



## HDTN Software Test Report (version 2.0.0)

National Aeronautics and  
Space Administration

Document No: HDTN-RPT-045



Revision: -  
Effective Date: 8/21/2025

**Space Operations Mission Directorate (SOMD)  
Space Communications and Navigation (SCaN)  
High-Rate Delay Tolerant Networking (HDTN) Project**

**John H. Glenn Research Center**

CAGE Code No.: 1QFP5

21000 Brookpark Road, Cleveland, Ohio 44135

# HDTN Software Test Report (version 2.0.0)



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Space Operations Mission Directorate (SOMD) High-Rate Delay Tolerant Networking (HDTN) Project			
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## PREFACE

Space Communications and Navigation (SCaN) is developing new communications technologies to increase the amount of science data returned on future space missions. The High-Rate Delay Tolerant Networking (HDTN) project at NASA Glenn Research Center (GRC) will provide reliable internetworking as a high-speed path for moving data between spacecraft payloads, and across communication systems that operate on a range of different rates.

This document provides the results from verification activities performed on the HDTN v2.0.0 release candidate.

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## DOCUMENT HISTORY LOG

Status (Preliminary/ Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
baseline	N/A	08/21/2025	Initial Release

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## 1.0 INTRODUCTION

This report documents verification results from the testing performed July 28, 2025 through August 4, 2025. All tests were performed at NASA GRC in Brook Park, OH.

### 1.1 Identification

This paragraph contains a full identification of the system and the software to which this document applies, including, as applicable, identification number(s), title(s), abbreviation(s), version number(s), and release number(s).

#### 1.1.1 Test Hardware

Execution of HDTN-TEST-039 HDTN Software Test Procedure took place on a virtual machine hosted on a hypervisor in the server room at the Aerospace Communications Facility (ACF) within NASA's John H. Glenn Research Center.

*Table 1-1 Test Hardware Configuration*

Name	Hostname	Operating System	RAM (GB)	Processor Cores	Location
<b>Bastion (Host)</b>	bastion.hdtm.lan	Oracle Linux Server 8.10	64	16	RM 209
<b>Test Virtual Machine</b>	vtest.hdtm.lan	Ubuntu 20.04	16	12	RM 106
<b>FreeBSD Virtual Machine</b>	freebsd1.hdtm.lan	FreeBSD 14.3	8	8	RM 106
<b>OpenBSD Virtual Machine</b>	openbsd1.hdtm.lan	OpenBSD 7.7	24	10	RM 106
<b>Oracle Virtual Machine</b>	oracle-cicd.hdtm.lan	Oracle Linux Server 8.10	24	10	RM 106
<b>MacOS Virtual Machine</b>	mac-mini-intel.hdtm.lan	MacOS 14.7.2	8	6	RM 106
<b>Windows Virtual Machine</b>	win2.hdtm.lan	Windows 11 Server	16	16	RM 106
<b>ISS Virtual Machine</b>	hdtngw2.hdtm.lan	Debian 10.13	8	8	RM 106

No configuration-controlled hardware was used in the execution of HDTN-TEST-038 HDTN Flight Software Inspection Test Procedures.

#### 1.1.2 Software Under Test

Source code for the HDTN v2.0.0 release candidate used to complete the testing summarized in this report is located in the configuration-managed HDTN source code GitLab repository:

<https://gitlab.grc.nasa.gov/hdtm-v4/hdtm/-/tags/2.0.0-rc1> (Git Hash: 1A4F381A)

#### 1.1.3 Test Scripts

The test scripts utilized during the testing summarized in this report are located in the configuration-managed HDTN Test GitLab repository: <https://gitlab.grc.nasa.gov/hdtm-v4/hdtm-tests/-/tags/2.0.0-rc1> (Git Hash: 30136ED4)

#### 1.1.4 Test Personnel

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The tables below identify the personnel that participated in each phase of verification activities and describe the roles of each individual during testing.

*Table 1-2 List of Personnel and Roles - HDTN-TEST-039*

Name	Role
Nadia Kortas	Test Operator
Wade Smith	Software Quality Assurance/Witness
Ethan Schweinsberg	Software Test Lead/Witness
John Nowakowski	Project Manager/Witness
José Lombay-González	Software Lead/Witness
Tad Kollar	Witness

*Table 1-3 List of Personnel and Roles - HDTN-TEST-038*

Name	Role
Eric Brace	Test Operator
Wade Smith	Software Quality Assurance/Witness
Ethan Schweinsberg	Software Test Lead/Witness
John Nowakowski	Project Manager/Witness
José Lombay-González	Software Lead/Witness

## 1.2 System Overview

HDTN takes advantage of modern hardware platforms to substantially reduce latency and improve throughput compared to existing Delay Tolerant Networking (DTN) operations. The HDTN implementation maintains interoperability with existing deployments of DTN that conform to current IETF RFCs. At the same time, HDTN defines a new data format better suited to higher-rate operation. It defines and adopts a massively parallel pipelined and message-oriented architecture, allowing the system to scale gracefully as its resources increase. HDTN's architecture also supports hooks to replace various processing pipeline elements with specialized hardware accelerators. This offers improved Size, Weight, and Power (SWaP) characteristics while reducing development complexity and cost.

## 1.3 Document Overview

This test report contains the results from software verification activities described in HDTN-TEST-039 HDTN Software Test Procedure (STPr) and HDTN-TEST-038 HDTN Flight Software Inspection Test Procedures.

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## 2.0 APPLICABLE DOCUMENTS

### 2.1 Reference Documents

This section lists the number and title of each document referenced in this specification.

*Table 2-1: Applicable Documents*

Document number	Revision	Document title	Effective Date
NPR 7150.2	D	NASA Software Engineering Requirements	03/08/2022
GLPD 7150.2	Change 2	GRC Software Engineering Requirements	07/19/2016
GRC-SW-TPLT-STR	A	Software Test Report Template	04/15/2011
HDTN-PLAN-022	-	HDTN Software Verification and Validation Plan	01/19/2024
HDTN-REQ-008	B	HDTN Software Requirements Specification	07/24/2025
HDTN-TEST-038	-	HDTN Software Inspection Test Procedures	07/30/2025
HDTN-TEST-039	-	HDTN Software Test Procedure	07/25/2025

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## **3.0 OVERVIEW OF TEST RESULTS**

### **3.1 Overall Assessment of the Software Tested**

Verification testing summarized in this report covered all software requirements specified in HDTN-REQ-008 HDTN Software Requirements Specification (SRS). All tests performed against the HDTN Software PASSED.

### **3.2 Impact of Test Environment**

One of the virtual machines used during testing (freebsd1.hdtm.lan) was down at the start of the test and needed to be rebooted. Another virtual machine (hdtngw2.hdtm.lan) needed to be rebooted during testing when it was failing to properly calculate the transmission rate (described in section 4.1.2.2). However, after reboot, neither system adversely affected the test activities.

### **3.3 Recommended Improvements**

This report has identified no recommendations for improvements to the test environment. It does recommend an improvement to the test procedure (Section 4.1.2.2) and the incorporation of redlines recorded during the execution of HDTN-TEST-039 HDTN Software Test Procedure (as captured in the as-run record) in an updated revision of the test procedure.

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## 4.0 DETAILED TEST RESULTS

### 4.1 HDTN Software Test Procedure

#### 4.1.1 Summary of Test Results

An evaluation of HDTN release candidate test readiness was performed on July 25, 2025, prior to initiating execution of test procedures. The release candidate was determined to have met all criteria necessary to begin verification.

This phase of software verification was performed on July 28, 2025 with test personnel located in the ACF building (B330) in the HDTN lab (R209).

All requirements listed in HDTN-REQ-008 HDTN Software Requirements Specification (SRS) with a verification method of Test or Demonstration were verified during this phase of verification. A summary of the results for each test executed during this phase is documented in Table 4-1: Summary of Test Results. Any problems encountered and deviations from approved test procedures are documented in later sections of this report. References to problems or deviations applicable to each test are recorded in the table.

*Table 4-1: Summary of Test Results*

Test Procedure Section	Requirements tested	Pass/ Fail	Problem Reference	Deviation Reference
3.3 Software Configuration	N/A	N/A	4.1.2.1	N/A
5.1 HDTN Core Test Procedure	LTP-001, LTP-002, LTP-003, LTP-004, LTP-005, LTP-006, LTP-007, LTP-009, LTP-010, LTP-011, LTP-012, LTP-013, LTP-014, LTP-015, LTP-016, LTP-017, LTP-018, LTP-019, LTP-020, LTP-021, LTP-022, LTP-023, LTP-024, LTP-025, LTP-027, LTP-028, LTP-029, LTP-030, LTP-031, LTP-032, LTP-033, LTP-034, LTP-035, LTP-036, LTP-037, LTP-038, LTP-040, LTP-041, LTP-042, LTP-043, BPSSec-001, BPSSec-002, BPSSec-003, BPSSec-004, BPSSec-005, BPSSec-006, BPSSec-007, BPSSec-008, BPSSec-009, BPSSec-010, BPSSec-013, BPSSec-014, BPSSec-015, BPSSec-018, BPSSec-019, BPSSec-020, BPSSec-021, BPSSec-022, BPSSec-023, BPSSec-024, BPSSec-025, BPSSec-026, BPSSec-027, BPSSec-028, BPSSec-029, BPSSec-030, BPSSec-032, BPSSec-033, BPSSec-035, BPSSec-036, BPSSec-037, BPSSec-040, BPSSec-041, BPSSec-042, BPSSec-043, BPSSec-044, BPSSec-046,	Pass	4.1.2.2	N/A

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	BPSec-047, BPSec-048, BPSec-050, BPSec-051, BPSec-052, BPSec-053, BPSec-054, BPSec-055, BPSec-056, BPSec-057, BPSec-058, BPSec-059, BPSec-060, BPSec-061, BPv7-024, BPv6-001, BPv6-003, BPv6-004, BPv6-005, BPv6-006, BPv6-007, BPv6-008, BPv6-009, BPv6-010, BPv6-011, BPv6-012, BPv6-013, BPv6-014, BPv6-015, BPv6-016, BPv6-017, BPv6-018, BPv6-019, BPv6-020, BPv6-021, BPv6-022, BPv6-027, BPv6-028, BPv6-030, BPv6-031, BPv6-032, BPv6-033, BPv6-035, BPv6-037, BPv6-038, BPv6-039, BPv6-042, BPv6-043, HDTNROUTING-001, HDTNROUTING-002, HDTNROUTING-003, HDTNROUTING-006, BPv7-003, BPv7-004, BPv7-005, BPv7-007, BPv7-008, BPv7-009, BPv7-010, BPv7-013, BPv7-014, BPv7-015, BPv7-016, BPv7-017, BPv7-018, BPv7-019, BPv7-020, RTPBP-001, RTPBP-002, RTPBP-003, STCP-001, STCP-002, STCP-003, STCP-004, STCP-005, STCP-006, STCP-007, STCP-008, UDPCL-001, UDPCL-002, UDPCL-003, UDPCL-004, TCPCL-001, TCPCL-002, TCPCL-003, TCPCL-004, TCPCL-005, TCPCL-006, TCPCL-007, TCPCL-011, TCPCL-012, TCPCL-013, TCPCL-016, TCPCL-017, TCPCL-022, TCPCL-023, TCPCL-025, TCPCL-026, TCPCL-027, TCPCL-028, TCPCL-029, TCPCL-030, TCPCL-031, TCPCL-032, TCPCL-033, TCPCL-034, TCPCL-035, TCPCL-038, TCPCL-040, TCPCL-041, TCPCL-042, TCPCL-044, TCPCL-045, TCPCL-046, TCPCL-051, HDTNTLM-001, HDTNTLM-002, HDTNTLM-003,		
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	HDTNTLM-004, HDTNTLM-005, HDTNTLM-006, HDTNREQ-001, HDTNREQ-003, HDTNREQ-005, HDTNREQ-007, HDTNREQ-009, HDTNREQ-010, HDTNREQ-008, HDTNREQ-006, HDTNREQ-004, HDTNREQ-002			
5.2 HDTN GUI Test Procedure	HDTNGUI-002, HDTNGUI-008, HDTNGUI-009, HDTNGUI-009, HDTNGUI-012, HDTNGUI-011, HDTNGUI-005, HDTNGUI-005, HDTNGUI-007, HDTNGUI-007, HDTNGUI-006, HDTNGUI-006, HDTNGUI-004, HDTNGUI-004, HDTNGUI-013, HDTNGUI-013, HDTNGUI-013, HDTNGUI-010, HDTNGUI-010, HDTNGUI-001, HDTNGUI-005, HDTNGUI-005, HDTNGUI-007, HDTNGUI-007, HDTNGUI-006, HDTNGUI-006, HDTNGUI-004, HDTNGUI-004, HDTNGUI-007, HDTNGUI-007, HDTNGUI-004, HDTNGUI-003, HDTNGUI-003, HDTNGUI-004	Pass	N/A	4.1.3.1 4.1.3.2
5.3 HDTN Applications Test Procedure	HDTNBPGEN-001, HDTNBPGEN-002, HDTNBPGEN-003, HDTNBPGEN-004, HDTNBPGEN-005, HDTNBPGEN-006, HDTNBPGEN-007, HDTNBPGEN-008, HDTNBPGEN-009, HDTNBPGEN-010, HDTNBPGEN-012, HDTNBPGEN-013, HDTNBPGEN-014, HDTNBPGEN-015, HDTNBPGEN-016, HDTNBPGEN-017, HDTNBPGEN-018, HDTNBPGEN-019, HDTNBPGEN-020, HDTNBPGEN-021, HDTNBPSNK-001, HDTNBPSNK-002, HDTNBPSNK-003, HDTNBPSNK-004, HDTNBPSNK-005,	Pass	N/A	N/A

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	HDTNBPSNK-006, HDTNBPSNK-007, HDTNBPSNK-008, HDTNBPSNK-009, HDTNBPSNK-010, HDTNBPSNK-011, HDTNBPSNK-012, HDTNPING-001, HDTNPING-002, HDTNPING-003, HDTNPING-004, HDTNPING-005, HDTNPING-006, HDTNPING-007, HDTNPING-008, HDTNPING-009, HDTNPING-010, HDTNPING-011, HDTNPING-012, HDTNBPSF- 001, HDTNBPSF-002, HDTNBPSF-003, HDTNBPSF- 004, HDTNBPSF-005, HDTNBPSF-006, HDTNBPSF- 007, HDTNBPSF-008, HDTNBPSF-009, HDTNBPSF- 010, HDTNBPSF-011, HDTNBPSF-012, HDTNBPSF- 013, HDTNBPSF-014, HDTNBPSF-015, HDTNBPSF- 016, HDTNBPSF-017, HDTNBPSF-018, HDTNBPSF- 019, HDTNBPSF-020, HDTNBPRF-002, HDTNBPRF- 003, HDTNBPRF-004, HDTNBPRF-005, HDTNBPRF- 006, HDTNBPRF-007, HDTNBPRF-008, HDTNBPRF- 009, HDTNBPRF-010, HDTNBPRF-011, HDTNBPRF- 012, HDTNBPSP-001, HDTNBPSP-003, HDTNBPSP- 004, HDTNBPSP-005, HDTNBPSP-006, HDTNBPSP- 007, HDTNBPSP-008, HDTNBPSP-009, HDTNBPSP- 010, HDTNBPSP-011, HDTNBPSP-012, HDTNBPSP- 014, HDTNBPSP-015, HDTNBPSP-016, HDTNBPRP- 001, HDTNBPRP-002,		
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	HDTNBPRP-004, HDTNBPRP-005, HDTNBPRP-006, HDTNBPRP-007, HDTNBPRP-008, HDTNBPRP-009, HDTNBPRP-010, HDTNBPRP-011, HDTNSTRMS-001, HDTNSTRMS-002, HDTNSTRMS-003, HDTNSTRMS-004, HDTNSTRMS-005, HDTNSTRMS-006, HDTNSTRMS-007, HDTNSTRMS-008, HDTNSTRMS-009, HDTNSTRMS-011, HDTNSTRMS-012, HDTNSTRMS-013, HDTNSTRMS-014, HDTNSTRMS-015, HDTNSTRMS-016, HDTNSTRMR-001, HDTNSTRMR-002, HDTNSTRMR-003, HDTNSTRMR-004, HDTNSTRMR-005, HDTNSTRMR-006, HDTNSTRMR-007, HDTNSTRMR-008, HDTNSTRMR-010, HDTNSTRMR-012, HDTNSTRMR-013, HDTNSTRMR-015			
6.0 Test Framework Cleanup	N/A	N/A	N/A	4.1.3.3 4.1.3.4

#### 4.1.2 Problems Encountered

##### 4.1.2.1 Static Analysis Errors

While performing steps described in Section 3.3, the GitLab project is configured to perform static analysis tests against the source code. The report from this test found 175 errors. These are documented in APPENDIX D Static Analysis Report.

The GitLab issue <https://gitlab.grc.nasa.gov/hdtn-v4/hdtn/-/issues/566> was created with the known errors from the static analysis. These were reviewed prior to the test activities and were considered as having no impact for the purpose of the test activities.

##### 4.1.2.2 Intermittent Automated Test Failures

In Step 10 of Section 5.1, the *os-specific-tests-linux [iss]* test initially failed and, upon re-running, failed again. Investigation revealed two anomalies:

1. The expected transfer rate was not achieved (HDTNREQ-002)

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2. Data transfer occurred only in the last few seconds of the 30-second test despite the test being designed to transfer data the entire duration.

The test passed on the third attempt, but anomaly #2 persisted. After rebooting the target virtual machine (hdtngw2), the test was successful on the fourth attempt with no anomalies. Subsequent tests showed no further issues. The root cause was identified as the state of the target virtual machine, likely due to interference from another process.

Despite temporary automated test failures, the requirement (HDTNREQ-002) was verified as HDTN achieved the expected rate.

It is recommended to revise the procedure to include a step for resetting the virtual machine before testing to ensure it is in a known state.

#### **4.1.3 Deviations from Test Procedures**

##### **4.1.3.1 Primary Block Spelling**

In steps 18 and 43 of Section 5.2, the word “primary” in the Expected Result column was misspelled. This has been corrected via redline.

##### **4.1.3.2 Ping IPN number**

In step 24 of Section 5.2, the Test Operator Action incorrectly refers to “ipn:12.XXXX BPv7”. This has been corrected to “ipn:13.XXXX BPv7” via redline.

##### **4.1.3.3 Wrong Step Numbers**

In step 13 of Section 6.0, “step 16” and “step 17” have been corrected to “step 11” and “step 12” via redline.

##### **4.1.3.4 Download Extra Artifacts**

An additional step (step 14) was added to Section 6.0, via redline, to capture the action of downloading all the Junit test artifacts from the automated tests and uploading them to SharePoint. This additional step preserves the pass/fail logs of the automated tests.

### **4.2 HDTN Software Inspection Test Procedures**

#### **4.2.1 Summary of Test Results**

An evaluation of HDTN release candidate test readiness was performed on July 31, 2025, prior to initiating execution of inspection test procedures. The release candidate was determined to have met all criteria necessary to begin verification.

This phase of software verification was performed on July 31, 2025 and August 4, 2025. Execution of these test procedures was conducted in virtual meetings over Microsoft Teams.

All requirements listed in HDTN-REQ-008 HDTN Software Requirements Specification (SRS) with a verification method of Inspection were verified during this phase of verification. A summary of the results for each test executed during this phase is documented in Table 4-2: Summary of Inspection Test Results. Any problems encountered and deviations from approved test procedures are documented in later sections of this report. References to problems or deviations applicable to each test are recorded in the table.

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Table 4-2: Summary of Inspection Test Results

Test Procedure Section	Requirements tested	Pass/Fail	Problem Reference	Deviation Reference
3.1.2 Test Software Setup Procedure	N/A	N/A	N/A	N/A
4.2 Software Configuration	N/A	N/A	N/A	N/A
6.1 Compressed Bundle Header Encoding (CBHE) Unit Inspection	BPv6-002	Pass	N/A	N/A
6.2 Concise Binary Object Representation (CBOR) Encoding Inspection	BPv7-001	Pass	N/A	4.2.3.1
6.3 Bundle Structure Encoding Inspection	BPv7-002 BPv7-006	Pass	N/A	N/A
6.4 Cyclic Redundancy Check (CRC) Types Inspection	BPv7-011	Pass	N/A	N/A
6.5 Bundle Confidentiality Block (BCB) Disallowed Security Targets 1 Inspection	BPSec-011	Pass	N/A	N/A
6.6 Routing Algorithm Selection Inspection	HDTNROUTING-005	Pass	N/A	N/A

#### 4.2.2 Problems Encountered

No problems affecting execution of the test procedures were encountered during this phase of verification.

#### 4.2.3 Deviations from Test Procedures

##### 4.2.3.1 Concise Binary Object Representation (CBOR) Encoding Inspection Deviations

Concise Binary Object Representation (CBOR) Encoding Inspection execution included the following deviations from approved procedures and plans:

- This test was performed over two test sessions. Steps 1-86 of the test were performed on July 31, 2008. Steps 87-132 of the test were performed on August 4, 2025. Evidence already collected from source code files on July 31 was used for both sessions.
- Additional steps were added between step 25 and step 26 by redlining to capture the definition of `Bpv7AbstractSecurityBlock::SerializeBpv7`.
- Step 103 was removed by redlining. This step was identical to step 102 and did not need to be re-executed.
- The name of `m_optionalSubjectPayloadFragmentLength` was corrected by redlining in step 107.
- Step 111 was removed by redlining. The variable `m_securityContextId` is set to the value of an encoded variable, but is not itself encoded.
- The name of `idValuePairVec.first` was corrected by redlining in step 114.

These deviations were approved by software quality assurance present during execution of the test.

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## 5.0 TEST LOG

As-run records for each verification test session are attached to this test report.

*Table 5-1: Test Log*

Test Procedure	Date	As-Run Record
HDTN-TEST-039	07/28/2025	APPENDIX C APPENDIX D
HDTN-TEST-038	07/31/2025	APPENDIX E
HDTN-TEST-038	08/04/2025	APPENDIX F

## 6.0 NOTES

N/A

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## APPENDIX A ACRONYMS

*Table A-1: Acronyms*

Acronym	Definition
ACF	Aerospace Communications Facility
CAGE	Contract and Government Entity
CM	Configuration Management
DTN	Delayed Tolerant Networking
GLPD	Glenn Policy Directive
GRC	NASA John H. Glenn Research Center
HDTN	High-Rate Delay Tolerant Networking
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirements
PDF	Portable Document Format
RAM	Random Access Memory
SCaN	Space Communications and Navigation
SOMD	Space Operations Mission Directorate
SDD	Software Design Description
SRS	Software Requirements Specification
STPr	Software Test Procedure
STR	Software Test Report
TBD	To Be Determined
TBR	To Be Reviewed
TBW	To Be Written
UUT	Unit Under Test

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## APPENDIX B TBD/TBR LIST

This appendix provides a list of all currently open TBD/TBR items contained within this document.

Where a TBD/TBR is included within the text of this document, they **will** be incrementally numbered starting from STR045\_001 (preceded by a “-”, dash) and formatted in ***bold italics***. As an example: ***TBD-STR045\_001*** for TBD or ***TBR-STR045\_001*** for TBR.

Additionally, each TBD/TBR **will** be entered into GitLab Issues in the HDTN SDF Repository as a task. Each task **will** be assigned to a software team member responsible for addressing the need through completion.

Completion is defined here such that the TBD/TBR is addressed within this document and its respective task is closed out.

*Table B-2: TBD/TBR List*

TBD/TBR ID	Description	Task ID	Status	Section
<b>TBD</b>				
N/A	N/A	N/A	N/A	N/A
<b>TBR</b>				
N/A	N/A	N/A	N/A	N/A

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## **APPENDIX C HDTN STPR 20250728**

See PDF attachment: Appendix C - HDTN-TEST-039 rev - HDTN STPr (as-run 20250728).pdf.

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## APPENDIX D STATIC ANALYSIS REPORT

See PDF attachment: Appendix D – Static Analysis Report.pdf.

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## **APPENDIX E HDTN INSPECTION 20250731**

See PDF attachment: Appendix E - HDTN-TEST-038 HDTN Inspection STPr (as-run 20250731).pdf.

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## **APPENDIX F HDTN INSPECTION 20250804**

See PDF attachment: Appendix F - HDTN-TEST-038 HDTN Inspection STPr (as-run 20250804).pdf.