May 1st, 1:00 PM

Paper Session III-C - Tracking and Data Acquisition (T&DA) Support to Launch Vehicles by the Tracking and Data Relay Satellite System (TDRSS)

Margery Bacon

Follow this and additional works at: http://commons.erau.edu/space-congress-proceedings

Scholarly Commons Citation
NASA
Tracking and Data Relay Satellite System

Discover... the reliable, economical, unparalleled, satellite data relay system.
The Tracking and Data Relay Satellite System (TDRSS) is the heart of the National Aeronautics and Space Administration (NASA) Space Network. TDRSS is a space based system of geosynchronous satellites, managed by the Goddard Space Flight Center (GSFC) and includes the GSFC Network Control Center (NCC) and the White Sands Complex (WSC) in New Mexico, that together provide near continuous communications and tracking services to low earth orbiting spacecraft, launch vehicles, and various suborbital platforms.

With the addition of the Guam Remote Ground Terminal (GRGT) scheduled to be operational in July 1998, TDRSS will be capable of providing continuous global communications and tracking services.

The TDRSS constellation is configured as shown.
Expendable Launch Vehicles (ELVs) joined the TDRSS customer community becoming operational in October 1995. Atlas/Centaur, Titan/Centaur, and soon Titan/IUS and Sea Launch vehicles will receive required and mandatory coverage through TDRSS.

As of March 1997, TDRSS had successfully supported 14 ELV launches; 6 Atlas/Centaur, 6 Titan/Centaur, 1 Shuttle/IUS and 1 Titan/IUS. TDRSS met, or exceeded, requirements for each mission.

TDRSS service is “better, faster and cheaper.” It is better because it provides global coverage with a demonstrated 99.99% availability. It is faster because all data is available in real-time and TDRSS is continuously operating, on-station and available when your countdown begins. TDRSS is an order of magnitude cheaper and more reliable than aircraft based telemetry platforms.

TDRSS provides superior global critical launch communications coverage.

**TDRSS /ELV Support**

TDRSS provides ELV customers with Liftoff through Critical Periods communications. TDRSS is available to support:

- Liftoff
- Main Engine Burns
- Vehicle Separation
- Spacecraft Separation
- Vehicle Blowdown
- N H Depletion
TDRSS has been providing customers data since 1983. TDRSS/ELV customers benefit from the experience of the NASA technical support team. This team contains experts in all disciplines necessary to ensure the communications success of the ELV mission. The technical support team is available to provide static and dynamic link analysis using the Communications Link Analysis Simulation System (CLASS), assist with compatibility options, perform compatibility and end-to-end testing, and supply operations management expertise. The technical support team members include:

- Operations Management
- CLASS Link Analysis
- Flight Dynamics
- Systems Testing
- Real-time Mission Support

TDRSS features include flexible customer service configurations, minimal data latency, quick signal acquisition (<1 second), redundant data paths and low maintenance and operations costs. TDRSS is an established operational on-station system which can respond on very short notice for mission support.

### ELV Customer Support Configurations

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Data Rate</th>
<th>Convolutional Encoding</th>
<th>Modulation</th>
<th>Transmitter</th>
<th>Antenna</th>
<th>Operational Link Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titan/Centaur</td>
<td>128 kbps</td>
<td>Rate 1/2</td>
<td>BPSK</td>
<td>15.5 Watts</td>
<td>6dB RCP</td>
<td>+7.2 dB</td>
</tr>
<tr>
<td>Atlas/Centaur</td>
<td>256 kbps</td>
<td>Rate 1/2</td>
<td>BPSK</td>
<td>26 Watts</td>
<td>4dB RCP</td>
<td>+10.7 dB</td>
</tr>
</tbody>
</table>

### Space Network Data Latency

- Information for potential Range Safety Applications

**Eastern Range (ER):**
- 270.00 ms ELV to TDRS to WSC
- 30.76 ms WSC to GSFC
- 19.42 ms GSFC to CD&SC
- < 5.00 ms CD&SC to CCC

Total ER Delay 325.18 ms

**Western Range (WR):**
- 270.00 ms ELV to TDRS to WSC
- 30.76 ms WSC to GSFC
- 31.46 ms GSFC to WR

Total WR Delay 332.22 ms
Each of the original series of Tracking and Data Relay Satellites (TDRS) transmits and receives in three frequency bands; C, S and Ku-Bands from seven antennae. At Ku-band TDRS has a 100 mile diameter Earth footprint, at S-band TDRS has an 800 mile diameter Earth footprint. TDRS is fully automated and offers a wide range of flexible communications services. Data rates from 100 bits per second up to 300 million bits per second are supported.
The space segment, the Tracking and Data Relay Satellites (TDRSs), operate as bent-pipe data repeaters, relaying signals between WSC and each customer vehicle. The TDRSS constellation consists of four schedulable satellites, plus on-orbit spares. The WSC controls the TDRS spacecraft and provides the interface to the TDRSS customers and the additional ground element support facilities. The WSC is the control center for the TDRS spacecraft, configuring the ground support equipment, monitoring the TDRS health and status telemetry, and ensuring round-the-clock operations success.

The ground segment provides the direct RF interface to the TDRS space segment. The WSC relays bi-directional data between the customer’s Mission Control Center (MCC) and the customer’s satellite. The TDRSS mission is to provide highly reliable communications services to a customer community of scientists and experimenters, spacecraft operators, mission control centers, and agencies or organizations that utilize the NASA TDRSS Space Network.

Reliable communications are essential to the success of every mission. In order to ensure a continuity of TDRSS services well into the next century, three additional TDRS spacecraft have been procured. The first of the TDRS-H,I, J series will be on orbit in 1999.

The WSC consists of two highly automated functionally identical ground terminals, the White Sands Ground Terminal (WSGT), and the Second TDRSS Ground Terminal (STGT) located several miles apart. WSC provides a relay interface between the space segment, the ground segment and the other ground elements including the Network Control Center (NCC), the Flight Dynamics Facility (FDF) and customer Mission Control Centers.

The WSC, or TDRSS ground segment, includes the transmit and receive equipment to support the three types of available customer satellite communications services: Multiple Access (MA), K-Band Single Access (KSA) and S-Band Single Access (SSA). Tracking service can be provided through any of the three types of communication services. TDRSS provides either two-way range, two way Doppler, or one-way Doppler measurements. Sampled range and Doppler data are routed from the WSC to the GSFC Flight Dynamics Facility (FDF) for orbit determination.
The WSC consists of:

- Three 18.3 meter K-Band customer traffic antennas
- Three 19 meter K-Band customer traffic antennas with backup TDRS S-Band TT&C capability.
- Two 10 meter TDRS S-Band TT&C antennas
- Two co-located operations buildings with associated RF, signal processing, data processing, and control center equipment.
- A co-located Software Maintenance and Training Facility and a hardware maintenance depot repair facility.
- A co-located logistics and engineering facility.

Each ground terminal includes two fully redundant independent Space Ground Link Terminals (SGLT) which provide the ground RF interface, the transmit and receive equipment, multiple access RF and demodulation equipment, and the multiplexing/demultiplexing, buffering, switching and interface with the NASCOM data transport equipment. In addition, each ground terminal has a spare SGLT which can be utilized by a spare TDRS or reserved as a “hot standby” for a primary SGLT. The spare SGLTs do not have Multiple Access (MA) capability.

The Goddard Space Flight Center (GSFC) Network Control Center (NCC) schedules and manages all TDRSS resources. Services provided to TDRSS customers are in accordance with a schedule prepared by the NCC. The basic schedule is provided to the WSC at least 24 hours in advance, with updates accepted to within 10 minutes of event start-time. Service changes such as data rate changes, can be easily accommodated through reconfiguration requests. Reconfigurations can be initiated within 15 seconds after the schedule process is started at the WSC. Additionally the NCC can provide TDRSS control message generation for customers that have minimal or only occasional support requirements. TDRSS customers directly control and monitor the scheduled TDRSS links during real-time operations with their vehicles.
TDRSS Telecommunication Services

**General**
TDRSS services are designated as Forward or Return, Multiple Access (MA), or Single Access (SA). This introduction provides a brief definition of those TDRSS services.

**TDRSS Forward Services**
TDRSS forward service is defined as a communication path which generally originates at the customer control center and is routed through the Tracking and Data Relay Satellite (TDRS) to the customer's vehicle. Typically, the forward service is utilized for customer vehicle commanding. Forward service data rates are variable depending on the selection of SA or MA service utilization as well as specified frequency (K band or S band).

**TDRSS Return Services**
TDRSS return service is defined as the communication path which generally originates at the customer vehicle and is routed through TDRS back to the customer control center or data acquisition location. Typically, the return service is utilized for the return of telemetry and science data. Return service data rates are variable depending on the selection of SA or MA service utilization as well as specified frequency (K band or S band).

**Multiple Access Service**
The MA service provides dedicated return service to customers with real-time, playback, and science data rates up to 100 kbps. Return service support can be provided for up to five simultaneous customers per TDRS at a time. Forward service operations are time shared with a maximum individual customer data rate of 10 kbps and will support one customer per TDRS at a time. The MA service operates at S band (fixed frequency and polarization).

**Single Access Service**
Four SA services are available through each of the steerable TDRS SA antennas:

- S band single access forward (SSAF)
- S band single access return (SSAR)
- K band single access forward (KSAF)
- K band single access return (KSAR)

Forward service operation supports data rates to 300 kbps at SSAF and to 25 mbps at KSAF. Return service operations are supported at data rates to six mbps at SSAR (rate 1/2 coded) and 300 mbps (uncoded) KSAR.

**Tracking Service**
TDRSS tracking support provides all position, time, and frequency data necessary to maintain precise customer vehicle orbit prediction (acquisition), orbit determination (tracking), and attitude determination and control.
The next series of TDRS Spacecraft (TDRS- H, I, J)

TDRS-H, I, and J will perform onboard MA return service beamforming for five simultaneous customers and support higher return data rates. Additionally, TDRS-H, I, J will have Ka-band forward and return service. Initial launch is scheduled for July 1999. These spacecraft provide enhanced capabilities and will extend the mission of the TDRSS Space Network beyond the year 2015.

The following chart provides a comparison of the service capabilities available with the current TDRS 1-7 series of satellites and the TDRS H, I, J series of satellites.

### TDRSS /TDRS-H, I, J Baseline Service Comparison

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>TDRS 1-7</th>
<th>TDRS H, I, J</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SINGLE ACCESS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-BAND</td>
<td>FWD 300 kbps</td>
<td>300 kbps</td>
<td>NO CHANGE</td>
</tr>
<tr>
<td></td>
<td>RTN 6 Mbps</td>
<td>6 Mbps</td>
<td></td>
</tr>
<tr>
<td>Ku-BAND</td>
<td>FWD 25 Mbps</td>
<td>25 Mbps</td>
<td>NO CHANGE</td>
</tr>
<tr>
<td></td>
<td>RTN 300 Mbps</td>
<td>300 Mbps</td>
<td></td>
</tr>
<tr>
<td>Ka-BAND</td>
<td>FWD N/A</td>
<td>50 Mbps</td>
<td>23/25-27 GHz frequency band</td>
</tr>
<tr>
<td></td>
<td>RTN N/A</td>
<td>300 Mbps</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF LINKS PER SPACECRAFT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 SSA</td>
<td>2 SSA</td>
<td>For TDRS-H, I, J, simultaneous operation of S &amp; Ku and S &amp; Ka services via a single SA antenna are required</td>
</tr>
<tr>
<td></td>
<td>2 KuSA</td>
<td>2 KuSA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 KaSA</td>
<td>2 KaSA</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF MULTIPLE ACCESS LINKS PER SPACECRAFT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWD</td>
<td>1 @ 10 kbps</td>
<td>1 @ 10 kbps (8 dB over TDRSS)*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8 dB over TDRSS)*</td>
<td>Anticipated SSA users &lt;3 Mbps offloaded to TDRS-H, I, J MA</td>
<td></td>
</tr>
<tr>
<td>RTN</td>
<td>20 @ 50 kbps</td>
<td>5 @ 1.5 Mbps</td>
<td></td>
</tr>
<tr>
<td>CUSTOMER TRACKING</td>
<td>150 meters 3 sigma</td>
<td>150 meters 3 sigma</td>
<td>NO CHANGE</td>
</tr>
</tbody>
</table>

* 34 to 42 dBW adjustable in 1 dB steps
TDRSS fulfills a wide range of data communications... immediately.