

Commonality and Variability Analysis to Partition the Waveform/Terminal Functionality in a Family of SATCOM Systems

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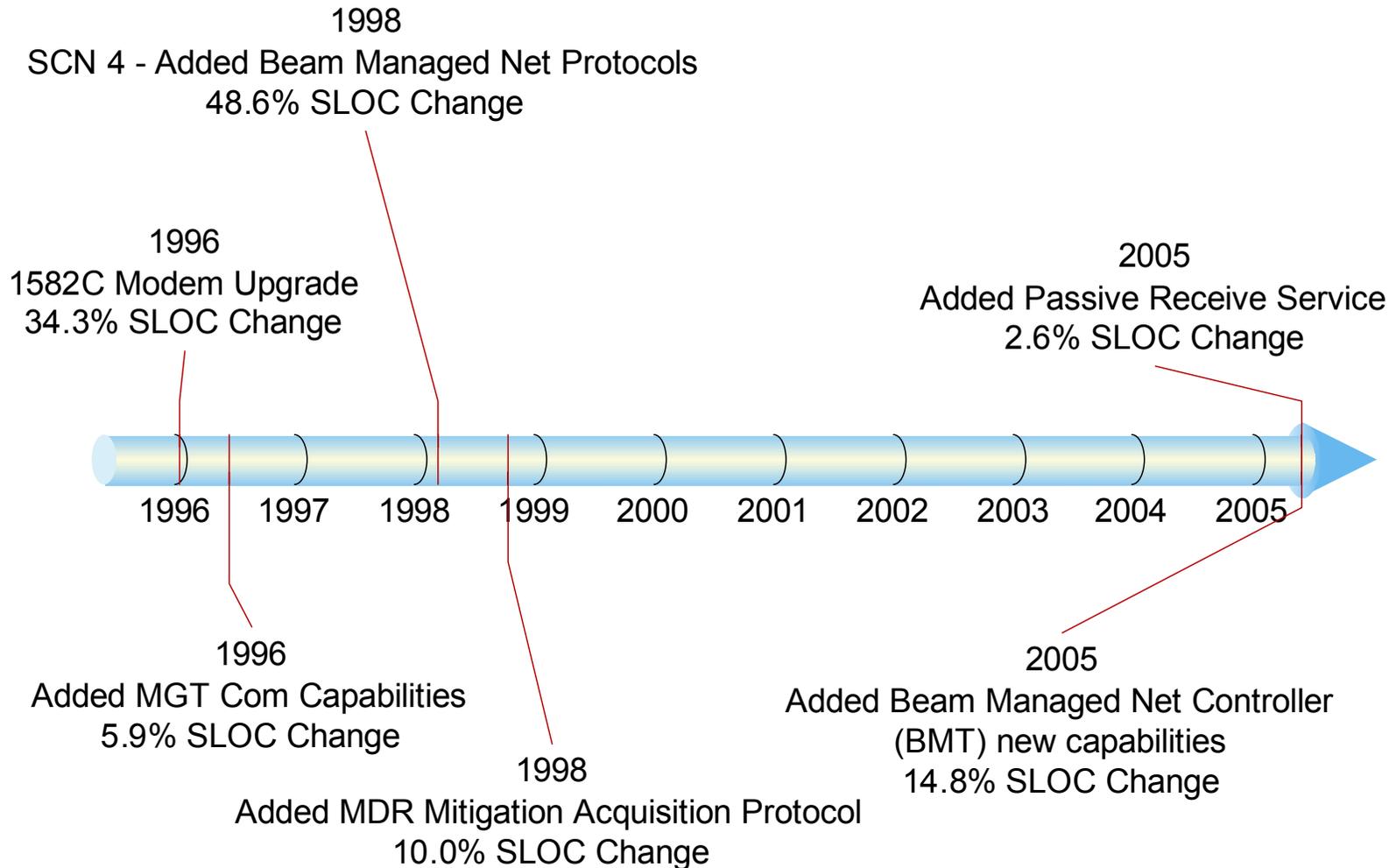
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One Waveform Goal

- Government pays only once for waveform development, waveform shared among platforms
 - Maximum cost savings on those elements of the waveform that are common across all platform types
- Issues:
 - The more that the implementation of an element varies across platforms, the smaller the benefit from “one waveform” development for that element
 - The more that an element is likely to change with time, the greater the issues with managing change, configuration control etc.
- Cost savings could be negated if the variations (over platforms and time) are such that defining the full set of requirements, developing the different implementation options, additional complexity, managing changes, problem-solving, accommodating new platforms etc. outweigh the advantage of one-time, one-source development

AF LDR Waveform Software Changes Starting 10 Years after Waveform “Finalized”

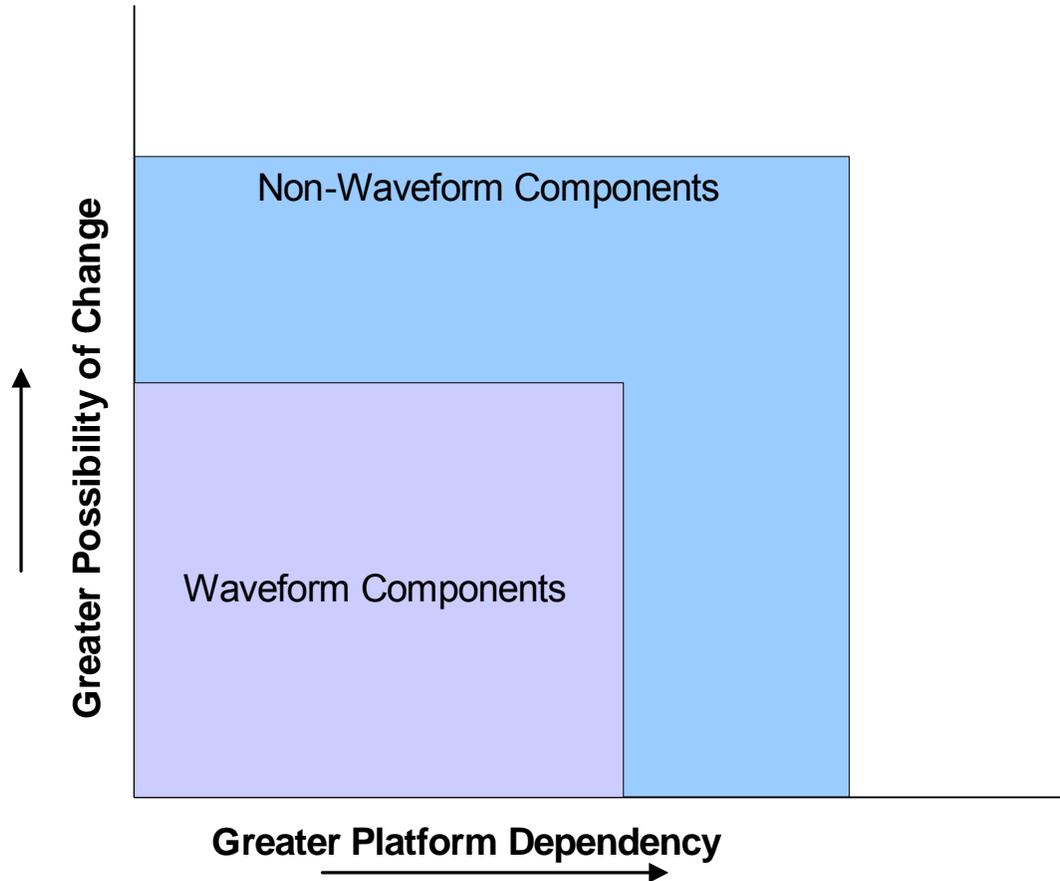


No changes in the “core” waveform functions over this period

Third-Party Waveform Development

- Excluding platform dependent components from the waveform boundary facilitates third-party development
 - Waveform developers should not be required to develop a suite of waveform variations to match the needs of diverse platforms
 - Waveform developers cannot be expected to perform the system engineering and analysis needed to address the requirements of diverse platforms
- Excluding components that are likely to change from the waveform boundary facilitates third-party development
 - Minimize life-cycle support and maintenance required from the waveform developer
 - Deliver and be done.

Defining Waveform Components



Waveform boundary should include components that can be expected to have little variability over time and platforms

Waveform/Platform Boundary

- Key is a variability analysis
- Definition – “Communication Suite” encompasses software (including VHDL) elements that perform:
 - Physical and link layer processing
 - Modulation, Coding, Interleaving
 - Channel structure
 - TDMA structure
 - TRANSEC
 - Signaling Protocols
 - Payload/Terminal
 - Terminal/Terminal (“Transparent Messages”)
 - DBRA
 - Uplink and Downlink Acquisition
 - Including antenna and PA control
 - Uplink and Downlink Time Tracking
 - Including interface to platform motion aiding if present
- Goals of variability analysis:
 - Determine which elements of the “Communication Suite” belong inside the “Waveform” boundary

Variability Analysis- Key Questions

- Which elements of the “Communication Suite” are likely to change over time?
- Which elements of the “Communication Suite” depend on the platform?
- For those elements that depend on the platform:
 - How extensive are the variations across platform types?
 - How practical to implement a superset of platform requirements for the element?
 - How easy is it to anticipate the requirements of new platforms?

Variability Analysis (Physical/Link Layer)

- ✓ Modulator/Demodulator
 - Maximum burst rate and supported modulation types vary as a function of platform EIRP, G/T and terminal specification
 - Common element solution:
 - Implement full set of modulation types
 - Limited SWAP cost to smaller platforms
 - ✓ Interleaver/Deinterleaver
 - Maximum data rate varies as a function of platform EIRP, G/T and terminal level specification
 - Special interleavers for specific platform requirements (e.g., Navy TIP, Scintillation)
 - Common element solution
 - Implement full set of interleavers
 - Implement maximum data rate capability
 - Limited SWAP cost to smaller platforms
- OR**
- Use parallel processing to achieve higher data rates
 - Possibly less efficient implementation for larger platforms

✓ Inside the Waveform Boundary
✗ Outside the Waveform Boundary

Variability Analysis (Physical/Link Layer)

- ✓ Encoder/Decoder
 - Maximum data rate varies as a function of platform EIRP, G/T and terminal level specification
 - Special decoder features for specific platform requirements (e.g., channel statistics)
 - Common element solution
 - Implement decoder with all platform-specific features
 - Minor impact
 - Implement maximum data rate capability
 - SWAP cost to smaller platforms
- OR**
- Use parallel processing to achieve higher data rates
 - Possibly less efficient implementation for larger platforms
- ✓ TRANSEC Algorithms
 - No variability with standardized frequency interface
- ✓ TDMA/FDMA Processing
 - No significant variability

✓ Inside the Waveform Boundary

✗ Outside the Waveform Boundary

Variability Analysis

RSL Processing and DL Acquisition

- ✓ Received Signal Level (RSL) Processing (modem estimates of RSL used for downlink acquisition, performance monitoring, and antenna tracking)
 - Platform independent if generalized to support all antenna tracking approaches
- X Downlink Acquisition. Multiple platform and antenna dependencies:
 - G/T
 - Antenna beamwidth
 - Antenna dynamic capability
 - Blockages
 - Fading
 - Pointing error
 - Attitude
 - Location
 - Stabilization
 - Time error
 - Implementation that optimizes downlink acquisition time for all platforms would consist of a number of special cases, negating the advantage of common development
 - Defining requirements, completing analysis and managing complexity are major challenges

✓ Inside the Waveform Boundary

X Outside the Waveform Boundary

Variability Analysis

Downlink Time/Frequency Tracking

- ✓ Time/Frequency error estimates
 - Platform independent
- ✗ Time/Frequency tracking loops. Many platform dependencies:
 - Motion
 - Side information about motion
 - Compensation for offset, error, drift, latency
 - Use of preamble pull-in for high burst rate downlink modes
 - Motion Aiding Source
 - Compensation for time offset between dual antennas
 - Blockages
 - Scintillation/Foliage Fading
 - Loop Design
 - Implementation that optimizes time tracking performance for all platforms would be complex and may consist of a number of special cases
 - Defining requirements, completing analysis and managing complexity are major challenges

- | |
|---------------------------------|
| ✓ Inside the Waveform Boundary |
| ✗ Outside the Waveform Boundary |

Variability Analysis

Uplink Acquisition and Tracking

- ✓ Uplink acquisition and tracking probes
 - No platform dependencies
- ✗ Uplink acquisition and tracking algorithms. Many platform dependencies:
 - Power probing
 - Protocol repeats
 - Blockages/Fading
 - Fallback procedures
 - Frequency standard accuracy

✓ Inside the Waveform Boundary

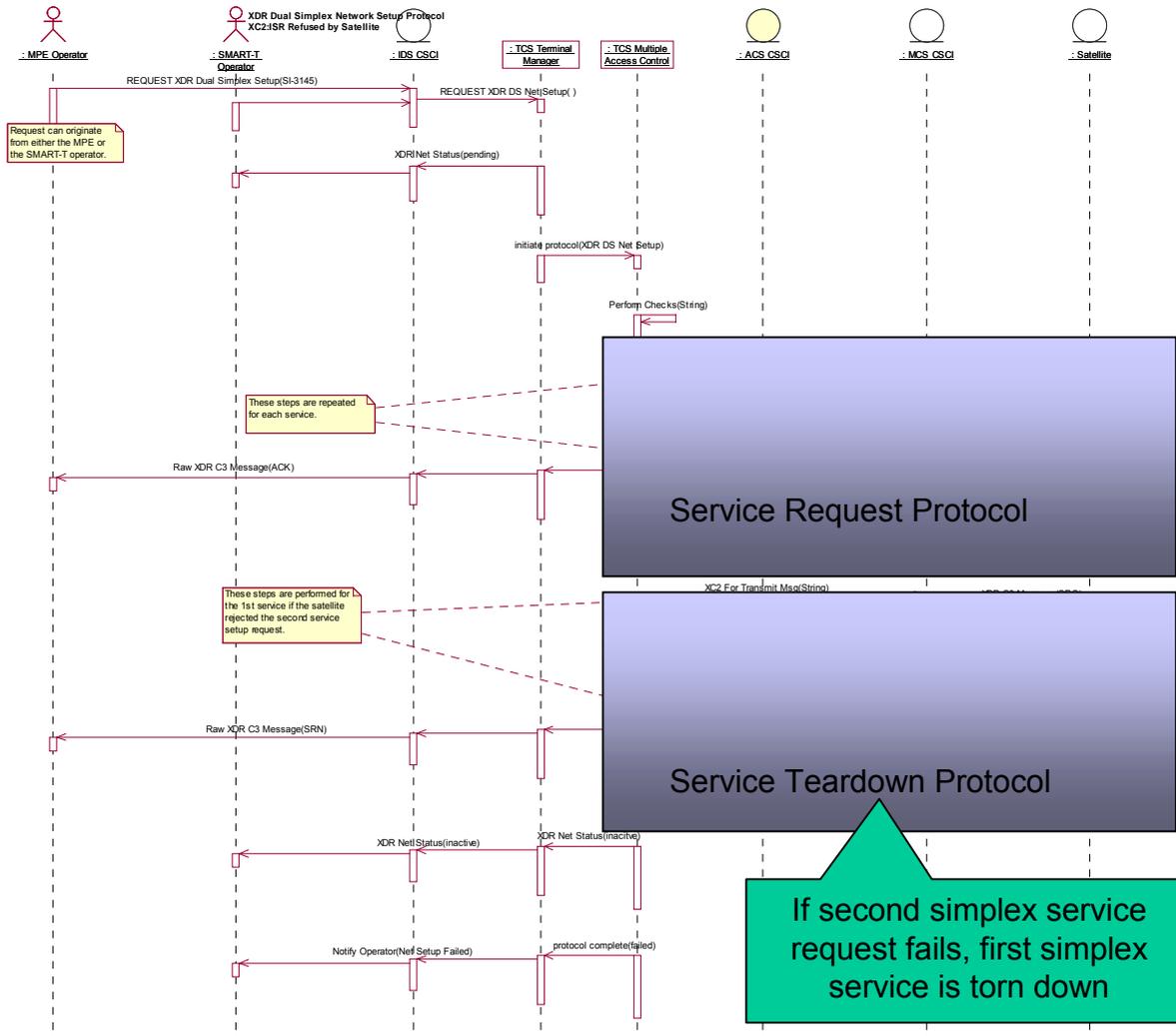
✗ Outside the Waveform Boundary

Variability Analysis Protocols

- ✓ Terminal-Payload Signaling Protocol Implementation
 - Defined by PTICD, little or no variation over time or platform
- X Protocol Usage (Resource allocation, protocol selection and sequencing, failure recovery, operator and database interaction etc.)
 - Platform specific and likely to change with time
- X Terminal to Terminal Signaling Protocols (Transparent message protocols)
 - “Core” protocols used by all terminals are potential candidates for waveform boundary
 - Platform specific protocols are not
 - Area of likely enhancement and changes over time
 - Accounts for many of the changes/enhancements on AF Milstar
- ✓ TSAT DBRA
 - Desirable to have a common implementation across all platforms

- ✓ Inside the Waveform Boundary
- X Outside the Waveform Boundary

Protocol Usage Example



- SMART-T uses dual simplex networks to establish a full duplex link
- Terminal-Payload signaling protocols for setup, teardown, join etc. are defined by PTICD and fall within waveform boundary
- Protocol Usage, which includes error recovery cases (e.g., second simplex network setup fails) are application specific and fall outside of the waveform boundary
- One of many examples

Recommended Waveform Boundary

