## A Common Data Link (CDL) For Space-Based Communications: Migration of Airborne Hardware to Space

Richard Galindez<sup>(1)</sup>, Darren Morrow<sup>(1)</sup>, Tom Kamlowsky<sup>(1)</sup>, Todd Wilstead<sup>(1)</sup>, Brent Ovard<sup>(1)</sup>, Alex Hailu<sup>(2)</sup>, Ron Reeves<sup>(2)</sup>, Myron E. Moore<sup>(2)</sup>, and John S. Fairbanks<sup>(2)</sup>

(1)Communications Systems West

(2)Telemetry West
L-3 Communications Corporation (L-3)
640 North 2200 West
P.O. Box 16850
Salt Lake City, UT 84116
801-594-3124, Telephone
801-594-2729, FAX
Richard.Galindez@L-3com.com

**Session Topic:** Advanced Technologies

ABSTRACT: CDL (Common Data Link) is the US military's standard communications waveform for Intelligence Surveillance & Reconnaissance (ISR) in airborne platforms. In supporting this standard, the military has numerous air, sea and ground CDL systems for theater connectivity.

What is missing from current CONOPS are space assets that can bring their tactical ISR data directly into the theater, allowing for responsive tasking and collection. With the advent of the Space CDL design, we can bring real-time tactical data into existing theater ground stations.

Bringing space imagery in-theater from direct tasking is a feat never done before even by large satellites. The in-theater satellite imagery concept will be tested out with a small satellite demonstration, implementing a CDL waveform, using a modified airborne qualified CDL communications system in late 2005.

The space qualified CDL design leveraged off a L-3 airborne design to the greatest extent possible, but several aspects of L-3's design had to be altered for space applications and operations. Part selection alone was a significant driver in our design approach. Migrating a state-of-the-art, high data rate, communications, airborne design to space is no simple task since the list of approved parts is drastically limited. L-3 also leveraged the CTX-886 Space Transmitter for all non-baseband design portions.

The success of L-3's design created a significant savings in power, weight and volume over our existing airborne designs; a 58% power reduction, a 45% weight reduction, and a 73% volume reduction. Other design enhancements to the hardware include:

- Operation in absence of software control
- Independent power for uplink and downlink
- Control by either the On Board Processor or Ground Station
- Radiation tolerant components

The performance, hardware and characteristics will also be discussed within the paper.

#### Introduction

L-3's Space CDL program developed a 274 Mbps downlink for LEO application. Funding was through the Army Space Program Office (ASPO) for the end-goal of bringing imagery into the theater for the warfighter.

The program was funded through Critical Design Review (CDR) for the downlink. Additional funding allowed L-3 to build and test a brassboard baseband processor and RF section. The initial program requirements are defined in Table 1 below.

Table 1. Downlink Initial Requirements. L-3 Team exceeded several requirements during the design phase.

System				
Parameters	Requirements			
Downlink Data Rate	274 Mbps			
<b>Downlink Frequency</b>	CDL X-Band			
Waveform	CDL			
Design/Reliability	>0.99 for 2yr mean mission			
Goal	duration			
Encryption	CDL Compatible Type 1			
Orbital Altitude	800 Km			
Orbital Inclination	60 deg			
_	29.7% (30 minutes maximum /			
Duty Cycle	101 min orbit)			
Data Intenface	6 channels Legacy Data and			
Data Interface	Clock (CDL BR-274D)			
Control Interface	Discrete			
Size	8.5" x 8.5" x 2.8"			
Weight	8.5 lbs +/- 15%			
Power	44 Watts +/- 10%, not inc PA			
Ground Terminal				
Support	MIST Compatibility			
<u>Environmental</u>				
Parameters	Requirements			
EMI/EMC	MilStd - 461C			
Outgassing	Total Mass Loss (TML) <= 1%			
	Collected Volatile Condensable			
	Materials (CVCM) <= 0.1%			
Explosive				
atmosphere	No hot pins			
Corrosion	Controlled dissimilar metals			

Launch & Ascent	
Temperature	-20 to 50°C
Humidity	≤ 55%
	down to 10-5 torr, 40 torr/sec
Pressure	decay
Pyroshock	4000G 10,000Hz – detailed curve
Acceleration	10G static
Vibration	10Grms
On Orbit	
Temperature	
(baseplate)	-19 to 56°C op, -50 to 85°C non-op
Radiation	15krad total ionizing dose

L-3 also began development of the CDL COMSEC and Uplink slices. At the end of our funding we reached IPDR (Internal Preliminary Design Review) for the COMSEC slice and completed SRR (System Requirements Review) for the Uplink slice. A mechanical stack for the system follows in Figures 1 and 2 below.

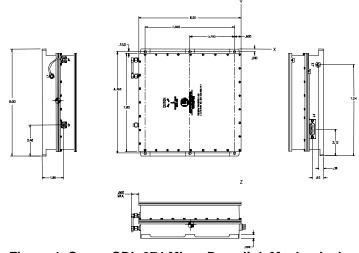


Figure 1. Space CDL 274 Mbps Downlink Mechanical Stack-up (8.5" x 8.5" x 2.88")

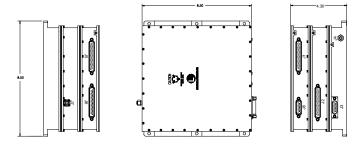


Figure 2. Space CDL 200 Kbps Uplink and COMSEC Mechanical Stack-up (8.5" x 8.5" x 4.3")

### **Design Enhancements**

Our designs leveraged the existing CDL airborne systems developed over the years. Significant waveform code was ported over to the rad hard design. In addition to the code reuse, many enhancements were made from a standard airborne design to focus on the space requirements.

- Operation in absence of software control
- Independent power for uplink and downlink
- Control by either the On Board Processor or Ground Station
- Radiation tolerant components

While several of these enhancements sound like common sense for the space industry, they are not common or necessary for the airborne communications industry.

The most significant enhancements are the reduction in size, weight and power as compared to a similar airborne system as shown in Table 2.

Table 2. Size weight and power for the space qualified system represents a significant savings over a similar airborne system.

Similar Airborne CDL System	Dimensions (inches)	Weight (pounds)	Power (W)
Modem Section	15.75 x 11 x 11.18	41.6	188
TOTAL	1938 cu-in	41.6 lb	188.0 W
Space Qualified CDL System	Dimensions (inches)	Weight (pounds)	Power (W)
Downlink Stack	8.5 x 8.5 x 2.88	9.0	25.2
Uplink/COMSEC Stack	8.5 x 8.5 x 4.3	13.5	53.8
TOTAL	518.8 cu-in	22.5 lb	79.0 W

Overall reduction from airborne to space qualified system is:

- Volume reduced by 73%
- Weight reduced by 45%
- Power reduced by 58%

### **NEW Development, LEGACY Design**

While the Space CDL development is new, the design leverages heavily from the existing L-3 flight heritage CTX-886 Space Transmitter.

- Existing chassis layout used for the Downlink to maintain the same environmental ruggedness
- Internal module layout maintained
- Swapped out the Baseband data processor for the CDL Baseband processor
- Power Amplifier removed for greater flexibility in power amplifier product requirements



Figure 3. L-3 Space CDL Leverages the Flight Heritage CTX-886 Design

The Uplink and COMSEC designs leverage the rich space and airborne design heritage across the board. Overall block diagram is depicted in Figure 4.

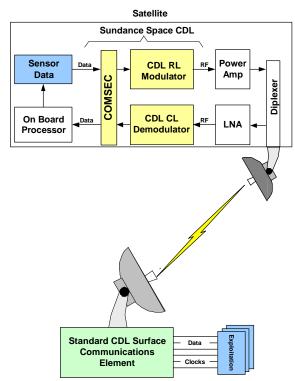


Figure 4 CDL System Block Diagram, allowing connectivity to existing CDL Surface Communications Elements

# **Appendix**

# Common Data Link Description

Referenced from Joint Interoperability Test Command (http://jitc.fhu.disa.mil/cdl/desc.html)

In 1979, the Common Data Link (CDL) Program foundation originated the Interoperable Data Link (IDL) program. The United States Force/Assistant of Secretary Defense (USAF/ASD) and the National Security Agency (NSA) developed the IDL the U-2 platform. In 1988, the Office of the ASD (OASD)/Command, Control, Communications, and Intelligence (C3I) recognized the success of the IDL program with a decision to develop a standard communication architecture that would be common across all Department of Defense (DoD) Services. OASD/C3I mandated the CDL proliferation to collection involved in the users dissemination of wideband Intelligence, Surveillance, and Reconnaissance (ISR) data.

CDL is a full-duplex, jam resistant spread spectrum, point-to-point digital link. The uplink operates at 200kbps-and possibly up to 45Mbps. The downlink can operate at 10.71 -45 Mbps, 137 Mbps, or 274 Mbps In addition; rates of 548Mbps and 1096Mbps will be supported.

The Common Data Link (CDL) program is designed to achieve data link interoperability and provide seamless communications between multiple Intelligence, Surveillance. and Reconnaissance (ISR) collection systems operated by armed services and government provides full-duplex. agencies. CDL digital microwave communications resistant. between the ISR sensor, sensor platform, and surface terminals. The CDL Program establishes data link standards and specifications identifying compatibility and interoperability requirements between collection platforms and surface terminals across user organizations.

Figure 5 depicts the basic CDL signal flow from user interface to radio frequency (RF) output.

The left side is a ground configuration and the right side is an airborne configuration. The basic CDL user interface is comprised of various modules (mux input channels) to a tunable RF output in the Ku band.

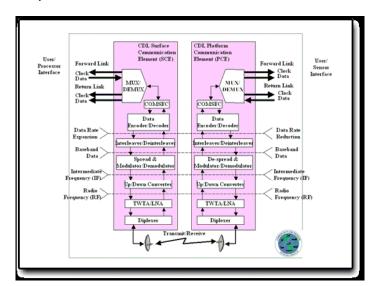


Figure 5 Functional Block Diagram