Space Shuttle Program Solid Rocket Booster Decelerator Subsystem

CONTRACTOR'S FINAL REPORT
SEPTEMBER 1985
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Prepared By

James W. Barnard

Approved:

W. R. Woodis
SRB Decelerator Subsystem Program Manager
Martin Marietta Corporation
FOREWORD

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1.0 INTRODUCTION

1.1 Purpose

This document presents a technical synopsis of the Space Shuttle Solid Rocket Booster Decelerator Subsystem Program conducted for NASA-MSFC under Contract NAS8-32122 during the period between 6 July 1976 (ATP) and 31 May 1985.

1.2 Scope

This report covers the work by Martin Marietta Denver Aerospace under Exhibit A, Statement of Work (SOW), to Contract NAS8-32122 to design, analyze, develop, integrate, manufacture, test, deliver, provide field support for, maintain and refurbish the SRB Decelerator Subsystem and the Decelerator Subsystem Support Equipment and Tooling. The tasks described herein are organized in accordance with the SRB DSS Work Breakdown Structure (WBS) 1.4.1.6.1, as depicted in Exhibit A, SOW, of the contract.

2.0 REFERENCE DOCUMENTATION

SE-019-075-2H SRB DSS Configuration End Item Specification, Part I & II

ICD-3-44006 SRB DSS Forward Skirt and Nose Assembly Interface Control Document

ICD-2-4A002 SRB DSS Retrieval Station Interface Control Document
3.0 WORK PERFORMANCE SUMMARY

The purpose of the SRB Decelerator Subsystem Program under Contract NAS8-32122 was to develop and fly a parachute system to recover the Space Shuttle solid rocket boosters for refurbishment and reuse. These boosters are the heaviest payloads known to have been recovered by parachute. That this objective has been successfully achieved is evidenced by the recovery in good condition of all boosters flown to date with the exception of those from STS-4 which were lost due to a failure not associated with parachute performance. The capability of the Decelerator Subsystem to recover the boosters in good condition has also been demonstrated despite some parachute failures. The planned objective of 20-flight usage of each reusable component appears to be attainable, with indications that more reuses are possible. Martin Marietta's efforts on the SRB Decelerator Subsystem Program have resulted in a savings of millions of dollars through successful recovery and refurbishment of the solid rocket boosters.

3.1 DECELERATOR SUBSYSTEM MANAGEMENT - WBS 1.4.1.6.1.1

WBS 1.4.1.6.1.1.1 - Project Planning and Direction - From the beginning, Martin Marietta has maintained a dedicated team of technical and managerial personnel on the SRB Decelerator Subsystem program. A functional Table of Organization of the program, a brief description of each function, and a listing of key personnel is shown in Appendix I. It should be noted that in many instances key personnel have been with the program throughout its history.

A major function of SRD DSS management is support of the various reviews required during the course of the program's history. These include Preliminary Requirements Reviews (PRR), Preliminary Design Reviews (PDR), Critical Design Reviews (CDR), CDR, Flight Readiness Reviews (FRR), Test Readiness Reviews (TRR), and Design Certification Reviews (DCR).

WBS 1.4.1.6.1.1.2 - Configuration Management - A Configuration Management Plan, SRB-DSS-CM01, was submitted, approved and published as a Type I document (requiring customer approval) in accordance with the Contract Statement of Work (SOW). The plan describes the Martin Marietta Corporation (MMC) Configuration Management system which completely satisfies the requirements of WBS 1.4.1.6.1.1.2 of the Statement of Work.

SRB Decelerator Subsystem configuration baseline is defined in the Configuration End Item specification, Part II, which has been revised at various major program milestones. The configuration baseline was revised upon approval of the Large (136 ft. D) Main Parachutes. Another update has been submitted to define the Filament Wound Case (FWC) SRB DSS and the Main Parachute Flotation Subsystem.

Change control was effected by MMC Change Control Board in conjunction with the MSFC Level III and IV CCB. Some 350 changes to the basic contract have been processed.
WBS 1.4.1.6.1.1.3 - Information Management - A Data Management system was established to process data, documentation, and information throughout the history of the program in an efficient, timely manner, in accordance with the Information Requirements Document (IRD), SE-019-024-2H-R. The IRD has been continuously reviewed for adequacy as evidenced by the thirty-nine (39) revisions made to it, the most recent in October 1984.

WBS 1.4.1.6.1.1.4 - Procurement Management (also covers WBS 1.4.1.6.1.3.2, 1.4.1.6.1.3.3 and 1.4.1.6.1.3.4) - A procurement management system was established early in the program to monitor subcontractor activity. The major subcontractor, Pioneer Parachute Company (PPC), Manchester, Connecticut, was responsible for detail design and fabrication of the parachutes, as well as development of refurbishment procedures and support to the refurbishment operations at the PRF. In addition, PPC personnel participated in the Material Review Board.

Additional subcontracts were let with Space Ordnance Systems, Inc., of Canyon Country, CA, for development and production of reefing line cutters, and Crown Rotational Molded Products, Marked Tree, Arkansas, for construction of the Wet Parachute Transportation Containers. Construction of load cells and production of some drogue parachute retention brackets was subcontracted to Beowulf Corporation, Huntsville, Alabama.

A summary of subcontract activity is presented in Appendix II.

WBS 1.4.1.6.1.1.5 - Safety, Reliability, and Quality Assurance - An Inspection System Plan was generated to satisfy the requirements of Data Requirement SRB-DSS-RA13. The plan established the controls and requirements during the design, fabrication, assembly, test, and final acceptance of program flight hardware, spares and related ground support equipment. In addition, a Quality Operating Plan was developed in support of the Parachute Refurbishment Facility (PRF) at Kennedy Space Center. All quality plans and operating procedures satisfy the requirements of NHB5300.4(IC) and were verified by both MMC and NASA quality audits.

The Martin Automated Reporting System (MARS) is used to identify, track and disposition non-conforming articles and material. This system provides rapid identification of non-conformances, controls segregation to the extent required, and provides initial review and disposition by Quality, as well as formal action by certified MRB personnel when required. The MARS directs component removal, system corrective action, and the restoration of component/system integrity. After failed parts analysis and cause identification, corrective action assignments are made to the responsible/affected department. The MARS copies and serial numbers are reentered on affected build and test documentation. These are available for incremental review and retained for component history, as well as flowing into the centralized data system.

A System Safety Plan (SRB-DSS-RA10) was instituted to implement the requirements of NHB5300.4 (ID-2) Chapter 2, "Safety, Reliability, Maintainability and Quality Provisions for the Shuttle Procedure." This plan...
was implemented upon initiation of the design phase, continued through all
program phases and applied to functional organizations required for full scale
development, test and evaluation, production hardware, and operations phases.
This plan was supplemented by a Drop Test Safety Plan encompassing Phase I and
II of the Drop Test Program at the National Parachute Test Range and Dryden
Flight Research Center. Monthly Safety Summary Reports (SRB-DSS-RA22) were
generated to present safety inspection results, highlight safety concerns, and
track injuries/lost time for the KSC-PRF activity.

Problem and Resolution Reports (SRB-DSS-RA08) were initiated to provide
problem identification, corrective action responsibilities and closure
status. These are summarized in Appendix III, Table A.

Qualification testing was performed on pyrotechnically initiated
reefing line cutters and parachute load sensors. These are summarized in
Appendix III, Table B.

3.2 DEVELOPMENT - WBS 1.4.1.6.1.2

WBS 1.4.1.6.1.2.1 - Subsystem Analysis and Integration (including WBS
1.4.1.6.1.2.7) - Analysis was conducted to assure compatibility of the DSS
with the SRB, including weight and volume constraints, interface loads, and
operating conditions. Performance analyses were made for the original
baseline (115 ft D₀ main) DSS, the Large Main Chute (136 ft D₀) subsystem,
and for the Filament Wound Case (FWC) Decelerator Subsystem. This included
studies to select the DSS deployment altitude from the trajectory conditions
provided, size and configure the parachutes, optimize reefing schedules,
select main chute deployment altitude, and determine other detailed subsystem
design parameters. The results of these analyses were published as
SRB-DSS-SE16, Subsystem Analysis Report. Due to changes in SRB mass
properties and predicted flight performance characteristics, changes in DSS
design, and incorporation of modifications to improve performance, numerous
revisions and addenda to SE16 were published. These are listed in Table A,
Appendix V.

In a similar manner, the subject of loads analysis was addressed in
SRB-DSS-SE11, Design Loads Analysis Report. Revisions to the basic document
were made to reflect changes to the baseline mass properties and predicted
flight performance characteristics as well as to update the report for Large
Main Parachutes, FWC DSS design, and the Flotation Subsystem. The loading
which would be induced by a single parachute failure during the flight of FWC
SRBs was also addressed. These reports are enumerated in Table B, Appendix V.

Mass properties of the SRB DSS were analyzed and reported in SRB-DSS-
SE01 in a number of increments including the baseline (115 ft. dia.) Small
Main Chute (SMP) subsystem; the SMP DSS with corrosion resistant main
parachute riser attach fittings; Large Main Parachute (136 ft. dia.) DSS; and
LMPs with the new Flotation Subsystem. These reports are listed in Appendix
V, Table C. The actual weights of individual subsystems as installed in SRB
nose assemblies were reported in SRB-DSS-SE07 for each flight set delivered.
These Actual Weight Reports are also listed in Table D of Appendix V.
A Failure Modes and Effects Analysis (FMEA) was conducted to determine the results of failure of various components in the Decelerator Subsystem. The results of this analysis as well as a list of critical components were reported in SRB-DSS-RA03, Failure Modes/Effects Analysis and Critical Items List.

Structural analysis of the SRB-DSS followed an evolutionary path dictated by changes in requirements and hardware, and refinements in load definition. Standard, accepted aerospace analysis techniques were employed on all parts. Finite element models were prepared and utilized to determine internal load and stress distributions in the Main Parachute Support Structure (MPSS), for example.

The MPSS was first designed and analyzed for loads imposed by the 115 ft. D₀ main parachutes utilizing the Martin Denver Space Frame Program. In this model, the SRB frustum interfaces were represented by axial members having stiffness equivalent to the corresponding frustum attach frames. Detail elements were analyzed by hand using predicted loads from this model.

For the design modification to incorporate the 136 ft. D₀ parachutes, a NASTRAN model of the MPSS was created. Loads and stresses were compared to assure equivalency with the previously developed model. Changes were made in the bipod struts, isogrid corner fitting attach bolts and forward tie ring interface splice plates to accommodate the larger loads.

For the shortened MPSS study, a second NASTRAN model was created, for the first time incorporating the forward tie ring. Here, the SRB frustum interfaces were represented by a stiffness matrix derived from the frustum finite model reduced to the specific interface locations. Based on predicted loads and stresses, hardware (bipod struts) was designed and analyzed to reinforce the shortened isogrid panels and react lateral loads at the outboard aft corners of the panels. A test-derived distribution was used as a basis for the axial acceleration input loads occurring at frustum separation. Computer predicted stresses based on this distribution were used to verify the integrity of the forward tie ring for all flight load configurations.

Loads imposed on other items such as the main and drogue deck fittings were determined by test and/or dynamic simulation analyses. The main and drogue deck fittings were also affected by changes in subsystem design and parachute loadings. These were analyzed by both hand and finite element techniques as required to assure structural integrity.

Structural stress analyses of SRB DSS mechanical components were published in the SRB-DSS-SE03, Stress Analysis Report, series. These reports, listed in Table E, Appendix V, covered subjects such as identification of critical loading conditions, free body diagrams, discussion of load path, methods of analysis, assumptions and significant margins of safety.

In addition to periodic upgrades to SE03 reflecting component changes or anomalies, addenda were used to present stress analysis for loads predicted for specific SRB flights or conditions not covered in the basic SE03.
document. These addenda were usually published only where predicted loads for a given flight exceeded previously analyzed values.

At each step of subsystem design and development, care was taken to review the effect of design and design changes on interfaces. Proposed Interface Revision Notices (PIRNs) were submitted to Interface Control Document ICD-3-44006, Decelerator Subsystem SRB Forward Skirt and Nose Assembly, to define parachute riser attach fitting loads for 115 ft diameter and 136 ft diameter main parachutes. Similarly, PIRNs were submitted to ICD-2-4A002, SRB Retrieval Station, to define parachute retrieval and recovery configurations. These PIRNs were reviewed by the customer and, following approval, issued as Interface Revision Notices (IRNs) for incorporation into the applicable document.

To establish the performance requirements for design, development, manufacturing, refurbishment and verification of the SRB Decelerator Subsystem, and to formalize interface requirements by reference to the appropriate ICDs, the Configuration End Item Specification, SE-019-075-2H, was created and provided to Martin Marietta as an exhibit to the contract. This document is divided into two parts. Part I establishes the performance requirements of the SRB DSS, including as reference data initial SRB re-entry trajectory parameters. Various other requirements were also included in the Part I CEI specification. These include release of the main parachutes from the forward skirt at water impact, development flight load sensors, and anticipated environmental conditions under which the various components must successfully operate.

Even prior to STS-1, it became apparent that flight conditions on the DDT&E missions were going to exceed the design conditions defined in the basic Part I specification so that the performance requirements with regard to water impact velocities could not be met by the SRB DSS. As a result, the 20-series Appendices were created to document the differences between the original performance requirements and the anticipated subsystem performance on the DDT&E flights, STS-1 through 6. Despite the somewhat greater terminal velocities of the SRB and frustum, both were recovered in good condition on five of the six DDT&E flights. (The boosters on STS-4 were not recovered due to premature separation of the main deck fitting separation nuts, a problem not attributable to the Decelerator Subsystem.)

Additional exceptions to the basic CEI specification were established in Appendix 11 of that document, for the Large (136 ft D₀) Main Parachutes, and in Appendix 12 for the Filament Wound Case SRB Decelerator Subsystem.

Part II of SE-019-075-2H was created to establish the requirements for complete identification and acceptance of all units of the SRB DSS to be delivered to NASA-Marshall Space Flight Center. The configuration baseline was established at Configuration Inspection, in 1978, and revised in September 1984 to include 136 ft diameter main parachutes as an alternate configuration for use with steel cased SRBs. At that time, the configurations installed on BI013 became the baseline for 115 ft D₀ mains on the steel case SRBs. The configuration flown on mission 41D (STS-14) was established for Large Main Parachutes.
In July 1985, SCN 67 was submitted to United Space Boosters, Inc., to revise the Part II specification to re-baseline the SRB Decelerator Subsystem configurations. This revision, when approved, establishes the configuration to be flown on BIO20 (136 ft $D_0$ - Large Main Parachutes) as the new baseline for steel cased SRBs. The 115 ft $D_0$ main chutes with the 52.5 ft dia. drogue parachute, as configured on BIO33, becomes the Filament Wound Case (FWC) SRB DSS. In addition the Main Parachute Flotation Subsystem, as installed on BIO26 and subsequent flights becomes a baseline for all systems.

Post flight analysis, originally scheduled for the first four DDT&E shuttle flights, continues on an on-going basis after each flight. This includes analysis of film data and whatever instrumentation was included on the flight. Some flights are equipped for loads measurement, but most are not. Recently, some flights have been equipped with on-board cameras set up to record the main chute deployment and inflation. A post-flight report, TM-12, is published after each flight to present the data and results of analysis.

Anomaly analysis has been conducted to identify the causes and conditions of Large Main Parachute failures which have occurred on a number of flights. Boosters continue to be recovered in good condition in spite of this problem, since the failure of a single large main chute results in a water impact velocity approximately equal to that of a booster with three small mains.

WBS 1.4.1.6.1.2.2.1 - Special Engineering Analysis - Technical Directives were received by MMC from MFSC directing certain activities be performed. Some of these TDs involved tasks such as review of Interface Revision Notices (IRNs) to Interface Control Documents, or shipping of certain hardware to subcontractors, etc. The majority of the 126 TDs required special engineering analyses in accordance with this WBS. A list of Technical Directives is shown in Table F, Appendix V.

The results of these and other engineering studies were published in sixty-nine Technical Notes, the subjects of which are listed in Table G, Appendix V. Fifteen of these Technical Notes were the direct product of TDs.

WBS 1.4.1.6.1.2.2 - Engineering Design - The Decelerator Subsystem design was a joint effort between Martin Marietta Corporation and its subcontractors, the principal supplier being Pioneer Parachute Corporation. Maximum use was made of the technical expertise of each organization in its respective field.

Pioneer Parachute, for example, was responsible (subject to MMC approval) for detail design and fabrication of the parachutes, as well as development of the refurbishment techniques and repair procedures.

Following detail design by MMC, metal hardware was subject to a "make or buy" analysis and a majority of components, e.g., the Main Parachute Support Structure (MPSS), Main Riser Attach Fittings and Drogue Retention Brackets, were produced in-house at Denver. Certain other components of the
Decelerator Subsystem such as load cells and a later lot of Drogue Retention Brackets were purchased from Beowulf Corporation of Huntsville, Alabama.

Pyrotechnically actuated reefing line cutters were developed for the Decelerator Subsystem by Space Ordnance Systems based on existing technology.

Materials selection and control has been conducted in accordance with SE-020-009-2H, Rev. A, SE-019-094-2H, Rev A, and MSFC-SPEC-522A, under supervision of a Material Review Board (MRB). Processes were selected in accordance with SE-R-006A, and a materials control and verification plan, SRB-DSS-SE09, was implemented early in the program.

Studies were conducted of factors affecting reuse and refurbishment, and design changes incorporated as necessary to assure cost effective operation of the DSS. For example, the Drogue Riser Attach Fittings were originally designed as single use items; after experience on STS-1 and -2, it was decided that they could be reclassified as reusable items and refurbishment procedures were developed, and approved by MSFC. In another example, the original prototype FWC drogue, flown on Development Air Drop Number 10, was a continuous-radial design which proved to be very difficult to repair after use. When the drogue was redesigned prior to DAD-11, one of the changes was to revert to the discrete radial-vent line-radial type of construction which facilitates repair. The baseline drogue, and both small and large main chutes already utilized this construction.

Because both sizes of main parachutes utilize the same operational main deck fittings, the Decelerator Subsystem maintains the flexibility of being able to utilize either size canopy on steel case SRBs as logistics or operational conditions dictate. (All three chutes on a given SRB must be of the same diameter, however.)

The Decelerator Subsystem has been designed to facilitate recovery of a majority of its components for refurbishment and reuse. The initial design provided for Parachute Location Aids (PLAs) to assist in recovery of the parachutes from the ocean. Although PLA mass simulators were flown on the first series of drop tests, the idea was dropped from consideration early in the program. A provision for the use of acoustic beacons (sonar "pingers") was made in the parachute design for the first six Shuttle missions, but this, too, was deleted after it was found that visual acquisition of the boosters eliminated the requirement and that the parachute risers masked too much of the sound pattern to be very effective.

On STS-1, -2 and -3, the main deck fittings were released from the SRB at water impact to permit easier handling of both the boosters and the parachutes. Pyrotechnic separation nuts holding the main parachute riser attach fittings to the forward dome of the SRB were fired at water impact, releasing the deck fittings and parachutes. The residual tension in the main parachute risers deployed the deck fittings over the sides of the boosters. The parachutes settled into the water with each chute suspended from a float attached to the apex of the parachute canopy.
During these first three flights it was found that the apex floats were subject to considerable damage during chute deployment so that a total of three parachutes failed to float and were not recovered. As a result, apex floats were omitted from further use, and the parachutes have been left attached to the boosters for STS-4 through BI025. The chutes are manually disconnected by the divers during recovery operations. This has been identified as an operation involving risk to the divers. Separation of the chutes at impact is now a requirement with the result that a different parachute flotation approach utilizing floats connected to the main deck fittings has been recently introduced. Current planning calls for inclusion of the Main Parachute Flotation Subsystem on BI026 and subsequent flights. The use of retroreflective cover material on the floats aids in spotting the floats on the ocean surface during retrieval and recovery operations. As the floats are easily spotted even under night visibility conditions, active retrieval aids remain unnecessary.

The use of a drogue chute/frustum retrieval line and retrieval line (the so-called "peanut") float to assist in retrieval of those components has continued on steel case SRB DSS. As a result of data obtained on drop test DAD-13, the retrieval line, float and retrieval line bridle have been eliminated from the FWC drogue chute configuration.

During ground tests at Space Ordnance Systems, it was found that the reefing line cutters would not consistently cut the 3-ply Kevlar FWC drogue chute reefing lines at temperatures of 200 degrees F. The cutter blades, which have been previously qualified to cut nylon reefing lines at elevated temperatures, were redesigned to use 13-8 Mo steel instead of the original 17-4 PH stainless, and subsequently qualified to cut 4-ply Kevlar at 200°F.

Following a number of flights, varying degrees of damage to main parachutes in the form of tears and friction burning has been noted. While this has not resulted in any major degradation to the Decelerator Subsystem mission performance, i.e., boosters continue to be recovered in good condition, the program design team has responded to the potential of such chute damage with a number of design changes.

In particular, some of the chute damage was determined to have been caused by contact with various surfaces of the Main Parachute Support Structure and inside surfaces of the frustum. An interim fix in the form of frustum foam fairings and bipod strut foam fairings was placed on BI013. This fix was applied in a timely manner and caused no impact on the Shuttle launch schedule. Subsequently, isogrid corner fairings were added to the DSS configuration, and have been part of the system since BI014.

Although the fairing modifications have definitely resulted in reduction of some types of damage, a problem with torn parachute ribbons has persisted. The program engineering team has continued its analysis and has come up with a number of recommendations for modifications to eliminate the problem. Some of these range from elimination of canopy bag ties and inclusion of rip-stops in the canopies to shortening of the MPSS or deployment from a softpack container.
A detailed list of the current SRB Decelerator Subsystem components is shown in the CEI Specification, Part II.

**WBS 1.4.1.6.1.2.3 - Development Tests** - A development test program was conducted to verify that the subsystem was ready for SRB flight application. The program consisted of a number of tests at various levels ranging from parachute element structural tests to structural tests of key parachute attachment and support hardware, to ground dynamic tests of parachute pack assemblies, and culminated in air drop tests of complete subsystems.

The range of tests is summarized in two documents: SRB-DSS-TM01 Verification Plan defines the development testing, excluding the air drop test program; SRB-DSS-TM06, Drop Test Plan, defines the air drop test program.

SRB-DSS-TM01 was prepared at the start of the program and has been updated as needed for new development tests resulting from major extensions to the subsystem. Introduction of the large main parachutes, the subsystem for the filament wound case SRB and the addition of the flotation subsystem, caused the major updates to the plan.

**WBS 1.4.6.1.2.3.1 - Air Drop Tests** - The Drop Test Plan also was prepared at the start of the program to define the scope, techniques and responsibilities in the drop test program. Appendices were prepared to define the specific objectives, requirements, guidelines and constraints for each drop test.

Reporting of drop tests was contained in three documents: SRB-DSS-TM09, Drop Test Quick Look Report; SRB-DSS-TM10, Drop Test Data Report; and SRB-DSS-TM11, Drop Test Final Report. The Quick Look Report was published within 3 days after a test in which a significant event occurred, the Data Report was published within 3 weeks after each drop test, and the Final Reports in four increments: one after drop tests DAD-1 and -2, one after tests -3 through -6, one after tests -7 through -9, and the last after completion of the balance of the fourteen air drop tests.

The development test program is summarized in Appendix VII, which lists test plans and reports for all development tests.

**WBS 1.4.1.6.1.2.3.2 - Ground Tests** - Each ground test was initiated by the preparation of a test plan that was coordinated with the customer before implementation. Upon completion of the ground tests a test report was published.

**WBS 1.4.1.6.1.2.4 - Verification** - A verification program was initiated in accordance with the Verification Plan, SRB-DSS-TM01, as discussed in Section 1.4.1.6.2.3 of this report. A DSS Certification of Qualification (COQ) was created and submitted to MSFC for each Shuttle flight to certify the flight readiness of the DSS. Martin Marietta document MCR-80-1343, Qualification Summary Report, defines how verification is accomplished.
WBS 1.4.1.6.1.2.5 - Support Equipment & Tooling (SE&T) and Special Test Equipment - Decelerator Subsystem support equipment is broken down into five categories:

(1) Initial Delivery Items
(2) Interim Support Equipment (ISE)
(3) Refurbishment Support Equipment (RSE)
(4) Drop Test Support Equipment
(5) VAFB Support Equipment

Initial Delivery Items were those pieces of support equipment defined under the original SOW. A list of these items is shown in Table A, Appendix VII. These items were designed, built and delivered to support the initial program operations; functional adequacy was demonstrated in the first phase of the drop test program. Three items designed and built for use in the Drop Test Program are listed in Table B, Appendix VII. These were subsequently delivered to KSC as Interim Support Equipment (ISE).

In 1978 MMC was directed to establish basic Refurbishment Support Equipment requirements and detail designs for such equipment. Document SRB-DSS-SE24-1, Design Criteria for Support Equipment, written in accordance with SW-E-0002B, established design, construction and testing criteria for RSE.

As the program developed and more parachute refurbishment experience was gained, requirements for Refurbishment Support Equipment were refined, the units fabricated and delivered. A series of Abbreviated Item Description (AID) Sheets (SRB-DSS-SE25) were written and published for the delivered RSE items. The final list of RSE is contained in Table C, Appendix VII. The quantities delivered are also shown. Items identified in the initial analysis but not built or delivered show "N/A" in the "Qty Delivered" column.

Additional items of equipment were designed to support the Air Drop Test Program. These items were primarily designed to handle components of the Drop Test Vehicle (DTV), although the ISE hardware was also utilized in support of the Drop Test Program.

Two additional support equipment items have been designed, built and delivered. These are the Parachute Reel Stand and the Wet Parachute Transportation Container. These items are utilized to support Shuttle operations at Vandenberg AFB, California. As no Parachute Refurbishment Facility exists there, it was deemed more cost effective to ship recovered SRB parachutes to the PRF at Kennedy Space Center than to build a PRF at VAFB.

The Wet Parachute Transportation Container was designed and built by Crown Rotational Molded Products of Marked Tree, Arkansas. It is designed to hold one main parachute in a wet condition to prevent salt crystallization in the nylon during cross-country shipment. Eight of these containers have been delivered to Port Hueneme, California, for use by the Air Force.
The Parachute Reel Stand is designed to hold parachute reels transferred from the recovery vessel so that the parachutes may be unrolled into the Wet Chute Container for shipment.

WBS 1.4.1.6.1.2.6 - KSC PRF Development - The KSC Operation developed from the DAD test program field operation at El Centro, CA. Some of the Martin Marietta and Pioneer Parachute drop test crew and equipment were transferred to KSC where offices were established in Hangar N at the Cape Canaveral Air Force Station. A work area was provided in Hangar "n" since the Parachute Refurbishment Facility (PRF) was currently under construction. The first flight set of parachutes for STS-1 were packed at PPC, Manchester, Connecticut, and delivered to KSC in shipping containers. The first two clustering operations for SRBs A07 and A08 (STS-1) were performed in Hangar "n" with the aid of its overhead crane. The clustering operation was performed to the procedures developed for the DAD test program.

Martin Marietta's original charter for the KSC operation was to develop procedures and an operating system to refurbish the hardware and manage the PRF for the first six DDT&E shuttle flights. During this period, MMC was to train the Booster Assembly Contractor personnel (USBI) and on the sixth refurbishment, the operation would be turned over to them. The scope of work was later reduced to four DDT&E flights, then expanded to the MBAC contract award (January 1985) in approximately one year contract increments. This evolution made long range planning and management of the PRF operation difficult.

Due to major delays in the shuttle launch schedule, it was decided to begin packing all SRB parachutes at KSC as the PRF had been completed and accepted by NASA-KSC. The parachutes for STS-2 (A09/A10) were delivered to the PRF unpacked and were packed by MMC and PPC personnel to the PPC packing procedures. Since these procedures did not comply with required NASA format standards, and equipment available in the PRF differed from that at PPC, the procedures were subsequently rewritten into MMC format.

Unlike the packing and clustering procedures which evolved from earlier operations, the procedures for handling and refurbishment of flown hardware were developed at the PRF. Table A in Appendix VIII lists all the Flight Hardware Refurbishment Procedures with original release date published under this contract.

During this contract period, the KSC operation has packed and delivered subsystems for sixteen (16) flights through Flight 51D. These include:

- New 115' MC Packed ........... 42
- Refurbished 115' MC Packed .......... 39
- New 136' MC Packed ........... 21
- New 54' DC Packed ........... 14
- Refurbished DC Packed .......... 18
- New 52' DC Packed ........... 2

T36
Packing of mains, drogues, pilots and extraction chutes for the DAD 7-14 drop test program at China Lake, California, and the dynamic strip testing at Sandia Labs was performed in the PRF. Also, the mass simulation clusters and drogues for the MVGVT vehicles and the cluster and drogue for the VAFB FVV forward assembly were packed and assembled at the PRF.

The KSC operation conducted the post flight inspection and refurbishment of fourteen (14) flights (through 51A). Extensive investigations subsequent to flights STS-3, STS-4, STS-9, STS-11, and STS-13 resulting from major parachute damage, loss of parachutes and the loss of boosters on STS-4 were supported by the KSC operation. Visual evidence produced by a static strip test in the PRF during the STS-4 investigation was a major contribution to the resolution of that failure.

Personnel training was accomplished as delineated in SRB-DSS-LS04, Refurbishment Training Plan. Some training courses are for safety familiarization and KSC area access and are administered by various KSC contractors. Courses required to perform hands-on work on flight hardware require certifications, requirements for which are defined in the training plan.

WBS 1.4.1.6.1.2.7 - Special Studies - See WBS 1.4.1.6.1.2.1 and WBS 1.4.1.6.1.2.2.

3.3 MANUFACTURING - WBS 1.4.1.6.1.3

WBS 1.4.1.6.1.3.1 - Manufacturing Engineering - Manufacture of SRB DSS flight hardware included four categories:

(a) Metallic components of parachute/support connection structure
(b) Parachutes and other fabric components
(c) Reefing line cutters
(d) Load sensors

Category (a) items are discussed herein; items in categories (b), (c) and (d) are supplied by subcontractors and are discussed in detail under WBS 1.4.1.6.1.4.

The category (a) structural items were manufactured by Martin Marietta at the Denver, Colorado, facility except for one lot of Drogue Retention Ratchet Assemblies, Part No. 82700101060. A detailed list of components manufactured at the Denver plant is included in Table A, Appendix IX. Certain of the detail items were fabricated using numerically controlled machines. These parts are indicated in Table A, Appendix IX.

Several special purpose tools were designed and fabricated for the SRB DSS. These are listed in Table B, Appendix IX.
WBS 1.4.1.6.1.3.2 - Main Parachute Assembly - See WBS 1.4.1.6.1.1.4.

WBS 1.4.1.6.1.3.3 - Drogue Parachute Assembly - See WBS 1.4.1.6.1.1.4.

WBS 1.4.1.6.1.3.4 - Pilot Parachute Assembly - See WBS 1.4.1.6.1.1.4.

WBS 1.4.1.6.1.3.5 - Deleted from SOW.

WBS 1.4.1.6.1.3.6 - Other Deliverable Hardware - See WBS 1.4.1.6.1.2.5.

WBS 1.4.1.6.1.3.7 - Refurbishment of Flight Hardware and Provisioning of Support Hardware Spare Parts and Bulk Materials - Development and maintenance of procedures which provide instructions to perform flight hardware refurbishment and for Refurbishment Support Equipment (RSE) design and maintenance were completed in response to Data Requirements in the Information Requirements Document, SE-019-024-2H-R.

The refurbishment procedures provide very detailed, step-by-step instructions for performing parachute packing, inspection, repair, clustering, cleaning, metal component refurbishment and aging effects testing.

The RSE-related procedures give information on the design criteria, the description and maintenance requirements for RSE utilized in refurbishment of flight hardware.

Each procedure used for SRB DSS operations required initial validation and/or approval by MSFC for release, and approval for Procedure or Document Change Notices (PCNs, DCNs). Initial approval for all procedures was by the MSFC Contracting Officer. Validation of specific procedures was obtained by performing the first specified operations by the procedure, and incorporating redlined comments approved by each member of the validation team. Validation, PCN, and DCN approval requirements vary and have changed several times through the course of the program. The IRD Data Requirements specify these approval cycle procedures. Procedures are given either a Type 1 (approval by the customer is required), Type 1* (special approval cycle) or Type 2 (approval by the customer not required) category in accordance with the applicable DR. Type 1* documents such as the LSO3-X series, are approved in-house by MMC with subsequent approval by MSFC Program Quality Representative at KSC. Table A, Appendix VIII, lists the Flight Hardware Refurbishment Procedures.

Production operations performed at the PRF under this contract consist of refurbishment, assembly and checkout activities and production control. The refurbishment cycle for the SRB DSS hardware is presented in the Processing Flow Diagram (Figure 1, Appendix VIII), followed by a description of each phase of the cycle. Specific operating procedures are contained in the SRB DSS KSO Operations Procedures (KOP) 0-06 and 0-07, listed in Table VIII-B.

WBS 1.4.1.6.1.3.8 - Repair of Government Furnished Hardware - Repair of Government Furnished Equipment (GFE) was carried out on Main Parachute Support Structure (MPSS) S/N 0000008, which was damaged during removal from the
frustum following one of the Shuttle missions. An Engineering Change Proposal, RC5391, to repair this MPSS was submitted to and approved by MSFC. Standard MMC documentation was prepared, and inspection of the MPSS by MMC Quality Assurance was conducted to assure compliance with design drawings.

A number of load cells, which were damaged in handling at the SRB Refurbishment Facility, were refurbished by Beowulf Corporation, Huntsville, Alabama. (See Appendix II, Procurement Management, for quantities and subcontract numbers.)

3.4 CHANGE ACTIVITY - WBS 1.4.1.6.1.4

WBS 1.4.1.6.1.4.1 - Engineering Change Proposals - During the period of performance approximately 230 Class I changes were submitted via Engineering Change Proposals (ECPs) for NASA Level III change board approval. An additional 96 Class II changes were submitted for information and concurrence of classification in accordance with DD 8040.12A. These changes were also processed through the MMC Level IV change board prior to implementation.

3.5 SUPPORT EQUIPMENT - WBS 1.4.1.6.1.5

See WBS 1.4.1.6.1.2.5 and Appendix VII.

3.6 SRB/DSS REUSABLE PARTS - WBS 1.4.1.6.1.6

As a follow-on to the initial delivery of flight hardware, MMC was directed to supply two (2) complete Decelerator Subsystems less refurbishment kit items. The drawing numbers and quantities delivered were specified in Table V of the SOW of the contract. This table is reproduced as Table B, Appendix II, of this report.

3.7 LARGE MAIN PARACHUTES - WBS 1.4.1.6.1.7

See WBS 1.4.1.6.1.2.1.

3.8 FILAMENT WOUND CASE SRB DSS - WBS 1.4.1.6.1.8

See WBS 1.4.1.6.1.2.1.
4.0 CONCLUSIONS AND RECOMMENDATIONS

The recovery of the Solid Rocket Boosters presented a major challenge. The SRB represents the largest payload ever recovered and presents the added complication that it is continually emitting hot gases and burning particles of insulation and other debris. Some items, such as portions of the nozzle, are large enough to burn through the nylon parachute material. The SRB Decelerator Subsystem program was highly successful in that no SRB has been lost as a result of inadequate performance of the DSS.

There have, however, been significant problems in the development of the SRB/DSS that in some cases remain unsolved. The most serious issue is the continuation of a pattern of friction burn damage and occasional gore failures that occur on the main parachutes. Fortunately, only one (of three) main chutes per SRB has failed so far and performance with two main parachutes has proven to be acceptable. Efforts to eliminate main parachute deployment damage has not been completely successful. Several modifications to alleviate or survive this damage are currently being evaluated. These include addition of rip-stop ribbons, deletion of canopy ties, development of an effective vent break system and reducing the severity of the main parachute deployment environment.

The majority of the damage to the main parachutes has been caused (directly or indirectly) by two requirements imposed upon the system at its inception. These requirements were deployment out of a rigid container (frustum) and attachment of flotation and/or retrieval aids to the apex of the parachutes. The location and retrieval aids have just about all been eliminated as a result of drop test and/or flight failures. If any future systems such as the SRB/DSS are to be developed, the concept definition phase must put recoverability first and retrievability second.

Several problems were encountered during the development of the 136 ft. diameter large main parachute. The first problem was a severe infold. The large diameter vent and long vent lines, resulting from the selection of a 160 gore design, prevented direct application of the parachute handbook (AFFDL-TD-78-151). We selected the vent line length after determining the as-built dimensions and load/elongation characteristics of the vent components and determining the effect of vent line length variations on vent band loads. The vent line length selection corresponded to the point at which the vent band load started to increase rapidly with increasing vent line length. The resulting configuration has eliminated the infolding problem on the LMP. Another, more obvious, effect of the large number of gores is the increase in cost of the parachute.

The selection of wide (1.75 in) vent lines in an attempt to block the large vent was a mistake, at least for clustered parachutes. This approach appears to be acceptable for single chute application where a relatively slow inflation rate can be tolerated. We were forced to install a continuous ribbon vent cap to achieve acceptable cluster performance with the LMP. Before this vent cap was installed, two chutes lagged into second stage on at least two occasions and one lagged into third stage on several occasions.
This vent modification has not eliminated the uneven cluster inflation, but based upon the limited test sample available at this writing (four cluster deployments) the cluster performance is less than desired, but is probably acceptable. The low first stage reefing ratio (17% CgA) also contributes to the uneven cluster performance experienced with the LMP.

One final significant lesson learned during the development of the SRB/DSS related to the fabrication of the 48 ft. filament wound case (FWC) drogue. In an attempt to maximize the strength per gore of this design, a continuous suspension line (reinforced radial) concept was selected. This design was very difficult to build and during drop test (even at a load of 53% of design limit load) significant separation of the MIL-W-4088 TY 26 reinforcement from the radial occurred. This result indicated that the load was not properly shared between the radial and the reinforcing member and that unacceptable refurbishment activity would result if this design was used for the operational FWC drogue.
APPENDIX I

PROGRAM MANAGEMENT

(W.B.S. 1.4.1.6.1.1)
APPENDIX I-A - Description of SRB-DSS Major Organizational Functions

Program Manager - (W.R. Woodis) - Provides day-to-day direction to assure accomplishment of program requirements. Also currently acts as Director of Technical Operations. Reports to Martin Marietta Denver Aerospace Director of Spacecraft Systems, L.J. Lippy.

Deputy Program Manager - (J.W. Gurr) - Assures implementation, performance and completion of program requirements. Also currently acts as director of Business Management Operations. Reports to Program Manager.

Customer Liaison - (E. McKee) - Provides liaison with NASA-MSFC and USBI at Huntsville, Alabama.

Director of Technical Operations - (W.R. Woodis - Acting) - Co-ordinates technical activities and interfaces with Customer providing technical expertise on the SRB Decelerator Subsystem.

Director of Subsystem Design Analysis - (R.D. Moog) - Supervises and performs analysis of DSS pre-flight performance characteristics based on subsystem design and predicted flight conditions, as well as performing post-flight analysis and preparation of flight performance reports. Member of Flight Evaluation Group.

Systems Engineering/Design Lead - (F.I. Tallentire/D. Koleqa-Deputy) - Supervises and performs systems integration for the SRB-DSS Program, providing engineering guidance regarding design, test, configuration management and technical documentation. Applies parachute design expertise to both development and operational aspects of the program.

KSC Field Operations/Parachute Refurbishment Facility (PRF) Manager - (R. Ewart) - Supervises all facets of Martin Marietta Corporation operations at Kennedy Spaceflight Center. Co-ordinates and supervises packing, clustering and refurbishment activities at the PRF in support of Shuttle Flight Operations involving the SRB Decelerator Subsystem.

Quality Assurance - (J. Christianson) - Co-ordinates all activities involving SRB-DSS quality, reliability and safety functions. Material Review Board (MRB) Chairman; Project Board Chairman; Project Liaison for Customer and Vendor Quality; reviews and approves new or changes to engineering or procedures; manages Quality/Safety budgets; maintains hardware data packages, KSC quality procedures.

Manufaturing/Production Co-ordinator - (A. Grant) - Co-ordinates scheduling and production control of SRB-DSS hardware items manufactured in-house at Martin Marrieta.

Business Management Operations - (J.W. Gurr - Acting) - Co-ordinates and supervises activities relating to contractual functions and negotiations between the SRB-DSS program and customers and suppliers.
Contract and Data Management - (J. Fletcher) - Supervises activities relating to preparation and submittal of engineering and contract change proposals, specification changes, data documentation, assures compatibility and accuracy of all program documentation. Also provides engineering release, implements and maintains SRB DSS configuration management system in conjunction with systems engineering.

Contracts Administration - (S. Thogersen) - Maintains contract and participates in negotiations with customer and suppliers.

Cost Management - (J. Thomas) - Prepares and issues budgets, monitors all costs against plans; co-ordinates, prepares and supports all data cost inputs to financial reports and all manpower reports as required.

Planning - (H. Hull) - Prepares and monitors schedule, supports program management in flight readiness reviews, PDR's and CDR's.

Materiel Representative - (D. Olsen) - Provides program direction, control, co-ordination and management to Materiel line operations. Supports development and preparation of program requirements, planning and scheduling, as well as implementation of procurement technical and administrative requirements. Monitors material schedules and performance. Co-ordinates purchase requisition and supports status meetings.

Estimating - (S. Gudzune) - Prepares cost estimates for preparation of proposals resulting from solicited and unsolicited changes to the basic SRB-DSS contract.

Subcontracts Administration - (A. Sustrick) - Monitors subcontractor activities including preparation of change orders, negotiating changes, monitoring production schedules.
APPENDIX I-B - Key Personnel History

Program Manager
C.W. Spieth
R.E. Vosbeek
W.R. Woodis
M.E. Wakefield
W.R. Woodis (Current)

Technical Director
W.R. Woodis (Current)
R.D. Moog

Contract Mgr/Adm.
R.S. Shepler
E.P. Heil, Jr.
T.D. Hohman
J.L. Palmer
M.A. Osborne
S.A. Thogersen (Current)

Parachute PIE
J.R. McCandless

Systems Eng.
F.I. Tallentire
D.J. Kolega (Current)
APPENDIX II

PROCUREMENT MANAGEMENT

(W.B.S. 1.4.1.6.1.1.4)
Table II-A

Listed below are procurements for the SRB/DSS Program:

**Pioneer Parachute Company**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GC6-190032, CPIF/AF, Competitive Procurement, Sixty-One (61) Change Orders, Sixty-Seven (67) Amendments.</td>
</tr>
<tr>
<td>12 Each 54' Drogue Pack Assy, P/N 4200</td>
</tr>
<tr>
<td>36 Each 115' LMC Pack Assy, P/N 4300</td>
</tr>
<tr>
<td>12 Each Drogue Refurbishment Kits, P/N 4374</td>
</tr>
<tr>
<td>36 Each Main Refurbishment Kits, P/N 4375</td>
</tr>
<tr>
<td>12 Each Drogue Retention Kits, P/N 4400</td>
</tr>
<tr>
<td>12 Each Main Retention Kits, P/N 4450</td>
</tr>
<tr>
<td>12 Each Tow Pendant Attachment Lanyards, P/N 4501</td>
</tr>
</tbody>
</table>

**Replacement Parts**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Each 115' Main Canopies, P/N 4320</td>
</tr>
<tr>
<td>24 Each Risers, P/N 4324</td>
</tr>
<tr>
<td>48 Each Dispension Bridles, P/N 4325</td>
</tr>
<tr>
<td>2 Each Drogue Canopies, P/N 4220</td>
</tr>
<tr>
<td>24 Each Drogue Suspension Lines, P/N 4323</td>
</tr>
<tr>
<td>12 Each Pilot Pack Assy, P/N 4100</td>
</tr>
</tbody>
</table>

**RD3-133080, CPIF, Follow-On Procurement, One (1) Change Order, Six (6) Amendments.**

**C. DESCRIPTION OF WORK/ARTICLES TO BE FURNISHED BY THE CONTRACTOR**

Within the scope of work set forth in paragraph B, above, the CONTRACTOR shall accomplish the following:


2. Fabricate eight (8) each part number 4470-501, main chute pack retention kit.

3. Fabricate thirty-six (36) each part number 4329-507, riser boot, main parachute (DDT&E).

4. Fabricate forty eight (48) each part number 4325-509, main riser, (Note: Seventy-two (72) each delivered under GC6-190032).

5. Fabricate two (2) each part number 4220-525, canopy assembly, drogue parachute.

6. Fabricate twenty-four (24) each part number 4223-503, suspension line group, drogue parachute.
RD3-133101, CPIF, Follow-On Procurement, No Change Orders, Seven (7) Amendments.

C. DESCRIPTION OF WORK/ARTICLES TO BE FURNISHED BY THE CONTRACTOR

Within the scope of work set forth in Paragraph B, above, the contractor shall accomplish the following:

1. Fabricate thirteen (13) each part number 4920-505 canopy assemblies.
2. Fabricate thirteen (13) each part number 4910-503 deployment bag assemblies.
3. Fabricate one hundred four (104) each part number 4924-503 dispersion bridle assemblies.
4. Fabricate fifty-two (52) each part number 4325-509 main riser assemblies.

Space Ordnance Systems

Note: Martin Marietta took over subcontracting responsibilities with SOS, from Pioneer Parachute Company, to insure on-time deliveries and lower prices. Both objectives were achieved. The results were significant.

XD4-400876, FP, Follow-On Procurement Failure Analysis, Closed Out.

RD4-400880, FP, Follow-On Procurement, 3 1/2 Second Cutters, Closed Out.

6 Each 3.5 Second Delay Cutters, P/N 115460

XD4-400890, FP, Follow-On Procurement, Lat Testing, One (1) Amendment, Closed Out.

1 Lot UT Testing on 14 Cutter Units for qualifying cutters to cut 2 ply Kevlar plus margin.

XD4-400891, FP, Follow-On Procurement, Three (3) Ply Development Cutters.

12 Each 7 Second Cutters
12 Each 12 Second Cutters

XD4-400895, FP, Follow-On Procurement, Development of 1.5 Second Delay Cutters, Closed Out.

3 Each 1.5 Second Delay Cutters
Beowulf Corporation

0 RC7-061604, Competition Procurement, Original Fabrication of Load Sensors.

72 Each 125K Load Sensors, P/N 827001010029-020
72 Each 35K Load Sensors, P/N PD7400192-039

0 RD4-400875, Follow-On Procurement, Load Sensor Calibration, Closed Out.

10 Each Drogue Load Sensors, 35K

0 RD4-400877, Follow-On Procurement, Load Sensor Calibration, Closed Out.

7 Each Drogue Load Sensors, 35K

0 XD4-400878, Follow-On Procurement, Load Sensor Refurbishment, Closed Out.

7 Each Drogue Load Sensors, 35K

0 XD4-400879, Follow-On Procurement, Load Sensor Refurbishment, Two (2) Amendments, Closed Out.

2 Each Drogue Load Sensors, 125K

0 XD4-400881, Follow-On Procurement, Load Sensor Refurbishment.

1 Lot Phase I Evaluation
1 Each 125 K Load Sensor, P/N 82700101029-020, CAT I Repair
23 Each 125 K Load Sensors, P/N 82700101029-020, CAT II Repair
13 Each 35 K Load Sensors, P/N PD7400192-039, CAT I Repair
10 Each 35 K Load Sensors, P/N PD7400192-039, CAT II Repair
13 Each 35 K Load Sensors, P/N PD7400192-039, CAT III Repair

0 XD4-400887, Follow-On Procurement, Load Sensor Refurbishment.

6 Each 125 K Load Sensors, P/N 82700101029-020 SAT II Repair

0 XD4-400888, Follow-On Procurement, Load Sensor Refurbishment.

8 Each 125 K Load Sensors, P/N 82700101029-020, CAT I Repair
4 Each 125 K Load Sensors, P/N 82700101029-020, CAT II Repair

0 XD4-400894, Follow-On Procurement, Load Sensor Refurbishment.

2 Each 35 K Load Sensors, P/N PD7400192-009, CAT I Repair
4 Each 35 K Load Sensors, P/N PD7400192-009, CAT II Repair
2 Each 125 K Load Sensors, P/N 82700101029-020, CAT I Repair
0 TH3-133102, Follow-On Procurement, Tooling Order.

0 TH5-400897, Follow-On Procurement, Tooling Order.

Crown Rotational Molded Products, Inc.

0 RD3-133108, Single Source Procurement, Wet Parachute Transportation Containers.

8 Each Wet Parachute Transportation Containers, P/N DP100115

0 RD4-400882, Competitive Procurement, Flotation Gear.
### Table II-B

**SRB/DSS Reusable Parts**

<table>
<thead>
<tr>
<th>Martin Marietta Nomenclature</th>
<th>Quantity Per Subsystem</th>
<th>Total Quantity</th>
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<tbody>
<tr>
<td>82700101050-019 Structure Assy - Support, Main Parachute</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>82700101057-009 Structure Assy - Main Parachute Support</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>82700101057-019 Structure Assy - Main Parachute Support</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>82700101057-020 Support Fitting Main Parachute Support</td>
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<td>12</td>
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<td>82700101063-009 Support Fitting Main Parachute Support</td>
<td>6</td>
<td>12</td>
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<table>
<thead>
<tr>
<th>Pioneer Nomenclature</th>
<th>Quantity Per Subsystem</th>
<th>Total Quantity</th>
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<tbody>
<tr>
<td>4320-513 Canopy Assy Main Parachute</td>
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<tr>
<td>4310-511 Deployment Bag Assy Main Chute</td>
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<tr>
<td>4324-503 Dispersion Bridle Main Parachute</td>
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<td>4325-509 Main Riser Main Parachute</td>
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<td>4369-7 Bag Assy - Center Main Parachute Floation Assy</td>
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<td>4369-3 Bag Assy - Right Main Parachute Floation Assy</td>
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<td>4369-5 Bag Assy - Left Main Parachute Floation Assy</td>
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<td>6</td>
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<td>4369-105 Floation Block - Left Main Parachute Floation Assy</td>
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<tr>
<td>4369-103 Floation Block - Right Main Parachute Floation Assy</td>
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<tr>
<td>4369-107 Floation Block - Center Main Parachute Floation Assy</td>
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<tr>
<td>4369-15 Riser Assy, Side Bag</td>
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<td>4369-81 Riser Assy, Center Bag</td>
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<td>4220-523 Canopy Assy - Drogue Parachute</td>
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<tr>
<td>4223-503 Suspension Line Group - Drogue Parachute</td>
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<td>24</td>
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</table>

* Shipped assembled into a subassembly. No part number assigned to the subassembly.
APPENDIX III

SAFETY, RELIABILITY AND QUALITY ASSURANCE

(W.B.S. 1.4.1.6.1.1.5)
<table>
<thead>
<tr>
<th>PROBLEM REPORT NO.</th>
<th>PROBLEM</th>
<th>RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRB-DSS-RA08-1</td>
<td>Main Riser Load Cell Failed Qualification Vib Test</td>
<td>Vendor Processes Updated and Additional Wire Stress Relief Provided</td>
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<td>SRB-DSS-RA08-2</td>
<td>2 Reefing Line Cutters Failed 40 ft. Drop Qualification Test</td>
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<td>Engineering Change Made and Design Passed Acceleration Tests</td>
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<td>4 Reefing Line Cutters Failed During Qualification Testing - Failed To Function after 8 ft. Drop</td>
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<td>Link Fittings Failed Magnetic Particle Examination Due to Cracks</td>
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<td>Rocket Sled Test Malfunction - Tow Cable Failure</td>
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<td>Rocket Sled Test Malfunction - Incomplete and Premature Drogue Deployment</td>
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<td>Failure caused by test load strap failure. Revised analysis predicts positive forward ring margin for all flight conditions.</td>
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APPENDIX IV

GOVERNMENT FURNISHED EQUIPMENT MANAGEMENT

(GFE)

W.B.S. 1.4.6.1.1.6
Table IV - Government Furnished Equipment - NAS8-32122

<table>
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IV-3
### Table IV - Government Furnished Equipment - NAS8-32122 (Continued)

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<td>MSFC10A00481-1</td>
<td>CDF Manifold</td>
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<td>N65629</td>
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<td>N65691</td>
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### Table IV - Government Furnished Equipment - NAS8-32122 (Continued)

<table>
<thead>
<tr>
<th>Contractor Part No.</th>
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<tr>
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<td>N718982YB</td>
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<td>N78847</td>
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<td>NAS1291-C8</td>
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<td>Bolt</td>
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<td>NAS1587-20C</td>
<td>Washer, CSK, 1</td>
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<td>NAS1587-6</td>
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<td>S201 BTV TRNSPOR</td>
<td>S201 BTV TRNSPOR</td>
<td>Ea.</td>
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<td>S202 LOADR TRACK</td>
<td>S202 Loader Track</td>
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<td>S212 Bolster</td>
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<td>S214 Indicator C&amp;L</td>
<td>S214 Cable/LK IND</td>
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<td>Seal ABZ 553</td>
<td>Seal ABZ 553</td>
<td>Ea.</td>
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<td>Sealant Samplers</td>
<td>Sealant Samplers</td>
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<td>SEB26100001-210</td>
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IV-6
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<th>Nomenclature</th>
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<th>Qty</th>
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<td>NASA Stand Init</td>
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<td>NSI Detonator</td>
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<td>Bore Sigh</td>
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<td>Silicone Compound</td>
<td>Silicone No. 36</td>
<td>Cm.</td>
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<td>Sled Test Hardware</td>
<td>Hardware</td>
<td>Lt.</td>
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<td>STS-13 Flaps</td>
<td>STS 13 Flaps</td>
<td>Ea.</td>
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<td>Tires</td>
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<td>Ea.</td>
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<td>Transport Tube</td>
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<td>XCH11</td>
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<td>Cable Elec 91929</td>
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APPENDIX V

SUBSYSTEM ANALYSIS AND INTEGRATION

(W.B.S. 1.4.1.6.1.2.1 and including 1.4.1.6.1.2.7, 1.4.1.6.1.7.1 and 1.4.1.6.1.8.1)
TABLE V-A
MASS PROPERTIES STATUS REPORT (SRB-DSS-SEO1)

<table>
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<tr>
<th>Report No.</th>
<th>Subject</th>
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<td>SEO1-1</td>
<td>Baseline subsystem</td>
<td>August 1976</td>
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<td>SEO1-2</td>
<td>Baseline subsystem</td>
<td>September 1976</td>
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<td>SEO1-3</td>
<td>Baseline subsystem</td>
<td>October 1976</td>
</tr>
<tr>
<td>SEO1-4</td>
<td>Baseline subsystem</td>
<td>November 1976</td>
</tr>
<tr>
<td>SEO1-5</td>
<td>Baseline subsystem</td>
<td>February 1977</td>
</tr>
<tr>
<td>SEO1-6</td>
<td>Baseline subsystem</td>
<td>May 1977</td>
</tr>
<tr>
<td>SEO1-7</td>
<td>Baseline subsystem</td>
<td>September 1977</td>
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<tr>
<td>SEO1-8</td>
<td>Baseline subsystem</td>
<td>March 1978</td>
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<tr>
<td>SEO1-9</td>
<td>Baseline (115') DSS w/o Pingers or Flashing lights</td>
<td>October 1978</td>
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<tr>
<td>SEO1-10</td>
<td>SMF (115') DSS w/corrosion resistant deck fittings</td>
<td>February 1982</td>
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<tr>
<td>SEO1-11</td>
<td>LMP (136') Main chute DSS</td>
<td>June 1983</td>
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<td>SEO1-11,</td>
<td>LMP (136') Main chute, w/flotation subsystem</td>
<td>April 1985</td>
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<td>DCN-1</td>
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TABLE V-B
SRB-DSS-SE03 Stress Analysis Report
Directory of Changes

<table>
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<tr>
<th>DCN</th>
<th>Description</th>
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<tr>
<td>SE03</td>
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<td>SE03</td>
<td>Rev. A (See Table of Contents)</td>
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DCN's are used to update or include additional subsections or appendices to Basic Document.

DCN 1
-added Pages C-7b and C-7c to Appendix C, Ratchet Bracket Analysis -July 1978

DCN 2
-Revised Pages 16, 19 -September 1978

DCN 3
-Revise Pgs 38-42 in App. E2, Trim FWD Tie Ring Splice Plate -October 1978

DCN 4
-Added Drogue CANO Loads to Parachute Strength Analysis Pgs 1, 20 & 24, App. F -November 1978

DCN 5
-Added Drogue Radial Extension 200°F Joint Test Results, Pg 22, 22a, App. F. -June 1979

DCN 6

DCN 7
-Updated Main Deck Fitting Loads Analysis, D1-D18, for DTV Overload -March 1980

DCN 8
-Added Sonar Beacon Mounting Bracket, D36-D45 (Cancelled) -March 1980

DCN 9
-Not Applicable -Never Issued

DCN 10
-Added App. G, Large Main Chute -September 1982

DCN 11
-Added Drogue Deck Fitting Fatigue Analysis A65-A76 -February 1984

DCN 12
-Added App. H, Filament Wound Case -June 1983

DCN 13
-Added MPSS Fracture Criticality Analysis, GE6-1 to GE6-6 -January 1984

DCN 14
-Upgrade App. G, for Large Main Parachute -September 1984

DCN 15
-Main Deck Fitting Fracture Mechanics Analysis, D2-1, D2-25 -September 1984
**TABLE V-B (Cont.)**

SRB-DSS-SE03 Stress Analysis Report  
Directory of Changes (Cont.)

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<tr>
<td>16</td>
<td>Drogue Deck Fitting Stress Analysis FWC Subsystem, HA 1.1 - HA 1.64</td>
<td>June 1985</td>
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<td>17</td>
<td>Shortened MPSS Stress Analysis Appendix J (Pending) See DCN 19</td>
<td>March 1985</td>
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<tr>
<td>18</td>
<td>Float Stress Analysis, Added Appendix K</td>
<td>April 1985</td>
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<td>19</td>
<td>Shortened MPSS Stress Analysis Update, Supercedes DCN 17, Appendix J</td>
<td>May 1985</td>
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<td>20</td>
<td>FWC Drogue Deck Fitting Analysis, Supercedes DCN 16, Bridle Link Assy, FWC DSS Strength Analysis, Appendix HA1, HA2, and HF1</td>
<td>June 1985</td>
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</table>

**ADDENDA** - Are used to present Stress Analysis for specific flight predicted loads or conditions, not adequately covered in Basic Document. Addenda are not usually published when predicted loads for a given flight do not exceed previously analyzed values.

1. (6/80) STS-1  
   Drogue Deck Fitting Analysis for Drogue Loads to 279.1 KIPS, Main Deck Fitting Analysis (DFE), for loads up to 174.1 KIPS, MPSS Analysis up to 25.5 G's, Updated Parachute Strength Analysis.

2. (9/81) STS-2  
   Drogue Deck Fitting Analysis for Drogue Loads to 319.1 KIPS, Main Deck Fitting Analysis (DFI) for loads up to 197.7 KIPS, MPSS Analysis up to 27.6 G's, Updated Parachute Strength Analysis.

3. (3/82) STS-3  
   Drogue Deck Fitting Analysis for Drogue Loads to 328.1 KIPS, Updated Drogue Strength Analysis.

4. (5/82) STS-4  
   Updated Parachute Strength Analysis, Reused Drogues.

5. (6/83) STS-8  
   Updated Parachute Strength Analysis, Reused Mains.

6. (8/83) STS-9  
   Updated Parachute Strength Analysis, Used Drogues.

7. (10/84) 51-A  
   Main Deck Fitting (DFI) for LMP Loads to 232.5 KIPS, Updated LMP Strength Analysis.

8. (10/84) 51-A  
   Main Deck Fitting (DFI) for LMP with Modified Vent Loads to 208 KIPS, Updated LMP Strength Analysis for used chutes.

9. (6/85) BI020-24  
   Operational Main Deck Fittings for LMP Loads to 208 KIPS.
| SE07-1 | SRBA07 | STS-1 | April 1981 |
| SE07-2 | SRBA08 | STS-1 | April 1981 |
| SE07-3 | SRBA09 | STS-2 | April 1981 |
| SE07-4 | SRBA10 | STS-2 | April 1981 |
| SE07-5 | SRBA11 | STS-3 | October 1981 |
| SE07-6 | SRBA12 | STS-3 | October 1981 |
| SE07-7 | SRBA13 | STS-4 | May 1982 |
| SE07-8 | SRBA14 | STS-4 | May 1982 |
| SE07-9 | SRBA15 | STS-5 | May 1982 |
| SE07-10 | SRBA16 | STS-5 | May 1982 |
| SE07-10 DCN1 | SRBA16 | STS-5 | May 1982 |
| SE07-11 | SRBA17 | STS-6 | September 1982 |
| SE07-12 | SRBA18 | STS-6 | September 1982 |
| SE07-13 | SRBA51 | STS-7 | February 1983 |
| SE07-14 | SRBA52 | STS-7 | February 1983 |
| SE07-15 | SRBA53 | STS-8 | March 1983 |
| SE07-16 | SRBA54 | STS-8 | March 1983 |
| SE07-17 | SRBA55 | STS-9 | September 1983 |
| SE07-18 | SRBA56 | STS-14/16 (41D) | September 1983 |
| SE07-19 | SRBA57 | STS-11 (41B) | September 1983 |
| SE07-20 | SRBA58 | STS-11 (41B) | September 1983 |
| SE07-21 | SRBA59 | STS-14/16 | |
| SE07-22 | SRBA60 | STS-9 | January 1984 |
| SE07-23 | SRBA56 (Repack) | (STS-1416 - 41D) | January 1984 |
| SE07-24 | SRBA59 (Repack) | | May 1984 |
| SE07-25 | SRBA61 | STS-13 (41C) | May 1984 |
| SE07-26 | SRBA62 | STS-13 (41C) | May 1984 |
| SE07-27 | SRBA63 | BIO13L/STS-17(41G) | May 1984 |
| SE07-27 Rev A SRBA63 | BIO13L/STS-17(41G) | | November 1984 |
| SE07-28 | SRBA64 | BIO13R/STS-17(41G) | May 1984 |
| SE07-28 Rev A SRBA64 | BIO13R/STS-17(41G) | | November 1984 |
TABLE V-C (Cont.)

Actual Weight Reports (SRB-DSS-SE07)

<p>| SE07-29 | SRBA65       | BI014L(STS-19(51A)) | November 1984 |
| SE07-30 | SRBA66       | BI014R(STS-19(51A)) | November 1984 |
| SE07-31 | SRBA67       | BI015L(STS-20(51C)) | November 1984 |
| SE07-32 | SRBA68       | BI015R(STS-20(51C)) | November 1984 |
| SE07-33 | SRBA69       | BI016R(STS-24(51B)) | November 1984 |
| SE07-34 | SRBA70       | BI016R(STS-24(51B)) | November 1984 |
| SE07-37 | SRBA73       | BI018L(STS-23/51D)  | March 1985    |
| SE07-38 | SRBA74       | BI018R(STS-23/51D)  | March 1985    |
| SE07-39 | SRBA75       |                        | March 1985    |
| SE07-40 | SRBA76       |                        | March 1985    |</p>
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<td>Rev B</td>
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<td>March 1978</td>
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<td>LMP</td>
<td>October 1982</td>
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<td>DCN3</td>
<td>Single chute failure; FWC</td>
<td>November 1983</td>
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<td>LMP</td>
<td>February 1984</td>
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<td>DCN7</td>
<td>Rev. FWC Section 10 (CDR)</td>
<td>June 1985</td>
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<td>DCN6</td>
<td>Flotation Subsystem</td>
<td>April 1985</td>
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<td>Addendum 1</td>
<td>STS1</td>
<td>May 1980</td>
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# TABLE V-E
Subsystem Analysis Report (SRB-DSS-SE16)

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<td>Subsystem Analysis Report</td>
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<td>(STS-1)</td>
<td>June 1980</td>
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<td>Subsystem Analysis (FWC)</td>
<td>November 1983</td>
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<td>DCN4 to SE16-3</td>
<td>LMP</td>
<td>May 1984</td>
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<td>Revise FWC SRB Sect.: PDR</td>
<td>July 1984</td>
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<td>Revise FWC</td>
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<td>001</td>
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<td>Reference Data for Parachute Refurbishment</td>
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<td>SRB &amp; Components Transporation Limits</td>
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<td>and 006B</td>
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<td>Min. Altitude Deployment Study 2/23/77</td>
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<td>Main Chute Tether Study</td>
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<td>013 &amp; 013A</td>
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<td>TN-32122-065</td>
<td>Reefing Cutter Tolerances (Lot AAC)</td>
<td>13 Dec. 1984</td>
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<td>TN-32122-067</td>
<td>Summary Final Report, Preliminary Design Study for Main Parachute Deployment from &quot;Soft&quot; Container</td>
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### TECHNICAL NOTES

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<td>Preflight Prediction Report, Mission 51-F (BIO17)</td>
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APPENDIX VI

DEVELOPMENT TESTS

W.B.S. 1.4.1.6.1.2.3
## Appendix VI  Development Tests

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* Pioneer Parachute Documents
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**DTV Hardware**

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* Pioneer Parachute Documents

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**Flight Hardware**

- **Main Parachute Dynamic Strip Test**  
  - SRB-DSS-TM03-1

- **Drogue Parachute Dynamic Strip Test**  
  - SRB-DSS-TM15-6
  - SRB-DSS-TM03-2

- **Pilot Parachute, Dynamic Strip Test**  
  - SRB-DSS-TM03-3

- **Energy Absorber Dynamic Strip Test**  
  - SRB-DSS-TM03-4

- **Drogue Parachute Acceleration Test**  
  - SRB-DSS-TM03-8

- **Drogue Parachute Vibration Test**  
  - SRB-DSS-TM03-9

- **Nose Cap Ejection Rocket Sled Test**  
  - SRB-DSS-TM03-10
  - Baseline Pilot and Drogue Deployment Test

- **Drogue Chute Dynamic Strip Test**  
  - SRB-DSS-TM15-7
  - SRB-DSS-TM03-19
  - Rocket Sled Powered Test

- **Drogue Chute Dynamic Strip Tests (110%)**  
  - SRB-DSS-TM15-10
  - SRB-DSS-TM03-23
  - Rocket Sled Powered FWC Drogue Chute Tests

- **FWC Drogue Chute Dynamic Deployment**  
  - SRB-DSS-TM15-8
  - SRB-DSS-TM03-24
  - FWC Pilot Chute Dynamic Strip Test

- **Pilot Chute Overload Dynamic Test (110%)**  
  - SRB-DSS-TM15-11
  - SRB-DSS-TM03-26
  - Rocket Sled Test, FWC Pilot Chute Overload

- **Pilot Chute Overload Deployment Test (110%)**  
  - SRB-DSS-TM15-9
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#### Main Parachute Flotation

- **Ocean Flotation Test**
  - SRB-DSS-TM03-27

- **Dynamic Deployment Test**
  - SRB-DSS-TM03-28

#### DTV Hardware

- **Pyro Separation Function Tests**
  - SRB-DSS-TM03-7
  - DTV Separation Charge Function Tests

#### Air Drop Tests

**Baseline System**

- **DAD-1**
  - SRB-DSS-TM06
  - Appendix I

- **DAD-2**
  - SRB-DSS-TM06
  - Appendix II
  - SRB-DSS-TM10-2
  - SRB-DSS-TM11-1
  - Final Report DAD 1 & 2

- **DAD-3**
  - SRB-DSS-TM06
  - Appendix III
  - SRB-DSS-TM09-3
  - SRB-DSS-TM10-3

- **DAD-4**
  - SRB-DSS-TM06
  - Appendix IV
  - SRB-DSS-TM09-4
  - SRB-DSS-TM10-4

- **DAD-5**
  - SRB-DSS-TM06
  - Appendix V
  - SRB-DSS-TM09-6
  - SRB-DSS-TM10-6

- **DAD-6**
  - SRB-DSS-TM06
  - Appendix VI
  - SRB-DSS-TM10-6
  - Final Report DAD 3,4,5 & 6

**Large Main Parachute System**

- **DAD-7**
  - SRB-DSS-TM06-1
  - Appendix VII (DCN 1 & 2)
  - SRB-DSS-TM09-7
  - SRB-DSS-TM10-7

- **DAD-8**
  - SRB-DSS-TM06-1
  - Appendix VIII
  - SRB-DSS-TM09-3
  - SRB-DSS-TM10-8
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APPENDIX VII

SUPPORT EQUIPMENT AND TOOLING (SE&T) AND SPECIAL TEST EQUIPMENT (STE)

W.B.S. 1.4.1.6.1.2.5 AND ALSO INCLUDING 1.4.1.6.1.3.6 AND 1.4.1.6.1.5 AND SUBPARAGRAPHS
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INTERIM SUPPORT EQUIPMENT

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VII-5
Table VII-C (Continued)

REFURBISHMENT SUPPORT EQUIPMENT

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Table VII-D
DROP TEST SUPPORT EQUIPMENT

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<td>82700201129</td>
<td>Sling Assembly</td>
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<td>82700201127*</td>
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<td>82700201130</td>
<td>Frustum Adapter</td>
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* Also were ISE items.
APPENDIX VIII

FIELD SUPPORT

W.B.S. 1.4.1.6.1.2.6
Table VIII-A

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<td>Post Flight Inspection, Damage Assessment and Disposition Procedure</td>
<td>02 Nov 81</td>
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<td>SRB-DSS-LS03-2</td>
<td>Standard Repair Procedures</td>
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<td>Main Parachute Cluster Assembly Procedure</td>
<td>05 Feb 81</td>
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<td>Transportation and Handling Procedure for SRB-DSS Components at KSC</td>
<td>07 Feb 81</td>
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<td>SRB-DSS-LS03-8</td>
<td>Refurbishment Procedure SRB-DSS Metal Components</td>
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<td>SRB-DSS-LS03-9</td>
<td>SRB-DSS Aging Effects Procedure</td>
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<td>MCR-80-1371</td>
<td>Packing Procedure, Pilot Parachute Pack Assembly</td>
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Additional procedures were written to define the disciplines and responsibilities to manage the PRF operation. These KSC Operations Procedures (KOPS) were written by MMC PRF personnel and were structured after the KSC Pre-flight Operations Procedures (POP) which are a NASA requirement of other KSC contractors. The PRF KOPS are listed in Table B.
A. Recovery and Retrieval - The recovery and retrieval of SRB's and DSS components after launch from KSC is the responsibility of the Shuttle Processing Contractor (SPC). The parachutes are delivered directly to the PRF, on the covered retrieval reels, by the SPC. It is necessary to maintain the parachute materials wet, until washed with fresh water at the PRF, to prevent salt crystallization and consequent damage to the parachute.

B. Disassembly and Cleaning - The Main Parachute Support Structures (MPSS), main parachute deployment bags, MPSS bipod struts and clevises and drogue parachute attachment fittings are removed from the frustum and the drogue parachute attachment fittings are removed from the forward skirt by the BAC. These metallic items are rinsed with fresh water, corrosion preventive compound applied, then they are transferred to the PRF for refurbishment.

Disassembly, defoul, washing and drying of the parachutes is performed in the PRF in accordance with procedure, SRB-DSS-LS03-12. Defoul operations generally begin approximately 48 hours after launch and all parachutes are complete with the wash/dry operation within four working days.

C. Post Flight Inspection, Damage Assessment and Disposition - The inspection, damage assessment, post flight evaluation and return of flown DSS hardware to flight worthy status is performed in accordance with the Post Flight Inspection, Damage Assessment and Disposition Procedure, SRB-DSS-LS03-1.

Each reusable component of DSS hardware returned from flight is thoroughly inspected for fabric damage in accordance with the requirements of LS03-1. SRB-DSS Metal Components, are inspected in accordance with SRB-DSS-LS03-8. Non-conformances are dispositioned in one of the following categories:

- Acceptable as-is (MRB)
- Standard repair per SRB-DSS-LS03-2, Section 3
- Non-Standard Repair (MRB)
- Scrap (MRB)

Non-reusable metal and fabric components are physically segregated from other flight hardware and dispositioned as excess in accordance with MCR-83-1300, Plan for Materials Returned from Space.

In order to evaluate the relationship between the age and/or number of uses of an SRB DSS parachute and the strength of its component materials, various elements are removed from the parachute components and tested in accordance with SRB-DSS-LS03-9, Aging Effects Test Procedure.
D. Repair and Rework - Repair procedures for the most commonly identified anomalies or damage occurrences to SRB-DSS hardware are identified in the Standard Repair Manual. SRB-DSS-LS03-2 for fabric items and in SRB-DSS-LS03-8 for metallic items. Non-standard repairs are dispositioned by engineering with MRB concurrence. Validation testing is required in most cases at the discretion of the MRB. Rework of flight hardware is accomplished with modification instructions, Time Compliance Technical Instruction (TCTI), prepared and authorized by SRB-DSS engineering in Denver.

E. Certification for Reuse and Storage - Upon completion of the disposition instructions for a particular component and acceptance by QC, the component is certified for reuse. Once a previously flown component of DSS hardware has been certified for reuse, it is placed in storage with other DSS hardware until issued out for a subsequent SRB-DSS build-up.

No distinction has been made between new and reused flight hardware. The utilization of reused hardware takes precedence over new hardware in order to gain useful life data. Hardware in storage is considered as "open stock" and no attempt is made to ensure that components which previously flew together, fly together in future missions.

F. Packing and Clustering - Main parachute packing operations are performed in accordance with SRB-DSS-LS03-4 for SMP and SRB-DSS-LS03-10 for LMP. Main parachute clustering, the assembly of three main parachutes to the MPSS, is performed in accordance with SRB-DSS-LS03-6 for SMP and SRB-DSS-LS03-13 for LMP. The complete cluster assembly is then placed on a transportation pallet for delivery to the M-BAC.

Drogue parachute packing operations are performed in accordance with SRB-DSS-LS03-3. The packed drogue parachute is placed in a shipping container for delivery to the M-BAC.

Pilot parachutes are generally delivered prepacked in refurbishment kits. Many pilots, however, were modified and packed in the PRF in accordance with MCR-80-1371. Pilot parachutes, drogue retention kits, main and drogue attachment fittings, ratchet assemblies, struts and clevises are delivered as individual items to the M-BAC since these are assembled directly to the SRB structure.

G. Integration and Assembly - Installation of SRB-DSS hardware into the SRB frustum is performed in accordance with M-BAC assembly procedures. Martin Marietta PRF personnel performed the drogue and pilot integration and main riser assembly portions of the assembly procedure since certain critical parachute rigging operations were involved. All other DSS installation operations such as the cluster installation into the frustum, pilot chute bridle attachment to the nose cap and installation of attachment fittings to the frustum is performed by the M-BAC.
Configuration Management and Modifications - Configurations of the SRB-DSS is defined by Denver engineering per the usage and allocation DWG 82700100022. Requirements are delineated in "Configuration Requirements Lists" specifying current engineering revision levels and component configuration.

Hardware modifications resulting from design changes are performed to TCTI modification instructions developed by Denver Engineering and approved by the MMC Program Manager and customer engineering. An Incorporation Notification Card (INC) is submitted upon completion of the TCTI effort on all affected components.

Acceptance data packages are delivered with each major subsystem element identify the "authorized" and "as-built" configuration level and certification thereof. Detailed configuration management procedures are contained in KOP-0-05. Configuration changes to the DSS that affect assembly procedures, such as a component part number changes or a change in packing methods, are controlled by Procedure Change Notice (PCN) revisions to the assembly procedures.

Facilities - Facilities in support of this contract are the Parachute Refurbishment Facility, KSC building M7-657 and a 2000 square foot storage area in CCAFS building 60510. A 3000 square foot addition to the PRF for storage of DSS hardware has been authorized through MSFC FY86 funding.

Sewing Machines - Originally eleven (11) refurbished Singer Sewing Machines were purchased for the PRF operation. Except for two heavy duty 97-10 machines, each was a different machine for specific sewing operations based on Pioneer Parachutes production experience. These machines served the operation well through the early repair procedure development stages and when refurbishment production rates were low. Some of the machines, such as two-needle, four-needle and darning did not lend themselves to the refurbishment process and were never used.

Since the Singer Machines were no longer in production, replacement parts were becoming difficult to find and additional machines were needed to support the rapidly increasing shuttle launch rates. An effort to select an alternate sewing machine supplier was undertaken. Adler Sewing Machines was selected due to: (1) greater machine flexibility requiring fewer different models; (2) state-of-the-art automatic features for increased productivity; (3) parts availability; and (4) local service representatives.
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<td>Procedure Release and Change Control</td>
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<td>Flight Hardware Flow</td>
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<td>Test Sample Fabrication, Test and Information Control</td>
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<td>Photographic Support Procedure</td>
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APPENDIX IX

SRB DSS STRUCTURAL ITEMS
MANUFACTURED BY
MARTIN MARIETTA CORPORATION
### Table IX-A
#### SRB-DSS Fabricated Structural Items

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*Originally machined on ONSRUD. Converter to G&L. ONSRUD tape obsolete.
### Table IX-B

Active Test Tools by Contract

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