NAVY EARLY SUCCESS C-BAND DATALINK

HOST RANGE COMMUNICATIONS LINK

Jim Kaness, Revised 4 April 2002

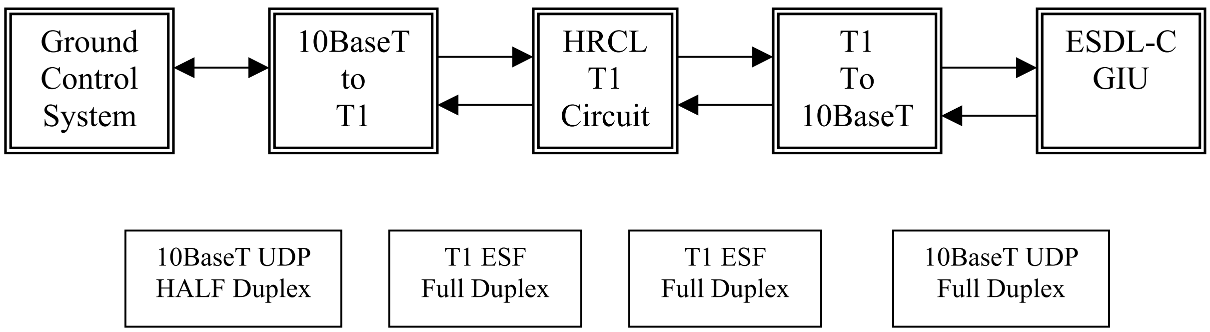
The ESDL will be designed and installed using true full-duplex Ethernet UDP/IP and T-1 interconnections to preclude collisions. The ESDL ground control system (the ITCS-KA) will be connected to this full-duplex network using a half-duplex 10BaseT UDP/IP interface as requested by John Haynes. The IP addresses will be selected to be unique to the system. It is not planned or desired that this network be connected to any other network. The ESDL will stand alone.

From the ITCS-KA, the uplink message will travel through one Ethernet/T-1 bridge near the ITCS-KA, through government-owned and dedicated T-1 circuits from Point Mugu Building 53 to Point Mugu Building 531, and connected through on a T-1 circuit from Point Mugu Building 531 to Laguna Peak Building 94 (or to San Nicolas Island Building 127), and through a second T-1/Ethernet bridge located near the Ground Sub-system GIU. For planning purposes we estimate up to 1000-feet of copper cable (T-1 and Ethernet interconnections) with a total delay of 0.67 microseconds, rounded up to 1 microsecond. For the initial prototype demonstration we will implement single, non-redundant T-1 service.

The ground control system must provide each target uplink message sufficiently early in time to allow for transmission delays encountered in the Ethernet and T-1 circuits, and delays due to GIU processing, so the message is ready for uplink transmission in the designated time slot. Discussions between the Navy and the contractor have identified that the message should arrive at the GIU no later than 3.5 milliseconds prior to the start of its designated time slot to be ready for transmission in its designated time slot. The message must leave the ITCS-KA earlier than its designated time slot by 3.5 milliseconds plus the transmission time delay from the ITCS-KA to the GIU.

Measured delays through the existing government-owned T-1 circuits are presented below. Delays through the two Ethernet/T-1 bridges will not be known until the bridge is selected, but are expected to be in the 1-2 millisecond range for each bridge- a total of 2-4 milliseconds through two bridges. A bridge must take in the entire message, store it, and process it before clocking it out the other side. The minimum latency to do this through two bridges (Ethernet to T-1 and T-1 to Ethernet) is the Ethernet message length plus the T-1 message length plus twice the processing time. With zero processing time, the minimum delay is about 1 millisecond through two bridges and their associated CSU/DSU's (an average of 0.5 millisecond per bridge with its CSU/DSU). Adding in some realistic processing time yields the 1-2 milliseconds per bridge mentioned above. The table below uses 1.5 milliseconds (1500 microseconds) as a default value.

From the discussion above and the tables below, the ITCS-KA must output each message 7.2 milliseconds early before the GIU is to send the message (3.5 milliseconds GIU processing plus 3.7 milliseconds transmission delay to SNI). Each of the 110 ESDL TDMA slots is 9.09 milliseconds long. **Therefore, a good rule of thumb would be to issue each message one slot before it is scheduled to be sent by the GIU.**



Based on the Navy ESDL – ITCS-KA Integration Summary, one target message over the HRCL contains the following bits (in each direction):

Ethernet Header	21	Words
EREM Header	3	Words
DLT Uplink Header	7	Words
Data Cargo	66	Words
Last Word	1	Word
TOTAL MESSAGE	98	Words
	x 16	bits/word
	1568	bits (in each direction)

One 15 Hertz Navy QF-4S/S+ target requires 15 messages/second times 1568 bits/message. This is a total requirement of 23,520 bits per second in each direction.

Six 15 Hertz targets (if we could control one per ground sub-system) would require a total of 141,120 bits per second (each direction)

Other targets will be controlled at 10 Hertz or lower rates.

ETHERNET MESSAGE

The 10BaseT message construct is shown below.

Ethernet Header 21 Words	Encryption Header 3 Words	Transponder Control Header 7 Words	Data Cargo 66 Words	Last Word

The following table shows that the Ethernet link and even the T-1 link are barely used and have ample bits left over for additional messaging.

	Full Duplex 10BaseT	**Full Duplex T-1**
Bits per Second (each way)	10,000,000	1,536,000
Seconds per Bit	0.1 Microsecond	0.6 Microsecond
Bits per Message	1568	1568
Seconds per Message	157 Microseconds	941 Microseconds
Maximum Targets	6	6
Maximum Messages per Target per Second (each way)	15	15
Maximum Messages per Second (each way)	90	90
Total 6-Target Message Time	14.2 Milliseconds	84.7 Miilliseconds
% Utilization for 6-Messages	1.42%	8.47%

Delays encountered through the T-1 links have been measured at Point Mugu and these one-way delays are presented in the table below. Delays through the Ethernet bridge/bridge will probably be in the 1-2 millisecond range at each end and will depend on the exact hardware chosen.

POINT MUGU T-1 DELAY MEASUREMENTS

Loopback at M13 Patch Panel

FROM SITE	**FROM BLDG.**	**TO SITE**	**TO BLDG.**	**MEASURED ONE-WAY DELAY (uS)**	**FIBER LENGTH MILES**	**FIBER DELAY uS.**	**MUX. DELAY uS.**
MUGU	531	SNI	127	650	70.0	578	72
MUGU	531	LPK	94	100	3.9	32	68
MUGU	531	MUGU	53	71	0.2	2	69

NOTES

1. uS stands for microseconds.
2. MUX Delay includes the multiplex equipment on both ends.
3. Fiber delay assumes a propagation velocity of 0.65 times the speed of light.

One-Way Delay to Laguna Peak GIU

Component	Component Delay	Cumulative Delay
Ethernet/T-1 Bridge	1500 microseconds (est.)	1500 microseconds
T-1, B-53 to B-531	71 microseconds	1571 microseconds
T-1, B-531 to B94	100 microseconds	1671 microseconds
T-1/Ethernet Bridge	1500 microseconds (est.)	3171 microseconds
1000-feet copper cable	1 microsecond	3172 microseconds

One-Way Delay to San Nicolas Island GIU

Component	Component Delay	Cumulative Delay
Ethernet/T-1 Bridge	1500 microseconds (est.)	1500 microseconds
T-1, B-53 to B-531	71 microseconds	1571 microseconds
T-1, B-531 to B127	650 microseconds	2221 microseconds
T-1/Ethernet Bridge	1500 microseconds (est.)	3721 microseconds
1000-feet copper cable	1 microsecond	3722 microseconds

Bridges and routers for true full duplex UDP 10BaseT to T-1 are available from several sources, but are not as common as the customary half-duplex TCP/IP equipment.

The "interface converter" currently under consideration for the 10BaseT to T-1 interface is the RIC-T1 with the IR-ETH/Q DTE interface. The unit is made by RAD Data Communications and is available through several distributors in the USA. Data sheets are downloadable from http://www.rad.com/products/family/ric-e1t1/ric-e1t1.htm

The IR-ETH/Q DTE interface mentioned above provides a DIP-switch for optioning the 10BaseT LAN interface to either half-duplex or full-duplex. The IR-ETH plug-in LAN interfaces can be ordered with a BNC connector for 10Base2 service.

PORT AND IP ADDRESSES

Point Mugu Nodes	Function	Port	IP
ITCS-KA	Transmit	5007	
	Receive	5008	
LPK GIU-1	Transmit	7102	
	Receive	7101	

ETHERNET HEADER

The 21-word Ethernet header provides for an Ethernet-II Network Access header and UDP/IP protocol as shown in the following table.

Variable	Word	Value	Description
Ethernet Protocol Header Words 1-7	Words 1 - 3 Words 4 - 6 Word 7	1122 3344 5566 0260 8CE8 CDBA 0800	Hardware destination address (example) Hardware source address (example) IP type is 0800
IP Header Words 8-17	Word 8	4500	IP Version = 4 Number of 32-bit words in header = 5 00h = Type of service (routine, normal delay)
	Word 9	0026	Length of header and all data (UDP and User)
	Word 10	50AB	Process ID = 50AB
	Word 11	0000	Fragment offset, set to 0
	Word 12	1E11	Time to live, set to 30 (1Eh); IP Protocol, UDP=17 (11h)
	Word 13	E99E	Checksum value of header
	Words 14 - 15	813D 3002	IP Address of Source (129.61.48.2 - example)
	Words 16 - 17	813D 3001	IP Address of Destination (129.61.48.1 - example)
UPD Header Words 18-21	Word 18	09F6 (example)	Source port number
	Word 19	09F6 (example)	Destination port number
	Word 20	0012	Length of UDP header and user data in bytes
	Word 21	7E51	UDP checksum value