Session A3: Setting Conditions for T&E Exploration
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Smart Data Selection (SDS)
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Outline

• Project Description
• System Description
• Bandwidth Efficient Algorithm
• Telemetry Compression
• Enhanced Telemetry Transmission
• Benefits to T&E
Project Description

“The dominant inherent nature to TM in DoD testing is sampled time-history data from an ultimately analog world, (which) is not going to change drastically regardless of how data is transmitted to ground. A factor that could change that fact most is the degree to which answers instead of data are obtained on board the test vehicle”

iNET Concept of Operations, v. 2007.1

• SDS seeks to change this inherent nature of telemetry in DoD testing by:
  - Developing an on-board capability to monitor and analyze test data in order to reduce the amount of data sent to the ground
  - Employing bandwidth efficient algorithms to reduce bandwidth requirements
  - Developing the capability to notify operators when data demonstrate abnormal behavior

Results in Significant Savings in Spectrum and Increased Operator Awareness
The SDS system:

- Analyzes pre-recorded data to identify behavioral trends
- Applies user-defined behavioral criteria
- Subscribes to all on-board parameters
- Determines what live data is of interest for real-time observation and analysis
- Applies bandwidth efficient algorithms to select measurements
- Generates specific messages to be sent to ground
- Provides alerts for data that demonstrate unexpected behavior
- Supports user feedback in response to alerts
System Description
Bandwidth Efficient Algorithms

• SDS applies extrapolation algorithms to selected data
  – Allows for TA transmission of extrapolation parameters rather than individual measurement values
  – Ground calculates and publishes with required frequency

• TA monitors error between extrapolation values and actual measurements

• If error threshold exceeded, new parameters are calculated and applied
Bandwidth Savings

• Representative test results:
  – ~45,000 measurements at 98.04 Hz

• Very small error threshold:
  – Error <= 0.01%
  – SDS requires less than 7% of original bandwidth

• Small error threshold:
  – Error <= 0.02%
  – SDS requires less than 3% of original bandwidth
Thermocouple Example

~45000 measurements @ 98.04 Hz
Bandwidth Savings

- 44091 Measurements
- Measurement Size = 2 bytes
- Error threshold of 0.01%
- 1001 EBE Resets
  - Transmission Cost =~3 Measurements
- Extrapolated Data = 1001 \times 2 \times 3 = 6006 bytes
- Raw Measurements = 44091 \times 2 = 88192 bytes
- SDS uses less than 7% of bandwidth required to send raw data
Enlarged View

- Smoothing Resets
- Extrapolation Resets
Enlarged View

- **Raw Values**
- **Extrapolated Value**
- **Smoothed Value**
Telemetry Compression

- Utilize existing SDS framework to apply compression to PCM
- Provide PCM compression within TmNS messages
- Apply lossless data compression algorithms in conjunction with error correction for significant bandwidth savings
Benefits of Compression

• Potential to yield a 70% increase in bandwidth utilization
  – Provides availability to great volume of test data
  – Provides ability to support increased number of test articles concurrently

• Utilization of telemetry data characteristics improves upon compression rates resulting application of standard lossless compression
Introduction of PCM Compression

On-Board Test Article

PCM Telemetry Stream with Minor Frames

PCM Telemetry Stream – SDS-PCM Frames inserted into Minor Frames for Transmission

SDS

Extract Minor Frames

Package as compressed SDS-PCM Frames

Ground-Based

PCM Telemetry Stream with Minor Frames

PCM Telemetry Stream – Minor Frames

SDS

Extract SDS-PCM Frames

Recreate Minor Frames
PCM Enhancement

• SDS implementation was based on TmNS message format
  – Test Article and Ground modules updated to process PCM minor frames embedded in TmNS messages

• New capability added to process PCM in traditional PCM environment
System Performance

- CPU Intel Core i7 – 3632QM @ 2.2 GHz
- RAM 8GB
- Windows 64 bits
- Current Capacity @ 50% CPU (no optimization)
  - 30,000,000 Msmts/sec
  - 16 bits/Msmt: 480 Mbits/sec uncompressed, <~ = 100 Mbits/sec compressed
- Target Capacity @ 50% CPU (some optimization)
  - 50,000,000 Msmts/sec
  - 16 bits/Msmt: 800 Mbits/sec uncompressed, <~ = 150 Mbits/sec compressed
Enhanced Telemetry Transmission

- Implement hybrid architecture to support the efficient transmission of real-time and recorded telemetry data in both the PCM and iNET environments
- Built using iNET standards and may be utilized by both the PCM and iNET environments
- Utilizes mechanisms to add packet-based telemetry capabilities on top of PCM-based data bus and transmission mechanisms with no changes to the existing test article data bus or radio
Traditional PCM Path
iNET and PCM Converted to Packet Telemetry
Benefits to T&E

• SDS
  – Bandwidth Savings/Increased Spectrum Efficiency
  – Enhanced Operator Awareness of Test Conditions

• Telemetry Compression
  – Potential to yield a 70% increase in bandwidth utilization
  – Utilization of telemetry data characteristics improves upon compression rates resulting application of standard lossless compression

• Hybrid Architecture
  – Deployment in a full PCM-based environment with incorporation of iNET standards
  – Supports hybrid environments that include both PCM and iNET standards
  – Supports use of both PCM and packet-based radios