

**Tracking and Data Relay Satellite (TDRS) K Program  
Code 454**

**WORK BREAKDOWN STRUCTURE (WBS)  
AND  
WBS DICTIONARY**

**EFFECTIVE: 04/16/2007  
EXPIRES: 04/15/2012**



National Aeronautics and  
Space Administration

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**Goddard Space Flight Center  
Greenbelt, Maryland**

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## SIGNATURE PAGE

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## DOCUMENT CHANGE RECORD

Sheet 1 of 1

REV LEVEL	DESCRIPTION OF CHANGES	APPROVED BY	DATE APPROVED
-	INITIAL RELEASE	J GRAMLING	04/16/2007

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## **CONFIGURATION (CM) FOREWORD**

This document is a Tracking and Data Relay Satellite (TDRS) Project Configuration Management-controlled document. Changes to this document require prior approval of the TDRS Project Manager. Proposed changes shall be submitted to the TDRS Configuration Management Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

Requirements conventions are as follows: a requirement is identified by “shall,” a good practice by “should,” permission by “may,” expectation by “will,” and descriptive material by “is” or “are.”

Questions or comments concerning this document should be addressed to:

**TDRS Configuration Manager**  
TDRS Configuration Management Office  
Mail Stop 454  
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Greenbelt, Maryland 20771

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## SCOPE

The WBS Dictionary addresses only the TDRS K and begins at Level 2. The contractor shall set up WBS items for each separate TDRS. For TDRS L, M, and N change the first digit of Level 1 to 2 for TDRS-L, 3 for TDRS M and 4 for TDRS N, respectively.

**This WBS/Dictionary shall be used for structuring the cost related to the contract. This WBS is traced to the TDRS SOW.**

### Level 0: Total Program

### Level 1: TDRS K, TDRS L, TDRS M, TDRS N

The overall structure for this document, beginning with level 2, is as follows:

Level 2: X.0 (i.e., 1.0, 2.0, 3.0...etc.)

Level 3: X.X (i.e., 1.1, 1.2, 1.3...etc.)

Level 4: X.X.X (i.e., 1.1.1, 1.1.2, 1.1.3...etc.)

Level 5: X.X.X.X (i.e., 1.1.1.1, 1.1.1.2, 1.1.1.3,...etc.)

The contractor shall not modify nor expand the WBS structure for levels 0, 1, or 2 horizontally. The WBS structure may be modified or expanded vertically at level 3 and below. The Contractor shall provide a CWBS to at least Level 4. If changes in wording at level 0, 1, or 2 are required by the Contractor, the Contractor may make wording adjustments; however, the structure shall remain unchanged. If the Contractor desires to establish a CWBS at a lower level than required, the Contractor may do so.

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## **WORK BREAKDOWN STRUCTURE (WBS) ELEMENTS**

### **1.0 PROGRAM MANAGEMENT**

- 1.1 Program Management Office
- 1.2 Resource Management
- 1.3 Schedule Management
- 1.4 Contract Management
- 1.5 Risk Management
- 1.6 Configuration Management
- 1.7 Subcontracts Management
- 1.8 Insurance
- 1.9 Task Management
- 1.10 NASA Customer Interface and Resident Office
- 1.11 Program Security
- 1.12 Documentation and Data Management
- 1.13 Program Reviews

### **2.0 SYSTEMS ENGINEERING**

- 2.1 Systems Engineering Management
- 2.2 Requirements Analysis and Allocations
- 2.3 Interface Definition, Allocation, Verification, and Control
  - 2.3.1 Space to Ground Interface
  - 2.3.2 Spacecraft Launch Vehicle Interface
- 2.4 Telecommunications Engineering and Analysis
- 2.5 Working Group Implementation and Management
- 2.6 Design and Performance Verification
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- 2.7 Systems Engineering and Analysis
- 2.8 Reviews and Audits
  - 2.8.1 NASA Reviews
  - 2.8.2 Engineering Peer Reviews
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- 2.9 Training

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### **3.0 SAFETY AND MISSION ASSURANCE**

- 3.1 Management
- 3.2 Safety Program
- 3.3 Mission Assurance
  - 3.3.1 Flight Hardware Assurance
  - 3.3.2 Flight Software Assurance
  - 3.3.3 Flight Operations Products Assurance
  - 3.3.4 Parts and Materials Program
  - 3.3.5 Subcontractor Assurance
  - 3.3.6 Ground Support Equipment Assurance
  - 3.3.7 WSC Hardware and Software Modifications Assurance

### **4.0 TECHNOLOGY**

### **5.0. PAYLOAD**

- 5.1 Management
- 5.2 Payload System Engineering
- 5.3 Multiple Access Subsystem
- 5.4 Payload Common Equipment Subsystem
- 5.5 Single Access Subsystem
- 5.6 Payload Harness Subsystem
- 5.7 Payload Module Integration & Test Program

### **6.0 SPACECRAFT**

- 6.1 Spacecraft Management
- 6.2 Spacecraft Systems Engineering
- 6.3 Attitude Control Subsystem
- 6.4 Structures and Mechanisms Subsystem
- 6.5 Thermal Control Subsystem
- 6.6 Propulsion and Reaction Control Subsystem
- 6.7 Tracking, Telemetry and Command Subsystem
- 6.8 Power and Electrical Subsystem
- 6.9 Harness Subsystem
- 6.10 On-Board Computer and Spacecraft Databus
- 6.11 Flight Software
  - 6.11.1 Planning and Requirements Analysis

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- 6.11.2 Design
- 6.11.3 Implementation
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- 6.11.6 Development and Verification Environment
- 6.12 Bus Module Integration & Test Program
- 6.13 Spacecraft Emulator

## **7.0 MISSION OPERATIONS**

- 7.1 Mission Operations Management
- 7.2 Transfer Orbit Mission
- 7.3 Deployments, Activation, and Calibration
- 7.4 On-Orbit Verification Program Execution and Acceptance
- 7.5 NASA Operations Products Development
- 7.6 NASA Sustaining Engineering Support

## **8.0 LAUNCH VEHICLE SERVICES AND OPERATIONS**

- 8.1 Launch Support Management
- 8.2 Launch Operations Planning and Coordination
- 8.3 Launch Interface Engineering
- 8.4 Interface Test and Analysis
- 8.5 Launch Campaign Operations
- 8.6 Launch Site Operations and Launch

## **9.0 GROUND SYSTEM MODIFICATION**

- 9.1 Ground System Modification Management
- 9.2 Systems Engineering
- 9.3 Hardware Development and Test
- 9.4 White Sands Complex Hardware Installation and Test
- 9.5 Software Development and Test
- 9.6 White Sands Complex Software Installation and Test
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9.11 Integration Logistics Support and Training

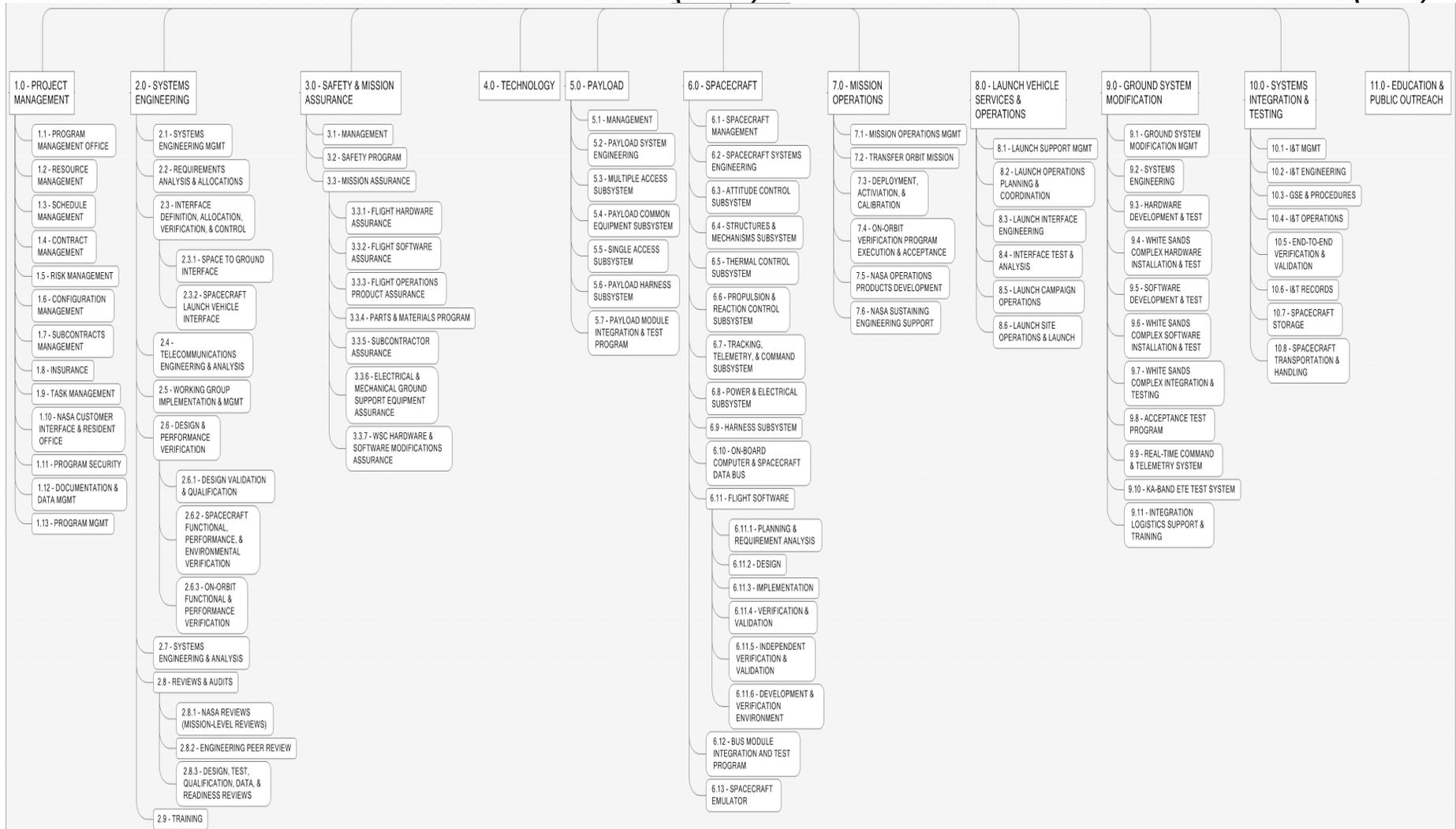
## **10.0 SYSTEMS INTEGRATION AND TESTING**

- 10.1 I&T Management
- 10.2 I&T Engineering
- 10.3 GSE and Procedures
- 10.4 I&T Operations
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- 10.6 I&T Records
- 10.7 Spacecraft Storage
- 10.8 Spacecraft Transportation and Handling

## **11.0 EDUCATION AND PUBLIC OUTREACH**

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**FIGURE 1: TRACKING AND DATA RELAY SATELLITE (TDRS) K PROGRAM WORK BREAKDOWN STRUCTURE (WBS)**



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## **WORK BREAKDOWN STRUCTURE (WBS) DICTIONARY**

### **1.0 PROJECT MANAGEMENT**

This element includes those efforts required for the monitoring, control, administration, and direction of the TDRS Program. It has programmatic authority over, and responsibility for all of the other Work Breakdown Structure (WBS) elements listed here or as may be assigned hereafter to this program. This element includes Resource, Schedule, Implementation Planning, Contract and Subcontract Management, and Support to National Aeronautics and Space Administration (NASA) Interfaces, and Management Reviews. This element also includes those efforts required in the support and generation of documentation and program reviews.

It also includes the efforts necessary to establish facilities required for development and testing such as; clean rooms, thermal vacuum chambers, thermal cycle chambers, vibration facilities, anechoic chambers, and spacecraft storage facilities.

### **1.1 PROGRAM MANAGEMENT OFFICE**

This element includes those efforts required for the management of the TDRS K Program. This element includes the office of the TDRS K Program Manager, and consists of the program manager and the program manager's staff. The program manager is responsible for the leadership and overall direction of the TDRS K Program. This element also includes all efforts needed to review and approve all Contract Data Requirements List (CDRL) data items for the program, review and approve all requirement changes under program control, and provide spacecraft, telecommunications, and software management oversight.

This element also includes those efforts required for ensuring the orderly implementation of the TDRS K Program. It involves the efforts required for development and refinement of the contract WBS, establishment of the WBS/Organizational matrix, and establishing requirements for program control and reporting. It also includes those efforts necessary for preparation, conduct, and documentation of program reviews, audits, and meetings. This element includes the development of systems and processes required for the program control, surveillance and reporting of overall contract activities to ensure disciplined performance of work. It includes Property Management, Environmental Compliance and Management, Export and International Traffic In-Arms Regulation (ITAR) Compliance, and Communications Security (COMSEC) custodianship.

### **1.2 RESOURCE MANAGEMENT**

This element includes those efforts required for the management, administration, and control of the TDRS K Program resources. It includes life cycle and cost analysis,

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development of budgets, funding plans and work authorization documents, administration of management reserve, status reporting, cost analysis, financial control, production of cost estimates, development and operation of the program performance measurement and reporting system(s), earned value management system, etc. It also includes: Resource Management, Cost Reporting, WBS Management, Earned Value Assessments, and Export Control.

### **1.3 SCHEDULE MANAGEMENT**

This element also includes those efforts required for the management, administration, control and maintenance of the TDRS K Program schedules and integrated scheduling system.

### **1.4 CONTRACT MANAGEMENT**

This element includes those efforts required for monitoring and control of the TDRS K prime contract with the Government to ensure compliance with all contractual requirements. This includes all functional and administrative support of the contractual interfaces with the Government and with other segments of the contractor's organization.

### **1.5 RISK MANAGEMENT**

This element consists of the efforts to provide for a proactive decision-making process to continuously identify and assess all TDRS K Program risks, prioritize risks, and develop strategies to mitigate and control those risks, and to implement the activities judged to be worthwhile. This element includes the effort to document all of these activities. This element will be applied to all phases of the TDRS K Program as an integral part of program management and be compatible with the risk management system used by the TDRS K Project Office.

### **1.6 CONFIGURATION MANAGEMENT**

This element includes those efforts required for the Configuration Control and Management functions for the entire TDRS K Program (documentation, hardware, software, Ground Support Equipment (GSE), operations products) and includes Configuration Control Board meetings; as well as the management, administration, control, and maintenance of the Configuration Control Program. This element is also responsible for the control, management, processing, and tracking of all requests for waivers and deviations, and Engineering Change Proposals.

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## **1.7 SUBCONTRACTS MANAGEMENT**

This element includes those efforts required for the execution, implementation, monitoring, and control of all TDRS K subcontracts. It includes the effort to modify existing contracts to flow TDRS Program Requirements.

## **1.8 INSURANCE**

This element includes those efforts required for the acquisition, control, and administration of all insurance the contractor deems necessary for the program.

## **1.9 TASK MANAGEMENT**

This element includes those efforts required for the performance, control, documentation, and reporting of mission-unique tasks performed during the term of the TDRS K contract. Task Assignments will be performed on a task basis as authorized by NASA. It is a level of effort function of 75,000 hours specified in the contract and directed by the Government during the development of the TDRS K Program. This element includes those efforts needed to develop all Special Engineering/Analysis deliverable/non-deliverable documentation.

## **1.10 NASA CUSTOMER INTERFACE AND RESIDENT OFFICE**

This element includes those efforts required to provide NASA representatives with local office facilities, supplies, and communications services. It includes all efforts necessary to provide government access to the program information, facilities, and personnel necessary for the government to effectively manage the contract and ensure mission success.

## **1.11 PROGRAM SECURITY**

This element consists of implementing security requirements for the TDRS K Program. Program security is defined as the protection of TDRS program assets (facilities, information, personnel, hardware, software, operations products, GSE, etc.) and their associated information and data from unauthorized access, use, disclosure, disruption, modification, or destruction to ensure the integrity, confidentiality, and availability.

## **1.12 DOCUMENTATION AND DATA MANAGEMENT**

This element includes those efforts required for the management, control, coordination and distribution of all formal and informal documentation (hardcopy, electronic media, photographs, etc.) required to perform the work required by the contract, and includes

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that work necessary to fulfill the contractual requirements of the TDRS K Program CDRL and other documentation requirements imposed by TDRS K Program requirements.

### **1.13 PROGRAM REVIEWS**

This element consists of the efforts for conducting reviews necessary for effective management and control of the program. It includes Monthly Program Status Reviews (MPSRs) with the TDRS Program Office. This element includes those efforts required for the capturing, tracking and responding to action items. This element includes those efforts needed to develop all program reviews deliverable/non-deliverable documentation.

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## **2.0 SYSTEMS ENGINEERING**

This element includes those efforts required for directing, specifying, and overseeing the design and technical development of the TDRS K and any proposed modifications or additions to the White Sands Complex (WSC) to ensure compliance with the contractual requirements and specifications. It addresses the design of the integrated system and the control and planning of the associated technical effort. These efforts include requirements analysis, development of the TDRS K Design Specification derived from the NASA requirements, generation of the systems and the spacecraft design, launch support, development and planning of the integrated test program, conducting trade studies, software engineering, specialty engineering, system architecture development and integrated test planning, system requirements writing, technical oversight and control and monitoring of the technical program. This element also includes those efforts required in the support and generation of documentation and reviews.

### **2.1 SYSTEMS ENGINEERING MANAGEMENT**

This element includes those efforts required for providing technical direction, oversight and technical resource allocation for the total TDRS K Program, including the system design and the spacecraft design, development and manufacture. Systems Engineering management includes the Program Systems Engineering Manager and staff. This element also includes all of those efforts needed to review and approve all other CDRL Data Items in the Systems Engineering category and provide configuration and data management oversight.

### **2.2 REQUIREMENTS ANALYSIS AND ALLOCATIONS**

This element includes those efforts required for systems engineering, analysis, and simulation for the development of the TDRS K specifications and the verification of performance requirements allocated to the spacecraft and the WSC. It includes provision for the development and verification of the TDRS K operations concepts and the Launch-to-Orbit Mission Analysis. It involves the analysis required to confirm the integrity of the combined TDRS K/WSC design to ensure that the performance requirements of the applicable specifications will be met over the spacecraft operational design life. It involves the allocation of functions, performance and operations to the TDRS K spacecraft, WSC and their subsystems, and the development and maintenance of a comprehensive traceability data base. It further involves the preparation and maintenance of the specifications developed, including the TDRS K Spacecraft Technical Requirements Specification, the Spacecraft Design Specification, and the WSC modifications specifications.

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## **2.3 INTERFACE DEFINITION, ALLOCATION, VERIFICATION, AND CONTROL**

This element includes those efforts required for specifying, managing, verifying, and controlling the technical boundaries between the User Satellite (USAT), the TDRS K and the WSC, as well as to other system elements and test systems. It involves specifying and maintaining the interfaces within these systems, including to the software. It also involves developing and maintaining the TDRS K Space/Ground interface control documentation and specifying (where appropriate), verifying, managing, and controlling the technical interfaces between the TDRS K and the WSC in accordance with this document.

It also involves developing the TDRS K Spacecraft/launch vehicle interface control documentation and specifying, verifying, managing, and controlling the technical interfaces between the TDRS K and the launch vehicle in accordance with this document.

### **2.3.1 Space to Ground Interface**

This element includes those efforts required for the development and maintenance for the TDRS K Space/Ground interface control documentation including all functional, performance, and operational aspects of the interface. It also includes documenting and specifying, verifying, managing, and controlling the technical interfaces between the TDRS K and the WSC in accordance with this document.

### **2.3.2 Spacecraft Launch Vehicle Interface**

This element includes those efforts required for the development of the TDRS K Spacecraft/launch vehicle interface control documentation and specifying, verifying, managing, and controlling the technical interfaces between the TDRS K and the launch vehicle in accordance with this document.

## **2.4 TELECOMMUNICATIONS ENGINEERING AND ANALYSIS**

This element includes those efforts required for the systems engineering and analysis of all telecommunication functions between USAT and elements of the space network, between the spacecraft and the ground, and between the spacecraft payload subsystems. It involves systems engineering, design and analysis in verifying the Forward and Return link requirements including TDRS K and WSC Gain Over Temperature (G/T) and Effective Isotropic Radiated Power (EIRP) for each service, Power Flux Density (PFD) restrictions, frequency/polarization plan management, and service channel bandwidth allocations. It includes requirements analysis and allocations, interface definition and control, spacecraft and WSC system engineering, and performance verification analyses to ensure end-to-end system telecommunications

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service requirements are satisfied. It also involves all activities necessary to establish, maintain and verify an end-to-end communications performance and TDRS K Tracking, Telemetry and Command (TT&C) subsystem simulation including all channel performance and operational impairments.

## **2.5 WORKING GROUP IMPLEMENTATION AND MANAGEMENT**

This element includes those efforts required for the working group implementation and management.

## **2.6 DESIGN AND PERFORMANCE VERIFICATION**

This element includes those efforts required to establish and maintain a System level Performance Verification Matrix (PVM), a spacecraft PVM and WSC PVM. It includes all the data reduction and analysis of all spacecraft and WSC test results including the spacecraft integration and environmental tests and all pre-launch tests. This element also includes those efforts required for performance trending, end-to-end polarity verification, WSC compatibility verification, and development of verification test procedures for use from unit level through system level (Spacecraft, WSC) integration.

### **2.6.1 Design Validation and Qualification**

This element includes those efforts required for the design validation and qualification, including interfaces between all spacecraft subsystems and environmental management between the spacecraft and the ground.

### **2.6.2 Spacecraft Functional, Performance, and Environmental Verification**

This element includes those efforts required for the spacecraft functional, performance and environmental verification. This element also includes those efforts required for the performance of end-to-end test.

### **2.6.3 On-Orbit Functional and Performance Verification**

This element includes those efforts required for the on-orbit functional and performance verification and all activities required to compile the data for the On-Orbit PVM and Acceptance Data Packages. It includes the On-Orbit Acceptance Review and closure of all actions from the review.

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## **2.7 SYSTEMS ENGINEERING AND ANALYSIS**

This element includes those efforts required for defining, performing and maintaining the necessary systems analyses required to assure compliance with all TDRS K Program requirements.

This element includes those efforts required for the development, allocation and maintenance of performance budgets and margins, including mass, power, communications links, alignments, spacecraft and antenna pointing, on-board computer resources, payload service availability, critical clearances, and propellant utilization and performance trending through on-orbit verification of each spacecraft. This element also includes the effort to provide all resources necessary to provide the maintainability, reliability and survivability engineering for the TDRS K Program.

This element includes those efforts needed to develop all systems engineering reviews deliverable/non-deliverable documentation.

This element includes those efforts required for assuring that each spacecraft undergoes a comprehensive End to End Test Equipment (ETE) baseband command and telemetry test (of all modes and formats) with the Space Network (SN) control center at WSC prior to the Pre-Ship Review. This element also includes those efforts required to assure that each spacecraft complete a Radio Frequency (RF) and baseband command and telemetry compatibility test with the Network to be used for any mission phase prior to Pre-Ship Review.

## **2.8 REVIEWS AND AUDITS**

This element includes those efforts necessary for preparation, conduct, and documentation of technical reviews, engineering peer reviews, unit/subsystem reviews, system reviews, support ground system reviews, and audits. This element includes those efforts required for the capturing, tracking and responding to action items. This element includes those efforts needed to develop all engineering reviews deliverable/non-deliverable documentation.

### **2.8.1 NASA Reviews (Mission-Level Reviews)**

This element consists of the work associated with supporting the NASA Program technical and management reviews to certify spacecraft readiness at the following NASA Program Reviews. This element includes those efforts needed to develop the reviews deliverable/non-deliverable documentation, including minutes and documented responses to actions items.

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### **2.8.2 Engineering Peer Review**

This element consists of the work associated with preparing for and conducting the engineering peer reviews. This element includes those efforts needed to develop the review documentation, including minutes and documented action item responses.

### **2.8.3 Design, Test, Qualification, Data, and Readiness Reviews**

This element consists of the work associated with preparing for and conducting the design, test, qualification, data and readiness reviews. This element includes those efforts needed to develop the review documentation, including minutes and documented action item responses. This element also consist of the work associated with preparing for and conducting Unit/Assembly/Subsystem/Module Reviews, Test Readiness Reviews, Test Data Reviews, and Consent to Break Configuration Reviews

## **2.9 TRAINING**

This element includes the effort to develop plans, processes, materials, and schedules required to train and certify ground operations personnel engaged in the inspection, test, checkout, maintenance, and operations of all assigned flight hardware, GSE, facilities, facility systems, and equipment to support the preflight processing, launch, operations, and maintenance of the TDRS spacecraft, modified ground system, and associated systems.

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### **3.0 SAFETY AND MISSION ASSURANCE**

This element includes those efforts required to define, implement and execute the Safety and Mission Assurance program for TDRS K and ensure that the TDRS K systems are developed, designed, manufactured, and tested in accordance with required mission assurance requirements and plans. This element also includes those efforts required in the support and generation of documentation and reviews. This element includes those efforts required for the overall monitoring and control of all TDRS K Mission Assurance functions. It encompasses all management, engineering and inspection functions for Spacecraft, Ground Modification, and Launch Services Mission Assurance (MA) including the MA Manager. This element includes MA management and planning, flight assurance status, and support of systems-level reviews. These efforts include the spacecraft development, implementation, and maintenance of a program for Parts, Processes and Materials, Reliability, QA, Safety, Software Assurance and Contamination Control. This element also includes those efforts required for the ground functional MA engineering and inspection activities necessary to meet STDN No. 927.4. These ground efforts include the development, implementation, and maintenance of a program for QA, safety, software assurance, and reliability. This element also includes all the efforts needed to develop and maintain all Safety and Mission Assurance (S&MA) CDRL items and implementation procedures and documentation.

#### **3.1 MANAGEMENT**

This element includes MA management and planning, flight assurance status, and support of systems-level reviews.

#### **3.2 SAFETY PROGRAM**

This element includes those efforts required for the overall monitoring and control of all TDRS K safety functions. It encompasses all engineering and inspection functions for Spacecraft, Ground Modification, GSE, Mission Operations, and Launch Services. It includes the safety program at all facilities where program work is being performed.

#### **3.3 MISSION ASSURANCE**

This element includes those efforts required for the overall monitoring and control of all TDRS K MA functions. It encompasses all engineering and inspection functions for Spacecraft, Ground Modification, and Launch Services MA.

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### **3.3.1 Flight Hardware Assurance**

This element includes the effort to provide all resources necessary to provide a flight hardware assurance program for the TDRS K Program. This element includes the effort to provide all resources necessary to provide the assurance program for all test and operations procedures for the TDRS K Program.

### **3.3.2 Flight Software Assurance**

This element includes the effort to provide all resources necessary to provide a flight software assurance program for the TDRS K Program.

### **3.3.3 Flight Operations Product Assurance**

This element includes the technical and management efforts to define, develop, implement, and execute the assurance program for all operations products to be used on the program, to include those used at the launch site, the contractor's Mission Control Center, and those delivered to NASA for use.

### **3.3.4 Parts and Materials Program**

This element includes the development and implementation of a Parts and Materials Management and Implementation program for the TDRS K Program. It also includes efforts to define, develop, and implement an effective QA Program that establishes quality requirements for Electronic, Electrical, Electromechanical (EEE) parts, contributes to the logistics processes, maintains effective configuration management, and establishes a sound problem reporting and corrective action system.

### **3.3.5 Subcontractor Assurance**

This element is the effort to levy, monitor, and audit program mission assurance requirements for major/critical subcontractors connected with the TDRS K program. This includes the efforts to ensure subcontractor's specifications and processes are complete and in compliance with program requirements, including parts and materials requirements. It includes ensuring all subcontractor supplied items meet program qualification requirements. It includes incoming inspection of deliverables from subcontractors.

### **3.3.6 Electrical and Mechanical Ground Support Equipment Assurance**

This element includes the effort to provide all resources necessary to provide an Electrical and Mechanical Ground Support Equipment assurance program for the TDRS

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K Program. This element includes the effort to provide all resources necessary to provide test and operations procedure assurance program for the TDRS K Program.

### **3.3.7 WSC Hardware and Software Modifications Assurance**

This element includes the effort to provide all resources necessary to provide a WSC Hardware and Software Modifications assurance program for the TDRS K Program.

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#### **4.0 TECHNOLOGY**

This element includes the effort related to technology development work, risk management and program reporting activities. This element also includes the effort required to generate a Technology Development Plan for each item which requires technology development and/or maturation.

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## **5.0 PAYLOAD**

This element includes those efforts required for analyzing, specifying, designing, verifying the design, building, and testing the TDRS telecommunications payload which is fully compliant with SN service requirements and other requirements of this contract. The Payload System consists of the Single Access System, Multiple Access System, Payload Common Equipment, and Payload Harness Subsystems. It includes both the communications equipment and the antenna assemblies. It includes all management, subsystems engineering and analysis, design, development, production, manufacturing, and test efforts necessary to prepare the Payload System for integration with the Spacecraft Bus. This element also includes those efforts required in the generation of documentation, data packages, and reviews.

### **5.1 MANAGEMENT**

This element includes those efforts required for the technical direction, administration and control of the payload production; including the payload design, development, manufacture, assembly and testing. This element also includes all of the efforts needed to review and approve all CDRL data items in the Payload System category.

### **5.2 PAYLOAD SYSTEM ENGINEERING**

This element consists of the efforts to lead the payload's overall system architecture definition and engineering functions. This includes the technical efforts of directing and controlling the integrated system engineering effort for the payload. It addresses the total payload design including performance margins and design approaches to assure meeting payload requirements, required life, operations concept development, design integrity analysis, intrasystem and intersystem compatibility assurance, reliability and maintainability, producibility, safety, survivability, training, and testability. This element also includes systems engineering for the payload and oversees all of the work associated with the development of the payload. It also includes all design audits associated with the payload.

### **5.3 MULTIPLE ACCESS SUBSYSTEM**

This element includes those efforts required to provide the Multiple Access system, including the Multiple Access Antenna required to satisfy the forward and return telecommunications and tracking service requirements. It encompasses the efforts required for management, subsystem engineering, design, manufacture, test, evaluation, and support of data reviews and subsystem audits.

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#### **5.4 PAYLOAD COMMON EQUIPMENT SUBSYSTEM**

This element includes those efforts required for providing the Space to Ground communications and payload common equipment which are necessary to fulfill the forward and return telecommunications and tracking service requirements. It encompasses the efforts required for management, subsystem engineering, design, manufacture, test, evaluation, and support of data reviews and subsystem audits.

#### **5.5 SINGLE ACCESS SUBSYSTEM**

This element includes those efforts required to provide the Single Access (SA) System, including the SA Antenna, including the feed assemblies required to satisfy the requirements of the SSA, Ku-Band Single Access (KuSA), and Ka-Band Single Access (KaSA) forward and return link services. This element also includes the antenna support structure. It encompasses those efforts required for subsystem engineering, design, manufacture, test, evaluation, and support of data reviews and subsystem audits.

#### **5.6 PAYLOAD HARNESS SUBSYSTEM**

This element includes those efforts required for producing the Payload Harness Subsystem. This element includes those efforts required for subsystem engineering, design, manufacture, test, evaluation, and support of data reviews and subsystem audits.

#### **5.7 PAYLOAD MODULE INTEGRATION AND TEST PROGRAM**

This element includes those efforts, including harness installation, required to assemble individual payload subsystems into an integrated payload system. Integration activities include the installation of communications electronic units on the payload module prior to the integration of the bus and payload modules. This element also includes the efforts related to testing the payload module including test management, test, evaluation, and review and analysis of test data.

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## **6.0 SPACECRAFT**

This element includes those efforts required for the design, analysis, fabrication, test, and verification of the design, building, and testing the TDRS spacecraft bus which satisfies all derived requirements for supporting the TDRS telecommunications payload, being designed to integrate with that payload to form a TDRS spacecraft capable of satisfying requirements of this contract, including launch vehicle compatibility.

### **6.1 SPACECRAFT MANAGEMENT**

This element includes those efforts required for the technical direction, administration and control of the TDRS K Spacecraft implementation; including the spacecraft design, development, manufacture, assembly and testing. This element also includes all of the efforts needed to review and approve all CDRL data items in the Spacecraft System.

### **6.2 SPACECRAFT SYSTEMS ENGINEERING**

This element includes those efforts required for the design (functional and performance) and development of the spacecraft. It addresses the total spacecraft design including performance margins and design approaches to assure achieving the required spacecraft life, spacecraft operations concept development, design integrity analysis, intrasystem and intersystem compatibility assurance, reliability and maintainability, producibility, safety, survivability, training, and testability. This element includes derivation of spacecraft safehold, fault protection, correction, and recovery requirements, their design, and verification/validation. It includes the allocation and control of critical clearances. This element also includes systems engineering for the spacecraft and oversees all of the work associated with the development of the spacecraft. It also includes all design audits associated with the spacecraft.

### **6.3 ATTITUDE CONTROL SUBSYSTEM**

This element includes those efforts required for producing the Attitude Control Subsystem (ACS). This subsystem provides the hardware and software functions necessary for spacecraft attitude determination and control; solar array and antenna pointing and control including antenna and solar array gimbal drive assemblies; and appendage deployment devices appendage momentum management; and thruster firing control. This includes the spacecraft safehold implementation. This element includes those efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

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#### **6.4 STRUCTURES AND MECHANISMS SUBSYSTEM**

This element includes those efforts required for producing the spacecraft Structures and Mechanisms Subsystem. This subsystem includes the spacecraft structure, providing support and mounting surfaces for all equipment and bearing the vehicle stress loads. It also includes the solar array structures. This element also includes the required mechanical interface and a structural test model. This element also includes the effort to design and plan for the development and test of any system in which one mechanical part moves relative to another mechanical part. It includes those efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

#### **6.5 THERMAL CONTROL SUBSYSTEM**

This element includes those efforts required for producing the Thermal Subsystem. This element includes those efforts required for deriving requirements, design, and verification/validation of the thermal control system. This element is responsible for maintaining the temperature of the spacecraft and modifying the heat transfer to and from each spacecraft subsystem so that component temperatures will remain within allowable ranges during the entire life of the mission. It includes those efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

#### **6.6 PROPULSION AND REACTION CONTROL SUBSYSTEM**

This element includes those efforts required for producing the Propulsion and Reaction Control subsystem. This subsystem provides the capability for achieving orbit changes, spacecraft momentum unloading, maneuvering into final orbit, transferring from the launch vehicle orbit to the geostationary orbit, and recovering from anomalous attitudes, in conjunction with the ACS. This element includes those efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

#### **6.7 TRACKING, TELEMETRY, AND COMMAND SUBSYSTEM**

This element includes those efforts required for deriving the requirements for, designing, and verifying the TT&C Subsystem. This subsystem provides the functions for gathering and formatting the spacecraft data to the ground and receiving commands from the ground to control all of the spacecraft functions. The TT&C Subsystem element includes all of the efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

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This element also includes those efforts required for producing the TT&C RF subsystem. This subsystem provides the functions for transmitting spacecraft telemetry and receiving spacecraft commands from both Ku- and S-band ground terminals. It provides the necessary equipment for developing range and range rate information to be used for tracking and positioning location computations. The TT&C RF subsystem element includes all of the efforts required for management, subsystem engineering, design, manufacture, test, evaluation, and support of data reviews and subsystem audits.

This subsystem also includes the COMSEC function for the spacecraft, including the efforts to design, test, document, and achieve National Security Agency (NSA) certification.

## **6.8 POWER AND ELECTRICAL SUBSYSTEM**

This element includes those efforts required for producing the Power and Electrical Subsystem. This subsystem generates, converts, regulates, stores, and distributes all electrical energy to and between spacecraft components. This element includes those efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

## **6.9 HARNESS SUBSYSTEM**

This element is the effort to design, and plan for the development and test of the harnesses that provides the power, data, and command paths, connections, production breaks and access points required to develop, assemble, operate, and verify TDRS throughout its life cycle. This element also includes the effort to design, and plan for the development and test of all grounding, shielding, circuit protection and circuit isolation provisions needed for safe operation in its development, test and operational environments.

## **6.10 ON-BOARD COMPUTER AND SPACECRAFT DATA BUS**

This element includes those efforts required for producing On-Board Computer and Spacecraft Data Bus. This element includes those efforts required for management, subsystem engineering, design, analysis, manufacture, test, evaluation, and support of data reviews and subsystem audits.

## **6.11 FLIGHT SOFTWARE**

This element includes those efforts required for deriving requirements, designing, implementing, integrating, and performing verification/validation of the Flight Software.

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This element includes those efforts required for management, subsystem engineering, design, development, test, evaluation, and support of data reviews and subsystem audits. This element also includes those efforts needed to maintain flight software standards and procedures.

#### **6.11.1 Planning and Requirement Analysis**

This element includes those efforts required for performing task planning, build release planning, requirement definition requirements review, interface requirement & definition.

#### **6.11.2 Design**

This element includes those efforts required for producing the architecture design, Preliminary Design, Preliminary Design Review Detailed Design, and Critical Design Review.

#### **6.11.3 Implementation**

This element includes those efforts required for implementing code, unit test, unit test review, database development, build integration test, Version Description Document (VDD) preparation, and Flight Software (FSW) release to the Test Team.

#### **6.11.4 Verification and Validation**

This element includes those efforts required for performing test planning, test plan peer review, test result review, test report generation, build verification test, system test readiness review, system validation testing, acceptance testing, and acceptance test review.

#### **6.11.5 Independent Verification and Validation**

This element includes those efforts required for supporting the NASA Independent Verification and Validation (IV&V) activity.

#### **6.11.6 Development and Verification Environment**

This element includes those efforts required for developing FSW development tools, including any high-fidelity simulator(s), external component simulators(s), test tools, Software Development Verification Facility (SDVF) development.

## **6.12 BUS MODULE INTEGRATION AND TEST PROGRAM**

This element includes those efforts, including harness installation, required to assemble, integrate, and test the bus module. This element also includes the efforts related to testing the bus module including test management, test, evaluation, and support of data reviews.

## **6.13 SPACECRAFT EMULATOR**

This element includes those efforts necessary to establish requirements and to design, develop, install, and test a spacecraft emulator that models spacecraft subsystems. It also includes all of the custom hardware necessary to run the software.

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## **7.0 MISSION OPERATIONS**

The management of the development and implementation of personnel, procedures, documentation, and training required to conduct mission operations, including transfer orbit, deployment, activation, and calibration, on-orbit flight operations, and post-acceptance service, storage, and contingency operations. This element includes tracking, commanding, receiving/processing telemetry, analyses of system status, trajectory analysis, orbit determination, maneuver analysis, target body orbit/ephemeris updates, and disposal of remaining end-of-mission resources. This element also includes those efforts required in the support and generation of documentation and reviews.

### **7.1 MISSION OPERATIONS MANAGEMENT**

This element includes those efforts required for the technical direction, administration and control of the TDRS K Mission Operations. This element also includes all of the efforts needed to review and approve all CDRL data items for Mission Operations.

### **7.2 TRANSFER ORBIT MISSION**

This element includes those efforts required for the transfer orbit mission of TDRS. It includes the facilities and operations products necessary to execute the transfer orbit mission. It includes the training and mission rehearsals necessary. It includes the monitoring of all spacecraft systems. It also includes the efforts that may be required to analyze and correct problems resulting from anomalous spacecraft Performance during the transfer orbit mission.

### **7.3 DEPLOYMENT, ACTIVATION, AND CALIBRATION**

This element includes those efforts required planning, developing and validating procedures, performing training and rehearsals, and executing the deployment, activation and calibration of TDRS. It includes the monitoring of all spacecraft systems. It also includes the efforts that may be required to analyze and correct problems resulting from anomalous spacecraft performance during the deployments, activation and calibration.

### **7.4 ON-ORBIT VERIFICATION PROGRAM EXECUTION AND ACCEPTANCE**

This element includes those efforts required to verify that the on-orbit spacecraft is operational, compatible with the WSC and capable of providing user services consistent with all applicable specifications. This element also includes those efforts required for the acceptance for the TDRS spacecraft. This element also includes those efforts required in the support and generation of documentation and reviews.

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This element also includes those efforts required for the performance of verification testing and on-orbit calibration of the spacecraft to assure Spacecraft/WSC compatibility. It includes efforts necessary to verify that each TDRS K Program spacecraft and the WSC together are capable of supporting the mission telecommunication and tracking services. It includes efforts necessary to demonstrate TDRS/WSC compatibility. This element also involves the preparation of test procedures, the conduct and direction of the tests, and the support of the data reduction, analysis and preparation of test reports.

This element also includes those efforts required to support and assist NASA in the verification testing necessary to demonstrate total TDRS/WSC compatibility with all segments of the SN. This element encompasses those contractor efforts necessary to support NASA in the conduct of the Space Network End-to-End Service Tests verifying telecommunication services, tracking services, end-to-end test services, the TDRS System operations interface, and the SN Project Operations Control Center (POCC) operations interface.

## **7.5 NASA OPERATIONS PRODUCTS DEVELOPMENT**

This element includes the effort to support the effort to derive requirements, design, implement, verify/validate, deliver, and integrate the operations products and data required to enable NASA operation of accepted spacecraft in the service, storage, and contingency modes of operations from the WSC.

## **7.6 NASA SUSTAINING ENGINEERING SUPPORT**

This element includes those efforts required for sustaining engineering and technical support to assist NASA and its WSC Maintenance and Operations (M&O) contractor in operating the TDRS K, modified ground systems, and other delivered systems. It includes analyzing spacecraft performance, developing and modifying spacecraft operating procedures, etc. This effort will begin one year before the launch of the first spacecraft and will terminate per the contract.

This element includes those efforts required for maintenance of the software. The following software is included: Spacecraft Emulator, Real-Time Command Telemetry System (RCTS), Ground System, Ka-Band ETE Test System, and the flight software. It also includes those efforts necessary to ship to the WSC, to reassemble, and to verify the development and test environments required for maintenance of the RCTS, the Spacecraft Emulator, and any flight software. It also includes those efforts necessary to train the M&O contractor to assume maintenance and operation of the RCTS, the Spacecraft Emulator, and all flight software and the environments themselves.

This element also includes those efforts required to investigate all spacecraft anomalies from the first launch to through the period specified by the contract. It also includes

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technical support at program reviews and Failure Review Boards (FRB), data compilation, FRB coordination and execution, and anomaly close-out in accordance with WSC reporting procedures.

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## **8.0 LAUNCH VEHICLE SERVICES AND OPERATIONS**

This element includes those efforts required for development of the interface requirements document, and all other documents required by the range or Kennedy Space Center (KSC), spacecraft ground pre-launch and facilities support planning, and activities required at the Eastern Test Range (ETR) to mate the spacecraft to the launch vehicle, to verify the spacecraft's compatibility with the launch vehicle, to support and certify launch safety, and to assure a successful launch. It also includes support of launch operations. This element also includes those efforts required in the support and generation of documentation and reviews.

### **8.1 LAUNCH SUPPORT MANAGEMENT**

This element includes those efforts required for the technical direction and administration and control of the Launch Support program. It includes all of those efforts required to review and approve all CDRL data items in the Launch Support category.

### **8.2 LAUNCH OPERATIONS PLANNING AND COORDINATION**

This element includes those efforts required for facilities support and personnel required for Launch Vehicle (LV)/TDRS integration and the monitor and support of the launch activities. It includes all of the activities necessary for management and planning involving the physical, functional, and environmental integration of the spacecraft with the LV, the ground processing facilities, and ground support equipment. It includes the preparation and provision of all applicable Launch Support CDRL documentation.

### **8.3 LAUNCH INTERFACE ENGINEERING**

This element includes those efforts required for the development the TDRS K Spacecraft/LV interface control documentation and specifying (where appropriate), verifying, managing, and controlling the technical interfaces between the TDRS K and the launch vehicle in accordance with this document.

### **8.4 INTERFACE TEST AND ANALYSIS**

This element includes the effort to provide all resources necessary to perform the interface electrical, mechanical, and thermal test and analysis. This effort shall include all tasks involving mounting, alignment, and support subsequent checkout. This element includes the effort to accommodate the TDRS procedures, data base parameters, and ground support equipment necessary for interface test and analysis.

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## **8.5 LAUNCH CAMPAIGN OPERATIONS**

This element includes those efforts required for integration of the spacecraft with the LV and the spacecraft checkout that occurs at the launch site. It includes support for testing that confirms the health and welfare of the spacecraft, verification of spacecraft performance after testing, verification of the launch interface, confirmation of the readiness for launch, support of safety requirements, and the conduct and support of all required launch simulations.

## **8.6 LAUNCH SITE OPERATIONS AND LAUNCH**

This element includes those efforts required for the actual support of the launch. It includes the monitoring of all spacecraft systems before and during the launch, and after orbit injection. It also includes the efforts that may be required to advise and correct problems resulting from anomalous spacecraft performance during the launch operations.

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## **9.0 GROUND SYSTEM MODIFICATION**

This element includes those efforts required for the management, requirements derivation and allocation, design, development, implementation, installation, integration and testing of new or modified hardware and software that may be required at the WSC to ensure compatibility with the TDRS K Program, including that required to implement the required COMSEC modifications. This element also includes those efforts required in the support and generation of documentation and reviews.

### **9.1 GROUND SYSTEM MODIFICATION MANAGEMENT**

This element includes those efforts required for the management, control, technical direction, and administration of all WSC modifications that may be required to ensure its successful completion and transition to operations. It includes the technical management functions necessary (including data and configuration management and QA) for oversight and control of all the subordinate WSC modification elements that follow.

### **9.2 SYSTEMS ENGINEERING**

This element includes those efforts required for the systems engineering of the WSC modifications in accordance with the requirements developed in WBS elements. It includes requirements analysis; identification of the total impact on the existing WSC design and the existing WSC interfaces (both internal and external); and identification of impacts on operations; and the effort required to do performance verification planning and analysis.

### **9.3 HARDWARE DEVELOPMENT AND TEST**

This element includes those efforts required for the design, development, implementation (including all unit, functional, and subsystem level testing) of new hardware (e.g. TDRS K TTC COMSEC equipment, TDRS K MA Ground Based Beamforming Equipment) required as well as modifications to existing hardware at the WSC to meet the TDRS K system/subsystem design specifications and Interface Control Documents (ICDs).

### **9.4 WHITE SANDS COMPLEX HARDWARE INSTALLATION AND TEST**

This element includes those efforts required for the installation, test and maintenance of new hardware required to modify existing hardware at the WSC in accordance with the system/subsystem design specifications and ICDs.

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## **9.5 SOFTWARE DEVELOPMENT AND TEST**

This element includes those efforts required for the design, development, implementation and maintenance required for new software and modifications to existing software. This also includes the acquisition, installation, and maintenance of commercial software at the WSC in accordance with the system/subsystem design specifications and ICDs.

## **9.6 WHITE SANDS COMPLEX SOFTWARE INSTALLATION AND TEST**

This element includes those efforts required for the installation, test and maintenance of new software required to modify existing software at the WSC in accordance with the system/subsystem design specifications and ICDs.

## **9.7 WHITE SANDS COMPLEX INTEGRATION AND TESTING**

This element includes those efforts required for the assembly and integration of all modified WSC systems and subsystems, including software, for verification and test at the contractor's facilities and at the WSC. WSC Integration, Verification and Test (IV&T) also covers the preparation of test plans and procedures, test execution, and documentation of test results.

## **9.8 ACCEPTANCE TEST PROGRAM**

This element includes those efforts required for the provisional and final acceptance test and transition of the Modified Ground System. This element also covers the preparation of test plans and procedures, test execution, and documentation of test results.

## **9.9 REAL-TIME COMMAND AND TELEMETRY SYSTEM**

This element includes those efforts necessary to establish requirements and to design, develop, document, and test a RCTS for the monitoring of spacecraft telemetry in real-time and for post-logging analysis and for real-time commanding of the spacecraft.

## **9.10 KA-BAND ETE TEST SYSTEM**

This element includes those efforts required for the development, documentation, and test of Ka-Band End-to-end test system. It also involves interface testing to verify proper connection of all Bus and Payload components.

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## **9.11 INTEGRATION LOGISTICS SUPPORT AND TRAINING**

This element includes those efforts required for preparing and implementing the TDRS K Integrated Logistics Support (ILS) program, analyzing the system design to identify logistic support requirements for the new or modified WSC hardware, and providing the resources necessary to assure effectiveness and economical logistics support of the equipment. These efforts will terminate one year after acceptance of the last spacecraft by NASA. Training includes all of the time, materials, and efforts required to provide training to NASA and WSC M&O personnel relative to the maintenance, operations, control, and performance of the new or modified WSC hardware and software.

This element also includes those efforts required for providing the time and materials necessary for training the WSC Maintenance and Operations (M&O) staff on the functions, operations and control of the TDRS spacecraft and Payload subsystems.

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## **10.0 SYSTEMS INTEGRATION AND TESTING**

This element includes those pre-launch factory efforts required for the design, development, preparation, implementation, execution, and documentation of the spacecraft integration and test program, including the environmental test program; and provision of the associated electrical and mechanical support equipment required for its execution. It also includes the assembly and integration of all spacecraft and payload components into a fully functional spacecraft and the verification of spacecraft performance under all specified environmental conditions. It also includes pre-launch Ground Spaceflight Tracking and Data Network (GSTDN)/Deep Space Network (DSN)/WSC and LV compatibility testing, the development of the required GSE, and spacecraft storage, maintenance and shipping. Each of the subordinate elements that follow includes the functions of management, engineering, design, manufacture, test and evaluation. This element also includes those efforts required in the support and generation of documentation and reviews. It includes collection of all test and inspection data required by the PVM.

### **10.1 I&T MANAGEMENT**

This element includes those efforts required for the technical direction, administration and control of the Spacecraft Integration and Test (I&T) program. This element also includes all of the efforts needed to review and approve all CDRL data items in the Spacecraft I&T category.

### **10.2 I&T ENGINEERING**

This element is the work required to verify by simulation, analysis and/or test that all TDRS K Program requirements are verifiable and have been satisfied. This element also includes the work required for specialty engineering disciplines and instrumentation to the spacecraft during I&T.

### **10.3 GSE AND PROCEDURES**

This element includes those efforts required for the design, development, fabrication and test of all electrical and mechanical GSE necessary to completely test and integrate the spacecraft and verify that it meets the specified performance. It also includes any special equipment necessary to handle, store, and transport the spacecraft or its components and any equipment used to perform off spacecraft mechanical testing of appendages or other equipment during I&T. It also covers any automated data processing equipment and software necessary to control and monitor the spacecraft, run the test procedures and analyze, display and plot the test data. This element also contains the design, development implementation and maintenance of the Mechanical

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Ground Support Equipment (MGSE). The MGSE includes Lifting Fixtures, Shipping & Storage Containers, Drill Templates, Assembly Jigs, and Purge Equipment.

#### **10.4 I&T OPERATIONS**

This element includes those efforts required for the assembly and integration of the spacecraft and payload, and any remaining appendages, electrical harnesses, antennas, and all other spacecraft and Payload components into a fully functional Spacecraft.

#### **10.5 END-TO-END VERIFICATION AND VALIDATION**

This element covers all of the functional, end-to-end, and environmental tests performed during I&T to verify spacecraft performance requirements, or to confirm that the spacecraft continues to meet performance. It also includes GSTDN/DSN and WSC pre-launch compatibility testing.

#### **10.6 I&T RECORDS**

This element includes those efforts necessary to document the progress through the I&T/transport/launch processing program. It includes a cumulative daily log for each spacecraft and photographs or videotape of significant tests, installations, close-out, moves, etc. It shall include all data required by the NSA for launch contingency procedure development and execution.

#### **10.7 SPACECRAFT STORAGE**

This element includes those efforts associated with the management, planning, design, implementation, execution, post-storage verification, maintenance and refurbishment for a TDRS spacecraft. In addition, this element includes those efforts needed to develop all Storage, Maintenance and Refurbishment hardware, and procedures and deliverables/non-deliverables.

#### **10.8 SPACECRAFT TRANSPORTATION AND HANDLING**

This element includes those efforts required for the management, planning, transportation and handling of the spacecraft from the spacecraft manufacturing facility, and safe delivery of the spacecraft to the launch site.

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## **11.0 EDUCATION AND PUBLIC OUTREACH**

This element includes the development of the Education and Public Outreach (EPO) portion of the TDRS Program. Provide for the EPO responsibilities in alignment with NASA's Strategic Plan for Education. This element also includes management and coordinated activities, formal education, informal education, public outreach, media support, and web site development.

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**APPENDIX A: ABBREVIATIONS AND ACRONYMS**

ACS	Attitude Control System
CDRL	Contract Data Requirements List
COMSEC	Communications Security
CMO	Configuration Management Office
DSN	Deep Space Network
EEE	Electronic, Electrical, Electromechanical
EIRP	Effective Isotropic Radiated Power
EPO	Education and Public Outreach
ETE	End to End Test Equipment
ETR	Easter Test Range
FRB	Failure Review Board
FSW	Flight Software
G/T	Gain Over Temperature
GSE	Ground Support Equipment
GSTDN	Ground Spaceflight Tracking and Data Network
I&T	Integration and Test
ICD	Interface Control Document
ILS	Integrated Logistics Support
ITAR	International Traffic In-Arms Regulation
IV&T	Integration Verification and Test
IV&V	Independent Verification and Validation
KaSA	Ka-band Single Access
KSC	Kennedy Space Center
KuSA	Ku-band Single Access
LV	Launch Vehicle
M&O	Maintenance and Operations
MA	Mission Assurance
MGSE	Mechanical Ground Support Equipment
MPSR	Monthly Program Status Reviews
NASA	National Aeronautics and Space Administration
NSA	National Security Agency
PFD	Power Flux Density
POCC	Project Operations Control Center
PVM	Performance Verification Matrix
QA	Quality Assurance
RCTS	Real-Time Command and Telemetry System
RF	Radio Frequency
S&MA	Safety and Mission Assurance
SA	Single Access
SDVF	Software Development Verification Facility
SN	Space Network

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**ABBREVIATIONS AND ACRONYMS (Continued)**

TDRS	Tracking and Data Relay Satellite
TT&C	Tracking, Telemetry and Command
USAT	User Satellite
VDD	Version Description Document
WBS	Work Breakdown Structure
WSC	White Sands Complex

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