ADVANCED TRACKING AND DATA RELAY SATELLITE SYSTEM

Daniel Stern
NASA Headquarters
Washington, D.C. 20546

ADVANCED TDRSS

PURPOSE:

• Provide NASA needs for satellite tracking and communications through the year 2012

• Maintain and augment the current TDRS System when available satellite resources are expended in the latter part of the next decade

• Provide the necessary ground upgrade to support the augmented services

• Introduce new technology to reduce system life-cycle cost.
ATDRSS Configuration

TDRS LAUNCH SCHEDULE

TDRS 1 - Launched 4/83; Degraded Capability
TDRS 2 - Lost in Challenger accident 1/86
TDRS 3 - Launched 9/88
TDRS 4 - Launched 3/89; replaced F-1

TDRS 5 - In orbit spare in 1990
TDRS 6 - Ground spare or fourth satellite in constellation
TDRS 7 - Replacement spacecraft; available 1992
TDRS 8 - Optional spacecraft; not available before 1994
ATDRS - Advanced TDRS; not available before July 1997
ADVANCED TDRSS STATUS

- Completed 18-month Conceptual Design Studies (Phase A) in March; Ford, GE, Hughes, Lockheed, TRW
- Phase B RFP to be released in August 1989 for a competitive award to multiple contractors
- Delivery of the first ATDRS is planned for July, 1997

ATDRSS PROGRAM SCHEDULE
TDRSS EVOLUTION

1995 TDRSS CLUSTER

1997 ADVANCED TDRSS

2000+ NEW CAPABILITIES

- Capability
  - Increase to 8 SA's with 4th Spacecraft
- 8 SA's
- Enhanced S-Band
- Ka-User SGL
- Satellite Expansion Capability
- Navigation Beacon (study)
- 650 MBPS Return
- Geo. Coverage
- Increased Spacecraft autonomy
- Demand Access (study)
- Cross Links
- Direct Data Distribution
- Laser Links
- Interoperability with Foreign DSR's

POTENTIAL SERVICES UNDER EVALUATION

- Cost vs. benefit of closing the zone of exclusion
- Increased single access capacity (>300 Mb/sec)
- Direct downlink to some locations or users
- Demand Access on MA channels
- Interoperability with other data relay satellite systems
- Increased satellite reliability and redundancy
- GEO user coverage
- Command/Navigation Broadcast (Beacon)
- Pre-Operational Demonstration (Satellite Expansion)

Status

Defer
✓
Defer
Study
✓
✓
Study
✓
## TDRSS / ATDRSS
### BASELINE SERVICE COMPARISON

<table>
<thead>
<tr>
<th>Single Access</th>
<th>Max. Rate (MBPS)</th>
<th>1996 TDRSS Cluster</th>
<th>2003 Advanced TDRSS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S-Band</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWD</td>
<td>0.3</td>
<td>8</td>
<td>4* + Spare</td>
</tr>
<tr>
<td>RTN</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ku-Band</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWD</td>
<td>25</td>
<td>8</td>
<td>4* + Spare</td>
</tr>
<tr>
<td>RTN</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ku-Band</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWD</td>
<td>50</td>
<td></td>
<td>4* + Spare</td>
</tr>
<tr>
<td>RTN</td>
<td>650</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total No. of Independent Pointable Antennas</strong></td>
<td>8</td>
<td>8 + 2 Spare</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Multiple Access</th>
<th>TDRSS</th>
<th>ATDRSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FWD</td>
<td>4 @ 10 KBPS</td>
<td>8 @ 10 KBPS (+3 dBW)</td>
</tr>
<tr>
<td>RTN</td>
<td>20 @ 50 KBPS</td>
<td>12 @ 3 MBPS**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tracking Accuracy</th>
<th>TDRSS</th>
<th>ATDRSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 M, 3 σ</td>
<td></td>
<td>Study improvement to 50M, 3 σ</td>
</tr>
</tbody>
</table>

* Minimum-possibly larger  ** MA Gain equal to TDRS Single Access - S-Band

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**QPSK**

- Expansion to Ka-Band obviates need for highly bandwidth-efficient modulation techniques
- Minimizes User and Spacecraft impact
## ATDRSS MODULATIONS

### Telecommand:

- **SQPN and data**
  - PN Range and Command Channel
  - PN Spread for ≤ 300 KBPS
  - New 50 MBPS Ka-Band is Balanced SQPSK

### Telemetry:

- **DG1, mode 1+2**
- **DG1, mode 3**
- **DG2**

- **SQPN and data**
  - PN Spread at Lower Rates

- **PSK in quadrature**
  - Only I-Channel is PN Spread

- **BPSK, QPSK, SQPSK**
  - Unbalanced and Balanced Mode
  - SQPSK Used for Equal I & Q Data Rates

## ATDRSS SIGNAL PARAMETERS

- **Bent-Pipe as TDRS**
- **$1 \times 10^{-5}$ BER**
- Convolutional Encoding/Viterbi Decoding at 1/2 & 1/3 rates for some modes as in TDRS
  - User can provide own End-to-End Encoding
CONCLUSIONS

• No ATDRS Spacecraft Requirement for New Modulation Techniques

• Data Rate of 650 MBps is Required
  - Opportunities Exist for Applications of Advanced Modulation Techniques for Ground Data Distribution

• Space Station Freedom Requirement for 650 MBps Data Some Time After the Year 2000