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

VERIFICATION AND VALIDATION REQUIREMENTS

EFFECTIVE: 04/04/2007
EXPIRES: 04/03/2012

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

SIGNATURE PAGE

Approved by: ______________________ Date: 4/16/07

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DOCUMENT CHANGE RECORD

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

CONFIGURATION MANAGEMENT (CM) FOREWORD

This document is a Tracking and Data Relay Satellite (TDRS)-K 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.”

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2.	Pg. 4-7; p4.5.6.c	Compatibility of all interactive spacecraft/WSC functions (such as autotrack (TBP)) shall be verified by analysis or test.		

1.0 INTRODUCTION

1.1 GENERAL

Verification is the process of confirming the functional, performance, and operational requirements of the Tracking and Data Relay Satellite (TDRS) K System as delivered by the Contractor. All requirements defined within all TDRS K Specifications and Interface Control Documents (ICDs), including contractor derived system, subsystem, and component level specifications, shall be verified. Acceptable methods of verification shall be testing, analyses, demonstration, similarity, and inspection. Evidence of verification shall consist of all design analyses, simulations, and test results and analyses at all levels of assembly.

1.2 SCOPE

This document establishes the minimum test verification requirements for the TDRS K System as depicted in Figure 1-1 “Verification Hierarchy”. The primary sources of requirements to be verified are the “Spacecraft Technical Requirements Specification”, the “TDRS K Ground System Requirements Specification”, The TDRS K Mission Assurance Requirements, and the contractor derived specifications. Verification of interface requirements for the spacecraft and the Evolved Expendable Launch Vehicle (EELV) are treated only to the extent specified in the “Spacecraft Technical Requirements Specification”. This document excludes verification of classified Communications Security (COMSEC) requirements. The environmental requirements contained herein are based on a protoflight approach to the development of the TDRS K Program Spacecraft. Requirements not appropriate for direct verification by ground based testing (e.g. Single Access (SA) Antenna pointing) shall be verified by analysis or demonstration supported by lower level test (e.g. Single Access [SA]) feed sum and difference patterns).

Requirements terminology is given below:

a. Shall. The verb used to express requirements.

b. Will, Should, May. Verbs used to aid the reader with understanding the scope or extent of requirements. These verbs do not express requirements.

c. TBP. “To be Proposed” by the contractor.

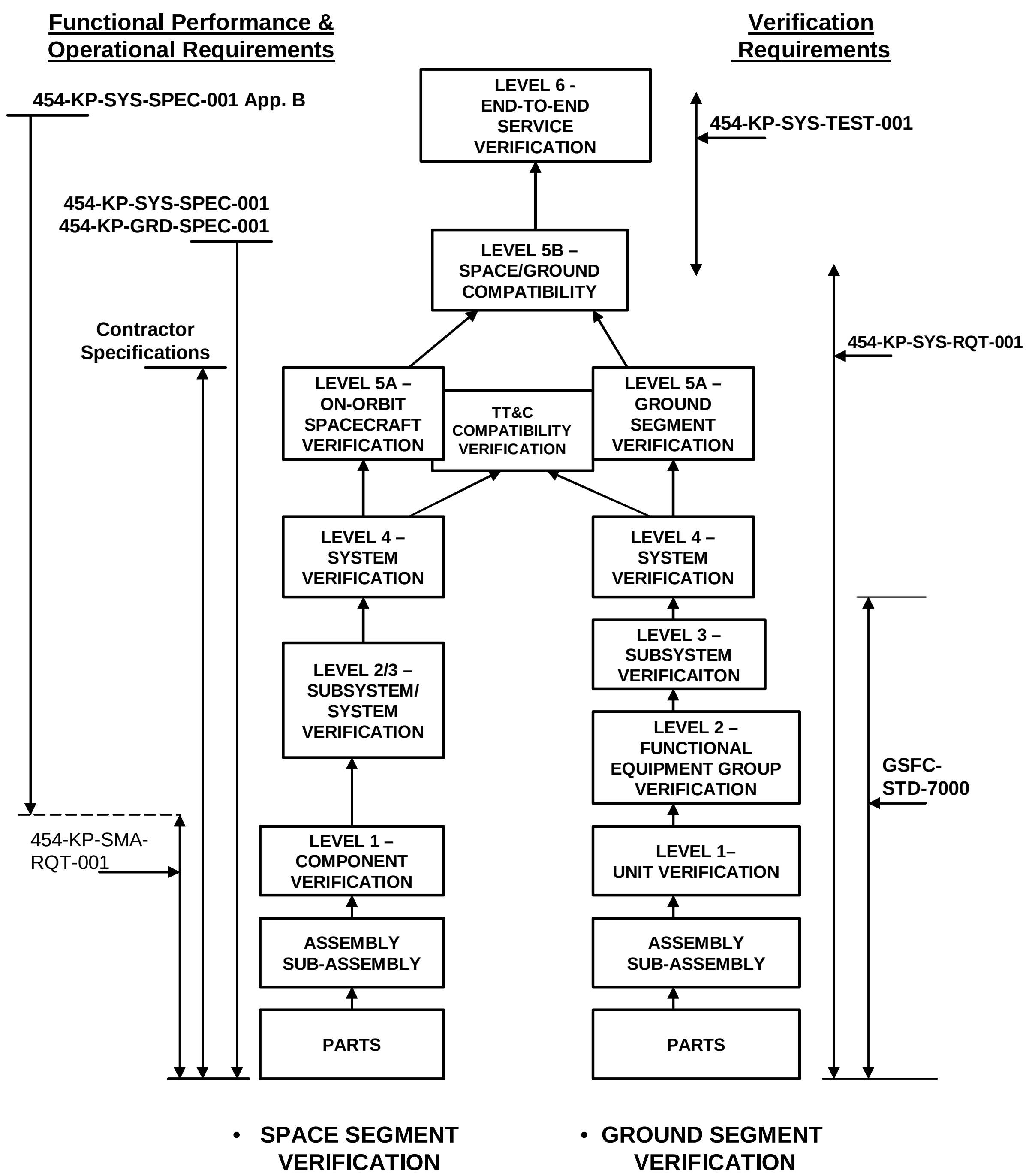

FIGURE 1-1: Verification Hierarchy

2.0 APPLICABLE DOCUMENTS

The following documents are applicable to the extent cited herein. In the event of a conflict between this document and those listed below, this document takes precedence over all except the Spacecraft Technical Requirements Specification, the Ground System Requirements Specification, and the On-Orbit Acceptance Test Specification.

454-KP-SYS-SPEC-001	TDRS K Program Spacecraft Technical Requirements Specification
454-KP-GRD-SPEC-001	TDRS K Program Ground System Requirements Specification
GSFC-STD-1000	Rules for the Design, Development, Verification, and Operation of Flight Systems, Revision C.2, 12 December 2006.
454-KP-SYS-RQT-002	GSFC Rules Compliance Matrix
GSFC-STD-7000	General Environmental Verification Standard (GEVS), issued April 2005
454-KP-SMA-RQT-001	TDRS K Program Mission Assurance Requirements
454-KP-SYS-TEST-001	TDRS K Program On-Orbit Acceptance Test Specification
MIL-STD-1522A	General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems

3.0 GENERAL REQUIREMENTS

a. All requirements defined within all TDRS K Program specifications and Interface Control Documents (ICDs), including all contractor-derived system, subsystem and component level specifications, shall be verified in accordance with this document.

b. Methods to be used for verification include testing, analysis, demonstration, similarity and inspection.

c. All test measurements shall be made against pass/fall criteria established before the start of each test. Measurement values shall be recorded.

d. Performance shall be verified in all operative modes under nominal and worst case conditions (e.g., temperature extremes with extreme power supply voltages).

e. Turn-on capability of all components at minimum and maximum temperatures shall be demonstrated.

3.1 SPACECRAFT REQUIREMENTS

a. All spacecraft components shall be subject to workmanship inspections and test upon completion of manufacture.

b. All components normally on during launch shall be powered on and meet functional and performance specifications during vibration and acoustic testing.

c. All spacecraft redundancy shall be verified by test prior to launch.

d. All spacecraft cross-strap modes shall be verified by test.

e. Life testing shall be performed on prototype units for all limited-life spacecraft components. Life testing shall be performed under conditions representative of those the component will experience in-orbit and during ground testing.

f. All spacecraft analytic models shall be verified by test.

3.2 WSC REQUIREMENTS

a. All White Sands Complex (WSC) new and/or modified components shall be subject to workmanship inspections and test upon completion of manufacture.

b. All mechanical, electrical, thermal, and heritage operational interfaces to WSC components shall be verified by test prior to installation.

c. All WSC modifications shall be verified backward compatible and providing no adverse effect on Space Network and TDRS F1-F10 operations

3.3 TEST EQUIPMENT REQUIREMENTS

a. All test equipment including test software shall be calibrated for proper performance prior to use.

b. The measurement accuracy of all test equipment shall be verified by test prior to use.

4.0 SPACECRAFT VERIFICATION REQUIREMENTS

4.1 ENVIRONMENTAL TEST REQUIREMENTS

Each TDRS K spacecraft shall be verified for operation over the full range of environments from launch through end-of-life. The tests include: thermal cycling, thermal balance, thermal-vacuum, vibration, acoustics, shock, depressurization, radiation, Electromagnetic Interference (EMI)/Electromagnetic Capability (EMC), and Electrostatic Discharge (ESD).

4.2 EEE PARTS VERIFICATION

a. All flight parts shall be selected, traced, controlled, analyzed, and handled per Section 11 of 454-KP-SMA-RQT-001, TDRS K Mission Assurance Requirements.

b. All Section 11 covered parts shall be derated per Section 11.6.2 for TDRS application.

c. A stress derating analysis shall be performed for all covered or non-covered parts. Stress parameters shall include operating voltages, current, and power as a function of temperature.

d. Parts applications that do not exceed 50% of the maximum rated part stress parameter and do not operate above 70 deg. C under worst case conditions, are acceptable for TDRS K application.

e. Parts applications that exceed the conditions specified in d, shall be submitted for approval.

f. Parts applications that exceed 75% of the maximum rated stress parameter and whose operating temperatures exceed 90 deg. C, shall be life tested for TDRS K application.

4.3 COMPONENT AND SUBSYSTEM VERIFICATION

a. The verification program shall verify compliance with all specified parameters of all component and subsystem specifications. Compliance shall be verified over all specified environments.

b. Spacecraft components and subsystems whose designs have no applicable previous flight history shall be verified by qualification, prototype, or protoflight level testing.

c. Spacecraft components and subsystems whose designs have applicable previous flight history shall be verified by acceptance level testing.

d. Following rework of any flight hardware, workmanship of the modified hardware shall be demonstrated by test, including as a minimum, 3-axis random vibration testing, thermal cycling and functional performance testing.

4.3.1 Spacecraft Component Electrical Function Test Requirements

a. Functional performance testing shall be conducted on each component to demonstrate that the hardware and software and their redundant elements meet their performance requirements in all operational modes, including operation at nominal predicted operating temperatures and at minimum and maximum predicted operating temperatures.

b. Functional performance testing shall be conducted on each component prior to and following each component environmental test.

c. One thousand hours (TBP) of operating time shall be accumulated on all electrical flight components that operate during “Service, On-Orbit Storage, or Safe-Hold modes” prior to spacecraft launch..

d Fifty (50) hours of failure-free operating time shall be accumulated on all non-critical components that are operational only during the Launch and Ascent modes.

d. One-hundred (100) hours of failure-free operation shall be accumulated on all redundant critical components that are operational only during the Launch and Ascent modes.

e. Three-hundred (300) hours of failure-free operation shall be accumulated on all non-redundant critical components that are operational only during the Launch and Ascent modes.

g Each component operational during the Service and/or Storage and Safe-Hold modes shall demonstrate failure-free performance for at least the last 200 hours of operation prior to integration on the spacecraft.

h. Subsystem testing shall include exercise of all software functions and modes.

4.3.2 Spacecraft Component Environmental Tests

Component level environmental tests include EMI/EMC, Thermal Cycling, Thermal Vacuum, Structural/Mechanical loading, Random Vibration, Sine Vibration, and for selected components acoustic testing. Test Levels and durations are given in GSFC-STD-7000 General Environmental Verification Standard (GEVS), Table 2.2-2. Workmanship tests to be completed upon manufacture of the component are thermal cycling and random vibration, and are specified below.

a. Electromagnetic susceptibility testing shall be performed on all protoflight spacecraft bus electronic components to demonstrate that the hardware will operate properly if subjected to conducted or radiated emissions from other sources expected to occur throughout hardware life.

b. Electromagnetic interference testing shall be performed on all protoflight spacecraft bus electronic components to demonstrate that the hardware does not generate either conducted or radiated signals that could hinder or degrade the operation of other spacecraft systems.

c. Electromagnetic susceptibility testing shall be performed on all active spacecraft payload components to demonstrate that the hardware will operate properly if subjected to conducted or radiated emissions from other sources expected to occur throughout hardware life.

d. Electromagnetic interference testing shall be performed on all active spacecraft payload components to demonstrate that the hardware does not generate either conducted or radiated signals that could hinder or degrade the operation of other spacecraft systems.

e Component susceptibility and emission testing shall be performed per GEVS, Section 2.5.

f. Component susceptibility testing shall demonstrate a 3 dB margin against the Radio Frequency Interference (RFI) environments of 454-KP-SYS-SPEC-001 Sections 5.2 and 14.2.

g. Component emission testing shall demonstrate a 3 dB margin against the emission limits of 454-KP-SYS-SPEC-001, Section 14.2.

h. The structural and mechanical performance and workmanship of components and subsystems shall be verified by test.

i. Component workmanship shall be established by random vibration test as specified in GEVS Section 2.4.2.5. (A one minute test along each of 3 axes) All components shall be powered on and monitored during this test.

j. The mechanical function of spacecraft mechanisms shall be verified by test, including torque margins and operating life.

k. Single Access Antenna gimbals shall be qualified to 2x life and include the Extended Field of View (FOV).

l. The Space-Ground Link (SGL) Antenna gimbals shall be qualified to 2x life.

m. Verification of pressurized equipment shall be in compliance with MIL-STD-1522A.

n. Temperature margins per GEVS Table 2.2-2 shall be established to provide allowances to compensate for uncertainties in the thermal parameters and to induce stress conditions to detect unsatisfactory performance and workmanship that would not otherwise be detected prior to flight.

o. All components shall be exposed to a minimum of eight (8) thermal cycles to demonstrate performance and workmanship prior to integration on the spacecraft. Components sensitive to vacuum effects shall be cycled in vacuum.

p. The mass properties of all spacecraft components shall be measured to include: mass, center of gravity, and moments of inertia.

q. All spacecraft components shall be tested for tolerance to shock environment per GEVS Section 2.4.4 in the appropriate configuration at the time of shock excitation.

4.4 SPECIAL TDRS K TESTS

a. All payload and Tracking, Telemetry, and Command (TT&C) high power amplifiers (Radio Frequency [RF] output power > 1 watt) shall have no less than 300 hours of burn-in operation.

b. All payload and TT&C solid state power amplifiers shall be tested for saturated power droop by driving the RF to at least 3 decibels (dB) compression for a minimum of 50 hours.

c. All TWTs shall have 1000 hours of burn-in and demonstrate stable parameters for at least the last 250 hours of burn-in.

d. All spacecraft power amplifiers shall be tested at maximum power in vacuum for at least 24 continuous hours.

e. All active payload components shall be characterized for gain transfer, gain slope, saturated gain, gain flatness, gain stability, amplitude linearity, phase shift, bandwidth, return loss, spurious output, power or gain control, Radio Frequency (RF) leakage, RF susceptibility, Amplitude Modulation (AM)/AM, AM/Phase Modulation (PM), outgassing, multipactor, frequency stability, incidental AM, Spurious PM, active and passive inter-modulation, and phase noise as applicable.

f. All payload passive components shall be characterized for gain transfer, phase transfer, power handling, multipactor, bandwidth, insertion loss, RF leakage, RF susceptibility, and passive inter-modulation.

g. All payload and TT&C antennas shall be tested for transmit co-polarization, transmit cross-polarization, receive co-polarization, receive cross-polarization, and transmit to receive isolation over their respective operational fields of view. Each antenna's radiated power handling capability shall be verified by analyses and test.

h. All payload and TT&C antennas shall be tested over their complete operational frequency bandwidths.

i. All SA auto-track patterns shall be measured.

j. All payload and TT&C antenna gain patterns shall be characterized over temperature.

k. All payload and TT&C antennas shown to be subject to deformation by thermal gradients shall be solar illumination tested and the deformation measured.

4.5 SPACECRAFT INTEGRATION AND TEST

4.5.1 <u>Spacecraft Environmental Verification and Testing Requirements</u>

a. The verification program shall verify compliance with all specified parameters of all spacecraft specifications. The compliance shall be verified over all specified environments.

b. Environmental testing of the first spacecraft shall be performed at protoflight levels.

c. Environmental testing of subsequent spacecraft shall be performed at acceptance levels.

4.5.2 Electrical Function Test Requirements

a. Comprehensive Performance Tests (CPTs) shall be conducted on the spacecraft prior to and following the spacecraft environmental test program, and during thermal vacuum at nominal predicted operating temperatures and at minimum and maximum predicted operating temperature extremes. Each CPT shall demonstrate that the hardware and software meet their performance requirements, including operation of all redundant elements.

b. In the absence of a CPT, Limited Performance Testing (LPT) shall be performed on the spacecraft prior to, during, and following each environmental test in order to demonstrate that functional capability has not been degraded by the tests. The LPT shall demonstrate that the performance of hardware and software functions is within acceptable limits.

c. Each spacecraft shall demonstrate failure-free performance for at least the last 200 hours of operation prior to launch.

d. Signal level control shall be demonstrated for all forward and return channels.

e. Response to pulsed and continuous interference for all forward and return channels shall be demonstrated.

f. Interfering pulse clipping and pulse stretching response shall be demonstrated.

g. All spacecraft command and telemetry shall be verified by test.

h. Spacecraft testing shall include exercise of all software functions and modes. The ability to load and dump spacecraft memory shall be verified. The ability to patch flight software with subsequent proper operation shall be verified.

i. All spacecraft modes shall be verified by test. Entry into all on-orbit spacecraft modes and return to Normal Mode shall be verified by test.

j. The spacecraft shall demonstrate the capability to successfully transition from Ascent to Acquisition to on-orbit Storage modes.

k. End-to-end polarity from sensor to actuator shall be verified by test.

l. End-to-end payload polarity shall be verified by test.

4.5.3 Electromagnetic Compatibility Test Requirements

a. A susceptibility test shall be performed to verify that the spacecraft will operate properly if subjected to conducted or radiated emissions from other sources which could occur during launch and on-orbit.

b. A spacecraft emissions test shall be performed to verify that the spacecraft does not generate either conducted or radiated signals that could hinder the operation of the launch vehicle or itself.

c. All EMC/EMI tests shall be conducted per GEVS Section 2.5.

d. The integrated spacecraft shall be tested for passive intermodulation.

e. The integrated spacecraft shall be tested for self interference and ring-around.

f. The integrated spacecraft shall be tested to verify the ETO configuration.

4.5.4 Structural and Mechanical Test Requirements

a. The dynamic characteristics of the spacecraft shall be verified by test, over a frequency range consistent with launch vehicle input and interaction with the spacecraft.

b. The strength of the spacecraft primary structure including margin, shall be verified by test.

d. The structural and mechanical performance and workmanship of each spacecraft shall be verified by test, upon exposure to all on-orbit conditions and expected launch environments, including low and high frequency dynamic events.

e. The mechanical function of spacecraft mechanisms shall be verified by test, including torque margins and operating life.

f. The dry mass and center of gravity of each spacecraft shall be verified by test.

g. All deployments shall be fully characterized over first motion and full travel. Critical clearances shall be verified by test of a fully thermal blanketed flight configuration.

h. A modal survey to 50 Hz shall be performed on the stowed launch configuration of the spacecraft.

i. Spacecraft level acoustic test shall be performed per GEVS Section 2.4.2.2.

j. Spacecraft random vibration tests shall be performed per GEVS Section 2.4.2.3.

k. Spacecraft Sine sweep vibration tests shall be performed per GEVS Section 2..4.3.1.

4.5.5 Vacuum and Thermal Environmental Test Requirement

a. Each spacecraft shall be subjected to thermal vacuum testing to verify the spacecraft thermal control subsystem design and to demonstrate satisfactory performance in modes representative of mission functions, at nominal predicted operating temperatures and at minimum and maximum predicted operating temperature extremes, including 10 deg. C margins for the prototype and 5 deg. C margins for subsequent spacecraft.

b. Each spacecraft shall be subjected to six (6) thermal cycles, four (4) of which shall be in vacuum per GEVS Section 2.6.2.4.

c. The spacecraft shall be configured for thermal vacuum testing such that the thermal balance of the spacecraft bus and payload including the Single Access Electronics Compartments (SACs) can be established.

d. The demonstrations of GEVS Section 2.6.2.6 shall be performed.

e. Forward and return maximum and minimum service signal delay measurements shall be made over all possible signal paths and temperature variations. The absolute propagation time delay for each configuration shall be measured, and the predicted propagation time delay uncertainty as a function of configuration and environment determined.

f. The relative propagation time delay between the two S-band Single Access Return Services shall be determined for realistic on-orbit environments.

4.5.6 Spacecraft/Ground Station Compatibility Verification

a. Compatibility of the spacecraft with the contractor’s mission control center, the Ascent Mode communications network, and the WSC shall be verified.

b. The compatibility of the spacecraft TT&C subsystem RF and digital design with the Ascent Mode network and the WSC shall be demonstrated by test.

c. Compatibility of all interactive spacecraft/WSC functions (such as autotrack TBP) shall be verified by analysis or test.

d. Compatibility of all contractor-implemented modifications to the WSC shall be verified for TDRS K Program spacecraft and backward compatible with existing TDRS spacecraft.

e. Compatibility of the electrical and mechanical interfaces between the launch vehicle and the TDRS K Program spacecraft shall be verified and form, fit and function demonstrated.

f. A pre-ship “over-the-air” “high-bay” WSC compatibility test shall be performed. This test shall use the spacecraft S-band TT&C system and corresponding WSC like S-band transmitter/modulator and receiver/demodulator. WSC software, command generator, telemetry processor, encryption/decryption equipment shall interface via NISN provided circuits. All TT&C clear and secure modes shall be demonstrated. All TT&C configurations, frequencies and data rates shall be demonstrated.

5.0 WSC VERIFICATION REQUIREMENTS

Verification of WSC modifications for both hardware and software shall follow a hierarchal approach depicted in Figure 1-1.

5.1 WSC COMPONENT LEVEL VERIFICATION

a. All component level software used in the User Service System (USS), Multiple Access (MA), Executive Automatic Data Processing Equipment (EXEC), Data Interface System (DIS), TT&C, and S-Band TT&C (S-TT&C) Automatic Data Processing Equipment (ADPE) shall meet the requirements of 454-KP-GRD-SPEC-001 Section 10.

b. All component level software shall meet the requirements of 454-KP-SMA-001 Section 6.

c. All component hardware used in the USS, TT&C, and S-TT&C shall meet the requirements of 454-KP-GRD-SPEC-001 Sections 14 and 15.

d. All stand-alone equipment (e.g. TDRS Spacecraft Emulator (TSE) and Real-Time Command and Telemetry System (RCTS) including hosted software shall meet the requirements of 454-KP-SMA-001 Section 6.

e. Verification of component mechanical and electrical interfaces shall be demonstrated with at the contractor’s facility with WSC equivalent racks, power supplies and air handling.

f. Verification of component signal interfaces shall be demonstrated with simulated WSC interfaces at the contractor’s facility.

g. Verification of component functional, performance and operational requirements shall be verified by test with simulated interfaces at the contractor’s facility.

h. All components shall be verified for compliance with the Reliability/Maintainability/Availability (RMA) requirements of 454-KP-GRD-SPEC-001, Section 13.

i. All components shall demonstrate compliance with WSC Ground Terminal (GT) mode control specified in 454-KP-GRD-SPEC-001, section 4.5.2.

j. Each component shall be verified as compliant with Maintenance Test Group (MTG) requirements of 454-KP-GRD-SPEC-001, Section 12.

k. Each component shall be verified compatible with the maintenance requirements of 454-KP-GRD-SPEC-001, Section 18.

l. All TT&C and STT&C components shall be verified compatible with security requirements of 454-KP-GRD-SPEC-001, Section 20

m. The Ka End-to-End Test Terminal antenna shall be range tested for antenna pattern and pointing requirements per 454-KP-GRD-SPEC-001 Appendix H.

n. The Ka End-to-End Test Terminal antenna shall verify the capability of re-pointing to any operational TDRS orbital slot within 20 minutes.

5.2 EQUIPMENT GROUP VERIFICATION

a. Group level verification shall be performed at the contractor’s facility.

b. The MA Equipment Group shall meet the functional, performance, interface, and operational requirements of 454-KP-GRD-SPEC-001 Appendix B.

c. The MA Equipment Group verification shall use simulated RF element inputs and calibration signals.

d. The TT&C Equipment Group shall meet the functional, performance, and operational requirements of 454-KP-GRD-SPEC-001 Sections 5.3, 5.5.4, and 6.0.

e. The TT&C Group shall meet the requirements of 454-KP-SYS-SPEC-001 Section 7.0 and Appendix A.

f. The Ka End-to-End Test Terminal shall meet the functional, performance, and operational requirements of 454-KP-GRD-SPEC-001, Appendix H.

5.3 SUBSYSTEM VERIFICATION

a. All equipment groups shall demonstrate compliance with their subsystem using simulated interfaces.

b. All equipment groups shall demonstrate compatibility with simulated Space-Ground Link Terminal SGLT Antenna Subsystem, Common Time and Frequency System (CTFS), DIS, Control and Display Computer Network (CDCN), TDRS Operations Control Center (TOCC), Local Area Network (LAN) and Software Maintenance and Training Facility (SMTF) interfaces.

5.4 SYSTEM LEVEL VERIFICATION

a. All equipment groups shall verify the compatibility of physical installation.

b. All equipment shall verify functional performance.

c. All software shall be verified for compatibility with WSC ADPE.

d. Impact compliance shall be verified by regression testing.

e. The TT&C and COMSEC shall be tested at base band with the TSE.

f. The TT&C shall be verified for TDRS K compatibility by testing with the spacecraft in the high bay.

5.5 GROUND SEGMENT VERIFICATION

a. The MA Equipment group shall perform shadow beam-forming using signals from an F1-F7 spacecraft. Compatibility with the DAS interface shall be demonstrated.

b. The Ka End-to-End Test Terminal shall perform forward and return service tests using an F8-F10 spacecraft.

c. Each modified WSC SGLT and S-TT&C shall perform shadow command and telemetry functions with F1-F7 and F8-F-10 series spacecraft to demonstrate backward compatibility.

d. Each modified WSC SGLT and S-TT&C shall control an F1-F7 and F8-F10 spacecraft to verify backward compatibility.

6.0 PRE-LAUNCH TESTING AND MISSION SIMULATIONS

a. The TDRS K Program spacecraft pre-launch testing shall verify that the spacecraft has not been damaged during shipping and handling, continues to operate as specified, is compatible with the launch vehicle, and is ready for launch.

b. The TDRS K Program pre-launch testing shall also include launch vehicle interface test verification, mating with the launch vehicle, and spacecraft processing typically performed at the launch site.

c. Spacecraft compatibility with the TT&C ground stations shall be demonstrated by an end-to-end test involving the spacecraft and all elements used to support the spacecraft during launch and ascent.

d. Mission simulations, using the TDRS K Program spacecraft emulator and all necessary SN, and ascent mode network elements shall be performed to validate nominal and contingency operating procedures and provide for operator training.

APPENDIX A – ABBREVIATIONS AND ACRONYMS

ADPE	Automatic Data Processing Equipment
AM	Amplitude Modulation
C	Centigrade
CDCN	Control and Display Computer Network
COMSEC	Communications Security
CPT(s)	Comprehensive Performance Test(s)
CTFS	Common Time and Frequency System
DAS	Demand Access System
dB	Decibels
Deg	Degrees
DIS	Data Interface System
EELV	Evolved Expendable Launch Vehicle
EMC	Electromagnetic Capability
EMI	Electromagnetic Interference
EXEC	Executive Automatic Data Processing Equipment
ESD	Electrostatic Discharge
FOV	Field of View
GEVS	General Environmental Verification Standard
GSTDN	Ground Space-Flight Tracking and Data Network
GT	Ground Terminal
Hz	Hertz
ICD(s)	Interface Control Document(s)
LAN	Local Area Network
LPT	Limited Performance Testing
MA	Multiple Access
MTG	Maintenance Test Group
PM	Phase Modulation
RCTS	Real-Time Command and Telemetry System
RF	Radio Frequency
RFI	Radio Frequency Interference
RMA	Reliability/Maintainability/Availability
SA	Single Access
SAC(s)	Single Access Electronics Compartment(s)
SGL	Space-Ground Link
SGLT	Space-Ground Link Terminal
SMTF	Software Maintenance and Training Facility
S-TT&C	S-Band Tracking, Telemetry, and Command
TBP	To Be Proposed
TDRS	Tracking and Data Relay Satellite
TOCC	TDRS Operations Control Center
TSE	TDRS Spacecraft Emulator
TT&C	Tracking, Telemetry, and Command
USS	User Service System

WSC	White Sands Complex

APPENDIX B: DEFINITIONS AND GLOSSARY

Acceptance Tests: The process that demonstrates that TDRS hardware is acceptable for spaceflight. It also serves as a quality control screen to detect deficiencies and normally to provide the basis for delivery of an item under terms of a contract (see Qualification Tests).

Component: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are transmitter, gyro package, actuator, motor, and battery.

Critical Component: A component whose function and performance are mandatory for mission success. (e.g. a single sting apogee motor with out any form of back-up)

Non-critical component: A component whose function and performance are not mandatory for mission success. (e.g. a temperature sensor)

Configuration: The functional and physical characteristics of parts, assemblies, equipment or systems, or any combination of these which are capable of fulfilling the fit, form, and functional requirements defined by performance specifications and engineering drawings.

Electromagnetic Interference: Electromagnetic energy which interrupts, obstructs, or otherwise degrades or limits the effective performance of the TDRS systems.

Electromagnetic Susceptibility: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

End-to-End Tests: Tests performed on the integrated ground and flight system to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

Failure: See Nonconformance.

Faraday Cage: The Faraday Cage is a conductive grounded enclosure designed to attenuate RF fields resulting from normal spacecraft operation and electrostatic discharges that might occur on external services of the spacecraft.

Fracture Control Program: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is the fracture control analysis, which includes the concepts of fail safe and safe life, defined as follows;

a. Fail-safe: Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

b. Safe-life: Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

Hardware: As used in this document, there are two major categories of hardware as follows:

Flight Hardware: Hardware to be used operationally in space. It includes the following subsets:

a. Proto-flight Hardware: Flight hardware of a new design; it is subject to a test program that combines elements of prototype and flight acceptance verification.

b. Follow-On Hardware: Flight hardware built in accordance with a design that has been qualified either as prototype or as proto-flight hardware; follow-on hardware is subject to a flight acceptance test program.

c. Spare Hardware: Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

d. Re-flight Hardware: Flight hardware that has been used operationally in space and is to be reused in the same way; the verification program to which it is subject depends on its past performance, current status, and the upcoming mission.

Level of Assembly: The environmental test requirements of generally start at the component or unit level assembly and continue hardware/software build through the system level (referred to in GEVS as the payload or spacecraft level). The assurance program includes the part level. Verification testing may also include testing at the assembly and subassembly levels of assembly; for test record keeping these levels are combined into a "subassembly" level. The verification program continues through launch, and on-orbit performance. The following levels of assembly are used for describing test and analysis configurations:

a. Assembly: A functional subdivision consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples are a power amplifier and gyroscope.

b. Component: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are electronic box, transmitter, gyro package, actuator, motor, battery. For the purposes of this document, "component" and "unit" are used interchangeably.

c. Module: A major subdivision of the payload that is viewed as a physical and functional entity for the purposes of analysis, manufacturing, testing, and recordkeeping. Examples include spacecraft bus, RF communication package, and launch vehicle.

d. Part: A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.

e. Payload: Those portions of the TDRS K Program spacecraft that receive, process, frequency convert, amplify, filter and retransmit radio signals to provide telecommunications services to users.

f. Subsystem: A functional subdivision of a payload consisting of two or more components. Examples are attitude control, electrical power subsystems, and RF communication package.

Link: Communications path from transmitter to receiver.

Margin: Margin is the difference between allocated value of the quantity (e.g., mass, power, etc.) and the estimated or measured value of a quantity. Margin is usually given in percent, where the numerator is the difference and the denominator is the allocated value of that quantity.

Mission: As related to a system, refers to the prime intended functions or capabilities. As related to the system specifications, refers to the specified performance characteristics of the system.

Module: See levels of assembly

Nonconformance: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformance falls into two categories--discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

Outgassing: The spontaneous evolution of gas or vapor from a material, and evolution of the decomposition products, in a vacuum.

Part: See Level of Assembly

Performance Verification: Determination by test, analysis, inspection, demonstration or a combination of these that a requirement is satisfied, and the particular item has been accepted as true to the design and ready for flight operations.

Qualification: The process of demonstrating that a given design and manufacturing approach will produce hardware that will meet all performance specifications when subjected to defined conditions more severe than those expected to occur during its intended use.

Redundancy: The use of more than one independent means of accomplishing a given function.

Reliability: The probability that a system, subsystem, component, or part will perform its intended function (1) for a specified period of time and (2) under stated conditions.

"Ring-Around": A spacecraft configuration in which the spacecraft transmits and receives in the same frequency band simultaneously, thereby creating self-jamming.

Safe-Hold Mode: A non-service providing contingency mode of TDRSS operations in which the satellite autonomously configures and maintains itself in safe thermal and power conditions for an extended period.

Sensor: An electrical, electromechanical, or optical device or instrument for measuring spacecraft attitude and/or motion. Examples are sun sensors, earth sensors, gyroscopes, and magnetometers.

Single Point Failure: A single element of a satellite design, the failure of which would result in loss of mission objectives.

Spacecraft: The TDRS satellite which includes the spacecraft bus and RF communication package.

Spacecraft Bus: Those portions of a spacecraft that provide the common services used by the RF communication package and that maintain the health and safety of the spacecraft.

Spacecraft Bus Subsystem: A portion of a spacecraft bus that performs a specific function. The major subsystems of the spacecraft bus are: structure, propulsion and reaction control, attitude control and pointing, command and data handling, thermal, and power.

Subsystem: See Level of Assembly

Temperature Cycle: A transition from some initial temperature condition to a temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

Temperature Stabilization: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

Thermal Balance Test: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal Vacuum Test: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperature based on those expected for the mission. The test, including gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

TDRS: The tracking and data relay satellites included in the TDRSS baseline architecture (F1 through F10)).

TDRS K Program spacecraft: The tracking and data relay satellites specified in this document.

Useful Life: The sum of the required on-ground storage life, the on-orbit operating life, and the on-orbit storage life of the TDRS K Program spacecraft.

Verification: See Performance Verification.

Vibroacoustics: Tests performed during the environmental test program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted components, etc.

/("slash"). (1) Indicates two or more entities being considered as one or as partners in a larger entity (e.g., the intrasite/intersite communications system), (2) indicates the partners of an interface (e.g., the ground terminal/GCF interface), and (3) indicates a ratio (e.g., G/T gain-to-noise temperature ratio, 3 km/sec).