are:

1. Continuous ferret reconnaissance of the USSR and satellite nations. Timeliness of the receipt of the intelligence information is essential.

2. Electronic reconnaissance capabilities should extend from 50 to above 10,000 mc. The modulation characteristics should be determined, and correlated with the frequency data in order to identify the signal source types.

3. The location of ground signal sources should be determined in a manner suitable for this unique application.

4. A minimum useful military system shall be made available at the earliest possible time, and the improved system capabilities shall be evolved in a logical and efficient manner.

B. Approach

Due to our limited present knowledge of the USSR radar environment, and the maze of electronic signals to be expected, the ferret reconnaissance program will begin with equipment capable of signal density analysis with detailed signal analysis equipment added in succeeding flights.

The planning has been divided into the following programs:

1. Equipment for pioneer ferret reconnaissance
2. Equipment for advanced ferret reconnaissance
   a. General reconnaissance
   b. Special Purpose reconnaissance
3. Equipment for continuous surveillance

The sub-system progression is from simple, low resolution, to more sophisticated equipments; the superposition of data gathered by each equipment leads to a realistic detailed synthesis of the enemy radar network. A preliminary analysis of the confidence limits and an investigation of the intelligence parameters is presented in the appendix.

Subtasks in the sub-system development will be the design and selection of components, with a logical progression to more sophisticated designs. The component subtasks are:

1. Antennas
2. Ferret Receivers
3. Data Processing Equipment
4. Data Recording Equipment
5. Data Transmission Equipment

C. Solutions and Recommendations

1. Operational Ranges

Each task will result in an operational military equipment; the operational capability of each equipment is given as follows:

1. Pioneer Ferret Reconnaissance Equipment. Measures coarse frequency, location, and prf of each intercept; approximate radar count by type and development; low resolution of intercepts (up to 50 percent).

2. Advanced Ferret Reconnaissance Equipment

2.1 General. Measures accurate frequency, prf, and pulse width of each intercept; more accurate location of each target; 75 to 90 percent correct classification of radar intercepts.

2.2 Special Purpose. Detection, identification and location of selected radar types, or detailed analysis of intercepted signals, including special signals (e.g., PCM, or PTM); high intercept probability and classification accuracy.

3. Continuous Surveillance Reconnaissance Equipment. The resolving power and analysis capability of the most sophisticated advanced reconnaissance equipment, plus wide band video recording and transmitting to enable the processing of special signals. Completely flexible data gathering and processing, and capable of programming from the ground.

Subtasks of the subsystem are:

1. Estimated antenna typical bandwidths for early equipments are one octave. Later equipments will use special antenna configurations. Super-broadbanding will be a goal in advanced reconnaissance equipment. (See appendix)

2. Receivers

2.1. Pioneer. 26 adjacent channel receivers for continuous coverage of 50-18,000 mc; low resolving power. (See appendix)

2.2 Advanced. Nine (9) scanning superheterodyne receivers which cover the range from 50-30,000 mc; good resolving power. (The operational characteristics and design criteria are described in the appendix.)

2.3 Continuous Surveillance. Receivers with large capability in analyzing signal intercepts; very good resolution, high intercept probability, and up to 90 percent correct classification of intercepts even in dense signal environments. Flexible operation which can be programmed from the ground.

3. Data Processing Systems

3.1 Pioneer. The Pioneer data processing equipment will integrate incoming prf's between 50-10,000 pps with an accuracy of ± 100 pps. Provision will be made for recording up to 26 channels of integrated prf's on a magnetic tape transport operating at 15 inches per second by means of commutation and pulse width recording. The individual techniques for accomplishing the above are present state of the art.

3.2 Advanced. The advanced data processing equipment will measure prf by the cycle counting technique with an accuracy ranging as high as 1% for the higher prf's. Pulse width will be measured by integration - boxcar technique to an accuracy of ± 20%. The prf indications will be stored as binary bits on magnetic tape, the pulse width signal will be stored as an analogue signal. The same tape transport will be used as in the Pioneer System. Four receiver outputs can be recorded on one magnetic track. Parallel tracks will be used to accommodate additional receivers.

3.3 Continuous Surveillance. The Continuous Surveillance equipment will be a modified version of the Pioneer and advanced equipment set up to select the desired signals for recording by the wide band tape recorder will be available.

4. Data Recording Systems

4.1 Pioneer. A tape transport mechanism must be developed capable of operating at 15 inches per second under the expected environmental conditions.

4.2 Advanced. The same mechanism will be used as for the Pioneer, however, provision will be made for multiple track recording to accommodate the increased amount of information which will be gathered.

4.3 Continuous Surveillance. A wide band video tape recorder capable of recording 1 mc signals must be developed by extending presently known techniques an order of magnitude.

5. Data Transmission Systems

5.1 Pioneer. A standard telemetering 50 watt transmitter must be modified to operate for long periods of time in the expected environment.

5.2 Advanced. A standard telemetering 50 watt transmitter must be modified to operate over long periods of time in the expected environment.

5.3 Continuous Surveillance. A video transmitter capable of 1-mc modulation and 10 watts output must be developed for transmitting the output of the wide band recorder to the ground intercept station.

2. State-of-the-Art

The present state-of-the-art as applicable to the tasks of the subsystem are:

1. Pioneer. The pioneer equipment is within the state-of-the-art, and uses mostly off-the-shelf components. It is based on present estimates of the operational and physical environment.

2. Advanced. The advanced equipment is also within the present state-of-the-art. Although some components are not yet shelf-items, no difficulty is anticipated for the intended operational period. The present estimate of subsystem capability is based on usage of currently available, or soon-to-be available reliable components.

3. Continuous Surveillance. Progression to the most sophisticated equipment relies on foreseeable component developments, such as:

3.1 Wide Band Video Recorders

3.2 Miniaturized Wide Band R-F Amplifiers

3.3 Super-broadband Antennas

3.4 Improved Component Reliability

3. Unusual Environmental Conditions

The most unusual environmental conditions will be nuclear and cosmic rays, and zero gravitational field.

Other environmental conditions are different only in severity from conditions to which military equipments are currently subjected. These are low temperature, partial vacuum and occluded [illegible] gases, and shock and vibration during launching.

4. Special Tests Prior to Freezing Design

1. Propagation tests to determine atmospheric effects and probable reliability of vehicle to ground communication.
2. Airborne tests to measure typical ground radar elevation patterns in typical terrains.
3. Ground tests to determine electrical characteristics of each unit separately.
4. Ground tests to determine electrical characteristics under simulated environmental conditions, such as low temperature, vibration, shock, and nuclear radiation tests; operation of units in every orientation to simulate operation in gravitationless environment.
5. Ground tests to determine subsystem characteristics under simulated operational environment. Use of special test devices to simulate multiple radar intercepts and evaluate reliability of operational analysis.
6. Accelerated life tests of components.
7. Tied-down launching tests of subsystems.
8. Airborne tests to determine operational characteristics of each unit separately.
9. Airborne tests to determine operational characteristics of complete subsystem.

5. The vehicle structural design cannot be frozen until all antenna designs are firm. The antenna designs in turn cannot be frozen until tests indicated in item 4 are performed.

6. A preliminary estimate of the pioneer sub-system reliability based on currently available components is a few hundred hours. The critical nature of major components is indicated in tabular form below.

Item	Expected Life	Notes
Commutators	Min: 50; Max: several hundred hours	Spares will be included with provision for automatic switching
Traveling Wave Tubes	1000 to 5000 hours	
Transmitting Tubes	1000 to 5000 hours	
Tape Transport Mechanism of Recorder	MIN. 1000 hours	

Based on these values, an expected life during the intended operational period of the pioneer sub-system should be 500 to 5000 hours. For the operational duty cycle anticipated, this should permit a year's operation.

The surveillance sub-system should be an order of magnitude better due to the industry wide effort to improve component reliability, and as a result of experience gained during the development of the pioneer sub-system.

7. The equipments should be mounted as follows:

Subject to least vibration

Maximum accessibility

Maximum shielding from radiation by nuclear power unit -- special protection for most critical components.

8. In order to complete airborne tests, the following GFE items will be required:

1. Domain Helicopter for typical radiation patterns and propagation tests.

2. B-50 Bomber for operational tests of sub-system.

9. None

10. Based on estimated size, weight, and power, and sophistication of each stage of the ferret reconnaissance sub-system (pioneer, advanced, and continuous surveillance) is compatible with:

1. Anticipated vehicle payload capacity during the intended operational period of each ferret stage.

2. The development from one stage to the next is an orderly progression from simple to more complex, from present to foreseeable state-of-the-art, and from lesser to greater reconnaissance capability.

3. Operational characteristics of each stage of ferret development is geared to anticipated intelligence needs.