

## 4 CHAPTER 4





## CONTENTS

Glossary of Abbreviations, Acronyms, and Definitions .....	4-ix
Referenced Documents .....	4-xiii
<b>4.1 INTRODUCTION .....</b>	<b>4-1</b>
4.1.1 Purpose of the Chapter .....	4-1
4.1.2 Applicability .....	4-1
<b>4.2 RESPONSIBILITIES AND AUTHORITIES .....</b>	<b>4-1</b>
4.2.1 Commanders, 45th Space Wing and 30th Space Wing .....	4-1
4.2.2 Offices of the Chiefs of Safety, 45th Space Wing and 30th Space Wing .....	4-2
4.2.3 Flight Analysis, 45th Space Wing and 30th Space Wing .....	4-2
4.2.4 Systems Safety, 45th Space Wing and Flight Termination System Safety, 30th Space Wing .....	4-2
4.2.5 Range Users .....	4-2
<b>4.3 AIRBORNE RANGE SAFETY SYSTEM POLICY .....</b>	<b>4-2</b>
4.3.1 Airborne Range Safety System Design .....	4-2
4.3.2 Technical Interchange Meetings .....	4-2
4.3.3 Noncompliance Requests .....	4-3
4.3.4 Tailoring .....	4-3
<b>4.4 DOCUMENTATION REQUIREMENTS .....</b>	<b>4-3</b>
4.4.1 Range Safety System .....	4-3
4.4.2 RSS Development, Qualification, Acceptance, Age Surveillance, Reuse, and Other Test Plans, Test Procedures, and Test Reports .....	4-3
4.4.3 RSS Installation and Checkout Procedures .....	4-3
4.4.4 RSS Prelaunch Test Results .....	4-4
4.4.4.1 FTS Prelaunch Test Results .....	4-4
4.4.4.2 RTS Prelaunch Test Results .....	4-4
4.4.5 RSS Component Test History .....	4-4
4.4.6 RSS Ground Support and Monitoring Equipment Calibration Program .....	4-4
4.4.7 RSS Component and System Test Failure Reports .....	4-5
4.4.7.1 Reporting Component Failure to Meet Specifications .....	4-5
4.4.7.2 Reporting Component Failure to Meet System Test Requirements .....	4-5
4.4.7.3 Reporting In-Flight Anomalies .....	4-5
4.4.8 Modifications to RSS Components and Systems .....	4-5
4.4.9 Antenna Patterns .....	4-5
4.4.10 Telemetry Measurement List .....	4-5
<b>4.5 FLIGHT TERMINATION SYSTEM GENERAL REQUIREMENTS .....</b>	<b>4-5</b>
4.5.1 Flight Termination System Description .....	4-5
4.5.1.1 Command Destruct System .....	4-6
4.5.1.2 Automatic Destruct System .....	4-6
4.5.2 FTS Standard Configuration .....	4-6
4.5.3 FTS Configuration for Orbital Inserted Stages and Payloads .....	4-6
4.5.4 FTS Requirements for Propulsion Systems Other Than a Stage of the Vehicle .....	4-6
4.5.5 FTS Requirements for Manned Vehicles .....	4-6
<b>4.6 FLIGHT TERMINATION ACTION REQUIREMENTS .....</b>	<b>4-7</b>
4.6.1 Liquid Propellant Vehicles .....	4-7
4.6.2 Solid Propellant Vehicles .....	4-7
4.6.3 Combination Liquid and Solid Propellant Vehicles .....	4-7
4.6.4 Solid Propellant Thrust Augmenting Rockets .....	4-7
4.6.5 Auxiliary Propulsion Systems .....	4-7
<b>4.7 FLIGHT TERMINATION SYSTEM DESIGN REQUIREMENTS .....</b>	<b>4-7</b>
4.7.1 FTS General Design Requirements .....	4-7
4.7.1.1 FTS Component Redundancy .....	4-7
4.7.1.2 FTS Design Simplicity .....	4-8
4.7.1.3 FTS Component Isolation .....	4-8
4.7.1.4 FTS Fratricide .....	4-8
4.7.1.5 FTS Software and Firmware .....	4-8
4.7.1.6 FTS Failure Mode, Effects, and Criticality Analysis .....	4-8
4.7.1.7 FTS Laser Systems .....	4-8
4.7.1.8 FTS Component Maximum Predicted Environment .....	4-8

## CONTENTS

4.7.2 FTS Environmental Design Margin .....	4-8
4.7.2.1 FTS Environmental Design Margin General Requirements.....	4-8
4.7.2.2 FTS Component Thermal Environment.....	4-9
4.7.2.3 FTS Component Random Vibration Environment.....	4-9
4.7.2.4 FTS Component Acoustic Noise Environment.....	4-9
4.7.2.5 FTS Component Shock Environment.....	4-9
4.7.2.6 FTS Component Acceleration Environment .....	4-9
4.7.2.7 Other FTS Component Environments .....	4-9
4.7.3 FTS Reliability.....	4-9
4.7.3.1 FTS Reliability Goal .....	4-9
4.7.3.2 FTS Single Point Failure.....	4-10
4.7.4 FTS Design Life.....	4-10
4.7.4.1 FTS Electrical Component Design Life.....	4-10
4.7.4.2 FTS Ordnance Component Design Life.....	4-10
4.7.5 FTS Arming Device Design.....	4-10
4.7.5.1 FTS Arming Device Design for Surface Launched Vehicles.....	4-10
4.7.5.2 FTS Arming Device Design for Air or Sea Launched Vehicles .....	4-10
4.7.6 FTS Prelaunch and In-Flight Safing Design .....	4-10
4.7.6.1 Prelaunch FTS Safing Design.....	4-10
4.7.6.2 In-Flight FTS Safing Design.....	4-10
4.7.7 FTS Electrical and Electronic Systems Design.....	4-11
4.7.7.1 FTS Piece/Part Selection Criteria.....	4-11
4.7.7.2 FTS Voltage and Current Parameters.....	4-11
4.7.7.3 FTS Transient Voltage Generation.....	4-11
4.7.7.4 FTS Voltage Protection .....	4-11
4.7.7.5 FTS Series Redundant Circuits.....	4-11
4.7.7.6 FTS Switch and Relay Selection Criteria.....	4-11
4.7.7.7 FTS Continuity and Isolation .....	4-11
4.7.7.8 FTS Circuit Isolation.....	4-11
4.7.7.9 FTS Circuit Shielding.....	4-12
4.7.7.10 FTS Circuit Protection .....	4-12
4.7.7.11 FTS Repetitive Function .....	4-12
4.7.7.12 FTS Sneak Circuits .....	4-12
4.7.7.13 FTS Watchdog Circuits .....	4-12
4.7.7.14 FTS Testability .....	4-12
4.7.7.15 FTS Self-Test Capability.....	4-12
4.7.7.16 FTS Interference Protection .....	4-12
4.7.8 FTS Low Voltage EED System Circuitry Design.....	4-12
4.7.9 FTS High Voltage EBW System Circuitry Design .....	4-13
4.7.10 FTS Laser Initiated Ordnance System Circuitry Design .....	4-13
4.7.10.1 Optic Systems.....	4-13
4.7.10.2 LIOS Power Sources .....	4-13
4.7.10.3 LIOS Safety Devices .....	4-13
4.7.10.4 LIOS Firing Circuits.....	4-13
4.7.10.5 LIOS Laser Emission Path Enclosures .....	4-14
4.7.10.6 LID Design Reliability .....	4-14
4.7.11 FTS Ordnance Train Design .....	4-14
4.7.11.1 FTS Ordnance Train General Design.....	4-14
4.7.11.2 FTS Ordnance System Initiating Device Installation.....	4-15
4.7.11.3 FTS Ordnance Interface .....	4-15
4.7.11.4 FTS Ordnance Hazard Classification and Compatibility .....	4-15
4.7.12 FTS Monitor, Checkout, and Control Circuit Design .....	4-16
4.7.12.1 FTS Monitor, Checkout, and Control Circuit General Design .....	4-16
4.7.12.2 FTS Monitor and Checkout Circuits .....	4-16
4.7.12.3 FTS Control Circuits.....	4-16
4.8 FTS COMPONENT DESIGN REQUIREMENTS.....	4-16
4.8.1 FTS Antenna System Design.....	4-16
4.8.1.1 FTS Antenna System Radio Command Coverage.....	4-16
4.8.1.2 FTS Antenna System Components.....	4-16
4.8.1.3 FTS Antenna System Compatibility .....	4-17

## CONTENTS

4.8.2 FTS Standard Command Receiver and Decoder Design .....	4-17
4.8.2.1 FTS Standard CRD General Design Requirements .....	4-17
4.8.2.2 Standard Receiver .....	4-17
4.8.2.3 Standard Decoders .....	4-19
4.8.3 FTS Secure Command Receiver and Decoder Design .....	4-20
4.8.3.1 Secure CRD Policy .....	4-20
4.8.3.2 Secure Receiver .....	4-20
4.8.3.3 Secure Decoder .....	4-20
4.8.4 FTS Wiring Design .....	4-21
4.8.5 FTS Fiber Optic Cable Design .....	4-22
4.8.6 FTS Electrical and Optical Connector Design .....	4-22
4.8.6.1 FTS Electrical Connectors .....	4-22
4.8.6.2 FTS Optical Connectors .....	4-23
4.8.7 FTS Battery Design .....	4-23
4.8.7.1 FTS Battery Design Life .....	4-23
4.8.7.2 FTS Battery Electrical Characteristics .....	4-24
4.8.7.3 FTS Battery Electrical Protection .....	4-24
4.8.7.4 FTS Battery Monitoring Capability .....	4-24
4.8.7.5 FTS Battery Pressure Relief .....	4-24
4.8.7.6 FTS Battery Accessibility .....	4-24
4.8.7.7 FTS Secondary Batteries .....	4-25
4.8.7.8 FTS Battery Initiators .....	4-25
4.8.7.9 Battery Identification .....	4-25
4.8.7.10 FTS Silver Zinc Cell and Battery Unique Requirements .....	4-25
4.8.7.11 FTS Nickel Cadmium Cell and Battery Unique Requirements (Reserved) .....	4-25
4.8.8 FTS Arming Device Design .....	4-25
4.8.8.1 FTS Arming Device General Design Requirements .....	4-25
4.8.8.2 FTS Electromechanical S&A Design .....	4-26
4.8.8.3 FTS High Voltage Exploding Bridgewire Firing Units Design .....	4-28
4.8.8.4 Laser Firing Unit, Optical Barrier, Optical S&A, and Ordnance S&A Design .....	4-28
4.8.8.5 FTS Arming and Safing Plugs Design .....	4-32
4.8.9 FTS Ordnance Components Design .....	4-32
4.8.9.1 FTS EEDs .....	4-32
4.8.9.2 FTS EBWs .....	4-33
4.8.9.3 FTS LIDs .....	4-34
4.8.9.4 FTS Percussion Activated Devices .....	4-35
4.8.9.5 FTS Explosive Transfer System .....	4-35
4.8.9.6 FTS Destruct Charge .....	4-36
4.8.10 FTS Shock and Vibrational Mounted Isolation Systems Design .....	4-37
4.8.11 Miscellaneous FTS Components Design .....	4-37
4.8.12 FTS Component Identification .....	4-37
4.9 RANGE TRACKING SYSTEM GENERAL REQUIREMENTS .....	4-37
4.9.1 Range Tracking System Ground Rules .....	4-37
4.9.2 Transponder System .....	4-37
4.9.3 GPS .....	4-37
4.10 RTS DESIGN REQUIREMENTS .....	4-38
4.10.1 RTS General Design Requirements .....	4-38
4.10.1.1 RTS Design Simplicity .....	4-38
4.10.1.2 RTS Software and Firmware .....	4-38
4.10.1.3 RTS Failure Modes, Effects, and Criticality Analysis .....	4-38
4.10.1.4 RTS Component Maximum Predicted Environment .....	4-38
4.10.2 RTS Environmental Design Margin .....	4-38
4.10.2.1 RTS Environmental Design Margin General Requirements .....	4-38
4.10.2.2 RTS Component Thermal Environment .....	4-38
4.10.2.3 RTS Component Random Vibration Environment .....	4-38
4.10.2.4 RTS Component Acoustic Noise Environment .....	4-39
4.10.2.5 RTS Component Shock Environment .....	4-39
4.10.2.6 RTS Component Acceleration Environment .....	4-39
4.10.2.7 Other RTS Component Environments .....	4-39

## CONTENTS

4.10.3 RTS Reliability.....	4-39
4.10.4 RTS Design Life .....	4-39
4.10.5 RTS Electrical and Electronics Systems Design.....	4-39
4.10.5.1 RTS Piece/Part Selection Criteria .....	4-39
4.10.5.2 RTS Voltage and Current Parameters.....	4-39
4.10.5.3 Transient Voltage Generation .....	4-40
4.10.5.4 RTS Voltage Protection .....	4-40
4.10.5.5 RTS Switch and Relay Selection Criteria .....	4-40
4.10.5.6 RTS Continuity and Isolation .....	4-40
4.10.5.7 RTS Circuit Isolation .....	4-40
4.10.5.8 RTS Repetitive Functions .....	4-40
4.10.5.9 RTS Watchdog Circuits .....	4-40
4.10.5.10 RTS Testability.....	4-40
4.10.5.11 RTS Self-Test Capability .....	4-40
4.10.5.12 Interference Protection.....	4-40
4.10.5.13 Output Response Time.....	4-40
4.11 RTS COMPONENT DESIGN REQUIREMENTS.....	4-40
4.11.1 RTS Transponder .....	4-40
4.11.1.1 Transponder Antenna System .....	4-40
4.11.1.2 Transponder.....	4-41
4.11.2 Global Positioning System.....	4-44
4.11.2.1 GPS Antenna System.....	4-44
4.11.2.2 GPS System .....	4-45
4.11.3 RTS Wiring Design.....	4-46
4.11.4 RTS Electrical Connector Design.....	4-47
4.11.4.1 RTS Electrical Connector General Design Requirements .....	4-47
4.11.4.2 RTS Electrical Connector Pins.....	4-47
4.11.4.3 RTS Connector Capacity .....	4-47
4.11.5 RTS Battery Design.....	4-47
4.11.5.1 RTS Battery Independence .....	4-47
4.11.5.2 RTS Battery Design Life .....	4-47
4.11.5.3 RTS Battery Electrical Characteristics .....	4-47
4.11.5.4 RTS Battery Electrical Protection.....	4-47
4.11.5.5 RTS Battery Monitoring Capability .....	4-48
4.11.5.6 RTS Battery Pressure Relief .....	4-48
4.11.5.7 RTS Battery Accessibility.....	4-48
4.11.5.8 RTS Secondary Batteries .....	4-48
4.11.5.9 RTS Battery Initiators .....	4-48
4.11.5.10 RTS Battery Identification .....	4-48
4.11.5.11 RTS Silver Zinc Cell and Battery Unique Requirements.....	4-48
4.11.5.12 RTS NiCad Cell and Battery Unique Requirements (Reserved) .....	4-49
4.12 TELEMETRY DATA TRANSMITTING SYSTEM DESIGN REQUIREMENTS .....	4-49
4.12.1 Telemetry Data Transmitting System General Description .....	4-49
4.12.2 TDTS General Design Requirements .....	4-49
4.12.3 TDTS Component Maximum Predicted Environment.....	4-49
4.12.4 TDTS Environmental Design Margin.....	4-49
4.12.4.1 TDTS General Environmental Design Margin.....	4-49
4.12.4.2 TDTS Component Thermal Environment .....	4-49
4.12.4.3 TDTS Component Random Vibration Environment .....	4-49
4.12.4.4 TDTS Component Acoustic Noise Environment .....	4-50
4.12.4.5 TDTS Component Shock Environment .....	4-50
4.12.4.6 TDTS Component Acceleration Environment .....	4-50
4.12.4.7 Other TDTS Component Environments.....	4-50
4.12.4.8 TDTS RF Link Analysis .....	4-50
4.12.5 TDTS In-Flight RSS Telemetry Data .....	4-50
4.13 RSS GROUND SUPPORT AND MONITORING EQUIPMENT DESIGN REQUIREMENTS.....	4-51
4.13.1 RSS Ground Support and Monitoring Equipment General Design Requirements .....	4-51
4.13.2 Destruct Initiator Simulator .....	4-51
4.13.2.1 Destruct Initiator Simulator Description.....	4-51

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## CONTENTS

4.13.2.2 Destruct Initiator Simulator Design .....	4-51
4.13.3 Laser Test Equipment.....	4-51
4.13.4 ER Operations Safety Console .....	4-51
4.13.4.1 ER Operations Safety Console Description .....	4-51
4.13.4.2 ER OSC Design .....	4-51
4.13.5 WR Safety Console and RSS Repeater System .....	4-52
4.13.5.1 WR Safety Console General Design .....	4-52
4.13.5.2 WR Safety Console FTS Pre-Flight and In-Flight Telemetry Monitors and Controls .....	4-52
4.13.5.3 WR Safety Console RTS Pre-Flight and In-Flight Telemetry Monitors .....	4-53
4.13.5.4 WR Safety Console Communications .....	4-53
4.13.5.5 WR Launch Facility RSS Repeater System.....	4-54
4.13.6 RSS Components Provided by the Range User.....	4-54
4.13.6.1 ER RSS Components Provided by the Range User.....	4-54
4.13.6.2 WR RSS Components Provided by the Range User.....	4-54
4.14 RSS ANALYSES REQUIREMENTS.....	4-54
4.14.1 RSS Analyses .....	4-54
4.14.1.1 RSS Failure Analysis.....	4-54
4.14.1.2 RSS Similarity Analyses.....	4-54
4.14.2 FTS Analyses .....	4-55
4.14.2.1 FTS Reliability Analysis .....	4-55
4.14.2.2 FTS Failure Modes, Effects, and Criticality Analysis.....	4-55
4.14.2.3 FTS Single Failure Point Analysis .....	4-55
4.14.2.4 FTS Battery Analyses .....	4-55
4.14.2.5 FTS Fratricide Analyses .....	4-55
4.14.2.6 FTS RF Link Analysis .....	4-55
4.14.2.7 FTS Antenna Heat Shield Fly-Off Analysis.....	4-55
4.14.2.8 FTS CRD Radiation Analysis.....	4-55
4.14.2.9 FTS Bent Pin Analysis.....	4-55
4.14.2.10 FTS LID Heat Dissipation Analysis .....	4-56
4.14.2.11 FTS Breakup Analysis .....	4-56
4.14.2.12 FTS Tip-Off Analysis .....	4-56
4.14.2.13 ADS Timing Analysis.....	4-56
4.14.2.14 Destruct Initiator Simulator Analysis .....	4-56
4.14.3 RTS Analyses.....	4-56
4.14.3.1 RTS Reliability Analysis.....	4-56
4.14.3.2 RTS Failure Modes, Effects, and Criticality Analysis .....	4-56
4.14.3.3 RTS Battery Analysis.....	4-56
4.14.3.4 RTS RF Link Analysis.....	4-56
4.14.3.5 RTS Antenna Analyses.....	4-56
4.14.3.6 RTS Antenna Heat Shield Fly-Off Analysis .....	4-57
4.14.4 TDTS Analyses .....	4-57
4.14.4.1 TDTS RF Link Analysis .....	4-57
4.14.4.2 TDTS Antenna Heat Shield Fly-Off Analysis .....	4-57

## CONTENTS

4.15 RSS TEST REQUIREMENTS .....	4-57
4.15.1 RSS General Test Requirements .....	4-57
4.15.1.1 Development Tests.....	4-57
4.15.1.2 Qualification Tests.....	4-57
4.15.1.3 Acceptance Tests .....	4-57
4.15.1.4 Age Surveillance Tests .....	4-58
4.15.1.5 Range Prelaunch Tests .....	4-58
4.15.1.6 Requalification or Delta Qualification Tests.....	4-58
4.15.1.7 Reuse Tests .....	4-58
4.15.1.8 Other Tests .....	4-58
4.15.2 FTS Component Tests.....	4-58
4.15.2.1 FTS Antenna System Qualification and Acceptance Tests .....	4-58
4.15.2.2 FTS CRD Qualification and Acceptance Tests .....	4-58
4.15.2.3 FTS Battery Qualification, Storage Life Verification, and Acceptance Tests .....	4-58
4.15.2.4 FTS Electromechanical S&A Device, EED and Rotor Lead Qualification, Acceptance, and Age Surveillance Tests .....	4-59
4.15.2.5 FTS EBW-FU Qualification and Acceptance Tests .....	4-59
4.15.2.6 FTS EBW Qualification, Acceptance, and Age Surveillance Tests .....	4-59
4.15.2.7 FTS Laser Firing Unit, Optical S&A, and Ordnance S&A Qualification and Acceptance Tests.....	4-59
4.15.2.8 FTS Laser Fiber Optic Cable Assembly Qualification and Acceptance Tests .....	4-59
4.15.2.9 FTS LID Qualification, Acceptance, and Age Surveillance Tests .....	4-59
4.15.2.10 FTS Percussion Activated Devices.....	4-59
4.15.2.11 FTS Explosive Transfer Component Qualification, Acceptance, and Age Surveillance Tests.....	4-59
4.15.2.12 FTS Destruct Charge Qualification, Acceptance, and Age Surveillance Tests .....	4-59
4.15.2.13 FTS Ordnance Subsystem Tests .....	4-59
4.15.2.14 FTS Shock and Vibrational Mounted Isolation Systems Qualification and Acceptance Tests .....	4-60
4.15.2.15 Miscellaneous FTS Component Qualification and Acceptance Tests .....	4-60
4.15.3 RTS Component Tests .....	4-60
4.15.3.1 RTS Antenna System Qualification and Acceptance Tests.....	4-60
4.15.3.2 RTS Transponder Qualification and Acceptance Tests.....	4-60
4.15.3.3 GPS Qualification and Acceptance Tests.....	4-60
4.15.3.4 RTS Battery Qualification, Storage Life Verification, and Acceptance Tests.....	4-60
4.15.4 TDTS Component Test Requirements.....	4-61
4.15.5 RSS Range Prelaunch Tests .....	4-61
4.15.5.1 RSS Range Prelaunch Tests General Requirements.....	4-61
4.15.5.2 FTS Range Prelaunch Component Tests .....	4-61
4.15.5.3 FTS Range Prelaunch System and Subsystem Tests.....	4-62
4.15.5.4 RTS Range Prelaunch Component Tests.....	4-65
4.15.5.5 RTS Range Prelaunch System and Subsystem Tests .....	4-65
APPENDIX 4A: RANGE SAFETY SYSTEM REPORT REQUIREMENTS .....	4-67
APPENDIX 4B1: RSS COMPONENT COMMON TEST REQUIREMENTS.....	4-77
APPENDIX 4B2: ANTENNA SYSTEM TEST REQUIREMENTS.....	4-92
APPENDIX 4B3: COMMAND RECEIVER/DECODER TEST REQUIREMENTS.....	4-95
APPENDIX 4B4: BATTERY TEST REQUIREMENTS .....	4-107
APPENDIX 4B5: MISCELLANEOUS COMPONENT TEST REQUIREMENTS.....	4-117
APPENDIX 4B6: S&A AND EED TEST REQUIREMENTS .....	4-119
APPENDIX 4B7: EBW FIRING UNIT AND EBW TEST REQUIREMENTS .....	4-136
APPENDIX 4B8: LASER INITIATED ORDNANCE TEST REQUIREMENTS.....	4-147
APPENDIX 4B9: ETS AND DESTRUCT CHARGE TEST REQUIREMENTS .....	4-164
APPENDIX 4B10: PERCUSSION ACTIVATED DEVICE TEST REQUIREMENTS.....	4-167
APPENDIX 4B11: SHOCK AND VIBRATION ISOLATOR TEST REQUIREMENTS.....	4-172
APPENDIX 4B12: TRANSPONDER TEST REQUIREMENTS.....	4-173
APPENDIX 4B13: GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS.....	4-183
APPENDIX 4B14: TELEMETRY DATA TRANSMITTER TEST REQUIREMENTS .....	4-192

## GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

**30 SW/SESX** - 30th Space Wing, Flight Termination Systems Safety

**45 and 30 SW** - 45th and 30th Space Wings

**45 and 30 SW/SE** - 45th and 30th Space Wings, Offices of the Chief of Safety

**45 and 30 SW/SES** - 45th and 30th Space Wings, Systems Safety Sections

**30 SW/SEY** - 30th Space Wing, Flight Safety Analysis Sections

**45 SW/SEOE** - 45th Space Wing ELV Operations Support and Analysis

**45 SW/SEOS** - 45th Space Wing STS Operations Support and Analysis

**AC** - alternating current

**ADS** - Automatic Destruct System

**AFR** - Air Force Regulation

**AFSC/AFLC** - Air Force Systems Command/ Air Force Logistics Command; now called Air Material Command

**AGC** - automatic gain control

**AM** - amplitude modulation

**AMC** - Air Material Command

**ANSI** - American National Standards Institute

**antenna** - a device capable of radiating or receiving radio-frequency electromagnetic energy

**ATP** - acceptance test procedure

**battery capacity** - (1) rated capacity: the capacity assigned by the battery manufacturer based on a set of specific conditions such as discharge temperature, discharge current, end of discharge voltage, and state of charge at start of discharge; (2) measured capacity: the capacity determined by the specific qualification tests, including any time the battery is under load during qualification; the end of discharge voltage is the minimum voltage that Flight Termination System components have been qualified to.

**C/A Code** - Coarse Acquisition Code

**cc** - cubic centimeter

**cDR** - conceptual design review

**CDR** - critical design review; Command Destruct Receiver

**CE** - conducted emission

**C/N<sub>0</sub>** - Received carrier/noise density ratio

**CRD** - Command Receiver/Decoder

**CS** - conducted susceptibility

**CW** - continuous wave

**crystal salts** - the formation of salt oxidation by the cathode/electrolyte process in batteries; the resulting salt can inhibit the electrochemical process, be a corrosive to the metal plates, and affect the salt solubility that, in turn, affects the passivation film.

**dB** - decibel, a unit of relative power. The decibel ratio between two powers levels, P1 and P2 is defined by the relation  $dB=10\log(P1/P2)$

**dBA** - decibels referenced to the "A" scale

**dBm** - decibels relative of one milliwatt

**DC** - direct current

**DDP-70** - a double-base composite propellant

**deviation** - a term used when a design noncompliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to beginning operations at Cape Canaveral Air Station or Vandenberg Air Force Base

**DGT** - Digital Translator

**DoD** - Department of Defense

**EBW** - high voltage exploding bridgewire, an initiator in which the bridgewire is designed to be exploded (disintegrated) by a high energy electrical discharge that causes the explosive charge to be initiated

**EBW-FU** - high voltage exploding bridgewire firing unit

**EED** - low voltage electroexplosive device

**EFP** - explosively formed projectile

**ELV** - expendable launch vehicle

## GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

**EMC** - electromagnetic compatibility

**EMI** - electromagnetic interference

**ER** - Eastern Range

**ERR** - Eastern Range Regulation

**ETL** - Explosive Transfer Line

**ETS** - Explosive Transfer System

**explosives** - all ammunition, demolition material, solid rocket motors, liquid propellants, pyrotechnics, and ordnance as defined in AFM 91-201 and DoD 6055.9-STD.

**FCDC** - flexible confined detonation cord

**Fire<sup>+</sup>** - command to initiate destruct energy to EBW used in a typical high voltage firing unit

**Fire<sup>0</sup>** - command to remove inhibit used in a typical high voltage firing unit

**FMECA** - Failure Modes, Effects, and Criticality Analysis

**fn** - isolator resonant frequency

**FOC** - fiber optic cable

**FOCA** - fiber optic cable assembly

**FSPO** - Flight Safety Project Officer, Western Range

**ft** - foot, feet

**FTS** - Flight Termination System; includes the Radio Controlled Command Destruct System, the Automatic Destruct System, and associated subsystems

**FU** - firing unit

**G** - gravity

**GDOP** - Geometrical Dilution of Precision

**GHz** - gigahertz

**GPS** - Global Positioning System

**GSE** - ground support equipment

**h** - hour, hours

**Hg** - Mercury

**HMX** - cyclotetramethylenetetranitramine

**HNS** - 2,2,4,4,6,6 hexanitrostilbene

**Hz** - Hertz

**IEEE** - Institute of Electrical and Electronics Engineers

**IIP** - Instantaneous Impact Point

**IF** - intermediate frequency

**IV&V** - independent verification and validation

**kHz** - kilohertz

**kV** - kilovolt

**launch vehicle** - a vehicle that carries and/or delivers a payload to a desired location; this is a generic term that applies to all vehicles that may be launched from the Eastern and Western Ranges, includes but not limited to airplanes; all types of space launch vehicles, manned launch vehicles, missiles and rockets and their stages; probes; aerostats and balloons; drones; remotely piloted vehicles; projectiles, torpedoes and air-dropped bodies

**LFU** - laser firing unit

**LID** - laser initiated device

**LIOS** - laser initiated ordnance system

**liquid electrolyte** - an electrolyte that stays in liquid form throughout an electrical reaction

**LPF** - low pass filter

**LSC** - linear shaped charges

**MDC** - mild detonating cord

**MDF** - mild detonating fuse

**Meets Intent Certification** - A certification used to indicate an equivalent level of safety is maintained despite not meeting the exact requirements stated in this document

**MFCO** - Mission Flight Control Officer

**MHz** - megahertz

**MIC** - meets intent certification

**MIL-STD** - military standard

**min** - minute, minutes

**mismatching** - the improper installation and/or connection of connectors

**MPE** - maximum predicted environment

**NASA** - National Aeronautics and Space Administration

## GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

**NFPA** - National Fire Protection Association

**NIST** - National Institute of Standards and Testing

**NSA** - National Security Agency

**NSI** - NASA Standard Initiator

**NTISS** - National Telecommunications and Information Systems Security

**OCV** - open circuit voltage

**operating life** - the period of time in which prime power is applied to electrical and/or electronic components without maintenance or rework

**optical coverage ratio** - the percentage of the surface area of the cable core insulation covered by a shield

**OSC** - Operations Safety Console

**OSHA** - Occupational Safety and Health Act

**P-Code** - Precision Code

**PAD** - percussion activated device

**payload** - the object(s) within a payload fairing carried or delivered by a launch vehicle to a desired location; this is a generic term that applies to all payloads that may be delivered from the ER and WR; includes but is not limited to satellites, other spacecraft, experimental packages, bomb loads, warheads, reentry vehicles, dummy loads, cargo, and any motors attached to them in the payload fairing

**PDOP** - Position Dilution of Precision

**PDR** - Preliminary Design Review

**PETN** - pentaerythritoltetranitrate

**power source** - (1) a battery; (2) the point of direct current (DC) to alternating current (AC) conversion for capacitor charged systems

**pps** - pulses per second

**PRF** - pulse repetition frequency

**Primacord** - explosive detonating cord

**primary battery** - a battery that is not intended to be recharged and that is disposed of in controlled conditions when the battery has delivered all of its electrical energy

**PSD** - Power Spectrum Density

**Q** - resonant amplification factor

**QPSK** - Quadrature Phase Shift Key; also PSK

**RCC** - Range Commanders Council

**RCO** - Range Control Officer

**RDX** - cyclotrimethylenetrinitramine

**RF** - radio frequency

**RFML** - Radio Frequency Measurement Laboratory

**RMS** - root mean square

**RSS** - Range Safety System

**RSSR** - Airborne Range Safety System Report

**RTS** - Range Tracking System; includes the tracking aid and/or GPS and associated subsystems

**S&A** - Safe and Arm Device

**sc** - standard cubic centimeter

**sec** - second, seconds

**secondary battery** - a battery that may be restored after discharge by the passage of electrical current in the opposite direction to that of discharge

**self-test capability** - the capability of a microprocessor to employ a self-test to detect errors and to output the results via telemetry

**separate power source** - a dedicated and independent source of power

**service life** - the period of time between the initial lot acceptance testing and the subsequent age surveillance testing for ordnance

**SFP** - single failure point

**shelf life, battery** - the specified period of time a battery may be stored in a logistical environment and still perform to all specifications when placed in service

**shelf life, explosive** - the period of time between explosive loading and end use

**single point ground** - the one interconnection for a grounded circuit with other circuits

**SNR** - signal-to noise ratio

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## GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

**solid electrolyte** - an electrolyte that is absorbed in a gelatinous or semi-solid composition

**SSTO** - signal strength telemetry output; also known as AGC

**std** - standard

**storage life** - the period of time during which an item can remain in storage without having its operability affected; the operating and storage life clocks start at burn-in or acceptance test

**STS** - space transportation system

**TDTS** - Telemetry Data Transmitting System

**threshold sensitivity** - the minimum RF input signal level at which a CRD meets all performance specifications

**TIM** - Technical Interchange Meeting

**Torr** - 1 millimeter of Mercury pressure

**transponder** - the portion of the airborne Range tracking system that receives and decodes interrogations and generates replies to the interrogations. The transponder permits the ground instrumentation radar to furnish significantly greater precision and accuracy data at much greater distances and prevents mistracking of powered vehicles due to interference of exhaust plumes or spent stages.

**UN** - United Nations

**VAFB** - Vandenberg Air Force Base

**Vac** - Voltage, alternating current

**Vdc** - Voltage, direct current

**VDL** - voice direct line

**vehicle** - launch vehicle and/or payload

**VSWR** - Voltage Standing Wave Ratio

**Vrms** - voltage root mean square

**waiver** - a designation used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production or an operational noncompliance is discovered after operations have begun at Eastern or Western Range

**wet stand time** - (1) the time from activation and initial load pulse to the beginning of qualification operational environmental testing of a liquid electrolyte battery; (2) for the actual use of batteries, the wet stand time is from the time of activation and initial load test to end of use

**WR** - Western Range

**WRR** - Western Range Regulation

**WSMC** - Western Space and Missile Center

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## REFERENCED DOCUMENTS

- 45 SWR 160-1, *Radiation Protection Program*
- AFTO 11A-1-47, *Explosive Hazard Classification Procedure*
- AFSC/AFLC Pamphlet 800-5, *Software Independent Verification and Validation*
- ASTM-E-748, *Standard Practices for Thermal Neutron Radiography of Material*
- DoDI 5000.2 AF Sup 1, *Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information System Acquisition Programs*
- DoD 6055.9-STD, *DoD Ammunition and Explosives Safety Standards*
- ELV-JC-002D, *Parts, Materials, and Processes Control Program for Expendable Launch Vehicles*
- MIL-C-38999J, *General Specification for Connector, Electrical Circular, Miniature, High Density Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts*
- MIL-STD-202, *Test Methods for Electronic and Electrical Component Parts*
- MIL-STD-453, *Inspection, Radiographic*
- MIL-STD-461, *Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility*
- MIL-STD-462, *Measurement of Electromagnetic Interference Characteristics*
- MIL-STD-785, *Reliability Program for System and Equipment Development and Production*
- MIL-STD-810, *Environmental Test Methods and Engineering Guidelines*
- MIL-STD-1543, *Reliability Program Requirements for Space and Missile Systems*
- National Policy Directive, 1988, *National Policy on Application of Communication Security to Command Destruct Systems*
- NAVSEAINST 8020.3/TB 700-2/DLAR 8200.1, *Explosive Hazard Classification Procedure*
- RCC 106, *Telemetry Standards*
- RCC 253, *Missile Antenna Pattern Coordinate System and Data Formats*
- RCC 313, *Flight Termination Receiver/Decoder Design, Test, and Certification Requirements*
- RCC 319, *Flight Termination Systems Commonality Standard*
- VAFBR 161-1, *Control of Ionizing Radiation*



# CHAPTER 4 AIRBORNE RANGE SAFETY SYSTEM DOCUMENTATION, DESIGN, AND TEST REQUIREMENTS

## 4.1 INTRODUCTION

### 4.1.1 Purpose of the Chapter

The purpose of this Chapter is to establish the documentation, design, and test requirements for a Range Safety System (RSS) on vehicles launched from the Eastern Range (ER) and/or Western Range (WR). The following major topics are addressed:

- 4.2 Responsibilities and Authorities
- 4.3 Airborne Range Safety System Policy
- 4.4 Documentation Requirements
- 4.5 Flight Termination System General Requirements
- 4.6 Flight Termination Action Requirements
- 4.7 Flight Termination System Design Requirements
- 4.8 FTS Component Design Requirements
- 4.9 Range Tracking System General Requirements
- 4.10 RTS Design Requirements
- 4.11 RTS Component Design Requirements
- 4.12 Telemetry Data Transmitting System Design Requirements
- 4.13 RSS Ground Support and Monitoring Equipment Design Requirements
- 4.14 RSS Analyses Requirements
- 4.15 RSS Test Requirements

Design requirements for other vehicle and payload systems and their ground support equipment (GSE) are in Chapter 3. When conflicts arise be-

tween this Chapter and other referenced documents, this Chapter takes precedence. Conflicts between referenced documents shall be resolved by Range Safety.

### 4.1.2 Applicability

Unless otherwise noted, the requirements in this Chapter are applicable to the following components that make up the Airborne RSS:

**NOTE:** Unless otherwise noted, RSS in this Chapter is limited to only the Airborne Range Safety System.

- a. Flight Termination System (FTS), including the radio controlled Command Destruct System, the Automatic Destruct System, and associated subsystems
- b. Range Tracking System (RTS), including the tracking aid system and associated subsystems
- c. Telemetry Data Transmitting System (TDTS)

## 4.2 RESPONSIBILITIES AND AUTHORITIES

### 4.2.1 Commanders, 45th Space Wing and 30th Space Wing

The Commanders, 45th Space Wing (45 SW) and 30th Space Wing (30 SW) are responsible for determining the applicability of this document or the Range Commanders Council (RCC) 319 when Range Users intend to launch a vehicle from multiple ranges, including the Eastern Range (ER) and the Western Range (WR).

#### 4.2.2 Offices of the Chiefs of Safety, 45th Space Wing and 30th Space Wing

The 45th Space Wing, Office of the Chief of Safety (45 SW/SE) and the 30th Space Wing, Office of the Chief of Safety (30 SW/SE) are responsible for approving all noncompliances to the requirements of this Chapter.

#### 4.2.3 Flight Analysis, 45th Space Wing and 30th Space Wing

The 45th Space Wing, Flight Operations Support and Analysis Elements (45 SW/SEOE & SEOS) and the 30th Space Wing, Flight Safety Analysis Section (30 SW/SEY) are responsible for determining the need for an RSS, including a command and automatic flight termination system on launch vehicles and payloads in accordance with the requirements in Chapter 2 of this document.

#### 4.2.4 Systems Safety, 45th Space Wing and Flight Termination System Safety, 30th Space Wing

The 45th Space Wing, Systems Safety Section (45 SW/SES) and the 30th Space Wing, Flight Termination Systems Safety Section, (30 SW/SES) are responsible for the following: **NOTE:** Unless otherwise noted, all references to Range Safety in this chapter refer to the System Safety Section or the Flight Termination Safety Section.

*a.* Reviewing and approving the conceptual design, detail design, and test requirements for the RSS

*b.* Resolving problems associated with the design, installation, checkout, and use of the RSS

*c.* Reviewing and recommending action on all noncompliances

*d.* Attending meetings, design reviews, procedures reviews, and monitoring tests conducted on any Range Safety System component or system including installation of such components on launch vehicles. **NOTE:** This participation is essential for safety to fully understand the design and operating characteristics of RSS components and is cost effective for the range user when requesting safety approvals. It simplifies the process and time involved to obtain RSS approvals.

#### 4.2.5 Range Users

Range Users are responsible for the following:

*a.* Meeting the requirements of Chapters 2 and 4 of this document when launching vehicles from the Eastern Range (ER) or Western Range (WR)

*b.* When launching vehicles from multiple ranges, meeting the requirements of this document or the RCC Standard 319-92 as determined by the Range Commanders. **NOTE:** All RCC documents can be obtained from the Range Commands Council Secretariat, ATTN: STEWS-SA-R, White Sands Missile Range, New Mexico 88002-5110, Phone: (505) 678-1107 or DSN 258-1107, FAX: (505) 678-7519 or DSN 258-7519.

*c.* Submitting RSS design and test documentation in a timely manner

*d.* Notifying Range Safety of meetings, design reviews tests including installation of the RSS on the vehicle at least two weeks to allow sufficient time to review documentation, design material and test plans in preparation to provide adequate and meaningful comments and recommendations. It is important to note that RSS approval cannot be granted unless Range Safety is fully cognizant of all aspects of the RSS. **NOTE:** No meetings or tests shall be conducted without Range Safety or a designated representative being in attendance unless otherwise approved by Range Safety.

*e.* Ensuring RSS compatibility with the Range ground support and monitoring equipment. **NOTE:** Ground support and monitoring equipment system characteristics may be obtained from the appropriate Range organization through Range Safety office.

### 4.3 AIRBORNE RANGE SAFETY SYSTEM POLICY

#### 4.3.1 Airborne Range Safety System Design

*a.* It is the policy of the ER and the WR that the design of the RSS be simple, uncomplicated, and safe, and meet the reliability and design requirements as specified in this Chapter.

*b.* Final acceptance of the RSS for each launch depends on the satisfactory completion of all required prelaunch tests and system installation functions. All design, test, data, or procedural discrepancies shall be resolved prior to RSS launch approval.

#### 4.3.2 Technical Interchange Meetings

*a.* Separate and independent RSS concept design reviews, preliminary design reviews, and critical design reviews from the vehicle design review shall be held with Range Safety participation.

*b.* Meeting dates shall be coordinated with Range Safety.

c. Technical interchange meeting supporting data shall be submitted 14 calendar days prior to scheduled meeting.

d. Full details for all interchange meeting can be found in Chapter 1.

### 4.3.3 Noncompliance Requests

a. Potential noncompliances to the requirements of this Chapter shall be identified and presented at the earliest possible time, preferably during the conceptual design review.

b. Deviation, waiver, and Meets Intent Certification (MIC) requests shall be submitted for review and approval separately, and all approved deviations, waivers, and MICs shall be included in the Range Safety System Report as an appendix.

c. Full details for submitting noncompliance requests can be found in Chapter 1 and Appendix 1A.

### 4.3.4 Tailoring

a. The requirements outlined in this Chapter can be tailored for each specific program, considering applicability, design pedigree, design complexity, state of the art technology, cost, and risk.

b. Full details for the tailoring process can be found in Chapter 1 and Appendix 1A.

## 4.4 DOCUMENTATION REQUIREMENTS

### 4.4.1 Range Safety System

Range Safety System Reports (RSSRs) shall be developed by the Range User in accordance with the requirements in Appendix 4A and submitted to Range Safety for review and approval.

a. The RSSR is the medium through which RSS approval is obtained.

b. The RSSR is a detailed description of the Flight Termination System (FTS) system analysis results, design data, reliability data, component design data, ground support systems data, and test data; the Range Tracking System (RTS); and the Telemetry Data Tracking System (TDTS). **NOTE:** All schematics, functional diagrams, and operational manuals shall have well defined, standard Institute of Electrical and Electronics Engineers (IEEE) or MIL-SPEC terminology and symbols.

c. Three copies of initial and updated RSSRs shall be submitted to Range Safety for review 45 calendar days prior to each design review (conceptual, preliminary, and critical). **NOTE:**

Data submittal items such as procedures, component operation, specifications, and manuals that cannot be included in the RSSR because of size or configuration shall be referenced in the applicable sections and submitted as attachments. The RTS and TDTS descriptions shall be included as appendixes.

d. The final RSSR shall be submitted to Range Safety for review and approval no later than four months prior to the first scheduled launch.

e. The formal acceptance of the RSS will only be granted after approval of the final RSSR and its appendixes.

### 4.4.2 RSS Development, Qualification, Acceptance, Age Surveillance, Reuse, and Other Test Plans, Test Procedures, and Test Reports

a. Detailed development, qualification, acceptance, age surveillance, reuse, and other RSS test plans and test procedures shall be developed by the Range User and submitted to Range Safety for review and approval 45 calendar days prior to the need date. **NOTE:** A test procedure may not be required if Range Safety determines that the test plan alone adequately addresses the test parameters during each test sequence.

b. Test plans and test procedures shall be approved by Range Safety prior to testing.

c. Once approved, test plans and procedures shall not be revised. **NOTE:** Revisions to any part of an approved test plan or procedure require that the test plan or procedure be resubmitted to Range Safety for review and approval.

d. Each test report shall be provided to Range Safety for review and approval.

e. A list of all test plans, test procedures, and test reports shall be incorporated as appendixes to the RSSR.

### 4.4.3 RSS Installation and Checkout Procedures

a. Detailed procedures for checkout, calibration, and installation of all components of the RSS and its associated ground checkout equipment, including the launch day countdown procedures, shall be developed by the Range User and submitted to Range Safety for review and approval no later than 45 calendar days prior to the need date. **NOTE:** Previously used procedures may be submitted 30 calendar days prior to the need date.

*b.* Once approved, these procedures shall not be revised. **NOTE:** Revisions to any part of an approved procedure require that the procedure be resubmitted to Range Safety for review and approval.

*c.* A list of all procedures shall be incorporated as an appendix to the RSSR.

**Test** section of this Chapter

#### 4.4.4 RSS Prelaunch Test Results

The following test results for each launch shall be submitted to Range Safety in a timely manner to facilitate a launch ready status:

##### 4.4.4.1 FTS Prelaunch Test Results

*a.* One copy of the following Range prelaunch test results shall be submitted to Range Safety for each receiver/decoder specified by serial number no later than 30 calendar days prior to launch of that receiver/decoder:

1. Results of the vendor acceptance test

2. Results of the bench test required by the **FTS CRD Range Prelaunch Bench Test** section of this Chapter (ER only)

3. Results of the bench test required by the **FTS CRD Range Prelaunch Bench Test** section of this Chapter (WR only)

4. Results of the in-vehicle test required by the **ER CRD Prelaunch Systems Test** section of this Chapter (ER only)

*b.* Results of the antenna system test required by the **FTS Antenna Systems Prelaunch Tests** section of this Chapter

*c.* Results of the battery test required by the **FTS Battery Prelaunch Tests** section of this Chapter shall be submitted as soon as possible but no later than 24 h after completion of the test.

*d.* Any additional data that Range Safety deems necessary shall be submitted on a case-by-case basis.

##### 4.4.4.2 RTS Prelaunch Test Results

*a.* Results of the antenna system test, as required by the **RTS Antenna Systems Prelaunch Tests** section of this Chapter

*b.* Results of the tracking aid vendor acceptance test

*c.* Results of the **RTS Transponder Prelaunch Bench Test** section of this Chapter

*d.* Results of the **RTS GPS Prelaunch Bench Test** sections of this Chapter

*e.* Results of the **RTS GPS Systems Prelaunch**

f. Results of the transponder RF closed loop mode performance test as required by the **RTS Transponder System Level Performance Test** section of this Chapter. **NOTE 1:** Results of this test shall be annotated on WSMC Form 5625. **NOTE 2:** Transponder performance characteristic data from this test is distributed to personnel at the WR tracking radar sites. To permit a timely dissemination of this data, WSMC Form 5625 shall be provided to Range Safety no later than 20 working days prior to the forecast launch date.

g. Results of the battery load and activation test required by the **RTS Battery Prelaunch Tests** section of this Chapter shall be submitted as soon as possible but no later than 24 h after the completion of the test.

#### 4.4.5 RSS Component Test History

a. A test history shall be maintained for each RSS component with the exception of DC cabling.

b. The test history shall be made available to Range Safety upon request.

c. The test history shall include the following information:

1. Component serial number
2. Date of initial manufacture
3. Date of initial acceptance test procedure
4. Date of modification with brief description of the modification
5. Date of any subsequent tests or acceptance test procedures
6. Date of test and/or retest
7. Reason for the retest (failure, exceeded the certification period)
8. For each test, the test procedure shall be referenced and the parts of the test attempted shall be identified.
9. Any tests performed by the Range shall be annotated by the Range on the test history.

#### 4.4.6 RSS Ground Support and Monitoring Equipment Calibration Program

a. A calibration program for ground support test equipment and for equipment in the ER Operations Safety Console and the WR Safety Console shall be developed and submitted to Range Safety for review and approval and included in the RSSR.

b. Data relative to calibration of the FTS ground support systems shall be provided to Range Safety upon request.

#### 4.4.7 RSS Component and System Test

### Failure Reports

Systems or components that fail to meet manufacturer specifications or the limits imposed by this Chapter shall not be approved for flight until corrective action, acceptable to Range Safety, has been made. **NOTE:** The requirement for reporting failure of a component or system to meet the requirements of a specific test applies to the tracking aid. It can be fulfilled by a properly executed WSMC Form 5632.

#### 4.4.7.1 Reporting Component Failure to Meet Specifications

a. The failure of an RSS component or an identical non-RSS component to meet specifications shall be reported verbally to Range Safety within 72 h and in writing within 14 calendar days of the date the failure is noted.

b. This requirement includes failure of tests conducted at the supplier plant, contractor's plant, or at the Range.

c. A formal report containing a description of the failure, an analysis of the failure, and planned corrective actions shall be submitted to Range Safety within 30 calendar days of the failure analysis completion regardless of when or where the failure occurred. **NOTE:** Components whose test data reflect the unit is out-of-family when compared to other units shall be considered as out of specifications.

#### 4.4.7.2 Reporting Component Failure to Meet System Test Requirements

a. The failure of an RSS component to meet system test requirements contained in this Chapter shall be reported verbally to Range Safety within 72 h of the failure.

b. A written report containing a description and analysis of the failure and planned corrective actions planned shall be submitted to Range Safety before the component is approved for flight.

#### 4.4.7.3 Reporting In-Flight Anomalies

a. Any in-flight anomaly occurring in an RSS component or identical non-RSS component shall be reported to Range Safety immediately. **NOTE:** Anomalies include exposing an RSS component to an environment exceeding the maximum predicted environment (MPE).

b. A detailed written report containing a description and analysis of the anomaly and planned cor-

rective actions shall be submitted to Range Safety before the component will be approved for any subsequent flights.

#### 4.4.8 Modifications to RSS Components and Systems

*a.* Modification or change to an approved RSS, RSS associated equipment, components, component identification, test procedures, performance test limits, basic characteristics, and ratings, including any firmware or software used on flight and ground equipment or any changes that may affect the safety and reliability of the RSS shall not be made without prior Range Safety approval.

*b.* If modifications are made without the approval of Range Safety, the approval of the entire system and approval to launch shall be revoked automatically until the change is approved.

*c.* Modification proposals, including the same type of data that would be required for the approval of a new system, shall be submitted to Range Safety for review and approval 60 calendar days prior to implementation and shall be submitted as an amendment to the RSSR.

#### 4.4.9 Antenna Patterns

*a.* One copy of RSS antenna patterns on floppy discs and in graphical representation, developed in accordance with RCC document 253, shall be submitted to the Range.

*b.* The submittal schedule is found in RCC 253.

#### 4.4.10 Telemetry Measurement List

Range Users shall submit the telemetry measurement list as required in the **TDTS In-Flight RSS Telemetry Data** section of this Chapter.

### 4.5 FLIGHT TERMINATION SYSTEM GENERAL REQUIREMENTS

#### 4.5.1 Flight Termination System Description

*a.* A typical flight termination system (FTS) consists of a command destruct system, and an automatic destruct system.

*b.* Ideally, each powered stage of a vehicle should contain both a command and automatic destruct system.

*c.* Each new vehicle shall be evaluated and a determination made by Range Safety concerning FTS configuration. **NOTE:** Considerations such as

added weight, cost, vehicle design, breakup analysis, destruct response time, and mission objectives often result in acceptable alternative configurations. Range Safety may require Range Users to supply documentation such as breakup analysis (with or without destruct action) and tip-off analysis to support the evaluation.

*d.* The requirement for these and/or other analyses shall be identified by Range Safety as early in the conceptual design phase as possible.

##### 4.5.1.1 Command Destruct System

A typical command destruct system consists of an antenna, battery, Command Receiver and Decoder (CRD), controls, relays, liquid engine shutdown devices, arming devices, destruct charges, and associated circuitry.

##### 4.5.1.2 Automatic Destruct System

A typical automatic (ADS) consists of a power source, control logic, activation device, arming device, destruct charge, and associated circuitry.

##### 4.5.1.2.1 Automatic Destruct System General Requirements.

*a.* An ADS shall be installed on each powered stage or strap-on motor not containing a command FTS if determined to be required by the Flight Safety Analysis Section.

*b.* The individual powered stage or strap-on motor ADS shall be designed to be activated upon launch vehicle breakup or premature separation of the individual powered stage or strap-on motor.

*c.* Each stage requiring an electrically initiated ADS shall contain dedicated power sources to supply the energy required to initiate destruct ordnance.

##### 4.5.1.2.2 ADS Action Requirements.

*a.* Activation of the ADS on a stage or other propulsion system shall result in the appropriate flight termination action required by the **Flight Termination Action Requirements** section of this Chapter.

*b.* This action shall preclude the possibility of any stage being capable of powered flight without a method of flight termination.

##### 4.5.1.2.3 ADS Activation and Timing.

*a.* The ADS may be activated by any method such as lanyard, microswitch, break wires, or similar activation or sensing device that activates the system upon launch vehicle breakup or premature separation.

*b.* A breakup analysis shall determine the best method of ADS activation and locations of ADS components to maximize ADS survivability during a breakup scenario.

*c.* The ADS shall be designed to survive vehicle breakup or inadvertent stage separation loads and initiate destruct action.

*d.* A timing analysis shall be performed on the ADS to calculate the worst case time between ADS triggering and final destruct action.

#### **4.5.2 FTS Standard Configuration**

*a.* The command FTS shall be installed on or above the last (uppermost) propulsive stage of the vehicle that is capable of violating Range Safety criteria.

*b.* All other stages capable of violating Range Safety criteria shall contain flight termination actuation devices capable of accomplishing the action required in the **Flight Termination Action Requirements** section of this Chapter.

#### **4.5.3 FTS Configuration for Orbital Inserted Stages and Payloads**

*a.* When an FTS is required, orbital inserted stages and payloads shall contain actuating devices capable of flight termination.

*b.* The FTS requirement for payloads may be met by locating the FTS for the payload at the launch vehicle/payload interface.

#### **4.5.4 FTS Requirements for Propulsion Systems Other Than a Stage of the Vehicle**

Propulsion systems such as ullage systems rockets, retro-rockets, or escape rockets that are not considered a stage of the vehicle, and that present radiological, toxicological, explosive, or other hazards in the event of premature ignition or separation, may require an FTS.

#### **4.5.5 FTS Requirements for Manned Vehicles**

*a.* Manned vehicle FTSs shall comply with all requirements of this document with the exception that the manned portion of the vehicle shall not require destruct capability.

*b.* If manned vehicles are flown unmanned, all requirements of this document shall be met.

*c.* Additional FTS requirements for manned vehicles are listed below:

*1.* The effect of abort action on engine shut-

down shall be approved by Range Safety.

*2.* Time delays between engine shutdown and destruct action required for crew escape shall be provided by the Range in the ground equipment. The extent of these delays shall be determined by vehicle parameters, the type of escape system, and the degree of hazard presented to public safety.

*3.* Payloads and their booster stages transported on or within a manned portion of a launch vehicle will be evaluated by Range Safety to determine the need for an FTS.

### **4.6 FLIGHT TERMINATION ACTION REQUIREMENTS**

#### **4.6.1 Liquid Propellant Vehicles**

*a.* For vehicles consisting of all liquid propellant stages, both engine shutdown and destruct capability are required for each stage of the vehicle.

*b.* The Range transmitted ARM command shall be used as a preterminate logic function in the FTS receiver and shall cause nondestructive engine shutdown of all thrusting stages and inhibit ignition of all other liquid stages.

*c.* The subsequent Range transmitted DESTRICT command or activation of the Automatic Destruct System (ADS) shall cause the following actions to occur:

*1.* For liquid propellant stages using toxic propellants, the destruct charges shall cause penetration of the propellant tanks and initiate rapid burning of the propellants so that as much propellant as possible is consumed or dispersed.

*2.* For liquid propellant stages using non-toxic propellants, the destruct charges shall cause penetration of the fuel and oxidizer propellant tanks to the extent necessary for rapid dispersion of the propellants.

*d.* The destruct charge shall not detonate the liquid propellants.

#### **4.6.2 Solid Propellant Vehicles**

*a.* For vehicles consisting of all solid propellant stages, the Range transmitted ARM command shall be used only as a preterminate logic function within the FTS receiver.

*b.* The subsequent Range transmitted DESTRICT command or activation of the automatic FTS shall cause the destruct charge to destroy the pressure integrity of the motor and should ignite any non-burning propellant.

*c.* Destruct action shall cause a condition of zero

thrust or any residual thrust shall cause tumbling such that no significant lateral or longitudinal deviation of the impact point could result.

*d.* For propellant formulations (double-base composites like DDP-70 and cross-linked Poly Ethylene Glycol [PEG] high energy formulations) that are sensitive to shock to the extent that impact at a velocity greater than 250 ft/sec may result in detonation or explosion, destruct charges shall be designed to split the motor case and break up the propellant grain into fragments. **NOTE:** The goal is to have fragments not greater than 10,000 lb.

*e.* The destruct charge shall not detonate the solid propellant.

#### 4.6.3 Combination Liquid and Solid Propellant Vehicles

For vehicles using a combination of liquid and solid stages, the requirements of the **Liquid Propellant Vehicles** and **Solid Propellant Vehicles** sections of this Chapter are applicable to individual stages.

#### 4.6.4 Solid Propellant Thrust Augmenting Rockets

When solid propellant thrust augmenting rockets are used with a liquid propellant stage, they shall be treated as solid propellant stages and the **Solid Propellant Vehicles** section of this Chapter shall apply.

#### 4.6.5 Auxiliary Propulsion Systems

If required, the FTS for auxiliary propulsion systems shall cause the same actions as required in the following sections of this Chapter: **Liquid Propellant Vehicles**, **Solid Propellant Vehicles**, and **Combination Liquid and Solid Propellant Vehicles**.

### 4.7 FLIGHT TERMINATION SYSTEM DESIGN REQUIREMENTS

#### 4.7.1 FTS General Design Requirements

##### 4.7.1.1 FTS Component Redundancy

**NOTE:** The only exceptions to this redundancy requirement, if approved by Range Safety, are FTS antenna/RF transmission systems.

*a.* All launch vehicles and payloads and their stages determined by Range Safety to need an FTS shall contain redundant FTS command and automatic destruct components.

*b.* This redundancy shall be structural, mechanical, and electrical with maximum practical phy-

sical separation between redundant components.

*c.* Physically redundant components shall be mounted in different orientations on different axes where technically possible.

*d.* There shall be one dedicated battery for each redundant leg of the FTS.

*e.* The batteries used in the FTS shall be independent of all other vehicle systems.

*f.* Redundant destruct charges shall be provided unless Range Safety approved analyses (breakup, space considerations, feasibility, reliability, and other analyses) clearly indicate that redundant destruct charges are not required.

##### 4.7.1.2 FTS Design Simplicity

*a.* The number of FTS components and piece/parts shall be kept to an absolute minimum.

*b.* The destruct command output signal from the command receiver and decoder (CRD) shall be designed to go directly to FTS arming devices such as safe and arm (S&A), exploding bridgewire firing unit (EBW-FU), and laser firing unit (LFU). **NOTE:** Any component that interrupts this direct path shall be technically justified.

##### 4.7.1.3 FTS Component Isolation

FTS components shall be independent of other vehicle components and systems.

##### 4.7.1.4 FTS Fratricide

*a.* FTS design shall be such that the flight termination action of a stage will not sever interconnecting FTS circuitry or ordnance to other stages until the other stages have been initiated.

*b.* Analysis verifying compliance with this requirement may be required by Range Safety.

##### 4.7.1.5 FTS Software and Firmware

*a.* All software and firmware used in FTS shall be subjected to independent verification and validation (IV & V) in accordance with DoDI 5000.2, AF Sup 1paragraph 3-9 and AFSC/AFLC Pamphlet 800-5 or equivalent.

*b.* Approval shall be obtained from Range Safety prior to production of the component or system.

*c.* Once approved, any modification shall be validated in the same manner and approved by Range Safety prior to further production.

##### 4.7.1.6 FTS Failure Mode, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis

(FMECA) shall be performed in accordance with MIL-STD-1543 (Task 204) or equivalent.

#### 4.7.1.7 FTS Laser Systems

Laser systems shall meet the requirements of Vandenberg Air Force Base (VAFB) Regulation 161-6 and the 45th Space Wing Radiation Protection Program (45 SPWR 160-1).

#### 4.7.1.8 FTS Component Maximum Predicted Environment

##### 4.7.1.8.1 Determining FTS Component Maximum Predicted Environment Levels.

a. An analytical approach for determining FTS component maximum predicted environment (MPE) levels such as shock, thermal, and vibration shall be developed by the Range User and submitted to Range Safety for review and approval.

b. The analytical approach shall use existing flight data from other similar vehicles (if available), analysis, computer modeling, and subsystem testing such as bracket and truss vibration testing.

c. If there are fewer than three existing flight data samples, a minimum 3 decibel (dB) margin for vibration, 4.5 dB for shock, and 11°C for thermal shall be added to the analytical environment to obtain the predicted MPE.

##### 4.7.1.8.2 Validating the FTS Predicted MPE.

The predicted MPE shall be validated by actual environmental load measurements taken during launch and flight of at least three vehicles. If all data does not correlate, then additional load measurements on additional vehicles shall be taken.

#### 4.7.2 FTS Environmental Design Margin

##### 4.7.2.1 FTS Environmental Design Margin General Requirements

a. The FTS shall be designed to function normally under environmental forces greater than those that would result in breakup of the vehicle.

b. FTS components, including methods of attachment, mounting hardware, and cables and wires, shall be designed to function within performance specifications when exposed to environmental levels that exceed the ground transportation, pre-launch processing, checkout, and launch through end of Range Safety responsibility.

c. FTS design shall take into consideration the test requirements in Appendixes 4B1 through 4B11.

#### 4.7.2.2 FTS Component Thermal Environment

##### 4.7.2.2.1 Nonordnance Devices.

a. Unless otherwise specified by Range Safety, FTS nonordnance devices shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be -34°C to +71°C. *EXCEPTION: Batteries shall meet the requirements in paragraph a above.*

c. The nonordnance devices shall be designed to survive the thermal environment for a minimum of 24 qualification cycles and 8 acceptance cycles. *EXCEPTION: Batteries shall meet the requirements in Appendix 4B4.*

##### 4.7.2.2.2 Ordnance Devices.

a. Unless otherwise specified by Range Safety, FTS ordnance devices shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be -54°C to +71°C.

c. Ordnance devices shall be designed to survive this thermal environment for a minimum of 8 cycles.

##### 4.7.2.3 FTS Component Random Vibration Environment

a. Unless otherwise specified by Range Safety, FTS components shall be designed to survive random vibration environments that are 6 dB above the MPE level or a minimum of 12.2 Grms, whichever is greater.

b. The minimum design duration shall meet the following criteria:

1. Three times the expected flight exposure time or 3 min per axis, whichever is greater, for qualification

2. The flight exposure time or 1 min per axis, whichever is greater, for acceptance

c. The minimum frequency range shall be from 20 to 2000 Hz.

##### 4.7.2.4 FTS Component Acoustic Noise Environment

a. Unless otherwise specified by Range Safety, FTS components shall be designed to survive acoustic noise that are 6 dB above the MPE level or a minimum 144 dB overall sound pressure for acoustic, whichever is greater.

b. The minimum design duration shall meet the

following criteria:

1. Three times the expected flight exposure time or 3 min, whichever is greater, for qualification
2. The flight exposure time or 1 min, whichever is greater, for acceptance

#### **4.7.2.5 FTS Component Shock Environment**

*a.* Unless otherwise specified by Range Safety, FTS components shall be designed to a margin of 6 dB above the MPE level or a minimum of 1300 G, whichever is greater.

*b.* The duration shall simulate the actual shock environment.

*c.* The minimum frequency range shall be from 100 to 10,000 Hz.

*d.* The minimum number of shocks shall be 3 shocks per axis for each direction, positive and negative, for a total of 18 shocks.

#### **4.7.2.6 FTS Component Acceleration Environment**

*a.* Unless otherwise specified by Range Safety, FTS components shall be designed to 2 times the MPE level or a minimum of 20 G, in each direction, whichever is greater.

*b.* The minimum duration for acceleration shall be 5 min per axis.

#### **4.7.2.7 Other FTS Component Environments**

*a.* Other environments applicable to FTS components are humidity, salt fog, dust, fungus, explosive atmosphere, thermal vacuum, electromagnetic compatibility (EMC), electromagnetic interference (EMI), sinusoidal vibration, and other non-operational environments.

*b.* Tests and test levels for these environments are described in Appendixes 4B1 through 4B10.

### **4.7.3 FTS Reliability**

#### **4.7.3.1 FTS Reliability Goal**

*a.* The overall FTS system reliability goal shall be a minimum of 0.999 at the 95 percent confidence level.

*b.* This reliability goal shall be satisfied by

combining the design approach and testing requirements described in this Chapter.

*c.* A reliability analysis shall be performed in accordance with guidelines in MIL-STD-785 to demonstrate the reliability goal was used in the concept and detailed design of the components and/or system.

#### **4.7.3.2 FTS Single Point Failure**

*a.* The FTS, including monitoring and checkout circuits, shall be designed to eliminate the possibility of a single failure point (SFP) inhibiting the function of the system or causing an undesired output of the system.

*b.* An SFP analysis shall be performed to verify compliance with this requirement.

### **4.7.4 FTS Design Life**

#### **4.7.4.1 FTS Electrical Component Design Life**

*a.* Electrical components shall have their operating and storage life specified.

*b.* The operating and storage life for electrical components starts at completion of the initial acceptance test.

*c.* Range Safety shall be notified if the operating and storage life of an FTS component expires prior to launch.

*d.* If required, expired component retest shall be determined by mutual agreement between Range Safety and the Range User.

#### **4.7.4.2 FTS Ordnance Component Design Life**

*a.* Ordnance components shall have their service life and shelf life specified.

*b.* Range Safety shall be notified if the service life of a component expires prior to launch.

*c.* If required, expired component retest shall be determined by mutual agreement between Range Safety and the Range User.

### **4.7.5 FTS Arming Device Design**

#### **4.7.5.1 FTS Arming Device Design for Surface Launched Vehicles**

*a.* The FTS arming device for surface launched vehicles shall be designed so that all command and automatic FTS arming devices are armed prior to arming launch vehicle and payload ignition circuits.

*b.* Remote hardline and RF telemetry shall be provided to verify the armed status of each FTS arming device.

#### 4.7.5.2 FTS Arming Device Design for Air or Sea Launched Vehicles

For those air or sea launched vehicles in which propulsive ignition occurs after first motion, an ignition interlock shall be provided for mechanically or electrically armed systems so that ignition cannot occur unless the FTS arming devices are armed.

#### 4.7.6 FTS Prelaunch and In-Flight Safing Design

##### 4.7.6.1 Prelaunch FTS Safing Design

Redundant ground safing systems shall be provided to remotely safe the FTS arming device.

##### 4.7.6.2 In-Flight FTS Safing Design

###### 4.7.6.2.1 ADS Safing.

*a.* The airborne safing system hardware and software used to safe the ADS shall be single fault tolerant against inadvertent safing.

*b.* Safing shall depend on a minimum of two independent vehicle parameters such as altitude and time.

*c.* Unless otherwise specified by Range Safety, the single fault tolerant safing requirement shall be met by providing an airborne safing system which requires two independent and physically separate control devices such as a guidance computer and an external timer to safe the ADS.

###### 4.7.6.2.2 Command FTS Safing.

*a.* In some cases, it may be necessary to safe the command FTS in flight when the vehicle has proceeded beyond the limits of Range Safety responsibility.

*b.* The need to safe the FTS shall be justified and approved by Range Safety.

*c.* In these cases, the safing action shall be accomplished by automatic functions within the vehicle

*1.* The airborne safing system hardware and software used to safe the command destruct system shall be single fault tolerant against inadvertent safing.

*2.* Safing shall depend on a minimum of two independent vehicle parameters such as altitude and time.

*3.* Unless otherwise specified by Range Safety, the single fault tolerant safing requirement shall be met by providing an airborne safing system that requires two independent and physically separate control devices such as a guidance computer and an external timer to safe the command FTS.

rate control devices such as a guidance computer and an external timer to safe the command FTS.

*d.* In the event safing cannot be accomplished automatically and can be justified to and approved by Range Safety, safing can be accomplished by radio command using command transmitters.

#### 4.7.7 FTS Electrical and Electronic Systems Design

##### 4.7.7.1 FTS Piece/Part Selection Criteria

*a.* Piece/parts used in FTS electronic components shall meet the requirements of ELV-JC-002D (including Amendment 2) for Category 1 components.

*b.* Addition, subtraction, or replacement of piece/parts in a Range Safety approved FTS component shall require specific approval.

##### 4.7.7.2 FTS Voltage and Current Parameters

*a.* The input voltage range of each component shall be specified, and the current in the stand-by and operating modes shall be noted in the specification.

*b.* The components shall meet the requirements of this Chapter at any voltage level between the minimum and maximum specified.

*c.* The components shall not produce an output or be damaged because of low or fluctuating input voltage.

##### 4.7.7.3 FTS Transient Voltage Generation

All FTS and vehicle system interface components containing reactive elements such as relays, electrical motors or similar devices, that are capable of producing transient voltages shall be provided with suppression circuitry to prevent interference or damage to other FTS components.

##### 4.7.7.4 FTS Voltage Protection

*a.* FTS components shall not be damaged by the application of up to 45 volts, direct current (Vdc) or the open circuit voltage (OCV) of the power source, whichever is greater.

*b.* This voltage shall be applied in both normal and reverse polarity modes to the component power input ports for a period not less than 5 min.

##### 4.7.7.5 FTS Series Redundant Circuits

FTS components that use series redundant branches in the firing circuit to satisfy the no single failure point (SFP) requirement shall provide monitoring circuits or test points to verify integrity

of each redundant branch after assembly.

#### 4.7.7.6 FTS Switch and Relay Selection Criteria

*a.* Any power transfer switch and/or assembly shall not change state as a result of input power drop-out for a period of 50 milliseconds minimum.

*b.* Relays shall be designed and/or selected to prevent chatter.

*c.* Relays that are series inhibits shall be mounted on axes to minimize the potential of vibration or shock activating more than one of the relays simultaneously.

*d.* Electromechanical and solid-state switches and relays used in the firing circuit shall be capable of delivering the maximum firing current for a time interval at least 10 times the duration of the intended firing pulse.

#### 4.7.7.7 FTS Continuity and Isolation

*a.* The isolation resistance of the output pin to input pins and case ground shall not be less than 2 megohms.

*b.* The resistance from each pin to common return and/or case ground shall also be specified.

*c.* Measurements that are polarity-sensitive, such as those containing diodes, shall be identified.

*d.* Significant pin-to-pin measurements shall be included where their inclusion will provide meaningful data relative to the health of the component.

#### 4.7.7.8 FTS Circuit Isolation

*a.* FTS circuitry shall be shielded, filtered, grounded, or otherwise isolated to preclude energy sources such as electromagnetic energy from the Range and/or launch vehicle causing interference that would inhibit the functioning of the system or cause an undesired output of the system.

*b.* Electrical firing circuits shall be isolated from the initiating ordnance case, electronic case, and other conducting parts of the vehicle.

*c.* If a circuit must be grounded, there shall be only one interconnection (single point ground) with other circuits.

*d.* The interconnection (single point ground) shall be at the power source only. **NOTE:** Static bleed resistors between 10 kilohms and 100 kilohms are not considered to violate the single point ground. Other ground connections with equivalent isolation will be handled on a case-by-case basis.

*e.* Ungrounded circuits, capable of building up

static charge, shall be connected to the structure by static bleed resistors of between 10 kilohms and 100 kilohms.

#### 4.7.7.9 FTS Circuit Shielding

*a.* Shields shall not be used as intentional current carrying conductors.

*b.* Electrical firing circuits shall be completely shielded or shielded from the initiating ordnance, EBW firing unit, or laser firing unit (LFU) back to a point in the firing circuit at which filters or absorptive devices eliminate RF entry into the shielded portion of the system.

*c.* RF shielding shall provide a minimum of 85 percent of optical coverage ratio. **NOTE:** A solid shield rather than a mesh would have 100 percent coverage.

*d.* There shall be no gaps or discontinuities in the termination at the back faces of the connectors nor apertures in any container that houses elements of the firing circuit.

*e.* Electrical shields terminated at a connection shall be joined around the full 360° circumference of the shield.

*f.* The DC bonding resistance between connection points of the shielded system, metallic enclosures, and structural ground shall be 2.5 milliohms or less.

*g.* Firing, control, and monitor circuits shall be shielded from each other.

#### 4.7.7.10 FTS Circuit Protection

*a.* The FTS firing circuitry shall not contain fuses or similar type protection devices. For exceptions to this requirement, see the **FTS Battery Design** section of this Chapter. **NOTE:** Current limiting resistors are permitted in firing circuits.

*b.* When the output of FTS component is interfaced with vehicle functions such as CRD ARM command, the output circuit shall be protected against overcurrent including a direct short by such means as fuses, circuit breakers, and limiting resistors.

#### 4.7.7.11 FTS Repetitive Function

All circuitry, elements, components, and subsystems of the FTS shall be capable of withstanding, without degradation, repetitive functioning for 100 times or 5 times the expected number of cycles required for checkout and operation, whichever is greater.

#### 4.7.7.12 FTS Sneak Circuits

Firing circuit design shall preclude sneak circuits and unintentional electrical paths such as ground loops and failure of solid state switches.

#### 4.7.7.13 FTS Watchdog Circuits

Watchdog circuits that automatically shutdown or disable FTS circuitry when certain parameters are violated, such as snap-on and snap-off circuits in power supplies, shall be specifically approved by Range Safety. The parameters shall be specified in the component specification and included in testing.

#### 4.7.7.14 FTS Testability

FTS and associated ground support and monitoring equipment design shall provide the capability to perform the prelaunch tests described in the **RSS Test Requirements** section of this Chapter.

#### 4.7.7.15 FTS Self-Test Capability

*a.* If the component uses a microprocessor, it shall have the capability to perform a self-test (error detection) and output the results via telemetry.

*b.* The self-test shall be capable of initiation by POWER ON and upon receiving a special test command.

*c.* Failure of a self-test shall not intentionally disable the component.

*d.* The execution of a self-test shall not inhibit the processing intended function of the unit or cause any output to change state.

#### 4.7.7.16 FTS Interference Protection

The FTS component shall be designed to meet the requirements of MIL-STD-461, Class A2, Methods: CE 102, CE 106, CS 101, CS 103, CS 104, CS 105, CS 114, CS 115, CS 116, RE 102, RE 103, and RS 103. For RS 103 test C-band and S-band frequencies shall use 0 dBm instead of MIL-STD-461 level.

#### 4.7.8 FTS Low Voltage EED System Circuitry Design

In addition to the requirements noted in the **FTS Electrical and Electronic Systems Design** section of this Chapter, the following requirements shall be met for low voltage EED systems:

*a.* An electromechanical safe and arm (S&A) device is required for interruption of the firing circuit and ordnance train.

*b.* The EED system circuitry shall be designed to limit the power produced at each EED by the electromagnetic environments acting on the system to a level at least 20 dB below the pin-to-pin DC no-fire power of the EED.

*c.* The FTS shall be designed to provide for final electrical connections to the initiator to be made as late in the countdown as possible.

*d.* The operating current delivered to an EED shall be a minimum of (1) 1.5 times the all-fire (qualification test level) or (2) 2 times the Bruceton or (3) the manufacturer recommended sure-fire current, whichever is greater.

*e.* The operating current specified above shall be at the lowest system battery voltage and using the worst case system tolerances.

#### 4.7.9 FTS High Voltage EBW System Circuitry Design

In addition to the requirements noted in the **FTS Electrical and Electronic Systems Design** section of this Chapter, the following requirements shall be met for high voltage EBW systems:

*a.* EBW systems shall use arming and safing plugs, in addition to EBW Firing Units (EBW-FUs).

*b.* Trigger circuits shall be designed to activate upon the input of a single destruct signal during flight.

*c.* Any component and/or circuit such as inhibits or Fire Zero (Fire<sup>o</sup>) that interrupts these direct paths shall be technically justified.

*d.* The FTS shall be designed to provide for final electrical connections to the initiator to be made as late in the countdown as possible.

*e.* Operating voltage delivered to an EBW shall be a minimum of (1) 1.5 times the all-fire (qualification test level) or (2) 2 times the Bruceton or (3) the manufacturer recommended sure-fire voltage, whichever is greater.

*f.* The EBW initiator shall be designed to initiate reliably (0.999 at 95 percent confidence level) by application of an electrical pulse from an EBW-FU that conforms to the program specifications as approved by Range Safety.

*g.* Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish reliability.

## 4.7.10 FTS Laser Initiated Ordnance System Circuitry Design

### 4.7.10.1 Optic Systems

*a.* The laser initiated ordnance system (LIOS) optic system design shall preclude stray energy sources such as photostrobe, magnified sunlight, arc welding, xenon strobe, lightning, static electricity, and RF from causing interference that would inhibit system function or cause an undesired output.

*b.* This requirement shall be demonstrated during development and qualification testing.

*c.* The FTS shall be designed to provide for final optical connections to the initiator to be made as late in the countdown as possible.

### 4.7.10.2 LIOS Power Sources

*a.* LIOS power sources shall have a minimum of two independent and verifiable inhibits.

*b.* One of these inhibits for the main laser shall be a power interrupt plug that removes all airborne and ground power to the laser firing unit (LFU).

### 4.7.10.3 LIOS Safety Devices

**4.7.10.3.1 High Voltage LIOS Safety Devices.** High voltage LIOSs shall use one of the following safety devices:

#### *a.* Laser Firing Units

*1.* An LFU shall be used in conjunction with two optical barriers capable of being armed and safed and locked and unlocked remotely.

*2.* A manual safe plug capable of interrupting power to the barrier control circuits shall be provided.

#### *b.* An optical S&A

#### *c.* An ordnance S&A

**4.7.10.3.2 Low Voltage LIOS Safety Devices.** Low voltage LIOSs such as Diode Lasers shall use one of the following safety devices:

#### *a.* An optical S&A

#### *b.* An ordnance S&A

### 4.7.10.4 LIOS Firing Circuits

In addition to the requirements noted in the **FTS Electrical and Electronic Systems Design** section of this Chapter, the following requirements shall be met for LIOS Firing Circuits:

*a.* Energy delivered to an LID shall be a minimum of (1) 2 times the all-fire (qualification test level) or (2) the manufacturer recommended sure-fire energy level, whichever is greater.

*b.* LIOS firing circuits shall be designed to activate upon the input of a single destruct signal during flight.

*c.* Any component and/or circuit such as inhibits or Fire Zero (Fire<sup>o</sup>) that interrupts these direct paths shall be technically justified.

*d.* Low Energy Level End-to-End Test Requirements. If a low energy level end-to-end test is to be performed by the Range User when the LIOS is connected to the receptor ordnance, the following criteria shall be met:

*1.* The energy level shall be less than 1/10,000 of the no-fire level of the LID.

*2.* The single failure mode maximum energy level of the test system shall be less than 1/100 of no-fire level of the LID.

*3.* The test source shall emit a different wave length than the main firing unit laser.

*4.* One of the following inhibit options shall be implemented during a low energy level test:

*(a)* An ordnance S&A device and a safe plug that interrupts power to the main laser shall be required.

*(b)* Three independent verifiable inhibits shall be in place to preclude inadvertent initiation of the LID by the main firing unit laser during the low level energy test. One of the inhibits shall be a safe plug that interrupts power to the main laser.

*e.* LIOS Main Laser Subsystem Firing Test Requirements. If a main laser subsystem firing test is performed by the Range User when the LIOS is connected to the receptor ordnance, a minimum of three independent, verifiable inhibits shall be in place.

*1.* Two of the inhibits shall be optical barriers capable of being independently locked in place.

*2.* The third inhibit shall be a safe plug that interrupts the power control circuit or circuits to the optical barriers.

### 4.7.10.5 LIOS Laser Emission Path Enclosures

Lasers shall be completely enclosed during check-out or provided with ground support equipment that can enclose the laser emission path at all times the system is powered.

### 4.7.10.6 LID Design Reliability

*a.* LIDs shall be designed to initiate reliably

(0.999 at the 95 percent confidence level) by application of an energy pulse from an LFU that conforms to the program specifications as approved by Range Safety.

*b.* Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish reliability.

#### **4.7.11 FTS Ordnance Train Design**

##### **4.7.11.1 FTS Ordnance Train General Design**

*a.* Destruct ordnance trains may include any or all of the following items:

1. Initiators and/or detonators
2. Energy transfer lines
3. Boosters
4. Explosive manifolds
5. Destruct charges

*b.* The destruct ordnance train shall be designed to reliably initiate with the energy provided by the command or automatic FTS.

*c.* Upon initiation, the destruct action shall reliably propagate through the ordnance train, initiate the destruct charges, and result in the appropriate destruct action.

*d.* Destruct ordnance shall be designed, but not limited to, a service life of at least 10 years.

*e.* The service life of each production lot of ordnance train components containing explosives must be verified by tests contained in Appendixes 4B1 and 4B6 through 4B10.

*f.* The decomposition, cook-off, and melting temperatures of all explosives shall be at least 30°C higher than the maximum predicted environmental temperature to which the material will be exposed during storage, handling, installation, and transportation.

*g.* Specific approval from Range Safety is required for all explosive compositions.

*h.* Explosive ordnance shall be manufactured in accordance with documented procedures and process control.

*i.* Manufacturer process controls shall provide a supplier controlled baseline that assures subsequent production items can be manufactured that are equivalent in performance, quality, and reliability to initial production items used for qualification and flight.

*j.* Redundant destruct charges shall be used unless otherwise approved by Range Safety.

*k.* If a single destruct charge is approved, the destruct charge shall be initiated by a minimum of two structurally and functionally independent initiators. Linear-shaped charges shall be initiated at each end by an independent initiator.

*l.* An electrically conductive path shall exist between metallic part(s) of the ordnance train (excluding the electrically initiated detonator), fittings, bracket holder, and the vehicle ground plane. The bonding resistance shall not exceed 5 ohms.

*m.* The bonding resistance between the electrically initiated detonator, the detonator holder such as an S&A device, metallic fitting, and the vehicle ground plane shall not be greater than 2.5 milliohms per each connection.

##### **4.7.11.2 FTS Ordnance System Initiating Device Installation**

*a.* Ordnance systems shall be designed so that the initiating devices can be installed in the system just prior to final electrical and/or optical hookup on the launch pad.

*b.* The initiating device locations shall be accessible to facilitate installation and/or removal and electrical and/or optical connections as late as possible in the launch countdown.

*c.* Launch complexes shall be designed to accommodate this accessibility requirement.

##### **4.7.11.3 FTS Ordnance Interface**

*a.* All ordnance components and interfaces, including S&A rotor leads and/or booster charges, shall be designed with the following performance margins:

*1.* The ability of the detonating donor to propagate the detonation to the receptor without failure shall be demonstrated by one of the following methods:

*(a)* A minimum of 10 firings using a donor charge that is 75 percent or less of the minimum specified charge and at the nominal operating temperature shall be conducted. Half of the test firings shall be conducted using the minimum specified air gap and half conducted using the maximum specified air gap.

*(b)* A minimum of 10 firings using the specified nominal donor charge and at the nominal operating temperature shall be conducted. Half of these test firings shall be conducted using an air gap

that is at least four times the maximum design air gap width or a 0.15 in. gap (whichever is greater) and half conducted using an air gap that is 50 percent of the minimum design air gap.

2. Axial and/or angular alignment tolerance shall be specified for each ordnance fitting interface. A minimum of 10 firings shall be conducted at the nominal temperature to demonstrate that the ordnance items will function when offset 4 times the nominal alignment tolerance at maximum air gap.

3. Unless otherwise agreed to by Range Safety, margin testing shall be conducted in an enclosure that simulates the actual internal volume of flight configuration.

*b.* Detonation interconnects or crossovers shall not be used between redundant explosive trains unless approved by Range Safety.

*c.* Detonation transfer in an ordnance train shall be accomplished using the end-to-end transfer mode.

1. Designs that preclude use of the end-to-end transfer mode may use end-to-side or side-to-end, in that order of preference.

2. Side-to-side detonation transfer mode shall not be used unless approved by Range Safety.

*d.* The distance from the point of ordnance train initiation by electrical and/or optical energy to the destruct charge shall be as short as possible.

#### 4.7.11.4 FTS Ordnance Hazard Classification and Compatibility

*a.* Ordnance items shall be assigned to the appropriate Department of Defense (DoD) or United Nations (UN) hazard classification and the storage compatibility group in accordance with DoD 6055.9-STD.

*b.* Items that have not previously been classified and cannot be classified based on similarity with previously classified items shall be tested in accordance with AFTO 11A-1-47 (NAVSEAINST 8020.3/TB 700-2/DLAR 8220.1) and classified accordingly. **NOTE:** The Range User is responsible for having the tests run and submitting the results to Range Safety.

*c.* Ordnance items shall also have a Department of Transportation (DOT) classification.

*d.* The Range User shall provide documentation demonstrating proper classification to Range Safety prior to delivery of the ordnance to the Ranges.

#### 4.7.12 FTS Monitor, Checkout, and Control Circuit Design

##### 4.7.12.1 FTS Monitor, Checkout, and Control Circuit General Design

*a.* Monitor, checkout, and control circuits shall be designed so that the actual status of critical parameters can be monitored directly during prelaunch and flight. Critical parameters to be monitored are specified in the **TDTS In-Flight RSS Telemetry Data, ER Operations Safety Console, and WR Safety Console and RSS Repeater System** sections of this Chapter.

*b.* Monitor, control, and checkout circuits shall be completely independent of the firing circuits and shall use a separate and non-interchangeable electrical connector.

*c.* Monitor, control, and checkout circuits shall not be routed through ARM or SAFE plugs unless approved by Range Safety.

*d.* The electrical continuity of one status circuit (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

##### 4.7.12.2 FTS Monitor and Checkout Circuits

*a.* The function of the FTS shall not be affected by the external shorting of a monitor circuit or by the application of any positive or negative voltage between 0 and 45 Vdc for up to 5 min to an FTS monitor circuit.

*b.* Monitor and checkout current in an EED system firing line shall not exceed 1/10 the no-fire current of the EED or 50 milliamperes, whichever is less.

*c.* The monitor circuit that applies current to the EED shall be designed to limit the open circuit output voltage not greater than 1 volt.

*d.* Monitor circuits shall be designed so that application of operational voltage shall not cause inadvertent function or loss of function of the FTS nor cause the FTS to be armed.

*e.* Resolution, accuracies, and data rate for monitor circuit outputs shall be specified for both RF and hardline and shall be submitted to Range Safety for review and approval.

*f.* Maximum and minimum values for monitor circuit outputs shall be specified and submitted to Range Safety for review and approval.

##### 4.7.12.3 FTS Control Circuits

Control circuits shall be electrically isolated from the firing circuit so that a stimulus in these circuits

does not induce a stimulus greater than 20 dB of activation level in the firing circuit.

## 4.8 FTS COMPONENT DESIGN REQUIREMENTS

### 4.8.1 FTS Antenna System Design

#### 4.8.1.1 FTS Antenna System Radio Command Coverage

*a.* The FTS antenna system shall provide adequate gain coverage over 95 percent of the radiation sphere.

*b.* The FTS shall be capable of reliable operation with signals having electromagnetic field intensity 12 dB below the intensity provided by the Range at any point along the vehicle trajectory where the Range retains safety responsibility for the flight vehicle.

*c.* Deep nulls in the pattern shall be minimized both as to the number of nulls and angular width.

*d.* The entire ground and airborne command FTS shall be subjected to an RF link analysis that shall show a minimum of 12 dB margin.

*e.* The RF link analysis shall include path losses due to plume or flame attenuation, aspect angle, vehicle trajectory, ground system RF characteristics, and any other possible attenuation factors.

*f.* Antenna patterns shall be provided to Range Safety in accordance with RCC 253 and shall be used in the RF link analysis.

#### 4.8.1.2 FTS Antenna System Components

*a.* Power splitters, combiners, hybrids, coaxial cables or other passive devices used to connect the antenna to the CRD shall be considered as part of the FTS antenna system.

*b.* An RF coupler shall be used on FTSs that employ multiple antenna.

*1.* Hybrid couplers that inherently offset the phase ( $90^\circ$  or  $180^\circ$ ) between the outputs are preferred.

*2.* Use of other style couplers shall be technically justified and approved by Range Safety.

*3.* If a dedicated, independent FTS antenna system is used for each CRD, each antenna system shall meet the requirements specified in this section.

*d.* The bandwidth of the FTS antenna system shall be  $\pm 180$  kilohertz (kHz) minimum.

*e.* FTS antenna system components shall be designed for a nominal 50 ohms impedance.

*f.* The antenna system shall have a voltage standing wave ratio (VSWR) of 2:1 or less across

*g.* If FTS antenna heat shields are used, they

shall be considered part of the antenna system and shall be subjected to all the antenna system requirements for design, test, pattern measurements and approval. **NOTE:** All antenna heat shields shall be subjected to a fly-off analysis that includes test data reflecting antenna performance with and without the heat shields.

#### 4.8.1.3 FTS Antenna System Compatibility

The FTS antenna system shall be fully compatible with the ground command transmitters and their left-hand circular polarized antennae.

### 4.8.2 FTS Standard Command Receiver and Decoder Design

In addition to the requirements specified below, information on the FTS Command Receiver and Decoder (CRD) design and test requirements may be found in the RCC 313. In the case of conflicts between the requirements of this Chapter and RCC 313, the requirements of this Chapter shall take precedence.

#### 4.8.2.1 FTS Standard CRD General Design Requirements

*a.* ARM, DESTRICT, and optional output commands shall be routed through a separate connector(s) from input power, monitor circuits, and RF inputs.

*b.* RF inputs shall be routed through a dedicated connector.

*c.* After initial adjustment, the CRD shall perform in accordance with the requirements of this section without subsequent adjustment.

*d.* The CRD sealing shall be designed to survive exposure to environments such as humidity, salt, and fog as described in Appendix 4B1.

*e.* The CRD shall be capable of delivering the specified power to the specified load on each output at any CRD input power supply voltage level between the minimum and maximum.

*f.* The output load impedance characteristics shall be defined in the procurement specification and all output load testing must be conducted under the specified load characteristics.

*g.* The maximum leakage current through the command destruct output port shall be specified in the procurement specification and shall not be more than 50 microamperes.

**4.8.2.1.1 CRD Interference Protection.** The CRD shall be designed to meet the requirements of MIL-STD-461, methods CE102, CE106, CS101, CS103, CS104, CS105, CS114, CS115, CS116, RE102, RE103, and RS103. *EXCEPTIONS: CS104 limits are changed to 60 dB above threshold sensitivity at center frequency; and RS103 shall be at least 0 dBm throughout the following frequency ranges: 2200-2400 MHz, 5400- 5900 MHz, and 9200-9600 MHz.*

**4.8.2.1.2 CRD Radiation Analysis.** Launch vehicle and payload systems shall be analyzed to ensure that radiations profiled are not greater than the environment the CRD is tested to.

**4.8.2.1.3 CRD Transient Response.** The tolerance-to-transient voltages shall be specified for each input/output connector.

a. Amplitude, polarity, rise time, and duration shall be identified.

b. The CRD shall not produce any output and shall meet the performance requirements after the application of the specified transient.

#### **4.8.2.2 Standard Receiver**

**4.8.2.2.1 Standard Receiver Operating Frequency Band.**

a. The receiver shall be operable over the frequency range of 400-450 MHz.

b. Unless otherwise directed by Range Safety, all ER/WR receivers shall be factory tuned to 416.5 MHz by use of fixed tuning elements.

c. Operating frequency changes shall require rework at the original manufacturer.

**4.8.2.2.2 Standard Receiver Input VSWR and Impedance.** The receiver RF input VSWR shall be 2:1 or less with respect to 50 ohms across the specified bandwidth of the assigned operating frequency.

**4.8.2.2.3 Standard Receiver RF Sensitivity.** The receiver measured threshold sensitivity shall be between -107 dBm and -116 dBm across a 50 ohms impedance. **NOTE:** Subsequent sensitivity bench test results shall be within  $\pm 3$  dB of original acceptance test measurements.

**4.8.2.2.4 Standard Receiver Maximum Usable RF Input.** The receiver shall be capable of operating within its performance specification

limits during and after the application of RF signal levels between the threshold and +13 dBm.

**4.8.2.2.5 Standard Receiver Operational Bandwidth.** The receiver shall initiate and sustain all command functions over a continuous range of  $\pm 45$  kHz from the assigned RF center frequency when subjected to command tones having deviations of plus and minus  $30 \pm 3$  kHz peak per tone and at the specified threshold sensitivity level.

**4.8.2.2.6 Standard Receiver Peak to Valley Ratio.** The intermediate frequency (IF) filter peak-to-valley ratio shall not exceed 3 dB within  $\pm 45$  kHz of the assigned operating frequency.

**4.8.2.2.7 Standard Receiver Continuous Wave Bandwidth.** The receiver shall provide an IF bandwidth of 180 kHz minimum at 3 dB points and 360 kHz maximum at the 60 dB points.

**4.8.2.2.8 Standard Receiver Noise Immunity.** The CRD shall not produce command outputs when subjected to an RF signal of -95 dBm that is FM modulated with white noise at an amplitude of 12 dB higher than the highest measured deviation threshold of any individual audio tone. The white noise spectrum shall be at least 0 to 600 kHz.

**4.8.2.2.9 Standard Receiver Capture Ratio.** The application of an unmodulated RF signal at the assigned frequency at a level up to 80 percent (-2 dB) below the desired, modulated RF carrier signal shall not capture the receiver or interfere with the desired signal.

**4.8.2.2.10 Standard Receiver Signal Strength Telemetry Output Monitor.** While operating into a 10 kilohms load, the Signal Strength Telemetry Output (SSTO) voltage of the receiver shall meet the following requirements:

a. The SSTO output level quiescent (no RF signal) condition shall be  $0.5 \pm 0.25$  Vdc.

b. The SSTO measured command threshold sensitivity input condition shall be 0.1 Vdc minimum above the quiescent value.

c. The SSTO output level shall reach a maximum ( $4.75 \pm 0.25$  Vdc) with no less than 500 microvolts (-53 dBm) of RF input.

d. The shape of the transfer function shall not exceed approximately 1.0 Vdc change in voltage for each 13 dB change in RF input signal over the range between threshold and saturation.

e. The maximum SSTO voltage shall not exceed 5 Vdc under all conditions.

*f.* The slope of the SSTO voltage shall not change polarity from measured threshold to +13 dBm. **NOTE:** The slope of the SSTO voltage is monotonic with no more than 50 mV droop after saturation has been reached.

*g.* The SSTO voltage shall not be used as a command output monitor.

**4.8.2.2.11 Standard Receiver Amplitude Modulation (AM) Rejection.** The CRD shall not produce an output from any decoder channel under the following conditions:

*a.* An RF input signal at the assigned center frequency of -90.1 dBm (7 microvolts) with 50 percent AM modulation by the assigned RCC tone frequencies

*b.* An RF input signal at the assigned frequency of -85.4 dBm (12 microvolts) signal with 50 percent AM modulation by the assigned RCC tone frequencies

*c.* An RF input signal at the assigned RF center frequency of -67 dBm (100 microvolts) with 100 percent peak AM modulation at Low Pass Filter (LPF) 3 dB frequencies of 3.5 kHz or 7.0 kHz.

**4.8.2.2.12 Standard Receiver Dynamic Stability.** The receiver shall not produce false commands or spurious outputs as a result of changing input VSWR, including open and short RF transmission circuits.

**4.8.2.2.13 Standard Receiver Warm-Up Time.** The receiver shall meet all performance requirements within a time period specified in the procurement document or 3 min, whichever is less, after application of DC power.

**4.8.2.2.14 Standard Receiver Out-Of-Band Rejection.**

*a.* The receiver shall be immune to all out-of-band frequencies.

*b.* Special emphasis shall be given to those signals originating from 2.2 to 2.4 GHz continuous wave (CW), from 5.4 to 5.9 GHz pulsed, and from 9.2 to 9.6 GHz pulsed.

*c.* Out-of-band rejection shall be a minimum of 60 dB above measured threshold sensitivity.

*d.* The receiver shall provide at least 60 dB of rejection from 10 to 1,000 MHz, excluding the frequency band within the 60 dB bandwidth at the assigned center frequency referenced to the response at the center frequency.

### 4.8.2.3 Standard Decoders

#### 4.8.2.3.1 Standard Decoder General Design Requirements.

*a.* The decoder shall simultaneously output three channels: ARM, DESTROY, and CHECK CHANNEL. **NOTE:** Any additional decoder output channels shall be approved by Range Safety.

*b.* The decoder shall process a minimum of 4 RCC audio tone inputs simultaneously.

*c.* The RCC audio tone frequencies and their tolerances are shown in Table 4-1.

**Table 4-1  
RCC Standard Decoder Tones**

RCC Tone	Frequency (in kHz)
1	7.50
2	8.46
3	9.54
4	10.76 (CHECK CHANNEL)
5	12.14
6	13.70
7	15.45
8	17.43
9	19.66
10	22.17
11	25.01
12	28.21
13	31.83
14	35.90
15	40.49
16	45.68
17	51.52
18	58.12
19	65.56
20	73.95

Tolerances: Frequency  $\pm 0.1$  percent  
Amplitude  $\pm 1$  dB  
Distortion <2 percent total harmonic distortion

**4.8.2.3.2 Standard Decoder Standard Logic Sequence.** Unless otherwise specified by Range Safety, the decoder shall not produce a command output under any condition or set of conditions except those described below and shown in Table 4-2.

*a.* ARM command

*1.* RCC Tones 1 and 5 are applied in any order.

*2.* Removal of Tone 5 while switching from ARM to DESTROY shall not cause the loss of ARM output.

*b.* DESTROY command

*1.* With RCC Tones 1 and 5 applied (ARM), Tone 5 is removed and Tone 2 is applied.

*2.* If Tone 2 is applied before Tone 5 is removed, neither the ARM nor the DESTROY

shall be lost or inhibited.

*c.* CHECK CHANNEL command

1. With RCC Tone 4 applied, the decoder shall be capable of driving the external load.

2. The presence or absence of Tone 4 shall not affect the performance or function of the other decoder channels.

*d.* Other sequential coding techniques for ARM and DESTRUCT commands may be used if they fall within the capability of the range transmitting system and if approved by Range Safety.

**Table 4-2**  
**Standard Logic Sequence**

Logic Sequence	Decoder Output
Tones 1 and 5	ARM
Tones 1 and 5 followed by: remove Tone 5 and apply Tone 2	DESTRUCT
Tone 4	CHECK CHANNEL

**4.8.2.3.3 Standard Decoder Channel Deviation Threshold and Range.**

*a.* The RF deviation threshold for each channel shall be between plus and minus 9 and between plus and minus 18 kHz per tone.

*b.* The decoder shall not provide any output at deviation levels of less than plus and minus 9 kHz per tone.

*c.* Each decoder channel shall provide proper, intermittent free output when the tones are deviated over the range of plus and minus 27 kHz to plus and minus 33 kHz per tone and at a two tone deviation of plus and minus 54 to 66 kHz.

**4.8.2.3.4 Standard Decoder Channel Bandwidth.** The decoder channel bandwidth required for the generation of a tone detected output shall meet the following criteria:

*a.* The 2 dB channel bandwidth shall be  $\pm 1$  percent of the assigned tone frequency minimum, when measured at the board or box level.

*b.* The 14 dB channel bandwidth shall be  $\pm 4$  percent of the assigned tone frequency maximum, when measured at the box level.

*c.* The 20 dB channel bandwidth shall be  $\pm 4$  percent of the assigned tone frequency maximum, when measured at the decoder board level.

**4.8.2.3.5 Standard Decoder Adjacent Channel Rejection.** The decoder shall not produce an output on unkeyed channels or cause a keyed channel to drop out in the presence of adjacent channel interference resulting from any combination of simultaneous tones with carrier FM deviation set at

plus and minus 50 kHz.

**4.8.2.3.6 Standard Decoder Response Time.** The response time of each function shall be between 4 milliseconds and 25 milliseconds from the time the command is received by the CRD.

**4.8.3 FTS Secure Command Receiver and Decoder Design**

**4.8.3.1 Secure CRD Policy**

*a.* To comply with national policy directive *National Policy on Application of Communication Security to Command Destruct System* issued in 1988, Range Users are required to provide secure CRDs on FTSs.

*b.* Secure CRDs are designed to prevent inadvertent flight termination command outputs caused by unauthorized and/or accidental radio transmissions.

*c.* The timetable for implementation of this requirement is contained in the directive.

*d.* Only the Range Commanders are empowered to waive all or part of this policy.

*e.* The use of secure CRDs are not a Range Safety requirement.

**4.8.3.2 Secure Receiver**

The secure receiver shall meet the requirements in **FTS Standard Command Receiver and Decoder General Design Requirements** and **Standard Receiver** sections of this Chapter.

**4.8.3.3 Secure Decoder**

**4.8.3.3.1 Secure Decoder General Design Requirements.**

*a.* The secure decoder design shall be approved by Range Safety.

*b.* The Ranges will consider any design that satisfies the manager of the National Telecommunications and Information Systems Security (NTISS) requirements while maintaining Range Safety reliability requirements.

*c.* Secure decoder designs shall be compatible with existing secure flight termination transmitting equipment. **NOTE:** Designs that result in the re-design of existing secure flight termination transmitting equipment require long range planning and extensive coordination and approval efforts.

#### 4.8.3.3.2 Secure Decoder Minimum Output Channel.

*a.* The secure decoder is required to output 3 channels: ARM, DESTRUCT, and PILOT TONE.

*b.* Any additional decoder output channels shall be approved by Range Safety.

#### 4.8.3.3.3 Secure Decoder Tone Frequency.

The tones and tolerances used in the secure mode are shown in Table 4-3. **NOTE:** These are not standard RCC audio tones.

**Table 4-3**  
**Secure Decoder Tones**

Secure Tone	Frequency (kHz)
1	7.35
2	8.40
3	9.45
4	10.50
5	11.55
6	12.60
7	13.65
Pilot	15.45

Tolerances: Frequency  $\pm 0.1$  percent  
Amplitude  $\pm 1$  dB  
Distortion  $< 2$  percent total harmonic distortion

#### 4.8.3.3.7 Secure Decoder Response Time.

The time interval between the complete reception of the 11th character (tone pair) of the command message at the front end of the receiver and the occurrence of the respective decoder output shall not exceed 25 milliseconds.

#### 4.8.3.3.4 Secure Decoder Logic Sequence.

*a.* The decoder input command message shall consist of an 11 character, frequency modulated, tone pattern.

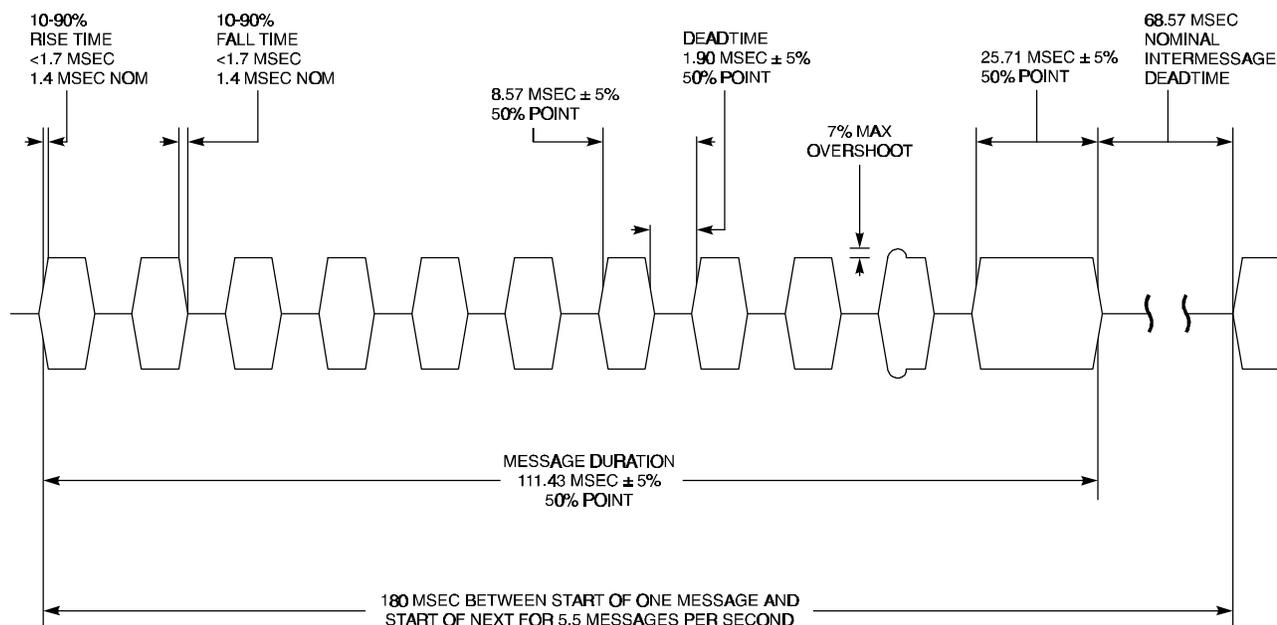
*b.* Each character shall consist of the sum of two tones of frequencies specified in the above paragraph and form a high-alphabet code.

*c.* The secure high-alphabet command codes are provided to the Range User by the National Security Agency (NSA).

*d.* For a typical secure command message format, refer to Figure 4-1.

**4.8.3.3.5 Secure Decoder ARM (Engine Shutdown) Command.** The arm output shall be active only after successfully decoding a high-alphabet encoded ARM command and shall stay on continuously.

**4.8.3.3.6 Secure Decoder DESTRUCT Command.** The destruct output shall be active only after successfully decoding a high-alphabet encoded DESTRUCT command and a currently active ARM and shall stay on continuously.



**Figure 4-1**  
**Typical Secure Command Message Format**

**4.8.3.3.8 Secure Decoder Tolerance.** Decoder tolerance to tone drop, tone imbalance, abnormal logic, and message timing shall be specified.

**4.8.3.3.9 Secure Decoder Channel Bandwidth.** The decoder channel bandwidth shall be  $\pm 40$  Hz minimum at 2 dB and  $\pm 600$  Hz maximum at 20 dB.

**4.8.3.3.10 Secure Decoder Automatic RESET Command.**

*a.* The CRD may be designed to have the capability to reset a latched output command by processing a RESET command.

*b.* The RESET command capability shall be erased from the flight CRD prior to launch.

**4.8.3.3.11 Secure Decoder Memory Life.** Following coded message loading into the receiver, the codes shall remain in memory for a period of not less than 120 days without primary DC power being applied.

**4.8.3.3.12 Secure Decoder Channel Deviation Threshold and Ranges.**

*a.* The RF deviation threshold for each channel shall be between plus and minus 9 and between plus and minus 18 kHz per tone.

*b.* The decoder shall not provide any output at

deviation levels of less than plus and minus 9 kHz per tone.

*c.* Each decoder channel shall provide proper, intermittent free output when the tones are deviated over the range of plus and minus 27 kHz to plus and minus 33 kHz per tone and at a two tone deviation of plus and minus 54 to 66 kHz.

#### 4.8.4 FTS Wiring Design

*a.* Twisted shielded pairs shall be used unless other configurations such as coaxial leads can be shown to be more effective.

*b.* For low voltage circuits, the insulation resistance between the shield and conductor shall be greater than 2 megohms at 500 Vdc minimum.

*c.* For high voltage circuits, the insulation resistance between the shield and conductor shall be greater than 50 megohms at 150 percent of the rated output voltage or 500 Vdc whichever is greater.

*d.* Wiring and harness shall be capable of withstanding 1500 Vac (RMS) 60 Hz at sea level pressure between mutually insulated points and the case or housing.

*e.* Wire shall be of sufficient size to adequately handle 150 percent of the design load for continuous duty signals of 100 sec or more. For

signals of less than 100 sec duration, the wire and insulation shall be selected to conform to the insulation temperature class of wire.

*f.* Splicing of firing circuit wires or overbraid shields is prohibited.

*g.* The use of wire wrap to connect wires or shields is prohibited.

*h.* Wires and cables shall be given support and protection against abrasion or crimping.

#### 4.8.5 FTS Fiber Optic Cable Design

*a.* Fiber optic cable (FOC) design shall preclude stray energy sources such as photostrobe, magnified sunlight, arc welding, xenon strobe, lightning, static electricity, and RF from causing interference that would inhibit system function or cause an undesired output.

*b.* The requirement in paragraph *a* above shall be demonstrated during development and qualification testing.

*c.* Fiber optic cable minimum bend radius shall be specified and demonstrated during development and qualification testing.

*d.* Fiber optic cable fatigue characteristics and cable ability to survive compressive and impact loads experienced during handling shall be specified and demonstrated during development and qualification testing.

*e.* Materials selected for use in fiber optic cables shall not degrade the optical performance of the cable, laser, or other optical devices due to outgassing onto optical surfaces during its service life.

*f.* Fiber optic cable shall withstand an axial pull of 100 lb for a minimum of 1 min. **NOTE:** This requirement may be relaxed to 30 lb for 1 min if a final continuity test is performed prior to final closeout and just prior to launch.

*g.* The fiber optic cable shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  standard cubic centimeter/second(s) (scc/sec) helium.

*h.* Fiber optic cable shall be given support and protection against abrasion and crimping.

#### 4.8.6 FTS Electrical and Optical Connector Design

##### 4.8.6.1 FTS Electrical Connectors

###### 4.8.6.1.1 FTS Electrical Connector General Design Requirements

*a.* FTS connectors shall be designed in accordance with the requirements of MIL-C-38999J or the equivalent and the requirements of this section.

*b.* Plug and socket type connectors are required.

*c.* Outer shells of connectors shall be made of metal.

*d.* Connectors shall be selected to eliminate the possibility of mismating. **NOTE:** Mismating includes improper installation as well as connecting wrong connectors.

*e.* Connectors shall be of the self-locking type or lock wiring shall be used to prevent accidental or inadvertent demating.

*f.* Connector design shall ensure that the shielding connection is complete before the pin connection.

*g.* Source circuits shall terminate in a connector with female contacts.

*h.* Connectors relying on spring contact shall not be used.

*i.* The mated connectors shall withstand an axial pull on the cable or harness of at least 30 lb for a minimum of 1 min.

###### 4.8.6.1.2 FTS Electrical Connector Pins

*a.* Circuit assignments and isolation of pins within a connector shall be such that any single short circuit occurring as a result of a bent pin shall not result in more than 10 percent of the all fire current on the firing circuit or does not have an adverse effect on the FTS.

*b.* A bent pin analysis shall be performed on all FTS connectors.

*c.* There shall be only one wire per pin.

*d.* In no case shall a connector pin be used as a terminal or tie-point for multiple connections.

###### 4.8.6.1.3 FTS Electrical Connector Redundancy

*a.* Where redundant circuits are required by Range Safety, separate cables and connectors shall be used.

*b.* Redundant circuits shall meet the following criteria:

1. The elements of a redundant circuit shall not be terminated in a single connector where the loss of such cable or connector will negate the redundant feature.

2. Redundant circuits shall be separated to the maximum extent possible.

3. All firing circuit harnesses shall be isolated from other harnesses.

#### 4.8.6.1.4 FTS Electrical Connector Capacity.

a. Connectors shall be capable of adequately handling 150 percent of the design load for continuous duty signals of 100 sec or more.

b. For continuous duty signals less than 100 sec duration, the connector shall be selected to conform to the insulation temperature class of the inert materials.

#### 4.8.6.1.5 FTS Electrical Connector Unverifiable Connection.

a. Electrical connections that cannot be subjected to a continuity or functional test following the final mate shall be designed to meet the following criteria:

1. A straight pin within specifications cannot be misaligned during the mating process so that the circuit is no longer functional.

2. A connector with a bent or misaligned pin out of specification will prevent the connector from mating.

b. A qualification test program shall be developed by the Range User to demonstrate compliance with these requirements.

c. The qualification test plan and test results shall be submitted to Range Safety for review and approval.

#### 4.8.6.2 FTS Optical Connectors

a. Optical connectors shall be of the self-locking type or lockwiring shall be used to prevent accidental or inadvertent demating.

b. Optical connectors shall be designed to eliminate misalignment and minimize attenuation.

c. Optical connectors shall be selected to eliminate the possibility of mismating. **NOTE:** Mismating includes improper installation as well as connecting wrong connectors.

d. Optical connectors and receptacles shall be provided with self-locking protective covers or caps that shall be installed except when the connector or receptacle is in use.

e. Protective covers or caps shall provide protection against environmental damage during transportation, storage, installation, and handling.

f. An absolute minimum of connectors shall be used in a fiber optic cable system.

g. Mated connectors shall have a leak rate of no greater than the equivalent of  $5 \times 10^{-6}$  scc/sec helium. **NOTE:** This requirement may be relaxed under the following conditions: (1) if a continuity test is performed after final closeout and just prior to launch; (2) if contamination sensitivity testing during qualification and acceptance testing shows that this level of cleanliness is not a concern.

h. Mated connectors shall withstand an axial pull on the cable of at least 100 lb for a minimum of 1 min. **NOTE:** This requirement may be relaxed to 30 lb for 1 min if a continuity test is performed after final closeout and just prior to launch.

i. Performance margin, misalignment such as gap or offset, and contamination sensitivity of each fiber optic cable connector interface shall be specified and demonstrated by tests.

j. All connectors shall be capable of being mated and/or demated at least five times the number of planned cycles, but not less than 100 cycles, and still be within the performance requirements of the connector specification.

k. Optical cables shall use single fiber connectors. **NOTE:** The use of multiple optical fiber connectors requires specific Range Safety approval.

#### 4.8.7 FTS Battery Design

##### 4.8.7.1 FTS Battery Design Life

a. Batteries shall be of sufficient capacity to allow for load and activation checks, launch countdown checks, and any necessary hold time.

b. Sufficient battery life shall be available for 150 percent of the mission time for which Range Safety has flight safety responsibility or 30-min hang-fire hold time plus mission time. The mission time includes the minus count time starting when the FTS has switched to the final internal power configuration (battery) through normal flight, with two ARM and DESTROY commands at the end of the time period. **NOTE:** The 30-min, hang-fire hold time applies only to vehicles using solid propellants and vehicles using solid propellant ignition systems.

c. An analysis shall be provided to demonstrate compliance with sufficient battery life availability at launch prior to the qualification test.

d. Battery Storage Life

1. The battery shall meet design requirements of this section after a storage life of a minimum of two years from date of manufacture.

2. Lot buys shall include enough cells to provide a continuous data base throughout the life of the lot in accordance with Appendix 4B4.

#### 4.8.7.2 FTS Battery Electrical Characteristics

a. Batteries used to provide power to EED initiators shall be capable of meeting the following criteria:

1. Delivering (1) 1.5 times the all-fire current (qualification test level) or (2) 2 times the Bruceton current or (3) manufacturer recommended sure-fire current, whichever is greater.

2. The pulse duration of the current pulse shall be two times greater than the duration required to fire the initiator or 100 msec, whichever is greater.

3. This pulse capacity shall include the expected number of command sets (ARM and DESTROY) planned during the destruct end-to-end test but not less than 4 command sets plus flight commands and ground processing pulses including load checks, conditioning, and firing of initiators.

4. The current shall be delivered to the ordnance initiator at the lowest system battery voltage, using the worst case system tolerances.

b. The lowest system battery voltage, including all load conditions, shall be the FTS electrical components' minimum acceptance-test voltage. *EXCEPTION: The minimum voltage during pulse applications due to firing low voltage initiators shall be FTS electrical components' minimum qualification-test voltage.*

c. The resistance between all battery terminals and between each terminal or pin to case shall be 2 megohms or greater when measured at a potential of  $500 \pm 25$  VDC prior to activation of the battery.

#### 4.8.7.3 FTS Battery Electrical Protection

a. Battery connectors shall be designed to prevent reverse polarity.

b. Diodes shall be used to prevent reverse current. **NOTE:** The diodes may be placed in the battery or in external circuitry.

c. If a battery is not connected to the system, the battery terminals or connector plug shall be taped, guarded, or otherwise given positive protection against shorting.

d. The battery shall be capable of accepting without damage or degradation an overcharge. The percentage overcharge based on nominal capacity rating of the battery and cell shall be specified. This shall include a maximum time limit based on the nominal charging rate.

#### 4.8.7.4 FTS Battery Monitoring Capability

a. The voltage of each battery shall have the capability to be monitored within 2 percent accuracy via telemetry and hardline.

b. Batteries requiring heating or cooling to sustain performance shall have monitoring capability indicating the temperature of each battery. **NOTE:** The temperature sensor and telemetry combined measurement tolerance should be less than  $1.0^{\circ}\text{F}$ . This will allow qualification temperature margins to be reduced from  $10^{\circ}\text{C}$  to  $10^{\circ}\text{F}$ .

c. The battery current shall have the capability to be monitored via telemetry or hardline.

#### 4.8.7.5 FTS Battery Pressure Relief

a. Battery cases shall be designed to a 3:1 ultimate safety factor with respect to worst case pressure build-up for normal operations.

b. The battery case pressure build-up shall take into account hydraulic and temperature extremes.

c. Sealed batteries and cells shall have pressure relief capability.

d. Pressure relief devices for sealed batteries and cells shall be set to operate at a maximum of 1.5 times the operating pressure and sized such that the resulting maximum stress of the case does not exceed the yield strength of the case material.

#### 4.8.7.6 FTS Battery Accessibility

a. Batteries shall be easily accessible for inspection and replacement.

b. Provisions shall be made in the battery design to permit open circuit voltage and load testing of each cell when assembled in the battery case. **NOTE:** This testing shall take place at the Range.

#### 4.8.7.7 FTS Secondary Batteries

*a.* Batteries used in the secondary mode shall have a cycle life greater than the number of cycles to be experienced during normal processing and flight.

*b.* Battery charging circuits shall be external to the launch vehicle.

*c.* Battery charging shall be designed to prevent a runaway battery temperature and adjust current rates accordingly with a high temperature limit cutoff.

*d.* The temperature-based control shall be in addition to other methods of charge control.

*e.* An analysis shall be provided to demonstrate compliance with the battery charging temperature and current control.

#### 4.8.7.8 FTS Battery Initiators

The battery initiator and associated firing circuitry shall meet the requirements of the **FTS Low Voltage EED System Circuitry Design** section of this Chapter.

#### 4.8.7.9 Battery Identification

Each battery shall be permanently identified with the following information:

- a.* Component name
- b.* Type of construction/chemistry
- c.* Manufacturer identification
- d.* Part number
- e.* Lot and serial number
- f.* Date of manufacture
- g.* Shelf Life

#### 4.8.7.10 FTS Silver Zinc Cell and Battery Unique Requirements

*a.* Batteries shall consist of cells made from electrodes plates with the same lot date code.

*b.* Silver zinc cells that will be used for EED systems shall be optimized for pulse loading with voltage regulation above the qualification low voltage of the other electrical portions of the FTS.

*c.* Separator material shall be designed that a positive margin of useful material is available after the end of wet stand time and electrical use.

*d.* Electrolyte additives shall be specified.

*e.* Batteries shall be designed to allow activation of cells within the battery.

*f.* Electrode plate connection to cell terminals shall be maintained when exposed to qualification environments.

*g.* Heaters shall be designed to insure consistent heating of all cells.

*h.* Cell cases shall be designed to not leak when exposed to qualification environments.

*i.* Cell and battery manufacturing process shall be documented. This documentation shall include identification of all processes used from receipt of materials to final assemble. No changes to the process shall be allowed without Range Safety concurrence.

*j.* Silver zinc batteries only used in the primary mode shall have a minimum wet stand time of 60 days. Silver zinc batteries used in the secondary mode shall have:

1. A maximum number of secondary cycles specified
2. A charge retention life for each secondary cycle specified
3. An activated service life (total activated time) specified.

*k.* Silver zinc batteries shall provide the capability to individually charge each cell if the battery is to be used in the peroxide state or is used in the monoxide state but requiring electrically conditioning of the electrodes.

*l.* Minimum soak time shall be specified for both vacuum fill or gravity fill of electrolyte.

*m.* Absorption devices shall be provided to accommodate electrolyte release. This device shall not provide a conductive path between cell terminals or the cell terminals and the battery box.

*n.* Silver zinc cells that will be used in the monoxide state shall have a specified peroxide removal process.

#### 4.8.7.11 FTS Nickel Cadmium Cell and Battery Unique Requirements (Reserved)

### 4.8.8 FTS Arming Device Design

#### 4.8.8.1 FTS Arming Device General Design Requirements

Arming devices used on FTSs include electromechanical safe and arm devices (S&As), high voltage exploding bridgewire firing units (EBW-FUs), and laser firing units/optical S&As/ordnance S&As.

*a.* Arming devices are required on all FTSs.

*b.* All arming devices shall be capable of being functionally tested by ground test equipment at the launch site.

*c.* Test equipment shall be designed to simulate

input signals to the arming device and to verify that subsequent arming device outputs are within performance specifications.

*d.* No arming device shall produce a destruct output as the result of a single component failure.

*e.* All FTS arming device designs shall comply with the system arming and safing requirement sections contained within this Chapter.

*f.* Each arming device shall be designed for a service life of at least 10 years after passing its acceptance test.

*g.* FTS arming devices shall not require adjustment throughout their service life.

#### 4.8.8.2 FTS Electromechanical S&A Design

##### 4.8.8.2.1 Electromechanical S&A General Design Requirements.

*a.* When the S&A device is in the SAFE position, it shall provide mechanical isolation of the EED from the explosive train and electrical isolation of the firing circuit from the EEDs by means of:

1. The power and return lines of the firing circuit shall be disconnected.

2. The bridgewire shall be shorted and grounded through a resistor having a resistance value between 10 kilohms and 100 kilohms.

3. The explosive train shall be interrupted by a mechanical barrier capable of containing the output energy of the EED without initiating the explosive.

*b.* SAFE to ARM Transition.

1. Transition from the SAFE to ARM position shall require 90° of rotation of the mechanical barrier for rotating S&As containing ordnance in the barrier.

2. SAFE to ARM transition tolerances for other electromechanical S&A devices require specific Range Safety approval.

*c.* When the S&A device is in the ARM position, it shall meet the following criteria:

1. Connect power and return line of the firing circuit

2. Align the explosive train with the receptor ordnance and allow reliable initiation of 0.999 at the 95 percent confidence level

3. Bruceton type testing or other statistical methods acceptable to Range Safety shall be performed to establish initiation reliability.

*d.* Detonation Propagation.

1. The S&A device shall not be capable of

propagating the detonation with the barrier rotated at least 50° from SAFE for a 90° rotational barrier.

2. The S&A device shall not be capable of propagating the detonation with the barrier at 50 percent of the travel distance between ARM and SAFE for sliding barriers.

3. The S&A device shall contain fragments when functioned in both arm and safe configurations.

*e.* Electromechanical S&A device locations on the vehicle shall be accessible to facilitate installation and/or removal of electrical and/or ordnance connections during final vehicle closeout.

*f.* S&A electrical contacts (firing circuit) should be designed not to chatter when exposed to flight loads (acoustic, shock, and vibration).

**NOTE:** If chattering is experienced during environmental testing, the acceptability of this chatter shall be demonstrated by analysis.

*g.* Shielding Cap.

1. The S&A device shall have shielding caps attached to the firing connectors during storage, handling, transportation, and installation up to firing line connection.

2. The shielding caps shall have a solid metal outer shell that make electrical contact with the firing circuit case in the same manner as the mating connector.

*h.* Motor Stalling.

1. The S&A devices shall be designed to meet all performance requirements after the application of maximum operational arming voltages continuously for periods of up to 5 min with the safing pin installed.

2. Stalling shall not create a hazardous condition when arming voltages are applied continuously for 1 h with the safing pin installed.

*i.* The S&A device shall be required to propagate a detonation after a 6-ft drop on to a steel plate if the effects of the drop are not detectable.

*j.* The S&A shall not initiate and shall be safe to handle for subsequent disposal after subjected to a 20-ft drop on to a steel plate.

*k.* The electromechanical S&A device sealing shall be designed to survive exposure to environments such as humidity, salt fog, fungus resistance, explosive atmosphere, and fine salt described in Appendix 4B1 without degradation.

##### 4.8.8.2.2 Electromechanical S&A ARM and

### SAFE Mechanisms.

a. The S&A device shall be designed to incorporate provisions to safe the ordnance train from any rotor and/or barrier position.

b. The time required to ARM or SAFE an electromechanical S&A device shall not exceed 1 sec after application of the actuation signal.

c. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

d. A mechanical lock within the S&A shall prevent inadvertent transfer from the arm to safe position (or vice versa), under all operational environments without the application of any electrical signal.

e. S&As shall be capable of being remotely safed and armed.

f. S&As shall not be capable of being manually armed, but shall be capable of being manually safed.

g. Electromechanical S&A remote and manual safing shall be accomplished without passing through the armed position.

#### 4.8.8.2.3 Electromechanical S&A Status Indicators.

a. The electrical continuity of one status circuit of the electromechanical S&A device (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

b. Electromechanical S&A Remote and Visual Status Indicators.

1. A remote status indicator shall be provided to show the armed or safed condition.

2. A visual status indicator shall also be provided to show the armed or safe condition by simple visual inspection.

3. Easy access to the visual status indicator shall be provided throughout ground processing.

4. During checkout, the remote status indicator circuits shall be capable of being monitored by Range ground support equipment.

c. The S&A ARM signal shall only be indicated visually or remotely when the device is in a position that aligns the explosive train with the receptor ordnance and allows reliable initiation.

d. The S&A SAFE signal shall not be indicated

visually or remotely unless the device is less than 10° from the SAFE position for rotating systems or 10 percent from the SAFE position for sliding barriers.

e. No visual indication of SAFE or ARM shall appear if the device is in between the SAFE and ARM positions. **NOTE:** The S&A will be considered "not safe" or armed if the indicator does not show SAFE.

#### 4.8.8.2.4 Electromechanical S&A Safing Pins.

A safing pin shall be used in the S&A device to prevent movement from the SAFE to the ARM position when arming power is applied.

a. Rotation and/or transition of the mechanical barrier to the aligned explosive train and electrical continuity of the firing circuit to the EED shall not be possible with the safing pin installed.

b. The safing pin shall be accessible through final launch complex clear.

c. When inserted and rotated, the safing pin shall manually safe the device.

d. The force required for safing pin insertion shall be between 20 and 40 lb and/or 20 to 40 in. lb of torque.

e. Removal of the safing pin shall not be possible if the arming circuit is energized. The retention mechanism of the safing pin shall be capable of withstanding an applied force of at least 100 lb tension or a torque of 100 in-lb without failure.

f. Removal of the safing pin shall not cause the device to automatically arm.

g. Removal of the safing pin shall be inhibited by a locking mechanism requiring 90° rotation of the pin. The removal force shall be 3 to 10 in. lb of torque.

#### h. Warning Streamers

1. The safing pin shall provide a means of attaching warning streamers.

2. When installed, all safing items shall be marked by a red streamer.

#### 4.8.8.2.5 Electromechanical S&A Explosive Devices.

a. Each explosive device such as an EED, booster charge, or rotor leads in an S&A assembly shall be designed in accordance with each applicable section in this Chapter.

b. Each explosive device such as an EED, booster charge, or rotor leads in an S&A assembly shall be hermetically sealed to the equivalent of 5 X

$10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

c. Each explosive device such as an EED, booster charge, or rotor leads in an S&A assembly shall be individually subjected to qualification and acceptance testing.

#### **4.8.8.3 FTS High Voltage Exploding Bridge-wire Firing Units Design**

##### **4.8.8.3.1 EBW-FU General Design Requirements.**

a. The EBW-FU shall provide circuits for capacitor charging, bleeding, charge interruption, and triggering.

b. The EBW-FU charged capacitor circuit shall have a dual bleed system with either system capable of independently bleeding off the stored capacitor charge.

c. EBW-FU design shall provide a positive, remotely controlled means of interrupting the capacitor charging circuit.

d. The EBW-FU shall be capable of being remotely safed and armed.

e. A gap tube shall be provided to interrupt the discharge of the high voltage capacitor in the output circuit.

f. The insulation resistance between each EBW-FU high voltage output circuit and the case shall be designed to be not less than 50 megohms at two times the maximum operating voltage or 500 Vdc whichever is greater.

g. The isolation resistance between EBW-FU output circuits and any other circuits shall be not less than 50 megohms.

h. EBW-FUs shall be designed to be discriminatory to spurious signals in accordance with the requirements in MIL-STD-461.

i. EBW-FUs shall have an operating life of at least five times the expected number of firings required for checkout and operations or 1,000 firings without degradation.

j. The EBW-FU shall be capable of a power ON duty cycle of not less than 45 min with a power OFF period of not more than 2 min.

k. The EBW-FU shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

l. The FTS shall be designed so that all high voltage capacitors in the EBW-FUs can be functionally tested using EBW simulators within 24 h of launch.

##### **4.8.8.3.2 EBW-FU Monitor Circuits.**

a. At a minimum, EBW-FU monitor circuits shall provide the status of the trigger capacitor, high voltage capacitor, arm and destruct input, inhibit input (if used), and power.

b. EBW-FU monitor circuits shall allow for fault isolation and failure diagnosis of assembled units.

c. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other status circuit.

##### **4.8.8.3.3 EBW-FU Remote DISCHARGED and CHARGED Indicators.**

a. EBW-FU Remote DISCHARGED Indicators.

1. Remote DISCHARGED indicators for EBW-FUs shall not appear unless the capacitor bank voltage is one-half or less of the No-Fire voltage of the EBW.

2. The EBW-FU shall be considered "not safe" if the indicator does not show DISCHARGED.

b. EBW-FU Remote CHARGED Indicators.

1. Remote CHARGED indicators for EBW-FUs shall not appear unless the capacitor bank voltage is at least 95 percent of the capacitor's nominal operating voltage.

2. The exact voltage used to establish the CHARGED indication shall be determined by the Range User and Range Safety after evaluating the EBW-FU firing performance characteristics.

#### **4.8.8.4 Laser Firing Unit, Optical Barrier, Optical S&A, and Ordnance S&A Design**

a. The following Laser Firing Unit, Optical Barrier, Optical S&A, and Ordnance S&A design requirements shall be applied according to the safing device used.

b. The conceptual configuration of the safing devices to be used shall be coordinated with Range Safety as early as possible to ensure that the configuration is acceptable.

##### **4.8.8.4.1 Laser Firing Units.**

a. *Laser Firing Unit General Design Requirements.*

1. Laser firing units (LFUs) shall provide a positive, remotely controlled means of interrupting the power to the firing circuit.

2. Capacitor charging circuits shall have a

dual bleed system with each system capable of independently bleeding off the stored charge.

3. A gap tube shall be provided that interrupts the discharge of a high voltage capacitor in the output circuit in a high voltage LFU.

4. LFUs shall be designed to be discriminatory to spurious signals in accordance with MIL-STD-461.

5. Low voltage LFUs shall provide a continuous spurious energy monitor and/or detection circuit on the input firing line capable of indicating a minimum of one-tenth of the minimum input firing voltage or current level.

6. LFUs shall have an operating life of at least five times the expected number of cycles required for checkout and operations or 1,000 firings without degradation.

7. The LFU shall be capable of a power ON duty cycle of not less than 45 min with a power OFF period of not more than 2 min.

8. The LFU shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

*b. Laser Firing Unit Monitor Circuits.*

1. At a minimum, LFU monitor circuits shall provide the status of the trigger capacitor, high voltage capacitor, arm and destruct input, barrier position, barrier locked/unlocked, inhibit input, and power as applicable.

2. LFU monitor circuits shall allow for fault isolation and failure diagnosis of assembled units.

3. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other status circuit.

*c. Laser Firing Unit Remote CHARGED and DISCHARGED Indicators*

1. A remote DISCHARGED indicator for LFUs that use a capacitor bank shall not appear unless the capacitor bank voltage is 50 percent or less of the no-fire voltage of the LID. **NOTE:** The LFU will be considered "not safe" if the indicator does not show DISCHARGED.

2. A remote CHARGED indicator for LFUs that use a capacitor bank shall not appear unless the capacitor bank is at least 95 percent of the capacitor's nominal operating voltage.

3. The exact voltage used to establish the CHARGED indication shall be determined by the Range User and Range Safety after evaluating the

LFU firing performance characteristics.

#### 4.8.8.4.2 Optical Barriers.

##### a. Optical Barrier General Design Requirements.

1. The safe position of the optical barrier shall be capable of absorbing or redirecting the complete optical energy source to a safe receiver.

(a) The barrier shall be capable of absorbing and/or redirecting 100 times the maximum energy that the laser can generate.

(b) Depending on barrier design, the safety factor shall be calculated using several possible variables such as distance from nominal beam spot to the edge of the barrier or edge of aperture, distance or degrees between ARM and SAFE, laser energy deflected, and mechanical tolerances.

2. The optical barrier shall maintain the safety margin and function nominally after being pulsed by the main laser a minimum of four times the expected lifetime number of pulses or 10 pulses whichever is greater at the maximum firing rate and power of the laser.

3. The control of barriers, mechanical locks and monitors shall be independent of the firing circuit.

4. A constant 5 min application of arming voltage with the mechanical lock of the barriers engaged shall not cause the optical train to go to the ARM position.

5. All optical barriers shall be designed to withstand repeated cycling from the ARM to the SAFE positions for at least 1,000 cycles without any malfunction, failure, or deterioration in performance. **NOTE:** If the device is to be used for a program with a known operating life cycle, Range Safety may accept a design cycle life of at least five times the expected number of cycles.

##### b. Optical Barrier Status Indicators.

1. A remote status indicator of the optical barriers located in LFU or optical S&A shall be provided.

2. A visual indicator of optical barrier status shall also be provided on the device or at a nearby location so that it is easily seen by operating personnel.

(a) If a visual indicator is provided on the barrier, it shall be readily accessible to personnel on the complex and/or facility.

(b) If a visual indicator on the LFU or

S&A device is not provided, redundant electronic remote status indicators shall be provided at the launch pad and launch control center to show the armed or safe status of the LFU or S&A barriers.

##### 3. ARM and SAFE position.

(a) The ARM position shall not be indicated unless the optical barriers are in a position that will align the optical train and allow initiation of the LID with the required 0.999 reliability at a 95 percent confidence level.

(b) The SAFE position shall not be indicated unless the optical barriers are in the SAFE position that will not align the optical train and not allow initiation of the LID with a reliability of 0.999 at 95 percent confidence.

(c) Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish ARM and SAFE reliability.

(d) The optical barrier will be considered not safe or armed if the indicator does not show SAFE.

#### 4.8.8.4.3 Optical S&As.

a. When an optical safe and arm device is in the laser safe position, the following criteria shall be met:

1. The optical transfer assembly shall be interrupted by a minimum of two mechanical barriers that can be mechanically locked in place.

2. The main laser power circuit shall be electrically disconnected. **NOTE:** This main laser power interrupt capability will not be required if the power circuit to the mechanical barriers is interrupted by an Arm/Safe plug.

3. Optical S&As shall be capable of being remotely safed and armed.

4. Optical S&As shall not be capable of being manually armed but they shall be capable of being manually safed.

5. Remote and manual safing shall be accomplished without passing through the armed position.

b. The optical S&A barriers shall meet the requirements of the **Optical Barriers** section of this Chapter.

c. Optical S&A shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

d. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other

status circuit.

*e.* The S&A shall provide status of the optical barriers (ARM, SAFE), barriers locked/unlocked, and electrical inhibits.

*f.* The insulation resistance between each S&A circuit and the case shall not be less than 2 megohms at 500 Vdc.

*g.* All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

*h.* A constant 5 min application of S&A arming voltage shall not cause malfunction, failure, or deterioration in performance.

*i.* The time required to ARM or SAFE an S&A device shall not exceed 1 sec after application of the actuation signal.

#### 4.8.8.4.4 Ordnance S&A.

*a. FTS Ordnance S&A General Design Requirements.*

1. When the S&A device is in the SAFE position, the explosive train shall be interrupted by a mechanical barrier capable of containing the output energy of the explosive.

2. SAFE to ARM Transition.

(a) Transition from the SAFE to ARM position shall require 90° of rotation of the mechanical barrier for rotating S&As containing ordnance in the barrier.

(b) SAFE to ARM transition tolerances for other electromechanical S&A devices require specific Range Safety approval.

3. When the S&A device is in the ARM position, it shall meet the following criteria:

(a) Alignment of the explosive train with the receptor ordnance and allow reliable initiation of 0.999 at 95 percent confidence level.

(b) Bruceton type testing or other statistical methods acceptable to Range Safety shall be performed to establish initiation reliability.

4. Detonation Propagation.

(a) The S&A device shall not be capable of propagating the detonation with the barrier rotated at least 50° from SAFE for a 90° rotational barrier.

(b) The S&A device shall not be capable of propagating the detonation with the barrier at 50 percent of the travel distance between ARM and

SAFE for sliding barriers.

(c) The S&A device shall contain fragments when functioned in both ARM and SAFE configurations.

5. Ordnance S&A device locations on the vehicle shall be accessible to facilitate installation and/or removal ordnance connections during final vehicle closeout.

6. Motor Stalling.

(a) The S&A devices shall be designed to meet all performance requirements after the application of maximum operational arming voltages continuously for periods of up to 5 min with the safing pin installed.

(b) Stalling shall not create a hazardous condition when arming voltages are applied continuously for 1 h with the safing pin installed.

7. The S&A device shall be required to propagate a detonation after a 6-ft drop on to a steel plate if the effects of the drop are not detectable.

8. The S&A shall not initiate and shall be safe to handle for subsequent disposal after being subjected to a 20-ft drop on to a steel plate.

9. The ordnance S&A device sealing shall be designed to survive exposure to environments such as humidity, salt fog, fungus resistance, explosive atmosphere, and fine salt described in Test Appendix 4B1.

*b. Ordnance S&A Arm and Safe Mechanisms.*

1. The S&A device shall be designed to incorporate provisions to safe the ordnance train from any rotor and/or barrier position.

2. The time required to ARM or SAFE an electromechanical S&A device shall not exceed 1 sec after application of the actuation signal.

3. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

4. A mechanical lock in the S&A shall prevent inadvertent transfer from the ARM to SAFE position (or vice versa), under all operational environments without the application of any electrical signal.

5. S&As shall be capable of being remotely safed and armed.

6. S&As shall not be capable of being

manually armed, but shall be capable of being manually safed.

7. Ordnance S&A remote and manual safing shall be accomplished without passing through the armed position.

*c. Ordnance S&A Status Indicators.*

1. The electrical continuity of one status circuit of the electromechanical S&A device (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

2. Ordnance S&A Remote and Visual Status Indicators.

(a) A remote status indicator shall be provided to show the armed or safed condition.

(b) A visual status indicator shall also be provided to show the armed or safe condition by simple visual inspection.

(c) Easy access to the visual status indicator shall be provided throughout ground processing.

(d) During checkout, the remote status indicator circuits shall be capable of being monitored by Range ground support equipment.

3. The S&A ARM signal shall only be indicated visually or remotely when the device is in a lock position that aligns the explosive train with the receptor ordnance and allows reliable initiation.

4. The S&A SAFE signal shall not be indicated visually or remotely unless the device is less than 10° from the SAFE position for rotating systems or 10 percent from the SAFE position for sliding barriers.

5. No visual indication of SAFE or ARM shall appear if the device is in between the SAFE and ARM positions. **NOTE:** The S&A will be considered "not safe" or armed if the indicator does not show SAFE.

*d. Ordnance S&A Safing Pins.* A safing pin shall be used in the S&A device to prevent movement from the SAFE to the ARM position when arming power is applied.

1. Rotation and/or transition of the mechanical barrier to the aligned explosive train shall not be possible with the safing pin installed.

2. The safing pin shall be accessible through final launch complex clear.

3. When inserted and rotated manually, the safing pin shall manually safe the device.

4. The force required for safing pin insertion shall be between 20 and 40 lb and/or 20 to 40 in. lb

of torque.

5. Removal of the safing pin shall not be possible if the arming circuit is energized. The retention mechanism of the safing pin shall be capable of withstanding an applied force of at least 100 lb tension or a torque of 100 in. lb without failure.

6. Removal of the safing pin shall not cause the device to automatically ARM.

7. Removal of the safing pin shall be inhibited by a locking mechanism requiring 90° rotation of the pin. The removal force shall be 3 to 10 in. lb of torque.

*8. Warning Streamers*

(a) The safing pin shall provide a means of attaching warning streamers.

(b) When installed, all safing items shall be marked by a red streamer.

*e. Ordnance S&A Explosive Devices.*

1. Each explosive device such as an LID, booster charge, or rotor leads in an S&A assembly shall be designed in accordance with each applicable section of this document.

2. Each explosive device such as an LID, booster charge, or rotor leads in an S&A assembly shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

3. Each explosive device such as an LID, booster charge, or rotor leads in an S&A assembly shall be individually subjected to qualification and acceptance testing.

#### **4.8.8.5 FTS Arming and Safing Plugs Design**

a. Safing plugs shall be designed to be manually installed to provide electrical isolation of the input power from the EBW-FU or LFU.

b. Arming plugs shall be designed to be manually installed to provide electrical continuity from the input power to the EBW-FU or LFU.

c. Arming and Safing plugs shall be designed to be positively identifiable by color, shape, and name.

d. The design of arming and safing plugs and their location shall ensure easy access for plug installation and removal just prior to final launch complex clear.

#### **4.8.9 FTS Ordnance Components Design**

##### **4.8.9.1 FTS EEDs**

###### **4.8.9.1.1 EED All-Fire and No-Fire Levels.**

a. The all-fire current level design shall be at 99.9 percent firing level with a 95 percent confidence level.

b. The no-fire current level design shall be at 0.1 percent firing level with 95 percent confidence level.

c. The all-fire and no-fire current level shall be demonstrated using the Bruceton test or other statistical testing methods acceptable to Range Safety.

#### 4.8.9.1.2 EED General Design Requirements.

a. Carbon bridgewires and conductive mixes without bridgewires are prohibited.

b. The EED autoignition temperature shall not be less than 150°C.

c. Insulation resistance between pin-to-case shall not be less than 2 megohms at 500 Vdc.

d. EEDs shall be designed to withstand a constant direct current firing pulse of 1 ampere minimum and 1 watt power minimum for a period of 5 min minimum duration without initiation or deterioration of performance.

e. EEDs shall be designed to withstand electrostatic discharge without being fire, dud or deteriorate in performance when subjected to the following conditions:

1. As a result of being subjected to an electrostatic discharge of 25 kV (kilovolt) from a 500 picofarad capacitor applied in the pin-to-case mode without a series resistor

2. As a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-pin mode with a 5 kilohms resistor in series

f. EEDs shall be designed to survive the RF environments as defined in the testing criteria described in Appendix 4B6.

g. The outer case of the EED main body shall be made of conductive material.

h. The EED main body shall not rupture or fragment when the device is fired. **NOTE:** Displacement or deformation of the connector and main housing is permissible; rupture or deformation of the outer end is permissible.

i. The EED shall not initiate and will perform to specification after being subjected to a 6-ft drop onto a steel plate.

j. The EED shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The EED is not required to function after the 40-ft

drop test.

k. EED initiator pins (terminals) shall withstand an axial pull of at least 18 lb for not less than 1 min or meet an alternate specification acceptable to Range Safety.

l. The EED shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

#### 4.8.9.2 FTS EBWs

##### 4.8.9.2.1 EBW All-Fire and No-Fire Levels.

a. The all-fire current and voltage level design shall be at 99.9 percent firing level with a 95 percent confidence level.

b. The no-fire current and voltage level design shall be at 0.1 percent firing level with 95 percent confidence level.

c. The all-fire and no-fire current and voltage level shall be demonstrated using the Bruceton test or other statistical testing methods acceptable to Range Safety.

##### 4.8.9.2.2 EBW General Design Requirements.

a. Explosive materials shall be a secondary explosive such as PETN or RDX.

b. Autoignition temperature of the EBW shall not be less than 150°C.

c. The insulation resistance pin-to-case design shall not be less than 50 megohms at two times the maximum operating voltage or 500 Vdc, whichever is greater.

d. EBW designed shall include a voltage blocking gap.

1. The gap breakdown voltage shall not be less than 650 Vdc when discharged from a  $0.025 \pm 10$  percent microfarad capacitor.

2. The nominal gap breakdown voltage tolerance shall be specified and approved by Range Safety.

e. The EBW shall not fire, dud or deteriorate in performance upon being subjected to a voltage of 125 Vac (RMS) at 60 Hz applied across the terminals or between the terminals and the EBW body for 5 min.

f. The EBW shall not fire or degrade to the extent that it is unsafe to handle when 230 Vac (RMS) at 60 Hz is applied across the terminals or between the terminals and EBW body for 5 min.

g. The EBW shall not fire, dud, or deteriorate in performance upon being subjected to a source of 500 Vdc having an output capacitance of  $1.0 \pm 10$

percent microfarads applied across the terminals or between the terminals and the EBW body for 60 sec.

*h.* The EBW shall be designed to withstand electrostatic discharge without being fire, dud or deteriorate in performance when subjected to the following conditions:

*1.* As a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-case mode without a series resistor

*2.* As a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-pin mode with a 5 kilohms resistor in series

*i.* The EBW shall not fire, dud, or deteriorate in performance after exposure to that level of power equivalent to absorption by the test item of 1.0 watt average power at any frequency within each RF energy range specified in Table 4-4. The RF energy shall be applied across the input terminals of the EBW detonator for 5 sec.

**Table 4-4**  
**RF Sensitivity**

Frequency (in Megahertz)	Type
5 - 100	Continuous Wave
250 - 300	Continuous Wave
400 - 500	Continuous Wave
800 - 1000	Continuous Wave
2000 - 2400	Continuous Wave
2900 - 3100	Continuous Wave
5000 - 6000	Continuous Wave
9800 - 10000	Continuous Wave
16000 - 23000	Pulse Wave <sup>a</sup>
32000 - 40000	Pulse Wave <sup>a</sup>

<sup>a</sup>Pulsed repetition frequency shall be not less than 100 Hertz and the pulse width shall be a minimum of 1.0 microsecond.

*j.* The EBW shall not initiate and will perform to specification after being subjected to a 6-ft drop onto a steel plate.

*k.* The EBW shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The EBW is not required to function after the 40-ft drop test.

*l.* EBW initiator pins (terminals) shall withstand an axial pull of at least 18 lb for not less than 1 min or meet an alternate specification acceptable to Range Safety.

*m.* EBW initiators shall be hermetically sealed

to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

#### 4.8.9.3 FTS LIDs

##### 4.8.9.3.1 LID All-Fire and No-Fire Levels.

*a.* The all-fire energy level design shall be at 99.9 percent firing level with a 95 percent confidence level.

*b.* The no-fire energy level design shall be at 0.1 percent firing level with 95 percent confidence level.

*c.* The all-fire energy level shall be at least ten times the no-fire energy level.

*d.* The all-fire and no-fire energy level shall be demonstrated using the Bruceton test or other statistical testing methods acceptable to Range Safety.

*e.* The all-fire and no-fire energy level shall also, shall take into account the effects of the temperature of the explosive as well as effects caused by manufacturing variations in explosive grain size and pressure.

*f.* The LID shall also be designed to withstand the no-fire energy level for a minimum of 5 min without firing or dudding the LID.

*g.* LIDs in flight configuration shall be tested to determine their susceptibility to all stray energy sources such as strobe, sunlight, arc welder, flash-lamps, lightning, RF, AC and DC electrical energy present during prelaunch processing and the flight environment.

*1.* The susceptibility to stray energy applies to both inadvertent firing and dudding.

*2.* LID sensitivity characteristics to these energy sources shall be established by testing a minimum of 45 LIDs per the Bruceton test or other statistical testing method acceptable to Range Safety.

*3.* At a minimum, statistical testing shall include spot size, pulse width, energy density, and wave length.

*4.* A correlation between the test specified in paragraph 2 above and the no-fire level established for the LID shall be provided to Range Safety for review and approval. At a minimum, the LID no-fire energy shall be  $10^4$  greater than any credible stray energy source.

*5.* If the LID sensitivity requirements stated above are not met, the explosive train shall remain disconnected until just prior to final pad evacuation for launch or an ordnance S&A device shall be re-

quired between the LID and explosive transfer system.

compliance with this requirement.

#### 4.8.9.3.2 LID General Design Requirements.

*a.* The autoignition temperature of the LID shall not be less than 150°C.

*b.* LIDs shall not use primary explosives.

*1.* If modified secondary (composition) explosives are used, their sensitivity characteristics shall be established by test in accordance with MIL-STD-1751, ADA 086259, or the equivalent.

*2.* The test requirements and test report shall be reviewed and approved by Range Safety.

*c.* LIDs shall have specific energy density, spot size, pulse width, and wavelength characteristics with specified tolerance level for each characteristic.

*d.* The LID shall be designed to function normally when subjected to a firing pulse of at least 2 times the operational pulse energy including worst-case LFU, fiber optic cable assembly (FOCA), and connector loss tolerances.

*e.* LIDs shall be designed to withstand electrostatic discharge without being fired, dudged, or deteriorating in performance when subjected to a discharge of 25 kV from a 500 picofarad capacitor. The test configuration shall be approved by Range Safety.

*f.* LIDs shall not initiate and will perform to specification after being subjected to a 6-ft drop test onto a steel plate.

*g.* The LID shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop test onto a steel plate. **NOTE:** The LID is not required to function after the 40-ft drop test.

*h.* LIDs shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

*i.* LIDs shall have a capability of shielding the energy density levels greater than 1/10,000 of the no-fire level of the ordnance initiator during prelaunch processing, shipment, storage, handling, installation, and testing. This energy constraint shall be applied at the end of the fiber optic cable just prior to its entrance into the laser ordnance initiator and/or reflective coating.

*j.* LIDs shall have a capability to dissipate heat faster than single failure conditions can input into the device without initiating or dudging. An analysis shall be provided to demonstrate

*k.* Optical Shielding and Protection Caps.

*1.* Optical shielding and protective caps shall be provided for LIDs during prelaunch processing, including shipment, storage, handling, installation and testing.

*2.* These devices shall prevent exposure of the LID to energy density levels greater than 1/10,000 of the no-fire level of the LID.

*3.* Reflective coatings of the LID shall not be considered part of the shield.

*4.* The shielding cap shall be designed to accommodate the tool used during installation without the removal of the cap.

*l.* For LID that incorporate fiber optic cable as an integral part of the LID (Pigtail). The pigtail design shall be capable of withstanding an axial pull of 100 lb for 1 min. This requirement may be relaxed to 30 lb if a final continuity test is performed prior to final close out and just prior to launch.

#### 4.8.9.4 FTS Percussion Activated Devices

*a.* Percussion Activated Device (PAD) lanyard pull system shall provide for a protective cover over the lanyard to prevent inadvertent pulling.

*b.* The PAD shall contain fragments when functioned.

*c.* The PAD location on the vehicle shall be accessible to facilitate installation and/or removal of ordnance connection during final vehicle close out.

*d.* The PAD shall be required to perform to specifications after being subjected to a 6-ft drop onto a steel plate if the effects of the drop are undetectable.

*e.* The PAD shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The device is not required to function after this test.

*f.* Lanyard breaking strength shall be at least 5 times the operating tension.

*g.* The PAD shall be sealed. The leak rate through the PAD seal shall not be greater than  $10^{-4}$  scc/sec helium.

*h.* The operating energy delivered by the firing mechanism shall be at least 2 times the all fire energy of the primer.

*i.* The firing mechanism and primer shall reliably function with an impact of at least 2 times the operational energy (4 times all-fire).

*j.* The firing mechanism shall be designed to meet

the following criteria:

*1.* The firing pin mechanism shall be designed such that it does not come in contact with the primer unless it is pulled to the all-fire distance.

*2.* After the firing pin mechanism is pulled the all-fire distance, the mechanism shall automatically release and allow the firing pin to strike the primer.

*k.* The minimum no-fire pull force level shall be 50 lb. Releasing the lanyard with a 50 lb pull force shall not cause firing or degradation of the PAD. **NOTE:** This is the force that is guaranteed to not allow the firing pin mechanism to release.

*l.* The spring constant of the firing spring shall be specified. The PAD shall be designed to allow testing to verify the specified spring constant.

*m.* A safing pin for the PAD is required that prevents movement of the firing pin mechanism.

*1.* When the pin is installed, it shall be capable of preventing a 200 lb pull on the lanyard from causing the fire mechanism to move.

*2.* The force required for safing pin insertion and removal shall be between 20 to 40 lb and/or 20 to 40 inch-pounds of torque when the lanyard is unloaded.

*3.* With a preload of 50 lb applied to the lanyard, the pin shall not be capable of being removed when subjected to two times the required force for safing pin insertion/removal in paragraph *m 2* above.

*4.* A positive verification shall be designed to ensure the safing pin is installed correctly.

*n.* The safing pin shall be accessible until final clearance of the launch pad.

*o.* The safing pin shall have a red warning streamer.

*p.* Ordnance used in the PAD shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec Helium or other leak rate approved by Range Safety.

*q.* Each explosive device contained within the PAD shall be individually subjected to qualification and acceptance testing.

#### 4.8.9.5 FTS Explosive Transfer System

Explosive transfer systems (ETS) are used to transmit the initiation reaction from the initiator to the destruct charge. Most explosive transfer system (ETS) harnesses contain flexible confined detonation cord (FCDC), mild detonating cord (MDC), or a mild detonating fuse (MDF) terminated by end booster caps or manifolds.

a. Explosives used in ETS lines shall be secondary explosives.

b. The end booster caps and manifolds design shall contain the necessary explosive charges to transfer the reaction from one interface to another in the system.

c. Flexible confined detonating cord (FCDC) shall not fragment or separate from end fittings upon initiation. **NOTE:** Gaseous emission is permissible.

d. All ETS donor and receptor interface components shall support the overall FTS reliability goal.

e. The flexible portion of the ETS shall have its minimum bend radius specified so that the system reliability is maintained.

f. ETS fittings shall be designed and located to facilitate installation of the destruct system ordnance components in the launch vehicle as late as practical.

g. All ETS interconnections shall be capable of being visually inspected to verify proper connection.

h. Fittings that must not be reversed or interchanged shall be designed so that reverse installation or interchange is not possible.

i. Fitting placement on the launch vehicle shall not create a potential for installation misalignment.

j. All ETS interconnections shall provide for safety (lock) wiring or a Range Safety approved equivalent.

k. All ETS interconnections shall be capable of connection and disconnection at least 5 times the number of planned cycles.

l. Exposed end fittings shall be equipped with protective caps.

m. An electrically conductive path shall exist between the metallic sheath and end fitting, and between end fittings connected by a manifold type components. As a goal, the bonding resistance should be designed to be 2.5 milliohms but in no case shall it exceed 5 ohms.

n. ETS components shall be capable of withstanding an axial pull of at least 100 lb for 1 min without degradation.

o. The ETS shall be capable of performing its function after being subjected to a 6-ft drop onto a steel plate if the effects of the drop are not detectable.

p. The ETS shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The ETS

is not required to function after the 40-ft drop test.

q. ETS components shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

#### 4.8.9.6 FTS Destruct Charge

Destruct charges may be linear shaped charges, conical shaped charges, pancake charges, explosively formed projectiles (EFPs), or primacord (detonating cord).

a. Explosive Composition.

1. Destruct charges shall use secondary high explosives such as PETN, RDX, HMX, or HNS.

2. Explosives shall be non-hygroscopic.

3. Specific approval from Range Safety is required for all explosive compositions.

b. Destruct charges shall be compatible with the initiator and ETS to ensure reliable initiation consistent with the overall FTS reliability goal.

c. Destruct charge initiation shall result in the appropriate flight termination action as described in the **Flight Termination Action Requirements** section of this Chapter.

d. Destruct charges shall be designed to sever or penetrate the required maximum thickness of the specified material. The following margin shall be demonstrated:

1. Five charges shall be test fired using 1.5 times the maximum thickness of the specified material at the maximum stand-off.

2. For Range Users using Class 1.1 propellant, the required margin will be determined on a case-by-case basis to avoid detonation of the propellant.

e. Linear Shaped Charge.

1. Flexible or non-flexible linear shaped charges (LSC) shall be designed so that at their minimum bend radius, the sheath shall not crack nor expose the explosive core, and the charge shall function reliably along its total length.

2. LSC shall be designed and manufactured to ensure that outer sheath and explosive charge asymmetries are minimized.

f. Impression stamping for identification or warnings shall not be used on destruct charges and associated fittings.

g. Destruct charge holders and/or brackets shall be designed for stiffness and strength to ensure proper charge orientation such as distance and alignment during flight.

h. Destruct charges and associated fittings shall be capable of withstanding an axial pull of a least

50 lb for a 1-min minimum without degradation.

*i.* The destruct charge shall not detonate and both detonation and target severance shall function properly after a 6-ft drop on to a steel plate if the effects of the drop are not detectable.

*j.* The destruct charge shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate.

**NOTE:** The destruct charge is not required to function after the 40-ft drop test.

*k.* Destruct charges shall be hermetically sealed to the equivalent of  $5 \times 10^{-6}$  scc/sec helium or other leak rate approved by Range Safety.

#### 4.8.10 FTS Shock and Vibrational Mounted Isolation Systems Design

*a.* Any system that uses a shock and/or vibrational isolation system such as vibrational mounts, foam rubber, rubber washers or gaskets that are essential to ensure the induced environmental survivability of a component shall be approved by Range Safety.

*b.* The shock and/or vibrational isolator shall be designed and controlled to the following criteria:

1. Isolator characteristics shall be specified in the source control drawing.

2. The allowable variation of the resonant amplification factor ( $Q$ ), isolator resonant frequency ( $f_n$ ) and the product of the square root of  $f_n$  and  $Q$  about nominal values shall be stated in all three principal axes.

3. When elastomeric isolators are used, they shall be bonded to the supporting hardware, minimizing the variations in the  $f_n$  and  $Q$ .

4. When metallic isolators such as spring or steel mesh types are used, they shall be in a container to prevent contamination.

#### 4.8.11 Miscellaneous FTS Components Design

Proposed concepts for electrical, electronic, mechanical, ordnance, and other components and/or boxes used in the FTS and not presently identified in this Chapter shall be submitted to Range Safety for evaluation and determination of minimum design and testing requirements.

#### 4.8.12 FTS Component Identification

At a minimum, each FTS component shall be identified with the following information:

*a.* Component name

*b.* Manufacturer identification

*c.* Part number

*d.* Lot and serial number

*e.* Date of manufacture

### 4.9 RANGE TRACKING SYSTEM GENERAL REQUIREMENTS

#### 4.9.1 Range Tracking System Ground Rules

*a.* All vehicles launched from the Range or under Range Safety control shall be equipped with a transponder system or a Global Positioning System (GPS) for flight safety applications.

*b.* Ballistic missiles that fly close to the Kwajalein Atoll or impact in the Kwajalein lagoon shall use a coherent transponder.

*c.* The RTS requirements stated in this Chapter apply to coherent and non-coherent C-band (5400-5900 MHz) transponders except as noted.

#### 4.9.2 Transponder System

*a.* The transponder system shall be capable of operating within the parameters established for normal operation of the associated ground tracking facilities. **NOTE:** Specific radar locations and characteristics, including effective radiated power and minimum reply flux densities, can be obtained from the Range.

*b.* The Range selects the radars required to provide adequate flight safety support for each specific launch.

*c.* The Range assigns carrier frequencies and interrogation pulse code parameters to individual launch agencies to facilitate multiple launch operations and prevent electromagnetic interference.

*d.* The design, manufacture, installation, and testing of the transponder system shall conform to the requirements in this Chapter.

#### 4.9.3 GPS

*a.* The use of a GPS translator or receiver shall be considered on a case-by-case basis until adequate experience has been gained to define these requirements.

*b.* GPS airborne systems include L-Band antenna systems, translators and/or receivers, power combiners and dividers, diplexers, cabling, connectors, and power.

*c.* If the airborne GPS system shares common components with vehicle telemetry systems, shared

components shall comply with GPS system design and test requirements. Examples of shared components include telemetry transmitters, S-Band down-link antennas, and associated cabling and power dividers.

d. The GPS system, including ground processing equipment for translator systems, shall provide a state vector, in accordance with the **Tracking Source Adequacy** section in Chapter 2 of this document.

#### 4.10 RTS DESIGN REQUIREMENTS

##### 4.10.1 RTS General Design Requirements

###### 4.10.1.1 RTS Design Simplicity

The number of piece/parts shall be kept to an absolute minimum.

###### 4.10.1.2 RTS Software and Firmware

a. All software and firmware used in RTS shall be subjected to independent verification and validation (IV&V) in accordance with DoDI 5000.2 AF, Sup 1, paragraph 3-9 and AFSC/AFLC Pam-phlet 800-5 or equivalent.

b. Approval shall be obtained from Range Safety prior to production of the component or system.

c. Once approved, any modification shall be validated in the same manner and approved by Range Safety prior to further production.

###### 4.10.1.3 RTS Failure Modes, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis (FMECA) shall be performed in accordance with MIL-STD-1543 (Task 204) or equivalent. Any tailoring shall be accomplished by Range Safety and the Range User.

###### 4.10.1.4 RTS Component Maximum Predicted Environment

###### 4.10.1.4.1 Determining RTS Component Maximum Predicted Environment Levels.

a. An analytical approach for determining RTS component maximum predicted environment (MPE) levels such as shock, thermal, and vibration shall be developed by the Range User and submitted to Range Safety for review and approval.

b. The analytical approach shall use existing flight data from other similar vehicles (if available), analysis, computer modeling, and subsystem testing such as bracket and truss vibration testing.

c. If there are fewer than three existing flight

data samples, a minimum 3 decibel (dB) margin for vibration, 4.5 dB for shock, and 11°C for thermal shall be added to the analytical environment to obtain the predicted MPE.

###### 4.10.1.4.2 Validating the Predicted RTS MPE.

The predicted MPE shall be validated by actual environmental load measurements taken during launch and flight of at least three vehicles. If all data does not correlate then additional load measurements on additional vehicles shall be taken.

##### 4.10.2 RTS Environmental Design Margin

###### 4.10.2.1 RTS Environmental Design Margin General Requirements

a. RTS components, including methods of attachment, mounting hardware, and cables and wires, shall be designed to function within performance specifications when exposed to environmental levels that exceed the ground transportation, prelaunch processing, checkout, and launch through end of Range Safety responsibility.

b. RTS design shall take into consideration the test requirements in Appendixes 4B1, 4B2, 4B4, 4B5, 4B12, and 4B13.

###### 4.10.2.2 RTS Component Thermal Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be minus 34°C to +71°C. *EXCEPTION: Batteries shall meet the requirements in paragraph a above.*

c. The components shall be designed to survive the thermal environment for a minimum of 24 qualification cycles and 8 acceptance cycles. *EXCEPTION: Batteries shall meet the requirement as stated in Appendix 4B4.*

###### 4.10.2.3 RTS Component Random Vibration Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to survive random vibration environments that are 4.5 dB above the MPE level or 12.2 Grms, whichever is greater.

b. The minimum design duration shall be:

1. Three times the expected flight exposure time or 3 min per axis, whichever is greater, for qualification

2. The flight exposure time or 1 min per axis, whichever is greater, for acceptance

c. The minimum frequency range shall be 20 to 2000 Hz.

#### **4.10.2.4 RTS Component Acoustic Noise Environment**

a. Unless otherwise specified by Range Safety, RTS components shall be designed to survive acoustic noise that are 4.5 above the MPE level or a minimum 144 dB overall sound pressure for acoustic, whichever is greater.

b. The minimum design duration shall meet the following criteria:

1. Three times the expected flight exposure time or 3 min, whichever is greater, for qualification

2. The flight exposure time or 1 min, whichever is greater, for acceptance

#### **4.10.2.5 RTS Component Shock Environment**

a. Unless otherwise specified by Range Safety, RTS components shall be designed to a margin of 6 dB above the MPE level or a minimum of 1300 G, whichever is greater.

b. The duration shall simulate the actual shock environment.

c. The maximum frequency range shall be from 100 to 10,000 Hz.

d. The minimum number of shocks shall be 3 shocks per axis for each direction, positive and negative, for a total of 18 shocks.

#### **4.10.2.6 RTS Component Acceleration Environment**

a. Unless otherwise specified by Range Safety, RTS components shall be designed to 2 times the MPE level or a minimum of 20 G, whichever is greater, in each direction.

b. The minimum duration for acceleration shall be 5 min per axis.

#### **4.10.2.7 Other RTS Component Environments**

a. Other environments applicable to RTS components are humidity, salt fog, dust, fungus, explosive atmosphere, thermal vacuum, EMC, EMI, sinusoidal vibration, and other nonoperational environments.

b. Tests and test levels for these environments are described in Appendixes 4B1, 4B2, 4B4, 4B5, 4B12, and 4B13.

### **4.10.3 RTS Reliability**

a. The overall RTS reliability goal shall be as follows:

1. 0.995 at the 95 percent confidence level for the transponder system

2. 0.999 at the 95 percent confidence level for the GPS

b. This reliability goal shall be satisfied by combining the design approach and testing requirements described in this Chapter.

c. A reliability analysis shall be performed in accordance with guidelines set forth in MIL-STD-785 to demonstrate the reliability design was used in the concept and detailed design of the components and/or system.

### **4.10.4 RTS Design Life**

a. Electrical components shall have their operating and storage life specified.

b. The operating and storage life for electrical components starts at completion of the initial acceptance test.

c. Range Safety shall be notified if the operating and storage life of an RTS component expires prior to launch.

d. If required, expired component retest shall be determined by mutual agreement between Range Safety and the Range User.

### **4.10.5 RTS Electrical and Electronics Systems Design**

#### **4.10.5.1 RTS Piece/Part Selection Criteria**

a. Piece/parts selected for use in RTS electronic systems shall be consistent with the launch vehicle reliability requirements.

b. Addition, subtraction, or replacement of piece/parts within a Range Safety approved RSS component shall require specific approval.

#### **4.10.5.2 RTS Voltage and Current Parameters**

a. The input voltage range of each component shall be specified, and the current in the stand-by and operating modes shall be noted in the specification.

b. The components shall meet the requirements of this Chapter at any voltage level between the minimum and maximum specified.

c. The components shall not be damaged because of low or fluctuating input voltage.

#### 4.10.5.3 Transient Voltage Generation

All RTS and vehicle system interface components containing reactive elements such as relays, electrical motors or similar devices, that are capable of producing transient voltages shall be provided with suppression circuitry to prevent interference or damage to other RTS components.

#### 4.10.5.4 RTS Voltage Protection

*a.* RTS components shall not be damaged by the application of up to 45 Vdc or the open circuit voltage of the power source, whichever is greater.

*b.* This voltage shall be applied in both normal and reverse polarity modes to the component power input ports for a period not less than 5 min.

#### 4.10.5.5 RTS Switch and Relay Selection Criteria

*a.* Any power transfer switch and/or assembly shall not change state as a result of input power drop-out for a period of 50 milliseconds minimum.

*b.* Relays shall be designed and/or selected to prevent chatter.

#### 4.10.5.6 RTS Continuity and Isolation

*a.* The resistance from each pin to common return and case ground shall be specified.

*b.* Measurements that are polarity sensitive, such as those containing diodes, shall be identified.

*c.* Significant pin-to-pin measurements shall be included where their inclusion will provide meaningful data relative to the reliability of the component.

#### 4.10.5.7 RTS Circuit Isolation

*a.* RTS circuitry shall be shielded, filtered, grounded, or otherwise isolated to preclude energy sources such as electromagnetic energy from the Range or launch vehicle causing interference that would inhibit the functioning of the system.

*b.* There shall be only one interconnection (single point ground) with other circuits.

#### 4.10.5.8 RTS Repetitive Functions

All circuitry, elements, components, and subsystems of the RTS shall be capable of withstanding, without degradation, repetitive functioning for 100 times or five times the expected number of cycles required for checkout and operation, whichever is greater.

#### 4.10.5.9 RTS Watchdog Circuits

Unless otherwise agreed by Range Safety, watchdog circuits that automatically shutdown or disable RTS circuitry when certain parameters are violated are disallowed.

#### 4.10.5.10 RTS Testability

RTS and associated ground support and monitoring equipment design shall provide the capability to perform the testing described in the **RSS Test Requirements** section of this Chapter.

#### 4.10.5.11 RTS Self-Test Capability

*a.* If the component uses a microprocessor, it shall have the capability to perform a self-test (error detection) at power ON.

*b.* When possible or feasible, the results of the self-test shall be an output function and observable from the vehicle telemetry.

*c.* Failure of a self-test shall not intentionally disable the component.

*d.* The execution of a self-test shall not inhibit the processing intended function of the unit.

#### 4.10.5.12 Interference Protection

The RTS shall be designed to meet the requirements of MIL-STD-461 or the equivalent.

#### 4.10.5.13 Output Response Time

The time needs for the RTS to satisfy all performance requirements after final power application shall be specified.

### 4.11 RTS COMPONENT DESIGN REQUIREMENTS

#### 4.11.1 RTS Transponder

##### 4.11.1.1 Transponder Antenna System

##### 4.11.1.1.1 Transponder Antenna System General Design Requirements.

*a.* The antenna system shall provide adequate gain coverage over 95 percent of the radiation sphere.

*b.* The antenna system shall minimize variations in phase due to changes in the angular orientation of the vehicle with respect to the radar in both roll and pitch coordinates.

*c.* The antenna system shall operate at the frequencies selected by the Range for the specific program between 5.4 and 5.9 GHz and have 3 dB bandwidths of at least  $\pm 20$  MHz with respect to the selected frequencies.

d. The antenna system shall display a voltage standing wave ratio (VSWR) less than 1.5:1 or 4 percent power reflected when excited from a source with the same impedance as the planned cable installation at the assigned frequencies.

e. The antenna system shall operate within specifications, with no arcing or damage, at twice the normal RMS and peak excitation power at any atmospheric pressure between 0.0001 and 760 Torr (mm of Hg).

f. Antenna gain and phase patterns shall be provided to Range Safety for each new airborne tracking system.

g. The gain of the antenna system relative to an isotropic radiator and the phase of the far field radiation relative to the antenna excitation shall be measured at 1° increments over the radiation sphere at the Range assigned frequencies and required polarizations.

h. If antenna heat shields are used, they shall be considered part of the antenna system and shall be subjected to all the antenna system requirements for design, test, pattern measurements, and approval. **NOTE:** All antenna heat shields shall be subjected to a fly-off analysis that includes test data reflecting antenna performance with and without the heat shields.

#### 4.11.1.1.2 Transponder Antenna System Electrical Performance.

a. The antenna system shall provide adequate gain coverage over 95 percent of the radiation sphere to yield a link margin of 0 dB or greater for the following conditions:

1. Interrogation uplink
2. The reply downlink with the radars selected by the Range
3. Anytime the vehicle is physically capable of impacting an inhabited land mass

b. Antenna gain variation shall be no greater than  $\pm 5$  dB in the roll plane and 10 dB between 10° and 170° in the pitch plane.

c. Antenna phase angle variation shall be no greater than 50° in the roll plane and twice the distance of farthest radiation element from the roll axis divided by the wave length multiplied by 360 equals the maximum permitted phase variation in degrees between the pitch angles of 10° and 170° in the pitch plane.

d. Antenna phase rate variation shall be 30° per degree of roll maximum.

e. The pitch phase variation rate maximum in degrees phase per degree pitch shall be no greater than the 6.284 times the distance of the farthest radiating element from the roll axis divided by the carrier wave length in the same units at any pitch angle more than 5° from the roll axis.

#### 4.11.1.1.3 Transponder RF Link Analysis.

a. A complete RF link analysis shall be performed by the Range User to verify adequate gain coverage over 95 percent of the radiation sphere.

b. The antenna patterns shall be provided in accordance with RCC 253 and shall be used in the RF link analysis.

c. The RF link margin shall be no less than 0 dB relative to the required signal power for the individual radars selected by the Range.

#### 4.11.1.1.4 Transponder Antenna Analysis and Evaluation Data Requirements.

a. *ER Antenna Analysis and Evaluation Requirements.* Antenna analysis and evaluation data requirements shall be coordinated with the Range.

b. *WR Antenna Analysis and Evaluation.* At a minimum, the following shall be provided for evaluation and analysis:

1. Power gain relative to an isotropic radiator over the entire radiation sphere at 1° increments
2. Relative phase between excitation and far-field radiation over the entire radiation sphere at 1° increments
3. Input reflection coefficient (VSWR) versus frequency over a span of 20 MHz centered on each of the WR assigned frequencies the antenna is intended to operate

4. Items *b* through *e* of the **Transponder Antenna System Electrical Performance** section of this Chapter.

#### 4.11.1.2 Transponder

##### 4.11.1.2.1 Transponder General Design Requirements.

a. *Non-Coherent Transponder Frequency Separation.* The reply carrier frequency of the non-coherent transponder shall be separated from the assigned interrogation carrier frequency by a minimum of 50 MHz.

b. *Transponder Antenna RF Impedance Mismatch Considerations.* The transponder shall suffer no damage and shall meet all requirements after operating with the antenna connector open or

shorted.

*c. Transponder Pulse Repetition Frequency (PRF) Response.* The transponder shall meet all performance requirements when replying to valid interrogations at any rate between 160 and 2600 pulses per second.

*d. Transponder Interrogation Response.* The transponder shall reply to at least 99 percent of valid interrogations at signal powers equal to or above the measured RF threshold sensitivity under all operating conditions.

*e. Transponder Power Source Switching.* The operational performance of the transponder shall not be degraded by its internal or external power supply nor by repetitive switching between them. **NOTE:** If it is necessary to protect the transponder, a Range Safety approved power delay timer may be used. The time between power loss and recycle of the delay timer shall be the maximum and the warm-up time shall be the minimum needed to protect the transponder.

*f. Transponder Random Triggering.* Transponder random triggering shall be no greater than 5 pulses per sec under all uninterrogated and interrogated operational conditions.

*g. Transponder System Delay.*

1. The transponder shall have a minimum of one fixed reply delay setting of  $2.5 \pm 0.1$  microseconds.

2. The delay variation versus input signal (dBm) shall be less than 30 nanoseconds for input signal levels of 0 dBm to -65 dBm. **NOTE:** The minimum test measurement data points are at 0, -10, -20, -30, -40, -50, -57, -60, -62, -65 -67, and -70 dBm.

3. The delay variation versus input frequency (MHz) shall be less than 30 nanoseconds for input frequency changes of  $\pm 1.5$  MHz. **NOTE:** The minimum test measurement data points are at -1.5, -1.0, -0.5, +0.5, +1.0 and +1.5 MHz.

4. The delay variation versus pulse repetition frequency (PRF) pulse per second (PPS) shall be less than 30 nanoseconds for changes in PRF from 160 pps to 1600 pps. **NOTE:** The minimum test measurement data points are at 160, 480, 800, 960, 1440, and 1600 pps.

5. The delay variation versus operating voltage shall be less than 30 nanoseconds for changes in voltage from 24 to 32 volts. **NOTE:** The minimum test measurement data points are at 24, 26, 28, 30 and 32 volts.

*h. Coherent Transponder Phase Coherence Accuracy.*

1. For ballistic missiles, the contribution of the transponder to Doppler errors shall be less than  $200^\circ$  per sec root mean square (RMS) over the particular electrical, thermal, and mechanical operational environment.

2. For space vehicles, the contribution of the transponder to Doppler errors shall be less than  $20^\circ$  per second RMS over the particular electrical, thermal, and mechanical operational environment.

**4.11.1.2.2 Transponder Receiver.**

*a. Transponder Receiver Frequency Range.*

The receiver shall operate at the program assigned frequency that is within the allocated frequency range of 5.4 to 5.9 GHz.

*b. Transponder Receiver Frequency Variation Acceptance.* The receiver shall meet all performance requirements to any valid interrogation that is within  $\pm 2$  MHz from the tuned center frequency.

*c. Transponder Receiver Off Frequency Rejection.* The transponder receiver shall provide at least 80 dB of rejection from 0.15 to 10 GHz excluding the tuning range.

*d. Transponder Receiver Image Rejection.* The response of a superheterodyne receiver to a signal at its image frequency shall be a minimum of 60 dB relative to the tuned center frequency.

*e. Transponder Receiver Bandwidth.*

1. The transponder receiver 3 dB bandwidth shall be 11 MHz  $\pm 3$  MHz.

2. The transponder receiver 40 dB bandwidth shall be 60 MHz maximum.

*f. Transponder Receiver RF Sensitivity.* The transponder receiver measured RF threshold sensitivity level shall be -70 dBm or lower. **NOTE 1:** The guaranteed RF threshold sensitivity is the level specified in the procurement document and is the minimum level where the transponder will meet all performance specifications. **NOTE 2:** The measured RF threshold sensitivity level is that RF level where at least 99 percent response to valid interrogations and less than 5 pps response to system noise. **NOTE 3:** Additional delay variation beyond 30 nanoseconds is permitted beyond -65 dBm as specified in **Transponder System Delay** section of this Chapter and this requirement.

*g. Transponder Receiver Dynamic Range.*

1. The transponder receiver dynamic range shall be between 0 and -65 dBm.

2. The transponder receiver shall respond to valid interrogations with less than 30 nanoseconds delay variation and less than 10 nanoseconds delay jitter while meeting all other performance requirements.

*h. Transponder Receiver Maximum Input Signal.* The transponder receiver shall not be damaged when subjected to input signals of +20 dBm at the assigned interrogation frequency.

*i. Transponder Receiver Pulse Width Acceptance.* The transponder receiver shall respond to an interrogation pulse width between 0.25 to 1.5 microseconds.

*j. Transponder Receiver Risetime and Fall-time Acceptance.*

1. The transponder receiver shall respond to valid interrogations with pulse rise times less than 200 nanoseconds under all operating conditions.

2. The transponder receiver shall respond to valid interrogations with fall times of 0.5 microseconds or less under all operating conditions.

*k. Transponder Receiver Pulse Code Spacing.*

1. Transponder receiver pulse code spacing shall be between 3 and 12 microseconds with a setting tolerance of  $\pm 25$  nanoseconds. **NOTE:** Pulse code spacing shall be established by the Range on an individual program basis.

2. The interrogation pulse code spacing shall be between 150 and 300 nanoseconds and the receiver shall reject all others outside these limits.

*l. Transponder Receiver Decoder Immunity.* No response is permitted to 100 microsecond pulse width coded or uncoded pulse trains nor unmodulated continuous wave (CW) signals within the dynamic signal strength range between 0 and -65 dBm. The transponder receiver shall respond only to double pulse coded interrogations unless approved by Range Safety.

**4.11.1.2.3 Transponder Transmitter.**

*a. Transponder Transmitter Frequency Range.* The transponder transmitter shall operate at the program assigned frequency that is within the allocated frequency range of 5.4 to 5.9 GHz.

*b. Transponder Transmitter Frequency Stability.*

1. The non-coherent transponder transmitter frequency stability shall be  $\pm 3$  MHz from the assigned frequency after the minimum stabilization

period.

2. The coherent transponder transmitter frequency stability shall be no greater than the maximum drift that will permit the transponder to reply coherently to valid interrogations at the assigned frequency  $\pm 3$  MHz and satisfy all other operational requirements.

*c. Transponder Transmitter Frequency Drift Rate.* The transponder transmitter frequency drift rate shall be 1 MHz per min maximum under all operating conditions.

*d. Transponder Transmitter Duty Cycle.* The transponder transmitter duty cycle shall be capable of sustaining a constant 2600 interrogations per sec minimum.

*e. Transponder Transmitter Recovery Time.* The transponder transmitter recovery time shall be 50 microseconds maximum with no reduction in reply power, change in frequency, or reply pulse shape. **NOTE:** Replies may be inhibited during the transponder recovery period.

*f. Transponder Transmitter Overinterrogation Protection.* Transponder transmitter overinterrogation protection shall meet the following criteria:

1. The response shall be restricted to duty cycle limitations.

2. The overinterrogation protection shall prevent damage to the transponder.

3. The overinterrogation protection shall prevent excessive power consumption.

4. The overinterrogation protection shall recover to normal operation in no more than 500 microseconds after the interrogation rate falls to or below 2600 valid interrogations per sec.

*g. Transponder Transmitter Peak Power Output.*

1. The transponder transmitter peak power output shall be of sufficient amplitude to provide a downlink margin of 0 dB based on the RF link analysis.

2. The RF link analysis shall include the following data:

(a) 95 percent radiation sphere antenna power gain

(b) Vehicle cable loss

(c) Polarization loss

(d) Atmospheric attenuation

(e) Plume attenuation

(f) Uplink and downlink free space attenuation using the least sensitive radar assigned by the Range at the limit of Range Safety responsibility.

#### *h. Transponder Transmitter Spectral Characteristics.*

1. The transponder transmitter pulsed RF spectrum shall not exceed 3.0 divided by the pulse width in microseconds at the quarter power points.

2. Coherent transponder transmitter central fine line jitter shall not exceed 1 Hz, and the central line 3dB bandwidth shall not exceed 40 Hz (as measured in a 10 Hz resolution bandwidth and 30 Hz video bandwidth).

3. Coherent transponder transmitter interline noise and spurs shall be a minimum of 20 dB below the central fineline power.

#### *i. Transponder Transmitter Pulse Characteristics.*

1. Non-coherent transponder transmitter pulse width shall be no greater than  $500 \pm 100$  nanoseconds.

2. Transponder transmitter pulse width jitter standard deviation (one sigma) shall not exceed 10 nanoseconds measured at the half power points.

3. Transponder transmitter pulse amplitude variation shall not exceed 1 dB over the operating PRF range.

4. Transponder transmitter pulse amplitude jitter shall not exceed 0.5 dB peak-to-peak measured on a pulse-to-pulse basis.

5. Transponder transmitter pulse transition times shall not exceed a rise time of 100 nanoseconds and a fall time of 150 nanoseconds. **NOTE 1:** A design goal is to have equal rise and fall times. **NOTE 2:** Transition times are measured between the 10 percent and 90 percent levels.

### **4.11.2 Global Positioning System**

#### **4.11.2.1 GPS Antenna System**

##### **4.11.2.1.1 GPS Antenna System General Design Requirements.**

*a.* The GPS receive antenna system (L-Band GPS satellite to vehicle) shall provide adequate gain over the complete radiation sphere to ensure that the GPS system provides uninterrupted vehicle tracking (the GPS solution can be continuously maintained) from before lift-off through end of Range Safety responsibility.

*b.* The GPS receive antenna system shall minimize variations in phase noise and slope.

*c.* A GPS transmit (missile to ground) RF link analysis shall be performed by the Range User using the power gain specification for 95% of the radiation sphere.

1. The link margin shall be no less than 0 dB

relative to the required signal power for the individual telemetry receiving systems selected by the Range.

2. Antenna and trajectory data required to perform the link analysis shall be submitted.

3. The antenna patterns shall be provided in accordance with the RCC document 253, RCC Standard Coordinate System and Data Formats for Antenna Patterns.

4. S-Band downlink dropouts due to liftoff and staging events must be addressed in the RSSR. Description of dropouts shall include anticipated duration and causes such as plume attenuation and multipaths.

*d.* In all cases, the GPS receive and transmit link margins shall be sufficient to ensure uninterrupted vehicle tracking from before liftoff through end of Range Safety responsibility. This requirement applies to all possible unplanned and erratic paths that the vehicle may fly without mandatory destruct.

**4.11.2.1.2 GPS Receive Antenna System (GPS Satellite to Launch Vehicle).** This system is used to receive L-Band signals (L1 and/or L2) from GPS satellites and pass RF energy to the GPS translator or receiver.

*a.* The antenna shall have 3 dB bandwidths of at least the channel code main lobe bandwidth.

*b.* The antenna system shall display a voltage standing wave ratio (VSWR) of less than 2.5:1 or 4 percent power reflected when excited from a source with the same impedance as the planned cable installation at the assigned frequencies.

*c.* Antenna gain and phase patterns shall be provided to Range Safety for each program. The gain of the antenna system relative to an isotropic radiator and the phase of the far field radiation relative to the antenna excitation shall be measured at two degree increments over the complete radiation sphere at the operational L-Band frequencies and polarizations.

*d.* The GPS receive (GPS satellite to missile) antenna systems shall provide adequate gain throughout 100 percent of the radiation sphere to ensure uninterrupted tracking.

*e.* Antenna Pattern Data. The following pattern data is the minimum required for evaluation and analysis:

1. Power gain relative to a right circular polarized isotropic radiation over the entire radiation sphere at two degree increments.

2. Relative phase excitation and far-field radiation over the entire radiation sphere at two degree increments.

3. Input reflection coefficient (VSWR) versus frequency over a span described as 3 dB points in paragraph *a* above.

4. GPS antennas shall be tested in accordance with Appendix 4B2.

**4.11.2.1.3 GPS Transmit Antenna System (Missile to Ground).** This system is used to transmit (downlink - typically S-Band) GPS translator signals/state vectors and GPS dedicated telemetry to ground telemetry receiving station(s). The GPS transmit system may share a S-Band antenna system if GPS transmit system and other S-Band functions such as missile telemetry are not degraded below respective requirements.

*a.* The antenna shall have 3 dB bandwidth sufficient to pass the output of the GPS translator/receiver.

*b.* The antenna system shall display a voltage standing wave ratio (VSWR) of less than 1.5:1 or 4 percent power reflected when excited from a source with the same impedance as the planned cable installation at the assigned frequencies.

*c.* The antenna system shall operate within required specifications, with no arcing or damage, at twice the normal RMS and peak excitation power at any atmospheric pressure between 0.0001 and 760 Torr (mm. of Hg).

*d.* Antenna gain and phase patterns shall be provided to Range Safety for each program. The gain of the antenna system relative to an isotropic radiator and the phase of the far field radiation relative to the antenna excitation shall be measured at two degree increments over the complete radiation sphere at the operational S-Band frequencies and polarizations.

*e.* The GPS transmit (missile to ground) antenna system shall provide adequate gain throughout 95 percent of the radiation sphere to ensure closure of the RF link with sufficient margin to provide uninterrupted data.

*f.* Antenna Pattern Data. The following pattern data is the minimum required for evaluation and analysis:

1. Power gain relative to a right circular polarized isotropic radiation over the entire radiation sphere at two degree increments

2. Relative phase excitation and far-field

radiation over the entire radiation sphere at two degree increments

3. Input reflection coefficient (VSWR) versus frequency over a span described as 3 dB points in paragraph *a* above

4. GPS antennas shall be tested in accordance with System Appendix 4B2.

#### 4.11.2.2 GPS System

**4.11.2.2.1 GPS Translator and Receiver General Design Requirements.**

*a. Operational Life.* The translator and receiver shall meet all operational requirements from receipt through end of mission.

*b. Stabilization Time.* The time needed after power application for the translator/receiver to satisfy all performance requirements shall be minimized, measured, and shall be specified and then documented during development, qualification, and acceptance testing.

*c. Antenna RF Impedance Mismatch.* The translator/receiver shall suffer no damage and meet all requirements after operating with the antenna connector open or shorted.

*d. Power Source Switching.* The operational performance of the translator/receiver shall not be degraded by its internal or external power supply or by repetitive switching between them

##### 4.11.2.2.2 GPS Digital Translator.

*a. Probability of Bit Error.* The bit probability error shall be less than or equal to  $10^{-6}$ .

*b. Delay Time.* The input-to-output delay time for the digital translator and associated GPS ground equipment shall be less than 250 milliseconds or TBD.

*c. Delay Time Consistency.* The overall GPS input-to-output time delay shall be constant across in-band frequencies to within plus or minus 40 nanoseconds.

*d. Delay Time Stability.* The average time delay through the GPS channel shall be stable or calibrate to within plus or minus 40 nanoseconds over the operational (mission) period. Stability shall be achieved after a 2 minute warm up. These requirements shall be met for all input signals from -110 dBm to -145 dBm.

*e. Frequency Accuracy.* The frequency accuracy of the S-Band and RF output shall remain within 20 parts-per-million of design center frequency.

*f. Frequency Drift.* The frequency drift of the

S-Band RF output shall maintain a 0.1 sec double Allan variance of better than 1 part in 10 to the 10th.

*g. Frequency Stability.* Frequency stability for the S-Band carrier shall be specified.

*h. Noise Figure.* The noise figure shall be no greater than 3.5 dB.

*i. Contribution to Error.* The translator shall not contribute to error in pseudo-range calculation.

*j. S-Band Spectral Characteristics and Spurious Emissions.* S-Band spectral characteristics shall comply with Range Commander's Council document 106-93.

*k. Suppression.* For translators that use suppressed carrier for the S-Band downlink suppression shall be specified.

*l. Phase Linearity.* Phase Linearity from 1574 to 1576 MHz and 1226 to 1228 MHz shall be specified.

*m. L<sub>1</sub>/L<sub>2</sub> Bandpass Characteristics.* L<sub>1</sub>/L<sub>2</sub> bandpass characteristics shall be specified.

*n. Phase Jitter.* Phase jitter shall be specified for maximum predicted vibration environment.

*o. Peak Input Voltage.* The translator shall be able to withstand a 45 Vdc input.

*p. RF Overload.* Susceptibility to combinations of up to three out-of-band continuous wave signals shall be specified. The translator must be able to withstand an in-band RF overload of 10 dBm for one minute without degradation after the overload is removed.

#### 4.11.2.2.3 GPS Receiver.

*a. System Noise.* The system noise figure established by the preamplifier shall be established in the receiver specification. In no case shall the noise figure exceed 3.5 dB.

*b. Immunity to In-Band Interfering Signal.* Receiver immunity to in-band interfering signals shall be specified as a function of tracking and signal acquisition levels (3 dB reduction).

*c. State Vector.* The receiver shall provide a state vector of required accuracy under all dynamic conditions of the vehicle.

*d. Rapid Re-Lock Capability.* The re-lock time after loss of a satellite shall be specified and approved by the Range.

*e. Time to First Fix.* Time to first fix shall be specified and approved by the Range.

*f. State Vector Data Rate.* State vector updates shall be provided to the Range at a rate of not less than 20 Hz.

*g. Delay Time.* The input-to-output delay time shall be less than 250 milliseconds or TBD.

*h. De-Selection of Faulty Satellites.* The receiver must have an inherent capability to identify and de-select faulty satellites. The satellite selection/de-selection routine must be approved by Range Safety.

*i. Telemetry.* The receiver shall provide the following data to the Range via telemetry: satellite assignments, lock status, ephemeris ready, currency of ephemeris, pseudo and delta range, state vector, state vector quality, PDOP, GDOP, signal quality, C/N<sub>0</sub>, satellite health bit, and age of data.

*j. Phase Linearity.* Phase linearity from 1574 to 1576 MHz and 1226 to 1228 MHz shall be specified.

*k. L<sub>1</sub>/L<sub>2</sub> Bandpass Characteristics.* L<sub>1</sub>/L<sub>2</sub> bandpass characteristics shall be specified.

*l. Phase Jitter.* Phase jitter shall be specified for maximum predicted vibration environment.

*m. Sensitivity.* Sensitivity of the receiver must be TBD dBm or greater.

*n. Out-of-Band Signals.* Immunity to out-of-band signals shall be specified.

*o. Peak Input Voltage.* The receiver shall be able to withstand a 45 Vdc input.

*p. RF Overload.* Susceptibility to combinations of up to three out-of-band continuous wave signals shall be specified. The receiver must be able to withstand an in-band RF overload of 10 dBm for 1 min without degradation after the overload is removed.

#### 4.11.2.2.4 Integrated GPS/Inertial System. TBD

### 4.11.3 RTS Wiring Design

*a.* The insulation resistance between the shield and conductor shall be greater than 2 megohms at 500 Vdc minimum.

*b.* Wiring and harness shall be capable of withstanding 1500 Vac (RMS) 60 Hz at sea level pressure between mutually insulated points and the case or housing.

*c.* Wire shall be of sufficient size to adequately handle 150 percent of the design load.

*d.* Wires and cable shall be given support and protection against abrasion or crimping.

#### 4.11.4 RTS Electrical Connector Design

##### 4.11.4.1 RTS Electrical Connector General Design Requirements

- a. RTS connectors shall be designed in accordance with the requirements of MIL-C-38999J or the equivalent and the requirements of this section.
- b. Plug and socket type connectors are required.
- c. Outer shells of connectors shall be made of metal.
- d. Connectors shall be selected to eliminate the possibility of mismatching. **NOTE:** Mismatching includes improper installation as well as connecting wrong connectors.
- e. Connectors shall be of the self-locking type or lock wiring shall be used to prevent accidental or inadvertent demating.
- f. Connector design shall ensure that the shielding connection is complete before the pin connection.
- g. Source circuits shall terminate in a connector with female contacts.
- h. Connectors relying on spring contact shall not be used.
- i. The mated connectors shall withstand an axial pull on the cable or harness of at least 30 lb for a minimum of 1 min.

##### 4.11.4.2 RTS Electrical Connector Pins

- a. There shall be only one wire per pin.
- b. In no case shall a connector pin be used as a terminal or tie-point for multiple connections.

##### 4.11.4.3 RTS Connector Capacity

Connectors shall be capable of adequately handling 150 percent of the design load.

#### 4.11.5 RTS Battery Design

##### 4.11.5.1 RTS Battery Independence

RTS batteries shall be independent of the batteries for the FTS and TDTS.

##### 4.11.5.2 RTS Battery Design Life

- a. Batteries shall be of sufficient capacity to allow for load and activation checks, launch countdown checks, and any necessary hold time.
- b. Sufficient battery life shall be available for 150 percent of the mission time for which Range Safety has flight safety responsibility or 30-min, hang-fire hold time plus mission time. Mission time includes the minus count time starting when the

RTS has switched to the final internal power configuration (battery) through normal flight. **NOTE:** The 30-min, hang-fire hold time applies only to vehicles using solid propellants and vehicles using solid propellant ignition systems.

- c. An analysis shall be provided to demonstrate compliance with sufficient battery life availability at launch prior to the qualification test.

##### d. Battery Storage Life

1. The battery shall meet design requirements of this section after a storage life of a minimum of two years from date of manufacture.

2. Silver zinc batteries shall have a minimum wet stand time of 60 days.

3. Lot buys shall include enough cells to provide a continuous data base throughout the life of the lot in accordance with Appendix 4B4.

##### 4.11.5.3 RTS Battery Electrical Characteristics

- a. Batteries used to provide power to the RTS shall be capable of delivering 1.5 times the expected maximum current draw.

1. The current shall be delivered to the RTS at the lowest system battery voltage, using the worst case system tolerances. The lowest system battery voltage shall be based on the RTS component voltage range.

2. The lowest system battery voltage including all load conditions shall be the RTS electrical components' minimum acceptance test voltage.

- b. The resistance between all battery terminals and between each terminal or pin to case shall be 2 megohms or greater when measured at a potential of  $500 \pm 25$  Vdc prior to activation of the battery.

##### 4.11.5.4 RTS Battery Electrical Protection

- a. Battery terminal connectors shall be designed to prevent reverse polarity.

- b. Diodes shall be used to prevent reverse current. **NOTE:** The diodes may be placed in the battery or in external circuitry.

- c. If a battery is not connected to the system, the battery terminals or connector plug shall be taped, guarded, or otherwise given positive protection against shorting.

- d. The battery shall be capable of accepting without damage or degradation an overcharge. The percentage overcharge based on nominal capacity rating of the battery and cell shall be specified. This shall include a maximum time limit based on the nominal charging rate.

#### 4.11.5.5 RTS Battery Monitoring Capability

*a.* The voltage of each battery shall have the capability to be monitored within 2 percent accuracy via telemetry and hardline.

*b.* Batteries requiring heating or cooling to sustain performance shall have a telemetry channel indicating the temperature of each battery. **NOTE:** The temperature sensor and telemetry combined measurement tolerance should be less than 1.0°F. This will allow qualification temperature extremes to be reduced from 10° C to 10° F.

*c.* The battery current shall have the capability to be monitored via telemetry or hardline.

#### 4.11.5.6 RTS Battery Pressure Relief

*a.* Battery cases shall be designed to a 3:1 ultimate safety factor with respect to worst case pressure build-up for normal operations.

*b.* The battery case pressure build-up shall take into account hydraulic and temperature extremes.

*c.* Sealed batteries and cells shall have pressure relief capability.

*d.* Pressure relief devices for sealed batteries and cells shall be set to operate at a maximum of 1.5 times the operating pressure and sized such that the resulting maximum stress of the case does not exceed the yield strength of the case material.

#### 4.11.5.7 RTS Battery Accessibility

*a.* Batteries shall be easily accessible for inspection and replacement.

*b.* Provisions shall be made in the battery design to permit open circuit voltage and load testing of each cell when assembled in the battery case. **NOTE:** This testing shall take place at the Range.

#### 4.11.5.8 RTS Secondary Batteries

*a.* Batteries used in the secondary mode shall have a cycle life greater than the number of cycles to be experienced during normal processing and flight.

*b.* Battery charging circuits shall be external to the launch vehicle.

*c.* Battery charging shall be designed to prevent a runaway battery temperature and adjust current rates accordingly with a high temperature limit cutoff.

*d.* The temperature-based control shall be in addition to other methods of charge control.

*e.* An analysis shall be provided to demonstrate compliance with the battery charging temperature

and current control.

#### 4.11.5.9 RTS Battery Initiators

The initiator and associated firing circuitry shall meet the requirements of the **FTS Low Voltage EED System Circuitry Design** section of this Chapter.

#### 4.11.5.10 RTS Battery Identification

Each battery shall be permanently identified with the following information:

- a.* Component name
- b.* Type of chemistry
- c.* Manufacturer identification
- d.* Part number
- e.* Lot and serial number
- f.* Date of manufacture
- g.* Shelf Life

#### 4.11.5.11 RTS Silver Zinc Cell and Battery Unique Requirements

*a.* Batteries shall consist of cells made from electrodes plates with the same lot date code.

*b.* Batteries shall be designed to allow activation of cells within the battery.

*c.* Electrode plate connection to cell terminals shall be maintained when exposed to qualification environments.

*d.* Heaters shall be designed to insure consistent heating of all cells.

*e.* Cell cases shall be designed to not leak when exposed to qualification environments.

*f.* Cell and battery manufacturing process shall be documented. This documentation shall include identification of all processes used from receipt of materials to final assemble. No changes to the process shall be allowed without Range Safety concurrence.

*g.* Silver zinc batteries only used in the primary mode shall have a minimum wet stand time of 60 days. Silver zinc batteries used in the secondary mode shall have:

1. A maximum number of secondary cycles specified
2. A charge retention life for each secondary cycle specified
3. An activated service life (total activated time) specified.

*h.* Silver zinc batteries shall provide the capability to individually charge each cell if the battery is to be used in the peroxide state or is used in the

monoxide state but requiring electrically conditioning of the electrodes.

*i.* Minimum soak time shall be specified for both vacuum fill or gravity fill of electrolyte.

*j.* Absorption devices shall be provided to accommodate electrolyte release. This device shall not provide a conductive path between cell terminals or the cell terminals and the battery box.

*k.* Silver zinc cells that will be used in the monoxide state shall have a specified peroxide removal process.

#### 4.11.5.12 RTS NiCad Cell and Battery Unique Requirements (Reserved)

### 4.12 TELEMETRY DATA TRANSMITTING SYSTEM DESIGN REQUIREMENTS

#### 4.12.1 Telemetry Data Transmitting System General Description

Telemetered data, particularly data concerning the status of the RSS components and the launch vehicle performance, form an integral part of the missile flight control system. These components and subsystems are subject to the same level of scrutiny as other portions of the RSS. The determination of which portions of the TDTS that will be subjected to this scrutiny is made on a program-by-program basis as early in the program as possible.

#### 4.12.2 TDTS General Design Requirements

*a.* The TDTS operating frequency shall be compatible with the Range Ground Support Stations.

*b.* The TDTS design shall have adequate capacity to transmitting the required status of the RSS components and/or functions.

*c.* Piece/parts selected for use in TDTS electronic systems shall be consistent with launch vehicle reliability requirements.

*d.* Calibration data on each demodulated telemetry measurement shall be provided by the Range User. **NOTE:** The telemetry measurements received shall be within the actual output of the item monitored for all non-discrete outputs.

*e.* The transmitter shall be tested in accordance with the requirements in Appendix 4B14.

#### 4.12.3 TDTS Component Maximum Predicted Environment

*a.* An analytical approach for determining TDTS component maximum predicted environment (MPE) levels such as shock, thermal, and vibration

shall be developed by the Range User and submitted to Range Safety for review and approval.

*b.* The analytical approach shall use existing flight data from other similar vehicles (if available), analysis, computer modeling, and subsystem testing such as bracket and truss vibration testing.

*c.* If there are fewer than three existing flight data samples, a minimum 3 decibel (dB) margin for vibration, 4.5 dB for shock, and 11°C for thermal shall be added to the analytical environment to obtain the predicted MPE.

#### 4.12.4 TDTS Environmental Design Margin

##### 4.12.4.1 TDTS General Environmental Design Margin

*a.* TDTS components, including methods of attachment, mounting hardware, and cables and wires, shall be designed to function within performance specifications when exposed to environmental levels that exceed the ground transportation, prelaunch processing, checkout, and launch through end of Range Safety responsibility.

*b.* TDTS design shall take into consideration the test requirements in Appendix 4B14.

##### 4.12.4.2 TDTS Component Thermal Environment

*a.* Unless otherwise specified by Range Safety, TDTS components shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

*b.* The minimum design thermal range shall be minus 34°C to +71°C. *EXCEPTION: Batteries shall meet the requirements in paragraph a above.*

*c.* The components shall be designed to survive the thermal environment for a minimum of 24 qualification cycles and 8 acceptance cycles. *EXCEPTION: Batteries shall meet the requirement as stated in Appendix 4B4.*

##### 4.12.4.3 TDTS Component Random Vibration Environment

*a.* Unless otherwise specified by Range Safety, TDTS components shall be designed to survive random vibration environments that are 4.5 dB above the MPE level or 12.2 Grms, whichever is greater.

*b.* The minimum design duration shall be:

*1.* Three times the expected flight exposure time or 3 min per axis, whichever is greater for qualification

2. The flight exposure time or 1 min per axis, whichever is greater, for acceptance

c. The minimum frequency range shall be 20 to 2000 Hz.

#### 4.12.4.4 TDTs Component Acoustic Noise Environment

a. Unless otherwise specified by Range Safety, TDTs components shall be designed to survive acoustic noises that is 4.5 dB above the MPE level or a minimum 144 dB overall sound pressure for acoustic, whichever is greater.

b. The minimum design duration shall meet the following criteria:

1. Three times the expected flight exposure time or 3 min, whichever is greater, for qualification

2. The flight exposure time or 1 min, whichever is greater, for acceptance

#### 4.12.4.5 TDTs Component Shock Environment

a. Unless otherwise specified by Range Safety, TDTs components shall be designed to a margin of 6 dB above MPE level or a minimum of 1300 G, whichever is greater.

b. The duration shall simulate the actual shock environment.

c. The minimum frequency range shall be from 100 to 10,000 Hz.

d. The minimum number of shocks shall be 3 shocks per axis for each direction, positive and negative, for a total of 18 shocks.

#### 4.12.4.6 TDTs Component Acceleration Environment

a. Unless otherwise specified by Range Safety, TDTs components shall be designed to 2 times the MPE level or a minimum of 20 G in each direction, whichever is greater.

b. The minimum duration for acceleration shall be 5 min per axis.

#### 4.12.4.7 Other TDTs Component Environments

a. Other environments applicable to TDTs components are humidity, salt fog, dust, fungus, explosive atmosphere, thermal vacuum, electro-

magnetic compatibility (EMC), electromagnetic interference (EMI), sinusoidal vibration, and other non-operational environments.

b. Tests and test levels for these environments are described in Appendix 4B1.

#### 4.12.4.8 TDTs RF Link Analysis

a. A complete RF link analysis shall be performed by the Range User to verify adequate gain coverage over 95 percent of the radiation sphere.

b. The antenna patterns shall be provided in accordance with RCC 253 and shall be used in the RF link analysis.

c. The RF link margin shall be no less than 0 dB relative to the required signal power for the individual TM receiving stations selected by the Range to reliably decode the TM signal.

#### 4.12.5 TDTs In-Flight RSS Telemetry Data

a. Sufficient TDTs data shall be telemetered to determine the adequacy of the RSS throughout powered flight and to aid in preflight and post-flight analysis.

b. The Range User shall provide a telemetry measurements list and Range Safety shall identify any further mandatory measurements.

c. At a minimum, the following telemetry data shall be provided to the ground receiving station. **NOTE:** The TDTs data requirements listed below are not necessarily all inclusive:

1. An analog channel for SSTO voltage for each CRD

2. All decoder outputs for each CRD

3. Status of each arming device (ARM or SAFE)

4. An analog channel for voltage monitoring for each RSS battery

5. An analog channel for current monitoring for each RSS battery

6. Status of any special RSS electrical inhibits

7. Each firing unit logic for EBW and laser ordnance systems such as ARM input, power, high and low capacitor voltage, and trigger voltage

8. Automatic Destruct System (ADS) status

9. A separate analog channel for each RSS battery temperature if the battery is temperature sensitive

10. Power switch status (INTERNAL and EXTERNAL)

### 4.13 RSS GROUND SUPPORT AND MONITORING EQUIPMENT DESIGN REQUIREMENTS

Ground support equipment includes, but is not limited to, the ER Operations Safety Console, the WR Safety Console, the FTS console, other blockhouse consoles, antenna couplers (hats), RF sensitivity, and insertion loss test equipment

#### 4.13.1 RSS Ground Support and Monitoring Equipment General Design Requirements

*a.* Design requirements for ground support and test equipment used to perform mandatory Range Prelaunch Tests shall be reviewed and approved by Range Safety.

*b.* All RSS ground support and test equipment shall be designed to meet industry safety requirements such as those defined in American National Standards Institute (ANSI), Occupational Safety and Health Act Administration (OSHA), National Fire Protection Association (NFPA), and other applicable standards.

*c.* Ground Support Equipment (GSE) Maintenance

*1.* All GSE used for checkout and monitoring of the RSS shall be verified on a periodic basis.

*2.* The verification pass/fail criteria and frequency of verification shall be documented in a formal procedure.

*d.* Test Equipment Calibration

*1.* All test equipment used for testing and monitoring of the RSS shall be periodically calibrated by a laboratory whose standards are traceable to the National Institute of Standards and Testing (NIST).

*2.* All test equipment shall bear evidence of current calibration when in use.

#### 4.13.2 Destruct Initiator Simulator

A destruct initiator simulator shall be provided for all command and automatic destruct system tests, Wet Dress Rehearsals, Countdown Demonstration Tests, or similar tests including Range prelaunch tests.

##### 4.13.2.1 Destruct Initiator Simulator Description

The destruct initiator simulator is a device whose electrical and optical characteristics match as closely as possible the electrical and optical char-

acteristics of the actual destruct initiator.

##### 4.13.2.2 Destruct Initiator Simulator Design

*a.* The destruct initiator simulator shall be designed to simulate the actual destruct initiator.

*b.* The destruct initiator simulator shall also be capable of monitoring the firing circuit output current, voltage, or energy and latch on when the operating current, voltage, or energy for the initiating device is outputted from the firing circuit.

*c.* An analysis shall be provided to demonstrate compliance with this requirement.

*d.* The destruct initiator simulator shall be capable of remaining connected throughout ground processing until the electrical connection of the actual initiators is accomplished.

*e.* The destruct initiator simulator designed shall provide an interlock capability to permit the issuance of destruct commands by test equipment only if the simulator is installed and connected to the firing lines.

*f.* For low voltage initiators, the simulator shall provide a stray current monitoring device such as fuse or automatic recording system capable of indicating a minimum of 1/10 of the maximum no-fire current. This stray current monitoring device shall be installed in the firing line.

#### 4.13.3 Laser Test Equipment

*a.* All laser test equipment that has the capability to directly or indirectly fire the LID shall be assessed and approved by Range Safety.

*b.* Laser test equipment shall be designed to meet the following criteria:

*1.* The energy level shall be less than 1/10,000 of the no-fire level of the LID.

*2.* The single failure mode energy level of the test equipment shall be less than 1/100 of the no-fire level of the LID.

*3.* The test source shall emit a different wave length than the firing unit laser.

#### 4.13.4 ER Operations Safety Console

##### 4.13.4.1 ER Operations Safety Console Description

The ER Operations Safety Console (OSC) is located in the launch control center (blockhouse). It contains indication devices showing the status of the FTS and vehicle-peculiar functions critical to flight safety during prelaunch and up to lift-off.

#### 4.13.4.2 ER OSC Design

*a.* An ER OSC design shall be developed and submitted to Range Safety for review and approval. (See the **Operations Safety Console Requirements** section in Chapter 3 of this document for additional non-FTS related ER OSC requirements.)

*b.* There shall be no SFP components in the ground support equipment or Firing Room systems that will cause the loss of a safety critical system monitor (as determined by Range Safety) at the OSC.

*c.* The OSC shall be designed in accordance with the requirements in MIL-STD-1472, or equivalent.

*d.* When applicable, the following vehicle FTS status shall be provided continuously to the OSC during prelaunch and up to lift-off:

1. Signal Strength Telemetry Output voltage for each CRD

2. Power for each CRD (ON/OFF, External/Internal power)

3. Monitors for all decoder outputs for each CRD

4. Status of all arming devices and all inhibits

(*a*) Optical S&A Devices. Barrier position (SAFE/ARM), barrier locked/unlocked, and electrical power status of the main laser

(*b*) Ordnance S&A Devices. SAFE and ARM

(*c*) Electromechanical S&A Devices. SAFE and ARM

(*d*) Other electronic arming devices or inhibits. **NOTE:** The exact circuits to be monitored will be determined by Range Safety.

(*e*) EBW FU. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input and power

(*f*) Laser High Voltage Firing Unit. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input, barrier positions, barriers locked/unlocked and power

5. Laser power status

6. Battery status

(*a*) Voltages of each FTS airborne battery and FTS ground command and automatic power supply

(*b*) Battery temperature of each FTS airborne battery and FTS ground command and automatic power supply

(*c*) Battery current of each FTS airborne battery and FTS ground command and automatic

power supply

(*d*) Provisions for monitoring battery life, operating time, or other means of monitoring energy remaining for flight

7. Proper functioning of destruct initiator simulators

8. FTS power transfer switch status (ON/OFF and AIRBORNE/GROUND)

9. Monitors for vehicle-peculiar functions critical to flight safety and other vehicle peculiar functions critical to FTS as identified by Range Safety

10. Status of the Range Command Transmitter carrier (ON/OFF)

#### 4.13.5 WR Safety Console and RSS Repeater System

##### 4.13.5.1 WR Safety Console General Design

*a.* A WR Safety Console design shall be developed and submitted to Range Safety for review and approval.

*b.* An FTS control console shall be provided and maintained by the Range User.

*c.* The FTS control console shall be located in the launch control center in a position that provides a viewing capability of the countdown time indicator and either the launch controller consoles or the launch sequencer control consoles, as applicable.

*d.* The FTS control console shall provide seating accommodations for two persons with access to the console controls and monitors by either person. **NOTE:** This console is designed to provide monitor and control capability for one person designated by the Range User to perform tasks defined by approved test procedures including countdown and launch manuals. The second position at this console is occupied by the Flight Safety Project Officer (FSPO). The FSPO supports test operations by analyzing RSS performance and evaluating RSS flight readiness and also acts as the Range User interface for resolution of RSS problems. The FSPO also provides coordination of the final ready-to-launch system acceptance issued by the Mission Flight Control Officer (MFCO). This requirement may be satisfied by providing two separate consoles to perform the required functions (The FSPO will require only the monitor capability).

##### 4.13.5.2 WR Safety Console FTS Pre-Flight and In-Flight Telemetry Monitors and Controls

As applicable, the following FTS pre-flight and in-

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flight telemetry monitors and controls shall be provided continuously during prelaunch and through lift-off by the Range User:

*a.* Signal Strength Telemetry Output voltage for each CRD

*b.* Controls and power status for each CRD (ON/OFF, External/Internal power)

*c.* Monitors for all decoder outputs for each CRD

*d.* Status and controls of all arming devices and all inhibits

*1.* Optical S&A Devices. Barrier position (SAFE/ARM), barrier locked/unlocked, and electrical power status of the main laser

*2.* Ordnance S&A Devices. SAFE/ARM

*3.* Electromechanical S&A Devices. SAFE/-ARM

*4.* Other electronic arming devices. The exact circuits to be monitored shall be determined by Range Safety.

*e.* EBW FU. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input and power

*f.* Laser High Voltage Firing Unit. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input, barrier positions, barriers locked/unlocked and power

*g.* Laser power status

*h.* Sensors to monitor voltages of each FTS airborne battery and FTS ground command and automatic power supply

*i.* Battery temperature

*j.* Battery current

*k.* Provisions for monitoring battery life, operating time, or other means of monitoring energy remaining for flight

*l.* Proper functioning of destruct initiator simulators

*m.* FTS power transfer switch status (ON/OFF and AIRBORNE/GROUND)

*n.* Monitors for vehicle-peculiar functions critical to flight safety. Controls in the console shall be capable of being locked or safed to the OFF position if they are considered to be a safety hazard by Range Safety.

*o.* Status and alert signaling system to activate status and alert remote display on the MFCO console to indicate GO or NO-GO status of the airborne FTS

*p.* In all cases, the provided monitors shall be continuously available to the FSPO during pre-

flight tests and missile flight.

#### 4.13.5.3 WR Safety Console RTS Pre-Flight and In-Flight Telemetry Monitors

Provisions shall be made by the Range User to provide the following RTS pre-flight and in-flight telemetry monitors:

- a. RTS power mode monitors (ON/OFF, external or internal)
- b. Sensors to Monitor RTS Applied Voltage. **NOTE:** CRT displays for this purpose are preferred; however, the option exists to provide either voltmeters or voltage comparator circuits with status lights.
- c. Sensors to monitor RTS current consumption for quiescent and interrogation modes. The sensors shall be compatible with those described in paragraph *b* above.
- d. Provisions for monitoring battery life or operating time
- e. Additional monitors may be required depending on the nature of the system and individual components. If required, the additional monitors will be identified at the appropriate design review.
- f. In all cases, the provided monitors shall be continuously available to the Safety representative.

#### 4.13.5.4 WR Safety Console Communications

The following communications capability shall be provided at the FSPO console and shall be available continuously throughout any simulated countdown tests, countdown and flight:

- a. Primary Voice Direct Line (VDL) to Mission Flight Control Officer (MFCO) in Building 7000
- b. Backup VDL to MFCO
- c. VDL to Range Control Officer (RCO) in Building 7000
- d. One class "A" telephone dial line
- e. Countdown Net (monitor only)
- f. Backup Countdown Net (monitor only), if required by Range User
- g. Any other net used for updating and/or changing the status of the FTS or RTS. **NOTE:** More communications capability may be required
- h. The FSPO console shall have the capability to monitor one or more nets while simultaneously talking on another.
- i. More communications capability may be required depending on specific vehicle design and monitoring requirements. An example of this

would be an additional VDL from the FSPO console to the Telemetry Instrumentation Processing System (TIPS) area of the WR in Building 7000.

#### 4.13.5.5 WR Launch Facility RSS Repeater System

a. If the RF propagation path from the vehicle antenna to the Range instrumentation site (radar, command transmitter, telemetry receiving station) is not adequate to ensure a good RF interface of the vehicle RSS prior to launch, an RF repeater system shall be provided.

b. Provisions shall be made for direct connection of the Range test van(s) to the vehicle RSS through the repeater system.

#### 4.13.6 RSS Components Provided by the Range User

##### 4.13.6.1 ER RSS Components Provided by the Range User

a. If secure CRDs are used, the Range User shall supply three flight configured secure CRDs to 45 SW. **NOTE:** The three flight configured secure CRDs are required for verification of secure flight code load, testing and trouble shooting throughout the program.

b. Two of the secure CRDs shall be supplied to the Range Contractor for Range system tests and calibrations.

c. The third secure CRD (Code Insertion Verification Unit) shall be used by the Range User to verify that the same secure code has been loaded into the launch vehicle CRDs as well as the command transmitter Message Storage Units.

##### 4.13.6.2 WR RSS Components Provided by the Range User

a. CRDs. The Range User shall provide two flight configured CRDs for compatibility testing and troubleshooting throughout the life of the program. **NOTE:** One CRD may be a qualification unit and the other can be a production unit.

b. Range Tracking System. The Range User shall provide two flight configured transponders and/or GPS units for compatibility and type testing and troubleshooting throughout the life of the program. **NOTE:** One unit can be a qualification unit and the other a production unit.

c. Test Sets. The 30 SW RF Measurement Lab has a variety of test sets to perform certification testing of CRDs and transponders. If the CRD,

transponder, and/or GPS is not compatible with existing radio frequency measurement laboratory (RFML) test sets, the Range User shall provide test sets for this purpose or provide funding to modify existing test sets, if required.

#### 4.14 RSS ANALYSES REQUIREMENTS

##### 4.14.1 RSS Analyses

###### 4.14.1.1 RSS Failure Analysis

A failure analysis and corrective actions shall be performed for each RSS component that fails to meet specifications, tolerances, or test procedure requirements.

###### 4.14.1.2 RSS Similarity Analyses

*a.* As required, qualification by similarity analysis shall be performed.

*b.* If qualification by similarity is not approved, qualification testing shall be performed in accordance with the requirements of this Chapter.

*c.* If component or piece part A is to be considered as a candidate for qualification by similarity to a component or piece part B that has already been qualified for use, all of the following conditions shall apply:

###### 4.14.1.2.1 Component (Black Box) Similarity Analysis.

*a.* Component A shall be a minor variation of component B. Dissimilarities shall require understanding and evaluation in terms of weight, mechanical configuration, thermal effects, and dynamic response.

*b.* Components A and B shall perform similar functions, with A having equivalent or better capability and variations only in terms of performance such as accuracy, sensitivity, formatting, and input/output characteristics.

*c.* Components A and B shall be produced by the same manufacturer in the same location, using identical tools and manufacturing processes.

*d.* The environments encountered by component B during its qualification or flight history shall have been equal to or more severe than the qualification environments intended for component A.

*e.* Component B shall have successfully passed a post-environmental functional test series indicating survival of the qualification stresses.

*f.* Component B shall have been a representative flight article.

*g.* Component B shall not have been qualified by similarity or analysis.

*h.* In cases where all the criteria in the above paragraphs is not satisfied, qualification based on engineering analysis plus partial testing may be permissible.

###### 4.14.1.2.2 Piece/Parts Similarity Analysis.

Addition, subtraction, or replacement of piece/parts within a Range Safety approved RSS component shall require specific approval.

*a.* Piece part A shall have similar electrical and mechanical specifications such as weight, mounting configuration, power rating, switching speed, and leakage rate as piece part B. **NOTE:** Technical justification showing design qualification by similarity shall be submitted to Range Safety for review and approval for any differences in specification between piece part A and B.

*b.* Environments such as shock, thermal, and vibration encountered by piece part B during its qualification or flight history shall have been equal to or more severe than the qualification environments intended for piece part A.

*c.* Piece part B shall have successfully passed a post-environmental functional test series indicating survival of qualification stresses.

*d.* Piece part B shall not have been qualified by similarity.

##### 4.14.2 FTS Analyses

###### 4.14.2.1 FTS Reliability Analysis

A reliability analysis shall be performed in accordance with the requirements in MIL-STD-785 to demonstrate the reliability goal was used in the concept and detailed design of the components and/or system and shall include the following data:

*a.* A discussion of how the FTS meets the design requirements of single fault tolerance and the design goal of .999 reliability at the 95 percent confidence level

*b.* Identification of FTS reliability model input and apportionment

*c.* Predicted reliability computations for all FTS subsystems and components

*d.* A description of the effects of storage, transportation, handling, and maintenance on FTS component reliability.

#### **4.14.2.2 FTS Failure Modes, Effects, and Criticality Analysis**

A Failure Modes, Effects, and Criticality Analysis (FMECA) shall be performed in accordance with MIL-STD-1543, Task 204 or equivalent.

#### **4.14.2.3 FTS Single Failure Point Analysis**

A single failure point (SFP) analysis shall be performed to verify that no single failure can cause FTS activation or disable the FTS.

#### **4.14.2.4 FTS Battery Analyses**

*a.* Prior to the qualification test, an analysis shall be performed to demonstrate that sufficient FTS battery life is available at launch.

*b.* An analysis shall be also performed to demonstrate compliance with the FTS battery charging temperature and current control.

#### **4.14.2.5 FTS Fratricide Analyses**

An analysis may be required to verify that the flight termination action of a stage will not sever interconnecting FTS circuitry or ordnance to other stages until other stage FTSs have been initiated.

#### **4.14.2.6 FTS RF Link Analysis**

*a.* The entire ground and airborne command FTS shall be subjected to an RF link analysis that shall show a minimum of 12 dB margin.

*b.* The RF link analysis shall include path losses due to plume or flame attenuation, aspect angle, vehicle trajectory with or without heat shields, ground system RF characteristics, and other attenuation factors.

#### **4.14.2.7 FTS Antenna Heat Shield Fly-Off Analysis**

An Antenna heat shield fly-off analysis shall be performed to ensure that the RF link margin would not be adversely affected.

#### **4.14.2.8 FTS CRD Radiation Analysis**

Launch vehicle and payload systems shall be analyzed to ensure that CRD radiation profiled are not greater than the environment the CRD is tested to.

#### **4.14.2.9 FTS Bent Pin Analysis**

A bent pin analysis shall be performed to verify that any single short circuit occurring as a result

of a bent pin shall not result in more than 10 percent of the all-fire current on the firing circuit or does not have an adverse effect on the FTS.

#### **4.14.2.10 FTS LID Heat Dissipation Analysis**

An analysis shall be performed to demonstrate that the LIDs dissipate heat faster than single failure conditions can input into the device without initiating or dudding.

#### **4.14.2.11 FTS Breakup Analysis**

**NOTE:** The purpose of the breakup analysis is to determine where and when a vehicle is most likely to break up under the credible failure scenarios. This data is used to ensure FTS components and separation detection systems are properly designed and located to maximize FTS survivability in the analyzed failure scenarios. An FTS breakup analysis (with and without destruct action) may be required to determine the design of the FTS. If required, the following breakup scenarios shall be considered in the breakup analysis:

*a.* Breakup due to aerodynamic loading effects at high angle of attack trajectories during early stages of flight at 5 second increments

*b.* An engine hard-over nozzle induced tumble during various phases of flight of each stage

*c.* Vehicle events/sequencing that, when activated, can result in damaging the FTS hardware or inhibit the functionality of the FTS

#### **4.14.2.12 FTS Tip-Off Analysis**

An FTS tip-off analysis may be required to determine the design of the FTS.

#### **4.14.2.13 ADS Timing Analysis**

An ADS timing analysis shall be performed to calculate the worst case time between ADS triggering and final destruct action.

#### **4.14.2.14 Destruct Initiator Simulator Analysis**

An analysis shall be performed to demonstrate that the destruct initiator simulator monitors the firing circuit output current, voltage, or energy and latch on when the operating current, voltage, or energy for the initiating device is outputted from the firing circuit.

### **4.14.3 RTS Analyses**

#### **4.14.3.1 RTS Reliability Analysis**

A reliability analysis shall be performed in accordance with the requirements in MIL-STD-785 to

demonstrate the reliability goal was used in the concept and detailed design of the components and/or system and shall include the following data:

- a. A discussion of how the RTS meets the design requirements of single fault tolerance and the design goal
- b. Identification of RTS reliability model input and apportionment
- c. Predicted reliability computations for all RTS subsystems and components
- d. A description of the effects of storage, transportation, handling, and maintenance on RTS component reliability.

#### 4.14.3.2 RTS Failure Modes, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis (FMECA) shall be performed in accordance with MIL-STD-1543, Task 204 or equivalent.

#### 4.14.3.3 RTS Battery Analysis

- a. Prior to the qualification test, an analysis shall be performed to demonstrate that sufficient RTS battery life is available at launch.
- b. An analysis shall be performed to demonstrate compliance with the RTS battery charging temperature and current control.

#### 4.14.3.4 RTS RF Link Analysis

- a. The entire ground and airborne command RTS shall be subjected to an RF link analysis that shall show a greater than 0 dB margin.
- b. The RF link analysis shall include path losses due to plume or flame attenuation, aspect angle, vehicle trajectory, with and without heatshield, ground system RF characteristics, and other attenuation factors.

#### 4.14.3.5 RTS Antenna Analyses

**4.14.3.5.1 ER RTS Antenna Analysis.** RTS antenna analysis and evaluation requirements shall be coordinated with the Range.

**4.14.3.5.2 WR RTS Antenna Analysis and Data Requirements.** At a minimum, the following data shall be provided for evaluation and analysis:

- a. Power gain relative to an isotropic radiator over the entire radiation sphere at 1° increments
- b. Relative phase between excitation and far-field radiation over the entire radiation sphere at 1° increments
- c. Input reflection coefficient (VSWR) versus

frequency over a span of 20 MHz centered on each of the WR assigned frequencies the antenna is intended to operate.

#### 4.14.3.6 RTS Antenna Heat Shield Fly-Off Analysis

Antenna heat shield fly-off analysis shall be performed to ensure that the RF link margin would not be adversely affected.

#### 4.14.4 TDTs Analyses

##### 4.14.4.1 TDTs RF Link Analysis

- a. The entire ground and airborne TDTs shall be subjected to an RF link analysis that shall show a greater than 0 dB margin.
- b. The TDTs link margin calculations and loss considerations shall be patterned after the requirements in RCC 253.

##### 4.14.4.2 TDTs Antenna Heat Shield Fly-Off Analysis

Antenna heat shield fly-off analysis shall be performed to ensure that the RF link margin would not be adversely affected.

### 4.15 RSS TEST REQUIREMENTS

#### 4.15.1 RSS General Test Requirements

a. The RSS, including all of its components and methods of attaching fittings or installing the system, shall be tested to certify to Range Safety that the complete system and individual components function within performance specifications when exposed to environmental levels that exceed the maximum predicted or actual flight levels during their service life.

- b. All test plans shall include instructions on how to handle procedural deviations.
- c. The instructions shall describe test failure reaction requirements in detail.
- d. All test schedules shall be provided to Range Safety.

1. The test schedules shall be updated as applicable.

2. Qualification testing shall not begin without Range Safety or a designated representative being present and approving the start of the test unless otherwise agreed in writing by Range Safety.

##### 4.15.1.1 Development Tests

Development tests validate hardware design concepts and assist in the evolution of designs from the

conceptual phase to the operational phase. An objective of these tests is to identify hardware problems early in their design evolution so that any required actions can be taken prior to starting formal qualification testing and fabrication of production hardware.

Range Safety review and approval of development test plans and procedures may not be required if the components and systems under development are considered by Range Safety to be a non-unique application of existing technology. This determination will be made by Range Safety on a case-by-case basis.

#### 4.15.1.2 Qualification Tests

*a.* RSS components may be qualified by qualification testing or by similarity analysis as described in the **RSS Analyses Requirements** section of this Chapter.

*b.* Qualification tests involve two types of tests: component tests and subsystem tests. These tests demonstrate that adequate margin exists in the final product to ensure the design specifications and the environmental design margin requirements of this Chapter are met.

*c.* Qualification test levels are established to exceed the range of environments and stresses expected from acceptance testing through flight.

*d.* The following requirements shall be met in qualification testing:

*1.* Except for ordnance, batteries, and safe and arm devices, component qualification tests shall be performed on a minimum of 3 test articles (actual flight units).

*2.* Test articles subjected to qualification testing are considered expended and shall not be used for flight.

*3.* All qualification testing shall use flight hardware (flight connectors, cables, cable clamping scheme, attaching hardware such as vibration and shock isolators, brackets, and bolts) in-flight configuration.

#### 4.15.1.3 Acceptance Tests

Acceptance tests are conducted to demonstrate that each production end item is acceptable for delivery. Acceptance tests are designed to reveal inadequacies in the manufacturing process such as workmanship, material, and quality. The following requirements shall be met for acceptance tests:

*a.* The acceptance test environmental levels shall

be at the maximum predicted or actual environments for ground transportation, pre-launch processing, check-out, launch, through end of Range Safety responsibility.

*b.* The performance parameter measurements shall establish a baseline that can be used to ensure that there are no data trends present in successive tests that indicate a degradation of performance within specification limits that could result in unacceptable performance in flight.

*c.* Acceptance testing shall be performed on 100 percent of all RSS components.

#### 4.15.1.4 Age Surveillance Tests

Age surveillance tests are performed periodically to ensure that ordnance components have not degraded over time.

The following requirement shall be met for age surveillance testing: Age Surveillance Tests shall be conducted on each production lot to demonstrate that each ordnance component will perform satisfactorily during its specified service life.

#### 4.15.1.5 Range Prelaunch Tests

Range Prelaunch tests involve component, system or subsystem tests. These tests are conducted at the Range to ensure that ground and airborne RSS components and systems are functioning properly prior to launch.

#### 4.15.1.6 Requalification or Delta Qualification Tests

Requalification or delta qualification tests are required for components that incorporate changes in vendor, vendor location, design, manufacturing, processing, environmental levels, or other requirements.

#### 4.15.1.7 Reuse Tests

Reuse tests are performed on previously flown and recovered RSS components. These tests are conducted to demonstrate that each reused RSS component meets the design requirements specified in the component specification. The following requirements shall be met for reuse testing:

*a.* Performance parameter measurements shall establish a baseline that can be used to ensure there are no data trends present in successive tests that indicate a constant degradation of performance within specification limits that could result in unacceptable performance in subsequent flights.

*b.* Design margins, environments, and reuse and refurbishment plans shall be addressed early in the design cycle when reuse is desired.

#### **4.15.1.8 Other Tests**

*a.* Other tests are those special tests that Range Safety requires based on unique use or design. The requirement for and definition of these tests will be identified by Range Safety during the design review process.

*b.* At a minimum, RF compatibility between the FTS and other airborne systems and Range transmitters shall be tested in the flight configuration. Exact RF test requirements will be determined by Range Safety on a case-by-case basis.

#### **4.15.2 FTS Component Tests**

##### **4.15.2.1 FTS Antenna System Qualification and Acceptance Tests**

*a.* Antennas and their coaxial cables shall be qualification tested in accordance with Appendixes 4B1 and 4B2.

*b.* Antennas and all of their coaxial cables shall be acceptance tested in accordance with Appendixes 4B1 and 4B2.

*c.* Antennas shall also be tested to obtain the pattern data in accordance with RCC 253.

*d.* Components such as hybrid couplers, ring couplers, and power dividers shall be qualification and acceptance tested in the same manner as required for antennas.

##### **4.15.2.2 FTS CRD Qualification and Acceptance Tests**

*a.* CRDs shall be qualification tested in accordance with Appendixes 4B1 and 4B3.

*b.* CRDs shall be acceptance tested in accordance with Appendixes 4B1 and 4B3.

##### **4.15.2.3 FTS Battery Qualification, Storage Life Verification, and Acceptance Tests**

*a.* A minimum of 3 complete battery assemblies, 12 individual cells, and a lot sample of vent and safety devices such as fuses and diodes shall be qualification tested in accordance with Appendixes 4B1 and 4B4.

*b.* Storage life verification testing of 2 cells per year of the manufacturer stated dry life capability shall be performed in accordance with Appendixes 4B1 and 4B4.

*c.* All batteries shall be acceptance tested in ac-

cordance with Appendixes 4B1 and 4B4.

##### **4.15.2.4 FTS Electromechanical S&A Device, EED and Rotor Lead Qualification, Acceptance, and Age Surveillance Tests**

*a.* A minimum of 8 electromechanical S&A devices shall be qualification tested in accordance with Appendixes 4B1 and 4B6.

*b.* Three additional electromechanical S&A devices or simulated units shall be tested to demonstrate the safety of the S&A barrier in accordance with Appendixes 4B1 and 4B6.

*c.* All electromechanical S&A devices shall be acceptance tested in accordance with Appendixes 4B1 and 4B6.

*d.* Explosive components such as EED and Rotor Lead in electromechanical S&As shall be subjected to individual qualification, acceptance, and age surveillance testing in accordance with Appendix 4B1 and 4B6.

##### **4.15.2.5 FTS EBW-FU Qualification and Acceptance Tests**

*a.* EBW-FUs shall be qualification tested in accordance with Appendixes 4B1 and 4B7.

*b.* All EBW-FUs shall be acceptance tested in accordance with Appendixes 4B1 and 4B7.

##### **4.15.2.6 FTS EBW Qualification, Acceptance, and Age Surveillance Tests**

All EBWs shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B7.

##### **4.15.2.7 FTS Laser Firing Unit, Optical S&A, and Ordnance S&A Qualification and Acceptance Tests**

*a.* Laser firing units, optical S&As, and ordnance S&As shall be qualification tested in accordance with Appendixes 4B1 and 4B8.

*b.* Laser firing units, optical S&As, and ordnance S&As shall be acceptance tested in accordance with Appendixes 4B1 and 4B8.

##### **4.15.2.8 FTS Laser Fiber Optic Cable Assembly Qualification and Acceptance Tests**

*a.* Laser FOCAs shall be qualification tested in accordance with Appendixes 4B1 and 4B8.

*b.* All laser FOCAs shall be acceptance tested in

accordance with Appendixes 4B1 and 4B8.

#### **4.15.2.9 FTS LID Qualification, Acceptance, and Age Surveillance Tests**

LIDs shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B8.

#### **4.15.2.10 FTS Percussion Activated Devices**

Percussion activated devices, including primer and booster charges shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B10.

#### **4.15.2.11 FTS Explosive Transfer Component Qualification, Acceptance, and Age Surveillance Tests**

All explosive transfer components (and subassemblies, if required by Range Safety) shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B9.

#### **4.15.2.12 FTS Destruct Charge Qualification, Acceptance, and Age Surveillance Tests**

*a.* All destruct charges shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B9.

*b.* In addition, a minimum of two tests shall be conducted to demonstrate compliance with each of the following requirements.

*1.* Destruct charge action shall not detonate the liquid and/or solid propellant.

*2.* Destruct charge action on toxic liquid propellant targets shall ignite the hydrazine-based fuel. **NOTE:** These special destruct charge tests in paragraph *b* above may be combined with Range approved development tests or may be waived all together by Range Safety if test data already exists demonstrating compliance.

#### **4.15.2.13 FTS Ordnance Subsystem Tests**

*a.* Full scale, subscale, segment, or coupon ordnance subsystem testing may be required to demonstrate destruct action on new or untested targets such as new propellant, new case and tank material, and new configurations.

*b.* Range Safety shall identify the requirement for ordnance subsystem tests as early in the conceptual design phase as possible.

*c.* Ordnance subsystem tests may be combined with the development test.

#### **4.15.2.14 FTS Shock and Vibrational Mounted Isolation Systems Qualification and Acceptance Tests**

*a.* Shock and vibration isolators shall be qualification tested as an assembly with the specific component using them.

*b.* Shock and vibration isolators shall be 100 percent acceptance tested in accordance with Appendix 4B11.

#### **4.15.2.15 Miscellaneous FTS Component Qualification and Acceptance Tests**

*a.* Miscellaneous FTS components that have not been identified in this Chapter shall be qualification tested in accordance with Appendixes 4B1 and 4B5.

*b.* The number of miscellaneous FTS components to be qualification tested shall be determined by Range Safety on a case-by-case basis.

*c.* All components shall be acceptance tested in accordance with Appendixes 4B1 and 4B5.

### **4.15.3 RTS Component Tests**

#### **4.15.3.1 RTS Antenna System Qualification and Acceptance Tests**

*a.* Antennas and their coaxial cables shall be qualification tested in accordance with Appendixes 4B1 and 4B2.

*b.* Antennas and all of their coaxial cables shall be acceptance tested in accordance with Appendixes 4B1 and 4B2.

*c.* Antennas shall also be tested to obtain the pattern data in accordance with RCC 253.

*d.* Components such as hybrid couplers, ring couplers, and power dividers shall be qualification and acceptance tested in the same manner as required for antennas.

#### **4.15.3.2 RTS Transponder Qualification and Acceptance Tests**

*a.* Transponders shall be qualification tested in accordance with Appendixes 4B1 and 4B12.

*b.* Transponders shall be acceptance tested in accordance with Appendixes 4B1 and 4B12.

*c.* Transponders that have been previously certified for use on a particular vehicle at the Range may require additional qualification testing

(environmental, survivability, and electromagnetic compatibility) if the transponder is to be used on a different type or model vehicle.

*d.* Qualification testing may be performed by an independent agency or the transponder vendor.

*e.* The identification of the test agency shall be determined on a case-by-case basis through a joint Range and Range User agreement.

*f.* The maximum time between acceptance tests shall be three years or one-half the shelf life of the unit, whichever is less.

*g.* At the WR, certain tests are performed by the WR RF Measurements Laboratory in accordance with a test plan developed in joint agreement between the WR and the Range User.

#### **4.15.3.3 GPS Qualification and Acceptance Tests**

*a.* GPS translators and receivers shall be qualification tested in accordance with Appendix 4B13.

*b.* GPS translators and receivers shall be acceptance tested in accordance with Appendix 4B13.

*c.* GPS translators and receivers that have been previously certified for use on a particular vehicle at the Range may require additional qualification testing (environmental, survivability, and electromagnetic compatibility) if the unit is to be used on a different type or model vehicle.

*d.* Qualification testing may be performed by an independent agency or the GPS unit vendor.

*e.* The identification of the test agency shall be determined on a case-by-case basis through a joint Range and Range User agreement.

*f.* The maximum time between acceptance tests shall be three years or one-half the shelf life of the unit, whichever is less.

*g.* At the WR, certain tests are performed by the WR RF Measurements Laboratory in accordance with a test plan developed in joint agreement between the Range and the Range User.

#### **4.15.3.4 RTS Battery Qualification, Storage Life Verification, and Acceptance Tests**

*a.* A minimum of 3 complete battery assemblies, 12 individual cells, and a lot sample of vent and safety devices such as fuses and diodes shall be qualification tested in accordance with Appendixes 4B1 and 4B4.

*b.* Storage life verification testing of 2 cells per year of the manufacturer stated dry life capability shall be performed in accordance with Appendixes 4B1 and 4B4.

*c.* All batteries shall be acceptance tested in accordance with Appendixes 4B1 and 4B4.

#### **4.15.4 TDTs Component Test Requirements**

The TDTs transmitter shall be qualification and acceptance tested in accordance with Appendix 4B14.

#### **4.15.5 RSS Range Prelaunch Tests**

##### **4.15.5.1 RSS Range Prelaunch Tests General Requirements**

*a.* The RSS component, system, and subsystem prelaunch tests described in this section shall be conducted at the Range following the qualification and acceptance testing.

*b.* Range Safety shall review and approve all Range prelaunch test procedures.

*c.* Range Safety or a designated representative shall be present during the performance of prelaunch tests unless otherwise agreed to by Range Safety in writing.

##### **4.15.5.2 FTS Range Prelaunch Component Tests**

###### **4.15.5.2.1 FTS Battery Prelaunch Tests.**

*a.* Bench testing shall be conducted on all FTS batteries prior to installation on the launch vehicle.

*b.* The following tests shall be included:

*1.* Open circuit voltage testing of the battery and each cell

*2.* Load testing of the completed battery assembly

*3.* Continuity and isolation testing of connectors

*4.* Pin to case voltage, to insure no electrolyte spillage during manual activation of batteries

*5.* Acceptance testing in accordance with Appendix B4 if not accomplished by the manufacturer

*c.* The time interval between these tests and launch shall be minimized in order not to exceed the activated stand time of the battery.

###### **4.15.5.2.2 FTS Electromechanical S&A Prelaunch Tests.**

*a.* Bench testing shall be conducted on all FTS S&A prior to installation on the launch vehicle.

*b.* The following tests shall be included:

*1.* Visual check for signs of physical defects

*2.* Electrical tests that arm and safe the S&A

3. Continuity and resistance checks of the EED circuit in both ARM and SAFE positions

4. Tests to verify that the device cannot be electrically armed when the safing pin is installed

5. Safing pin removal resistance tests

c. S&A bench tests shall be performed within 10 calendar days of launch.

d. If the FTS S&A devices have been electrically connected and the launch subsequently scrubbed, removal and retest may be required by Range Safety.

#### 4.15.5.2.3 FTS EBW Prelaunch Tests.

a. Bench testing shall be conducted on all FTS EBWs prior to installation on the launch vehicle.

b. The following tests shall be included:

1. Visual checks for physical defects

2. Bridgewire continuity test using a grid dip analyzer

3. High voltage static gap breakdown tests

c. EBW bench tests shall be performed within 10 calendar days of launch.

#### 4.15.5.2.4 FTS LID Prelaunch Tests.

a. Bench testing shall be conducted on all FTS LIDs prior to installation on the launch vehicle.

b. The tests to be performed shall be determined by Range Safety based on the design of the LIDs.

c. LID bench tests shall be performed within 10 calendar days of launch.

#### 4.15.5.2.5 FTS Optical S&A Prelaunch Tests.

a. Bench testing shall be conducted on all FTS Optical S&As prior to installation on the launch vehicle.

b. The tests to be performed shall be determined by Range Safety based on the design of the Optical S&As.

c. Optical S&A bench tests shall be performed within 10 calendar days of launch.

#### 4.15.5.2.6 FTS LIOS Ordnance S&A Prelaunch Tests.

a. Bench testing shall be conducted on all FTS Ordnance S&As prior to installation on the launch vehicle.

b. The tests to be performed shall be determined by Range Safety based on the design of the Ordnance S&As.

c. Ordnance S&A bench tests shall be performed within 10 calendar days of launch.

#### 4.15.5.2.7 FTS CRD Prelaunch Bench Tests.

#### a. ER Prelaunch Bench Tests.

1. Bench testing shall be conducted on all FTS CRDs prior to vehicle installation.

2. These tests include all CRD parameters at ambient temperature.

3. The CRD bench test shall be performed within 180 calendar days of the launch.

4. Vendor acceptance tests may be substituted for this bench test.

#### b. WR Prelaunch Bench Tests.

1. Bench testing shall be conducted on all FTS CRDs in a laboratory-type environment at the 30 SW RF Measurement Laboratory by RFML personnel prior to final installation of the units into the launch vehicle. **NOTE:** These tests provide additional verification that each CRD complies with the performance requirements of this Chapter.

2. WR certification following this test is valid for 120 calendar days.

#### 4.15.5.3 FTS Range Prelaunch System and Subsystem Tests

Systems and subsystem tests shall be repeated in whole or in part under the following conditions:

a. If, at any time subsequent to the prelaunch test, the integrity of the system is suspect or compromised by a configuration change, lightning strikes, mate/demate of any connectors, or other event

b. The launch is delayed by extended holds or recycles

#### 4.15.5.3.1 FTS Antenna Systems Prelaunch Tests.

a. Installed FTS antennas and associated RF transmission components shall be tested on each vehicle to determine antenna VSWR and transmission line insertion loss.

b. Calibrated antenna terminations (covers) and couplers (hats) shall be provided for all FTS antennae. **NOTE:** Covers and hats are mandatory for all in-vehicle closed-loop testing required in this Chapter.

c. The antenna termination and coupler calibration data shall be used in the in-vehicle system pass/fail criteria analysis.

d. If FTS antenna heat shields are used, they shall be installed during all in-vehicle system testing.

#### 4.15.5.3.2 FTS CRD System Prelaunch Tests.

#### a. ER CRD Prelaunch Systems Tests.

1. After installation in the launch vehicle, each CRD shall be tested at nominal voltage for threshold sensitivity and operating bandwidth.

2. Tests shall be performed to obtain calibration curves for the signal strength telemetry monitor on each CRD.

3. These tests shall be conducted within 90 calendar days of launch.

4. These tests are performed by Range User personnel in accordance with Range Safety approved procedures.

*b. WR CRD Prelaunch System Tests.*

1. An in-vehicle CRD system level performance test shall be conducted at the WR.

2. This test shall be performed as late in the receipt-through-launch readiness sequence as possible.

3. The test shall be performed by RFML personnel using the RFML mobile test van.

4. The performance characteristics derived from this test shall be compared with the characteristics derived from the bench level test.

5. If no significant differences are noted, the radio command system will be considered acceptable.

6. Depending on any unique or addition missile system or receiver and decoder requirements, other test areas may be required.

**4.15.5.3.3 FTS Standard Receiver and Decoder Prelaunch Tests.**

*a. FTS Command Open-Loop and Automatic End-to-End Tests.*

1. After installation of the FTS up to, but not including, the electrical and/or optical connection of the flight destruct initiators, an End-to-End Verification Test of the entire command and automatic FTS shall be performed.

2. The End-to-End Verification Test is conducted to prove the integrity of the ground and airborne FTS system including Range command control and transmitter systems, antenna transmission system, CRDs, flight batteries, engine shutdown valves, and automatic destruct system up to the point at which the flight destruct initiators will be electrically connected.

3. The End-to-End Verification Test shall be conducted as late in the Range User countdown as possible but not earlier than 48 h prior to launch if the FTS access compartment can be closed out.

**NOTE:** If the FTS access compartment cannot be closed out 48 h prior to launch, the end-to-end veri-

fication test shall be performed later in the countdown at a time when the FTS component access compartment can be closed out.

4. The configuration and performance requirements for this test are as follows:

(a) Destruct initiator simulators shall be installed in place of the flight initiators to verify that sufficient energy is delivered by both command and automatic circuits to initiate destruct.

(b) FTS command and automatic systems shall be powered by flight batteries.

(c) All receiver and decoder commands shall be transmitted to the vehicle open-loop by Range transmitters.

(d) All primary and redundant components and circuits in the vehicle command and automatic FTS system and the Range Command transmitter system shall be verified as operational.

*b. Final CRD RF Open-Loop Test.*

1. After removal of the destruct initiator simulators and electrical and/or optical connection of all flight destruct initiators, an RF open-loop test of the CRDs shall be performed.

2. The Open-Loop test is conducted to provide final prelaunch assurances that the Range Command transmitter systems, FTS antenna and transmission systems, and CRDs are functioning properly.

3. The Open-Loop test shall be performed as late in the Range User countdown as possible but not earlier than 60 min prior to launch.

4. The configuration and performance requirements for this test are as follows:

(a) All FTS arming devices are to remain in the SAFE position.

(b) All CRDs are powered by flight batteries.

(c) All receiver and decoder commands except DESTRUCT shall be transmitted open-loop to the vehicle by Range Command transmitters.

(d) All CRDs and primary and backup Range Command transmitters shall be tested and verified as operational.

5. Following a successful Open-Loop test, the CRDs (powered from flight batteries) and primary Range Command transmitter shall remain on through launch.

6. The WR requires that the Range Command transmitter transmit the CHECK CHANNEL command continuously through lift-off.

#### 4.15.5.3.4 FTS Secure Receiver and Decoder Prelaunch Tests.

##### a. Initial CRD RF Open-Loop Tests.

1. After installation of the command and automatic FTS up to, but not including, electrical and/or optical connection of flight destruct initiators and loading of the CRDs with secure flight codes, an RF Open-Loop test of the FTS command system shall be performed.

2. The Open-Loop test is conducted to prove the integrity of the ground and airborne command transmitter system (including the Range Command transmitter systems, vehicle antenna systems, and CRDs) up to the point at which the flight destruct initiators will be electrically and/or optically connected.

3. These tests shall be conducted as late in the Range User launch vehicle processing as practical.

4. The configuration and performance requirements for this test are as follows:

(a) Destruct initiator simulators shall be installed in place of the flight initiators to verify that sufficient energy is delivered by the FTS command system to initiate destruct.

(b) The FTS command system can be powered by either flight or ground power.

(c) Each CRD on the vehicle shall be loaded with the appropriate maintenance codes.

(d) All CRD commands required by the program shall be transmitted to the vehicle open-loop by Range Command transmitters using maintenance codes.

(e) All CRDs and primary and backup components in the Range Command transmitter system shall be verified as operational.

##### b. Command Closed-Loop and Automatic End-to-End Tests.

1. Following the loading of the CRDs with the required secure flight codes, but prior to electrical and/or optical connection of the flight destruct initiators, a Command Closed-Loop and Automatic End-to-End test of the entire command and automatic FTS shall be performed.

2. The Command Closed-Loop and Automatic End-to-End test is conducted to prove the integrity of the airborne FTS system including CRDs, flight batteries, engine shutdown valves, and the automatic destruct system up to the point at which the flight destruct initiators will be electrically and/or optically connected.

3. The Command Closed-Loop and Automatic End-to-End Test shall be conducted as late in the Range User countdown as possible but not earlier than 48 h prior to launch if the FTS access compartment can be closed out. **NOTE:** If the FTS access compartment cannot be closed out 48 h prior to launch, the Command Closed-Loop Automatic End-to-End test shall be performed later in the countdown at a time when the FTS component access compartment can be closed out.

4. The configuration and performance requirements for the Command Closed-Loop and Automatic End-to-End test are as follows:

(a) Destruct initiator simulators shall be installed in place of the flight initiators to verify that sufficient energy is delivered by both command and automatic circuits to initiate the initiators.

(b) FTS command and automatic systems shall be powered by flight batteries.

(c) All secure CRD commands required by the program shall be transmitted to the airborne CRDs closed-loop by Range User provided ground signal generators located at the launch pads.

(d) All primary and redundant components and/or circuits in the vehicle command and automatic FTS system shall be verified as operational.

##### c. Command CRD Closed-Loop Test.

1. After removal of the destruct initiator simulators and electrical and/or optical connections of all flight destruct initiators, a Command CRD Closed-Loop test shall be performed.

2. The Command CRD Closed-Loop test is conducted to provide final pre-launch assurance that the airborne command destruct system (CRDs and flight batteries) is functioning properly.

3. The Command CRD Closed-Loop test shall be performed as late in the Range User countdown as possible but not earlier than 60 min prior to launch or just prior to launch support tower rollback.

4. The configuration and performance requirements for this test are as follows:

(a) All FTS arming devices are to remain in the SAFE position.

(b) All CRDs are powered by flight batteries.

(c) All secure CRD commands required by the program except DESTRUCT shall be transmitted to the airborne CRD closed-loop by Range User provided ground signal generators

located at the launch pads.

(d) Each CRD shall be tested and verified as operational.

*d. Final CRD RF Open-Loop Test.*

1. Prior to launch, a final RF open-loop test of the CRD shall be performed.

2. The Final CRD RF Open-Loop test is conducted to provide final prelaunch assurance that the Range Command transmitter systems, FTS antenna systems, and CRDs are functioning properly.

3. The Final CRD RF Open-Loop test shall be performed after the command closed-loop test but prior to launch.

4. The configuration and performance requirements for this test are as follows:

(a) All FTS arming devices are to remain in the SAFE position.

(b) The CRDs are powered by flight batteries.

(c) The only command that will be transmitted open-loop to the vehicle CRDs by the Range Command transmitters will be the TEST command. **NOTE:** If the CRD successfully receives and decodes this command, it will initiate a self-test.

(d) All CRDs and primary and backup Range Command transmitter systems shall be tested and verified as operational.

(e) Following a successful open-loop test, the CRDs (powered from flight batteries) and primary Range Command transmitter shall remain on through launch. **NOTE:** The WR requires that the Range Command transmitter transmit PILOT TONE continuously through lift-off.

*e. WR Secure CRD Post-Flight Open-Loop Verification Test.*

1. A Post-Flight Open-Loop Verification test shall be performed at the WR following a successful launch and flight. **NOTE:** Secure FTS codes are declassified following a successful flight.

2. The Post-Flight Open-Loop Verification test is conducted to demonstrate that the Range Command transmitter system would have been able to generate and transmit flight termination commands if the vehicle had required destruct action. **NOTE:** This verification test provides assurances that the secure code loading procedures and the closed and open-loop testing performed pre-flight were written and executed properly. The exact time for this post-flight test shall be

established by Range Safety and Range User agreements.

3. The configuration and performance requirements for this test are as follows:

(a) Prior to launch, the post-flight verification CRD under RFML control shall be loaded with the same secure FTS codes that are loaded into the vehicle CRDs.

(b) As soon as possible after a successful flight, the Range shall issue and transmit open-loop all FTS command functions as applicable.

(c) The post-flight verification CRD, located in a mobile van under the control of RFML personnel, shall receive and decode all functions.

**4.15.5.4 RTS Range Prelaunch Component Tests**

**4.15.5.4.1 RTS Battery Prelaunch Test.**

a. Bench testing shall be conducted on all RTS batteries prior to installation on the launch vehicle.

b. The following tests shall be included:

1. Open circuit voltage testing of the battery and each cell

2. Load testing of the completed battery assembly

3. Continuity and isolation testing of connectors

4. Pin to case voltage to insure no electrolyte spillage during manual activation of batteries

5. Acceptance testing in accordance with Appendix 4B if not accomplished by the manufacturer

c. The time interval between these tests and launch shall be minimized in order not to exceed the activated stand time of the battery.

**4.15.5.4.2 RTS Transponder Prelaunch Bench Tests.**

**NOTE:** At the WR, in the interest of economy and testing standardization, the WR provides a portable test station operated by the 30 SW RF Measurements Laboratory to test the transponder.

a. At the WR, each transponder shall be performance tested in the bench test mode by the 30 SW RF Measurements Laboratory prior to its installation in the vehicle.

b. The WR RTS Transponder Bench test shall be conducted as late in the individual receipt-through-launch sequence as possible, consistent with the time requirements for test result data accumulation.

c. Certification is valid for 120 calendar days

after which recertification by bench test is required.

*d.* The WR RTS Transponder Bench test shall be performed according to a plan developed in joint agreement between Range Safety and the Range User.

*e.* In addition to those tests required to complete the WSMC Form 5625, Standard Tracking Transponder Performance Test, transponder performance characteristics to be tested shall be determined in a joint agreement between Range Safety and the Range User.

#### **4.15.5.4.3 RTS GPS Prelaunch Bench Test.** TBD

#### **4.15.5.5 RTS Range Prelaunch System and Subsystem Tests**

##### **4.15.5.5.1 RTS System Compatibility Test.**

*a.* An RTS system compatibility verification test, based on a Range Safety approved procedure, shall be performed.

*b.* The compatibility verification test is limited to the steps involved with controlling and monitoring the airborne system.

##### **4.15.5.5.2 RTS Antenna System Prelaunch Test.**

*a.* Installed RTS antennas and associated RF transmission components shall be tested on each vehicle to determine antenna VSWR and transmission line insertion loss.

*b.* Calibrated antenna terminations (covers) and couplers (hats) shall be provided for all RTS antennae. **NOTE:** Covers and hats are mandatory for all in-vehicle closed-loop testing required in this Chapter.

*c.* The antenna termination and coupler calibration data shall be used in the in-vehicle system pass/fail criteria analysis.

*d.* If RTS antenna heat shields are used, they shall be installed during all in-vehicle system testing.

##### **4.15.5.5.3 RTS Transponder System Level Performance Test.**

*a.* The RTS transponder shall be tested at the Range prior to launch.

*b.* The RTS Transponder System Level Performance test shall be performed as late in the individual vehicle receipt-through-launch readiness sequence as possible consistent with the time requirements for test result data submission.

*c.* The RTS Transponder System Level Per-

formance test shall be conducted in an RF closed-loop system mode.

*d.* The transponder shall not be removed from either the vehicle or the instrumentation wafer without Range Safety approval.

*e.* The transponder shall not be disconnected without Range Safety approval.

*f.* Specific requirements applicable to the RF closed-loop mode performance test are as follows:

*1.* RF loss factors shall be provided by the Range User for the RF cables, antennas of the transponder system, and the antenna couplers.

*2.* This test shall be performed in accordance with a plan developed in joint agreement between Range Safety and the Range User and shall furnish sufficient measurement data to allow completion of each applicable data item of WSMC Form 5625 or 5678, as applicable.

*3.* An RF closed-loop antenna and transponder system sensitivity and operational characteristics test shall be required at the Range if any connection in the antenna system, including transponder connections, are disconnected after completion of the transponder system level performance test.

*4.* The test shall be repeated after final connections to the antenna system and transponder are complete.

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**4.15.5.5.4** RF Open-Loop Tracking System Compatibility Verification Test.

*a.* An RF Open-Loop Tracking System Compatibility Verification test shall be conducted as late in the launch countdown as possible. **NOTE:** The purpose of the RF Open-Loop Tracking System Compatibility Verification test is to prove the integrity of both the airborne RTS and the ground system.

*b.* The verification test shall be conducted on airborne power and included in the launch agency countdown procedure.

*c.* The RF Open-Loop Tracking System Compatibility Verification test results are valid for a maximum of 12 h.

*d.* If the system or any portion of the system is compromised at any time after the initial test, the RF Open-Loop Tracking System Compatibility Verification test shall be repeated.

*e.* At the WR, if the test is inconclusive, a retest shall be performed using a Range portable transponder test system.

*f.* At the WR, the test results shall be documented on WSMC Form 5678, Standard Tracking Transponder Evaluation/Compatibility Test.

**4.15.5.5.5** RTS GPS System Prelaunch Test. TBD**4.15.5.5.6** RTS GPS Open-Loop Verification Test. TBD

## APPENDIX 4A RANGE SAFETY SYSTEM REPORT REQUIREMENTS

### 4A.1 INTRODUCTION

#### 4A.1.1 Purpose

*a.* The Range Safety System Report (RSSR) provides a detailed description of the RSS. It is the medium through which RSS approval is obtained from the launch Range.

*b.* The RSSR is a detailed description of the FTS system design specification data, reliability data, component design data, ground support systems data, and test data; the RTS; and the TDTS.

**NOTE:** All schematics, functional diagrams, and operational manuals shall have well defined, standard Institute of Electrical and Electronics Engineers (IEEE) or MIL-SPEC terminology and symbols.

*c.* Where applicable, previously approved documentation shall be referenced throughout the package.

#### 4A.1.2 Content

This Appendix contains the content preparation instructions for the data generated by the requirements delineated in Chapter 4 of Eastern and Western Range 127-1, Range Safety Requirements.

#### 4A.1.3 Applicability

This Appendix is applicable to all launch vehicles that require an RSS.

#### 4A.1.4 Submittal Process

The RSSR submittal periods are as follows:

*a.* A preliminary draft of the RSSR shall be provided 45 calendar days prior to each design review meeting (conceptual, Preliminary, and Critical).

*b.* The final RSSR shall be submitted at least four months prior to the first scheduled launch.

#### 4A.1.5 Final Approval

The formal acceptance of the RSS will be granted after approval of the final RSSR and its appendices.

#### 4A.1.6 Format

Contractor format is acceptable provided the information described in 4A.2 is provided.

*a.* RSSR main body.

*b.* Appendixes

1. FTS Appendix

2. RTS Appendix

3. TDTS Appendix

#### 4A.2.1 RSSR Main Body

The main body of the RSSR shall focus on the FTS with the exception of the general RSS.

##### 4A.2.1.1 Table of Contents and Glossary

The RSSR shall contain a table of contents and a glossary.

##### 4A.2.1.2 Introduction

The introduction shall address the scope and purpose of the RSSR.

##### 4A.2.1.3 FTS General System Description

The general system description section shall present a brief description of the launch vehicle and the FTS. The following items are included in this section:

*a.* A brief and general description of the launch vehicle

*b.* A brief and general description of the FTS, including a block diagram showing the location of all FTS components on the vehicle and the interfaces with other systems

*c.* A cable diagram of the FTS

*d.* A complete line schematic of the entire FTS from antenna to the destruct charge, including telemetry pick-off points and ground (umbilical) interfaces

##### 4A.2.1.4 FTS Detailed Component and System Descriptions

The detailed system description section includes a complete and detailed narrative description of all of the major components of the FTS. The following items are included in this section:

*a.* Narrative Description.

*1.* A complete and detailed description of the FTS operation including all possible scenarios and discussion of how FTS components function at the system and piece part level

### 4A.2 RSSR

The RSSR shall include:

## APPENDIX 4A

### RANGE SAFETY SYSTEM REPORT REQUIREMENTS

2. A complete and detailed description of each FTS component and how it functions, including specifications and schematics, mechanical and piece part specifications, and operating parameters

*b.* Detailed Schematics and Drawings.

1. Detailed schematics of the complete FTS showing component values such as resistance, capacitance, and wattage; tolerance; shields; grounds; connectors and pin numbers; and telemetry pick-off points

2. The schematics shall include all vehicle components and elements that interface with or share common use with the FTS.

3. All pin assignments shall be accounted for.

4. Drawings showing the location of all FTS system and subsystem components on the vehicle, including the following descriptions:

(a) Descriptions of element siting, mounting (attach points), and cable routing for physical isolation

(b) Descriptions of electrical connectors and connections and the electrical isolation of the FTS

5. An illustrated parts breakdown of all mechanically operated FTS components

#### 4A.2.1.5 FTS Analysis Results

As applicable, a summary of the results of the following analyses shall be included and the analyses shall be submitted separately:

*a.* Failure Analysis

*b.* Qualification by Similarity Analysis

*c.* Reliability Analysis

*d.* Failure Modes, Effects, and Criticality Analysis

*e.* Single Failure Point Analysis

*f.* Battery Analysis

*g.* Fratricide Analysis

*h.* RF Link Analysis

*i.* Antenna Heat Shield Fly-Off Analysis

*j.* CRD Radiation Analysis

*k.* Bent Pin Analysis

*l.* LID Heat Dissipation Analysis

*m.* Breakup Analysis

*n.* Tip-Off Analysis

*o.* ADS Timing Analysis

*p.* Destruct Simulator Analysis

#### 4A.2.1.6 FTS Ordnance Classification

The ordnance classifications for each ordnance device in accordance with DOT, DoD or UN and supporting documentation shall be included in this

section.

#### 4A.2.1.7 FTS Development, Qualification, Acceptance, Age Surveillance, and Reuse Test Plans, Procedures, and Reports

The following data shall be included in the body of the RSSR:

*a.* A list of test plans, procedures, and reports by title, number, and revision date

*b.* The maximum predicted flight loads for all anticipated environmental forces such as shock, vibration, and thermal for each FTS component, subsystem, and system,

*c.* A summary of the analyses or measurements used to derive the maximum predicted environments for each component

*d.* A matrix of the actual qualification and acceptance test levels used for each component, sub-system, and system in each test versus the predicted flight levels for each environment. The test tolerance allowed for each operational qualification test shall be included (for example, shock test at 6 dB over MPE with a  $\pm 3$  dB test tolerance)

*e.* A clear identification of those components qualified by similarity analysis or a combination of analysis and test

*f.* A summary of each applicable test report.

**NOTE:** The actual test report shall be submitted as a stand-alone document.

#### 4A.2.1.8 Software and Firmware Independent Verifications and Validations

A summary of software and firmware independent verification and validation shall be included.

#### 4A.2.1.9 FTS Modifications

The FTS modifications section shall include all proposed final modifications to an approved FTS, its associated equipment, component identification, test procedures, or any changes affecting the configuration and integrity of the FTS.

#### 4A.2.1.10 FTS Ground Support and Monitoring Equipment

The ground support and monitoring equipment section shall include a complete description of the ground test equipment used to checkout the FTS including contractor-peculiar tests. This section shall also include specifications and schematics for all test equipment.

## APPENDIX 4A

### RANGE SAFETY SYSTEM REPORT REQUIREMENTS

- a. Destruct initiator simulator
- b. RF Ground Support System
- c. RF Repeater system
- d. ER OSC and WR Safety console layout, display arrangement, and function of each monitor
- e. ER OSC and WR Safety console terminations including the following:

1. Schematics of all FTS monitor circuits from the FTS component pick-off points to the console termination

2. Calibration data for all monitor circuit terminations provided to the console

f. Any other ground support and monitoring equipment as required by Range Safety.

#### 4A.2.1.11 FTS Installation and Checkout

The installation and checkout section shall include the following information:

a. A list of procedures for checkout, calibration, and installation of all components, systems, and subsystems of the FTS and its associated ground checkout equipment, including launch day countdown

b. A task summary of each procedure, including:

- 1. Each separate task
- 2. The responsible agency
- 3. The objective of the procedure
- 4. Initial and final configuration
- 5. Equipment and support required
- 6. Description of task
- 7. Figures, as required

c. A flowchart indicating expected time sequence and location of each FTS procedure and task

#### 4A.2.1.12 FTS Unique Configuration

The unique configuration section shall include any information relevant to unique program requirements necessary to satisfy the Range.

#### 4A.2.1.13 FTS Noncompliances

The noncompliance section shall include all required and existing deviations, waivers, MICs, technical agreements, and understandings concerning the FTS.

#### 4A.2.1.14 FTS Changes to the RSSR

The change section shall include a summary of all changes to the last edition of the RSSR. All changes shall be highlighted using change bars or similar means of identification.

### 4A.2.2 Appendixes

#### 4A.2.2.1 FTS Appendix

a. FTS Development, Qualification, and Age Surveillance Test Reports Development, Qualification, and Age Surveillance Test Reports shall be included as stand-alone appendixes.

b. FTS compliance Checklist. The compliance checklist section shall include a checklist of all design, test, and data submittal requirements in Chapter 4. The following items are included in this section:

- 1. Criteria/Requirement
- 2. System
- 3. Compliance
- 4. Noncompliance
- 5. Not applicable
- 6. Resolution

7. References for compliance, noncompliance, not applicable. **NOTE:** The rationale for noncompliance and not applicable shall be included.

8. Copies of all Range Safety approved non-compliances including deviations, waivers, and formal Meets Intent Certifications (MICs) shall be included.

#### 4A.2.2.2 RTS Appendix

##### 4A.2.2.2.1 RTS General System Description.

The general system description section shall present a brief description of the RTS. The following items are included in this section:

a. A brief and general description of the RTS, including a block diagram showing the location of all RTS components on the vehicle and the interfaces with other systems

b. A cable diagram of the RTS

c. A complete line schematic of the entire RTS from antenna to the transponder or GPS unit, including telemetry pick-off points and ground (umbilical) interfaces

d. For GPS, it shall include the down link system.

**4A.2.2.2.2 RTS Detailed Component and System Descriptions.** The detailed system description section includes complete and detailed narrative description of all of the major components of the RTS. The following items are included in this section:

a. Narrative Description.

1. A complete and detailed description of the

## APPENDIX 4A

### RANGE SAFETY SYSTEM REPORT REQUIREMENTS

RTS operation including all possible scenarios and discussion of how RTS components function at the system and piece part level

2. A complete and detailed description of each RTS component and how it functions, including specifications and schematics, mechanical and piece part specifications, and operating parameters

*b.* Detailed Schematics and Drawings.

1. Detailed schematics of the complete RTS showing component values such as resistance, capacitance, and wattage; tolerance; shields; grounds; connectors and pin numbers; and telemetry pick-off points

2. The schematics shall include all vehicle components and elements that interface with or share common use with the RTS.

3. All pin assignments shall be accounted for.

4. Drawings showing the location of all RTS system and subsystem components on the vehicle, including the following descriptions:

*(a)* Descriptions of element siting, mounting (attach points), and cable routing for physical isolation

*(b)* Descriptions of electrical connectors and connections and the electrical isolation of the RTS

**4A.2.2.2.3** RTS Analysis Results. As applicable, a summary of the results of the following analyses shall be included and the analyses shall be submitted separately:

*a.* Failure Analysis

*b.* Qualification by Similarity Analysis

*c.* Reliability Analysis

*d.* Failure Modes, Effects, and Criticality Analysis

*e.* Battery Analysis

*f.* RF Link Analysis

*g.* Antenna Analysis

*h.* Antenna Heat Shield Fly-Off Analysis

**4A.2.2.2.4** RTS Development, Qualification, and Acceptance Test Plans, Procedures, and Reports. The following data shall be included:

*a.* A list of test plans, procedures, and reports by title, number, and revision date

*b.* The maximum predicted flight loads for all anticipated environmental forces such as shock, vibration, and thermal for each RTS component, subsystem, and system

*c.* A summary of the analyses or measurements

used to derive the maximum predicted environments for each component

*d.* A matrix of the actual qualification and acceptance test levels used for each component, subsystem, and system in each test versus the predicted flight levels for each environment. The test tolerance allowed for each operational qualification test shall be included (for example, shock test at 6 dB over MPE with a  $\pm 3$  dB test tolerance)

*e.* A clear identification of those components qualified by similarity analysis or a combination of analysis and test

*f.* A summary of each applicable test report.

**NOTE:** The actual test report shall be submitted as a stand-alone document.

**4A.2.2.2.5** Software and Firmware Independent Verifications and Validations. A summary of software and firmware independent verification and validation shall be included.

**4A.2.2.2.6** RTS Modifications. The RTS modifications section shall include all proposed final modifications to an approved RTS, its associated equipment, component identification, test procedures, or any changes affecting the configuration and integrity of the RTS.

**4A.2.2.2.7** RTS Ground Support and Monitoring Equipment. The ground support and monitoring equipment section shall include a complete description of the ground test equipment used to checkout the RTS including contractor peculiar tests. This section shall also include specifications and schematics for all test equipment.

*a.* RF Ground Support System

*b.* RF Repeater system

*c.* ER OSC and WR Safety console layout, display arrangement, and function of each monitor

*d.* ER OSC and WR Safety console terminations including the following:

1. Schematics of all RTS monitor circuits from the RTS component pick-off points to the console termination

2. Calibration data for all monitor circuit terminations provided to the console

*e.* Any other ground support and monitoring equipment as required by Range Safety.

**4A.2.2.2.8** RTS Installation and Checkout. The installation and checkout section shall include the following information:

## APPENDIX 4A

### RANGE SAFETY SYSTEM REPORT REQUIREMENTS

*a.* A list of procedures for checkout, calibration, and installation of all components, systems, and subsystems of the RTS and its associated ground checkout equipment, including launch day count-down

*b.* A task summary of each procedure, including:

1. Each separate task
2. The responsible agency
3. The objective of the procedure
4. Initial and final configuration
5. Equipment and support required
6. Description of task
7. Figures, as required

*c.* A flowchart indicating expected time sequence and location of each RTS procedure and task

**4A.2.2.2.9** RTS Unique Configuration. The unique configuration section shall include any information relevant to unique program requirements necessary to satisfy the Range.

**4A.2.2.2.10** RTS Noncompliances. The non-compliance section shall include all required and existing deviations, waivers, MICs, technical agreements, and understandings concerning the RTS.

**4A.2.2.2.11** RTS Changes to the RSSR. The change section shall include a summary of all changes to the last edition of the RSSR. All changes shall be highlighted using change bars or similar means of identification.

**4A.2.2.2.12** RTS Compliance Checklist. The compliance checklist section shall include a checklist of all design, test, and data submittal requirements in Chapter 4. The following items are included in this section:

- a.* Criteria/Requirement
- b.* System
- c.* Compliance
- d.* Noncompliance
- e.* Not applicable
- f.* Resolution

*g.* References for compliance, noncompliance, not applicable **NOTE:** The rationale for noncompliance and not applicable shall be included.

*h.* Copies of all Range Safety approved non-compliances including deviations, waivers, and formal Meets Intent Certifications (MICs) shall be included.

#### 4A.2.2.3 TDTs Appendix

The telemetry and parameter values section contains all FTS hardline and RF telemetry data. The following items shall be included in this section

##### 4A.2.2.3.1 TDTs General System Description.

*a.* A brief and general description of the TDTs, including a block diagram showing the location of all TDTs components on the vehicle and the interfaces with other systems

*b.* A complete line schematic of the entire TDTs from antenna to the transmitting unit, including ground (umbilical) interfaces.

**4A.2.2.3.2** TDTs Detailed Component and System Descriptions. The detailed system description section includes complete and detailed narrative description of all of the major components of the TDTs. The following items are included in this section:

*a.* Narrative Description.

1. A complete and detailed description of the TDTs operation including all possible scenarios and discussion of how TDTs components function at the system and piece part level

2. A complete and detailed description of each TDTs component and how it functions, including specifications and schematics, mechanical and piece part specifications, and operating parameters.

*b.* Detailed Schematics and Drawings.

1. Detailed schematics of the complete TDTs showing component values such as resistance, capacitance, and wattage; tolerance; shields; grounds; connectors and pin numbers.

2. The schematics shall include all vehicle components and elements that interface with or share common use with the TDTs.

3. All pin assignments shall be accounted for.

4. Drawings showing the location of all TDTs system and subsystem components on the

## APPENDIX 4A

### RANGE SAFETY SYSTEM REPORT REQUIREMENTS

vehicle, including the following descriptions:

(a) Descriptions of element siting, mounting (attach points), and cable routing for physical isolation

(b) Descriptions of electrical connectors and connections and the electrical isolation of the TDTS

**4A.2.2.3.3 TDTS Analysis Results.** As applicable, a summary of the results of the following analyses shall be included and the analyses shall be submitted separately:

- a. Failure Analysis
- b. Qualification by Similarity Analysis
- c. RF Link Analysis
- d. Antenna Heat Shield Fly-Off Analysis

**4A.2.2.3.4 TDTS Development, Qualification, and Acceptance Test Plans, Procedures and Reports.** The following data shall be included:

a. A list of test plans, procedures, and reports by title, number, and revision date

b. The maximum predicted flight loads for all anticipated environmental forces such as shock, vibration, and thermal for each TDTS component, subsystem, and system

c. A summary of the analyses or measurements used to derive the maximum predicted environments for each component

d. A matrix of the actual qualification and acceptance test levels used for each component, subsystem, and system in each test versus the predicted flight levels for each environment. The test tolerance allowed for each operational qualification test shall be included (for example, shock test at 6 dB over MPE with a  $\pm 3$  dB test tolerance)

e. A clear identification of those components qualified by similarity analysis or a combination of analysis and test

f. A summary of each applicable test report.

**NOTE:** The actual test report shall be submitted as a stand-alone document.

**4A.2.2.3.5 TDTS Modifications.** The TDTS modifications section shall include all proposed final modifications to an approved TDTS, its associated equipment, component identification, test procedures, or any changes affecting the configuration and integrity of the TDTS.

**4A.2.2.3.6 TDTS Ground Support and Monitoring Equipment.** The ground support and monitoring equipment section shall include a complete description of the ground test equipment used to checkout the TDTS including contractor peculiar tests. This section shall also include specifications and schematics for all test equipment.

- a. RF Ground Support System
- b. RF Repeater system
- c. Calibration data for all monitor circuit terminations provided to the console
- d. Any other ground support and monitoring equipment as required by Range Safety.

**4A.2.2.3.7 TDTS Installation and Checkout.** The installation and checkout section shall include the following information:

a. A list of procedures for checkout, calibration, and installation of all components, systems, and subsystems of the TDTS and its associated ground checkout equipment, including launch day count-down

b. A task summary of each procedure, including:

1. Each separate task
2. The responsible agency
3. The objective of the procedure
4. Initial and final configuration
5. Equipment and support required
6. Description of task
7. Figures, as required

c. A flowchart indicating expected time sequence and location of each TDTS procedure and task

**4A.2.2.3.8 TDTS Unique Configuration.** The unique configuration section shall include any information relevant to unique program requirements necessary to satisfy the Range.

**4A.2.2.3.9 TDTS Noncompliances.** The non-compliance section shall include all required and existing deviations, waivers, MICs, technical agreements, and understandings concerning the TDTS.

**4A.2.2.3.10 TDTS Changes to the RSSR.** The change section shall include a summary of all

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## APPENDIX 4A RANGE SAFETY SYSTEM REPORT REQUIREMENTS

changes to the last edition of the RSSR. All changes shall be highlighted using change bars or similar means of identification.

**4A.2.2.3.11 TDTS Compliance Checklist.** The compliance checklist section shall include a checklist of all design, test, and data submittal requirements in Chapter 4. The following items are included in this section:

- a.* Criteria/Requirement
- b.* System
- c.* Compliance

- d.* Noncompliance
- e.* Not applicable
- f.* Resolution
- g.* References for compliance, noncompliance, not applicable. **NOTE:** The rationale for non-compliance and not applicable shall be included.
- h.* Copies of all Range Safety approved non-compliances including deviations, waivers, and formal Meets Intent Certifications (MICs) shall be included.