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FABRICATION OF TWENTY-TWO SOUNDING ROCKET VEHICLE SYSTEMS

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Thiokol Chemical Corporation

Prepared for:

Air Force Cambridge Research Laboratories

September 1972

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13. ABSTRACT

Twenty-two sounding rocket systems were prepared and delivered by Thiokol Chemical Corporation consisting of fourteen (14) Ute-Tomahawk vehicles and eight (8) Paiute-Tomahawk vehicles. In addition to fabrication, assembly and adjustment of vehicle components, Thiokol provided additional related support to Air Force Cambridge Research Laboratories (AFCRL) in the form of static tests and computational, analytical, and field engineering services.

Rocket motors and igniters; the TE-416 Tomahawk, the TU-715 Ute, and the TU-716 Paiute were major components of the twenty-two sounding rocket systems. Other system components included the Ute/Paiute tail assembly, launch lugs, Ute/Paiute-Tomahawk interstage adapter, Tomahawk tail assembly, and Tomahawk despin modules.

Four Paiute booster motors were statically fired to verify the propellant batch. The tests demonstrated operation over the temperature range -75° F to +125° F and confirmed satisfactory operation after vibration and shock tests. On the basis of these tests the operational temperature range has been established at -75° F to +140° F.

Computations and analyses were completed for Ute/Paiute-Tomahawk vehicles to allow theoretical prediction of trajectories, roll rate and pitch natural frequency histories, static stabilities, wind weighting data, and heating analyses.

Field engineering services were provided in support of the launch of a Paiute-Tomahawk vehicle from Eglin Air Force Base, Florida. In a near nominal flight a payload weighing 215 pounds was carried to an apogee of 227 kilometers.

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Tomahawk						
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FOREWORD

This final report is submitted to Air Force Cambridge Research Laboratories (AFCRL) by Thiokol Chemical Corporation in compliance with Contract No. F19628-72-C-0166.

The contract was issued by the Electronic Systems Division (PPR); Air Force Systems Command, USAF; Laurence G. Hanscom Field; Bedford, Massachusetts 01730. Mr. Edward S. Mansfield served as Contract Monitor.

Management of work conducted on this contract was handled by Thiokol Chemical Corporation, Wasatch Division, P. O. Box 524, Brigham City, Utah 84302. Fabrication of Ute and Paiute booster motors and Paiute static tests were performed at the Wasatch Plant near Brigham City, Utah, while Tomahawk motor fabrication was performed by the Elkton Division at Elkton, Maryland. The Astro-Met Plant of the Wasatch Division had primary management responsibility and performed hardware fabrication, analytical services, and field engineering support.

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I INTRODUCTION

A program has been completed to provide twenty-two sounding rocket systems consisting of fourteen Ute-Tomahawk vehicles and eight Paiute-Tomahawk vehicles. Four additional Paiute booster motors were fabricated and statically fired to verify the batch of propellant used in all the boosters. Support was provided for computational, analytical and field engineering services.

This final report is presented in sections which describe the effort in each work area in more detail.

II FABRICATE AND STATIC FIRE FOUR PAIUTE MOTORS

Four TU-716, Paiute, booster motors designated serial numbers 003, 004, 005, and 006 were fabricated and fired in a static test stand to verify propellant characteristics and to confirm their capability to withstand environmental extremes. Static tests and pretest conditioning was in accordance with TWR-5750, "Test Requirements for Preproduction Testing of TU-716 Motors."

In the test sequence motor S/N 003 was subjected to vibration in a Board Course Test followed by Temperature Cycle Tests along with the other three motors. After temperature cycling, motor S/N 003 was subjected to shock in a Drop Test and subsequently static fired after conditioning at 60° F.

All four motors were subjected to the temperature cycles listed in Table I.

Post test analyses indicate the firing temperature range for the Paiute TU-716 motor can be extended to -75° F to $+140^{\circ}$ F. Storage temperature range has been demonstrated to be -75° F to $+175^{\circ}$ F.

All motors performed satisfactorily and met all test requirements.

TABLE I

TEMPERATURE HISTORY FOR PAIUTE MOTORS
S/N 003, 004, 005, and 006 PRIOR TO STATIC TESTS

Temperature (^{o}F)	Motor S/N	Time (hours)
Ambient	All	Start
175 ± 5	All	48.25
-75 ± 5	All	48.16
175 ± 5	All	48.00
-75 ± 5	All	48.09
175 ± 5	All	48.16
-75 ± 5	All	48.00
Ambient	006	163.00
Ambient	003, 004, and 005	162.00
60 ± 5 *	003	52.50
60 ± 5 *	004	51.50
125 ± 5 *	005	48.38
-75 ± 5 *	006	48.50

* Motor was fired in less than .5 hour after removal from conditioning box at temperature indicated.

III FABRICATE UTE MOTORS

Fourteen TU-715, Ute, booster motors were fabricated including igniters, MXU/35A modified per Thiokol drawing number 7U44048-02. Motors and igniters were delivered to Eglin AFB, Florida.

IV FABRICATE PAIUTE MOTORS

Eight TU-716, Paiute, booster motors were fabricated including igniters, MXU/35A modified per Thiokol drawing number 7U44048-02. Motors and igniters were delivered to Eglin Air Force Base, Florida.

V FABRICATE TOMAHAWK MOTORS

Twenty-two TE-416, Tomahawk, rocket motors were fabricated including pyrogen-type igniters TE-P-415 per Thiokol drawing number E-19504-05 equipped with 18-second pyrotechnic ignition delays. Tomahawk motors were fabricated with tension joint head caps per Thiokol drawing E-15209-25. Motors and igniters were delivered to Eglin Air Force Base, Florida.

VI FABRICATE FLIGHT HARDWARE

Twenty-two sets of flight hardware for Ute/Paiute-Tomahawk two-stage sounding rocket vehicles were fabricated and delivered to Eglin Air Force Base, Florida. This fabrication effort included; purchasing raw material and components, machining and inspection of mechanical components, wiring and assembly of electrical components in the interstage adapter and despin, assembly of mechanical components including adjustment and survey of tail assembly fins to establish the desired effective incidence angle, and marking and packaging for shipment.

Flight hardware items delivered for these sounding rocket systems are listed in the following table. All items can be used interchangeably on Ute-Tomahawk or Paiute-Tomahawk vehicles.

TABLE II

FLIGHT HARDWARE FOR TWENTY-TWO UTE/PAIUTE-TOMAHAWK SOUNDING ROCKET VEHICLES

Description	Drawing Numbers	Quantity
Interstage Adapter Assembly Ute/Paiute-Tomahawk	Assembly R-01814 including Interstage R-01640 (Rev. G)	22
Despin Module	Assembly R-01707-02 (Rev. C)	22
Ute/Paiute Tail Assembly	Assembly R-01665-02 (Rev. C)	22
Launch Lug Assembly Ajax-type for Ute/Paiute	Assembly R-01824 including Lugs C-01667 and C-01653	22
Launch Lug Assembly, MRL-type for Ute/Paiute	Assembly R-01822 including Lugs C-01806 and C-01805	22
Tomahawk Tail Assembly	Assembly R-01660 (Rev. C)	22

VII COMPUTATIONAL AND ANALYTICAL SERVICES

Theoretical analyses, adjusted for data obtained in previous flights, and digital computer codes were used to compute performance parameters for Ute/Paiute-Tomahawk vehicles. The performance parameters will be useful in predicting flight conditions for the twenty-two vehicles delivered under the contract. Prediction of flight conditions include trajectories, roll rate and pitch natural frequency histories, static stabilities, wind weighting data, and heating analyses.

In association with this task, field engineering support was provided at Eglin Air Force Base, Florida, for the flight of a Paiute-Tomahawk vehicle. Data from this flight indicated flight performance parameters were very near the pre-flight predictions. A payload weighing 215 pounds was launched at an elevation angle of 86 degrees and reached an altitude of 746,800 feet compared to the predicted apogee altitude of 755,000 feet.

VIII RELATED CONTRACTS

During a previous program conducted under Contract F19628-72-C-0067 from Electronic Systems Division (PPR), Air Force Systems Command, USAF, the development and fabrication of six Ute-Tomahawk sounding rocket vehicles was completed.

IX CONTRIBUTING PERSONNEL

Thiokol Chemical Corporation completed the effort required to deliver twenty-two sounding rocket systems by performing tasks in two company divisions and in two plants of one of the divisions.

Tasks and responsible task leaders are listed in Table III. A large number of other participants made significant contributions but are not listed for the sake of brevity.

TABLE III

CONTRIBUTING PERSONNEL - THIOKOL CHEMICAL CORPORATION

Task	Task Leaders	Division/Plant
Program Management	Mr. R. G. Moore Mr. G. C. Alford	Wasatch/Astro-Met Wasatch/Astro-Met
Fabricate Ute/Paiute Motors and Static Test	Mr. D. M. George	Wasatch/Wasatch
Fabricate Tomahawk Motors	Mr. J. Mallick	Elkton/Elkton
Fabricate Flight Hardware	Mr. J. D. Lashbrook	Wasatch/Astro-Met
Computational and Analytical Services	Mr. P. W. Hoekstra	Wasatch/Astro-Met

X PROGRAM RESULTS AND RECOMMENDATIONS

Program objectives for fabrication and delivery of twenty-two sounding rocket systems have been successfully completed. Four static tests of Paiute motors and a flight test of the Paiute-Tomahawk vehicle were completed with near nominal performance. Analyses and computations were compared to test results and indicate the performance parameters for the Ute-Tomahawk and Paiute-Tomahawk vehicles are well understood.

Ute/Paiute-Tomahawk sounding rocket systems provide proven transportation to carry scientific payloads for investigation of the upper atmosphere. In addition to the competitive cost of these systems, they offer advantages including: a wide range of payload-weight/apogee-altitude performance, capability for operations over a wide range of temperatures and in a variety of environments, complete interchangeability of flight hardware, and relative ease in field handling, assembly, and launch.