**1 INTRODUCTION**

**1.1 PURPOSE**

The purpose of this document is to describe the prototype testing conducted on the CCSDS Unified Space Link Protocol (USLP), CCSDS 732.1-R-3 (reference [2]).This is the third test plan draft of this plan prepared by the members of the CCSDS Space Link Protocol Group.

**1.2 SCOPE**

The scope of this document is testing to verify compatibility between independently developed CCSDS 732.1-R-3 USLP implementations by exercising the presence and absence of all optional fields, both individually and in combination, and by verifying their data during various boundary condition data field lengths.

Three implementations were developed and node locations for these tests are:

* USLP implementation from NASA Marshall Space Flight Center
* USLP implementation from DLR at German Aerospace Center.
* USLP implementation for Qinetiq supporting UKSA.

**1.3 APPLICABILITY**

The Unified Space Data Link Protocol is a Data Link Layer protocol (see reference [1]) to be used by space missions. USLP’s design meets requirements of space missions for efficient transfer of space application data of various types and characteristics over space-to-ground, ground-to-space, or space-to-space communications links (hereafter called space links).

This document applies to the prototype testing required to validate that NGSLP prototypes adequately demonstrate the specification in an independent fashion of version 3 of the red book.

**1.4 RATIONALE**

The CCSDS Procedures Manual states that for a Recommendation to become a Blue Book, the standard must be tested in an operational manner. The following requirements for an implementation exercise were excerpted from reference [1]:

“At least two independent and interoperable prototypes or implementations must have been developed and demonstrated in an operationally relevant environment, either real or simulated.”

This document outlines the Space Link Protocol Working Group’s approach to meeting this requirement for referenced [2].

**1.5 DOCUMENT STRUCTURE**

The first sections of this document describe the Test Plan for the prototyping activity; the last sections of the document provide a Test Report of the realized plan. Annex A provides acronyms and abbreviations.

**1.6 REFERENCES**

The following documents are referenced in this document. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS documents.

1. Procedures Manual for the Consultative Committee for Space Data Systems. CCSDS A00.0-Y-9. Yellow Book. Issue 9. Washington, D.C.: CCSDS, November 2003.
2. Unified Space Data Link Protocol, CCSDS 732x0r3. Red Book. Issue 3. Washington, D.C.: CCSDS, June 2018.
3. Communications Operation Procedure-1, CCSDS 232.1-B-2, Blue Book. Issue 2, Washington, D.C.: CCSDS, September 2010

**2 SUMMARY CONCLUSION/RECOMMENDATION**

The test plan and test reports documented herein substantiate that the organizations participating in the CCSDS Space Link Protocol Working Group have successfully conducted prototype testing of Unified Space Data Link Protocol, CCSDS 732x0r3 document. During the testing, USLP transfer frames of the various types were produced by two or more different organizations, and the ability to read/process the messages was demonstrated. Based on the diversity of agencies able to read/write transfer frames with diverse options, and the positive test results, the Space Link Protocol Group recommends that Unified Space Data Link Protocol, CCSDS 732x0r3 document be promoted to a Blue Book CCSDS Recommended Standard.

**3 Unified Space Link Protocol Testing Goals**

Testing of USLP exercises the ability to construct and utilize Unified Space Link Protocol:

* **Service Data Units**
	+ Packet SDU
	+ MAPA SDU
	+ Octet Stream SDU
	+ OCF\_SDU
	+ USLP Transfer Frame
* **USLP Services**
	+ MAP (Multiplexer Access Point) Packet service
	+ MAP Access (MAPA) Packet service
	+ MAP Octet Stream service
	+ Master Channel Operational Control Field (MC\_OCF) Service
	+ Virtual Channel Frame (VCF) Service
	+ Master Channel Frame (MCF) Service
	+ Insert Service
	+ COPs Management Service (optional)
* **USLP Protocol Data Units**
	+ USLP Transfer Frame
		- Transfer Frame Primary Header
		- Transfer Frame Insert Zone
		- Transfer Frame Data Field
		- Operational Control Field
		- Frame Error Control Field
* **USLP Protocol Procedures**
	+ MAP Packet Processing
	+ MAPA\_SDU Generation Function
	+ MAP Octet Stream Processing Function
	+ MAP Multiplexing Function
	+ Virtual Channel Generation Function
	+ Virtual Channel Multiplexing Function
	+ Master Channel Multiplexing Function
	+ All Frames Generation Function
	+ MAP Packet Extraction Function
	+ MAPA\_SDU Extraction Function
	+ MAP Octet Stream Extraction Function
	+ MAP Demultiplexing Function
	+ Virtual Channel Reception Function
	+ Virtual Channel Demultiplexing Function
	+ Master Channel Demultiplexing Function
	+ All Frames Reception Function
* **USLP Management Parameters**
	+ Parameters for a Physical Channel
	+ Managed Parameters for a Master Channel
	+ Managed Parameters for a Virtual Channel
	+ Managed Parameters for a MAP Channel
	+ Managed Parameters for a Packet Transfer
* **Protocol Specification with SDLS Option (optional)**
	+ SDLS Protocol
	+ Security Header
	+ Security Trailer
	+ Transfer Frame Data Field in a Frame with SDLS
	+ Operational Control Field in a Frame with SDLS
	+ Frame Error Control Field in a Frame with SDLS
	+ Packet Processing Function with SDLS
	+ Octet Stream Processing Function with SDLS
	+ Virtual Channel generation Function with SDLS
	+ Error reporting
	+ Packet Extraction Function with SDLS
	+ Octet Stream Extraction Function with SDLS
	+ Virtual Channel Reception Function with SDLS
	+ Virtual Channel Demultiplexing Function with SDLS
* **Managed Parameters with SDLS Option**
	+ Presence of Space Data Link Security Header
	+ Presence of Space Data Link Security Trailer
	+ Length of Space Data Link Security Header (octets)
	+ Length of Space Data Link Security Trailer (octets)
* **Frame Error Control Field Coding Procedures**
	+ CRC-16 FECF Encoding Procedure
	+ CRC-16 FECF Decoding Procedure
	+ CRC-32 FECF Encoding Procedure
	+ CRC-32 FECF Decoding Procedure

Tests described in Section 5 and Section 6 of this plan were conducted to meet the CCSDS requirements described in Section 2. Testing results are presented in Section 7.

 **3.1 USLP OVERVIEW**

First, the CCSDS Space Link Protocols WG has identified the following major deficiencies in existing link layer protocols:

1. Transfer Frame Size and Accountability is too limited for CCSDS agencies envisioned future mission set;
2. There are inadequate spacecraft ID assignments available in the current CCSDS link layer protocols.

Second, each of the four CCSDS link layer protocols (TM, TC, AOS, and Proximity-1) have unique formats and services that prohibit their reuse across the totality of all space link applications of CCSDS member space agencies.

As a result, the new space link protocol is a formulation that extends older protocols and adds new features to support technological innovation on new spacecraft missions. USLP is an evolutionary development from the experience and lessons gained on all earlier CCSDS packet oriented space link protocols. USLP not only accommodates but also supports:

* Onboard computational ability
* Modern security
* Increased data rates
* High performance coding option; e.g. LDPC
* Protocol Independent Label Switching feature

USLP is composed of variable length transfer frames with the simple (or degenerative) case as fixed. Test cases conducted demonstrate variable transfer frames. Because frames are variable, there is no need for code block alignment and therefore test cases demonstrating transfer frame and codeblock coupling.

USLP can substitute for any SLP protocol with various channel-coding mechanisms. Features that support generic applicability are exercised.

**4 TEST PLAN OVERVIEW**

Section 4 lists test configuration and requirements for this phase of validation (verification). Requirements allocation represents a comprehensive list and all requirements are to be exercise and verified.

Section 5 lists a set of test cases performed to exercise three implementations of these requirements and include optional capabilities.

MSFC, DLR and Qinetiq via VPN have conducted testing with the coordinated configuration provided by each team. MSFC acted as the common VPN endpoint between DLR and Qinetiq. Each VPN encompassed test machines on either side. Once the VPN was established, Marshall, DLR, and Qinetiq used Ping to identify and ensure all nodes were online.

 

**Figure 4-1 Test Configuration**

Each participant established at least one node. Unique test stations were established at each test site based on test conductors’ particular setup.

An IPSEC VPN protects connections. Test activities were initiated from each participant in turn with coordination from the other participant to ensure the existence of the optional fields included per test, as well as proper field content. UDP packet generators on either side that were used to generate the data the USLP transmitters encapsulated for transmission to its corresponding USLP receiver. Generated data was in the form of visually recognizable ASCII data.

Software configuration

1. DLR
	* LINUX based on SLES 12 with 64 bit
	* Executing on VMware virtual server
		1. 1 CPU (Intel(R) Xeon(R) CPU E5-2630 v3 @ 2.40GHz)
		2. 64-bit Architecture
		3. 4 GB RAM
	* Implemented in C++
2. MSFC HOSC
	* LINUX based on RHEL7.5 with 64 bit
	* Executing on VMware virtual server
		1. Dell 730
		2. 2 x Intel Xeon E5-2680 processor 2.70GHz
		3. 16 cores
3. QinetiQ
	* Ubuntu LINUX 14.04.02
	* Python version running is 2.7
	* Desktop
		1. Xeon E3-1200 v3/ 4th Gen core processor.
		2. Intel 8 series C220 chipset
		3. Nvidia GM107 GPU (GTX 750 Ti)

Test goals are non-performance related, that is to say functionality was tested and no attempt was made to establish upward performance bounds.

A UDP data generator transmits data to the USLP transmitter that encapsulates the UDP data into a USLP frame (with agreed-upon optional fields present or absent per test iteration) and transmits this USLP frame to USLP receiver. The USLP receiver extracts the user data and verifies the existence of optional fields is correct. This process was repeated with optional fields being added or removed for each test until all proper operations with or without optional fields have been verified. Data flow was verified for each direction with transmitters and receivers being reversed for each test.

The first test area exercises the TFDF-part of the USLP frame that comprises the largest available part of the USLP frame. It is composed of the TFDF header and the TFDZ as shown in figure 4-2.



**Figure 4-2 USLP Transfer Frame**

Different segmentation and streaming strategies are tested, resulting in all possible TFDZ construction rules. Therefore, it is necessary to use different SDU protocol types, namely CCSDS Space Packets, MAPA\_SDUs and Octet Streams. It is also necessary to distinguish between Fixed and Variable Length Frames.

**5 TEST PLAN DETAILS**

Eight test cases were identified to be exercised. Four basic test cases exercise basic capabilities, two test cases exercise COP functionality, and two test cases exercise SDLS features. Test case frames originate from each test node and are sent to the participating and complementary test node of the remote partner for ingest and processing. Frames are processed for syntax, recognition of fields, and parameters are processed properly. In effect, each partner is evaluating their partner’s test data.

**5.1 Basic test cases**

The four basic test cases are composed of two test cases for fixed frames and two test cases for variable frame; one in each direction for fixed and variable frames. Table 5-1 lists the requirements satisfied by the fixed length frames test cases. Table 5-2 list variable lengths frames and are identical.



Table 5-1 Test Cases for Fixed Length Frames

Each test is conducted in the configuration identified in section 4.



Table 5-2 Test Cases for Variable Length Frames

**5.2 TEST CASES SUPPORTING COMMAND OPERATIONS PROCEDURE -1**

Two test cases were developed to demonstrate COP-1 operations as specified in reference [3]. These test cases identify whole frame errors that may be passed from the C&S sublayer to USLP. Test cases are reciprocal in that each participant originates and responds to requests.

Fixed frames are used in order to simplify testing. Table 5-3 lists requirements satisfied by these test cases.



Table 5-3 Test Cases for Command Operations Procedures

These test cases do not verify COP only that USLP can support COP. They are composed of two scenarios, 1) no error conditions and 2) errors injected on the simulated link. COP-1 exchanges exercised used several pre-arranged/orchestrated COP activities. Emulated FOP and FARM are a sequence of pre-planned responses that USLP must support. Frames were analyzed for support to ensure the designed transfers exist. The test team only demonstrated with Type-A frames.

Procedure 1 – Good continuous link (continuous forward advancing sequence number):

1. Send a FOP transfer (FDU) on a specific VC (07)
2. Returns the transfer status with a CLCW on VC(07)



Figure 5-1 Test Flow

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| COPs Management Service Parameters | Description | Reference | Status | MSFC | Values |
| USLP-120 | USPID | Table 5 | M | Y | 00001 |
| USLP-38 | GVCID | 3.10.2.2.1 | O.1 | y | 110000000000101010 +000010 = 50334338 |
| USLP-39 | Port ID | 3.10.2.2.2 | O.1 | y | N/A |
| USLP-40 | Directive ID | 3.10.2.3 | M | y | User defined # - I pick 227 decimal |
| USLP-41 | Directive Type | 3.10.2.4 | M | y | Initiate AD service with CLCW |
| USLP-42 | Directive Qualifier | 3.10.2.5 | M | y | None |
| USLP-43  | Notification Type  | 3.10.2.6  | M | y | Accept  |
| USLP-44  | Notification Qualifier  | 3.10.2.7  | M | y | Confirm |

 Table 5-4 COP-1 Scenario Managed Parameters

**5.3 TEST CASES SUPPORTING SDLS**

Two test cases were developed to exercise the optional support for Space Data Link Security as specified in references [14] and [15] of USLP. Test cases exercise USLP with humanly readable isogrammatic security headers and trailers in transmitted frames. Identification of headers and trailers in received frames were based on managed parameter settings. Frames with security headers that did not match were observed and discarded. These test cases were conducted in concert with test case 0-3. In other words, security headers and trailers were inserted during basic test cases.

Variable frames were used in order to test for all options. Table 5-4 lists the requirements satisfied by these test cases.



Table 5-4 Test Cases for Space Data Link Security

**6 TEST PROCEDURES**

**6.1 BASIC TEST CASES**

Test cases 0-3 are considered basic and exercise fundamental USLP capabilities to include creation of Protocol Data Units (PDU) with their constituent parts. Construction rules are exercised in concert with managed parameters. Test configuration is shown in the following figure where each USLP implementation transfers a PDU via UDP.



Figure 6-1 Basic test cases network configuration

Packet contents were human readable in all instances to enable rapid verification. The following example is typical.

00 U N C 00 0d O P Y R I G H T A B L E 0 1

Each sender sends USLP frames to their counterpart independently in a simplex fashion. Test cases 0 and 1 are for fixed length frames. Test case 2-3 are for variable length frames. TC 0-3 omit optional features. Logs are retrieved after each test case for analysis. Set managed parameters are found in Annex B.

Test flow:

1. Users at MSFC, DLR, Qinetiq must initiate independent tests and have a complementary receiver.
2. Each managed parameter is varied across multiple frames, as defined in the specific requirements
3. Frames are forwarded to the remote recipient. Transmission can be simultaneous or independent.
4. Frames are received by each tester and parsed for valid items and correct construction.
5. Interruptions causing lost packets were retransmitted after analysis to ensure a complete test set.
6. Error condition flags will be reported in logs; e.g. USLP flags.

Construction rule definitions are enumerated in table 4.3 in the USLP specification [2]. Fixed and variable length frame rules apply respectively where test cases 0 and 1 are for fixed length frames and test cases 2 and 3 are for variable length frames. Optional features were omitted except for SDLS.

|  |  |  |
| --- | --- | --- |
| **TFDZ Construction Rule Value** | **Applicable to either Fixed or Variable-Length TFDZs** | **TFDZ Construction Rule Requirement** |
| 000 | Fixed  | **4.1.4.2.2.2.1**Packets Spanning Multiple Frames |
| 001 | Fixed  | **4.1.4.2.2.2.2**Start of MAPA\_SDU (Complete or Portion)  |
| 010 | Fixed  | **4.1.4.2.2.2.3**Continuing Portion of MAPA\_SDU  |
| 011 | Variable  | **4.1.4.2.2.2.4**Octet Stream |
| 100 | Variable | **4.1.4.2.2.2.5**Starting Segment |
| 101 | Variable | **4.1.4.2.2.2.6**Continuing Segment |
| 110 | Variable | **4.1.4.2.2.2.7**Last Segment |
| 111 | Variable | **4.1.4.2.2.2.8**No Segmentation |

Table 6-1 : Summary of the TFDZ Construction Rules

Retrieved logs were analyze after each test case. Test flow is identical in test cases 0 through 1.

Initial testing will be on frames less than 1500 octets with a time interval of several seconds between transmissions. This ensures that no frames are out of sequence. Subsequent testing will require transfer of frames at the limit, i.e. 64 K octets. Experience has indicated that over continental distance and using a VPN, packets can not be guaranteed to arrive in order. As a result, final testing of test cases 0-3 will require a file transfer. Each transfer will have three frames of three types of data: space packets, MAPA\_SDUs, and Octet streams.

* + 1. **EXPECTED RESULTS**

NASA/HOSC, DLR, and Qinetiq will successfully transfer and process both variable and fixed frames. Output notifications to other layers are emulated by print functions to ensure that data can be passed in the correct form. Assuming that these criteria are met, test cases 0 through 3 will be considered successful. In the event of discrepancies, participants in the test will conduct troubleshooting. Corrective actions identified will be applied before retest.

**6.2 COP TEST CASES**

Test cases 4-5 exercise support for COP-1 in USLP. Each test case requires two-way communication. Test case 4 has MSFC as the originator of an exchange and test case 5 originates with DLR or Qinetiq. In each case, the responder must reply in a simplex fashion with associated acknowledgements. Construction rules are exercised in concert with managed parameters. Test configuration is shown in the following figure where the originator transfers a file of representative frames.



 Figure 6-2 COP test case network configuration

These test cases verify that USLP can support COP and use several pre-arranged/orchestrated COP activities. FOP and FARM will not be real but a sequence of pre-planned responses that USLP must support. Frames are analyzed to ensure designed transfers exist. The second scenario of each test case will have errors injected on the simulated link.

Packet contents were human readable in all instances to enable quick verification. The specific pattern is the first 20 lines of the ***Rhyme of the Ancient Mariner*** by Samuel Taylor Coleridge. It can be found in Annex C. To be correct it must be transmitted in the exact order.

This test case uses COP-1 as defined in reference [3] for a type-A frame service.

Test flow:

As previously stated, two scenarios exercised for each COP-1 test case; good continuous link and bad link with a requested retransmit. (retransmit of 2).

Scenario 1 – good continuous link

1. FOP as source is "1" and sends to the same VC as the FARM uses.
2. FARM checks the sequence number.
3. If not proper sequence, FARM as source is "0" sends a CLCW with retransmit (should not occur).
4. FOP responds with a retransmit if status times out or CLCW has retransmit (we will not support COP timer for this test case.)

Scenario 2 – bad link

1. FOP as source is "1" and sends to the same VC as the FARM uses.
2. FARM checks the sequence number.
3. Intermittently between USLP and the test conductor one will drop a transfer between the FARM and USLP inducing the error of item 4 below.
4. If not proper sequence, FARM as source is "0" sends a CLCW with retransmit.
5. FOP responds with a retransmit if status times out or CLCW has retransmit. (COP timer was not supported for this test case.)

The following is the logical test configuration and managed parameters.



Figure 6-3 COP Logical test configuration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Item | Description | Reference | Status | MSFC | Values |
| COPs Management Service Parameters |  |  |  |  |  |
| USLP-120 | USPID | Table 5 | M | Y | 00001 |
| USLP-38 | GVCID | 3.10.2.2.1 | O.1 | y | 110000000000101010 +000010 = 50334338 |
| USLP-39 | Port ID | 3.10.2.2.2 | O.1 | y | N/A |
| USLP-40 | Directive ID | 3.10.2.3 | M | y | User defined # - I pick 227 decimal |
| USLP-41 | Directive Type | 3.10.2.4 | M | y | Initiate AD service with CLCW |
| USLP-42 | Directive Qualifier | 3.10.2.5 | M | y | None |
| USLP-43  | Notification Type  | 3.10.2.6  | M | y | Accept  |
| USLP-44  | Notification Qualifier  | 3.10.2.7  | M | y | Confirm |

Table 6-2 : COP Managed Service Parameters

* + 1. **EXPECTED RESULTS**

Test participants will successfully transfer and process both error free and error induced frames. Since FARM processing is between lower and upper procedures, a mechanism is inserted to vector traffic without interfering with non-optional USLP processing. Twenty lines of distinctive text are transferred. Success in order processing is for a criterion for completion of these test cases.

**6.3 SDLS TEST CASES**

As stated previously, two test cases exercise support for SDLS in USLP. Each test case requires one-way communication. Test case 6 has a sender as the originator of an exchange and test case 7 originates with receiver initiating the exchange. Test configuration is shown in the following figure where the originator transfers a file of a representative frame of the USLP implementation via UDP.



Figure 6-3 SDLS test cases network configuration

Packet contents were human readable in all instances to enable quick verification. The following example is typical.

Security Header – present in all VCIDs, length 3 “:h;”

Security Trailer – present in all VCIDs, length 8 “[-tral~]”

Each sender sends USLP frames to their counterpart independently in a simplex fashion. Test flow is the basic test case flow.

1. **TEST Results**

**7.1 Basic Test case 0 and 1 for short fixed length frames**



Test cases 0 and 1 exercise construction rules for fixed length frames. Two test teams conducted testing between MSFC/DLR and MSFC/Qinetiq. Each test team executed their test independently with MSFC being the common member. Test case 0 has MSFC as the source and test case 1 has DLR and Qinetiq initiating.

Initial testing is with small frames capable of exercising everything in USLP (except COP and MSB of frame length octet in transfer frame header and MSB of packet length octet) in the following configuration:

* 1. Frame length dictates spanning, idle fill
	2. Physical channel is fixed length of 55 octets
	3. Exercise all fixed length construction rules,
	4. Short and long packets tests multiple packets per frame
		1. packets that span 2 frames
		2. packets that span 3 frames
	5. One non-spanning SDU and one spanning SDU,
	6. All optional fields present every frame
		1. multiplexing multiple VCIDs
		2. MAP IDs
		3. exercising idle fill timeouts

Isogrammatic data fields were used to help identify errors in reassembly.

1. TVFN 12
2. SCID 42
3. sequence controlled frame counter length: 2
4. expedited frame counter length: 4
5. VCID 7 (variable)
6. MAP ID 8 - octet stream
7. VCID 62 (fixed)
8. MAP ID 14 – MAPA\_SDU

Example of isogrammatic data contained in a frame

c0 02 a6 r 00 " 02 00 00 00 00 00 00 U N C 00 0d O P Y R I G H T A B L E 0 1 e1 03 E



**7.2 Basic Test case 2 and 3 for short variable length frames**

Test cases 2 and 3 exercise construction rules for variable length frames. Two test teams conducted testing between MSFC/DLR and MSFC/Qinetiq Each test team executed their test independently with MSFC being the common member. Test case 2 has MSFC as the source and test case 3 has DLR and Qinetiq initiating.

Testing is with small frames capable of exercising everything in USLP (except COP and MSB of frame length octet in transfer frame header and MSB of packet length octet) in the following configuration:

Physical channel type is variable with a length of 42 octets

* 1. VCIDs 0 and 62 are both variable frame types
	2. VCID 7 frame type is variable
	3. MAP ID 8 data unit type is octet\_stream
	4. No optional fields present (no insert zone, no fecf, no ocf, no security header or trailer)
	5. Only variable frames are used
	6. Exercises multiple complete packets per variable frame while allowing only a single MAPA\_SDU per frame
	7. Exercises octet stream not available for fixed frames
	8. Exercises sending truncated frame on VCID 0 (truncated frame total length for VCID 0 set by managed parameter to 8)

Isogrammatic data fields were used to help identify errors in reassembly.

1. multiple small packets per single variable frame tfdf

c0 02 a0 00 00 18 02 00 0c e0 00 00 00 00 00 00 Z 00 00 00 00 00 01 X W

1. single larger packet spanning consecutive variable frames’ tfdfs (with 7-octet frame counter)

c0 02 a0 00 00 18 87 00 00 00 00 00 00 12 80 00 00 00 00 00 13 U N C O

c0 02 a0 00 00 18 87 00 00 00 00 00 00 13 a0 P Y R I G H T A B L

c0 02 a0 00 00 14 87 00 00 00 00 00 00 14 c0 E = J F K !

1. single SHORT MAPA\_SDU per variable frame tfdf

c0 02 a7 c2 00 0b 02 00 0f e5 d 4

1. single larger MAPA\_SDU spanning consecutive variable frames’ tfdfs (with 7-octet frame counter)

c0 02 a7 dc 00 18 87 00 00 00 00 00 00 15 85 b l a c k \_ q u a r

c0 02 a7 dc 00 18 87 00 00 00 00 00 00 16 a5 t z . s p h i n x -

c0 02 a7 dc 00 12 87 00 00 00 00 00 00 17 c5 v o w :

1. 8-octet truncated frame

c0 02 a0 01 M N P Q

1. octet stream frame

c0 02 a0 f0 00 10 84 00 00 00 0c d 1 3 5 7 9



**7.3 Basic Test case 2 and 3 for maximum variable length frames**



Test cases 2 and 3 for maximum frame size are not conducted in the same manner as all other test cases. Due to the test environment of transferring frames with UDP over a VPN across continental distance, large packets approaching the specification maximums are very difficult to test and deliver in the proper order. As a result, it is necessary as a test methodology to generate large packets and capture them in a file. These packets were sent via email and processed in a similar manner as small frames.

A total of nine maximum fixed length frames were sent with a single SDU per frame; three with CCSDS space packets, three with MAPA SDUs, and three with Octet streams. The use of Octet streams necessitates the use of variable construction rules. No scanning was conducted for sync markers. Each frame size is the maximum; e.g. max TFDZ is 65528 octets with a minimum header of 1 octet. Maximum transfer frame length value in the Transfer Frame Header is 65535 (binary 1111111111111111).

(Explanation is: With a bare, no-optional-fields frame, a 7-octet frame header and 1 octet frame counter \*\*\*( no counter is required)\*\*\* would leave TFDZ actual number of octets as 65536-8=65528 \*\*\*(65529 = TFDF )\*\*\*\*

Physical channel type is variable with a length of 65536 octets

1. VCIDs 0 and 62 are both fixed frame types for packet and MAPA\_SDU
2. VCID 7 frame type is variable for octet stream
3. No optional fields present (no insert zone, no fecf, no ocf, no security header or trailer)

A predictable data field data was used to help verify length and content.

A B C D E F G A B C D E F G ………..



* 1. **COP Test cases 4 and 5**



Test cases 4 and 5 exercised the use of COP-1 between two independent spacecraft with MSFC (SCID 27000) and Qinetiq (SCID 42). Initial testing conducted with Qinetiq (TC5) sent FOP FDUs and MSFC responding with CLCW. Injected error was only on the MSFC side. When MSFC acted as the FOP,5 good frames were sent before a frame was dropped frame. When MSFC acted as the FARM, 5 good frames were received and 2 frames dropped. Aggregation of data was left to each test team; MSFC would send one line of data per FDU and Qinetiq would send multiple lines of data per FDU. Following is the parsed data stream after injected error.



* 1. **SDLS Test cases 6 and 7**

Test cases 6 and 7 passed SDLS header and trailers between a sender and a consumer of USLP. Testing was with fixed and variable length transfers conducted with Qinetiq and DLR in concert with test cases 0 -3. Therefore, test case parameters were identical to those in section 7.1 with the addition of security headers and trailers were included in all VCIDs. Reception was verified in all cases.

Security Header –length 3 “:h;”

Security Trailer –length 8 “[-tral~]”

Annex A

Abbreviations and Acronyms

ARQ Automatic Repeat Queuing

ASM Attached Sync Marker

CC Channel Coding

CCSDS Consultative Committee for Space Data Systems

CLCW Communications Link Control Word

CLTU Communications Link Transmission Unit

COP Communications Operations Procedure

COP-1 Communications Operation Procedure 1

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.

 (German Space Agency)

FARM Frame Acceptance and Reporting Mechanism MAPA FECF Frame Error Control Field

FOP Frame Operation Procedure

GMAP Global Multiplexer Access Point

GMAP ID Global Multiplexer Access Point Identifier

GSCID Global Spacecraft Identifier

GVCID Global Virtual Channel Identifier

IN\_SDU Insert Service Data Unit

MAP Multiplexer Access Point

MAP ID Multiplexer Access Point Identifier

MAPA Multiplexer Access Point Access

MAPA\_SDU Multiplexer Access Point Access Service Data Unit

MAPP Multiplexer Access Point Packet

MC Master Channel

MC\_OCF Master Channel Operational Control Field

MCF Master Channel Frame

MCID Master Channel Identifier

MSB Most Significant Bit

MSFC Marshall Space Flight Center

NASA National Aeronautical and Space Administration

OCF Operational Control Field

OCF\_SDU Operational Control Field Service Data Unit

OID Only Idle Data (Transfer Frame)

OSI Open Systems Interconnection

PCID Physical Channel ID

PDU Protocol Data Unit

PICS Protocol Implementation Conformance Statement

PLCW Proximity Link Control Word

PVN Packet Version Number

QoS Quality of Service

RF Radio Frequency

SA Security Association

SANA Space Assigned Numbers Authority

SAP Service Access Point

SCID Spacecraft Identifier

SDLS Space Data Link Security

SDU Service Data Unit

SLP Space Link Protocol

SPDU Supervisory Protocol Data Unit

Sync Synchronization

TC TeleCommand

TFDF Transfer Frame Data Field

TFDZ Transfer Frame Data Zone

TFVN Transfer Frame Version Number

TM TeleMetry

UKSA United Kingdom Space Agency

UPID USLP Protocol ID

USLP Unified Space Data Link Protocol

VC Virtual Channel

VCF Virtual Channel Frame

VCID Virtual Channel Identifier

VN Version Number

Annex B

TC0-3 Managed Parameters

Annex C

TC4-5 COP FDU data

First 20 lines of the ***Rhyme of the Ancient Mariner*** by Samuel Taylor Coleridge

It is an ancient Mariner,

And he stoppeth one of three.

'By thy long grey beard and glittering eye,

Now wherefore stopp'st thou me?

The Bridegroom's doors are opened wide,

And I am next of kin;

The guests are met, the feast is set:

May'st hear the merry din.'

He holds him with his skinny hand,

'There was a ship,' quoth he.

'Hold off! unhand me, grey-beard loon!'

Eftsoons his hand dropt he.

He holds him with his glittering eye—

The Wedding-Guest stood still,

And listens like a three years' child:

The Mariner hath his will.

The Wedding-Guest sat on a stone:

He cannot choose but hear;

And thus spake on that ancient man,

The bright-eyed Mariner.