Session A3: Spectrum Efficient Technologies

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Smart Data Selection (SDS)

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U.S. AIR FORCE

AD INEXPLORATA
AFTC

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Outline

- Project Description
- SDS ConOps
- System Description
- Bandwidth Efficient Algorithm
- PCM Compression Enhancement
- System Performance
- 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

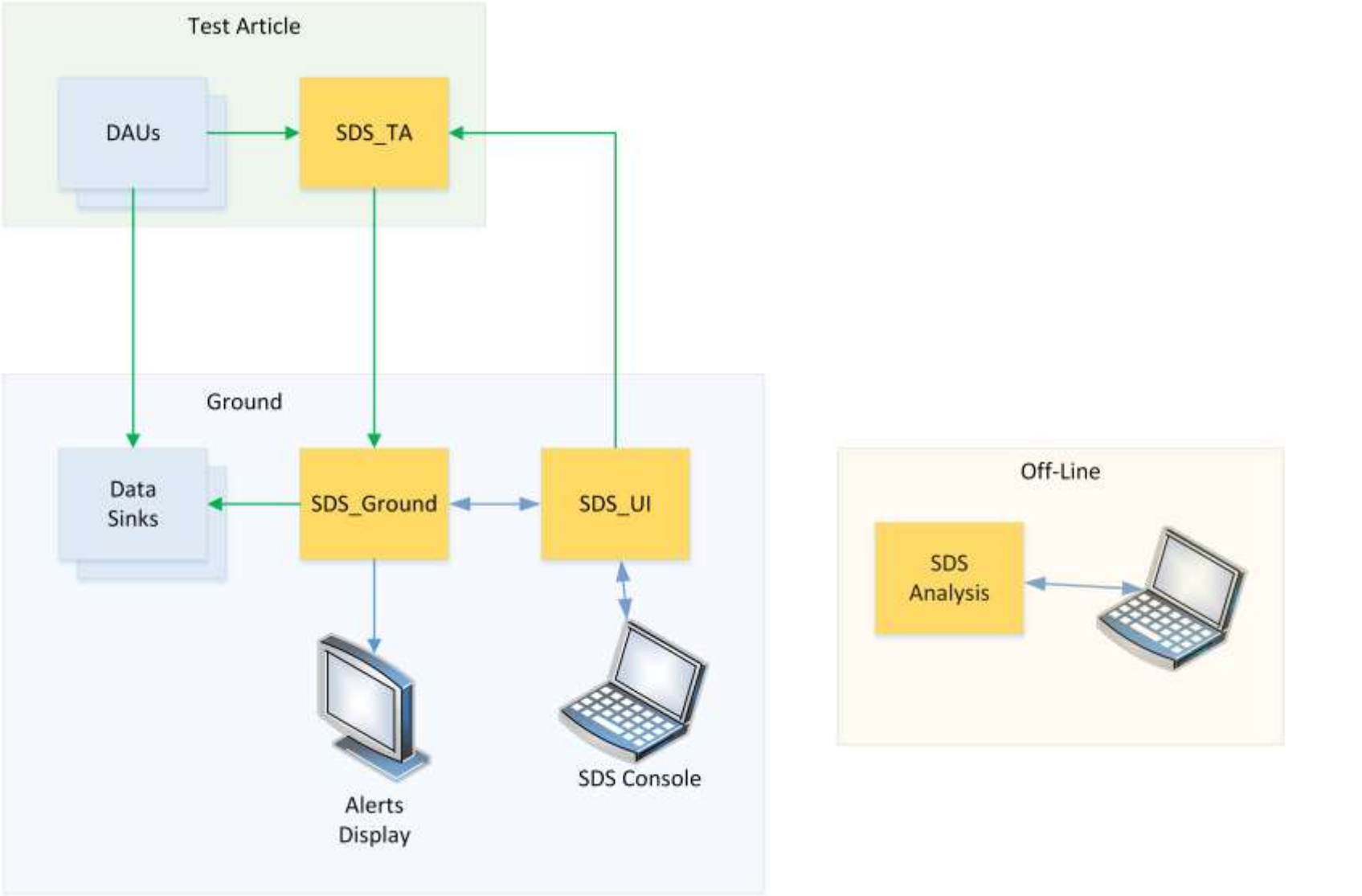
Results in Significant Savings in Spectrum and Increased Operator Awareness

SDS ConOps

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



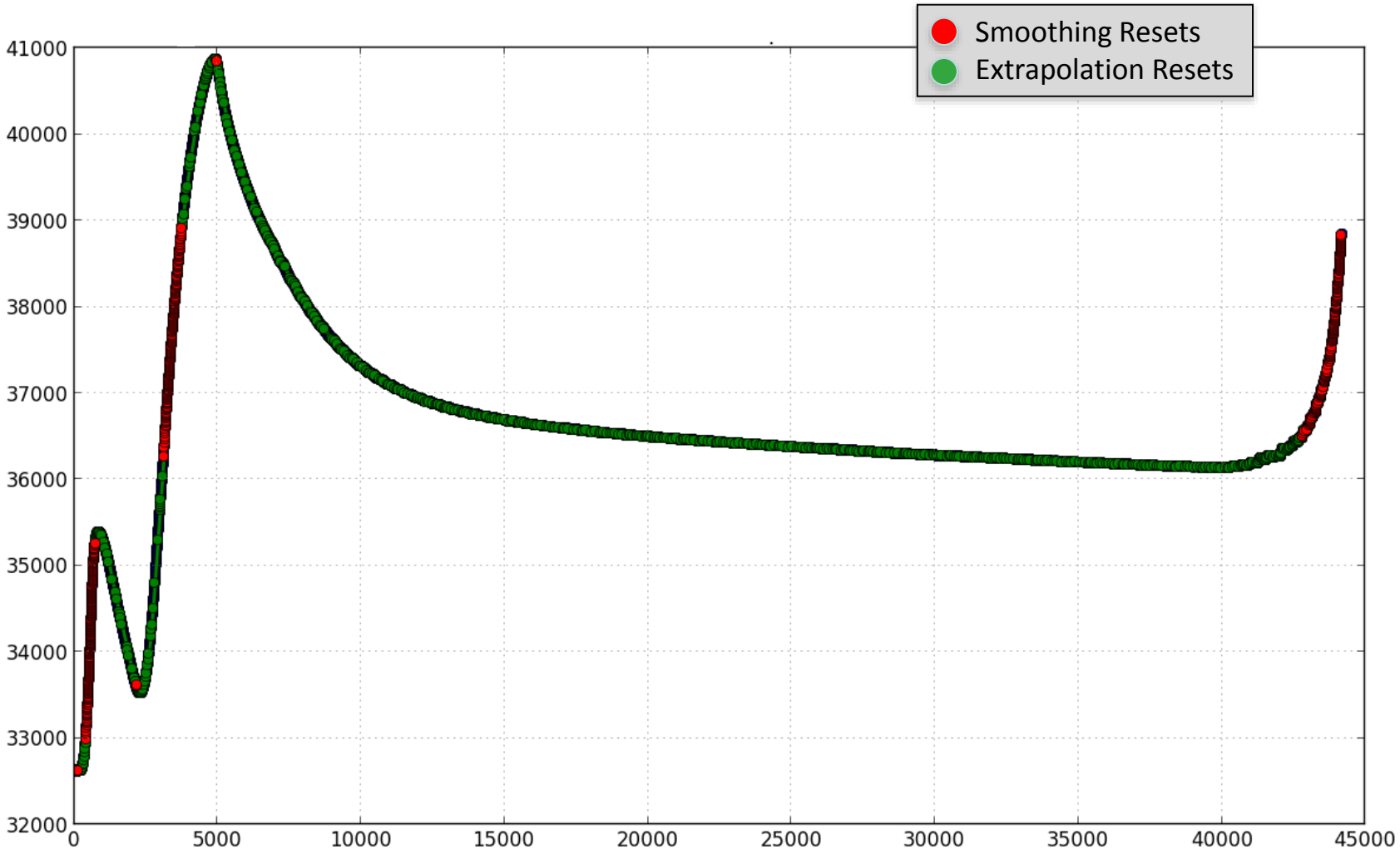
Bandwidth Efficient Algorithms

- 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

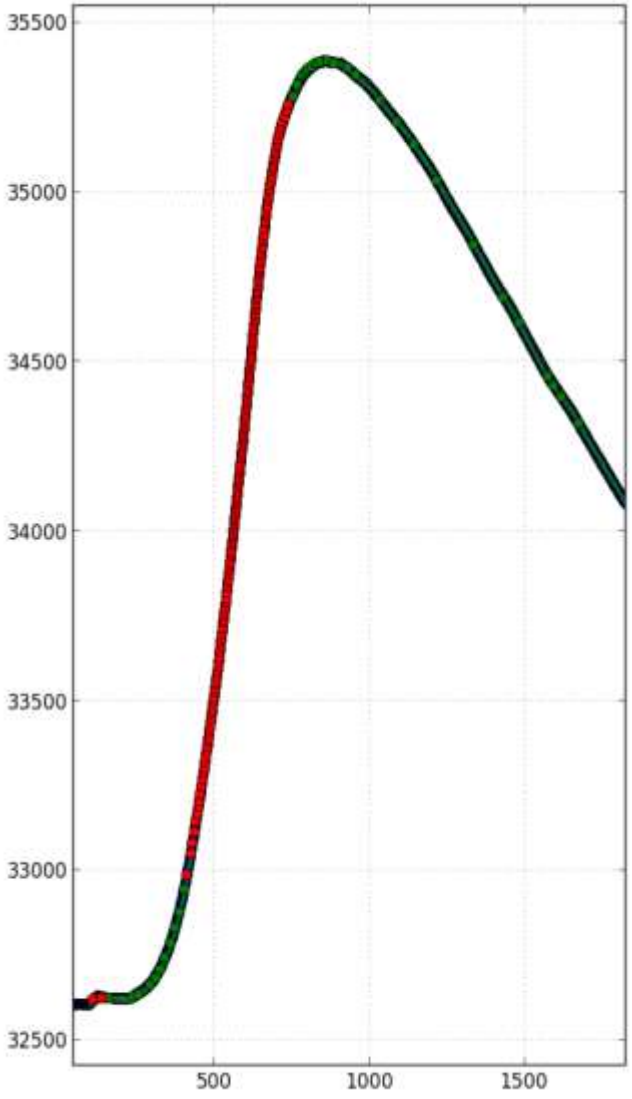


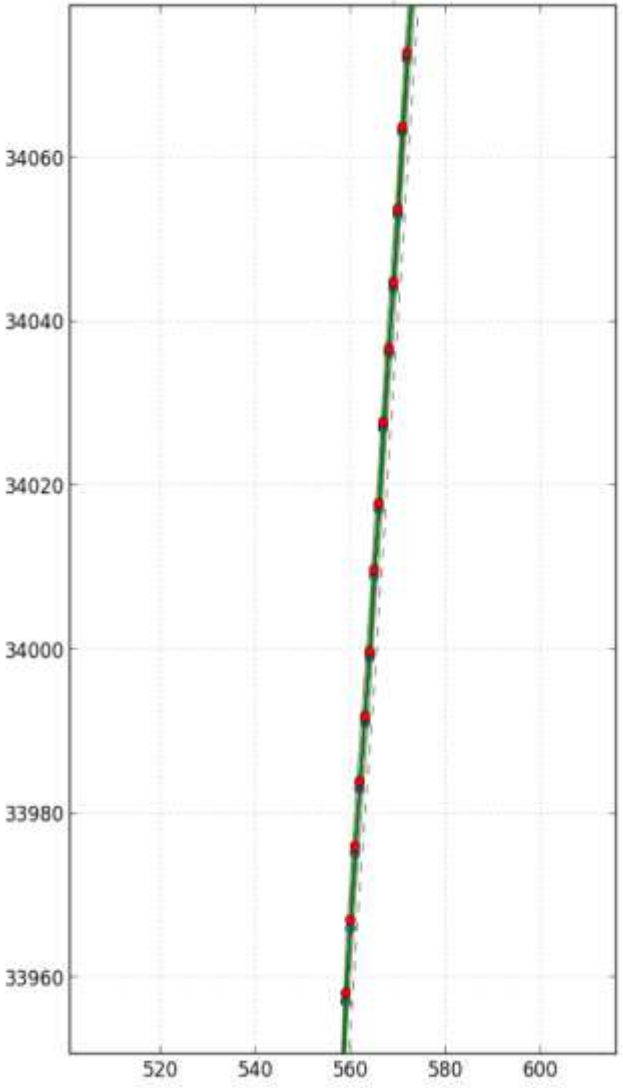
~45000 measurements @ 98.04 Hz

Bandwidth Savings

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

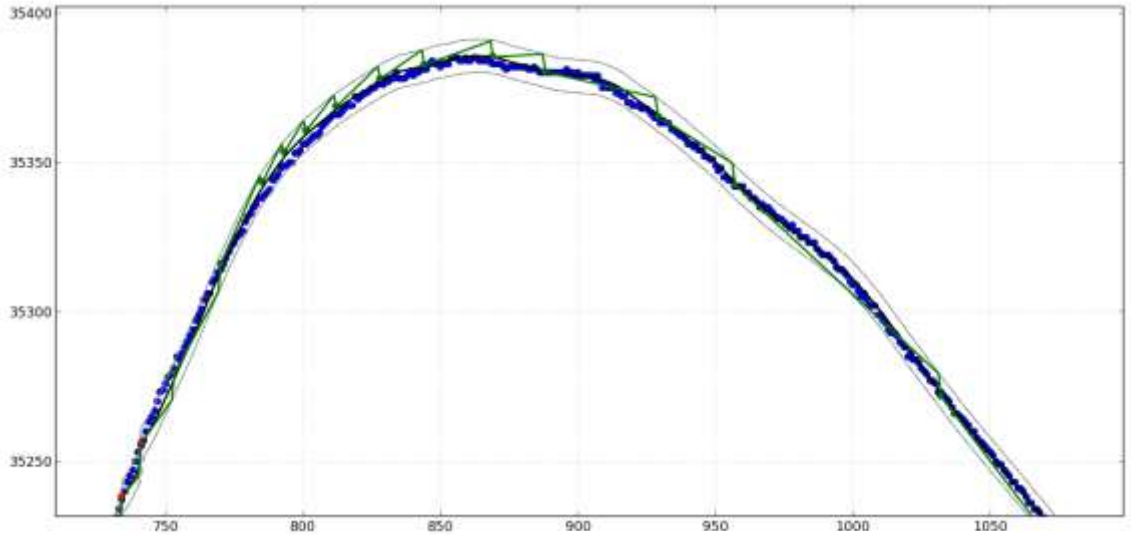
Enlarged View

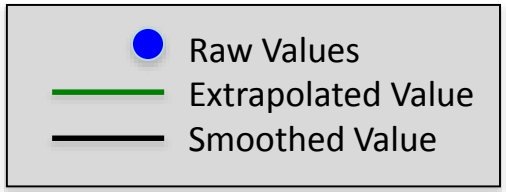


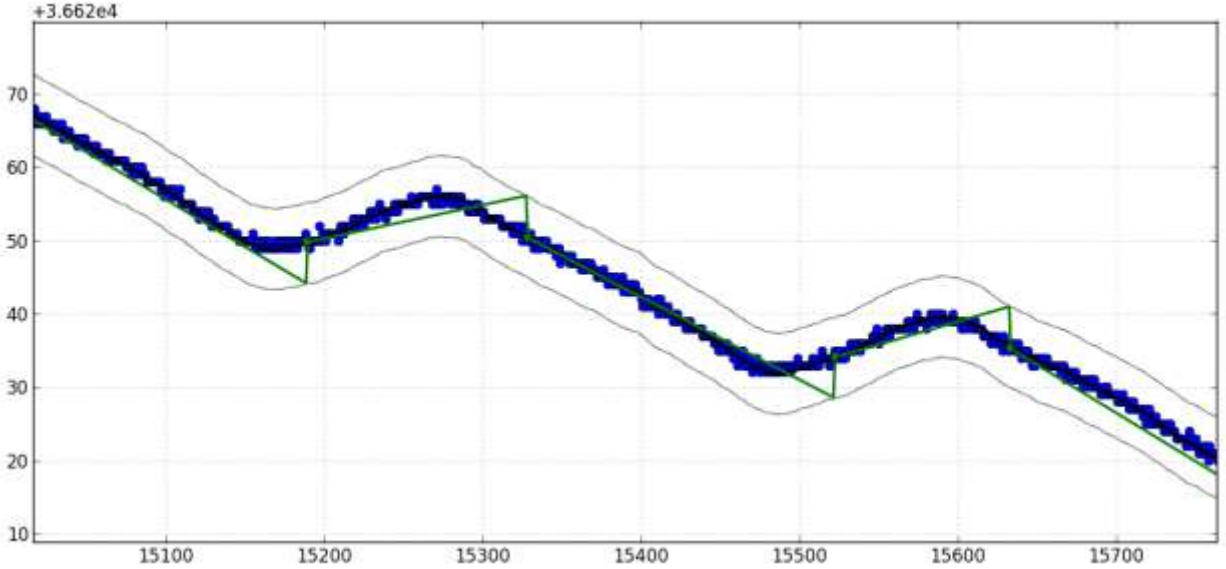


Smoothing Resets
Extrapolation Resets

Enlarged View







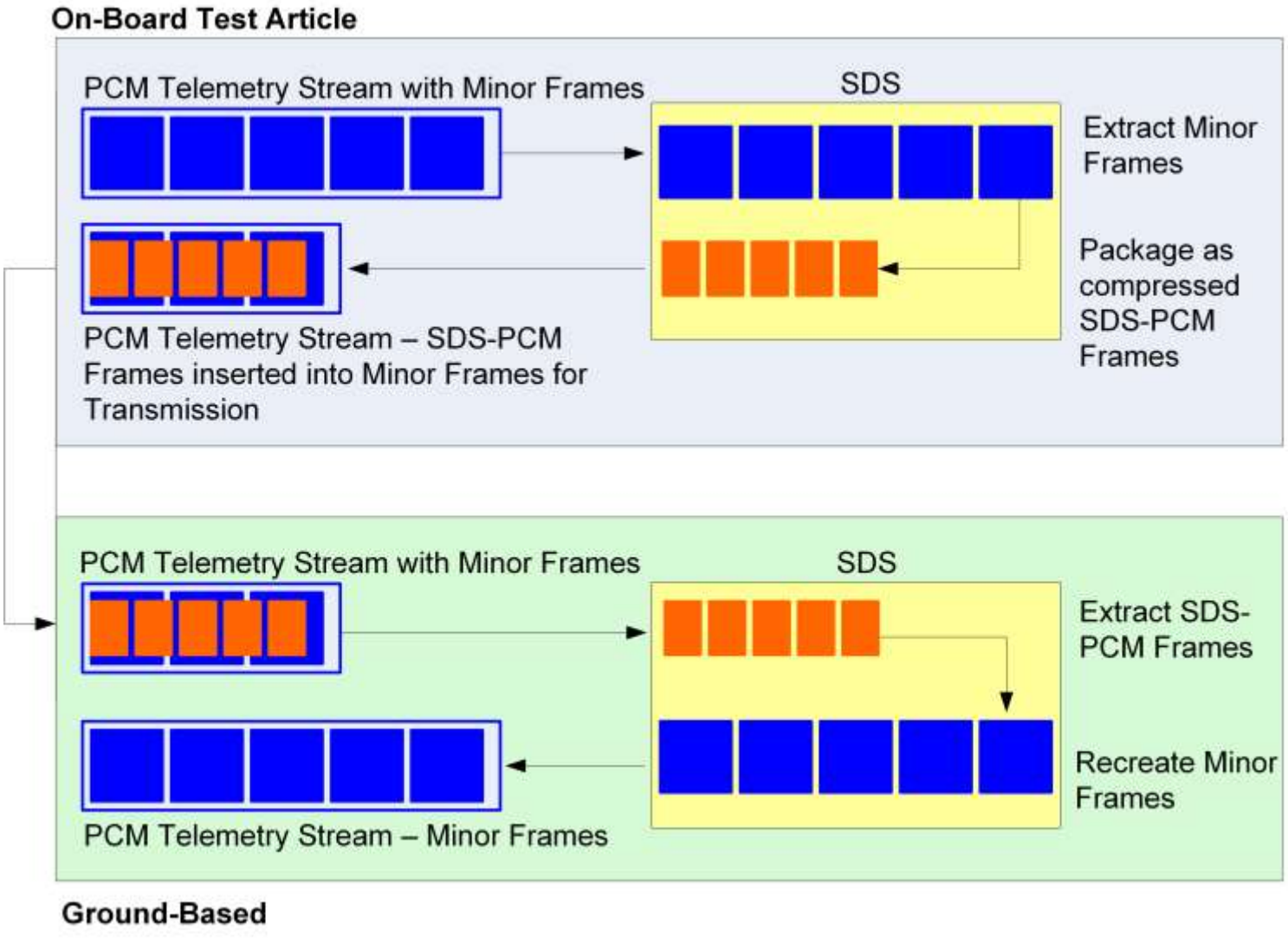
Introduction of PCM Compression

- 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



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

Benefits to T&E

- Bandwidth Savings/Increased Spectrum Efficiency
  - For measurements that demonstrate a normal behavior, transmit to the ground only a representation rather than the entire data set
- Simplified Pre-Test Configuration of Test Article Commutator
  - Analysis of pre-recorded test data allows for determination of expected behaviors
  - Allows for automatic configuration of transmission rates
- Enhanced Operator Awareness of Test Conditions
  - Automatic operator notification when data values outside of normal range
  - Allows operators to focus on situations requiring immediate attention