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AC-04306
VOLUME I
31 March 1965
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RADAR

PROGRAM [redacted]

VEHICLE 2355 SYSTEM REPORT (U)

VOLUME I – SUMMARY

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Volume I

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LOCKHEED MISSILES & SPACE COMPANY

AC-04306
Volume I
31 March 1965

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PROGRAM [redacted]

VEHICLE 2355 SYSTEM REPORT (U)

Volume I - Summary

Contract [redacted]
Supplemental Agreement Number 13

Prepared:

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Program [redacted]

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David D. Bradburn
Lt. Colonel, USAF
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Bye 36454/65

FOREWORD

This report covers the span of time from the inception of the first satellite borne radar system through the final evaluation of the on orbit performance of the first flight. An objective review is attempted, of the complete scope of activities associated with bringing a new system into being and of the system performance during an essentially nominal and troublefree mission.

From this review, it is hoped that the systems management and program control parameters which were found to be effective may be properly recognized and thereby enhance the organization and conduct of similar future activities.

The system definition and resulting configuration is reviewed in retrospect, together with the problems associated with this Program development and testing.

The engineering management concept and the test philosophy which were applied are outlined and restated, with the objectives of first recording these, and then attempting to objectively analyze them for areas susceptible to improvement. The Air Force - LMSC - Associate Contractor team is defined, as it existed during the development, testing and operation of Vehicle 2355.

The system performance from launch through recovery and thence to battery depletion is evaluated from the primary aspect of payload operation.

System performance is compared against predictions, and the performance accomplishments and achievements are enumerated.

The report is therefore, in addition to a flight report, a total summary of the composite effort associated with the preparation and operation of this system. From the system evaluation certain conclusions and recommendations are formulated which are intended to be useful for later work on similar systems.

Through the medium of the detailed information contained in this report, it is intended to properly acknowledge the efforts of all those who were instrumental in managing and conducting a program which produced a completely successful mission with the first flight of a new payload vehicle system.

PART I

Table of Contents

Report Numbering and Organization

The complete 2355 System Report is contained in three volumes.

Volume I - (PART I) - Summary

Volume II - (PART II) - Engineering

Volume III - (PART III) - Flight Performance

The report paragraph numbering is in accordance with the following convention:

First number indicates volume number

Second number indicates main paragraph number

Third number indicates a subparagraph

Fourth number indicates a further subdivision of a subparagraph

Figures are numbered consecutively within main paragraphs.

Reports By Participating Contractors

The complete system description and performance evaluation is contained in reports issued by the three contractors. These are listed here for reference by the reader:

Lockheed Missiles and Space Company:

Title: 2355 System Report, dated 31 March 1965.

Volume I - Summary

Volume II - Engineering

Volume III - Flight Performance

Goodyear Aerospace Corporation:

Title: Program Report, KP-II Orbital Doppler Radar, Thor/ Agena Satellite Program, dated 1 March 1965.

[redacted]

Title: [redacted]

PART I

Report Abstract

1.1 INTRODUCTION

This report is divided in three parts. Part I is an abstract containing those system parameters and performance factors of principal interest to a reader whose time may not permit a thorough review of the entire report. The System Description and System Performance are treated in much greater detail in Part II and Part III respectively; however, Program Management-Background, Program Objectives, Mission Description and Conclusions and Recommendations are contained entirely in Part I. The high interest content of the radar imagery dictated placing extensive examples in Part I. The fine resolution radar imagery, the imagery of engineering interest and the summary of data and performance pertaining to each item were provided for the System Report by the [redacted] Grateful acknowledgment is made for this contribution.

Part II is devoted to the technical aspect of the program development and discusses primarily those items which were peculiar to the satellite application of the radar payload. An adequate knowledge of the basic Agena vehicle and subsystems is assumed. In the course of solving the several developmental problems which were encountered - mounting of heavy and dense components, high voltage power supplies, fine attitude control, use of a wide band video data link, a new radar antenna design and the associated

flight sciences work - studies and research of a significant magnitude were conducted. It has been an objective in the preparation of Part II to allow the engineering personnel who were involved in these development problems to record the effort and results in a manner which they considered most significant and valuable, utilizing as guidelines the statements contained in the Foreword. Extensive basic data is included in this report, which was deliberately intended to be of a much broader and more thorough scope than a normal flight report. The payload is described in this Lockheed report in more detail than are the other subsystems, by use of excerpts from the Goodyear Aerospace Corporation Program Report. The test sequences and schedules which resulted therefrom are included for record purposes. The Air Force program management was extremely capable and knowledgeable of all details causing program delays. The resulting direction given to the participating contractors permitted the orderly solution of the problems and produced a system capable of predictable operation in orbit.

Part III generally follows the format of Part II in recording orbital performance data by subsystem. The principal section of Part III, Para. 3.4, is utilized as an archive for payload orbital data. The data included in Part III has been as extensive as the economics of time and effort would permit.

1.2 Program Organization

1.2.1 Program Management - Background

Based on an earlier proposal to the Air Force, Lockheed Missiles and Space Company was awarded a contract in November 1962, to place in orbit a coherent, side-looking radar system. The contract specified that Lockheed (System Associate Contractor) would provide overall systems engineering and technical direction of the program, as well as the Agena and its various subsystems (power, command and control, telemetry, etc.). [redacted] (Eastern Associate Contractor) was made responsible for designing the experiment, designing and constructing the optical correlator for processing the raw radar data, and evaluating the data obtained from the experiment. Goodyear Aerospace Corporation (Associate Contractor) was assigned the task of providing the payload hardware as well as participating in the experiment design, test and operation. The contract specified that two vehicles should be launched (2355 and 2356). The payload for 2357 was to be prepared. The payloads of each of the vehicles were to be essentially identical; the first vehicle originally was scheduled to be launched in April 1964. Figure 1.2.1.1 depicts the program management structure.

1.2.2 Contractor Responsibilities

1.2.2.1 Lockheed - System Associate Contractor - was assigned the responsibility of providing System Engineering and Technical Direction to the P-40 Program, subject to the overall management of the Secretary of the Air Force, Special Projects (SAFSP).

In addition to system management the Program Office was responsible for

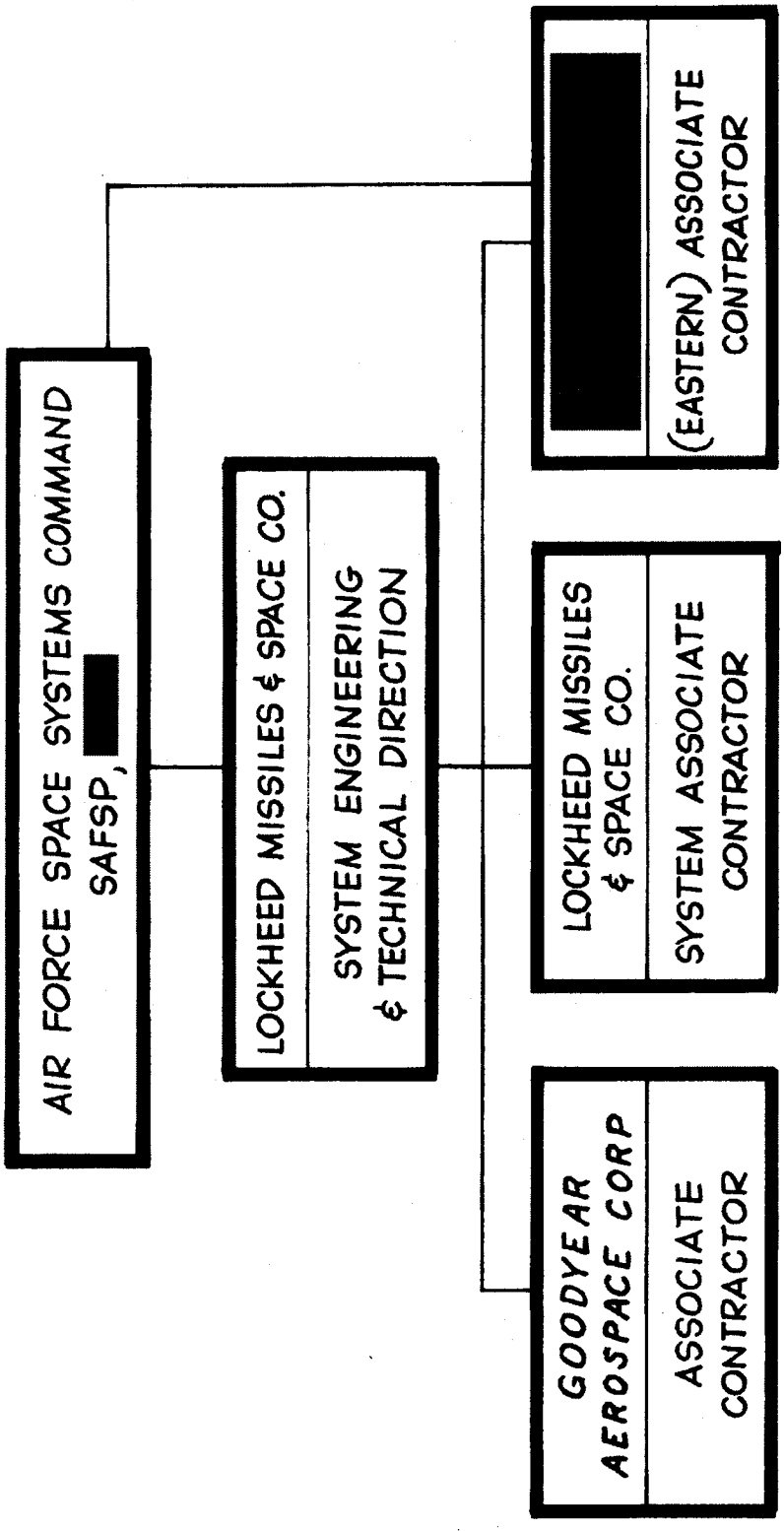

Figure 1.2.1.1 Program Management

coordinating all activities of the three Associate Contractors to insure a technically compatible program to meet planned objectives.

Responsibilities assumed by Lockheed to integrate all activities as necessary to achieve all flight objectives included, but were not limited to, the following:

- o Perform technical direction and engineering management within the parameters as established by SAFSP.
- o Determine system requirements and establish system performance through a coordinated study and analysis endeavor.
- o Recommend to SAFSP, the required research, development and experimentation to achieve program objectives.
- o Prepare the requirements for, and evaluate the Design Control Specifications, Acceptance Test Specifications, Engineering Analysis Reports, Test Procedures, and Specifications, by coordinating total effort with the Associate Contractors.
- o Analyze and make recommendations to the Air Force, as required, on System, Subsystem and Component development and test programs.
- o Establish a Systems Engineering and Technical Direction (SETD) capability to conduct continuous evaluation of equipment performance to determine the degree of compliance with all system functional and operational requirements.
- o Hold SETD meetings with Associate Contractors to coordinate latest changes necessary to meet program objectives, by performing technical evaluations of requests from the Associate Contractors for

design or performance waivers on components, subsystems, end item equipment, and ground support equipment, making recommendations to SAFSP regarding approval of changes.

- o Review, analyze and make recommendations to achieve interchangeability and compatibility of associated subsystem and equipment designs formulated by Associate Contractor.
- o Review the reliability programs established by the Associates to assure consistency, quality and adequacy of effort.
- o Assist Program management in determinimg Program milestones, design parameters, procurement techniques and releases.
- o Integrate AGE, GHE, Spares and all necessary flight support equipment to provide flight test vehicle and flight vehicle readiness.
- o Perform the necessary techniques for integration of GAC Radar equipment with LMSC payload antenna.
- o Perform qualification tests on payload system consisting of radar subsystem, space structure subsystem and recovery subsystem.
- o Provide the necessary assistance in pre-flight planning and programming, in-flight support analyses, post-flight T/M analyses and preparation of preliminary and final ephemeris.
- o Prepare and release a final System Report.

1.2.2.2 Goodyear Aerospace Corporation was assigned responsibilities as an Associate Contractor to fulfill the following requirements to meet the P-40 Program objectives:

- o Perform the necessary functions to accomplish the design, develop-

ment, procurement, manufacture, and development testing of the radar subsystem, not including the antenna, takeup reel, data link, interconnecting cabling, or the waveguide.

- o Design, develop and provide the necessary ground support equipment to meet the Program objectives, including all payload test equipment for payload units and system test sets for the payload as a subsystem.
- o Participate in the radar subsystem acceptance at LMSC facility.
- o Perform the retrofits, modifications and maintenance of the radar subsystem.
- o Recommend readiness and provide certification of the radar subsystem prior to systems test and launch.
- o Furnish wooden mock-ups for LMSC integrated mockup.
- o Perform the development and acceptance testing of the radar subsystem.
- o Assist in the qualification testing of the payload system in regard to the radar subsystem at Lockheed. Perform the necessary payload qualification at Goodyear.
- o Recommend and provide the necessary spares for the radar subsystem to give adequate backup to the Program.
- o Determine the need for, and provide the necessary tools, jigs, and similar items needed to install, check and adjust all components, subassembly, and assembly of the radar subsystem during the subsystem assembly and checkout.
- o Provide film recorders for tracking station data link recording.

- Assign field personnel to LMSC to assist in performing the necessary modifications and tests to assure technical integrity and technical capability of the radar subassembly and payload vehicle.

1.2.2.3 [redacted] was assigned responsibilities as an Associate Contractor to perform the following tasks:

- Provide technical advice and assistance to Lockheed Missiles and Space Company and Goodyear Aerospace Corp., in the areas of payload design and establishment of system requirements for flight operation.
- Design and build an advanced optical correlator for processing the payload data.
- Process (correlate) the payload data from the recovery capsule and the wideband data link.
- Perform payload data analysis and evaluation, including system performance evaluations against predictions.
- Issue a comprehensive report covering all work performed.

1.2.3 Security

The Program requirements for security were established by SAFSP [redacted] and are graphically portrayed in Fig. 1.2.3.1, Security Concept, on the next page.

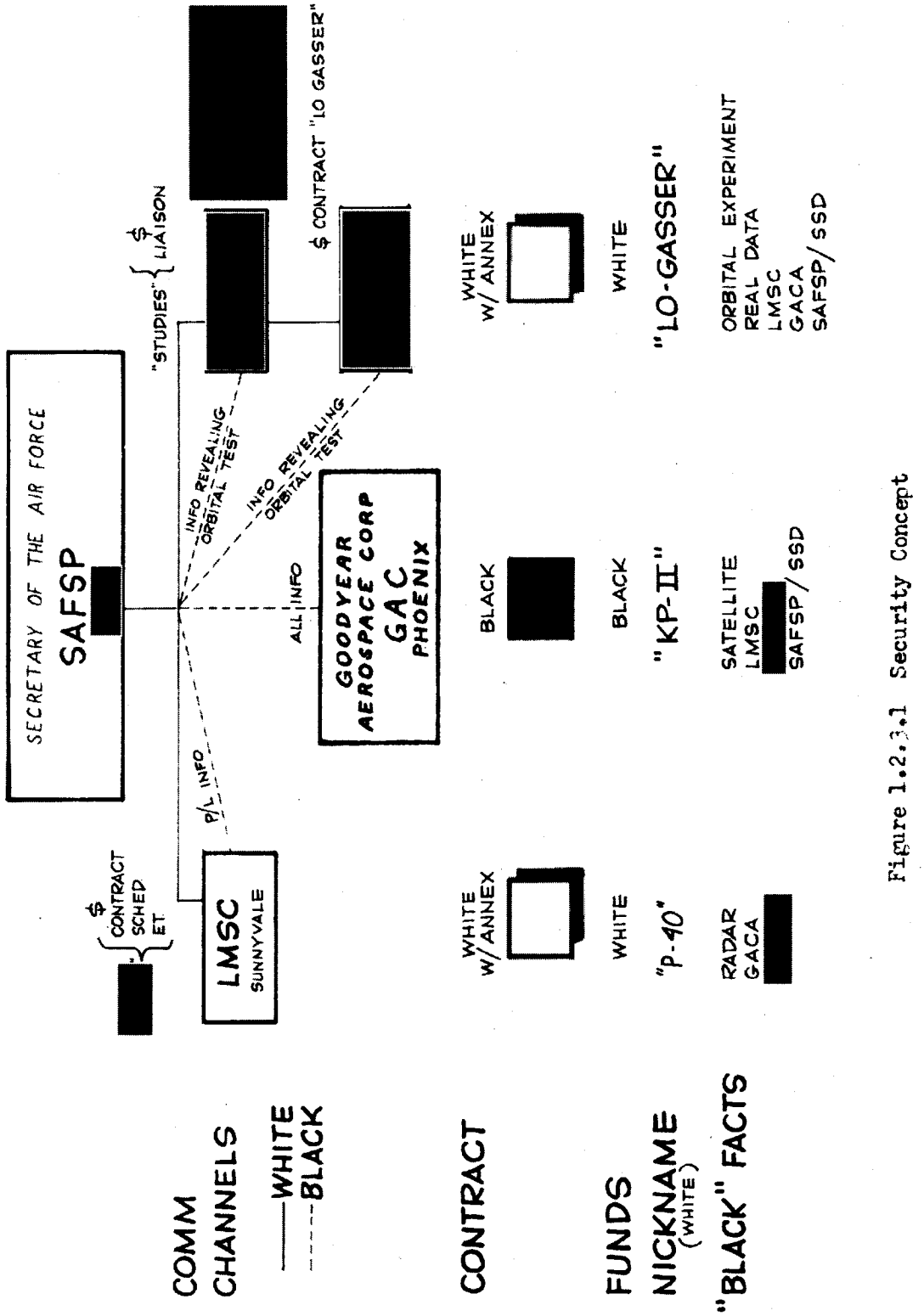

Figure 1.2.3.1 Security Concept

1.3 Program Objectives

Primary Mission Objective The primary objective of the orbital flight was to demonstrate that a fine-resolution radar strip map of a portion of the earth's surface can be generated through use of a satellite-borne synthetic-aperture radar system. For the purpose of this demonstration a resolution goal of 50 feet in azimuth and in slant range was established.

Secondary Mission Objectives A number of secondary objectives of scientific and/or engineering significance were also established. Among these are the following:

- o Quantitatively evaluate the performance of the radar system, with emphasis on azimuth-dimension behavior:
- o Determine the performance limits imposed by:
  - Payload design parameters
  - Payload in-flight performance
  - Vehicle attitude behavior
  - Atmospheric conditions
  - WBDL design and performance
- o Determine the reasons for any observed anomalous performance of the system:
- o Collect data on target-field reflectivity.
- o Develop engineering data useful for aerospace radar system designs.
- o Demonstrate the capability of the ground recording equipment to record useful data received via the WBDL.

Primary Vehicle Objectives The launch phase primary vehicle test objective was to inject the Agena (SS-01A) into a near circular orbit so that the satellite altitude would be 130 ± 13 nautical miles when passing between 30°N and 70°N geodetic latitudes with an orbit plane inclination of 70 ± 0.25 degrees.

The orbit phase primary vehicle test objectives were:

- o To maintain, during the minimum orbit life of 65 orbits, a stabilized horizontal attitude with the following tolerances (-Z axis up and -X axis forward):
  - . Deadband 0.15 ± 0.07 degrees, all axes
  - . Bias uncertainty ± 0.4 degrees, all axes
  - . Maximum pitch rate 0.002 degrees/second
  - . Maximum roll rate 0.005 degrees/second
  - . Maximum yaw rate 0.003 degrees/second
- o To yaw the vehicle to a bias angle of 2.44 ± 0.3 degrees to the left and to the right in response to commands.
- o To provide electrical power to sustain payload and vehicle life for a minimum of 65 orbits.
- o To command and control vehicle and payload operation.
- o To obtain data required for the generation and verification of commands to control vehicle and payload operation.

The recovery phase primary vehicle test objectives were:

- o To orient the SS-01A to a proper nose down attitude, separate the recovery capsule at the proper time and provide retro-thrust to

the capsule so that its re-entry trajectory falls within a predetermined recovery area.

- To recover the recovery capsule with its payload by air or surface units deployed for that purpose.

1.4 Mission Description

The mission of Vehicle 2355 was to place in orbit a coherent X-Band, side-looking radar system payload in order to obtain a high resolution terrain map. The payload was to be operated in realtime under command of the Vandenberg and New Hampshire Satellite Tracking Stations. Operation of the payload was to be limited to the Continental United States. The SS-01A vehicle was to be injected into a near circular orbit so that the altitude over the areas to be recorded would be approximately 130 nautical miles. Precise attitude stabilization of the vehicle would then orient the radar antenna so that the main lobe of the radar beam would be at a fixed depression or look angle of 55° from the horizontal, thereby illuminating a swath approximately 10 nautical miles wide at a distance of 93 nautical miles to the left of the satellite ground track.

The data obtained from the payload was in the form of target echoes which were synchronously demodulated to preserve both phase and amplitude of the signals. These signals, which constitute the raw radar map Data or doppler history of the illuminated terrain, were recorded photographically on film in a recoverable capsule aboard the satellite. Simultaneously, these signals were transmitted over the Wide Band Data Link to the tracking stations where they were again recorded photographically on film by ground based recorders and also electronically on wide band magnetic tape recorders. The film recorded in the satellite was to be recovered in the Pacific Ocean area by means of air catch of a recovery capsule. Figure 1.4 portrays the payload operating swaths and the tracking stations zero and five degrees elevation circles of coverage.