



HDTN Software Requirements Specification

Consultative Committee for Space Data Systems Fall Meeting

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Motivation

- Support protocol interoperability
- Streamline development process and implementation
- Easier to verify an implementation
- Facilitate technology transfer to other centers and organizations

Challenges

- RFCs are not written using the same language between all RFCs resulting in potential misconceptions.
- Many “Requirements” from the CCSDS documents are too broad and/or multiple requirements in one statement.
- CCSDS reports did not cross-reference always correctly to the RFC section.
- CCSDS reports would say a full section in the RFC is required but the section in the RFC contained no statements related to a potential requirement.

NASA Procedural Requirements (NPR) 7150.2D Summary

- Provides a set of requirements for software acquisition, development, maintenance, retirements, operations, and management
 - Planning, Requirements, Design, Implementation, Verification
- Supports NASA programs and projects in accomplishing their planned goals (e.g., mission success, safety, schedule, and budget) while satisfying their specified requirements.
- Level of compliance and rigor is associated with the class of the software to be built or acquired.

HDTN Software Requirements Specification (SRS) Summary

- Currently contains 417 requirements
- Documents requirements from Bundle Protocols and Convergence Layers Specification
 - Requirements written generically to capture capability
- Documents requirements for applications functionality
 - Starting point to identify functionality relevant for future missions
- Documents specific HDTN requirements
 - Project specific requirements

Bundle Protocol Requirements	
BPv6	43
BPv7	24
BPSec	60
RTP	4

Convergence Layer Requirements	
TCPCL	51
STCP	8
UDP	4
LTP	43

Application Requirements	
BPGen	21
BPSink	12
BPing	14
BPSendFile	20
BPReceiveFile	12
BPSendPacket	16
BPReceivePacket	11
BPSendStream	16
BPReceiveStream	15

HDTN Requirements	
Routing	6
HDTN	
Environmental	11
HDTN API	7
HDTN GUI	19

HDTN Related Documents

- Data Dictionary:
 - Describes the structure and content of HDTN data elements like variables, data structures, inputs, outputs, commands, file system structures, telemetry, data files, and configuration files.
 - Public release planned for 12/2024
- Architecture and Design Document:
 - Describes the software design and implementation for the High-rate Delay Tolerant Networking (HDTN) project.
 - Provides information for developers and maintainers about the software high level architecture, software modules interactions during operation, and detailed system flow.
 - Public release planned for early 2025
- Requirements Management Plan
 - Describes the process for the development and management of requirements during the software life cycle.

SRS Sample

SW Req ID	Title	Requirement	Rationale	Verification Method	Verification Statement
BPv7-004	Block Order	Block(s) following the primary block shall be a canonical block.	Every block other than the primary block is called a "canonical" block. Canonical blocks are the extension blocks for adding data to the bundle header total for extra information. Block order is defined in RFC 9171 sections 4.1 and 4.3.2.	Test	This requirement is verified when a test receives a bundle and confirms the block following the primary block conforms to the canonical block format.
BPv7-005	Bundle Structure Stop Code	A CBOR "break" stop code, terminating the array, shall be directly after the payload block.	The stop code tells the node that the bundle is finished. Block order is defined in RFC 9171 section 4.1	Test	This requirement is verified when a test receives a bundle and confirms the payload block is terminated by the CBOR "break" stop code.
BPv7-006	Bundle Encoding	The CBOR encoding of definite-length values of all fields in all blocks shall conform to the core deterministic encoding requirements specified in the data dictionary.	Indefinite-length items are not prohibited within the BPv7 specification. The use of CBOR is discussed in section 4.1 of RFC 9171. CBOR encoding is defined in RFC 8949.	Inspection	This requirement is verified when an inspection of the code shows all definite-length values in block fields are CBOR encodings.
BPv7-007	Primary Bundle Location	The first block in the bundle shall be a primary bundle block.	The location of the primary bundle block is defined in RFC 9171 section 4.1.	Test	This requirement is verified when a test receives a bundle and confirms the first block is a primary bundle block.
BPv7-008	Number of Primary Blocks	A bundle shall have exactly one primary bundle block.	The number of primary bundle blocks is defined in RFC 9171 section 4.1.	Test	This requirement is verified when a test receives a bundle and confirms only one primary bundle block exists.

Requirements Development Process

- Performed iterative process to derive requirements from each specification
- Reviewed CCSDS PICS requirements where applicable
- In older specs, a single PICS item may be too complex to verify
- We pulled out all “Shall”, “Must”, and “Required” statements from RFCs

A6 REQUIREMENTS

Item	Protocol Feature	Reference	Status	Support
baseLTP	The mechanisms required to effect red-part data transmission/reception from RFC 5326 except as noted in section 3 of this document.	This document, 3.1.1, 3.2–3.8. RFC 5326 sections 2.0, 3.0, 3.1, 3.1.4, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.3, 4.1, 4.2, 6.0, 6.1, 6.2, 6.3, 6.4, 6.5, 6.5, 6.6, 6.7, 6.8, 6.9, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16, 6.17, 6.18, 6.19, 6.20, 7.1, 7.3, 7.4, 7.5, 7.6, 7.7, 8.1 [as pertains to red data], 8.2 [as pertains to red data], 10.2.	M	

Requirements Development Process

- Developed set of candidate requirements
- Determined what aspects were design, data definitions or software requirements
- Refined language
- Conducted initial peer review for each specification
- Imported into MagicDraw model-based system engineering model
- Conducted formal review of completed draft SRS

	A	B	C	D	E
1	Section	Title	Description	Comment	Rationale
2	3.1	Segment Header	An LTP segment header shall consist of a version number, segment type flags, session id.		This is the LTP segment header format per HDTN data dictionary.
3	3.1	Session Id	Every session initiated by an LTP engine shall be uniquely identified by the session ID.	does a repeater create a new session to transmit the s	Each session needs a unique ID to distinguish it from other sessions.
4	3.2.1	Data Segment	An LTP data segment shall consist of client service id, offset, length, checkpoint serial number, report serial number, client service data.	Implemented, summarize in the Data Dictionary	This is the LTP data segment format per HDTN data dictionary.
5	3.2.2	Report Segment	An LTP report segment shall consist of report serial number, checkpoint serial number, upper bound, lower bound, reception claim count, reception claims.	Implemented	This is the LTP report segment format per HDTN data dictionary.
6		Report Segment	Any subsequent RS issued by the receiver MUST have the serial number value found by incrementing the last report serial number by 1.	Move these to the Data Dictionary	
7		Report Segment	When an RS is retransmitted however, its serial number MUST be the same as when it was originally transmitted	Move these to the Data Dictionary	

Requirements Analysis

- The RFCs contain design, functionality, and other information
 - Requires to sort through each requirement sentence if it was for a Design Document, Data Dictionary, or the Requirements Document.

	Required Items Found	Data Dictionary	Design Document	N/A or Not Implemented	Requirement	Requirement + Data Dictionary	Requirement + Design Document	Blank
BPv6	178	20	54	25	32	33	14	0
TCP	120	17	9	22	48	1	6	17
BPv7	181	43	39	57	31	6	3	2
LTP	151	63	22	17	38	3	4	2
UDP	6	0	0	0	3	3	0	0
STCP	8	1	0	0	5	2	0	0

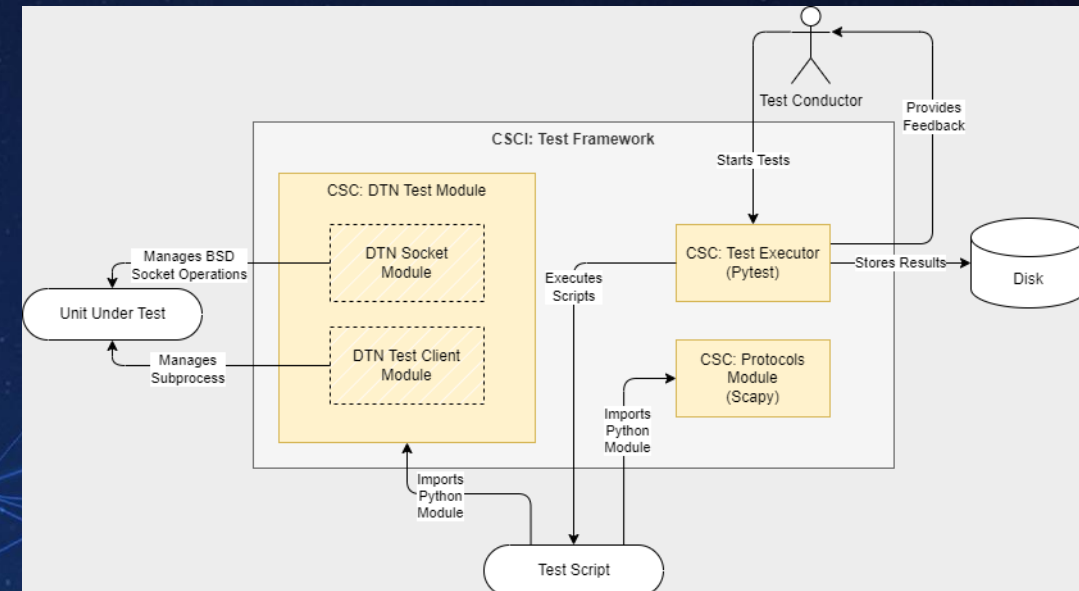
PICS vs. HDTN Requirements

- SRS requirements to PICS are not one-to-one
- We covered all sections called out in PICS references
- We included only what is implemented in HDTN
- More general statements in PICS might be broken into several requirements
- PICS discussing internal processing procedures (ex. Local Bundle Delivery) are design considerations and do not affect protocol interoperability

Protocol	Relevant Specification	CCSDS Mandatory Requirements	SRS Requirements
BP v6	CCSDS 734.2-B-1 (September 2015)	39	43
BP v7	CCSDS 734.2-P-1.1 (April 2023)	32	24
LTP	CCSDS 734.1-B-1 (May 2015)	10	43
BPsec	CCSDS 734.5-R-2 (September 2023)	50	60
SABR	CCSDS 734.3-B-1 (July 2019)	10	6
TCPCLv4	RFC 9174	NA	51
UDP	RFC 7122	NA	4
STCP	NA	NA	8
RTP	CCSDS 766.3-R-2 (May 2020)	2	4
Applications	NA	NA	137

Testing/V&V

- Majority of HDTN software requirements are verified automatically
- The HDTN Test Framework is collection of Python modules that automate the testing process
- Key features:
 - Generation of BPv6, BPv7, LTP, and TCPCL test data
 - Handles communication with the unit under test
 - Configures the unit under test depending on requirement needs
 - **Designed to work with any DTN implementation!**



Feedback

- Newer specifications' PICS seem clearer (BPsec versus LTP)
- Newer specifications have changing PICS after several implementations are already complete
- Difficulty in tracking document versions

A2.2 REQUIREMENTS LIST

Item	Description	Reference	Status	Support
1	The same security service MUST NOT be applied to a security target more than once in a bundle.	RFC 9172 Section 3.2	M	
2	A single security block MAY represent multiple security operations.	RFC 9172 Section 3.3	O	
3	A security target in a security block MUST be represented as the block number of the target block.	RFC 9172 Section 3.4	M	
4	The fields of the ASB SHALL be as specified in RFC 9172, Section 3.6.	RFC 9172 Section 3.6	M	
5	The block type code value of a BIB SHALL be as specified in Section 11.1 of RFC 9172.	RFC 9172 Section 3.7	M	
6	The block-type-specific data field of a BIB SHALL follow the structure of the ASB.	RFC 9172 Section 3.7	M	

BPsec PICS

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LTP PICS



Thank you!

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