# Space Network Support to Range Safety Concept & Feasibility Study Overview

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TDRSS

# Agenda

- Scope of the GSFC SN Range Safety Study
- Concept Assumptions
- Analysis Findings
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- Status of the GSFC SN Range Safety Study
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# Scope of the GSFC SN Range Safety Study

- **Scope**
  - **Focus of the Goddard Space Flight Center (GSFC) Space Network (SN) Support for Range Safety Study was for Missions launched from the Eastern Range (ER) and Western Range (WR)**
  - **Only Expendable Launch Vehicle (ELV) launches were evaluated**
  - **The Study investigated TDRSS S-Band Services along with Compatible Launch Vehicle (LV) Components and a Launch-Head Ground System**
  - **Presume that Tracking and Data Relay Satellite System (TDRSS) Services would be most Desired during Downrange Support (Over the Horizon)**
  - **Study Presumed SN Support in Conjunction with RSA Implementation**

# Concept Assumptions

- **Concept Caveats & Assumptions**
  - **Caveats**
    - The SN will not change current functionality. As with some other users, some exceptions may apply.
    - The study is focused around the current fleet of available TDRS. The Future TDRS Fleet (TDRS H,I,J) was noted but not considered in this analysis.
    - Approval is required by the National Telecommunications and Information Administration (NTIA) to use the TDRSS Forward Link (2025-2120 MHz) SSA High Power Flux Density Level (48.5 dBW) for this application.
    - The use of a transponder or a transceiver is addressed. The current recommendation is the use of a transceiver due to operational functionality and cost. The forward link modulation schemes include PN spread and non-spread carrier phase modulation. This study covers the feasibility of the SN supporting Range Safety, but does not address which is the best modulation technique. This decision requires further analysis.

# Concept Assumptions

- **Concept Caveats & Assumptions (cont'd)**
  - **Technical Assumptions**
    - The Range System at the launch head will be at the S-Band Frequency, TDRSS compatible
    - Command Encryption will be Performed at the Range Operations Control Center (ROCC)
    - Operational considerations will assist in resolving receiver power concerns
    - Ground communications to support RS will be via terrestrial circuits (point-to-point)
    - Utilization of the Shuttle Hi-Power Mode, 48.5 dBw (NTIA waiver)
    - The LV antenna system will be electronically optimized for aspect angles
      - » We are now investigating fixed omnis
    - Utilization of two TDRS SA antennas for redundant Forward/Return Links (one prime and one backup).
      - » Resource Challenges Exist
    - The ROCC will be able to schedule and control TDRSS services electronically
    - TDRSS Antenna pointing will be controlled from the ground via program track
    - Non-coherent operations allows for simultaneous/multiple TDRS Return link support

# Space Based Advantages

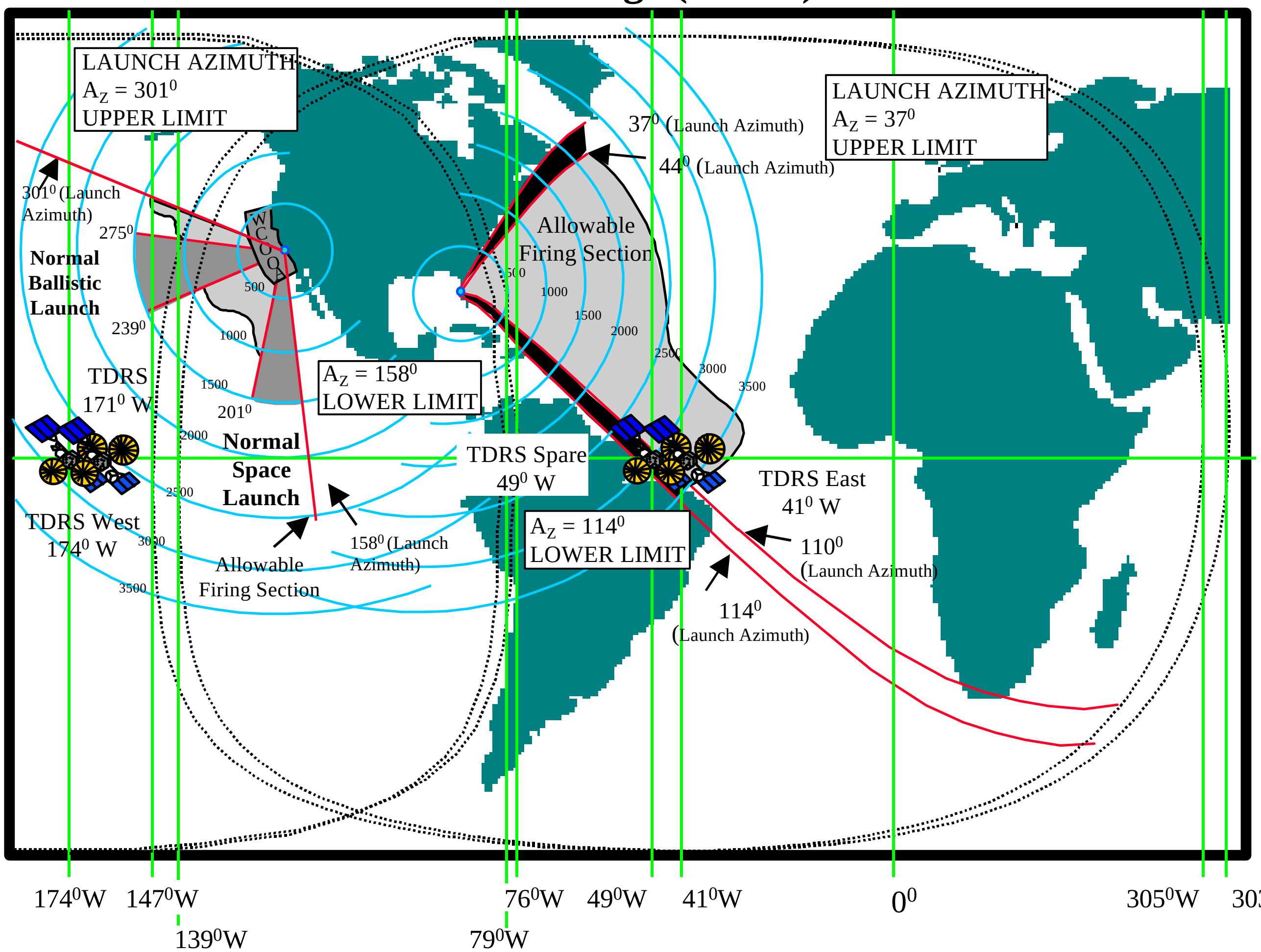
- Ready Asset
- Optimal Coverage Area
- Quick Reacq Time
- Redundant Paths (Ground)
- Low Maintenance & Operations Cost

# GSFC Analysis Findings

- **Coverage**
  - **Program Track**
    - **Launch Vehicle ephemeris uncertainty of ±4.5 seconds, uniformly distributed along the pre-flight predicted trajectory**
    - **The Launch Maneuver Sequence (LMS) used by TDRSS provides interpolation between vectors for smooth TDRS SSA pointing along the expected launch path.**
    - **Vector interpolation can be adapted in near realtime to allow the TDRS SSA pointing to be updated based on realtime LTAS data received from the Range through the support period.**
  - **TDRS S-Band footprint is approximately 700 miles circular on the Earth surface near the equator and becomes ellipsoid at higher or lower latitudes**
  - **Overlay of TDRS Coverage to the EWR 127-1 ER/WR Firing Range (next slide)**

# GSFC Analysis Findings

## Coverage (cont'd)



# GSFC Analysis Findings

- **Latency**
  - **The LV range safety data latency requirement is 500 milliseconds (EWR 127-1)**
  - **NASA NISN is investigating point to point terrestrial communications which would also decrease delay times.**

| Configuration (Terrestrial Circuits) | Time Delay (milliseconds) | |
|---|---|---|
| LV to TDRS to WSC | 270 ms | |
| WSC to GSFC | 30.76 ms | |
| | **Eastern Range** | **Western Range** |
| GSFC to CD&SC | 19.42 ms | - |
| CD&SC to CCC | <5 ms | - |
| GSFC to WR | - | 31.46 ms |
| **Total Latency** | 324.19 ms | 332.23 ms |

» **WSC Latency: One (1) microsecond (usec) for data rates below 250 kbps and .25 the bit period for data rates above 250 kbps.**

» Latency internal to the LV and the ROCC are estimates from data gathered by the authors. **LV on-board latency ~20ms and ROCC latency ~60 ms**

# GSFC Analysis Findings

- **Security**
  - **ROCC Encryption**
  - **PN Spreading vs BPSK Data Stream (anti-jamming)**
    - **A By-Product of PN Spreading is Anti-Jamming Characteristics**
  - **System Security Level**
    - The GSFC NCC designated Automated Information Sensitivity Level 3, the highest of the NASA defined levels.
    - Security requirements for the WSC are based on the requirements in NASA Hand Book (NHB) 2410.09 (NASA Automated Information Security Handbook), and the GSFC (GHB) 1600.1A (GSFC Security Manual)
    - Communications Security (COMSEC) procedures are in place and derived from and in relation to National Security measures. The elements have been evaluated and determined to be in compliance with the level 3 requirements defined in NASA Handbook 2410.9A and GSFC 1600.1A.
    - Range Safety Data Security Requirements will be thoroughly negotiated

# GSFC Analysis Findings

- **Scenarios**
  - Ground Based and Space Based Communications
  - Example Operational Scenario Options:
    - Option 1: Ground/Space Simultaneously (at the Same Target)
      - » Multichannel Receiver (possible intermodulation)
      - » Separate Channel for the Ground to Acquire, Separate Channel for the TDRS to Acquire. Both Systems Lock the LV and are Capable of Sending Destruct Commands
      - » Design and Power Discussions Required
      - » Proof of Concept Activity
    - Option 2: Switchover
      - » Standard Single Channel Receiver
      - » At a Predetermined Time Prior to Over the Horizon (OTH), Switchover from the Ground System Launch Head to the TDRSS at which Time the TDRSS Brings Up the Forward Link.
      - » In this Scenario, the Ground System Launch Head Over-Powers the TDRS Link To Capture the LV Receiver. The TDRS Link Program Tracks the LV with Modulation on the Forward Link. TDRSS will then be Capable of Quickly Acquiring the Forward Link.

# Status of the GSFC SN Range Safety Study

- **Baselined Document - July 1998**
- **Distribution**
  - Document Distributed late July, early August
  - Wider Distribution than the Draft Version provided in January 1998
- **Refinement of the Concept**
  - Document will be Enhanced in the Future as a Result of Discussions, Analyses, etc.
  - Document Change Notices (DCN) will be Produced Periodically to Update the Document
  - All Comments are Appreciate, at Any Time
- **On the Web - soon to be at: http://tip.gsfc.nasa.gov**

# Summary

- **Concept**
  - Will be Modified to Better Define the System Required for Range Safety Services
- **Feasibility**
  - Believed to be Feasible. Several Technical and Operational Areas Require Further Assessment
    - LV Transceiver Design
    - Antenna Design/Placement
    - Command Interference (Space and Ground)
    - Verifying Latency
    - Redundancy Issues (Ground/Space)
    - Range Acceptance
    - TDRSS Support Loading
  - Proof of Concept (i.e., Testing) is Recommended