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VDL/4 SARPs and Technical Manual Validation Activity

New DLS Implementation Report

Sponsored by

EUROCONTROL

rue de la Fusée, 96
B 1130 Bruxelles

Performed by

7900 Wisconsin Avenue,
Bethesda, Maryland. 20817 U. S. A

tel: +1-301-652-5306
e-mail: adsi@adsi-m4.com

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ADSI, INC.
7900 Wisconsin Avenue
Bethesda, Maryland 20814
U.S.A.

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Issue	Change ID	Description	Date	Author
0.1		Initial version, split the DLS-specific changes from the early source document.	08AUG03	SF
0.2		Initial draft release. Incorporated many new issues and solutions.	25AUG03	SF
0.3		Added some background material	25AUG03	PN
0.4		Added initial Eurocontrol comments	29AUG03	SF
0.5		Added pictures	3SEP03	SF
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1.0		Customer Release Version	4SEP03	PN
1.1		Incorporated comments, added latest NSCOP algorithm.	30SEP03	SF
1.2		Formatting changes	01OCT03	NF
1.3		Update of section 2.2, to reflect version 1.1 changes	13OCT03	NF

Compliance Traces

Approval

Author	Reviewer	Quality Acceptance
Name: Steve Friedman	Name: Prasad Nair	Name:
E-mail: steve@adsi-m4.com	E-mail: pn@pmei.com	E-mail:
Date: September 04, 2003	Date: September 04, 2003	Date:

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1. INTRODUCTION

1.1 Background

As part of the Eurocontrol effort to continue the development of VDL/4, ADSI was tasked to investigate and validate the new DLS recently adopted in the VDL/4 technical manual. Previously, ADSI had developed and implemented software for the new DLE and executed various tests on a number of our platforms. This validation report and its supporting data analysis are based on the material presented at AMCP-WG/M-5. However, to verify that the DLE specification was validated in its entirety, a new version of the VDL Mode 4 Technical Manual including all necessary changes resulting from validation actions undertaken has been drafted.

It should be noted that this validation effort was directed only among and between systems that implemented all recommendations contained in the appropriate sections of the Technical Manual. No attempt was made to verify correct interoperability between systems hosting different implementation options. Also, this effort focused upon validation of the DLS; although, some DLE-LME interactions were tested. However, the complete LME (reused from VDL/2) was not revalidated in this project. For this validation ADSI performed the following tasks:

Analyzed the appropriate sections of the ICAO VDL Mode 4 Technical Manual sections that address the DLS and ancillary related sections.
Identified and, as appropriate documented, Message Sequence Charts (MSC) that demonstrated compliance with the technical manual.
Provided confirmation of a model of the DLS in ADSI's proprietary software simulator.
Documented the results of the execution and validation of correct operation in our software simulator and subsequently in our VHF aviation ground stations and avionics hardware.
Documented the results of DLS tests with log verification of validation data generated from tests conducted on our hardware.
Provided a summary and conclusion of test results, proposed modifications and suggested next steps necessary to establish MOPS tests for the DLS section of the proposal.
Drafted, as appropriate, amendment proposals to the VDL Mode 4 Technical Manual in line with the simulation results for the consideration of the EUROCAE WG51/SG2 (VDL Mode 4 MOPS subgroup).

This validation and review of the technical manual has led to development of a well-validated specification. The software implementation offered has successfully performed the stated functionality. All recommendations were easily and completely implemented and have improved the performance of the system over its predecessor.

1.2 Organization of the Document

The document is organized as follows:

Section 2 identifies the hardware configuration and test set-up
Section 3 contains test descriptions and results
Section 4 is the conclusion
Appendix A contains an updated technical manual that includes all recommended changes.
This document identifies the specification against which the validation report was developed.

Appendix B contains the updated technical manual from Appendix A, shredded into a requirements table showing the requirements and the method(s) used in the validation. Appendix C contains the change proposals recommended for inclusion in the technical manual. The changes either directly or indirectly affect DLS operations. There are three types of changes proposed to the VDL Mode 4 Technical Manual: ones that are required (the current specification contains a contradiction, or is incorrect), ones that are suggested (because they improve performance, simplify coding, or improve readability), and finally the ones which are editorial in nature.

1.3 Acronyms

DLE	Data link entity
DLS	Data link service
DLPDU	Data link protocol data unit
LME	Link Management Entity
SNDCF	Sub-Network Dependent Convergence Function
VDL/2	VHF Data link Mode 2
VDL/4	VHF Data link Mode 4

2. VALIDATION OF THE DLE

2.1 Testing methodology

The hardware configuration consisted of a network of EFR data radios containing 2 air stations and a single ground station. Specifically, the host computers used in the validation suite all executed RedHat Linux v8.0. The air radios were ADSI EFR-DAIR-200-DFLN radios. The ground radio was an ADSI EFR-DGND-300-DFLN radio.

Radio antenna ports were inter-connected by attenuators (rather than radiating into the airspace) and the radio data ports were connected to the Linux computers via ethernet. The computers were connected to each other by a separate test lab ethernet. All log events were logged to a single log file (with appropriate tagging to differentiate the source). The primary test application was FTP. The FTP application was able to generate a very heavy load (as the host computer expected an ethernet speed connection) with interesting timing events and different priority messages. From these log files, a number of events that demonstrate the operation of the protocol was extracted and analyzed for protocol compliance.

The tests were performed with minimal attenuation (equivalent to an input signal of –30 dBm).

A schematic diagram showing the radio test network used is shown in the following figure:

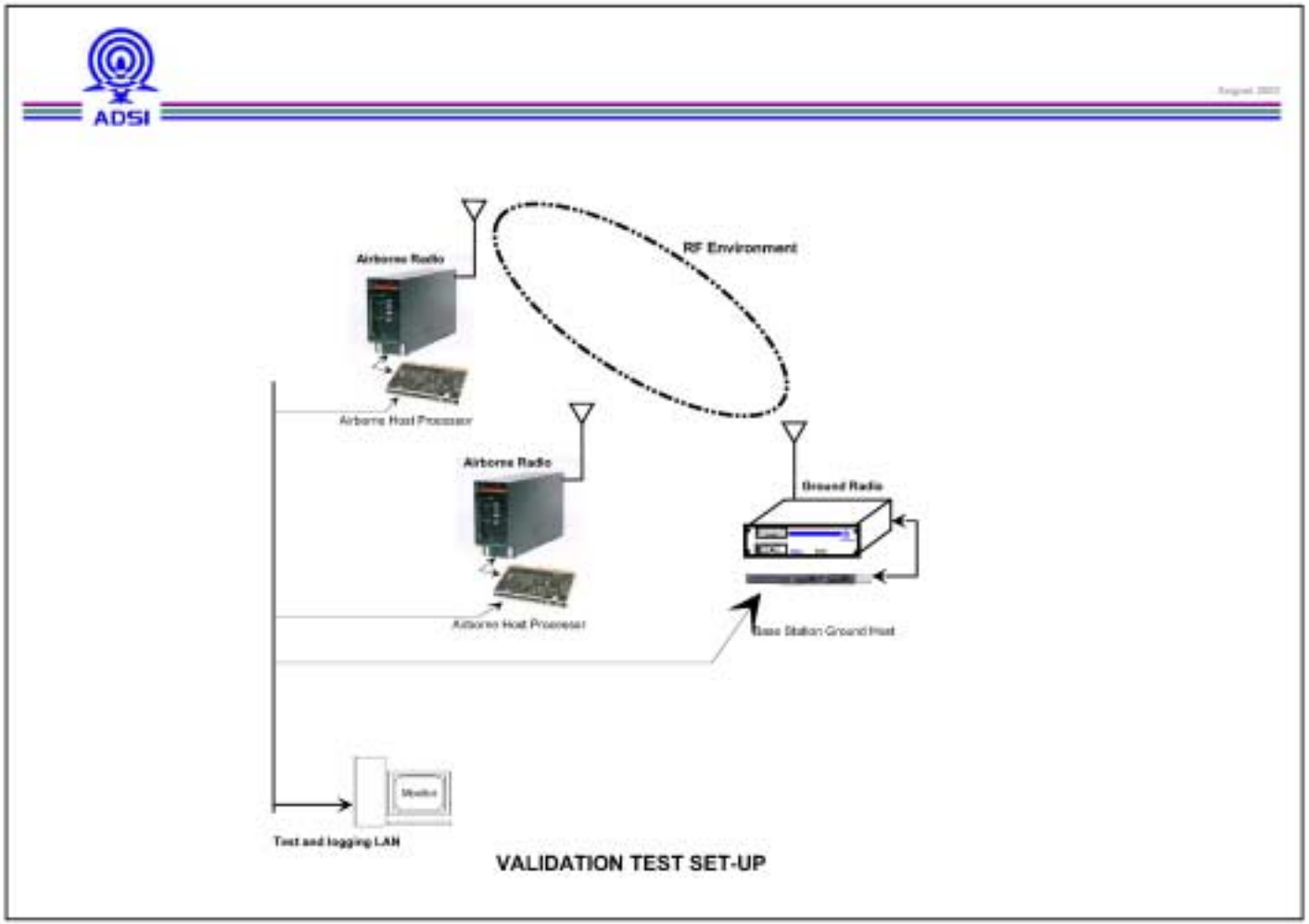
ADSI
RF Environment
Airborne Radio
Airborne Host Processor
Airborne Radio
Airborne Host Processor
Ground Radio
Base Station Ground Host
Monitor
Test and logging LAN
VALIDATION TEST SET-UP

2.2 New DLS text

New DLS text proposed can be found in Appendix A. Using a tool, developed at ADSI, Appendix B was generated from the contents of Appendix A. The Appendix (B) lists the original requirements and new requirements (resulting from this validation effort) and the specific testing performed to validate each requirement. The validation type qualifier is shown with one of the following codes indicating the nature of actions undertaken:

I – by inspection

M – Manufacturer's data. (***i.e.*** ADSI asserts that the requirement can be implemented, although it may not have been completely implemented in the software release used in the testing.)

N – not validated

S – tested and verified through simulation. (ADSI's software development environment has the capability to compile and execute the same source code used to cross-compile software targeted for the real avionics (radios) and the simulator used. The simulator provides greater capabilities for generating test and illegal frames to support exploration of timing-related events not otherwise easily duplicated in the avionics hardware that supports the final release software.)

T – tested in the targeted radio.

3. TEST RESULTS

The following figures document data transfer with hardware operating in accordance with configuration shown in Figure 1. The number at the top each double-column is the number of seconds since the start of the test. The number at the top of each column identifies the station. A solid box indicates a transmission because of a reservation. Text in red are transmissions and text in blue are receptions. Delays between transmissions and receptions are related to delays owing to random transmissions. In order to generate some priority issues, the short transfer was intentionally set slightly larger than the new default TM level. The tests consisted of ftp'ing from one station to another and transferring a 150 KB file. The two files were then compared to ensure that the transfer occurred without errors. D_data_req are requests from an upper layer to send data and d_data_ind is a delivery notification to the upper layer of data from a peer.

Figure 2 is an example Message Sequence Chart (MSC) with explanatory callouts describing various features on the MSC.

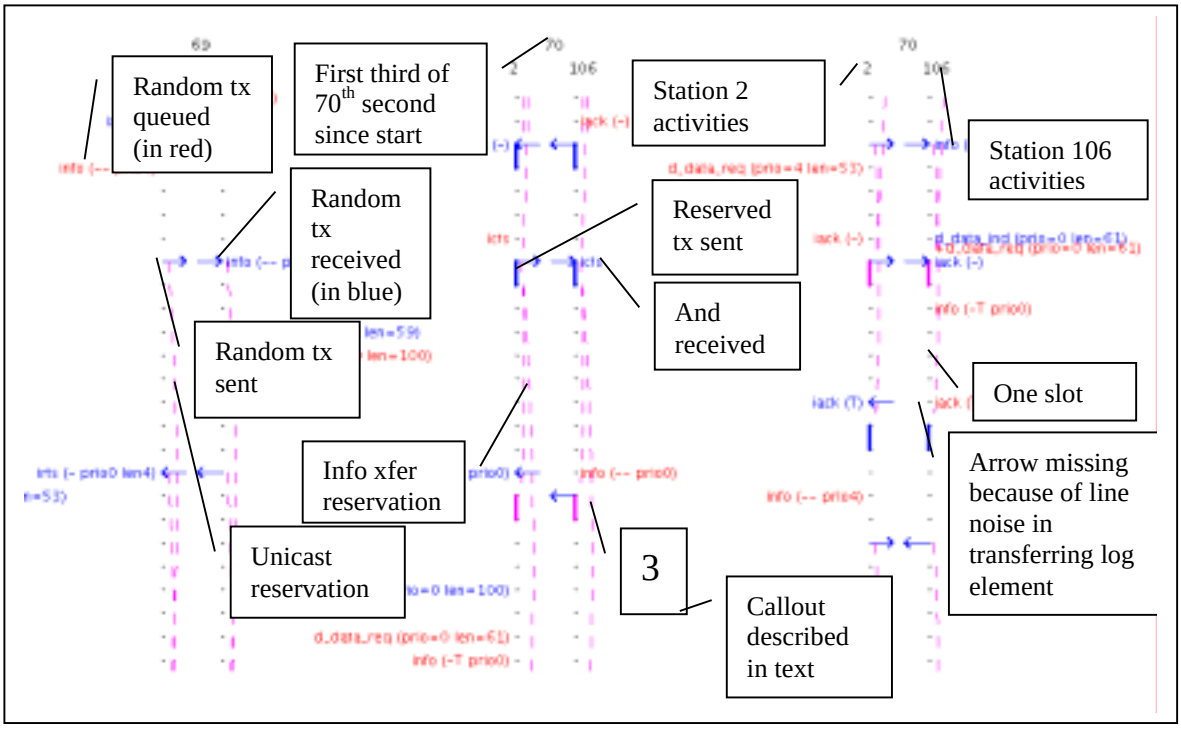

Figure 2 - Example Message Sequence Chart

3.1 NSCOP link management

Figure 3 shows NSCOP link initialization. This initialization was done with a poor connectivity to demonstrate the robustness of the link connection algorithm. As a consequence, this figure is drawn with a different scale (so there are 4 seconds or 300 slots per vertical column instead of the 1/3 of a second or 25 slots in every other figure). The following points can be seen in the figure:

1. As station 105 must initialize the link variables, it transmits a CTRL_RTS(IB=1) even though the length of the CTRL_CMD_LE is only 2 slots.
2. The CTRL_CMD_LE was not received by station 2 (the ground station) and so the ground station transmitted a CTRL_ACK (T) to NACK the CTRL.
3. As the link variables have been initialized in step 1, the air station now simply transmits the CTRL_CMD_LE in a short transfer procedure.
4. The ground station did not receive the acknowledgment of its CTRL_RSP_LE.
5. Finally, after four retransmission attempts, the ground station receives the CTRL_ACK and both sides treat the data link as up.

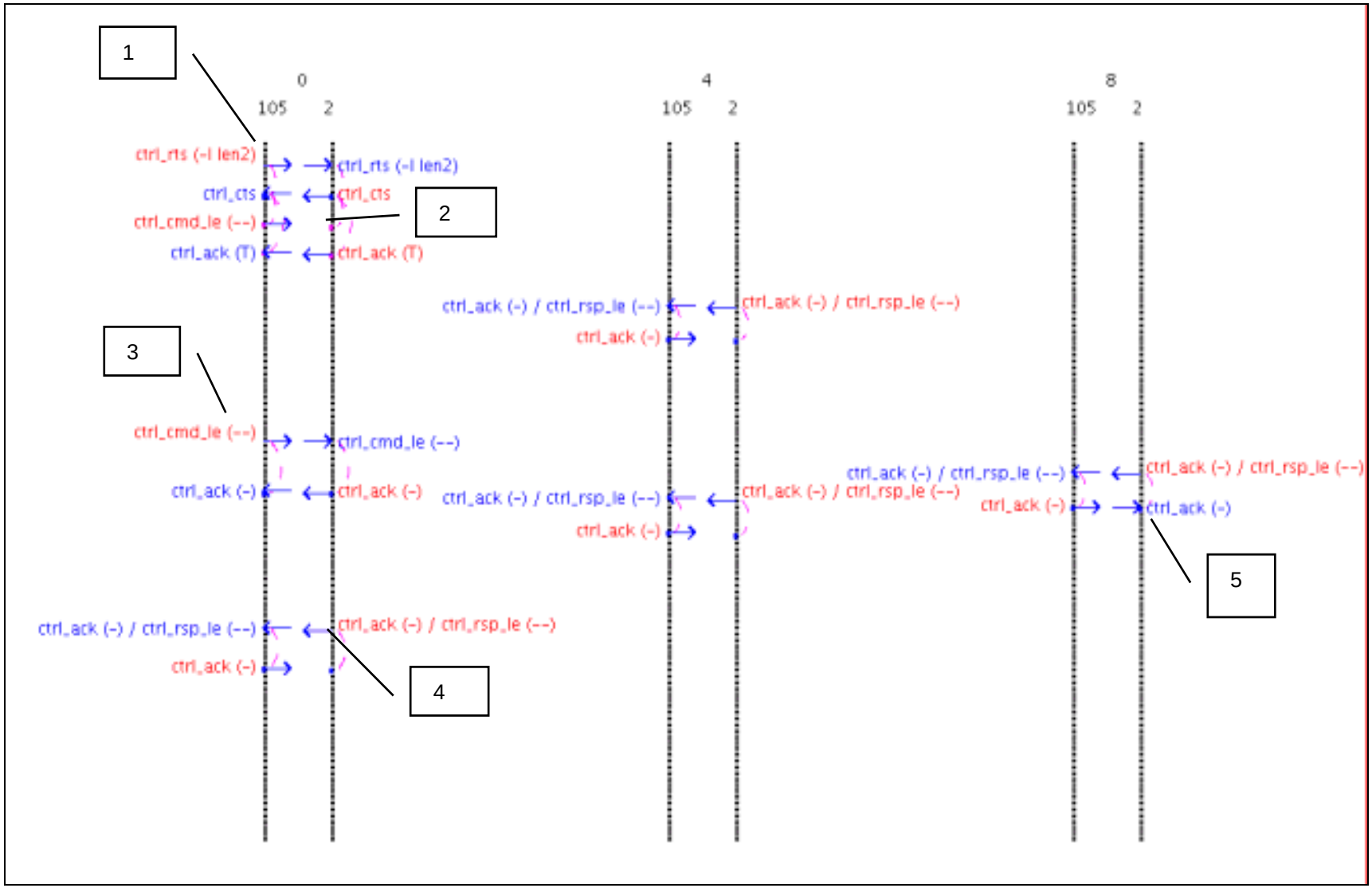

Figure 3 - NSCOP link initialization

3.2 ZOCOP link management

Figure 4 shows ZOCOP link initialization. After the initial SZOM transfer, the two stations transmit data normally. The following can be seen in the figure.

1. A d_data_req is received from the upper layer (in this case it is a TCP SYN packet).
2. The d_data_ind generates a d_data_req from the upper layer (in this case it is a TCP SYN-ACK packet). However, the INFO DLPDU can not be sent until after the SZOM/INFO_ACK. So, the response is held.
3. Once the SZOM/INFO_ACK is sent, the DLE immediately queues the INFO from step 2 for random transmission. (Unfortunately, the debug tool displayed both lines on top of each other.)

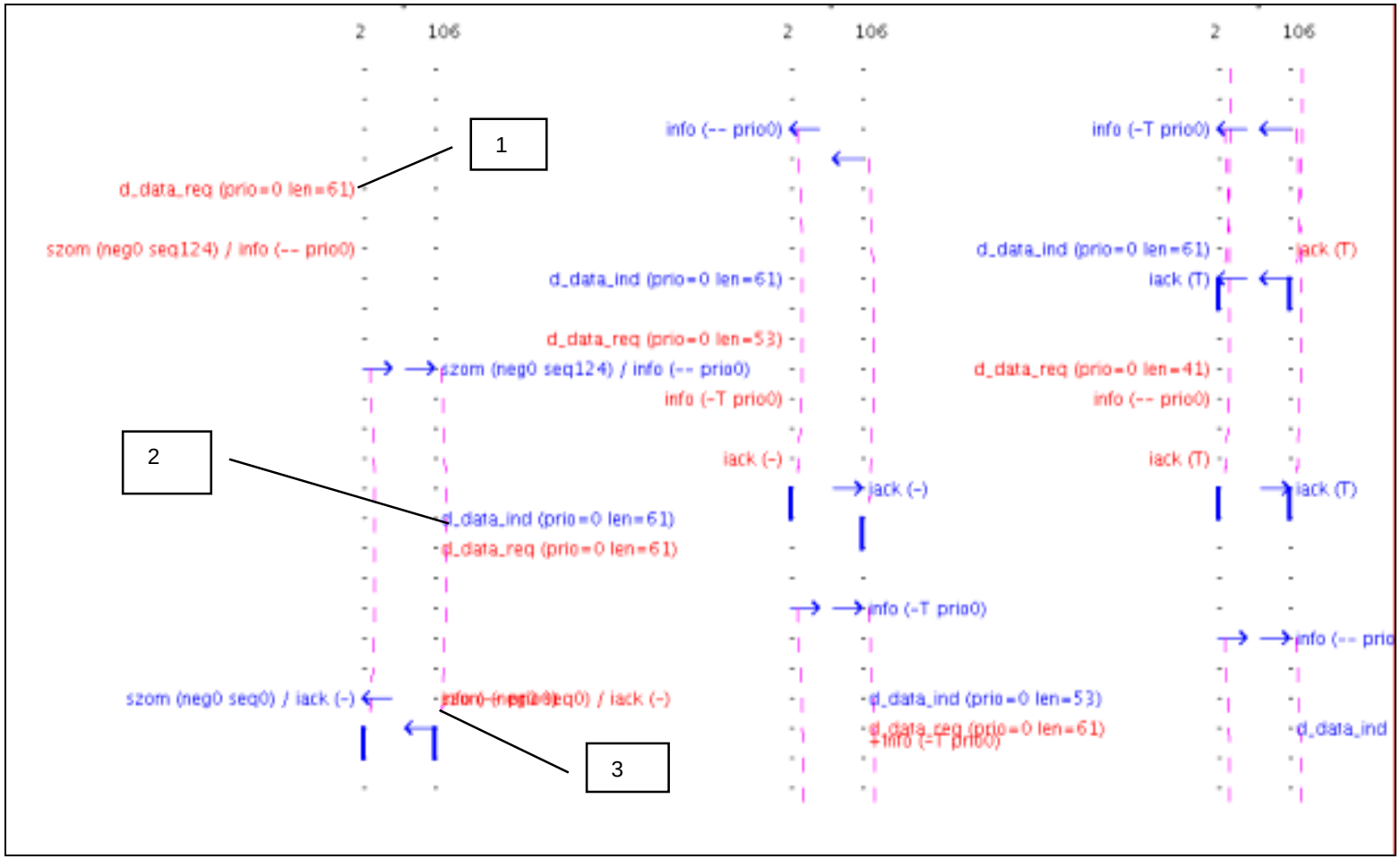

Figure 4 - ZOCOP link initialization

3.3 Data transfer

In Figure 5, multiple short data transfers can be seen. Additionally, the lack of holding up INFO transfers while INFO_ACKs are scheduled for transmission can be seen. Multiple random transmissions could have been avoided with that feature. The following points can be noted in this figure.

1. An INFO frame is submitted for random transmission.
2. The INFO frame is finally transmitted and received.
3. The INFO frame is received (the d_data_ind), the peer application generates a response (the d_data_req) and an INFO is submitted for random transmission.
4. The INFO frame from the previous step was transmitted. Note that one recommendation that was not made is to belay the INFO transmission so the reserved INFO_ACK includes an INFO_RTS. This would increase the latency of the INFO, but would improve its probability of delivery by converting a random transmission into a reserved transmission.
5. Just as in step 4, a random transmission is made rather than wait for the reserved slot in the future.

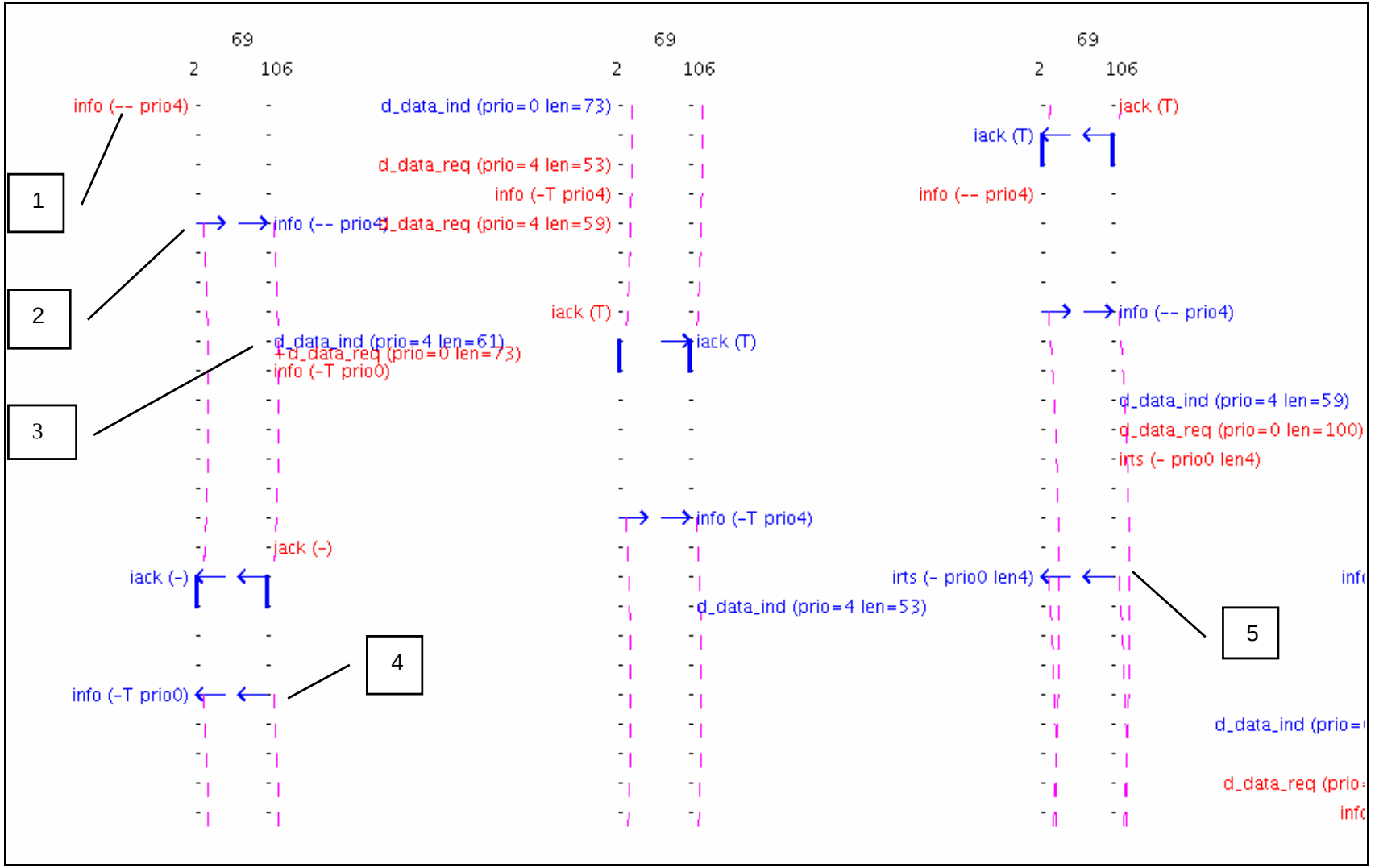

Figure 5 - A short data transfer

Figure 6 shows a long data transfer. In addition, it shows a collision of short INFO frames (which is resolved in the next figure; Figure 7). The following points can be seen on this figure.

1. An INFO_RTS is submitted randomly (it is the same as in the previous figure). The reservation is a unicast reservation type (as evidenced by the single dotted line).
2. The INFO_CTS is generated at the reserved slot. The reservation includes the info transfer resevation (as evidenced by the pair of dotted lines).
3. The INFO is transmitted in its reserved slot. Note that no reservation was made by this transmission for a future transmission.
4. The INFO_ACK was transmitted in its reserved slot. Note that no reservation was made by this transmission. Just prior to this point, the d_data_ind in station 106 generated a response.
5. The response from step 4 caused an INFO to be transmitted randomly. As before, an INFO_RTS was not sent in step 4 (which might have prevented the collision in step 7).
6. Just above step 4, station 2 received a d_data_req. As there was already an INFO frame outstanding (sent just prior to the d_data_req) when the d_data_req was received, station 2 had to wait until after the INFO_ACK just prior to this step until sending the INFO randomly.
7. Because of bad luck, the two INFO frames collided.

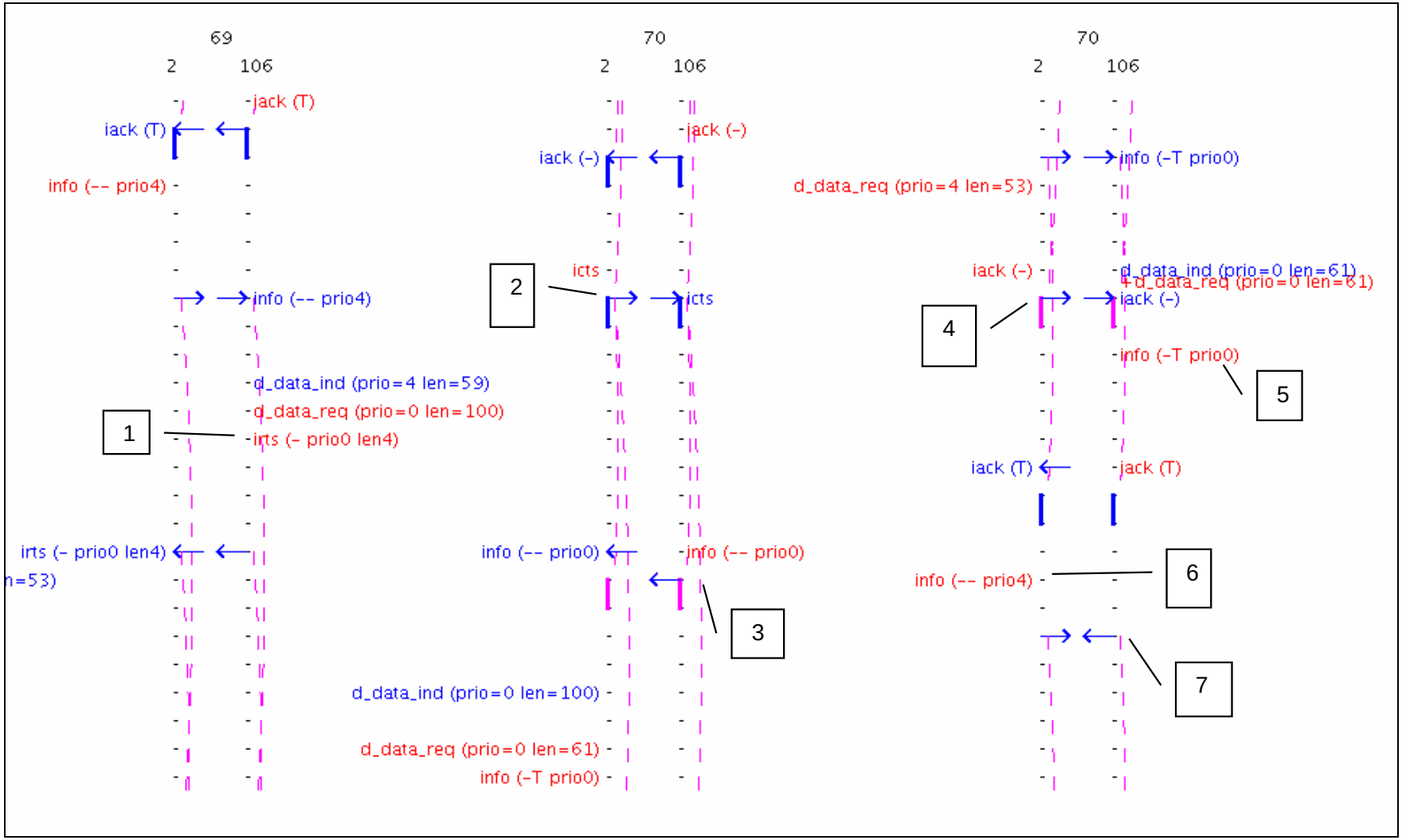

Figure 6 - Long data transfer and a collision

In Figure 7, station 2 retransmitted first and station 106 combines an INFO_RTS with its INFO_ACK. The following points can be seen.

1. This is the collision from the previous figure.
2. Station 2's DLE retransmitted first.
3. In responding with an INFO_ACK, station 106 determined that it could piggyback an INFO_RTS onto the INFO_ACK.

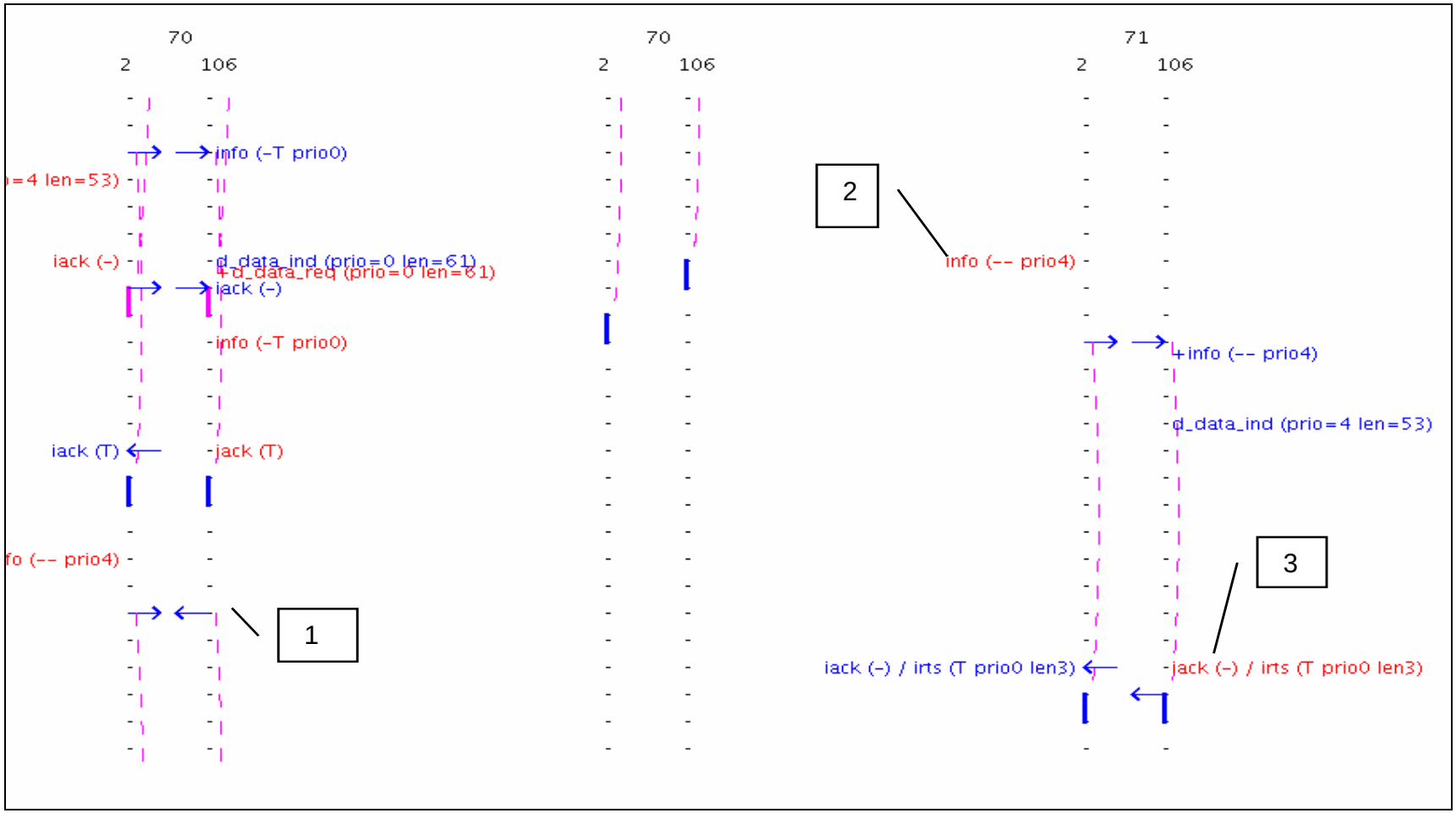

Figure 7 - Combined response

Figure 8 shows a large data transfer with fragmentation. At this point in the test, a request to get a 150KB file was submitted. This figure shows the initial submission of 3 maximum size ethernet frames, and the initial fragmentation of the packets. The following points can be noted in this figure.

1. The first three frames of the file to be transferred are submitted to the link layer.
2. The first fragment of the first frame is requested for transmission in an INFO_RTS that is piggybacked on another INFO frame queued for transmission.
3. The next step in the long procedure is the transfer of the piggybacked INFO_ACK and INFO_CTS.
4. The first fragment is finally sent (with M=1).

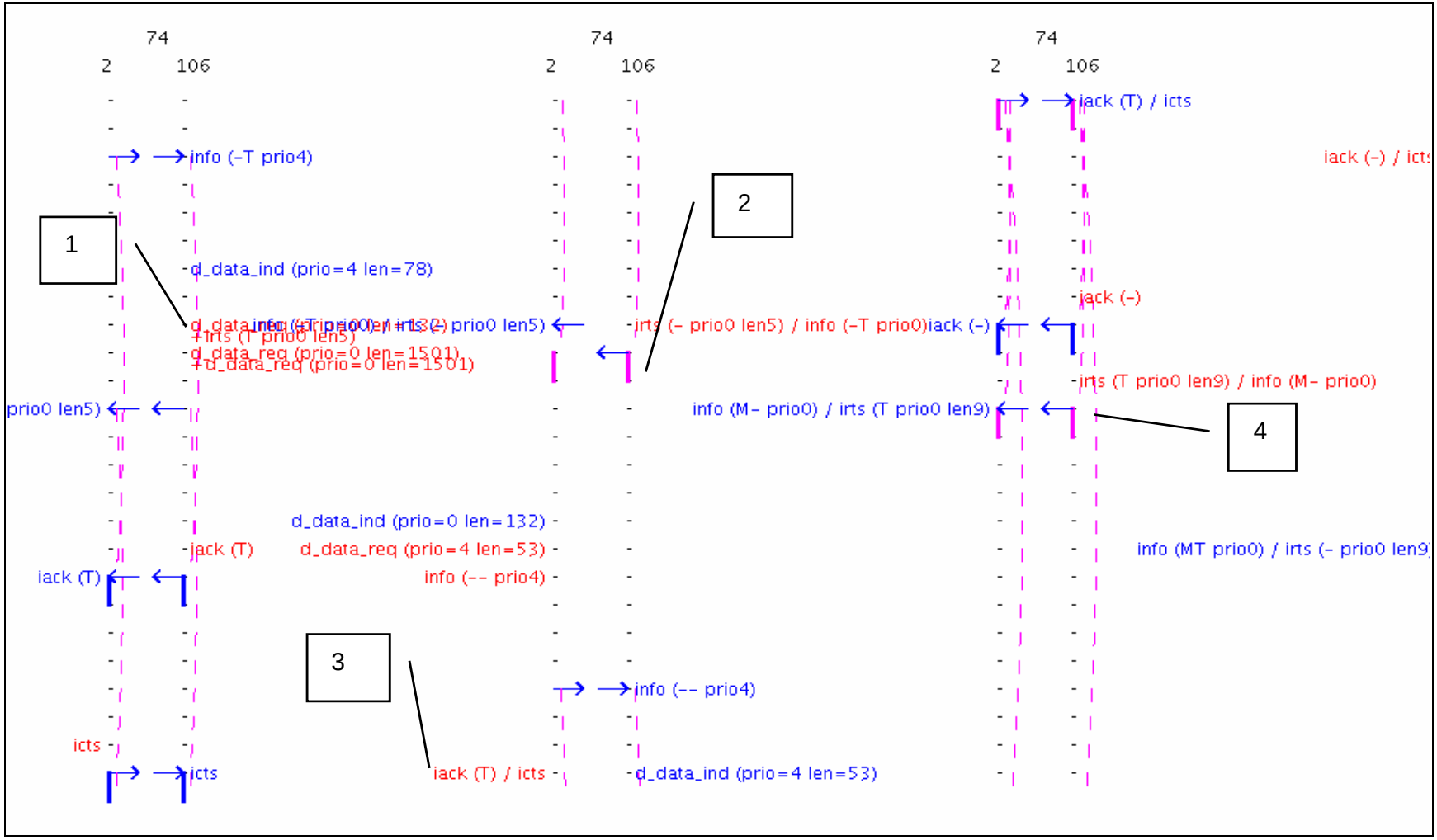

Figure 8 - Large data transfer request

Figure 9 is a capture after the delivery of the first user packet. It shows delivery of the first user data packet and the toggling of the M bit during the delivery. The following points can be noted on this figure.

1. The last fragment of the first frame is delivered (M bit is not set).
2. The d_data_ind is generated at the end of the frame.
3. The next INFO packet has an M bit set as it is the first fragment of the second frame.

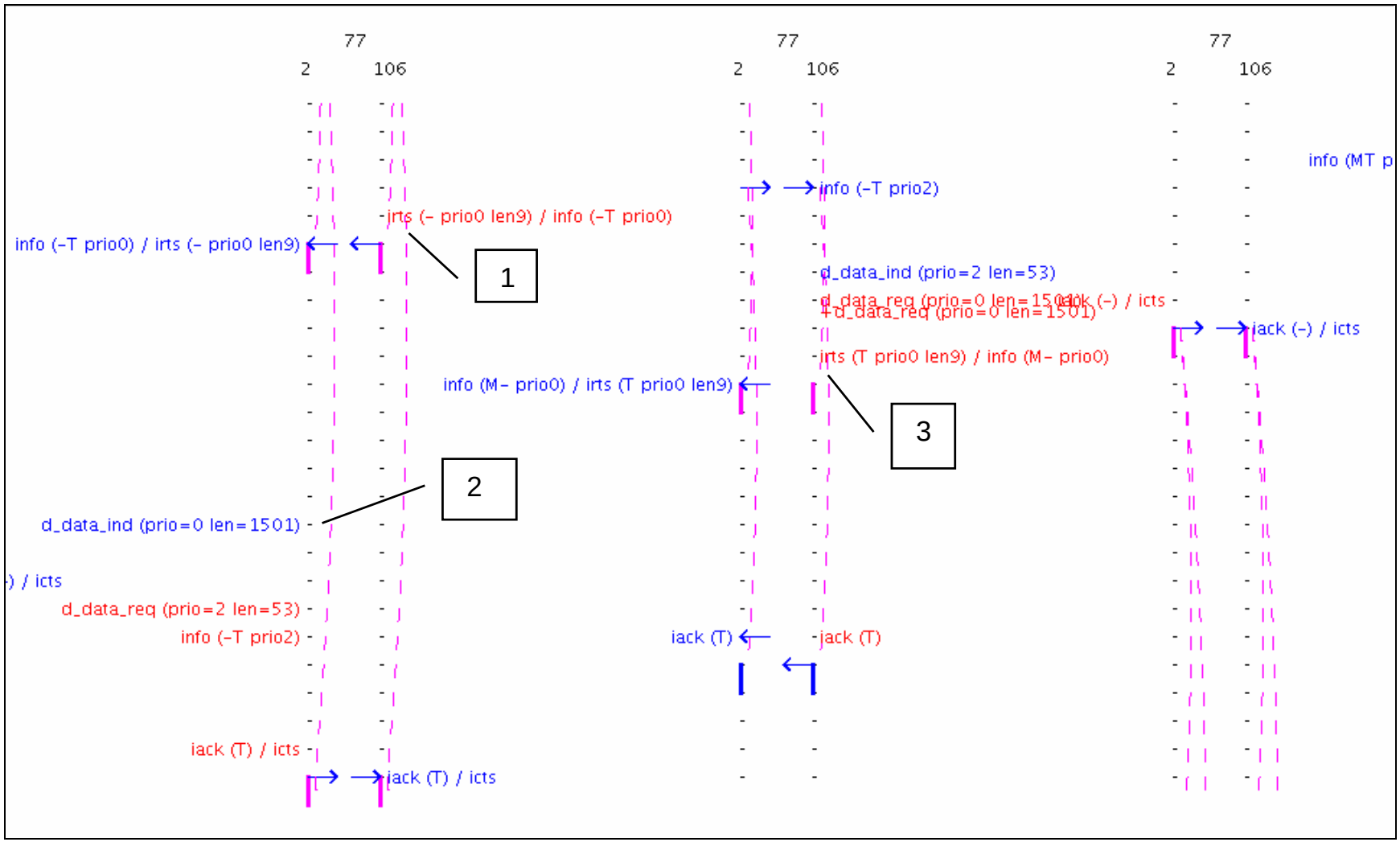

Figure 9 - Large data reassembly and delivery

Figure 10 shows a re-ordering because of priority. Two user packets are queued for delivery, the first being a priority 0 packet and the second being a priority 4 packet. However, the station piggybacks an RTS for the priority 0 packet with the INFO for the priority 4 packet. The following points can be noted in the figure.

1. A priority 0 d_data_req is received, followed by a priority 4 d_data_req.
2. The priority 4 INFO is transmitted, along with a piggybacked INFO_RTS for the priority 0 frame.

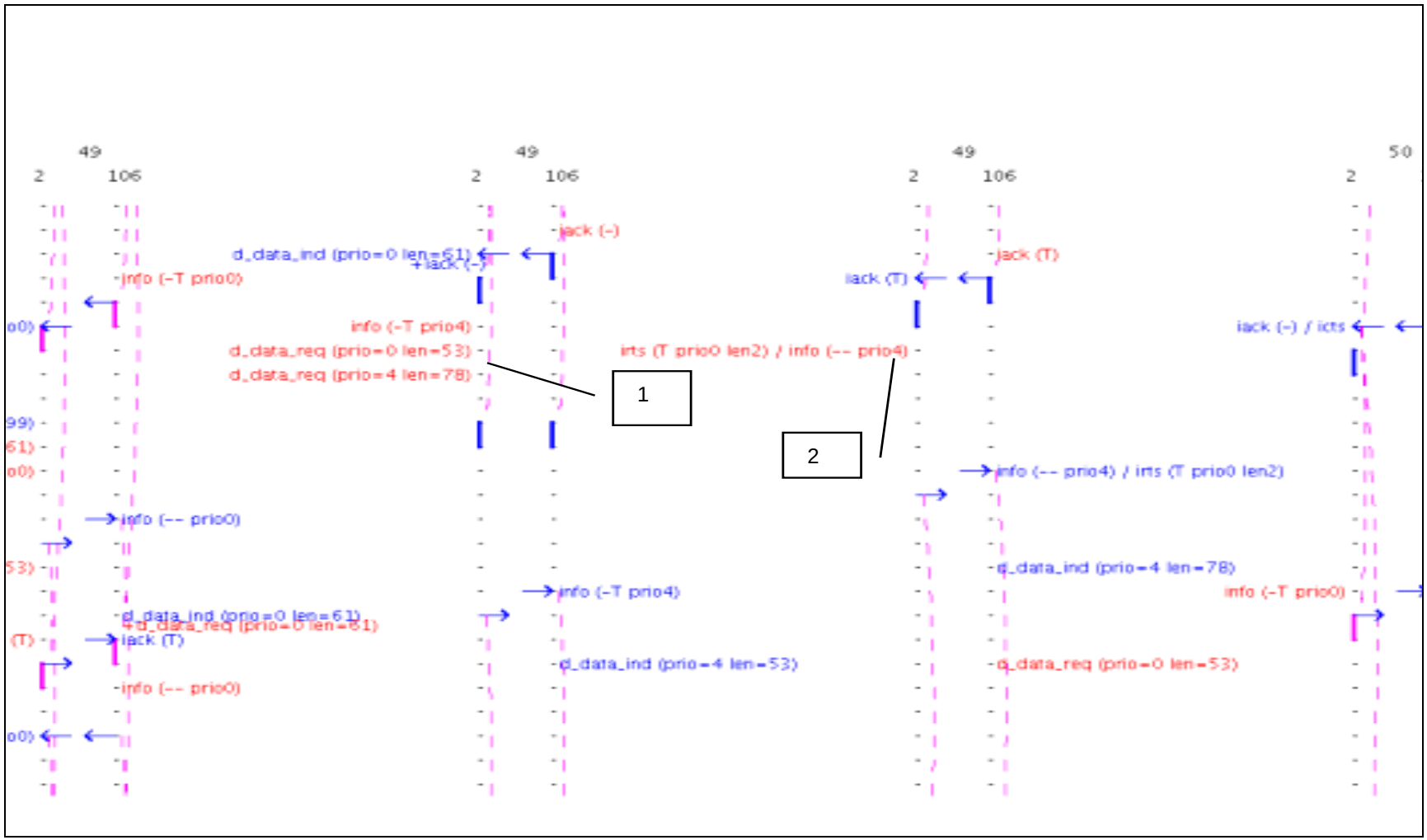

Figure 10 - Delivery in priority order

4. CONCLUSION

This validation procedure of the technical manual has led to the development of a specification that is well-validated and fully compliant with the specification noted in Appendix A. All functionality identified in the specification has been successfully demonstrated and data verified to comply with expected behavior. The recommendations were easily implemented and have helped improve the performance of the system.

A. NEW DLS TEXT

This text is the latest text that incorporates all of the proposed changes to this section. Those changes motivated by other parties will not be reflected in the list of changes in Appendix C. The initial three paragraphs are included to force Word to get the paragraph numbering correct.

1.1General Information
1.2MAC Sublayer
1.3VSS Sublayer

1.4 DLS SUBLAYER

The DLS shall support communications on a shared communications channel as described in this section.

1.4.1 Services

The DLS shall support bit-oriented simplex communications using a negotiated setup connection-orientated protocol (NSCOP) and a zero-overhead connection-orientated protocol (ZOCOP) between DLE pairs.

Note 1.- It is the intention that NSCOP is used for air/ground (A/G) communications and ZOCOP for air/air (A/A) communications.

Note 2.- Apart from the procedures for link setup and teardown, the NSCOP and ZOCOP protocols operate identically.

Note 3.- Any two stations have one DLE pair per frequency.

The DLS shall support broadcast and multicast connectionless communications.

The DLS shall provide the following services:

a) transmission of user data
b) indication that user data has been sent
c) reception of user data
d) indication that the DLS link has been established
e) indication that the DLS link has been broken

Stations supporting the communications functionality provided by the DLS shall simultaneously support at least 8 peer-to-peer links with other stations.

Stations not supporting the communications functionality provided by the DLS shall implement Section 1.4.2.2 and Section 1.4.4.7 only.

1.4.1.1 Data transfer

User data packets and LME data shall be transferred in the information fields of INFO, UDATA, and CTRL data link protocol data units (DLPDUs) which are collectively known as DATA DLPDUs. LME data shall be contained in CTRL and UCTRL DLPDUs only. The link layer shall process the largest packet size, specified in Section 1.4.3.5 of this document, without fragmenting. Larger packets shall be fragmented according to the procedures of Section 1.4.4.3.2. Only one data link user packet shall be contained in a DATA DLPDU.

Note 1. – The Frame Mode SNDCF may concatenate multiple packets, but this is presented as a single user data packet to the DLS.

Note 2. – UDATA DLPDUs consist of UINFO DLPDUs for broadcast of user data packets and UCTRL DLPDUs for broadcast of LME data.

1.4.1.2 DATA DLPDU duplicate suppression and sequencing

On a point-to-point connection, the receiving DLS sub-layer shall ensure that duplicated DATA DLPDUs are discarded and that all DATA DLPDUs which are part of a fragmented packet are delivered in the same order in which they appear in the packet.

Note.— A toggle bit is included in the DLS DLPDU format to facilitate duplicate suppression.

1.4.1.3 Error detection

The DLS ~~sub-layer~~ shall rely on the MAC layer to ensure that DLPDUs corrupted during transmission are detected and discarded.

Note.- 16-bit CRC is provided in the burst format to support this service – the MAC layer will reject corrupted packets.

1.4.1.4 Station identification

A receiving station shall accept unicast DLPDUs addressed to its current station address.

Note.— Unique source and destination addresses are included in the VDL Mode 4 DLS burst format to facilitate this service. DLPDUs addressed to the current station address are routed to the DLS by the VSS. However, non-unique addressing is possible – with the resultant communications risk minimized through the assurance that any link address is locally unique. The ATN requires a unique address and hence non-unique addressing is not for use with the ATN.

1.4.1.5 Broadcast addressing

A VDL Mode 4 station shall accept broadcast DLPDUs and accept multicast DLPDUs that have been multicast to addresses to which it is listening.

1.4.1.6 DLS Priority

The DLS shall accept an indication of priority of the DATA DLPDU as defined in Table 1-10.

Note.— The DLS service user's selection of priority affects the QoS parameters used in the transer of the DLS user packet as well as the ~~queueing~~queuing of the packet.

1.4.1.7 DLS link control DLPDUs

For the purposes of link control, the DLS shall provide the following DLS DLPDU types:

1. ACK DLPDUs, consisting of INFO_ACK and CTRL_ACK, for the purposes of acknolwedgement of DATA DLPDUs and DLS link control DLPDUs respectively
2. RTS DLPDUs, consisting of CTRL_RTS, INFO_RTS and UDATA_RTS, for the purposes of making reservations for the transfer of DATA DLPDUs
3. CTS DLPDUs, consisting of CTRL_CTS, INFO_CTS and UDATA_CTS, for the purposes of acknowledging RTS DLPDUs and providing slots for subsequent transmission of DATA DLPDUs
4. Other DLS link control DLPDUs, consisting of SZOM FRMR, FRMR_ACK, DM/DISC and DM/FRMR ~~and SZOM~~, for purposes of link initialisation, reset and maintenance.

1.4.2 DLS protocol specification

1.4.2.1 State Variables

The DLS shall maintain the state variables defined in Table 1-55 for each data link between two peer ~~stations~~DLEs.

Table 1-55. DLS state variables

State Variable	Usage
T_t	Current value of T bit (0 or 1) for transmitted DLPDUs.
T_r	Value of T bit (0 or 1) for last received DLPDU.
send array	an array storing user data packets and M-bit linked fragments queued for transmission (one per priority level)
receive array	an array storing received M-bit linked fragments queued for concatenation (one per priority level)

Note.- If the link is reset for any reason, the DLS will discard any fragments associated with a partially ~~sent~~ received packet.

1.4.2.2 Station address encoding

1.4.2.2.1 Address type

The address type field shall be encoded as defined in Table 1-55a.

Table 1-55a. Address type field encoding

Bit encoding			Description type	Bits 1 to 24
27	26	25		
0	0	0	Mobile	Non-unique identity
0	0	1	Aircraft	24-bit ICAO address
0	1	0	Ground vehicles	Nationally administered address space
0	1	1	Reserved	Future use
1	0	0	Ground station	ICAO-administered address space
1	0	1	Ground station	ICAO-delegated address space
1	1	0	Reserved	Future use

1	1	1	All stations broadcast	All stations

1.4.2.2.2 Non-unique identity address

A mobile station using the non-unique identity address shall randomly choose a 24-bit address. The non-unique identity address of all zeros shall not be used. The non-unique identity address of all ones shall be used as a destination address for broadcast applications only. All radio units located at a station shall use the same non-unique identity address.

If the station detects that another station is using the same random address, it shall stop transmitting on the current address; it shall then randomly select a new address that is not already present in its PECT. It shall use this new address in subsequent transmissions.

Note 1.— Processing of ambiguous data resulting from use of the non-unique address is an end system issue.

When using VDL Mode 4 for ATS applications, aircraft shall use the unique 24-bit ICAO address.

Note 2.— In this case bits 25, 26, and 27 of the full 27-bit address will be 1, 0, and 0 respectively, as is defined in Table 1-55a.

Note 3.—Mobiles using non-unique addresses cannot be unambiguously identified and this mode of use is itself inherently insecure. Higher level functions are required when there is a need to provide data origin authentication when non-unique addresses are used.

Note 4.—Non-unique addressing violates the subnetwork requirements of the ICAO ATN and mobiles using this addressing mode cannot implement ATN applications.

1.4.2.2.3 Aircraft specific addresses

The aircraft specific address field shall be the 24-bit ICAO aircraft address.

1.4.2.2.4 ICAO-administered ground station specific addresses

The ICAO-administered ground station specific address shall consist of a variable-length country code prefix (using the same country code assignment defined in Annex 10, Volume III, Chapter 9, Appendix 1, Table 1) and a suffix. The appropriate authority shall assign the bits in the suffix.

1.4.2.2.5 ICAO-delegated ground station specific addresses

The ICAO-delegated ground station specific address shall be determined by the organization to which the address space is delegated.

1.4.2.2.6 Broadcast and multicast addresses

The broadcast and multicast addresses shall be used only as a destination address for UDATA DLPDUs.

1.4.2.2.6.1 Broadcast and multicast address encoding

The broadcast and multicast addresses shall be encoded as in Table 1-56:

Table 1-56. Broadcast and multicast address encoding

Broadcast destination	Type field	Specific address field
All mobiles that use non-unique addresses	000	All ones
All mobiles	001	All ones
All ground stations of a particular provider	100 or 101, as necessary	Most significant bits: Variable length Provider code Remaining bits: All ones
All ground stations with ICAO-administered addresses	100	All ones
All ground stations	101	All ones
All stations	111	All ones

1.4.2.3 DLS burst formats

1.4.2.3.1 DLS burst

A DLS station shall transmit the DLS burst defined in Table 1-57 with the VSS user supplied QoS and reservation parameters.

Table 1-57. DLS burst format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
~~burst~~ message ID	5	res	~~0~~res	~~1~~res	~~1~~res	~~0~~1	~~0~~1	0	1
DLS DLPDU	6	As per Section 1.4.2.3.2							
	7								
	8								
	9								
	10								

All bits labelled res are reserved and shall be set to zero.

Note 1.— The DLS DLPDU field may continue past octet 10.

The DLS burst shall consist of one or two DLS DLPDUs combined according to the procedures of Section 1.4.4.12. A DATA DLPDU shall be the final field in the burst (and thus the burst can contain only one of these fields).

Note 2. — DLS burst will be able to combine up to two DLPDUs. DATA and UDATA must come last because they are variable length DLPDUs.

1.4.2.3.2 DLS DLPDU encoding

The DLS DLPDU field shall indicate the DLPDU type and contain, as appropriate, the priority subfield, the more bit, the toggle bit, the initialise bit and length subfield.

DATA DLPDUs shall consist of a single octet containing link control information and a variable length information field.DATA DLPDUs shall be encoded as defined in Table 1-57a.

Table 1-57a. DATA DLPDU encoding

Octet	n								n+1	.....	n+m
Bit	8	7	6	5	4	3	2	1			
CTRL	M	T	re	c/r	~~IB~~res	0	0	0	information field of length m octets		
INFO	M	T	pr_4	pr_3	pr_2	pr_1	1	0	information field of length m octets		
~~UCTRL~~Reserved	~~ucid$_4$~~X	~~ucid$_3$~~X	~~ucid$_2$~~X	~~ucid$_1$~~X	0	1	0	0	information field of length m octets		
~~UINFO~~ Reserved	0	0	0	0	1	1	0	0	information field of length m octets		
Reserved	X	X	X	1	1	1	0	0	information field of length m octets		
Reserved	X	X	1	0	1	1	0	0	information field of length m octets		
Reserved	X	1	0	0	1	1	0	0	information field of length m octets		
Reserved	1	0	0	0	1	1	0	0	information field of length m octets		

Note 1.— "X" means 0 or 1.

Note 2. — The c/r bit indicates whether the CTRL DLPDU is a command (c/r=0) or response (c/r=1). The re bit indicates whether a response is expected (re=1) or not (re=0).These subfields are defined in Section1.5.2.6.

Note 3.— ~~The command/response (c/r), response expected (re) and~~ The UCTRL ID (ucid) subfield~~s~~, ~~are~~ is defined in Table 1-71g. ~~and Section 1.5.2.6.~~

RTS and SZOM DLPDUs shall consist of two octets containing link control information ~~and~~ . RTS and SZOM DLPDUs shall be encoded as defined in Table 1-57b.

Table 1-57b. ~~RTS~~ Two-Octet DLPDUs encoding

Octet	N								n + 1							
Bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
CTRL_RTS	~~lg$_5$~~0	T	IB	0	1	0	0	1	~~pr$_4$~~ res	~~pr$_3$~~ res	~~pr$_2$~~ res	~~pr$_1$~~ res	lg_4	lg_3	lg_2	lg_1
INFO_RTS	~~lg$_5$~~0	T	0	1	1	0	0	1	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
UDATA_RTS	~~lg$_5$~~0	0	1	1	1	0	0	1	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
SZOM	neg_4	neg_3	neg_2	neg_1	1	1	0	1	seq_8	seq_7	seq_6	seq_5	seq_4	seq_3	seq_2	seq_1
Reserved	~~lg$_5$~~0	1	1	1	1	0	0	1	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
Reserved	1	X	X	0	1	0	0	1	X	X	X	X	X	X	X	X
Reserved	1	X	0	1	1	0	0	1	X	X	X	X	X	X	X	X
Reserved	1	0	1	1	1	0	0	1	X	X	X	X	X	X	X	X
Reserved	1	1	1	1	1	0	0	1	X	X	X	X	X	X	X	X

Note 3.— "X" means 0 or 1.

ACK, CTS and other DLS link control DLPDUs shall consist of one octet containing link control information. These DLPDUs shall be encoded as defined in Table 1-57c.

Table 1-57c. ~~ACK, CTS and other DLS link control~~Single octet DLPDUs encoding

Octet	n							
Bit	8	7	6	5	4	3	2	1
UDATA_CTS	0	0	1	1	1	0	1	1
INFO_ACK	0	T	0	1	0	0	0	1
INFO_CTS	0	~~T~~res	0	1	1	0	1	1
CTRL_ACK	0	T	~~IB~~es	0	0	0	0	1
CTRL_CTS	0	~~T~~res	~~IB~~res	0	1	0	1	1
Reserved	0	X	X	1	0	1	0	1
FRMR_ACK	1	0	0	1	0	0	0	1
FRMR	1	0	0	1	0	1	0	1
DM/DISC	1	0	1	1	0	1	0	1
DM/FRMR	1	1	1	1	0	1	0	1
Reserved	1	0	1	1	1	0	1	1
Reserved	1	1	0	1	0	0	0	1
Reserved	1	X	0	1	1	0	1	1
Reserved	1	X	X	0	0	0	0	1
Reserved	X	X	X	0	0	1	0	1
Reserved	1	X	X	0	1	0	1	1
Reserved	X	X	1	1	0	0	0	1
Reserved	X	X	X	X	0	0	1	1
Reserved	1	1	~~X~~0	1	0	1	0	1
Reserved	X	X	X	X	0	1	1	1
Reserved	X	1	1	1	1	0	1	1
~~SZOM~~	~~neg_4~~	~~neg_3~~	~~neg_2~~	~~neg_1~~	~~1~~	~~1~~	~~0~~	~~1~~
Reserved	X	X	X	X	1	1	1	1

Note4.— "X" means 0 or 1.

A station receiving a reserved DLPDU from a peer with which it has a link shall reset the link in accordance with the procedures of setion 1.4.4.11. A station receiving a reserved DLPDU from a peer with which is does not have a link shall either respond with a DM/DISC, DM/FRMR or simply ignore the DLPDU.

All reserved header bits (labelled "res") ~~are reserved and~~ shall be set to zero on transmit and ignored on reciept.

1.4.2.3.3 Toggle bit

The T (Toggle) bit shall be alternately set to zero and one on each successful transmission..

At the start of a communication between two stations, or when the link is reset, the toggle bit shall be initiated according to the procedures of Section 1.4.4.3.3.1 for NSCOP communication and Section 1.4.4.3.3.2 for ZOCOP communication.

Note.—The T (Toggle) bit is sufficient to provide duplicate detection and rejection.

1.4.2.3.4 More bit

The M (More) bit shall be set to zero to indicate the end of a user data packet and to one to indicate that this fragment is not the last fragment in a multi-fragment user data packet and that further fragments will be transmitted.

Note.—The M (More) bit is set to 0 if a user data packet is sent as a single fragment or on the last fragment of a fragmented user data packet and to 1 otherwise. The receiver reassembles a fragmented user data packet on reception before passing it to the user.

1.4.2.3.5 Priority subfield

The priority subfield (pr) shall indicate the priority level of the transmission as defined in Section 1.4.1.6.

1.4.2.3.6 Length subfield

The length subfield (lg) shall indicate the length of the DLS burst containing a DATA DLPDU in slots. It shall be encoded as one less than the absolute length.

Note. — The calculation of length needs to take account of the size of the reservation protocol (default is response) and the effects of bit stuffing. A length of 1 slot would be encoded as 0000 binary and the maximum length of 16 slots would be encoded as 1111 binary.

1.4.2.3.7 Initialise bit

~~When~~ Prior to sending a CTRL RTS or upon receipt of a CTRL RTS with the IB (~~iI~~nitialise~~) bB~~it) ~~is~~ set to one the ~~receiver~~ station shall initialise the T_t and T_r state variables and clear the send and receive arrays ~~whilst processing the DLPDU~~.

Note.— See Section 1.4.4.3.3.1 for the handling of INFO and CTRL DLPDUs in the process of being sent.

1.4.2.3.8 Negotiation subfield

The negotiation (neg) subfield shall indicate the link management parameters to be used for ZOCOP link control as defined in Table 1-57d:

Table 1-57d. Interpretation of negotiation subfield

Negotiation subfield	Parameters to use for ZOCOP link
0	VDL Mode 4 default parameters for version 0
1 – 15	Reserved for future use

1.4.2.3.9SZOM Sequence subfield

The SZOM sequence (seq) subfield shall indicate the SZOM sequence number.

1.4.2.3.10 UDATA DLPDU encoding

A DLS station wishing to send a UDATA shall transmit the UDATA burst defined in Table 1-57e with the VSS user supplied QoS and reservation parameters. The DLS station shall select between Tables 1-57e, 1-57f, or 1-57g based on the UDATA ID (udid) of the message as defined by Table 1-57h.

Table 1-57e. One-byte UDATA burst format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
Message ID, UDATA ID (ud1)	5	$ud1_5$	$ud1_4$	$ud1_3$	$ud1_2$	$ud1_1$	ucd	1	1
UDATA DLPDU	6	*Information field*							
	7								
	8								
	9								
	10								

Table 1-57f – Two byte UDATA burst format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
Message ID	5	1	1	1	1	0	ucd	1	1
UDATA ID (ud2)	6	$ud2_8$	$ud2_7$	$Ud2_6$	$ud2_5$	$ud2_4$	$ud2_3$	$ud2_2$	$ud2_1$
UDATA DLPDU	7	*Information field*							
	8								
	9								
	10								
	11								

Table 1-57g – Three-byte UDATA burst format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
Message ID	5	1	1	1	1	1	ucd	1	1
UDATA ID (ud3)	6	$ud3_{16}$	$ud3_{15}$	$Ud3_{14}$	$ud3_{13}$	$ud3_{12}$	$ud3_{11}$	$ud3_{10}$	$ud3_9$

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
	7	$ud3_8$	$ud3_7$	$Ud3_6$	$ud3_5$	$ud3_4$	$ud3_3$	$ud3_2$	$ud3_1$
UDATA DLPDU	8	*Information field*							
	9								
	10								
	11								
	12								

Note 1.— The UDATA DLPDU field may be up to ND4 octets long.~~continue past octet 12.~~

A DLS station sending a UCTRL shall set ucd to 0 and encode the appropriate ud1, ud2 or ud3 fields to the value of ucid per Table 1-57h. A DLS station sending a UINFO shall set ucd to 1 and encode the appropriate ud1, ud2 or ud3 field to the value of uinf per Table 1-57i.

Table 1-57h. Encoding of the UDATA ID (udid) value

UDATA ID (udid)	Encoded by
0-29	Table 1-57e, ud1 = udid
30-285	Table 1-57f, ud2 = udid – 30
286-65821	Table 1-57g, ud3 = udid – 286

Note 2.— The UCTRL ID (ucid) subfield, is defined in Section 1.5.2.6.

Table 1-57i. UINFO ID (uinf) assignments

UINFO ID (uinf)	Assignment
0-60000	Reserved for future use
60001-65821	Messages reserved for transmission by ground station only and defined by ground station operator

1.4.2.3.12 Compressed combined RTS/INFO DLPDU encoding (type 1)

A DLS station wishing to send a combined RTS and INFO DLPDU according to the procedures of Section 1.4.4.12 when the priority of the RTS is different to that of the INFO packet shall transmit the compressed combined RTS/INFO (type 1) burst defined in Table 1-57j~~i~~ with the VSS user supplied QoS and reservation parameters. The T bit for the RTS shall be the inverse of the INFO T bit.

Table 1-57ji. Compressed combined RTS/INFO (type 1) burst format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
Message ID	5	1	0	0	1	0	1	0	1
RTS priority and length	6	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
INFO priority, M and T	7	M	T	pr_4	pr_3	pr_2	pr_1	res	res
Compressed RTS/INFO (type 1) DLPDU	8	*Information field*							
	9								
	10								
	11								
	12								

Note.— The compressed combined RTS/INFO (type 1) DLPDU field may continue past octet 12.

1.4.2.3.13 Compressed combined RTS/INFO DLPDU encoding (type 2)

A DLS station wishing to send a combined RTS and INFO DLPDU according to the procedures of Section 1.4.4.12 when the priority of the RTS is the same as that of the INFO packet shall transmit the compressed combined RTS/INFO (type 2) burst defined in Table 1-57kj with the VSS user supplied QoS and reservation parameters. The T bit for the RTS shall be the inverse of the INFO T bit and the priority the same as the INFO priority.

Table 1-57kj. Compressed combined RTS/INFO (type 2) burst format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
Message ID, INFO M/T bits	5	M	T	1	0	0	1	0	1
RTS/INFO priority and RTS length	6	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
Compresssed RTS/INFO (type 2) DLPDU	7	*Information field*							
	8								
	9								
	10								
	11								

Note 1.— The compressed combined RTS/INFO (type 1) DLPDU field may continue past octet 11.

Note 2.- This burst format is intended to be used to link M-bit sequences where each fragment is part of the same user data packet and hence has the same priority.

1.4.3 DLS system parameters

The parameters needed by the DLS sublayer shall be as listed in Table 1-58.

DLS parameters for NSCOP communications shall be determined during the exchange of CTRL DLPDUs, if the default values are not to be used.

DLS parameters for ZOCOP communications shall be determined by the exchange of the negotiation subfield within the SZOM DLPDU.

Table 1-58. Data link service system parameters

Symbol	Parameter name	Minimum	Maximum	Default	Increment
TD1	ZOCOP link transmit reset timer	5 s	600 s	60 s	1 s
TD2	ZOCOP link receive reset timer	10 s	1200 s	90 s	1 s
ND1	Maximum number of octets in any user data packet	143 octets	2063 octets	1511 octets	1 octet
ND2	Maximum length of short DLS transmission	2 octets	~~2063~~ 496 octets	86 octets	1 octet
ND3	Maximum length of fragment	1 slot	~~32~~ 16 slots	5 slots	1 slot
ND4	Maximum length of UDATA burst	23 octets	496 octets	271 octets	1 octet

Note 1.- The value of ND3 should be chosen such that the length of each DLS transmission containing the fragment is less than the maximum length of the DLS transmission defined by ND1.

Note 2.-- Keep-alives have been eliminated from the protocol as peer presence is performed with sync bursts and ground stations transmit an alert on startup per Section 1.5.5.1.3.1 or the ground system transmits a broadcast connection handoff.

1.4.3.1 Parameter TD1 (ZOCOP transmit reset timer)

For a mobile station maintaining a ZOCOP link with another mobile station, Timer TD1 shall be reset when a DLPDU is sent to the peer. Timer TD1 shall not be cancelled. If Timer TD1 expires, then T_t shall be set to 0 and the send channel array shall be cleared.

Note.-- See Section 1.4.4.14.2 for an example of when the response reservation type is not used.

1.4.3.2 Parameter TD2 (ZOCOP receive reset timer)

For a mobile station maintaining a ZOCOP link with another mobile station, Timer TD2 shall be reset when a DLPDU is received from the peer. Timer TD2 shall not be cancelled. If Timer TD2 expires, the link shall be considered to be terminated.

1.4.3.3 Parameter ND1 (maximum number of octets of any user data packet)

The parameter ND1 shall define the maximum number of octets in any user data packet that a DLS may accept from the data link user or from a peer station. A station receiving a user data packet from a peer station greater in length than ND1 shall discard the packet and reset the link in accordance with the procedures of Section 1.4.4.11. A station receiving a user data packet from a data link user greater in length than ND1 shall discard the packet.

Note.- The maximum size of a user data packet for broadcast is set by parameter ND3.

1.4.3.4 Parameter ND2 (maximum length of short DLS transmission)

The parameter ND2 shall define the maximum size in octets of a short DLS transmission, including flags and reservation data, that shall be sent using the short transmission procedures defined in Section 1.4.4.5.

A burst occupying x slots shall contain up to 23 + (((x-1)*~~31~~ 63)/2) octets of data ~~if x is odd or 24 23.5 + (((x-1)*31 63)/2) octets of data if x is even~~ including ~~flags and~~ reservation data, CRC, and flags.

Note.— A slot can contain 32 octets of data. The last slot in a sequence should only contain 24 octets to allow for propagation guard time. Allowing an average octet/2 slots for bit stuffing, one slot could contain 23 octets of data including flags and reservation blocks. Two slots could contain 54 octets. Three slots could contain 86 octets, etc.

1.4.3.5 Parameter ND3 (maximum length of fragment)

The parameter ND3 shall define the maximum size in slots of a DLS burst.

~~Note.- To be used to control fragmentation and also applies to the maximum size of a burst containing a UDATA DLPDU.~~

1.4.3.6 Parameter ND4 (maximum length of a UDATA burst)

The parameter ND4 shall define the maximum size in octets of a UDATA burst including reservation data, CRC, and flags.

1.4.4 DLS procedures

Note.- Either station may send user data packets at any time and are considered peers with respect to management of the link.

1.4.4.1 Broadcast

Only UDATA DLPDUs shall be broadcast.

1.4.4.2 Setting of re-transmission parameter

For all DLS bursts containing CTRL, INFO, CTRL_RTS ~~and,~~ INFO_RTS and UCTRL_RTS DLPDUs, the quality of service parameters Q5min, Q5max, Q5mult, Q5exp and Q5num shall be set as defined in Table 1-58a.

Note.— Retransmission of DLS DLPDUs ~~is~~ may be handled in the VSS or DLS.

Table 1-58a. Re-transmission parameters

Symbol	Parameter name		Default
Q5min	VSS retransmission parameters	Minimum	1.0s
Q5max		Maximum	15s
Q5mult		Multiplier	1.45
Q5exp		Exponent	1.7
Q5num		number of attempts	4
Q5wait		maximum time to wait for a reply	20s

1.4.4.3 Selection of user data packet for transmission

1.4.4.3.1 User data packet priority

A sending station shall maintain a prioritised queue of user data packets for transmission.

When determining which user data packet to transmit, the highest priority user data packet shall be sent first.

The DLS DLPDUs CTRL and CTRL_RTS shall be classified as network management messages and given the highest priority.

The DLS DLPDUs INFO_RTS and UDATA_RTS shall be assigned the same priority as the DATA DLPDU with which they are associated.

Note.- All other DLS DLPDU types will be sent in pre-reserved slots(FRMR, DM/FRMR and DM/DISC) or take the priority of the DATA packet to which they are combined (SZOM) and hence priority is not an issue.

1.4.4.3.2 User data packet fragmentation

1.4.4.3.2.1 Determination of single or multiple fragment transmission~~number of segments~~

If the length of the DLS burst containing a CTRL or INFO DLPDU is greater than ~~ND3~~ ND2 ~~slots~~octets, the sending station shall fragment the user data packet and format it according to the procedures of Section 1.4.4.3.2.3. Otherwise the user data packet shall be sent as a single fragment formatted according to the procedures of Section 1.4.4.3.2.2.

The fragmentation of a user data packet shall take account of whether the station is combining a CTRL or INFO DLPDU with another DLS DLPDU in accordance with the procedures of Section 1.4.4.12.3.

1.4.4.3.2.2 Single fragment user data packet transmission

A single fragment user data packet shall be transferred as a CTRL or INFO DLPDU.

a) The M bit shall be set to zero.
b) For an INFO DLPDU, the pr bits shall indicate the priority of the DLPDU.

1.4.4.3.2.3 Multiple fragment user data packet transmission

A multiple fragment user data packet shall be transferred as a series of CTRL or INFO DLPDUs.

a) The M bit shall be set to 1 for all fragments except the last fragment.
b) The M bit shall be set to 0 for the last fragment.
c) For INFO DLPDUs, the pr bits shall indicate the priority of the DLPDU.

1.4.4.3.3 Setting of T bit

1.4.4.3.3.1 T bit initialisation for NSCOP communication

When there is no current established connection link (or link in the process of being established) between a mobile station DLE and a ground station DLE and the LME of either station requests the transmission of a CTRL user data packet, the sending station DLE shall fragment the user data packet in accordance with the procedures of 1.4.4.3.2 and send the fragments CTRL DLPDU using either the short transmission procedures (see Section) or the long transmission procedures (see Section 1.4.4.6). In the first fragmenttransmission, it shall send (either a CTRL DLPDU (short transmission procedures) or a CTRL_RTS, (long transmission procedures) and it shall set the IB bit to 1, the T bit to 0 and the state variable T_t to 0 follow the procedures of Section 1.4.2.3.7.

On receipt of a CTRL_RTS DLPDU (long transmission procedures), the receiving station shall send a CTRL_CTS with IB = 1 in accordance with the procedures of Section 1.4.4.6.3.

On receipt of a CTRL_CTS DLPDU with IB = 1 (long transmission procedures), the sending station shall send an INFO DLPDU with IB = 1 in accordance with the procedures of Section 1.4.4.6.4.

On receipt of a CTRL or CTRL_RTS DLPDU with IB = 1, the receiving station DLE shall set its own state variable T_t to 0, clear its receive arrays, and consider the link established for receipt of further DATA DLPDUs. The receiving station shall set IB = 1 in the CTRL_ACK response to the CTRL DLPDU.follow the procedures of Section 1.4.2.3.7. The sender and receiver shall consider the link initialised. The receiver shall immediately terminate any INFO transfers in progress. Any partially received CTRL DLPDUs shall be discarded. If any CTRL fragments had already been acknowledged, then the remainder of the CTRL DLPDU shall be abandoned; however, if no CTRL_ACK had been received for a CTRL DLPDU, then its transfer shall continue unaffected.

Note 1.— The DLE to which the mobile sent the CTRL_CMD may not be the DLE which responds with the CTRL_RSP. The IB bit in the CTRL_RSP may either be 0 or 1 depending on whether the responding DLE received the CTRL_CMD.

Note 2.— INFO DLPDUs and partially sent/received CTRL DLPDUs are abandoned mid-transfer on the presumption that the peer station restarted (there is no other legitimate reason for the IB=1); however, CTRL DLPDUs for which the first fragment had not been acknowledged may be in a CTRL collision and are thus not affected.

~~On receipt of the CTRL_ACK with T = 0 and IB = 1, produced in response to a CTRL DLPDU with IB = 1, the sending station shall set its state variable T_t to 1 and consider the link established for transmission of further DATA DLPDUs.~~

~~*Note. At this stage the state variables T_t for the sending station and T_r for the receiving station are initialised. The receiving station must separately initialise the state variables for data transfer in the opposite direction.*~~

The DLE shall consider the link connected upon direction from the LME. INFO, INFO_RTS, INFO_ACK, and INFO_CTS DLPDUs shall only be sent on links that are connected. Although a DLE may receive INFO DLPDUs (and generate INFO ACKs), it shall not transmit INFO DLPDUs until it receives a CTRL_ACK to its CTRL (M=0).

Note 3.— If the receiving LME indicates to the receiving DLE that the link is established after the receiving DLE's transmission of the CTRL_ACK, then the receiving DLE will not respond with a DM/FRMR to the INFO_RTS or INFO that it receives.

On receipt of a CTRL_RTS~~, CTRL_CTS~~or a~~, CTRL~~ or CTRL_ACK ~~DLPDU~~ in a DLS burst addressed to it for which IB is equal to ~~=~~ 1 and for which the T bit is equal to 1 a station shall ~~reset the link in accordance with the procedures of Section 1.4.4.11~~send a DM/FRMR. If a DLE with uninitialised state variables receives a CTRL_RTS DLPDU with IB equal to 0, then it shall respond with a DM/FRMR.

If a DLE receives an SZOM from a peer DLE with which it will only communicate using the NSCOP, it shall respond with a DM/FRMR.

1.4.4.3.3.2 T bit initialisation for ZOCOP communication

A mobile sending station (the "sending station") wishing to send data to a mobile station (the "receiving station") for which it does not currently have a link, shall send a DLS burst containing a Start Zero Overhead Mode (SZOM) DLPDU and the first INFO (short transmission procedures) or INFO_RTS (long transmission procedures) DLPDU to the receiving station using respectively the short transmission procedures (see Section 1.4.4.5) or the long transmission procedures (see Section 1.4.4.6). It shall set the negotiation subfield to the highest value that is supported by the DLS in the SZOM DLPDU, the sequence subfield to a value that it has not transmitted to the receiving station within the previous TD2 seconds, the T bit to 0 in the INFO DLPDU, and initialise its sending and receiving state variables.~~the state variable T_t to 0.~~

On receipt of an unsolicited SZOM DLPDU with a sequence subfield different from the most recently received SZOM from the sending station~~ combined with an INFO DLPDU (short transmission procedures) or INFO_RTS DLPDU (long transmission procedures)~~, the receiving station shall initialise its sending and receiving state variables ~~set its own state variable T_r to 0, clear its receive arrays~~ and consider the link established for receipt of further DLPDUs from the sending station. The receiving station shall send a SZOM DLPDU combined with an INFO_ACK (short transmission procedures) or an INFO_CTS (long transmission procedures) ~~-~~in the slot reserved for the transmission setting T=0. In the SZOM DLPDU, the receiving station shall set the negotiation field to the highest value that is supported by the DLS and the sequence subfield to 0. The receiving station shall not transmit any INFO or INFO_RTS DLPDUs to the

sending station prior to sending the SZOM/INFO_ACK or SZOM/INFO_CTS reserved transmission.

~~On receipt of the INFO_ACK (short transmission procedures) or INFO_CTS (long transmission procedures) combined with an SZOM DLPDU, the sending station shall set its state variable T_t to 1 and consider the link established for transmission of further DATA DLPDUs.~~

For both sending and receiving stations, link parameters shall be selected which correspond to the lower value of the negotiation subfields contained in the SZOM DLPDU sent by the sending station and in the SZOM DLPDU sent by the receiving station.

~~*Note. At this stage the state variables T_t for the sending station and T_r for the receiving station are initialised. The receiving station must separately initialise the state variables for data transfer in the opposite direction*~~.

A station that transmitted an SZOM to a peer shall retransmit its initial transmission in response to any DLPDU other than an SZOM, DM/DISC, DM/FRMR, or general failure until it receives an SZOM. After Q5num attempts, it shall report a failure to the DLE user.

1.4.4.3.3.3 Transfer after initialisation

When the T bit has been initialised, the sending station shall set the T bit for transmitted DLPDUs to the value of T_t.

1.4.4.4 Selection of transmission procedures

After a packet has been selected for transmission according to the procedures of Section 1.4.4.3 the sending station shall calculate the total length in octets of the DLS burst required to contain the DLPDU queued for transmission using the short transmission procedures defined in Section 1.4.4.6. The total length shall include the length of any reservation fields contained within the DLS burst, together with any flags. The calculation of the length of the DLS burst shall take account of whether the station will combine a DATA DLPDU with another DLS DLPDU in accordance with the procedures of Section 1.4.4.12.3. If the total length is less than or equal to ND2, then the station shall use short transmission procedures (Section 1.4.4.6) to transmit the queued data. Otherwise, the station shall use the long transmission procedures (Section 1.4.4.7). The M bit shall be set to 0 for a short transmission.

1.4.4.4.1Recommendation

If there are other DLPDUs queued for transmission, then the station should also include an RTS per Section 1.4.4.12.3.

1.4.4.5 Short transmission procedures

1.4.4.5.1 Transmission of DATA DLPDU

After the selection of a short transmission procedure, the sending station shall transmit a DLS burst containing the DATA DLPDU queued for transmission with QoS parameters as defined in Table 1-60 using the random access procedures. For CTRL and INFO DLPDUs, the T bit shall be set to T_t.

A burst containing a CTRL or INFO DLPDU shall contain a unicast request reservation field for the acknowledgement with the parameters in Table 1-60.

Note 1.— The priority field in the unicast request reservation field is set equal to the priority setting in the INFO DLPDU as specified in Table 1-60.

Note 2.— If the responder VSS sublayer has not received a response from the VSS user in the scheduled reservation it can send a general failure (see Section 1.3.20) with error type 7E hex or FE hex and a unicast request reservation (with itself as the transmitter) according to the procedures of Section 1.3.19.2.

1.4.4.5.2 Acknowledgement of DATA DLPDU

1.4.4.5.2.1 ~~Valid~~ Established link with sender

If a station receiving a CTRL or INFO DLPDU has an ~~valid~~ established link ~~to~~ with the sender it shall transmit a DLS burst containing an ACK DLPDU in the slot reserved by the unicast request reservation field contained in the ~~data~~ DATA DLPDU transmission:

a) A CTRL_ACK DLPDU shall be sent in response to a CTRL DLPDU and an INFO_ACK DLPDU sent in response to an INFO DLPDU.
b) The T bit shall be set to the value of the T bit in the received DATA DLPDU.

Note.— See Section 1.4.4.12 for an example of when the response reservation type is not used.

1.4.4.5.3 Non-receipt of acknowledgement

If an acknowledgement to a CTRL or INFO DLPDU is not received from the receiving station, the sending station shall retransmit the DLS burst containing the CTRL or INFO DLPDU and a unicast request reservation field according to the procedures of Section 1.3.21.

1.4.4.5.4 Action on receipt of a UDATA DLPDU

A station receiving a UDATA DLPDU shall forward the contents of the information field to the DLS user and take no further action.

Table 1-60. Short transmission INFO DLPDU parameters

Symbol	Parameter name	Default
V32	Minimum response delay	(54 msec) * M1 / 60 slots
V33	Maximum response delay	(5 sec) * M1 / 60 slots
V34	Source/destination control	0
V35	Broadcast control	0
V36	Length of reserved block	1 slot
Q1	Priority	Priority of INFO DLPDU
Q2a	Slot selection range constraint for level 1	150 NMI
Q2b	Slot selection range constraint for level 2	150 NMI
Q2c	Slot selection range constraint for level 3	0 NMI
Q2d	Slot selection range constraint for level 4	300 NMI
Q3	Replace queued data	FALSE
Q4	Number of available slots	3

1.4.4.6 Long transmission procedures

1.4.4.6.1 Transmission of request to send

After the selection of a long transmission procedure, the sending station shall transmit a DLS burst containing an RTS DLPDU to the receiving station in the transmit queue with QoS parameters as defined in Table 1-61. When using the long transmission procedure:

a) A station shall send a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU if a CTRL, INFO or UDATA DLPDU respectively is to be transmitted.
b) The pr subfield shall indicate the priority of the ~~DATA~~ INFO_RTS and UDATA_RTS DLPDUs to be transmitted (see Section 1.4.1.6).
c) The length subfield shall indicate the length of the DLS burst required to contain the DATA DLPDU (see Section 1.4.2.3.6).
d) For CTRL_RTS and INFO_RTS DLPDUs, the T bit shall be set to T_t.

Each burst shall contain a unicast request reservation field with the parameters set as defined in Table 1-61.

Note 1.- The ground may use the priority subfield to manage the link resource during congestion.

Note 2.- Transfer of broadcast data using the long transmission procedures involves directing the UDATA_RTS at a specific station, receiving a set of slots from that station via the UDATA_CTS and then broadcasting the UDATA in the reserved slots.

Note 3.- The priority field in the unicast request reservation field is set equal to the priority setting in the INFO DLPDU as specified in Table 1-61.

1.4.4.6.2 No response to RTS

Note.- If a response is not received to the RTS DLPDU, the station retransmits the DLS burst containing the RTS DLPDU and the unicast request according to the procedures of Section ***Error! Reference source not found.****.*

Table 1-61. Long transmission RTS DLPDU parameters

Symbol	Parameter name	Default
V32	Minimum response delay	(54 msec) * M1 / 60 slots
V33	Maximum response delay	(5 sec)* M1 / 60 slots
V34	Source/destination control	0
V35	Broadcast control	0
V36	Length of reserved block	1 slot
Q1	Priority	Priority of RTS
Q2a	Slot selection range constraint for level 1	150 nmi
Q2b	Slot selection range constraint for level 2	150 nmi
Q2c	Slot selection range constraint for level 3	0 nmi
Q2d	Slot selection range constraint for level 4	300 nmi
Q3	Replace queued data	FALSE
Q4	Number of available slots	3

1.4.4.6.3 Response to RTS

1.4.4.6.3.1 Response if a DATA DLPDU has not previously been received

If the responder has an ~~valid~~ established link ~~to~~ with the sender and the received DLPDU is ~~an~~ a UDATA_RTS ~~UDATA~~ or if the T bit within the CTRL_RTS or INFO_RTS DLPDU is not equal to T_r, then the receiving station shall transmit a CTS DLPDU in a DLS burst in the slot reserved by the RTS DLPDU.

~~a)~~ A CTRL_CTS, INFO_CTS or UDATA_CTS DLPDU shall be sent in response to a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU respectively
~~b) The T bit shall be set to T bit of the RTS DLPDU to which the CTS is a response~~

For CTRL_CTS and INFO_CTS DLPDUs, the burst shall contain an information transfer request reservation field and be transmitted with the parameters in Table 1-63, indicating the number of slots reserved for transfer of the DATA DLPDU.

For a UDATA_CTS DLPDU, the burst shall contain a unicast request reservation field and be transmitted with the parameters in Table 1-61, indicating the number of slots reserved for transfer of the DATA DLPDU.

1.4.4.6.3.2 Response if a DATA DLPDU has previously been received

If the responder has an ~~valid~~ established link ~~to~~ with the sender and if the T bit within the CTRL_RTS or INFO_RTS DLPDU is equal to T_r, then the receiving station shall transmit an ACK DLPDU in the slot reserved by the RTS.

a) A CTRL_ACK or INFO_ACK DLPDU shall be sent in response to a CTRL_RTS or INFO_RTS DLPDU respectively
b) The T bit shall be set to the value of the T bit in the received DATA DLPDU.

The DLS burst containing the ACK DLPDU shall contain a response reservation type except as determined by the procedures of Section 1.4.4.12.

1.4.4.6.3.3 Channel too busy

If the channel is too busy (either the receiving station cannot find a sufficiently large series of contiguous slots or the priority is too low for the channel utilization), then the receiving station shall transmit either a general confirm including a unicast reservation with V34 = 1 indicating when the responder will transmit an information transfer request in response to the RTS or a general failure (see Section 1.3.20) with error type = 01 hex.

Note .— If the responder sends a general failure (see Section 1.3.20) the sender can retransmit the RTS after the timeout defined by the back-off delay or in the slot reserved by the destination.

Table 1-62. General response to RTS parameters

Symbol	Parameter name	Default
Q1	Priority	Priority of RTS
Q2a	Slot selection range constraint for level 1	150 nmi
Q2b	Slot selection range constraint for level 2	150 nmi
Q2c	Slot selection range constraint for level 3	0 nmi
Q2d	Slot selection range constraint for level 4	300 nmi
Q3	Replace queued data	FALSE
Q4	Number of available slots	3

Table 1-63. CTS DLPDU parameters

Symbol	Parameter name	Default

Symbol	Parameter name	Default
V42	Length of information transfer	Sufficient to included requested INFO DLPDUs
V43	Minimum information transfer delay	(54 msec) * M1 / 60 slots
V44	Maximum information transfer delay	(5 sec) * M1 / 60 slots
V45	Minimum response delay	(54 msec) * M1 / 60 slots
V46	Maximum response delay	(5sec) * M1 / 60 slots
Q1	Priority	Priority of RTS
Q2a	Slot selection range constraint for level 1	150 nmi
Q2b	Slot selection range constraint for level 2	150 nmi
Q2c	Slot selection range constraint for level 3	0 nmi
Q2d	Slot selection range constraint for level 4	300 nmi
Q3	Replace queued data	FALSE
Q4	Number of available slots	3

1.4.4.6.4 Response to CTS

1.4.4.6.4.1 Transmission of DATA DLPDU

On receipt of a CTRL_CTS or INFO_CTS DLPDU in a DLS burst addressed to it ~~for which the T bit is equal to T_t~~ and with an information transfer request reservation field a station shall transmit the requested DATA DLPDU in the allocated reservation with the T bit set to T_t. The DLS burst containing the DATA DLPDU shall contain a response reservation type.

~~On receipt of a CTRL_CTS or INFO_CTS DLPDU in a DLS burst addressed to it for which the T bit is not equal to T_t shall reset the link in accordance with the procedures of Section 1.4.4.11.~~

On receipt of a UDATA_CTS DLPDU in a DLS burst addressed to it with a unicast request reservation field a station shall transmit the requested UDATA DLPDU in the allocated reservation.

1.4.4.6.4.2 Response if no information to transmit

If upon receipt of a CTS the station has nothing to transmit (e.g., after a reset), it shall ~~not~~ transmit one the following:

a) an FRMR if the link is connected;
b) a DM/DISC if the link is disconnected;
c) a DM/FRMR if the link is in the process of connecting.

1.4.4.6.4.3 Recommendation

If the station has not transmitted an INFO DLPDU and a higher priority user data packet arrived after the RTS had been transmitted, the station should transmit as much of the highest priority packets as will fit in the current reservation with the same value for T as contained in the RTS.

1.4.4.6.5 Acknowledging the data

1.4.4.6.5.1 DATA DLPDU received

A receiving station which transmitted a CTRL_CTS or INFO_CTS DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has received the DATA DLPDU ~~with the same setting of T bit as is contained in the CTS~~with a T bit not equal to T_r, shall ~~transmit in the slot reserved for an acknowledgement an ACK DLPDU in a DLS burst~~follow the procedures of 1.4.4.5.2.1.

~~a) A CTRL_ACK or INFO_ACK DLPDU shall be sent in response to a CTRL or INFO DLPDU respectively;~~
~~b) The T bit shall be set to the value of the T bit in the received DATA DLPDU.~~

~~The DLS burst containing the ACK DLPDU shall contain a response reservation type except as determined by the procedures of Sections 1.4.4.12.~~

1.4.4.6.5.2 Response if DATA DLPDU not received

A receiving station which transmitted a CTRL_CTS or~~,~~ INFO_CTS ~~or UDATA_CTS~~ DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has not received the CTRL or, INFO ~~or UDATA~~ DLPDU with a T bit not equal to T_r~~with the same setting of T bit as is contained in the CTS~~, shall transmit in the slot reserved for an acknowledgement an ACK DLPDU in a DLS burst.

a) A CTRL_ACK or INFO_ACK DLPDU shall be sent in response to a CTRL or INFO DLPDU respectively.
b) The T bit shall be set to the inverse of the value of the T bit in the last ~~transmitted CTS~~received RTS DLPDU.

Note.- The use of the T bit not equal to ~~the last transmitted CTS~~T_r indicates a "negative acknowledgement (NACK)"

The DLS burst containing the ACK DLPDU shall contain a response reservation type.

1.4.4.7 DLS not supported

If the responder to a CTRL, CTRL_RTS, INFO, INFO_RTS or SZOM DLPDU does not support the DLS, then it shall transmit a general failure (see Section 1.3.20) with an error type of 80 hex in the slot reserved by the unicast request reservation field contained in the data DLPDU transmission.

Note.-- The response upon receipt of a general failure, described in Section 1.3.20.1, is to not transmit another DLS burst to the sending station for the duration of the backoff timer.

1.4.4.8 No link with sender

If the responder to any ~~CTRL or~~ DLPDU other than a CTRL_RTS DLPDU with IB ~~not~~ equal to 1 or an ~~INFO or INFO_RTS DLPDU which is not combined with a~~ SZOM DLPDU DLPDU (which may be combined with an INFO or INFO_RTS DLPDU) ~~does not have~~neither has nor is attempting to establish a link with the sender, the responder shall send a DLS burst containing a DM/DISC DLPDU in the slot reserved by the unicast or information transfer request reservation field contained in the data DLPDU transmission. If the responder is trying to establish an NSCOP or ZOCOP link with the sender, then it shall respond with a DM/FRMR to any DLPDU other than a CTRL-related DLPDU or SZOM DLPDU for NSCOP and ZOCOP respectively.

Note.— Per Section 1.4.4.3.3.1, an NSCOP link is considered established when a DLE sends or receives the last fragment of a CTRL_RSP. Consequently, a DLE may be retransmitting the last fragment of a CTRL_RSP while it is acknowledging INFO DLPDUs.

1.4.4.9 User data packet reception

1.4.4.9.1 Receipt and forwarding of received DATA DLPDUs

When a CTRL or INFO DLPDU is received without errors from another station, the value of the T bit shall be inspected and recorded.

If this is:

a) ~~a CTRL DLPDU with IB = 1 or~~ an INFO DLPDU with the T bit set to zero combined with a SZOM DLPDU, or
b) the value of the T bit is not equal to T_r,

then the user data packet or user data packet fragment shall be accepted and T_r shall be set to the value of the T bit in the received INFO or CTRL DLPDU. Otherwise, the received user data packet or user data packet fragment shall be discarded as a duplicate.

When a UDATA DLPDU is received without errors from another station, it shall be passed to the service user as a single incoming user data packet. Otherwise it shall be discarded.

1.4.4.9.2 Concatenation of multiple fragment user data packets

If any preceding user data packet fragments have been received with, in the case of an INFO DLPDU, the same value of pr subfield and with the M bit set to one, then the user data part of the received DATA DLPDU shall be concatenated to the end of the user data packet fragments.

If the M bit is set to zero on the received DATA DLPDU, then the user data part of the received DATA DLPDU, including any user data packet fragments received earlier and with which it has been concatenated, shall be passed to the service user as a single incoming user data packet. ~~Otherwise, the received user data shall be retained awaiting the arrival of the remaining parts of the multiple fragment user data packet.~~

1.4.4.9.3 Unacknowledged DLPDUs

UDATA, DM/DISC, DM/FRMR and all ACK DLPDUs shall be unacknowledged.

1.4.4.10 Receipt of ACK DLPDU

1.4.4.10.1 Receipt of an expected ACK DLPDU

When an ACK DLPDU is received without errors from another station and there is an outstanding DATA DLPDU to be acknowledged, the value of the T bit shall be inspected and the following operations performed.

If T ~~=~~ is equal to T_t, then the DATA DLPDU shall be assumed successfully received and the value of T_t shall be set to the inverse of the current value of T_t.

If ~~T is not equal to T_t or if~~ the ACK DLPDU is not received by the expected reserved slot, then the sending station shall re-send the DATA DLPDU using the short or long transmission procedures as determined by the procedures of Section 1.4.4.4.

Note 1.-- Retransmission is based on the expected receipt time and not on the receipt of a NACK.

When a DATA DLPDU has been successfully received, the highest priority fragment (either the next fragment of the current user data packet or the first fragment/complete DLPDU of the next user data packet) in the send queue, if any, shall be selected for transmission using the procedures of Section 1.4.4.3.

Note 2.- The selection of highest priority allows the station to pre-empt eg a lower priority transfer of M-bit linked fragments with a higher priority user data packet or set of fragments.

1.4.4.10.2 Receipt of an unexpected ACK DLPDU

When an ACK DLPDU is received without errors from another station and there is no outstanding DATA DLPDU to be acknowledged, the value of the T bit shall be inspected and the following operations performed. If T is equal to T_t, then the link shall be reset as per section 1.4.4.11. If T is not equal to T_t, then the ACK shall be ignored.

1.4.4.11 Link reset

1.4.4.11.1 Link reset during link setup

The sending station shall disconnect the link by sending a DM/FRMR DLPDU, which is transmitted in the reservation placed for the reply. Upon receipt of a DM/FRMR DLPDU, the receiving station shall disconnect the link.

1.4.4.11.2 Link reset of an established link

The sending station shall reset the link by sending a FRMR DLPDU in a DLS burst placing a unicast reservation for the response. The sending station shall discard all outstanding user data packets in the send and receive array. The receiving station shall clear the state variables and clear the send and receive arrays. If a FRMR_ACK is not received in the reserved slot, the FRMR shall be sent again using the re-transmission procedures. Only when a~~n~~ FRMR_ACK has been received shall the station attempt to re-send data to the receiving station using the procedures of Section 1.4.4.4.If the sending station receives an INFO or RTS DLPDU from the peer whilst

waiting for a FRMR_ACK, it shall send an FRMR in response. Upon receipt of an unsolicited FRMR_ACK, a DLE shall respond with an FRMR.

On receipt of a FRMR DLPDU, the receiving station shall discard any outstanding fragments in the receive array and shall transmit a FRMR_ACK DLPDU in a DLS burst in the reserved slot.

1.4.4.12 Linking DLS DLPDU transmissions

An implementation of the DLS shall be capable of providing a combined DLPDU response even if the station does not initiate the use of combined DLPDUs.

1.4.4.12.1 Recommendation

A station with a queue of transmissions to send to a receiving station should link transmissions using the procedures set out in this section.

~~*An implementation of the DLS shall be capable of providing a combined frame response even if the station does not initiate the use of combined frames.*~~

1.4.4.12.2 Allowed DLPDU combinations

It shall be possible to combine the following DLPDUs:

RTS/DATA
ACK/CTS
ACK/DATA
ACK/RTS
SZOM/other DLPDUs as described in Section 1.4.4.3.3.2

Note.— Receipt of a combined DLPDU not listed in this section is handled in an implementation-defined manner.

1.4.4.12.3 Recommendation: Combined RTS/DATA DLPDUs

When a receiving station has selected a user data packet for transmission using the procedures of Section 1.4.4.3 it should also select the next user data packet with the highest priority and place an RTS DLPDU in the DLS burst containing the DATA DLPDU for the first user data packet~~.~~ ~~For CTRL_RTS and INFO_RTS DLPDUs,~~ ~~and~~ ,setting the T bit ~~shall be set~~in the RTS to the inverse of T_t~~. The DLS burst containing the RTS/DATA DLPDU shall contain~~ and append a response reservation type.

Note 1.—Because the DATA DLPDU is unlimited in length, the RTS must precede the DATA DLPDU. However, since the RTS contains the inverse T bit of the transmitted DATA DLPDU (as it is for the subsequent DATA DLPDU), it must be processed second.

Note 2.— —This recommendation also applies to the case where the short transmission procedures would normally be selected for transmission but for which there is an opportunity to combine it with the end of the previous long transmission procedure.

1.4.4.12.4 Combined ACK/CTS DLPDUs

On receipt of a RTS/DATA DLS burst, a station shall process the DATA DLPDU first according to the procedures of Section 1.4.4.6.5.1. If the station can find sufficient resources for a subsequent DATA DLPDU transfer, then the DLS burst containing the ACK DLPDU shall also contain a CTS DLPDU for the next DATA DLPDU transfer:

~~a)~~ A CTRL_CTS, INFO_CTS or UDATA_CTS DLPDU shall be sent in response to a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU respectively.
~~b) The T bit shall be set to the T bit of the RTS DLPDU to which the CTS is a response.~~

In the case of CTRL_CTS and INFO_CTS DLPDUs, instead of the response reservation type required by the procedures of Section 1.4.4.6.5.1, the burst shall contain an information transfer request reservation field transmitted using the parameters defined in Table 1-63, indicating the number of slots reserved for transfer of the DATA DLPDU.

1.4.4.12.5Combined DATA/ACK DLPDUs

A receiving station which has data that would fit into a single slot DLS burst containing an ACK DLPDU to send back to the sending station, shall include its own DATA DLPDU in this DLS burst. The burst shall contain a unicast request reservation field with the parameters in Table 1-61 for the acknowledgement of the DATA DLPDU.

Note.- Hence a station may combine a small transport acknowledgement with the ACK if this can be produced in time.

~~1.4.4.12.5~~1.4.4.12.6 Combined ACK/RTS DLPDUs

If a receiving station has data to send back to the sending station which cannot fit into a single slot DLS burst containing an ACK DLPDU, then the station shall combine an RTS DLPDU for its own DATA DLPDU in the DLS burst containing the ACK DLPDU and use the long transmission procedures for the data transfer.

~~1.4.4.12.6~~1.4.4.12.7 Recommendation – Combined ACK/RTS DLPDUs to different peers

If a station is sending an ACK DLPDU to one destination and has data to send to a different destination, then the station should include a unicast reservation field with sdf = 1 with the DLS burst containing the ACK and then transmit an RTS DLPDU to the new destination in the reserved slot.

Note.- This makes it possible for eg a ground station to link a series of transmissions to different destinations.

1.4.4.13 CTRL DLPDU

The CTRL DLPDU shall be used for the LME to establish and maintain links as defined in Section 1.5.

1.4.4.14 Procedures for air-air communication

Air-air communication services shall be supported by a zero-overhead connection oriented protocol (ZOCOP).

1.4.4.14.1 Air-air data exchange after link initialisation

When a ZOCOP link has been established, data shall be exchanged as determined by either the short or long transmission procedures as described in Sections 1.4.4.5 and 1.4.4.6.

1.4.4.14.2 Link maintainance

A station that has established a ZOCOP link with a peer, and which has not sent a packet to that peer for TD1 seconds, and that wishes to send a DATA packet to the peer, shall re-establish the link according to the procedures of Section 1.4.4.3.3.2.

A station shall regard the link as terminated if it has not transmitted to the same peer for TD1 seconds and if it has not received a transmission from the same peer for TD2 seconds.

A station shall regard the link as terminated if it receives a DM/DISC DLPDU or a DM/FRMR from the peer station or an attempt to send a packet to the peer station fails because of a failure notified by the retransmission procedures of Section 1.3.21.

1.4.4.14.3 Action on receipt of a CTRL parameter in a ZOCOP link

If a CTRL_RTS (IB=0), CTRL_CTS, CTRL, or CTRL_ACK DLPDU is received on an established ZOCOP link, then the receiver shall respond with a DM/FRMR in the reserved slot. If a CTRL_RTS (IB=1) is received on an established ZOCOP link, then the old link shall be considered disconnected and the receiver shall either proceed to establish the link via NSCOP procedures or respond with a general failure with a cause code indicating policy reasons.

B. REQUIREMENTS MATRIX

This matrix is based upon the text in Appendix A above and is generated by a tool. The main requirements that were not tested related to the newly introduced encoding/decoding algorithm for the compressed INFO/RTS DLPDU.

Section	Title	Num	Id	Requirement	Tested
'1.4	DLS SUBLAYER	1	1	The DLS shall support communications on a shared communications channel as described in this section.	I
'1.4.1	Services	1	2	The DLS shall support bit-oriented simplex communications using a negotiated setup connection-orientated protocol (NSCOP) and a zero-overhead connection-orientated protocol (ZOCOP) between DLE pairs.	IT
'1.4.1	Services			Note 1: It is the intention that NSCOP is used for air/ground (A/G) communications and ZOCOP for air/air (A/A) communications.	I
'1.4.1	Services			Note 2: Apart from the procedures for link setup and teardown, the NSCOP and ZOCOP protocols operate identically.	I
'1.4.1	Services			Note 3: Any two stations have one DLE pair per frequency.	I
'1.4.1	Services	2	3	The DLS shall support broadcast and multicast connectionless communications.	IT
'1.4.1	Services	3	4	The DLS shall provide the following services:	IT
'1.4.1	Services	4	5	a) transmission of user data	IT
'1.4.1	Services	5	6	b) indication that user data has been sent	IT
'1.4.1	Services	6	7	c) reception of user data	IT
'1.4.1	Services	7	8	d) indication that the DLS link has been established	IT
'1.4.1	Services	8	9	e) indication that the DLS link has been broken	IT
'1.4.1	Services	9	10	Stations supporting the communications functionality provided by the DLS shall simultaneously support at least 8 peer-to-peer links with other stations.	IT
'1.4.1	Services	10	11	Stations not supporting the communications functionality provided by the DLS shall implement Section 1.4.2.2 and Section 1.4.4.7 only.	IN

Section	Title	Num	Id	Requirement	Tested
'1.4.1.1	Data transfer	1	12	User data packets and LME data shall be transferred in the information fields of INFO, UDATA, and CTRL data link protocol data units (DLPDUs) which are collectively known as DATA DLPDUs.	IT
'1.4.1.1	Data transfer	2	13	LME data shall be contained in CTRL and UCTRL DLPDUs only.	IT
'1.4.1.1	Data transfer	3	14	The link layer shall process the largest packet size, specified in Section 1.4.3.5 of this document, without fragmenting.	IT
'1.4.1.1	Data transfer	4	15	Larger packets shall be fragmented according to the procedures of Section 1.4.4.3.2.	IT
'1.4.1.1	Data transfer	5	16	Only one data link user packet shall be contained in a DATA DLPDU.	IT
'1.4.1.1	Data transfer			Note 1: The Frame Mode SNDCF may concatenate multiple packets, but this is presented as a single user data packet to the DLS.	I
'1.4.1.1	Data transfer			Note 2: UDATA DLPDUs consist of UINFO DLPDUs for broadcast of user data packets and UCTRL DLPDUs for broadcast of LME data.	I
'1.4.1.2	DATA DLPDU duplicate suppression and sequencing	1	17	On a point-to-point connection, the receiving DLS sub-layer shall ensure that duplicated DATA DLPDUs are discarded and that all DATA DLPDUs which are part of a fragmented packet are delivered in the same order in which they appear in the packet.	IST
'1.4.1.2	DATA DLPDU duplicate suppression and sequencing			Note: A toggle bit is included in the DLS DLPDU format to facilitate duplicate suppression.	I
'1.4.1.3	Error detection	1	18	The DLS shall rely on the MAC layer to ensure that DLPDUs corrupted during transmission are detected and discarded.	IT
'1.4.1.3	Error detection			Note 16: bit CRC is provided in the burst format to support this service - the MAC layer will reject corrupted packets.	I
'1.4.1.4	Station identification	1	19	A receiving station shall accept unicast DLPDUs addressed to its current station address.	IT

Section	Title	Num	Id	Requirement	Tested
'1.4.1.4	Station identification			Note: Unique source and destination addresses are included in the VDL Mode 4 DLS burst format to facilitate this service. DLPDUs addressed to the current station address are routed to the DLS by the VSS. However, non-unique addressing is possible - with the resultant communications risk minimized through the assurance that any link address is locally unique. The ATN requires a unique address and hence non-unique addressing is not for use with the ATN.	I
'1.4.1.5	Broadcast addressing	1	20	A VDL Mode 4 station shall accept broadcast DLPDUs and accept multicast DLPDUs that have been multicast to addresses to which it is listening.	IT
'1.4.1.6	DLS Priority	1	21	The DLS shall accept an indication of priority of the DATA DLPDU as defined in Table 1-10.	IT
'1.4.1.6	DLS Priority			Note: The DLS service user's selection of priority affects the QoS parameters used in the transer of the DLS user packet as well as the queuing of the packet.	I
'1.4.1.7	DLS link control DLPDUs	1	22	For the purposes of link control, the DLS shall provide the following DLS DLPDU types:	IT
'1.4.1.7	DLS link control DLPDUs	2	23	1. ACK DLPDUs, consisting of INFO_ACK and CTRL_ACK, for the purposes of acknolwedgement of DATA DLPDUs and DLS link control DLPDUs respectively	IT
'1.4.1.7	DLS link control DLPDUs	3	24	2. RTS DLPDUs, consisting of CTRL_RTS, INFO_RTS and UDATA_RTS, for the purposes of making reservations for the transfer of DATA DLPDUs	IT
'1.4.1.7	DLS link control DLPDUs	4	25	3. CTS DLPDUs, consisting of CTRL_CTS, INFO_CTS and UDATA_CTS, for the purposes of acknowledging RTS DLPDUs and providing slots for subsequent transmission of DATA DLPDUs	IT
'1.4.1.7	DLS link control DLPDUs	5	26	4. Other DLS link control DLPDUs, consisting of SZOM FRMR, FRMR_ACK, DM/DISC and DM/FRMR, for purposes of link initialisation, reset and maintenance.	IT
'1.4.2.1	State Variables	1	27	The DLS shall maintain the state variables defined in Table 1-55 for each data link between two peer DLEs.	IT
'1.4.2.1	State Variables			Note: If the link is reset for any reason, the DLS will discard any fragments associated with a partially received packet.	I

Section	Title	Num	Id	Requirement	Tested
'1.4.2.2.1	Address type	1	28	The address type field shall be encoded as defined in Table 1-55a.	IT
'1.4.2.2.2	Non-unique identity address	1	29	A mobile station using the non-unique identity address shall randomly choose a 24-bit address.	IN
'1.4.2.2.2	Non-unique identity address	2	30	The non-unique identity address of all zeros shall not be used.	IN
'1.4.2.2.2	Non-unique identity address	3	31	The non-unique identity address of all ones shall be used as a destination address for broadcast applications only.	IN
'1.4.2.2.2	Non-unique identity address	4	32	All radio units located at a station shall use the same non-unique identity address.	IN
'1.4.2.2.2	Non-unique identity address	5	33, 34	If the station detects that another station is using the same random address, it shall stop transmitting on the current address; it shall then randomly select a new address that is not already present in its PECT.	IN
'1.4.2.2.2	Non-unique identity address	6	35	It shall use this new address in subsequent transmissions.	IN
'1.4.2.2.2	Non-unique identity address			Note 1: Processing of ambiguous data resulting from use of the non-unique address is an end system issue.	I
'1.4.2.2.2	Non-unique identity address	7	36	When using VDL Mode 4 for ATS applications, aircraft shall use the unique 24-bit ICAO address.	IN
'1.4.2.2.2	Non-unique identity address			Note 2: In this case bits 25, 26, and 27 of the full 27-bit address will be 1, 0, and 0 respectively, as is defined in Table 1-55a.	I
'1.4.2.2.2	Non-unique identity address			Note 3: Mobiles using non-unique addresses cannot be unambiguously identified and this mode of use is itself inherently insecure. Higher level functions are required when there is a need to provide data origin authentication when non-unique addresses are used.	I
'1.4.2.2.2	Non-unique identity address			Note 4: Non-unique addressing violates the subnetwork requirements of the ICAO ATN and mobiles using this addressing mode cannot implement ATN applications.	I
'1.4.2.2.3	Aircraft specific addresses	1	37	The aircraft specific address field shall be the 24-bit ICAO aircraft address.	IN

Section	Title	Num	Id	Requirement	Tested
'1.4.2.2.4	ICAO-administered ground station specific addresses	1	38	The ICAO-administered ground station specific address shall consist of a variable-length country code prefix (using the same country code assignment defined in Annex 10, Volume III, Chapter 9, Appendix 1, Table 1) and a suffix.	IN
'1.4.2.2.4	ICAO-administered ground station specific addresses	2	39	The appropriate authority shall assign the bits in the suffix.	IN
'1.4.2.2.5	ICAO-delegated ground station specific addresses	1	40	The ICAO-delegated ground station specific address shall be determined by the organization to which the address space is delegated.	IN
'1.4.2.2.6	Broadcast and multicast addresses	1	41	The broadcast and multicast addresses shall be used only as a destination address for UDATA DLPDUs.	IST
'1.4.2.2.6.1	Broadcast and multicast address encoding	1	42	The broadcast and multicast addresses shall be encoded as in Table 1-56:	IN
'1.4.2.3.1	DLS burst	1	43	A DLS station shall transmit the DLS burst defined in Table 1-57 with the VSS user supplied QoS and reservation parameters.	IN
'1.4.2.3.1	DLS burst	2	44	All bits labelled res are reserved and shall be set to zero.	IST
'1.4.2.3.1	DLS burst			Note 1: The DLS DLPDU field may continue past octet 10.	I
'1.4.2.3.1	DLS burst	3	45	The DLS burst shall consist of one or two DLS DLPDUs combined according to the procedures of Section 1.4.4.12.	IST
'1.4.2.3.1	DLS burst	4	46	A DATA DLPDU shall be the final field in the burst (and thus the burst can contain only one of these fields).	IST
'1.4.2.3.1	DLS burst			Note 2: DLS burst will be able to combine up to two DLPDUs. DATA and UDATA must come last because they are variable length DLPDUs.	I
'1.4.2.3.2	DLS DLPDU encoding	1	47	The DLS DLPDU field shall indicate the DLPDU type and contain, as appropriate, the priority subfield, the more bit, the toggle bit, the initialise bit and length subfield.	IST
'1.4.2.3.2	DLS DLPDU encoding	2	48, 49	DATA DLPDUs shall consist of a single octet containing link control information and a variable length information field.DATA DLPDUs shall be encoded as defined in Table 1-57a.	IST
'1.4.2.3.2	DLS DLPDU encoding			Note 1: "X" means 0 or 1.	I

Section	Title	Num	Id	Requirement	Tested
'1.4.2.3.2	DLS DLPDU encoding			Note 2: The c/r bit indicates whether the CTRL DLPDU is a command (c/r=0) or response (c/r=1). The re bit indicates whether a response is expected (re=1) or not (re=0).These subfields are defined in Section1.5.2.6.	I
'1.4.2.3.2	DLS DLPDU encoding			Note 3: The UCTRL ID (ucid) subfield, is defined in Table 1-71g.	I
'1.4.2.3.2	DLS DLPDU encoding	3	50	RTS and SZOM DLPDUs shall consist of two octets containing link control information.	IST
'1.4.2.3.2	DLS DLPDU encoding	4	51	RTS and SZOM DLPDUs shall be encoded as defined in Table 1-57b.	IST
'1.4.2.3.2	DLS DLPDU encoding			Note 3: "X" means 0 or 1.	I
'1.4.2.3.2	DLS DLPDU encoding	5	52	ACK, CTS and other DLS link control DLPDUs shall consist of one octet containing link control information.	IST
'1.4.2.3.2	DLS DLPDU encoding	6	53	These DLPDUs shall be encoded as defined in Table 1-57c.	IST
'1.4.2.3.2	DLS DLPDU encoding			Note 4: "X" means 0 or 1.	I
'1.4.2.3.2	DLS DLPDU encoding	7	54	A station receiving a reserved DLPDU from a peer with which it has a link shall reset the link in accordance with the procedures of setion 1.4.4.11.	IST
'1.4.2.3.2	DLS DLPDU encoding	8	55	A station receiving a reserved DLPDU from a peer with which is does not have a link shall either respond with a DM/DISC, DM/FRMR or simply ignore the DLPDU.	IST
'1.4.2.3.2	DLS DLPDU encoding	9	56	All reserved header bits (labelled "res")shall be set to zero on transmit and ignored on reciept.	IST
'1.4.2.3.3	Toggle bit	1	57	The T (Toggle) bit shall be alternately set to zero and one on each successful transmission..	IST
'1.4.2.3.3	Toggle bit	2	58	At the start of a communication between two stations, or when the link is reset, the toggle bit shall be initiated according to the procedures of Section 1.4.4.3.3.1 for NSCOP communication and Section 1.4.4.3.3.2 for ZOCOP communication.	IST
'1.4.2.3.3	Toggle bit			Note: The T (Toggle) bit is sufficient to provide duplicate detection and rejection.	I
'1.4.2.3.4	More bit	1	59	The M (More) bit shall be set to zero to indicate the end of a user data packet and to one to indicate that this fragment is not the last fragment in a multi-fragment user data packet and that further fragments will be transmitted.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.2.3.4	More bit			Note: The M (More) bit is set to 0 if a user data packet is sent as a single fragment or on the last fragment of a fragmented user data packet and to 1 otherwise. The receiver reassembles a fragmented user data packet on reception before passing it to the user.	I
'1.4.2.3.5	Priority subfield	1	60	The priority subfield (pr) shall indicate the priority level of the transmission as defined in Section 1.4.1.6.	IST
'1.4.2.3.6	Length subfield	1	61	The length subfield (lg) shall indicate the length of the DLS burst containing a DATA DLPDU in slots.	IST
'1.4.2.3.6	Length subfield	2	62	It shall be encoded as one less than the absolute length.	IST
'1.4.2.3.6	Length subfield			Note: The calculation of length needs to take account of the size of the reservation protocol (default is response) and the effects of bit stuffing. A length of 1 slot would be encoded as 0000 binary and the maximum length of 16 slots would be encoded as 1111 binary.	I
'1.4.2.3.7	Initialise bit	1	63	Prior to sending a CTRL_RTS or upon receipt of a CTRL_RTS with the IB (Initialise Bit) set to one the station shall initialise the Tt and Tr state variables and clear the send and receive arrays .	ISM
'1.4.2.3.7	Initialise bit			Note: See Section 1.4.4.3.3.1 for the handling of INFO and CTRL DLPDUs in the process of being sent.	I
'1.4.2.3.8	Negotiation subfield	1	64	The negotiation (neg) subfield shall indicate the link management parameters to be used for ZOCOP link control as defined in Table 1-57d:	IST
'1.4.2.3.9	SZOM Sequence subfield	1	65	The SZOM sequence (seq) subfield shall indicate the SZOM sequence number.	IST
'1.4.2.3.10	UDATA DLPDU encoding	1	66	A DLS station wishing to send a UDATA shall transmit the UDATA burst defined in Table 1-57e with the VSS user supplied QoS and reservation parameters.	IN
'1.4.2.3.10	UDATA DLPDU encoding	2	67	The DLS station shall select between Tables 1-57e, 1-57f, or 1-57g based on the user data id (udid) of the message as defined by Table 1-57h.	IN
'1.4.2.3.10	UDATA DLPDU encoding			Note 1: The UDATA DLPDU field may be up to ND4 octets long.	I
'1.4.2.3.10	UDATA DLPDU encoding	4	69	A DLS station sending a UCTRL shall set ucd to 0 and encode the appropriate ud field to the value of ucid per Table 1-57h.	IN

Section	Title	Num	Id	Requirement	Tested
'1.4.2.3.10	UDATA DLPDU encoding	5	70	A DLS station sending a UINFO shall set ucd to 1 and encode the appropriate ud field to the value of uinf per Table 1-57h.	IN
'1.4.2.3.10	UDATA DLPDU encoding			Note 2: The UCTRL ID (ucid) subfield, is defined in Table 1-71g. The UINFO ID (uinf) subfield is defined in Table 1-57i.	I
'1.4.2.3.12	Compressed combined RTS	1	71	A DLS station wishing to send a combined RTS and INFO DLPDU according to the procedures of Section 1.4.4.12 when the priority of the RTS is different to that of the INFO packet shall transmit the compressed combined RTS/INFO (type 1) burst defined in Table 1-57j with the VSS user supplied QoS and reservation parameters.	IN
'1.4.2.3.12	Compressed combined RTS	2	72	The T bit for the RTS shall be the inverse of the INFO T bit.	IN
'1.4.2.3.12	Compressed combined RTS			Note: The compressed combined RTS/INFO (type 1) DLPDU field may continue past octet 12.	IN
'1.4.2.3.13	Compressed combined RTS	1	73	A DLS station wishing to send a combined RTS and INFO DLPDU according to the procedures of Section 1.4.4.12 when the priority of the RTS is the same as that of the INFO packet shall transmit the compressed combined RTS/INFO (type 2) burst defined in Table 1-57k with the VSS user supplied QoS and reservation parameters.	IN
'1.4.2.3.13	Compressed combined RTS	2	74	The T bit for the RTS shall be the inverse of the INFO T bit and the priority the same as the INFO priority.	IN
'1.4.2.3.13	Compressed combined RTS			Note 1: The compressed combined RTS/INFO (type 1) DLPDU field may continue past octet 11.	IN
'1.4.2.3.13	Compressed combined RTS			Note 2: This burst format is intended to be used to link M-bit sequences where each fragment is part of the same user data packet and hence has the same priority.	IN
'1.4.3	DLS system parameters	1	75	The parameters needed by the DLS sublayer shall be as listed in Table 1-58.	IST
'1.4.3	DLS system parameters	2	76	DLS parameters for NSCOP communications shall be determined during the exchange of CTRL DLPDUs, if the default values are not to be used.	IST
'1.4.3	DLS system parameters	3	77	DLS parameters for ZOCOP communications shall be determined by the exchange of the negotiation subfield within the SZOM DLPDU.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.3	DLS system parameters			Note 1: The value of ND3 should be chosen such that the length of each DLS transmission containing the fragment is less than the maximum length of the DLS transmission defined by ND1.	I
'1.4.3	DLS system parameters			Note 2: Keep-alives have been eliminated from the protocol as peer presence is performed with sync bursts and ground stations transmit an alert on startup per Section 1.5.5.1.3.1 or the ground system transmits a broadcast connection handoff.	I
'1.4.3.1	Parameter TD1 (ZOCOP transmit reset timer)	1	78	For a mobile station maintaining a ZOCOP link with another mobile station, Timer TD1 shall be reset when a DLPDU is sent to the peer.	IST
'1.4.3.1	Parameter TD1 (ZOCOP transmit reset timer)	2	79	Timer TD1 shall not be cancelled.	IST
'1.4.3.1	Parameter TD1 (ZOCOP transmit reset timer)	3	80, 81	If Timer TD1 expires, then Tt shall be set to 0 and the send channel array shall be cleared.	IST
'1.4.3.1	Parameter TD1 (ZOCOP transmit reset timer)			Note: See Section 1.4.4.14.2 for an example of when the response reservation type is not used.	I
'1.4.3.2	Parameter TD2 (ZOCOP receive reset timer)	1	82	For a mobile station maintaining a ZOCOP link with another mobile station, Timer TD2 shall be reset when a DLPDU is received from the peer.	IST
'1.4.3.2	Parameter TD2 (ZOCOP receive reset timer)	2	83	Timer TD2 shall not be cancelled.	IST
'1.4.3.2	Parameter TD2 (ZOCOP receive reset timer)	3	84	If Timer TD2 expires, the link shall be considered to be terminated.	IST
'1.4.3.3	Parameter ND1 (maximum number of octets of any user data packet)	1	85	The parameter ND1 shall define the maximum number of octets in any user data packet that a DLS may accept from the data link user or from a peer station.	IST
'1.4.3.3	Parameter ND1 (maximum number of octets of any user data packet)	2	86	A station receiving a user data packet from a peer station greater in length than ND1 shall discard the packet and reset the link in accordance with the procedures of Section 1.4.4.11.	IS

Section	Title	Num	Id	Requirement	Tested
'1.4.3.3	Parameter ND1 (maximum number of octets of any user data packet)	3	87	A station receiving a user data packet from a data link user greater in length than ND1 shall discard the packet.	IS
'1.4.3.3	Parameter ND1 (maximum number of octets of any user data packet)			Note: The maximum size of a user data packet for broadcast is set by parameter ND3.	I
'1.4.3.4	Parameter ND2 (maximum length of short DLS transmission)	1	88, 89	The parameter ND2 shall define the maximum size in octets of a short DLS transmission, including flags and reservation data, that shall be sent using the short transmission procedures defined in Section 1.4.4.5.	IST
'1.4.3.4	Parameter ND2 (maximum length of short DLS transmission)	2	90	A burst occupying x slots shall contain up to 23 + (((x-1)*63)/2) octets of data including reservation data, CRC, and flags.	IST
'1.4.3.4	Parameter ND2 (maximum length of short DLS transmission)			Note: A slot can contain 32 octets of data. The last slot in a sequence should only contain 24 octets to allow for propagation guard time. Allowing an average octet/2 slots for bit stuffing, one slot could contain 23 octets of data including flags and reservation blocks. Two slots could contain 54 octets. Three slots could contain 86 octets, etc.	I
'1.4.3.5	Parameter ND3 (maximum length of fragment)	1	91	The parameter ND3 shall define the maximum size in slots of a DLS burst.	IST
'1.4.3.6	Parameter ND4 (maximum length of a UDATA burst)	1	92	The parameter ND4 shall define the maximum size in octets of a UDATA burst including reservation data, CRC, and flags.	IM
'1.4.4	DLS procedures			Note: Either station may send user data packets at any time and are considered peers with respect to management of the link.	I
'1.4.4.1	Broadcast	1	94	Only UDATA DLPDUs shall be broadcast.	IM
'1.4.4.2	Setting of re-transmission parameter	1	95	For all DLS bursts containing CTRL, INFO, CTRL_RTS, INFO_RTS and UCTRL_RTS DLPDUs, the quality of service parameters Q5min, Q5max, Q5mult, Q5exp and Q5num shall be set as defined in Table 1-58a.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.2	Setting of re-transmission parameter			Note: Retransmission of DLS DLPDUs may be handled in the VSS or DLS.	I
'1.4.4.3.1	User data packet priority	1	96	A sending station shall maintain a prioritised queue of user data packets for transmission.	IST
'1.4.4.3.1	User data packet priority	2	97	When determining which user data packet to transmit, the highest priority user data packet shall be sent first.	IST
'1.4.4.3.1	User data packet priority	3	98	The DLS DLPDUs CTRL and CTRL_RTS shall be classified as network management messages and given the highest priority.	IST
'1.4.4.3.1	User data packet priority	4	99	The DLS DLPDUs INFO_RTS and UDATA_RTS shall be assigned the same priority as the DATA DLPDU with which they are associated.	IST
'1.4.4.3.1	User data packet priority			Note: All other DLS DLPDU types will be sent in pre-reserved slots(FRMR, DM/FRMR and DM/DISC) or take the priority of the DATA packet to which they are combined (SZOM) and hence priority is not an issue.	I
'1.4.4.3.2.1	Determination of single or multiple fragment transmission	1	100	If the length of the DLS burst containing a CTRL or INFO DLPDU is greater than ND2 octets, the sending station shall fragment the user data packet and format it according to the procedures of Section 1.4.4.3.2.3.	IST
'1.4.4.3.2.1	Determination of single or multiple fragment transmission	2	101	Otherwise the user data packet shall be sent as a single fragment formatted according to the procedures of Section 1.4.4.3.2.2.	IST
'1.4.4.3.2.1	Determination of single or multiple fragment transmission	3	102	The fragmentation of a user data packet shall take account of whether the station is combining a CTRL or INFO DLPDU with another DLS DLPDU in accordance with the procedures of Section 1.4.4.12.3.	IST
'1.4.4.3.2.2	Single fragment user data packet transmission	1	103	A single fragment user data packet shall be transferred as a CTRL or INFO DLPDU.	IST
'1.4.4.3.2.2	Single fragment user data packet transmission	2	104	The M bit shall be set to zero.	IST
'1.4.4.3.2.2	Single fragment user data packet transmission	3	105	For an INFO DLPDU, the pr bits shall indicate the priority of the DLPDU.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.3.2.3	Multiple fragment user data packet transmission	1	106	A multiple fragment user data packet shall be transferred as a series of CTRL or INFO DLPDUs.	IST
'1.4.4.3.2.3	Multiple fragment user data packet transmission	2	107, 108	The M bit shall be set to 1 for all fragments except the last fragment.The M bit shall be set to 0 for the last fragment.	IST
'1.4.4.3.2.3	Multiple fragment user data packet transmission	3	109	For INFO DLPDUs, the pr bits shall indicate the priority of the DLPDU.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	1	110	When there is no established link (or link in the process of being established) between a mobile DLE and a ground DLE and the LME of either station requests the transmission of a CTRL user data packet, the sending DLE shall send the CTRL DLPDU using the long transmission procedures (see Section 1.4.4.6).	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	2	111	In the CTRL_RTS, it shall set the IB bit to 1, the T bit to 0 and follow the procedures of Section 1.4.2.3.7.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	3	112	On receipt of a CTRL_RTS DLPDU with IB = 1, the receiving DLE shall follow the procedures of Section 1.4.2.3.7.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	4	113	The sender and receiver shall consider the link initialised.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	5	114	The receiver shall immediately terminate any INFO transfers in progress.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	6	115	Any partially received CTRL DLPDUs shall be discarded.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	7	116, 117	If any CTRL fragments had already been acknowledged, then the remainder of the CTRL DLPDU shall be abandoned; however, if no CTRL_ACK had been received for a CTRL DLPDU, then its transfer shall continue unaffected.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication			Note 1: The DLE to which the mobile sent the CTRL_CMD may not be the DLE which responds with the CTRL_RSP. The IB bit in the CTRL_RSP may either be 0 or 1 depending on whether the responding DLE received the CTRL_CMD.	I

Section	Title	Num	Id	Requirement	Tested
'1.4.4.3.3.1	T bit initialisation for NSCOP communication			Note 2: INFO DLPDUs and partially sent/received CTRL DLPDUs are abandoned mid-transfer on the presumption that the peer station restarted (there is no other legitimate reason for the IB=1); however, CTRL DLPDUs for which the first fragment had not been acknowledged may be in a CTRL collision and are thus not affected.	I
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	8	118	The DLE shall consider the link connected upon direction from the LME.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	9	119	INFO, INFO_RTS, INFO_ACK, and INFO_CTS DLPDUs shall only be sent on links that are connected.	IST
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	10	120	Although a DLE may receive INFO DLPDUs (and generate INFO_ACKs), it shall not transmit INFO DLPDUs until it receives a CTRL_ACK to its CTRL (M=0).	IS
'1.4.4.3.3.1	T bit initialisation for NSCOP communication			Note 3: If the receiving LME indicates to the receiving DLE that the link is established after the receiving DLE's transmission of the CTRL_ACK, then the receiving DLE will not respond with a DM/FRMR to the INFO_RTS or INFO that it receives.	I
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	11	121	On receipt of a CTRL_RTS in a DLS burst addressed to it for which IB is equal to 1 and for which the T bit is equal to 1 a station shallsend a DM/FRMR.	IS
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	12	122	If a DLE with uninitialised state variables receives a CTRL_RTS DLPDU with IB equal to 0, then it shall respond with a DM/FRMR.	IS
'1.4.4.3.3.1	T bit initialisation for NSCOP communication	13	123	If a DLE receives an SZOM from a peer DLE with which it will only communicate using the NSCOP, it shall respond with a DM/FRMR.	IS
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	1	124	A mobile sending station (the "sending station") wishing to send data to a mobile station (the "receiving station") for which it does not currently have a link, shall send a DLS burst containing a Start Zero Overhead Mode (SZOM) DLPDU and the first INFO (short transmission procedures) or INFO_RTS (long transmission procedures) DLPDU to the receiving station using respectively the short transmission procedures (see Section 1.4.4.5) or the long transmission procedures (see Section 1.4.4.6).	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	2	125	It shall set the negotiation subfield to the highest value that is supported by the DLS in the SZOM DLPDU, the sequence subfield to a value that it has not transmitted to the receiving station within the previous TD2 seconds, the T bit to 0 in the INFO DLPDU, and initialise its sending and receiving state variables.	IST
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	3	126	On receipt of an unsolicited SZOM DLPDU with a sequence subfield different from the most recently received SZOM from the sending station, the receiving station shall initialise its sending and receiving state variables and consider the link established for receipt of further DLPDUs from the sending station.	IST
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	4	127	The receiving station shall send a SZOM DLPDU combined with an INFO_ACK (short transmission procedures) or an INFO_CTS (long transmission procedures) in the slot reserved for the transmission setting T=0.	IST
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	5	128	In the SZOM DLPDU, the receiving station shall set the negotiation field to the highest value that is supported by the DLS and the sequence subfield to 0.	IST
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	6	129	The receiving station shall not transmit any INFO or INFO_RTS DLPDUs to the sending station prior to sending the SZOM/INFO_ACK or SZOM/INFO_CTS reserved transmission.	IST
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	7	130	For both sending and receiving stations, link parameters shall be selected which correspond to the lower value of the negotiation subfields contained in the SZOM DLPDU sent by the sending station and in the SZOM DLPDU sent by the receiving station.	IST
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	9	132	A station that transmitted an SZOM to a peer shall retransmit its initial transmission in response to any DLPDU other than an SZOM, DM/DISC, DM/FRMR, or general failure until it receives an SZOM.	IS
'1.4.4.3.3.2	T bit initialisation for ZOCOP communication	10	133	After Q5num attempts, it shall report a failure to the DLE user.	IST
'1.4.4.3.3.3	Transfer after initialisation	1	134	When the T bit has been initialised, the sending station shall set the T bit for transmitted DLPDUs to the value of Tt.	IST
'1.4.4.4	Selection of transmission procedures	1	135	After a packet has been selected for transmission according to the procedures of Section 1.4.4.3 the sending station shall calculate the total length in octets of the DLS burst required to contain the DLPDU queued for transmission using the short transmission procedures defined in Section 1.4.4.6.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.4	Selection of transmission procedures	2	136	The total length shall include the length of any reservation fields contained within the DLS burst, together with any flags.	IST
'1.4.4.4	Selection of transmission procedures	3	137	The calculation of the length of the DLS burst shall take account of whether the station will combine a DATA DLPDU with another DLS DLPDU in accordance with the procedures of Section 1.4.4.12.3.	IST
'1.4.4.4	Selection of transmission procedures	4	138	If the total length is less than or equal to ND2, then the station shall use short transmission procedures (Section 1.4.4.6) to transmit the queued data.	IST
'1.4.4.4	Selection of transmission procedures	5	139	Otherwise, the station shall use the long transmission procedures (Section 1.4.4.7).	IST
'1.4.4.4	Selection of transmission procedures	6	140	The M bit shall be set to 0 for a short transmission.	IST
'1.4.4.4.1	Recommendation			If there are other DLPDUs queued for transmission, then the station should also include an RTS per Section 1.4.4.12.3.	IST
'1.4.4.5.1	Transmission of DATA DLPDU	1	141	After the selection of a short transmission procedure, the sending station shall transmit a DLS burst containing the DATA DLPDU queued for transmission with QoS parameters as defined in Table 1-60 using the random access procedures.	IST
'1.4.4.5.1	Transmission of DATA DLPDU	2	142	For CTRL and INFO DLPDUs, the T bit shall be set to Tt.	IST
'1.4.4.5.1	Transmission of DATA DLPDU	3	143	A burst containing a CTRL or INFO DLPDU shall contain a unicast request reservation field for the acknowledgement with the parameters in Table 1-60.	IST
'1.4.4.5.1	Transmission of DATA DLPDU			Note 1: The priority field in the unicast request reservation field is set equal to the priority setting in the INFO DLPDU as specified in Table 1-60.	I
'1.4.4.5.1	Transmission of DATA DLPDU			Note 2: If the responder VSS sublayer has not received a response from the VSS user in the scheduled reservation it can send a general failure (see Section 1.3.20) with error type 7E hex or FE hex and a unicast request reservation (with itself as the transmitter) according to the procedures of Section 1.3.19.2.	I

Section	Title	Num	Id	Requirement	Tested
'1.4.4.5.2.1	Established link with sender	1	144	If a station receiving a CTRL or INFO DLPDU has an established link with the sender it shall transmit a DLS burst containing an ACK DLPDU in the slot reserved by the unicast request reservation field contained in the DATA DLPDU transmission:	IST
'1.4.4.5.2.1	Established link with sender	2	145	a) A CTRL_ACK DLPDU shall be sent in response to a CTRL DLPDU and an INFO_ACK DLPDU sent in response to an INFO DLPDU.	IST
'1.4.4.5.2.1	Established link with sender	3	146	b) The T bit shall be set to the value of the T bit in the received DATA DLPDU.	IST
'1.4.4.5.2.1	Established link with sender			Note: See Section 1.4.4.12 for an example of when the response reservation type is not used.	I
'1.4.4.5.3	Non-receipt of acknowledgement	1	147	If an acknowledgement to a CTRL or INFO DLPDU is not received from the receiving station, the sending station shall retransmit the DLS burst containing the CTRL or INFO DLPDU and a unicast request reservation field according to the procedures of Section 1.3.21.	IST
'1.4.4.5.4	Action on receipt of a UDATA DLPDU	1	148	A station receiving a UDATA DLPDU shall forward the contents of the information field to the DLS user and take no further action.	ISTM
'1.4.4.6.1	Transmission of request to send	1	149	After the selection of a long transmission procedure, the sending station shall transmit a DLS burst containing an RTS DLPDU to the receiving station in the transmit queue with QoS parameters as defined in Table 1-61.	IST
'1.4.4.6.1	Transmission of request to send			When using the long transmission procedure:	I
'1.4.4.6.1	Transmission of request to send	2	150	a) A station shall send a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU if a CTRL, INFO or UDATA DLPDU respectively is to be transmitted.	IST
'1.4.4.6.1	Transmission of request to send	3	151	b) The pr subfield shall indicate the priority of the INFO_RTS and UDATA_RTS DLPDUs to be transmitted (see Section 1.4.1.6).	IST
'1.4.4.6.1	Transmission of request to send	4	152	c) The length subfield shall indicate the length of the DLS burst required to contain the DATA DLPDU (see Section 1.4.2.3.6).	IST
'1.4.4.6.1	Transmission of request to send	5	153	d) For CTRL_RTS and INFO_RTS DLPDUs, the T bit shall be set to Tt.	IST
'1.4.4.6.1	Transmission of request to send	6	154	Each burst shall contain a unicast request reservation field with the parameters set as defined in Table 1-61.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.6.1	Transmission of request to send			Note 1: The ground may use the priority subfield to manage the link resource during congestion.	I
'1.4.4.6.1	Transmission of request to send			Note 2: Transfer of broadcast data using the long transmission procedures involves directing the UDATA_RTS at a specific station, receiving a set of slots from that station via the UDATA_CTS and then broadcasting the UDATA in the reserved slots.	I
'1.4.4.6.1	Transmission of request to send			Note 3: The priority field in the unicast request reservation field is set equal to the priority setting in the INFO DLPDU as specified in Table 1-61.	I
'1.4.4.6.2	No response to RTS			Note: If a response is not received to the RTS DLPDU, the station retransmits the DLS burst containing the RTS DLPDU and the unicast request according to the procedures of Section Error! Reference source not found..	I
'1.4.4.6.3.1	Response if a DATA DLPDU has not previously been received	1	155	If the responder has an established link with the sender and the received DLPDU is a UDATA_RTS or if the T bit within the CTRL_RTS or INFO_RTS DLPDU is not equal to Tr, then the receiving station shall transmit a CTS DLPDU in a DLS burst in the slot reserved by the RTS DLPDU.	IST
'1.4.4.6.3.1	Response if a DATA DLPDU has not previously been received	2	156	A CTRL_CTS, INFO_CTS or UDATA_CTS DLPDU shall be sent in response to a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU respectively	IST
'1.4.4.6.3.1	Response if a DATA DLPDU has not previously been received	3	157	For CTRL_CTS and INFO_CTS DLPDUs, the burst shall contain an information transfer request reservation field and be transmitted with the parameters in Table 1-63, indicating the number of slots reserved for transfer of the DATA DLPDU.	IST
'1.4.4.6.3.1	Response if a DATA DLPDU has not previously been received	4	158	For a UDATA_CTS DLPDU, the burst shall contain a unicast request reservation field and be transmitted with the parameters in Table 1-61, indicating the number of slots reserved for transfer of the DATA DLPDU.	ISM
'1.4.4.6.3.2	Response if a DATA DLPDU has previously been received	1	159	If the responder has an established link with the sender and if the T bit within the CTRL_RTS or INFO_RTS DLPDU is equal to Tr, then the receiving station shall transmit an ACK DLPDU in the slot reserved by the RTS.	IS
'1.4.4.6.3.2	Response if a DATA DLPDU has previously been received	2	160	a) A CTRL_ACK or INFO_ACK DLPDU shall be sent in response to a CTRL_RTS or INFO_RTS DLPDU respectively	IS

Section	Title	Num	Id	Requirement	Tested
'1.4.4.6.3.2	Response if a DATA DLPDU has previously been received	3	161	b) The T bit shall be set to the value of the T bit in the received DATA DLPDU.	IS
'1.4.4.6.3.2	Response if a DATA DLPDU has previously been received	4	162	The DLS burst containing the ACK DLPDU shall contain a response reservation type except as determined by the procedures of Section 1.4.4.12.	IST
'1.4.4.6.3.3	Channel too busy	1	163	If the channel is too busy (either the receiving station cannot find a sufficiently large series of contiguous slots or the priority is too low for the channel utilization), then the receiving station shall transmit either a general confirm including a unicast reservation with V34 = 1 indicating when the responder will transmit an information transfer request in response to the RTS or a general failure (see Section 1.3.20) with error type = 01 hex.	ISM
'1.4.4.6.3.3	Channel too busy			Note: If the responder sends a general failure (see Section 1.3.20) the sender can retransmit the RTS after the timeout defined by the back-off delay or in the slot reserved by the destination.	I
'1.4.4.6.4.1	Transmission of DATA DLPDU	1	164	On receipt of a CTRL_CTS or INFO_CTS DLPDU in a DLS burst addressed to it and with an information transfer request reservation field a station shall transmit the requested DATA DLPDU in the allocated reservation with the T bit set to Tt.	IST
'1.4.4.6.4.1	Transmission of DATA DLPDU	2	165	The DLS burst containing the DATA DLPDU shall contain a response reservation type.	IST
'1.4.4.6.4.1	Transmission of DATA DLPDU	3	166	On receipt of a UDATA_CTS DLPDU in a DLS burst addressed to it with a unicast request reservation field a station shall transmit the requested UDATA DLPDU in the allocated reservation.	ISM
'1.4.4.6.4.2	Response if no information to transmit	1	167	If upon receipt of a CTS the station has nothing to transmit (e.g., after a reset), it shall transmit one the following:	IS
'1.4.4.6.4.2	Response if no information to transmit	2	168	a) an FRMR if the link is connected;	IS
'1.4.4.6.4.2	Response if no information to transmit	3	169	b) a DM/DISC if the link is disconnected;	IS

Section	Title	Num	Id	Requirement	Tested
'1.4.4.6.4.2	Response if no information to transmit	4	170	c) a DM/FRMR if the link is in the process of connecting.	IS
'1.4.4.6.4.3	Recommendation			If the station has not transmitted an INFO DLPDU and a higher priority user data packet arrived after the RTS had been transmitted, the station should transmit as much of the highest priority packets as will fit in the current reservation with the same value for T as contained in the RTS.	IST
'1.4.4.6.5.1	DATA DLPDU received	1	171	A receiving station which transmitted a CTRL_CTS or INFO_CTS DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has received the DATA DLPDU with a T bit not equal to Tr, shall follow the procedures of 1.4.4.5.2.1.	IST
'1.4.4.6.5.2	Response if DATA DLPDU not received	1	172	A receiving station which transmitted a CTRL_CTS or INFO_CTS DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has not received the CTRL or, INFO DLPDU with a T bit not equal to Tr, shall transmit in the slot reserved for an acknowledgement an ACK DLPDU in a DLS burst.	IS
'1.4.4.6.5.2	Response if DATA DLPDU not received	2	173	a) A CTRL_ACK or INFO_ACK DLPDU shall be sent in response to a CTRL or INFO DLPDU respectively.	IST
'1.4.4.6.5.2	Response if DATA DLPDU not received	3	174	b) The T bit shall be set to the inverse of the value of the T bit in the last received RTS DLPDU.	IST
'1.4.4.6.5.2	Response if DATA DLPDU not received			Note: The use of the T bit not equal to Tt indicates a "negative acknowledgement (NACK)"	I
'1.4.4.6.5.2	Response if DATA DLPDU not received	4	175	The DLS burst containing the ACK DLPDU shall contain a response reservation type.	IST
'1.4.4.7	DLS not supported	1	176	If the responder to a CTRL, CTRL_RTS, INFO, INFO_RTS or SZOM DLPDU does not support the DLS, then it shall transmit a general failure (see Section 1.3.20) with an error type of 80 hex in the slot reserved by the unicast request reservation field contained in the data DLPDU transmission.	IN
'1.4.4.7	DLS not supported			Note: The response upon receipt of a general failure, described in Section 1.3.20.1, is to not transmit another DLS burst to the sending station for the duration of the backoff timer.	I

Section	Title	Num	Id	Requirement	Tested
'1.4.4.8	No link with sender	1	177	If the responder to any DLPDU other than a CTRL_RTS DLPDU with IB equal to 1 or an SZOM DLPDU DLPDU (which may be combined with an INFO or INFO_RTS DLPDU) neither has nor is attempting to establish a link with the sender, the responder shall send a DLS burst containing a DM/DISC DLPDU in the slot reserved by the unicast or information transfer request reservation field contained in the data DLPDU transmission.	ISM
'1.4.4.8	No link with sender	2	178	If the responder is trying to establish an NSCOP or ZOCOP link with the sender, then it shall respond with a DM/FRMR to any DLPDU other than a CTRL-related DLPDU or SZOM DLPDU for NSCOP and ZOCOP respectively.	ISM
'1.4.4.8	No link with sender			Note: Per Section 1.4.4.3.3.1, an NSCOP link is considered established when a DLE sends or receives the last fragment of a CTRL_RSP. Consequently, a DLE may be retransmitting the last fragment of a CTRL_RSP while it is acknowledging INFO DLPDUs.	I
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	1	179	When a CTRL or INFO DLPDU is received without errors from another station, the value of the T bit shall be inspected and recorded.	ISTM
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	2	180	If this is:	I
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	3	181	a) an INFO DLPDU with the T bit set to zero combined with a SZOM DLPDU, or	IST
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	4	182	b) the value of the T bit is not equal to Tr,	IST
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	5	183, 184	then the user data packet or user data packet fragment shall be accepted and Tr shall be set to the value of the T bit in the received INFO or CTRL DLPDU.	IST
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	6	185	Otherwise, the received user data packet or user data packet fragment shall be discarded as a duplicate.	ISM

Section	Title	Num	Id	Requirement	Tested
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	7	186	When a UDATA DLPDU is received without errors from another station, it shall be passed to the service user as a single incoming user data packet.	IN
'1.4.4.9.1	Receipt and forwarding of received DATA DLPDUs	8	187	Otherwise it shall be discarded.	ISM
'1.4.4.9.2	Concatenation of multiple fragment user data packets	1	188	If any preceding user data packet fragments have been received with, in the case of an INFO DLPDU, the same value of pr subfield and with the M bit set to one, then the user data part of the received DATA DLPDU shall be concatenated to the end of the user data packet fragments.	IST
'1.4.4.9.2	Concatenation of multiple fragment user data packets	2	189	If the M bit is set to zero on the received DATA DLPDU, then the user data part of the received DATA DLPDU, including any user data packet fragments received earlier and with which it has been concatenated, shall be passed to the service user as a single incoming user data packet.	IST
'1.4.4.9.3	Unacknowledged DLPDUs	1	190	UDATA, DM/DISC, DM/FRMR and all ACK DLPDUs shall be unacknowledged.	ISM
'1.4.4.10.1	Receipt of an expected ACK DLPDU	1	191	When an ACK DLPDU is received without errors from another station and there is an outstanding DATA DLPDU to be acknowledged, the value of the T bit shall be inspected and the following operations performed.	IST
'1.4.4.10.1	Receipt of an expected ACK DLPDU	2	192, 193	If T is equal to Tt, then the DATA DLPDU shall be assumed successfully received and the value of Tt shall be set to the inverse of the current value of Tt.	IST
'1.4.4.10.1	Receipt of an expected ACK DLPDU	3	194	If the ACK DLPDU is not received by the expected reserved slot, then the sending station shall re-send the DATA DLPDU using the short or long transmission procedures as determined by the procedures of Section 1.4.4.4.	IST
'1.4.4.10.1	Receipt of an expected ACK DLPDU			Note 1: Retransmission is based on the expected receipt time and not on the receipt of a NACK.	I
'1.4.4.10.1	Receipt of an expected ACK DLPDU	4	195	When a DATA DLPDU has been successfully received, the highest priority fragment (either the next fragment of the current user data packet or the first fragment/complete DLPDU of the next user data packet) in the send queue, if any, shall be selected for transmission using the procedures of Section 1.4.4.3.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.10.1	Receipt of an expected ACK DLPDU			Note 2: The selection of highest priority allows the station to pre-empt eg a lower priority transfer of M-bit linked fragments with a higher priority user data packet or set of fragments.	I
'1.4.4.10.2	Receipt of an unexpected ACK DLPDU	1	196	When an ACK DLPDU is received without errors from another station and there is no outstanding DATA DLPDU to be acknowledged, the value of the T bit shall be inspected and the following operations performed.	IST
'1.4.4.10.2	Receipt of an unexpected ACK DLPDU	2	197	If T is equal to Tt, then the link shall be reset as per section 1.4.4.11.	IS
'1.4.4.10.2	Receipt of an unexpected ACK DLPDU	3	198	If T is not equal to Tt, then the ACK shall be ignored.	IST
'1.4.4.11.1	Link reset during link setup	1	199	The sending station shall disconnect the link by sending a DM/FRMR DLPDU, which is transmitted in the reservation placed for the reply.	IS
'1.4.4.11.1	Link reset during link setup	2	200	Upon receipt of a DM/FRMR DLPDU, the receiving station shall disconnect the link.	IS
'1.4.4.11.2	Link reset of an established link	1	201	The sending station shall reset the link by sending a FRMR DLPDU in a DLS burst placing a unicast reservation for the response.	IS
'1.4.4.11.2	Link reset of an established link	2	202	The sending station shall discard all outstanding user data packets in the send and receive array.	IS
'1.4.4.11.2	Link reset of an established link	3	203	The receiving station shall clear the state variables and clear the send and receive arrays.	IS
'1.4.4.11.2	Link reset of an established link	4	204	If a FRMR_ACK is not received in the reserved slot, the FRMR shall be sent again using the re-transmission procedures.	IS
'1.4.4.11.2	Link reset of an established link	5	205, 206	Only when a FRMR_ACK has been received shall the station attempt to re-send data to the receiving station using the procedures of Section 1.4.4.4.If the sending station receives an INFO or RTS DLPDU from the peer whilst waiting for a FRMR_ACK, it shall send an FRMR in response.	IS
'1.4.4.11.2	Link reset of an established link	6	207	Upon receipt of an unsolicited FRMR_ACK, a DLE shall respond with an FRMR.	IS

Section	Title	Num	Id	Requirement	Tested
'1.4.4.11.2	Link reset of an established link	7	208, 209	On receipt of a FRMR DLPDU, the receiving station shall discard any outstanding fragments in the receive array and shall transmit a FRMR_ACK DLPDU in a DLS burst in the reserved slot.	IS
'1.4.4.12	Linking DLS DLPDU transmissions	1	210	An implementation of the DLS shall be capable of providing a combined DLPDU response even if the station does not initiate the use of combined DLPDUs.	IN
'1.4.4.12.1	Recommendation			A station with a queue of transmissions to send to a receiving station should link transmissions using the procedures set out in this section.	IST
'1.4.4.12.2	Allowed DLPDU combinations	1	211	It shall be possible to combine the following DLPDUs:	IST
'1.4.4.12.2	Allowed DLPDU combinations	2	212	* RTS/DATA	IST
'1.4.4.12.2	Allowed DLPDU combinations	3	213	* ACK/CTS	IST
'1.4.4.12.2	Allowed DLPDU combinations	4	214	* ACK/DATA	IST
'1.4.4.12.2	Allowed DLPDU combinations	5	215	* ACK/RTS	IST
'1.4.4.12.2	Allowed DLPDU combinations	6	216	* SZOM/other DLPDUs as described in Section 1.4.4.3.3.2	IST
'1.4.4.12.2	Allowed DLPDU combinations			Note: Receipt of a combined DLPDU not listed in this section is handled in an implementation-defined manner.	I
'1.4.4.12.3	Recommendation			When a receiving station has selected a user data packet for transmission using the procedures of Section 1.4.4.3 it should also select the next user data packet with the highest priority and place an RTS DLPDU in the DLS burst containing the DATA DLPDU for the first user data packet ,setting the T bit in the RTS to the inverse of Tt and append a response reservation type.	IST
'1.4.4.12.3	Recommendation			Note 1: Because the DATA DLPDU is unlimited in length, the RTS must precede the DATA DLPDU. However, since the RTS contains the inverse T bit of the transmitted DATA DLPDU (as it is for the subsequent DATA DLPDU), it must be processed second.	I

Section	Title	Num	Id	Requirement	Tested
'1.4.4.12.3	Recommendation			Note 2: This recommendation also applies to the case where the short transmission procedures would normally be selected for transmission but for which there is an opportunity to combine it with the end of the previous long transmission procedure.	I
'1.4.4.12.4	Combined ACK	1	217	On receipt of a RTS/DATA DLS burst, a station shall process the DATA DLPDU first according to the procedures of Section 1.4.4.6.5.1.	IST
'1.4.4.12.4	Combined ACK	2	218	If the station can find sufficient resources for a subsequent DATA DLPDU transfer, then the DLS burst containing the ACK DLPDU shall also contain a CTS DLPDU for the next DATA DLPDU transfer:	IST
'1.4.4.12.4	Combined ACK	3	219	A CTRL_CTS, INFO_CTS or UDATA_CTS DLPDU shall be sent in response to a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU respectively.	IST
'1.4.4.12.4	Combined ACK	4	220	In the case of CTRL_CTS and INFO_CTS DLPDUs, instead of the response reservation type required by the procedures of Section 1.4.4.6.5.1, the burst shall contain an information transfer request reservation field transmitted using the parameters defined in Table 1-63, indicating the number of slots reserved for transfer of the DATA DLPDU.	IST
'1.4.4.12.5	Combined DATA	1	221	A receiving station which has data that would fit into a single slot DLS burst containing an ACK DLPDU to send back to the sending station, shall include its own DATA DLPDU in this DLS burst.	IS
'1.4.4.12.5	Combined DATA	2	222	The burst shall contain a unicast request reservation field with the parameters in Table 1-61 for the acknowledgement of the DATA DLPDU.	IST
'1.4.4.12.5	Combined DATA			Note: Hence a station may combine a small transport acknowledgement with the ACK if this can be produced in time.	I
'1.4.4.12.6	Combined ACK	1	223	If a receiving station has data to send back to the sending station which cannot fit into a single slot DLS burst containing an ACK DLPDU, then the station shall combine an RTS DLPDU for its own DATA DLPDU in the DLS burst containing the ACK DLPDU and use the long transmission procedures for the data transfer.	IST

Section	Title	Num	Id	Requirement	Tested
'1.4.4.12.7	Recommendation - Combined ACK			If a station is sending an ACK DLPDU to one destination and has data to send to a different destination, then the station should include a unicast reservation field with sdf = 1 with the DLS burst containing the ACK and then transmit an RTS DLPDU to the new destination in the reserved slot.	I
'1.4.4.12.7	Recommendation - Combined ACK			Note: This makes it possible for eg a ground station to link a series of transmissions to different destinations.	I
'1.4.4.13	CTRL DLPDU	1	224	The CTRL DLPDU shall be used for the LME to establish and maintain links as defined in Section 1.5.	IST
'1.4.4.14	Procedures for air-air communication	1	225	Air-air communication services shall be supported by a zero-overhead connection oriented protocol (ZOCOP).	IST
'1.4.4.14.1	Air-air data exchange after link initialisation	1	226	When a ZOCOP link has been established, data shall be exchanged as determined by either the short or long transmission procedures as described in Sections 1.4.4.5 and 1.4.4.6.	IST
'1.4.4.14.2	Link maintainance	1	227	A station that has established a ZOCOP link with a peer, and which has not sent a packet to that peer for TD1 seconds, and that wishes to send a DATA packet to the peer, shall re-establish the link according to the procedures of Section 1.4.4.3.3.2.	IST
'1.4.4.14.2	Link maintainance	2	228	A station shall regard the link as terminated if it has not transmitted to the same peer for TD1 seconds and if it has not received a transmission from the same peer for TD2 seconds.	IST
'1.4.4.14.2	Link maintainance	3	229	A station shall regard the link as terminated if it receives a DM/DISC DLPDU or a DM/FRMR from the peer station or an attempt to send a packet to the peer station fails because of a failure notified by the retransmission procedures of Section 1.3.21.	IST
'1.4.4.14.3	Action on receipt of a CTRL parameter in a ZOCOP link	1	230	If a CTRL_RTS (IB=0), CTRL_CTS, CTRL, or CTRL_ACK DLPDU is received on an established ZOCOP link, then the receiver shall respond with a DM/FRMR in the reserved slot.	IS
'1.4.4.14.3	Action on receipt of a CTRL parameter in a ZOCOP link	2	231, 232	If a CTRL_RTS (IB=1) is received on an established ZOCOP link, then the old link shall be considered disconnected and the receiver shall either proceed to establish the link via NSCOP procedures or respond with a general failure with a cause code indicating policy reasons.	IS

C. CHANGE PROPOSALS

C.1 DLS Change Proposals

In the extracts from the Technical Manual below, the highlighted text represents the modifications that are specific to the item under discussion.

C.1.1 DLPDU Formats

There are a few issues requiring explicit clarification in section 1.4.2.3.2:

-No response is defined for receipt of a reserved DLPDU. Although a FRMR is the presumed response, it is not explicitly stated in the technical manual. Carry out the following modifications:

- Add the sentence: "A station receiving a reserved DLPDU from a peer with which it has a link shall reset the link in accordance with the procedures of section 1.4.4.11. A station receiving a reserved DLPDU from a peer with which it does not have a link shall either respond with a DM/DISC, DM/FRMR or simply ignore the DLPDU."[1] immediately before the last sentence of the section.

- Modify the last sentence of the section as follows: "All reserved header bits ~~labeled res (~~i.e., marked by an X) ~~are reserved and~~ shall be set to zero on transmit and ignored on receipt.."

C.1.1.1 CTS Encoding

What is the point of the T bit in the CTS? On

INFO_RTS (T=t) -->
<-- INFO_CTS (T=not t)

we generate a FRMR (per 1.4.4.6.4.1). If that is the case, is there any benefit to having the T bit in the CTS? What value does it add (other than to provide more code that must be written to track the T bit and more tests that must be passed)? If the responding station were confused, it would respond with an INFO_ACK rather than an INFO_CTS (which would generate a FRMR if the INFO itself had never been sent, according to the proposal in Section C.1.7.1). We might as well just delete the T bit from the CTRL_CTS and INFO_CTS (or RES the bit if we want to make future use of it). The text proposals are provided here below. Note that the highlighted text represents the modifications relating to each specific item.

a) In Table 1-57c, replace T with res for the INFO_CTS and CTRL_CTS rows:

Table 1-57c. ~~ACK, CTS and other DLS link control~~Single octet DLPDUs encoding

Octet	N

[1] The license to either ignore the PDU or respond with a DM is based on ISO 7776 (LAP-B) practice.

Bit	8	7	6	5	4	3	2	1
UDATA_CTS	0	0	1	1	1	0	1	1
INFO_ACK	0	T	0	1	0	0	0	1
INFO_CTS	0	~~T~~res	0	1	1	0	1	1
CTRL_ACK	0	T	~~IB~~res	0	0	0	0	1
CTRL_CTS	0	~~T~~res	~~IB~~res	0	1	0	1	1
Reserved	0	X	X	1	0	1	0	1
FRMR_ACK	1	0	0	1	0	0	0	1
FRMR	1	0	0	1	0	1	0	1
DM/DISC	1	0	1	1	0	1	0	1
DM/FRMR	1	1	1	1	0	1	0	1
Reserved	1	0	1	1	1	0	1	1
Reserved	1	1	0	1	0	0	0	1
Reserved	1	X	0	1	1	0	1	1
Reserved	1	X	X	0	0	0	0	1
Reserved	X	X	X	0	0	1	0	1
Reserved	1	X	X	0	1	0	1	1
Reserved	X	X	1	1	0	0	0	1
Reserved	X	X	X	X	0	0	1	1
Reserved	1	1	~~X~~0	1	0	1	0	1
Reserved	X	X	X	X	0	1	1	1
Reserved	X	1	1	1	1	0	1	1
~~SZOM~~	~~neg_4~~	~~neg_3~~	~~neg_2~~	~~neg_1~~	~~1~~	~~1~~	~~0~~	~~1~~
Reserved	X	X	X	X	1	1	1	1

b) **In Section 1.4.4.3.3.1, delete CTRL_CTS in last paragraph**

"On receipt of a CTRL_RTS~~, CTRL_CTS~~or a~~, CTRL or CTRL_ACK DLPDU~~ in a DLS burst addressed to it for which IB is equal to ~~=~~1 and for which the T bit is equal to 1 a station shall ~~reset the link in accordance with the procedures of Section 1.4.4.11~~send a DM/FRMR. If a DLE with uninitialised state variables receives a CTRL_RTS DLPDU with IB equal to 0, then it shall respond with a DM/FRMR."

c) In Section 1.4.4.6.3.1, delete bullet (b) and re-style bullet (a) as a paragraph.

"

~~a)~~ A CTRL_CTS, INFO_CTS or UDATA_CTS DLPDU shall be sent in response to a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU respectively

~~b) The T bit shall be set to T bit of the RTS DLPDU to which the CTS is a response~~"

d) In Section 1.4.4.6.4.1, delete the phrase "for which the T bit is equal to T_t" and delete the second paragraph.

"On receipt of a CTRL_CTS or INFO_CTS DLPDU in a DLS burst addressed to it ~~for which the T bit is equal to T_t~~ and with an information transfer request reservation field a station shall transmit the requested DATA DLPDU in the allocated reservation with the T bit set to T_t.

~~On receipt of a CTRL_CTS or INFO_CTS DLPDU in a DLS burst addressed to it for which the T bit is not equal to T_t shall reset the link in accordance with the procedures of Section 1.4.4.11.~~"

e) In Section 1.4.4.6.5.1 and 1.4.4.6.5.2, first paragraph substitute "with the same setting of T bit as is contained in the CTS" with "a T bit not equal to T_r". The text is reproduced here below for these two sections respectively.

"A receiving station which transmitted a CTRL_CTS or INFO_CTS DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has received the DATA DLPDU ~~with the same setting of T~~

~~bit as is contained in the CTS~~with a T bit not equal to T_t, shall ~~transmit in the slot reserved for an acknowledgement an ACK DLPDU in a DLS burst~~follow the procedures of 1.4.4.5.2.1. "

and

"A receiving station which transmitted a CTRL_CTS or~~,~~ INFO_CTS ~~or UDATA_CTS~~ DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has not received the CTRL or, INFO ~~or UDATA~~ DLPDU with a T bit not equal to T_t~~with the same setting of T bit as is contained in the CTS~~, shall transmit in the slot reserved for an acknowledgement an ACK DLPDU in a DLS burst."

f) In Section 1.4.4.6.5.2, in the note, substitute "the last transmitted CTS" with "T_t":

"Note.- The use of the T bit not equal to ~~the last transmitted CTS~~T_t indicates a "negative acknowledgement (NACK)""

g) In Section 1.4.4.6.5.2. in bullet (b), substitute "transmitted CTS" with "received RTS":

"b) The T bit shall be set to the inverse of the value of the T bit in the last ~~transmitted CTS~~received RTS DLPDU."

C.1.1.2 New DM/FRMR DLPDU

For various reasons described elsewhere in this document, there is a need to define a new DLPDU – the DM/FRMR DLPDU. This DLPDU (as described below) is used by a station to indicate a FRMR and DM condition. No acknowledgment is necessary.

An error condition during initialization should be a rare event, and it is safer and simpler to simply restart the connection process with a clear indication of an error event rather than try to recover from the error.

The following are the necessary changes to implement the DM/FRMR DLPDU.

a) Add the DM/FRMR DLPDU to list item 4 in Section 1.4.1.7.

"4. Other DLS link control DLPDUs, consisting of SZOM FRMR, FRMR_ACK, DM/DISC and DM/FRMR ~~and SZOM~~, for purposes of link initialisation, reset and maintenance."

b) Add the DM/FRMR DLPDU to Table 1-57c with an encoding of 0xF5 and make the reserved line 11X1 0101 read as 1101 0101.

Table 1-57c. ~~ACK, CTS and other DLS link control~~Single octet DLPDUs encoding

Octet	n							
Bit	8	7	6	5	4	3	2	1
UDATA_CTS	0	0	1	1	1	0	1	1
INFO_ACK	0	T	0	1	0	0	0	1
INFO_CTS	0	~~T~~res	0	1	1	0	1	1
CTRL_ACK	0	T	~~IB~~res	0	0	0	0	1

CTRL_CTS	0	~~T~~res	~~IB~~res	0	1	0	1	1
Reserved	0	X	X	1	0	1	0	1
FRMR_ACK	1	0	0	1	0	0	0	1
FRMR	1	0	0	1	0	1	0	1
DM/DISC	1	0	1	1	0	1	0	1
~~DM/FRMR~~	~~1~~	~~1~~	~~1~~	~~1~~	~~0~~	~~1~~	~~0~~	~~1~~
Reserved	1	0	1	1	1	0	1	1
Reserved	1	1	0	1	0	0	0	1
Reserved	1	X	0	1	1	0	1	1
Reserved	1	X	X	0	0	0	0	1
Reserved	X	X	X	0	0	1	0	1
Reserved	1	X	X	0	1	0	1	1
Reserved	X	X	1	1	0	0	0	1
Reserved	X	X	X	X	0	0	1	1
Reserved	1	1	~~X~~0	1	0	1	0	1
Reserved	X	X	X	X	0	1	1	1
Reserved	X	1	1	1	1	0	1	1
~~SZOM~~	~~neg$_4$~~	~~neg$_3$~~	~~neg$_2$~~	~~neg$_1$~~	~~1~~	~~1~~	~~0~~	~~1~~
Reserved	X	X	X	X	1	1	1	1

c) Add the DM/FRMR DLPDU to the list in Section 1.4.4.9.3

"UDATA, DM/DISC, DM/FRMR and all ACK DLPDUs shall be unacknowledged."

d) Add the DM/FRMR DLPDU to the list in Section 1.4.4.14.2

"A station shall regard the link as terminated if it receives a DM/DISC DLPDU or a DM/FRMR from the peer station or an attempt to send a packet to the peer station fails because of a failure notified by the retransmission procedures of Section 1.3.21."

e) Modify Section 1.4.4.11 as:

"

1.4.4.11 Link reset

1.4.4.11.1 Link reset during link setup

The sending station shall disconnect the link by sending a DM/FRMR DLPDU, which is transmitted in the reservation placed for the reply. Upon receipt of a DM/FRMR DLPDU, the receiving station shall disconnect the link.

1.4.4.11.2 Link reset of an established link

The sending station shall reset the link by sending a FRMR DLPDU in a DLS burst placing a unicast reservation for the response~~, and~~. The sending station shall discard all outstanding user data packets in the send and receive array. The receiving station shall clear the state variables and clear the send and receive arrays. If a FRMR_ACK is not received in the reserved slot, the FRMR shall be sent again using the re-transmission procedures. Only when a~~n~~ FRMR_ACK has been received shall the station attempt to re-send data to the receiving station using the procedures of Section 1.4.4.4.If the sending station receives an INFO or RTS DLPDU from the peer whilst waiting for a FRMR_ACK, it shall send an FRMR in response. Upon receipt of an unsolicited FRMR_ACK, a DLE shall respond with an FRMR."

C.1.1.3 Inclusion of priority in the CTRL_RTS DLPDU

Since the CTRL DLPDU is always a priority 14 (and, in fact, has no means of identifying another priority), then why does the CTRL_RTS have a 4-bit priority field? Also, as the maximum transmission is 16 slots, the length field need only be 4 bits. The four priority bits and the fifth length bit should be reserved for some other use, as shown below:

Table 1-57b. ~~RTS~~ Two-Octet DLPDUs encoding

Octet	N								n + 1							
Bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
CTRL_RTS	~~lg$_5$~~res	T	IB	0	1	0	0	1	~~pr$_4$~~ res	~~pr$_3$~~ res	~~pr$_2$~~ res	~~pr$_1$~~ res	lg_4	lg_3	lg_2	lg_1
INFO_RTS	~~lg$_5$~~res	T	0	1	1	0	0	1	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
UDATA_RTS	~~lg$_5$~~res	0	1	1	1	0	0	1	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1
SZOM	neg_4	neg_3	neg_2	neg_1	1	1	0	1	seq_8	seq_7	seq_6	seq_5	seq_4	seq_3	seq_2	seq_1
Reserved	~~lg$_5$~~res	1	1	1	1	0	0	1	pr_4	pr_3	pr_2	pr_1	lg_4	lg_3	lg_2	lg_1

C.1.2 Ack of UDATA

Section 1.4.4.6.5.2 defines an ack to non-receipt of a UDATA. This makes no sense and should be:

"CTRL_CTS~~,~~ or INFO_CTS ~~or UDATA_CTS~~" and "CTRL~~,~~ or INFO ~~or UDATA~~"

C.1.3 NSCOP Link Initialization

C.1.3.1 Use of the IB bit

If the first CTRL DLPDU fragment (containing an IB=1) is lost, the NACK would (based on section 1.4.4.6.5.2) be a CTRL_ACK with T=1. However, section 1.4.4.3.3.1 states that CTRL_ACK with IB=1 and T=1 generates a FRMR. Also, section 1.4.4.11 states that the FRMR/FRMR_ACK exchange performs a 'link reset' and resets the state variables (but, what if they haven't been initialized yet!).

Section 1.4.2.3.7 says that when the IB is set, the receiving station initializes **all** variables. Section 1.4.4.3.3.1 says that when the IB is set, the receiving station initializes only half the variables (with a note indicating that the receiving station must separately initialize the other variables). This is a contradiction and only one section can be correct.

What is the appropriate response in the following scenario where the CTRL_ACK does not respond with the correct IB bit.

CTRL_CMD_LE (ib=1)
    CTRL_ACK (ib=0)
????

What is the appropriate response in the following scenario where the CTRL_RSP does not initialize the other half of the variables (per Section 1.4.4.3.3.1) and operates per Section 1.4.2.3.7.

CTRL_CMD_LE (ib=1)
CTRL_ACK (ib=1) (or, did this IB bit initialize the other half of the state variables?)
CTRL_RSP_LE (ib=0)
???

What is the appropriate response in the following scenario:

CTRL_CMD_LE (ib=1)
X—CTRL_ACK
CTRL_CMD_LE (ib=1) (this can only be determined to be a retransmission via the sequence parameter)

To solve all of these problems, the proposal is to harmonize on Section 1.4.2.3.7 and only include the IB bit in the CTRL_RTS. This solves another problem related to the retransmission of a CTRL (IB=1). To disambiguate between a retransmitted CTRL (IB=1) DLPDU and a new CTRL (IB=1) requires heuristic reasoning based on the CTRL sequence parameter. This entangled the DLS and LME processing unnecessarily and was itself not provably true in all conditions. If we harmonize on Section 1.4.4.3.3.1 instead, then we need to resolve the scenarios above.

a) In Section 1.4.2.3.7 carry out the following modifications and add a note as follows:

"~~When~~ Prior to sending a CTRL_RTS or upon receipt of a CTRL_RTS with the IB (~~i~~Initialise~~)~~ ~~b~~Bit~~)~~ ~~is~~ set to one the ~~receiver~~ station shall initialise the T_t and T_r state variables and clear the send and receive arrays ~~whilst processing the DLPDU~~.

Note.— See Section 1.4.4.3.3.1 for the handling of INFO and CTRL DLPDUs in the process of being sent."

b) Table 1-57a and 1-57c, substitute "IB" with "res" in all cells

Table 1-57a. DATA DLPDU encoding

Octet	n								n+1	.....	n+m
Bit	8	7	6	5	4	3	2	1			
CTRL	M	T	re	c/r	~~IB~~res	0	0	0	information field of length m octets		
INFO	M	T	pr_4	pr_3	pr_2	pr_1	1	0	information field of length m octets		
~~UCTRL~~Reserved	~~ucid$_4$~~X	~~ucid$_3$~~X	~~ucid$_2$~~X	~~ucid$_1$~~X	0	1	0	0	information field of length m octets		
~~UINFO~~ Reserved	0	0	0	0	1	1	0	0	information field of length m octets		
Reserved	X	X	X	1	1	1	0	0	information field of length m octets		
Reserved	X	X	1	0	1	1	0	0	information field of length m octets		
Reserved	X	1	0	0	1	1	0	0	information field of length m octets		
Reserved	1	0	0	0	1	1	0	0	information field of length m octets		

and

Table 1-57c. ~~ACK, CTS and other DLS link control~~Single octet DLPDUs encoding

Octet	n							
Bit	8	7	6	5	4	3	2	1
UDATA_CTS	0	0	1	1	1	0	1	1
INFO_ACK	0	T	0	1	0	0	0	1
INFO_CTS	0	~~T~~res	0	1	1	0	1	1

CTRL_ACK	0	T	~~IB~~res	0	0	0	0	1
CTRL_CTS	0	~~T~~res	~~IB~~res	0	1	0	1	1
Reserved	0	X	X	1	0	1	0	1
FRMR_ACK	1	0	0	1	0	0	0	1
FRMR	1	0	0	1	0	1	0	1
DM/DISC	1	0	1	1	0	1	0	1
DM/FRMR	1	1	1	1	0	1	0	1
Reserved	1	0	1	1	1	0	1	1
Reserved	1	1	0	1	0	0	0	1
Reserved	1	X	0	1	1	0	1	1
Reserved	1	X	X	0	0	0	0	1
Reserved	X	X	X	0	0	1	0	1
Reserved	1	X	X	0	1	0	1	1
Reserved	X	X	1	1	0	0	0	1
Reserved	X	X	X	X	0	0	1	1
Reserved	1	1	~~X~~0	1	0	1	0	1
Reserved	X	X	X	X	0	1	1	1
Reserved	X	1	1	1	1	0	1	1
~~SZOM~~	~~neg4~~	~~neg3~~	~~neg2~~	~~neg1~~	~~1~~	~~1~~	~~0~~	~~1~~
Reserved	X	X	X	X	1	1	1	1

c) Section 1.4.4.3.3.1 amended per Section C.1.3.4 below.

d) Delete all references to CTRL (IB=1) in the document:

a) Section 1.4.4.9.1, bullet (a), "~~a CTRL DLPDU with IB=1 or~~ an INFO…"

b) Table 1-69a, s/IB/X/ in octet n.

Table 1-69a. CTRL DLPDU format

Description	Octet	Bit Number							
		8	7	6	5	4	3	2	1
CTRL DLPDU header	n	M	T	re	c/r	~~IB~~ res	0	0	0
CTRL parameter 1: Parameter ID	n+1	id_8	id_7	id_6	id_5	id_4	id_3	id_2	id_1
Parameter length	n+2	lg_8	lg_7	lg_6	lg_5	lg_4	lg_3	lg_2	lg_1
Parameter value	n+3	$q1_8$	$q1_7$	$q1_6$	$q1_5$	$q1_4$	$q1_3$	$q1_2$	$q1_1$
	to	to							
	n+2 + lg	q_lg 8	q_lg 7	q_lg 6	q_lg 5	q_lg 4	q_lg 3	q_lg 2	q_lg 1
		more CTRL parameters							

C.1.3.2 Effect of lack of Tt and Tr bits in frame type

In ISO 4335 (HDLC) and ISO 7776 (LAP-B), the INFO packet includes both the send and receive sequence numbers (e.g., N(s) and N(r), respecitively). However, the new DLE frame type format did not have the space to include both the Tt and Tr bits. So, a separate ACK is included as necessary. This means that the LME and DLE state can be out of sync if the CTRL DLPDUs are delivered, but the CTRL_ACK was not. Since the inclusion of both bits would require a larger perturbation of the code than is desirable, we should do the next best thing by including a CTRL_ACK on the CTRL_RSP (IB=0). (Thus, two CTRL_ACKs would be sent – the one in the reserved slot and the other prepended to the CTRL_RSP / CTRL_RTS.) The alternative is to have a situation where:

CTRL_CMD_LE -->
X-- CTRL_ACK
<-- CTRL_RSP_LE
CTRL_ACK --X

where the DLEs are connected according to the LME, but can not send INFO packets. It is a real hassle to deal with since the CTRL and INFO frames don't contain the ACK bit (which would otherwise solve the problem).

C.1.3.3 DLE processing of CTRL Collision

Both peers can send a CTRL_RTS (IB=1) to its peer at the same time. This is called a CTRL collision. There are two problems here: one at the DLE layer (dealing with dueling IB=1 frames) and one at the LME layer (dealing with generation of the CTRL_RSP).

CTRL_RTS (IB=1) collision can occur at any time. The most obvious causes are:

1) race condition:
CTRL_RTS (IB=1)
CTRL_RTS (IB=1)

In case 1, the "correct"[2] implementation is for the receipt of the IB=1 DLPDU to cause:
both stations to re-initialize Tt and Tr (since they were just initialized, this should have no effect)
the higher numbered station to forget that it sent the CTRL_RTS, delete the CTRL that it was going to send and send a CTRL_CTS; the lower numbered station to forget that it received the CTRL_RTS, not send a CTRL_CTS, and proceed to deliver its CTRL DLPDU.

2) LRU rebooting
CTRL_RTS (IB=1)/CTRL_CMD
CTRL_RSP
(some time passes, left hand side reboots)
CTRL_RTS (IB=1)

[2] Where correct means globally optimal taken into account all necessary knowledge for this scenario. In practice, in may be impossible to achieve this solution as other scenarios may appear similar and require different solutions.

In addition, because the LME can generate a CTRL_CMD while the DLE is receiving a multi-fragment CTRL_CMD from a peer the following is possible

3) LME race condition
CTRL_RTS (IB=1)
CTRL_CTS
CTRL_CMD_LE (M=1, T=0)
CTRL_CMD_LE (the sending LME is unaware that a CTRL transfer is in progress)

In case 2, the "correct" implementation is for the receipt of the IB=1 DLPDU to case:
Both stations to reinitialize Tt and Tr
The higher-numbered station to transmit a CTRL_CTS, abort its CTRL delivery, and eventually send a CTRL_RSP and the lower-numbered station to ignore the CTRL_RTS and not generate a CTRL_CTS.

In case 3, the "correct" implementation is harder to define. It isn't clear that the first CTRL transfer should be aborted. It isn't clear that the second CTRL should be dropped on the floor.

As the rebooting event can occur at any point in the connection process, the protocol (of both the DLE and LME) must be robust to this problem. Because a VDL/4 DLE may not transmit for 60 seconds after rebooting, various race conditions involving rebooting and sending a CTRL_RTS (IB=1) right after sending/receiving a particularly troublesome DLPDU is impossible. In fact, the mandatory quiet period prevents many race conditions, as all of the DLE timers will have expired.

The strawman changes necessary to implement the above should be included in the changes in Section C.1.3.4 below or in some other section.

C.1.3.4 New Section 1.4.4.3.3.1

Below is the proposed text of the new section 1.4.4.3.3.1 for NSCOP initialization.

"**1.4.4.3.3.1 T bit initialisation for NSCOP communication**

When there is no ~~current~~ established ~~connection~~ link (or link in the process of being established) between a mobile ~~station~~ DLE and a ground ~~station~~ DLE and the LME of either station requests the transmission of a CTRL user data packet, the sending ~~station~~ DLE shall ~~fragment the user data packet in accordance with the procedures of 1.4.4.3.2 and~~ send the ~~fragments~~ CTRL DLPDU using ~~either the short transmission procedures (see Section) or~~ the long transmission procedures (see Section 1.4.4.6). In the ~~first fragment~~transmission~~, it shall send (either a CTRL DLPDU (short transmission procedures) or a~~ CTRL_RTS, ~~(long transmission procedures) and~~ it shall set the IB bit to 1, the T bit to 0 and ~~the state variable T_t to 0~~ follow the procedures of Section 1.4.2.3.7.

~~On receipt of a CTRL_RTS DLPDU (long transmission procedures), the receiving station shall send a CTRL_CTS with IB = 1 in accordance with the procedures of Section 1.4.4.6.3.~~

~~On receipt of a CTRL_CTS DLPDU with IB = 1 (long transmission procedures), the sending station shall send an INFO DLPDU with IB = 1 in accordance with the procedures of Section 1.4.4.6.4.~~

On receipt of a ~~CTRL or~~ CTRL_RTS DLPDU with IB = 1, the receiving ~~station~~ DLE shall ~~set its own state variable T_t to 0, clear its receive arrays, and consider the link established for receipt of further DATA DLPDUs. The receiving station shall set IB = 1 in the CTRL_ACK response to the CTRL DLPDU.~~follow the procedures of Section 1.4.2.3.7. The sender and receiver shall consider the link initialised. The receiver shall immediately terminate any INFO transfers in progress. Any partially received CTRL DLPDUs shall be discarded. If any CTRL fragments had already been acknowledged, then the remainder of the CTRL DLPDU shall be abandoned; however, if no CTRL_ACK had been received for a CTRL DLPDU, then its transfer shall continue unaffected.

Note 1.— The DLE to which the mobile sent the CTRL_CMD may not be the DLE which responds with the CTRL_RSP. The IB bit in the CTRL_RSP may either be 0 or 1 depending on whether the responding DLE received the CTRL_CMD.

Note 2.— INFO DLPDUs and partially sent/received CTRL DLPDUs are abandoned mid-transfer on the presumption that the peer station restarted (there is no other legitimate reason for the IB=1); however, CTRL DLPDUs for which the first fragment had not been acknowledged may be in a CTRL collision and are thus not affected.

~~On receipt of the CTRL_ACK with T = 0 and IB = 1, produced in response to a CTRL DLPDU with IB = 1, the sending station shall set its state variable T_t to 1 and consider the link established for transmission of further DATA DLPDUs.~~

~~*Note. At this stage the state variables T_t for the sending station and T_r for the receiving station are initialised. The receiving station must separately initialise the state variables for data transfer in the opposite direction.*~~

The DLE shall consider the link connected upon direction from the LME. INFO, INFO_RTS, INFO_ACK, and INFO_CTS DLPDUs shall only be sent on links that are connected. Although a DLE may receive INFO DLPDUs (and generate INFO_ACKs), it shall not transmit INFO DLPDUs until it receives a CTRL_ACK to its CTRL (M=0).

Note 3.— If the receiving LME indicates to the receiving DLE that the link is established after the receiving DLE's transmission of the CTRL_ACK, then the receiving DLE will not respond with a DM/FRMR to the INFO_RTS or INFO that it receives.

On receipt of a CTRL_RTS~~, CTRL_CTS or a, CTRL or CTRL_ACK DLPDU~~ in a DLS burst addressed to it for which IB is equal to ~~=~~ 1 and for which the T bit is equal to 1 a station shall ~~reset the link in accordance with the procedures of Section 1.4.4.11~~send a DM/FRMR. If a DLE with uninitialised state variables receives a CTRL_RTS DLPDU with IB equal to 0, then it shall respond with a DM/FRMR.

If a DLE receives an SZOM from a peer DLE with which it will only communicate using the NSCOP, it shall respond with a DM/FRMR."

C.1.3.5 Receipt of INFO DLPDU

What is the response to an INFO while the link is still being set up? Per Section 1.4.4.8, it should be a DM/DISC. Is this the desired behavior? Should we use the proposed DM/FRMR DLPDU instead? Both of these seem harsh since it is possible for the side sending the CTRL_ACK to the CTRL_RSP to believe the link is up while the other side (waiting for the CTRL_ACK as it missed the transmission) will not consider the link up. Section 1.5.7.4.3 calls out resending a CTRL_CMD_LE rather than a DM/DISC; this is wasteful when only the last fragment is awaiting an ACK. The requirement for DLE behavior should not be listed in the LME section. Section 1.4.4.8 must also be updated as CTRL DLPDUs no longer contain an IB bit. Finally, nowhere in the current document is it stated that, in the disconnected state, a response to a non-link establishing frame is a DM/DISC.

In addition, sections 1.5.7.4.3, 1.5.7.5.7, etc were copied from VDL/2 – which lacked a CTRL_ACK DLPDU and a unicasted UDATA DLPDU. Consequently, additional material is required to handle the situations (some of which are described above), when unicasted traffic is received when a CTRL_ACK is outstanding or where unicasted UDATA DLPDUs are received (which imply nothing about the state of the link).

The strawman proposal assumes that the DLE is in the connected state when the last fragment of the CTRL_RSP has been sent/received. Consequently, a station receiving an INFO-related DLPDU when in the disconnected state should send a DM/DISC; a station in the connecting state should send a DM/FRMR; and a station in the connected state should handle the frame appropriately. Note that the station may still be awaiting the CTRL_ACK for the CTRL_RSP – it is still in the connected state (although it will retransmit as necessary to receive the CTRL_ACK). The proposed text would read:

"1.4.4.8 No link with sender

If the responder to ~~a~~ any DLPDU other than a ~~CTRL or~~ CTRL_RTS DLPDU with IB ~~not~~ equal to 1 or an ~~INFO or INFO_RTS DLPDU which is not combined with a~~ SZOM DLPDU (which may be combined with an INFO or INFO_RTS DLPDU) neither ~~does not~~ has nor is trying to establish ~~have~~ a link with the sender, the responder shall send a DLS burst containing a DM/DISC DLPDU in the slot reserved by the unicast or info transfer request reservation field contained in the data DLPDU transmission. If the responder is trying to establish a link with the sender, then the responder shall respond with a DM/FRMR to any DLPDU other than a CTRL-related DLPDU or SZOM DLPDU if the responder is attempting to establish the link with NSCOP or ZOCOP, respectively.

Note.—Per Section 1.4.4.3.3.1, a link is considered established when a DLE sends or receives the last fragment of a CTRL_RSP. Consequently, a DLE may be retransmitting the last fragment of a CTRL_RSP while it is acknowledging INFO DLPDUs."

C.1.4 SZOM Operations

What is the appropriate response to an SZOM on an NSCOP link? We have the following alternatives:

a) Respond with an SZOM. But, this will have the affect of changing the operating parameters / procedures (i.e., tearing down the link after TD2 idle seconds rather than keeping it up indefinitely).
b) Ignore the DLPDU. This is bad because the other side will send the SZOM again.
c) FRMR. This makes some sense since the SZOM is undefined on an NSCOP link.

d) DM/DISC. This makes some sense as there is no response to a DM so the FRMR-sending station does not have to wait for the FRMR_ACK. However, now a station may tear down a link and cause a period of no-comm. However, this should only occur on a bug that should be caught during testing. The response differs from Section 1.4.4.8 since it is in response to an SZOM.
e) Send the proposed DM/FRMR (same effect as DM/DISC, only with an explicit FRMR indication). Note that this solution was presumed in the rewriting of Section 1.4.4.3.3.1.
f) Transmit a CTRL_CMD.

The proposed strawman solution is option (e). This text should be added to section 1.4.4.3.3.1:

If a station receives an SZOM from a peer with which it will only communicate using the NSCOP, it shall respond with a DM/FRMR.

Similarly, what is the response to a CTRL DLPDU (including CTRL_RTS, CTRL_CTS, or CTRL_ACK) on an ZOCOP link? The proposed strawman solution is option (e) as above unless the CTRL_RTS contains an IB=1, in which case the old link is effectively torn down and it is a policy decision whether to establish an NSCOP link. Add the following text:

"1.4.4.14.3 Action on receipt of a CTRL DLPDU on a ZOCOP link

If a CTRL_RTS (IB=0), CTRL_CTS, CTRL, or CTRL_ACK DLPDU is received on an established ZOCOP link, then the receiver shall respond with a DM/FRMR in the reserved slot. If a CTRL_RTS (IB=1) is received on an established ZOCOP link, then the old link shall be considered disconnected and the receiver shall either proceed to establish the link via NSCOP procedures or respond with a general failure with a cause code indicating policy reasons."

C.1.5 ZOCOP Link Initialization

Because of the following problems with Section 1.4.4.3.3.2, new proposed text is included in Section C.1.5.6.

C.1.5.1 T-bit initialization

In section 1.4.4.3.3.2, the note regarding T-bit initialization should state that both sides have been initialized. The easiest way to do this is to delete the note.

C.1.5.2 Missing SZOM response

What is the correct response in the following scenario:

SZOM/INFO
INFO_ACK (or even an INFO DLPDU)
???

This might occur in normal operations when one side's TD1 timer expires (or, in the case of an unexpected INFO, if the responding SZOM/INFO_ACK is lost). The strawman proposal is to explicitly state that the SZOM must be resent until it is acknowledged per the new text at the very end of section 1.4.4.3.3.2.

C.1.5.3 Duplicate first packet delivery

In the following scenario:

SZOM/INFO (DLPDU delivered)
X—SZOM/INFO_ACK (ack not received)
SZOM/INFO

The normal processing of the retransmitted SZOM will cause all received state variables to be reset and thus the INFO DLPDU will be delivered twice (and thus violating Section 1.4.1.2). Among the possible solutions to this problem are:

1) Determine (by some method) that the SZOM is a retransmission and do not reset the state variables. This method is not easy to prove is safe (since an SZOM could be sent after TD1 expired, potential race conditions must be carefully dealt with).
   a) Use a timer to determine when the SZOM is a duplicate. This is not likely to be provably safe under all race conditions.
   b) Use a single bit in the SZOM field as an SZOM_Toggle bit. This is a simpler version of the next solution which does not provide the guarantee of sequence number reuse.
   c) Add a second byte as a sequence number to the SZOM field. A station will use the same sequence number for all retransmissions and must ensure that the same sequence number is not transmitted to a peer station within TD2 seconds.
2) Only use long transmission procedures with the SZOM (i.e., SZOM/RTS is safe since no INFO DLPDUs have actually been transferred).

Either Option 1c or 2 can be shown to be safe. Since option 1c is more efficient, it is the proposed solution. The proposal entails:

1) Renaming Table 1-57b as “Two-byte DLPDU encodings” and renaming Table 1-57c as “One-byte DLPDU encodings”. Deleting SZOM from Table 1-57c and moving it to the end of Table 1-57b and adding a second byte with bits seq_1 through seq_8.
2) Adding a new Section 1.4.2.3.9 as follows: “1.4.2.3.9 SZOM Sequence subfield. The SZOM sequence (seq) subfield shall indicate the SZOM sequence number of this SZOM.”
3) Rewrite Section 1.4.4.3.3.2.

C.1.5.4 Colliding SZOM/INFO transmissions

There is no SZOM_ACK DLPDU so that colliding SZOM/INFO transmissions (i.e., two stations each send the other an SZOM/INFO ‘at the same time’) would be treated the same as an intentionally acknowledged SZOM exchange. However, the text in Section 1.4.4.3.3.2 implies different behavior depending on which DLPDU is coupled with the SZOM. This also has the unfortunate effect of not allowing each DLPDU to be processed independently and makes the coding more complicated. The resolution is for the processing to be dependent on whether the SZOM is unsolicited (i.e., a responding SZOM was not expected).

C.1.5.5 Premature INFO transmission

In the following scenario:

SZOM/INFO
D_DATA.ind

D_DATA.req

(where the responding station gets an upper layer response prior to transmitting the SZOM/ACK), the responding station has one of two choices:

1) transmit an SZOM/RTS (or SZOM/INFO) randomly, OR
2) wait for the reserved slot and transmit the SZOM/ACK and only then transmit the RTS (or INFO) randomly.

Since the random transmission can not be guaranteed to actually be transmitted either before or after the reserved slot, stations must queue all outgoing data until after the SZOM/ACK is actually transmitted. See Section C.1.5.6 for strawman text.

C.1.5.6 New Section 1.4.4.3.3.2

A mobile sending station (the "sending station") wishing to send data to a mobile station (the "receiving station") for which it does not currently have a link, shall send a DLS burst containing a Start Zero Overhead Mode (SZOM) DLPDU and the first INFO (short transmission procedures) or INFO_RTS (long transmission procedures) DLPDU to the receiving station using respectively the short transmission procedures (see Section 1.4.4.5) or the long transmission procedures (see Section 1.4.4.6). It shall set the negotiation subfield to the highest value that is supported by the DLS in the SZOM DLPDU, the sequence subfield to a value that it has not transmitted to the receiving station within the previous TD2 seconds , the T bit to 0 in the INFO DLPDU, and ~~the state variable T_t to 0~~initialize its sending and receiving state variables.

On receipt of an unsolicited SZOM DLPDU with a sequence subfield different from the most recently received SZOM from the sending station ~~combined with an INFO DLPDU (short transmission procedures) or INFO_RTS DLPDU (long transmission procedures)~~, the receiving station shall ~~set its own state variable T_t to 0, clear its receive arrays~~initialize its sending and receiving state variables and consider the link established for receipt of further DLPDUs from the sending station. The receiving station shall send a SZOM DLPDU combined with an INFO_ACK (short transmission procedures) or an INFO_CTS (long transmission procedures) in the slot reserved for the transmission setting T=0. In the SZOM DLPDU, the receiving station shall set the negotiation field to the highest value that is supported by the DLS and the sequence subfield to 0. The receiving station shall not transmit any INFO or INFO_RTS DLPDUs to the sending station prior to sending the SZOM/INFO ACK or SZOM/INFO CTS reserved transmission.

~~On receipt of the INFO_ACK (short transmission procedures) or INFO_CTS (long transmission procedures) combined with an SZOM DLPDU, the sending station shall set its state variable T_t to 1 and consider the link established for transmission of further DATA DLPDUs.~~

For both sending and receiving stations, link parameters shall be selected which correspond to the lower value of the negotiation subfields contained in the SZOM DLPDU sent by the sending station and in the SZOM DLPDU sent by the receiving station.

~~*Note. At this stage the state variables T_t for the sending station and T_t for the receiving station are initialised. The receiving station must separately initialise the state variables for data transfer in the opposite direction*~~.

A station that transmitted an SZOM to a peer shall retransmit its initial transmission in response to any DLPDU other than an SZOM, DM/DISC, DM/FRMR, or general failure until it receives an SZOM. After Q5num attempts, it shall report a failure to the DLE user.

C.1.6 Combined DLPDU issues

Reword 1.4.4.12.3 (currently containing a "shall" as follows). My recollection is that this was originally a note and we moved it to a shall because a reviewer felt that this implied a requirement; however, we can't have a shall in a recommendation either.

"1.4.4.12.3 Recommendation: Combined RTS/DATA DLPDUs

When a receiving station has selected a user data packet for transmission using the procedures of Section 1.4.4.3 it should also select the next user data packet with the highest priority and place an RTS DLPDU in the DLS burst containing the DATA DLPDU for the first user data packet~~. For CTRL_RTS and INFO_RTS DLPDUs~~, setting the T bit ~~shall be set~~in the RTS to the inverse of Tt.

Note 1.—Because the DATA DLPDU is unlimited in length, the RTS must precede the DATA DLPDU. However, since the RTS contains the inverse T bit of the transmitted DATA DLPDU (as it is for the subsequent DATA DLPDU), it must be processed second.

Note 2.- This recommendation also applies to the case where the short transmission procedures would normally be selected for transmission but for which there is an opportunity to combine it with the end of the previous long transmission procedure."

Author's Note: If we recommend that all recommendations be upgraded to requirements, then this rewording may be retained if it improves the readability of the spec, but is not required.

C.1.7 ACK processing

Because of the following problems with ACK processing, new proposed text is included in Section C.1.7.3.

C.1.7.1 Unexpected ACK

Section 1.4.4.10 states that an ACK with T equal to T_t acknowledges the DATA DLPDU and with T equal to not T_t generates a retransmission. It should also state operations if no DATA DLPDU was outstanding. The proposal is to ignore a NACK and FRMR an ACK per the strawman proposal.

C.1.7.2 Duplicate RTS handling

In the following scenario:
INFO_RTS(T=t)
X— INFO_CTS (with an info_xfer reserving the ACK slot **after** the following retransmission)
INFO_RTS(T=t) (retransmission)

The transmission by the right-hand station of the NAK (via an INFO_ACK(T=/t)) can only confuse the left-hand station regarding what exactly is being NAKed. A recommendation should be added such that the right-hand station does not transmit the NAK and retransmits the

INFO_CTS in the slot reserved for it by the INFO_RTS. Note that the left-hand station must still be capable of handling an unexpected NAK since race conditions may prevent the NAK from being elided. See the proposed strawman text for Section 1.4.4.10.

C.1.7.3 Strawman proposal

Demote Section 1.4.4.10 to 1.4.4.10.1, add a new section 1.4.4.10.2 and rename the existing 1.4.4.10, as follows:

"1.4.4.10 Receipt of ACK DLPDU
1.4.4.10.1 Receipt of an expected ACK
When an ACK DLPDU is received without errors from another station and there was an outstanding DATA DLPDU to be acknowledged, the value of the T bit shall be inspected and the following operations performed.

If T ~~=~~is equal to T_t, then the DATA DLPDU shall be assumed successfully received and the value of T_t shall be set to the inverse of the current value of T_t.

If ~~T is not equal to T_t or if~~ the ACK DLPDU is not received by the expected reserved slot, then the sending station shall re-send the DATA DLPDU using the short or long transmission procedures as determined by the procedures of Section 1.4.4.4."

Author's note: this change handles the effects of a RTS->, X-CTS, RTS-?, <-NAK (that is, the NAK is from the first CTS, which wasn't received) and therefore should be ignored. Whether the second RTS is received or not has no relevance. The easiest way to ensure that a NAK from a previous RTS doesn't interfere with the logic is to ignore all NAKs and only retransmit based on the expected receipt time.

When a DATA DLPDU has been successfully received, the highest priority fragment (either the next fragment of the current user data packet or the first fragment/complete DLPDU of the next user data packet) in the send queue, if any, shall be selected for transmission using the procedures of Section 1.4.4.3.

Note.- The selection of highest priority allows the station to pre-empt eg a lower priority transfer of M-bit linked fragments with a higher priority user data packet or set of fragments.

1.4.4.10.2 Receipt of an unexpected ACK

When an ACK DLPDU is received without errors from another station and there was no outstanding DATA DLPDU to be acknowledged, the value of the T bit shall be inspected and the following operations performed.

If T is equal to T_t, then the link shall be reset per Section 1.4.4.11.

If T is not equal to T_t, then the ACK shall be ignored."

C.1.8 Unsolicited CTS

What is the correct response to:

CTRL_CTS (or INFO_CTS)

Here a station receives an unsolicited CTS. It can either send a FRMR or nothing in the INFO slots. The problem is that determining that the CTS is unsolicited requires maintaining a state variable of when the RTS is outstanding. It is easier to simply ignore the CTS. However, the correct behavior is probably the FRMR (if the link is connected), DM/DISC (if the link is disconnected), or DM/FRMR (if the link is connecting) .

C.1.9 Link Endpoint

VDL/2 has a different address per frequency. This was done because of problems in ACARS with transmissions on one frequency being received on another (because of spurs, intermodulation, etc). VDL/4 has a single address for the station regardless of frequency of operation. So, autotune for VDL/2 is inherently to a different station.

Do we want:

1) The link endpoint to be the station address so we have one link across all frequencies (and so T bit isn't initialized on an autotune, no issues with spurs, image response, etc).
2) The link endpoint to be the station address / frequency pair so we have a peer connection per address/frequency and we validate that the state machines are robust in the presence of multiple-channel receptions (note that ACARS wasn't and this is why VDL/2 enforced a different address per frequency).
3) The link endpoint to be the station address / frequency / link ID so that we have explicit multi-link bonding where we take the (say) upper 3 bits of the 8-bit message ID and declare it to be the link ID. This is more work, but provides for the capability of greater than 19.2 kbps per aircraft. One mechanism for doing this is to simply have the initiating and responding stations use a link number which is unique for that side.

That is, what is the value of the T and IB bits in the various DLPDUs of an autotune? Option 3 is the most robust (and can be seen as a generalized form of option 2); however, it is more work. Option 2 is the most straightforward analog to VDL/2 (each frequency is considered a new link) and is the proposed strawman solution. The downside risk is that a naïve implementation might attempt to generate responses on multiple channels.

Another problem with option 2 is that the frequency parameter in the unicast and info transfer reservation types cannot (technically) be used since an INFO DLPDU on another frequency would constitute transfer over a different DLE pair. If it is desired to use the frequency parameter in the unicast / info transfer reservation types, then a new CTRL parameter would need to be defined to bond the INFO channels to the control channel for the purpose of defining what the link endpoint is.

C.1.10 FRMR Operations

Some minor issues with Section 1.4.4.11 (see text proposed below):

1) What is the appropriate response to an unsolicited FRMR_ACK? Standard ISO 4335 practices don't apply since the UA is not explicitly for a FRMR. In this case, the sending peer is implying a link reset that the receiving peer is unaware of. I suggest generating a FRMR, just to be safe.
2) Need to be explicit that we need to clear both T bits and both the send and receive array on receipt of a FRMR.
3) There is a cross-reference to 1.4.4.3.3 that is probably meant for another section.

1.4.4.11.2 Link reset of an established link

The sending station shall reset the link by sending a FRMR DLPDU in a DLS burst placing a unicast reservation for the response. The sending station shall discard all outstanding user data packets in the send and receive array. The receiving station shall clear the state variables and clear the send and receive arrays. If a FRMR_ACK is not received in the reserved slot, the FRMR shall be sent again using the re-transmission procedures. Only when a~~n~~ FRMR_ACK has been received shall the station attempt to re-send data to the receiving station using the procedures of Section 1.4.4.4. If the sending station receives an INFO or RTS DLPDU from the peer whilst waiting for a FRMR_ACK, it shall send an FRMR in response. Upon receipt of an unsolicited FRMR_ACK, a DLE shall respond with an FRMR.

C.1.11 Terminology

The terminology used in the DLS section is not clear. The following phrases *probably* refer to the same concept:

In section 1.4.4.3.3.1, "When there is no current connection"
In section 1.4.4.5.2.1, "has a valid link to the sender"
In section 1.4.4.8, "does not have a link with the sender"

This generates two immediate questions:

1. What is the difference between a "connection" and a "link"?
2. When is a link "valid" and (by implication) what is an invalid link?

Since link establishment behavior is slightly different from connection established behavior, precise wording is required to ensure interoperable behavior. The term "valid link" should be replaced with "link established" throughout Section 1.4.

The new link layer text talks about sending and receiving "stations" or "radio unit" (in Section 1.4.2.2.2). The old link layer text spoke about data link entities (or DLEs) to clarify that a station has multiple links and that a response is dependent on the status between a station and its peer station/system. By stating that the DLE is in the disconnected state, the connecting state, or the connected state, the status of the link is clear. The wording throughout the document should be harmonized on the state of a DLE. Every use of the word "station" or "radio unit" in Section 1.4 should be replaced with "DLE".

Section 1.4.4.3.3.2 paragraph one calls out "negotiation field" while Section 1.4.2.3.8 calls out "negotiation subfield". We should check to ensure that all terminology is consistent. Suggested modification to text in 1.4.4.3.3.2 to harmonise the negotiation subfield:

"It shall set the negotiation subfield to the highest value that is supported by the DLS in the SZOM DLPDU, the sequence subfield to a value that it has not transmitted to the receiving station within the previous TD2 seconds, the T bit to 0 in the INFO DLPDU, and initialise its sending and receiving state variables.~~the state variable T_t to 0.~~"

C.1.12 No enforcement of stop-and-wait

A possibly missing requirement is the forbidding of transmitting a DATA (with T=t) and (while waiting for the ACK) a DATA (with T=not t) between two link endpoints. (Section 1.4.4.9.1

shouldn't apply because we've already started a new T-bit transaction and can not open a new transaction until we've closed out the old one.) This should probably generate a FRMR on receipt of the subsequent DATA (or RTS) DLPDU. However, this might rank up there with "don't modify the contents of a DATA DLPDU" as an obvious requirement that need not be stated.

C.1.13 One-minute quiet period inconsistent with safety services

Rapid net entry is only applicable for sync bursts. It cannot be used for communications. However, communication functionality suffers from a one-minute quiet period after startup. This outage is inconsistent with the use of VDL/4 as a safety service. However, this is simple to fix on a data-link only frequency.

The one-minute quiet period is for stations to construct an accurate reservation table. However, data link communications only use info transfer, unicast, and response reservation types. In particular, if periodic and super-frame reservation types are forbidden on a channel, then the maximum quiet period can be dramatically reduced. A parameter can be defined (to be included in the directory of services and/or a ground-transmitted CTRL frame) that specifies that a reservation be made no more than [10] seconds[3] in the future. Since even standard frequency scanning (to learn of an appropriate peer's address) could be 10-20 seconds long, this imposes no additional delay on the usage of the VDL/4. While this does impose a restriction on the usage of a single VDL/4 channel for surveillance and communications, in practice this is probably not a significant restriction. And, if a CAA would desire to operate a single frequency with combined surveillance/communications operations, it would not be required to assert the parameter.

Moreover, a change of frequency (either because of frequency recovery, or planned retune) would be a problem unless a spare receiver existed. Finally, the protocol is not robust to a one minute delay between the autotune command and the actual CTRL_CMD_HO on the new frequency. (For that matter, a 10 second delay is a problem as well.)

This would allow those CAAs concerned about an outage after an LRU reboot to satisfy their concerns while allowing those CAAs concerned about single frequency operation to satisfy their concerns.

C.1.14 DLS parameters

C.1.14.1 ND2 default value

The default value of ND2 is 86 octets in Table 1-58. However, according to the formula in Section 1.4.3.4, a value of 3 slots yields 85 octets. So, Table 1-58 should use a default of 85 octets. However, it is not clear that the formula in Section 1.4.3.4 is correct. According to the formula, a one-slot message is 23 octets long. However, this did not include the overhead for: flags, CRC, source address, VSS user message ID, INFO DLPDU header, and unicast reservation type. The constant of 23 should either be reduced by 17 bytes or the need for this reduction should be mentioned in a note.

C.1.14.2 Broadcast DLPDU Length

[3] With a single bit, this would be [10] seconds. Using a byte, this could be configurable.

ND3 for a UDATA should be different than for an INFO since we use M-bit fragmentation to control the INFO DLPDU size. There is a note in Section 1.4.3.5 stating that this also applies to a UDATA DLPDU. However, CTRL/INFO DLPDUs can be broken up by M-bit fragmentation so ND3 is used as an optimization parameter (to control the amount of RF used in a transmission, the cost of a retransmission, etc) while for UDATA DLPDUs ND3 is a limit on their operational usage. As such, there should be a separate parameter for UDATA DLPDUs.

a) Add the ND4 parameter in Table 1-58 as follows:

Table 1-58. Data link service system parameters

Symbol	Parameter name	Minimum	Maximum	Default	Increment
TD1	ZOCOP link transmit reset timer	5 s	600 s	60 s	1 s
TD2	ZOCOP link receive reset timer	10 s	1200 s	90 s	1 s
ND1	Maximum number of octets in any user data packet	143 octets	2063 octets	1511 octets	1 octet
ND2	Maximum length of DLS transmission	2 octets	~~2063~~ 496 octets	86 octets	1 octet
ND3	Maximum length of fragment	1 slot	~~32~~ 16 slots	5 slots	1 slot
ND4	Maximum length of UDATA burst	147 octets	496 octets	271 octets	1 octet

b) **Delete the note in Section 1.4.3.5, as follows:**

"**1.4.3.5 Parameter ND3 (maximum length of fragment)**

The parameter ND3 shall define the maximum size in slots of a DLS burst.

~~Note. To be used to control fragmentation and also applies to the maximum size of a burst containing a UDATA DLPDU.~~"

c) Add a section 1.4.3.6 defining parameter ND4:

"1.4.3.6 Parameter ND4 (maximum length of a UDATA burst)

The parameter ND4 shall define the maximum size in octets of a UDATA burst."

C.1.15Efficient use of the RTS

Add a new Section 1.4.4.4.1:

"1.4.4.4.1 Recommendation

If there are other DLPDUs queued for transmission, then the station should also include an RTS per Section 1.4.4.12.3."

C.1.16 Better priority management

It is possible for ongoing low-priority traffic to improve the performance of high-priority traffic. When an RTS is transmitted it contains a priority; however, there is no reason why a higher priority packet cannot be sent instead so long as the lower priority DATA DLPDU is not being retransmitted. (Thus, the higher priority packet does not need to wait for the RTS-CTS transfer delay.) Since the INFO packet contains the priority field, the receiver should not rely on the INFO_RTS priority in any event (do we need to add this as a requirement?). Add a recommendation as a new Section 1.4.4.6.4.3:

"1.4.4.6.4.3 Recommendation

If the station has not transmitted an INFO DLPDU and a higher priority user data packet arrived after the RTS had been transmitted, the station should transmit as much of the highest priority packets as will fit in the current reservation with the same value for T as contained in the RTS.".

C.1.17 Policy reason denial

We should add a general failure code and LCR cause code of "denied for policy reasons" in case we want to deny an SZOM (with a general failure and the new general failure code) or CTRL_CMD_LE (with a CTRL_RSP_LCR and the new LCR cause code). Add the following:

a) In Table 1-54, define FDh as "Rejected for internal policy reasons". (and change the reserved span to end at FCh), as follows:

Table 1-54. Error type definition

Cause	Function	Parameter Encoding (prm bits 1 to 8)							
		8	7	6	5	4	3	2	1
00 hex	Unsupported local function. The parameters (defining the protocol options supported) will be filled in when defined.	0	0	0	0	0	0	0	0
01 hex	Out of local resources	Reserved							
02 hex	VSS user-specific local error	Defined by the VSS user							
03 hex	Terrestrial network not available	Reserved. Set to zero on transmit, ignore on receipt.							
04 hex	Terrestrial network congestion								
05-7D hex	Reserved								
7E hex	No response from VSS user								
7F hex	Other unspecified local reason.								
80 hex	Unsupported global function. The parameters (defining the protocol options supported) will be filled in when defined.	0	0	0	0	0	0	0	0
81 hex	Out of global resources	Reserved							
82 hex	VSS user-specific global error	Defined by the VSS user							
83 to ~~FD~~ FC hex	Reserved	Reserved. Set to zero on transmit, ignore on receipt.							
FD hex	Rejected for internal policy reasons								
FE hex	No response from VSS user								
FF hex	Other unspecified system reason.								

b) **In Table 1-72b, define FDh as "Rejected for internal policy reasons" (and change the reserved span accordingly**)

Table 1-72b. Cause code table

Cause	Function	Additional data encoding
00h	Bad local parameter. The additional data block, which may be repeated, Contains the PI of a parameter which cannot be Satisfied by this ground station. This cause will not be Sent for an illegal Connection Management parameter.	g_8 g_7 g_6 g_5 g_4 g_3 g_2 g_1 p_8 p_7 p_6 p_5 p_4 p_3 p_2 p_1
01h	Out of link layer resources.	undefined
02h	Out of packet layer resources.	
03h	Terrestrial network not available.	
04h	Terrestrial network congestion.	
05h	Cannot support autotune.	
06h	Station cannot support initiating handoff.	
07-7Eh	Reserved	
7Fh	Other unspecified local reason.	
80h	Bad global parameter. The additional data block, which may be repeated, Contains the PI of a parameter which cannot be Satisfied by any ground station in the system. This cause Will not be sent for an illegal Connection Management Parameter.	Identical to cause code 00
81h	Protocol Violation. The first octet of the additional data block contains: 1 - c/r bit (c bit) of the received CTRL; 2 - re bit of the received CTRL; 3 - Disconnected bit (d bit) shall be set to 1 if the LME has no links with the remote LME (the unexpected bit shall also be set to 1); 4 - Illegal bit (i bit) shall be set to 1 if the LME receives an illegal CTRL (i.e., not listed in Table 1-97 and described in Section 5.3.4); 5 - Unexpected bit (u bit) shall be set to 1 if the LME receives a legal CTRL which is not legal in the context in which it was received. The remaining octets contains the parameter value of the Connection Management parameter (m bits) if included in the illegal CTRL. After transmitting or receiving an LCR with this cause Code, an LME shall delete all of its links.	0 0 0 u i d p c m_8 m_7 m_6 m_5 m_4 m_3 m_2 m_1
82h	Ground system out of resources.	
83-~~FEh~~FCh	Reserved	
FDh	Rejected for internal policy reasons	
FEh	No response from VSS user	
FFh	Other unspecified system reason.	

C.1.18 Inconsistent list parallelism

In Section 1.4.1.7, bullet 4, the list of DLPDUs is described as being for "link initialization, reset, and maintenance" while the SZOM is listed last. The SZOM should be listed first to follow the structure of the description (or the DLPDUs should be listed in alphabetical order), as follows:

"Other DLS link control DLPDUs, consisting of SZOM FRMR, FRMR_ACK, DM/DISC and DM/FRMR ~~and SZOM~~, for purposes of link initialisation, reset and maintenance."

C.1.19 Combined list isn't clear.

In note 2 of Section 1.4.2.3.2, a list of 3 items (c/r, re, and ucid subfields) are defined separately. Thus the note should be reworded as two sentences (one dedicated to Table 1-71g and the other to Section 1.5.2.6).

C.1.20 Incorrect sense of logic in Q5wait operations

Section 1.4.1, the bulleted list, item (b) calls out a service as "indication that user data has been sent". First, what is the requirement for this? Can an ATN sub-network take advantage of this? Lastly, I would think that the more typical presumption would be that the data was sent and so an indication would only be required on failure. This should be replaced with "indication that the user data was not transferred within Q5wait seconds".

C.1.21 QOS Interface to DLS Service User

Section 1.4.1.6 says that the "DLS shall accept an indication of priority" but doesn't say from whom. Is it clear that this is from its upper layer in the DL_data.req? Is there an unstated requirement that it should include the priority (received from the peer) in the DL_data.ind? The presumption is that the Q5 parameters are consistent for any priority. Should this be included in a note of the following form: *"Note. – The DLS service user's selection of priority affects the QoS parameters used in the transfer of the DLS user packet as well as the queuing of the packet."*

C.1.22 Missing clarification on broadcast address

Clarify 1.4.2.2 to say that the all-ones non-unique address is to be used as a destination address only.

> "A mobile station using the non-unique identity address shall randomly choose a 24-bit address. The non-unique identity address of all zeros shall not be used. The non-unique identity address of all ones shall be used as a destination address for broadcast applications only. All radio units located at a station shall use the same non-unique identity address."

C.1.23 Missing useful cross-references

C.1.23.1 TD1 expiration

Need a note in section 1.4.3.1 pointing to 1.4.4.14.2 for other actions to take when TD1 expires.
"Note. – See Section 1.4.4.14.2 for a more complete set of actions when TD1 expires."

C.1.23.2 Exception to the use of the response reservation type

Section 1.4.4.5.2.1 should reference 1.4.4.12 as an exception to the use of the response reservation type.

"Note. – See Section 1.4.4.12 for an example of when the response reservation type is not used."

C.1.24 Unclear note

In section 1.4.2.1, I believe that the word "sent" should be "received" in the note.

C.1.25 Guidance on link termination

Is there a need to provide a summary of the reasons for link termination (e.g., DM/DISC, DM/FRMR, CTRL_LCR, CTRL_RTS (IB=1), pect-derived missed indication, etc)? If so, should it be added in the guidance material, in a note, or in the TM to be cited as various reasons why a link may be torn down. Are there any differences in the behavior of either the DLS or LME because of the reason for the disconnection? For example, section 1.4.4.14.2 attempts to provide a list of reasons why a link is terminated, but it is not complete.

C.1.26 Implied Implementation not correct

One is not sure about the value of the note in Section 1.4.4.2. First, we have found that better performance can be achieved if the DLS handles retransmissions. Second, since this isn't tested, it should read "...nominally is handled in the VSS" or (my preference) "...may be handled in the VSS or DLS".

C.1.27 Apparently redundant section

Section 1.4.4.3.2 and it subsections appear redundant.

It is not obvious what new requirements are added by 1.4.4.3.2 and its subsections. The definition of ND3 implies the use of single or multiple fragments. The requirement to take into account 1.4.4.12.3 doesn't appear to say anything. How to set the M and prio subfields are already defined in their appropriate sections. If anything need be said, it could be combined with 1.4.4.5 and 1.4.4.6. (c.f., the last sentence of 1.4.4.4.)

The title of 1.4.4.3.2.1 is "number of segments" but should be "number of fragments"? And, the title should not be 'determination of number' when it is only determining single or multiple fragment. Also, there are actually 3 possibilities (short unfragmented, long unfragmented, or long multi-fragments). This text would best belong in the guidance material with message sequence charts showing the behavior rather than as words.

On an editorial note, In section 1.4.4.3.2.2 and 1.4.4.3.2.3, the lists are not really lists and should just be combined into a single paragraph. Also, 1.4.4.3.2.2 says "set to zero" while 1.4.4.3.2.3 says "set to 1" and "set to 0". We should harmonize the style.

C.1.28 Incomplete proposal on defining the reservation priority subfield

Note 3 in Section 1.4.4.6.1 was added to define how the priority subfield of the unicast reservation type is set. If the text of 1.3.14.4.3 is unclear, then it should be reworded so that it is clear that the priority is set to the priority of the data expected to be transmitted in the reserved slot (and not the priority of the data currently being transmitted). Curiously, there is no priority field in the info transfer reservation type. In any event if the added note improved the clarity (which I do not believe), then we should probably do the same thing throughout the document (e.g., the unicast field in Section 1.4.4.6.3.1). My proposal is to clarify the use of the priority field in Section 1.3.14.4.3 and not add note 3 to Section 1.4.4.6.1.

C.1.29 Duplicate text in handling DATA DLPDU reception

Section 1.4.4.6.5.1 could be simplified by simply referring to Section 1.4.4.5.2.1 since the response is the exact same.

"A receiving station which transmitted a CTRL_CTS or INFO_CTS DLPDU in a DLS burst containing an information transfer request reservation field (and consequently has a reservation for an acknowledgement) and which has received the DATA DLPDU ~~with the same setting of T bit as is contained in the CTS~~with a T bit not equal to T_1, shall ~~transmit in the slot reserved for an acknowledgement an ACK DLPDU in a DLS burst~~follow the procedures of 1.4.4.5.2.1.

~~a) A CTRL_ACK or INFO_ACK DLPDU shall be sent in response to a CTRL or INFO DLPDU respectively;~~
~~b) The T bit shall be set to the value of the T bit in the received DATA DLPDU.~~

~~The DLS burst containing the ACK DLPDU shall contain a response reservation type except as determined by the procedures of Sections 1.4.4.12.~~"

C.1.30 Missing requirement on receipt of connection request failure

Section 1.4.4.7 specifies the transmission of a general failure if a station does not implement the DLS functionality. However, there are no requirements on storing this failure and not contacting the station again. We should add a requirement on a station receiving the general failure with error code = 0x80 (i.e., note this failure in the PECT and don't contact the station again).

"*Note.-- The response upon receipt of a general failure, described in Section 1.3.20.1, is to not transmit another DLS burst to the sending station for the duration of the backoff timer.*"

C.1.31 Misplaced requirement in fragment processing

Section 1.4.4.9.2, the last sentence of the second paragraph appears redundant or out of place (since it is speaking of M=1, which was handled in the first paragraph). I believe that it should be deleted; but, if others feel that it has value, then it should be moved to the end of the first paragraph.

"If any preceding user data packet fragments have been received with, in the case of an INFO DLPDU, the same value of pr subfield and with the M bit set to one, then the user data part of the received DATA DLPDU shall be concatenated to the end of the user data packet fragments while awaiting the arrival of the remaining parts of the multiple fragment user data packet.

If the M bit is set to zero on the received DATA DLPDU, then the user data part of the received DATA DLPDU, including any user data packet fragments received earlier and with which it has been concatenated, shall be passed to the service user as a single incoming user data packet. ~~Otherwise, the received user data shall be retained awaiting the arrival of the remaining parts of the multiple fragment user data packet.~~"

C.1.32Response to undefined combinations

Section 1.4.4.14.2 defines a list of combinations; however, I do not want to have to generate a FRMR on a combination not listed in this section. I would like to add the following note:

"*Note. – Receipt of a combined DLPDU not listed in this section is handled in an implementation-defined manner.*"

C.1.33Duplicate requirement in ACK/CTS combination

Both Sections 1.4.4.6.3.1 and 1.4.4.12.4 define the T bit for the ACK DLPDU. So, bullet (b) should be deleted as being redundant and item (a) should become in-line text. The text below is for section 1.4.4.12.4:
"

~~a)~~ A CTRL_CTS, INFO_CTS or UDATA_CTS DLPDU shall be sent in response to a CTRL_RTS, INFO_RTS or UDATA_RTS DLPDU respectively
~~b) The T bit shall be set to T bit of the RTS DLPDU to which the CTS is a response~~"

C.1.34VDL/2 copied functionality not correct

Section 1.4.1.3 calls out the DLS sub-layer as performing a task that the note assigns to the MAC layer. Given that the MAC layer sits below the VSS in the VDL/4, it cannot be considered part of the DLS (as it could in VDL/2). This needs to be reworded as "The DLS ~~sub-layer~~ shall rely on the MAC layer to ensure that DLPDUs corrupted during transmission are detected and discarded."

C.1.35UCTRL_RTS also retransmittable

Section 1.4.4.2, the UCTRL_RTS DLPDU should be listed amongst the DLPDUs that can be retransmitted using the parms of 1-58a, as below:

"For all DLS bursts containing CTRL, INFO, CTRL_RTS ~~and,~~ INFO_RTS and UCTRL_RTS DLPDUs, the quality of service parameters Q5min, Q5max, Q5mult, Q5exp and Q5num shall be set as defined in Table 1-58a."

C.2 LME Issues

C.2.1 Elimination of Keep-alive

During the development of the new DLE, it was decided to eliminate the keep-alive (i.e., the T4 timer and RR (P=1)) as it is no longer needed as the presence of the peer is performed with sync

bursts and ground stations are required to broadcast an alert during startup so aircraft re-connect. However, the requirement for this alert could not be found. The alert can be one of the following:

a) DM/DISC. This has no effect on a station that doesn't already have a link to the peer, so it can be broadcast easily, but it violates 1.4.4.1.
b) A new UCTRL packet. This is like a DM/DISC, but with a data field so that we can include useful information (e.g., the number of seconds until the station is capable of accepting connections).
c) Specify the broadcast CTRL_CMD_LCR (i.e., UCTRL with ucid=3) to transmit. This might have an effect on a station that doesn't already have a link to the peer.
d) Add a new parameter to the GSIF indicating that the station has no links.
e) An existing broadcast connection handoff based on higher-layer ground system intelligence.

There is a need to verify that the selected link clear alert interacts properly with the link endpoint discussion of Section C.1.9.

The proposal is to adopt solution (b) and (e) per the following:

a) Number the existing note as note 1 and add a note 2: "*Note 2.—Keep-alives have been eliminated from the protocol as peer presence is performed with sync bursts and ground stations transmit an alert on startup per Section 1.5.x. or the ground system transmits a broadcast connection handoff"*
b) Add a new Section 1.5.x:

A ground system that supports link connections shall transmit one of the following DLPDUs:

a) *a UCTRL_DM at least 3 times during the first minute of operation of every ground station;*
b) *a broadcast connection handoff from an appropriate ground station at least 3 times during the first minute when any ground station reboots.*

Note.—This may be accomplished either in fixed reservations or delayed burst transmissions.

Author's Note: The wording on item (b) above could be made clearer.

c) Modify Section 1.5.2.6 to define a UCTRL_DM field with ucid=4 and make 5-15 reserved: "ucid=4 indicates that the UCTRL DLPDU contains a UCTRL_DM as defined in Section xxx.

The UCTRL_DM shall define the period of time until an LME will accept new connections. If the most significant bit is a one, then all existing connections are disconnected without any automatic recovery. The seven least significant bits encode a field of 0-127 seconds of time until new connections will be accepted. The field is encoded per Table 1-71xx.

Table 1-71xx is a single-byte value

Author's Note: Do we want to include a note saying that, unlike the other UCTRL DLPDUs, this is not available as a CTRL parameter simply because no utility could be determined for it; however, if such a need is identified in the future, then it will be added?

C.2.2 Incomplete link disconnection list

Modify section 1.5.7.4 (and possibly others?) so that a DM/DISC is not the only reason for a link being disconnected. Since this document proposes the addition of a DM/FRMR and a UCTRL_DM DLPDUs, this section should be rewritten to not specify the mechanism by which the link was torn down. Either it should specify when a link is torn down, when no active links are available, or similar wording.

C.2.3 INFO transfer during link establishment

The behavior of the DLE during link establishment should be specified in the DLE section and not the LME section. In addition, VDL/2 (from which this was copied) could only retransmit the entire XID (and not the final fragment), and lacked a technical ACK on the XID. The following LME sections should be modified as shown.

1.5.7.4.3 Exceptional cases

If an LME receiving the CTRL_CMD_LE cannot establish the link with the sending LME, then it shall transmit a CTRL_RSP_LCR instead of a CTRL_RSP_LE. If the parameters in the CTRL_RSP_LE from the ground LME are not acceptable to the mobile LME, then the mobile LME shall transmit a DM/DISC to the ground. If the Autotune parameter is included in the CTRL_RSP_LE and the mobile LME is unable to perform the autotune, then the mobile LME shall respond with an CTRL_CMD_LCR (re=0); the link established on the current frequency shall not be affected~~. While waiting for a response to a CTRL_CMD_LE, a mobile LME receiving any unicasted frame other than an CTRL shall retransmit the CTRL_CMD_LE instead of transmitting a DM/DISC~~.

1.5.7.5.7 Exceptional cases

If the ground LME cannot satisfy the CTRL_CMD_HO, then it shall transmit a CTRL_RSP_LCR instead of a CTRL_RSP_HO; the current link shall not be affected. ~~While waiting for a response to a CTRL_CMD_HO, a mobile LME receiving any unicasted frame other than a CTRL from any ground station other than the current station shall retransmit the CTRL_CMD_HO.~~ If more than TL2 seconds have elapsed since the LME initiated the request to send the CTRL_CMD_HO, the aircraft LME shall attempt to handoff to another ground station; the current link shall not be affected. If the mobile LME cannot perform the autotune, it shall transmit a CTRL_CMD_LCR (re=0); the current link shall not be affected. If the parameters in the CTRL_RSP_HO are not acceptable to the mobile LME, then the mobile LME shall transmit a DM/DISC to the ground on the new link.

1.5.7.7.4 Exceptional cases

If the mobile LME cannot accept the handoff request, it shall respond with a CTRL_RSP_LCR; the current link shall not be affected. ~~While waiting for a response to a CTRL_CMD_HO, a ground LME receiving any unicasted frame other than a CTRL from the mobile shall retransmit the CTRL_CMD_HO.~~ If the parameters in the CTRL_RSP_HO are not acceptable to the ground LME, then the ground LME shall transmit a DM/DISC to the mobile on the new link.

C.2.4 LME processing of CTRL collision

Both peers can send a CTRL_CMD to its peer at the same time. This is called a CTRL collision. There are two problems here: one at the DLE layer (dealing with dueling IB=1 frames) and one at the LME layer (dealing with generation of the CTRL_RSP).

In VDL/2, the handling of colliding unnumbered frames (of which an XID is one) is discussed in the DLE section. When the LME was copied from VDL/2, it wasn't noticed that this was not included. Either a new section (in 1.5.7?) or as appropriate sentences throughout the relevant sections of 1.5.7.x that if an LME has transmitted a CTRL_CMD and receives a CTRL_CMD (rather than a CTRL_RSP), then if the station has a higher numbered link address it shall process the received CTRL_CMD (and disregard its CTRL_CMD). Similarly, the station with the lower numbered link address shall ignore the received CTRL_CMD and not generate a response.

C.3 Other technical issues

C.3.1 Need to mention DLS in DoS message

The DoS message should include an indication of DLS support for a frequency. Table x-yy should include an encoding for DLS.

C.3.2 Broadcast link management DLPDU

Table 1-69b, which details the encoding of the broadcast link management DLPDU, includes a parameter id and length. For ucid of 0 or 3, this table is correct. For ucid of 1, 2, and the proposed 4, this table is not correct as the parameter id and length are not included. (In order of my preference), either a note should be included at the bottom of the table indicating this, the descriptions of the individual ucid encoding should be expanded to explain this, or another table should be provided with each detailed ucid definition including which table it is encoded against. In addition, Table 1-57a has been updated with the new format for the CTRL DLPDU and Table 1-69b should be harmonized based on the new encoding.

C.3.3 Compressed UCTRL formats

Sections 1.5.3.6.6 and 3.2.7.1 talk about eliminating the parameter ID but don't mention eliminating the parameter length. I believe that this was an editing oversight during the drafting of the new DLS and the new compressed XID formats:

Section 1.5.3.6.6 and 3.2.7 should be modified as follows: "…within a ~~GSIF~~ UCTRL DLPDU with the...parameter and length ID shall be omitted and no other parameter shall be included in the ~~GSIF~~UCTRL DLPDU..."

Section 1.5.2.6, ucid=3 talks of 'ho' bit. This was changed to 're', but with the change to the CTRL names, the text can be clean up as:

> ucid=3 indicates that the UCTRL DLPDU contains a ~~broadcast~~ CTRL_ ~~CMD~~BCST_HO (the connection management parameter shall not be included). ~~The values of c/r and ho shall be assumed to be equal to 0.~~

Finally, the compressed UCTRL encoding added one byte over the previous compressed XID format for GSIFs. We need to verify that the basic one-slot messages can still be sent.

C.3.4 Performance Issues

While implementing the protocol layer, the following performance issues were noted. These are not described in great detail, since a proper simulation is required to determine optimal parameter settings. However, this section is included to indicate that the "out-of-the-box" performance of VDL/4 is not likely to be optimal without further work.

C.3.4.1 Retransmission parameters

The retransmission parameters were copied directly from VDL/2. These parameters and parameter values were based on my original simulations in 1992. The purpose for the exponential backoff delay is to stabilize the linear system that we model the channel as. However, the fairly high Q5mult, which was needed by VDL/2, may be too high for VDL/4 since the number of random accesses is lower (in particular, the ACKs are not transmitted randomly). In any event, since the 95% transfer delay is the parameter to be optimized, even a single retransmission will cause large delays.

C.3.4.2 Fragmentation parameter

A fragmented transmission consists of an RTS (unicast), CTS (info-xfer), RTS/INFO (response), CTS/ACK (info-xfer), etc. The number of transmissions is thus controlled directly by the size of the INFO DLPDU. The overhead (in bytes) is 2 slots for the initial RTS/CTS and about 1.7 slots per cycle (0.7 slots of the first slot of the INFO/RTS plus a slot for the ACK/CTS). Thus, the efficiency of the scheme asymptotically approaches (ND3 – 0.7) / (ND3 + 1).

As the ND3 affects the number of fragments to transfer a packet, the transfer latency is also affected by the delays between transmissions. For example, with an average delay to the selected slot of 5 slots and an ND3 of 5 slots, the transfer delay will be tripled as the select slot delay is suffered twice per INFO DLPDU relative to transmitting the packet in a single burst.[4] Thus, there is a definite tradeoff between making ND3 too large (and thus BER and/or slot selection difficulties dominate) and too small (and thus the overhead dominates).

C.3.5 Optimizing the slot selection algorithm

The slot selection algorithm for data link transmissions is not well designed. In particular, the algorithm should trade-off between an earlier transmission at an undesirable sieve level versus a later transmission at a more favorable sieve level in a simpler and more optimal fashion. The concept of multiple QoS parameter groups is both overly complex and sub-optimal. The slot selection algorithm for periodic transmissions (where any slot in the range is equally acceptable) is different from DLS transmissions (where earlier transmissions are preferable). Simulations are required to optimize this critical algorithm.

[4] This is because the data burst consumes 5 slots, the delay to the ACK consumes 5 slots, the ACK consumes 1 slot, and the delay to the next data burst consumes 5 slots. Thus, each 5-slot data burst occurs over a 16 slot window for a total increase in transfer latency of 320%. Of course, this ignores any packet losses. Since shorter packets will be received with higher probability than longer packets (because of bit error effects, chances of interference, etc), optimal performance requires balancing the effects of short packet length on delay and long packet length on retransmission.

C.4 Editorial Issues

C.4.1 Typographical errors

Section	Issue
1.4.1	Missing colon at end of 'provide the following services'
1.4.1	Last paragraph, s/Section 1.4.4.7only/Section 1.4.4.7 only/
1.4.2.1	Missing a period at end of note.
1.4.4	Note not terminated in a period.
1.4.2.2.2	Missing period after "Note 4"
1.4.2.3.2	1) Second and fourth paragraph not terminated in a period. 2) Notes are missing a terminating period. 3) The notes should be numbered.
1.4.2.3.5	The priority subfield is defined as p then used consistently throughout the document as pr. This has been harmonized to pr, as p is already used for the persistence value in the random access parameter,
1.4.2.3.6	"Note" and the note itself are not terminated in periods.
1.4.2.3.7	Capitalization of "Initialize Bit".
1.4.2.3.7	In the note, frame changed with DLPDU. All other instances verified.
1.4.3	Double spacing corrected.
1.4.3.4	The first para is missing a terminating period
1.4.3.5	Note not terminated in a period.
1.4.4.3.1	In the note, DM/FRMR is included.
1.4.4.3.1	Second and third paragraphs: s/CTRL,/CTRL/ and s/INFO_RTS,/INFO_RTS/
1.4.4.5.2.1	Bullet (a) not terminated in a period.
1.4.4.6.1	1) Second bullet (b) should be bullet c. 2) s/Note1/Note 1/ 3) Note 2 not terminated in a period.
1.4.4.6.2	the note should be in italics and the sentence is not terminated with a period.
1.4.4.12.4	The last paragraph of section 1.4.4.12.4 should really be 1.4.4.12.5 (and renumbering everything following accordingly)

C.4.2 Other editorial issues

The list style isn't consistent. Some of the lists should be converted to a simple paragraph as the list structure is not necessary. We have some lists which are

lettered and indented (e.g., Section 1.4.1),
lettered and not indented (e.g., Section 1.4.4.3.2.2)
numbered and indented (e.g., Section 1.4.1.7)
bulleted and indented (e.g., Section 1.4.4.12.2)
have a lead-in sentence (e.g., Section 1.4.1)
lack a lead-in sentence (e.g., Section 1.4.4.3.2.2)
have each item terminated by a colon, except for the penultimate item which is terminated with a conjunction (either "and" or "or") and a comma (nearly every other list)
have each item terminated in a period (e.g., Section 1.4.4.3.2.2)
have each item unterminated (e.g., Section 1.4.1)
have some items terminated and others not (e.g., Section 1.4.4.6.1)

What does it mean to 'inspect' a bit (e.g., per Section 1.4.4.9.1 or 1.4.4.10)? How does one test whether a bit has been inspected?

rename ND2 as "max length of a short DLS transmission" for clarification.

Section 1.4.4.11.2, the third sentence speaks of "a FRMR_ACK" and the fourth sentence speaks of "an FRMR_ACK". I prefer the former (which is how I pronounce it), but let's stick to one convention.

Section 1.4.4.12.5, perhaps we should add "small" to the description of the transport ack.