Space-Based IP Testing Using COTS Equipment

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Space-Based IP Testing Agenda

- Goals
- Network Topology
- Network Setup
- STS Interfaces and Links
- Test Results
- Conclusions
- Recommendations

Cisco/GRC Goals

- **Could we tie COTS interfaces into STS system without expensive modifications.**
- **Demonstrate use of COTS data networking equipment and protocols with STS and/or ISS *with delay* (600 msec in each link).**
- **Demonstrate applications such as VOIP, IPTV, Telnet, Wireless LANs.**

MCC Goals ?

- **Can a COTS router replace the OCA now.**

  - OCA lost 3 cards on the ground due to lightening strike.

  - Replacement may take up to 18 months

  - Running with no spares

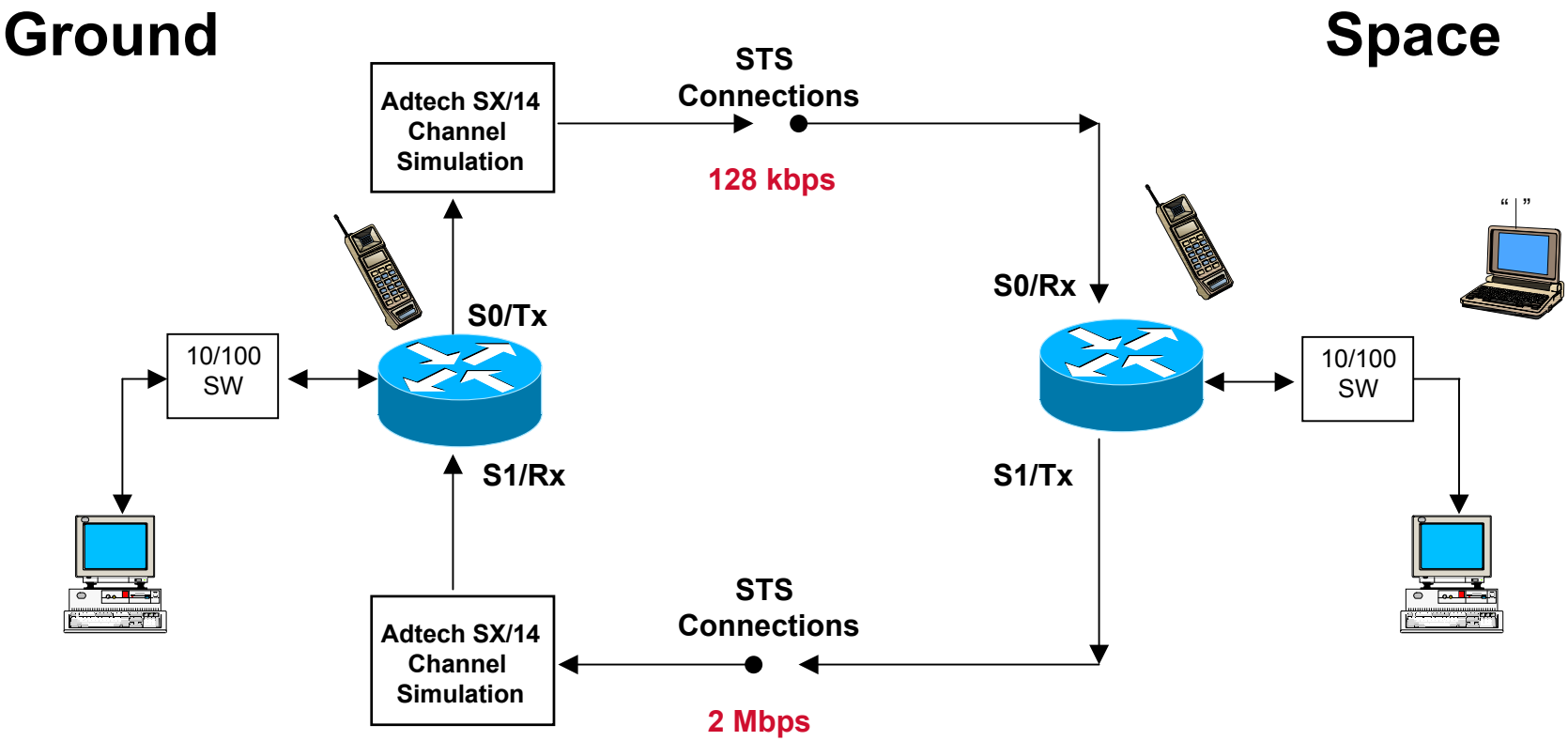
ESTL Goals

- **Ensure that all communications fully functions at the guaranteed BER, 1E-5.**

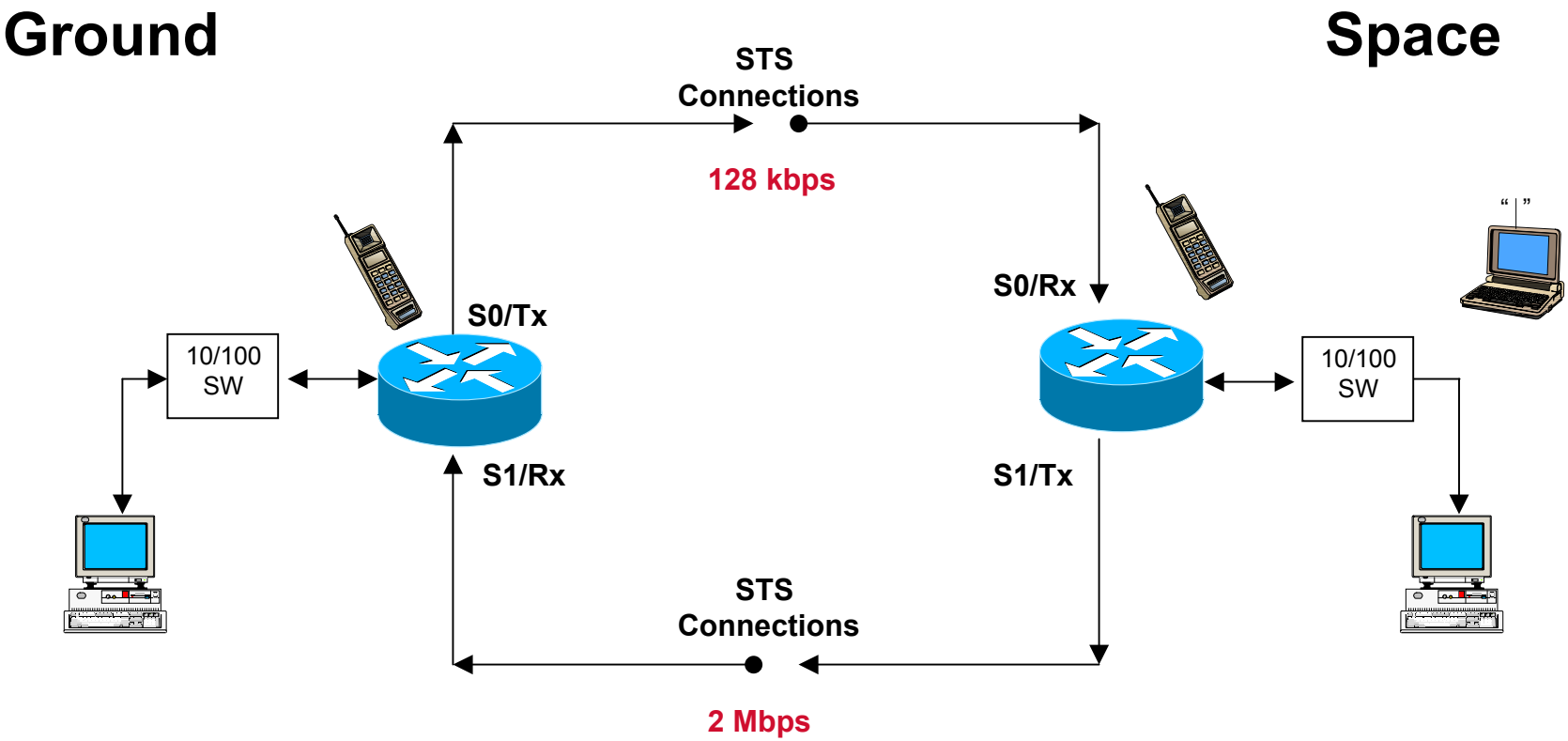
  - NASA certainly needs to do this if that is the truly an operational point.

- **Determine why something doesn't work (?)**

Network Topology with Delay



Network Topology without Delay



Network Setup

- RS-449 to STS Cabling (with and without delay units)
- Static Routes on simplex links
- DCE to DTE Clocking
- Use “no keep-alive” on simplex links
- Use “ignore-dcd” on DTE interface (be sure cables are connected first!)
- Set “clock rate” on DCE interfaces

Network Setup

- Use NRZI encoding. It solved all zeros, all ones and phase ambiguity problems.
- Use HDLC framing
- Use the “transmit” command on the receiving interface to transmit on the sending interface.

  int S1(Rx)

  transmit int S0(Tx)

STS Links

- ***ALL*** **links guaranteed to 1E-5 (even the FEC encoded link)**

  - Nobody could (would?) tell us what the guaranteed S/N is.

- **Nominal is Near-Error-Free**

STS Links

- Channel 2 FM and channel 3 FM are straight BPSK, no coding, no phase ambiguity resolution, no scrambling.
- Channel 3 PM is implemented as 5 parallel 10 Mbps convolutional encoders/decoders with an over guaranteed BER of 1E-5 after FEC.

		SOURCE					DESTINATION				
INTERFACE NUMBER	SIGNAL	SOURCE	LEVEL/ IMPEDANCE	SIGNAL DESCRIPTION	CONNECTION	CABLE TYPE/ IMPEDANCE	DESTINATION	LEVEL/ IMPEDANCE	SIGNAL DESCRIPTION	CONNECTION	INTERFACE
1	128 kbps FWD DATA	SPA	SEE NOTE 1/ 75 OHM	DIFF. BALANCED	TROMPETER PATCH PLUG PL 75-9	TSP/ 75 OHMS (TWC 78-2)	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE4)	
2	128 kHz CLOCK	SPA	SEE NOTE 1/ 75 OHM	DIFF. BALANCED	TROMPETER PATCH PLUG PL 75-9	TSP/ 75 OHMS (TWC 78-2)	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE4)	
3	128 kbps FWD DATA	QUEST ROUTER	RS422A/ 100 OHMS	DIFF. BALANCED		TROMPETER TWINAX (NOTE4)	SHUTTLE FORWARD LINK	RS422/ 78 OHM	BALANCED	TROMPETER PATCH JACK J 152	
4	128 kHz CLOCK	SHUTTLE FORWARD LINK	RS422/ 78 OHM	BALANCED	TROMPETER PATCH JACK J 72-F	TSP/ 75 OHMS (TWC 78-2)	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE4)	
5	8-48 Mbps RTN DATA	QUEST ROUTER	RS422A or HSSI (NOTE 5)	DIFF. BALANCED		COAX/ 50 OHMS	SPA	SEE NOTE 2/ 50 OHMS	SINGLE-ENDED	BNC PL 20-3	BAL./S.E. BUFFER
6	8-48 MHz CLOCK	QUEST ROUTER	RS422A or HSSI (NOTE 5)	DIFF. BALANCED		COAX/ 50 OHMS	SPA	SEE NOTE 2/ 50 OHMS	SINGLE-ENDED	BNC PL 20-3	BAL./S.E. BUFFER
7	2 Mbps RTN DATA	QUEST ROUTER	RS422A/ 100 OHMS	DIFF. BALANCED		TROMPETER TWINAX (NOTE4)	SPA	1.8-5.0 V_{PP}/ 75 OHM	DIFF. BALANCED	TROMPETER PATCH PLUG PL 75-9	
8	4 Mbps RTN DATA	QUEST ROUTER	RS422A/ 100 OHMS	DIFF. BALANCED		TROMPETER TWINAX (NOTE4)	SPA	1.8-5.0 V_{PP}/ 75 OHM	DIFF. BALANCED	TROMPETER PATCH PLUG PL 75-9	
9	2 Mbps RTN DATA	ESTGT IR	RS422A/ 100 OHMS	DIFF. BALANCED	TROMPETER PATCH JACK J 72-F	TWINAX/ 100 OHMS	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE4)	BAL./S.E. BUFFER
10	2 MHz CLOCK	ESTGT IR	RS422A/ 100 OHMS	DIFF. BALANCED	TROMPETER PATCH JACK J 72-F	TWINAX/ 100 OHMS	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE4)	BAL./S.E. BUFFER
11	4 Mbps RTN DATA	ESTL BIT SYNC	TTL/ 50 OHMS	SINGLE-ENDED	TROMPETER PATCH JACK J3-F	COAX/ 50 OHMS	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE6)	
12	4 MHz CLOCK	ESTL BIT SYNC	TTL/ 50 OHMS	SINGLE-ENDED	TROMPETER PATCH JACK J3-F	COAX/ 50 OHMS	QUEST ROUTER	RS422/ 78 OHM	DIFF. BALANCED	TROMPETER TWINAX (NOTE 6)	
13	8-48 MHz CLOCK	FEC	ECL/ 50 OHMS (-2 v)	DIFF. BALANCED (SEE NOTE 3)	TROMPETER PATCH JACK J72-F	COAX/ 50 OHMS	QUEST ROUTER	HSSI (NOTE 5)	DIFF. BALANCED	COAX/ 50 OHMS	
14	8-48 Mbps RTN DATA	FEC	ECL/ 50 OHMS (-2 v)	DIFF. BALANCED (SEE NOTE 3)	TROMPETER PATCH JACK J72-F	COAX/ 50 OHMS	QUEST ROUTER	HSSI (NOTE 5)	DIFF. BALANCED	COAX/ 50 OHMS	

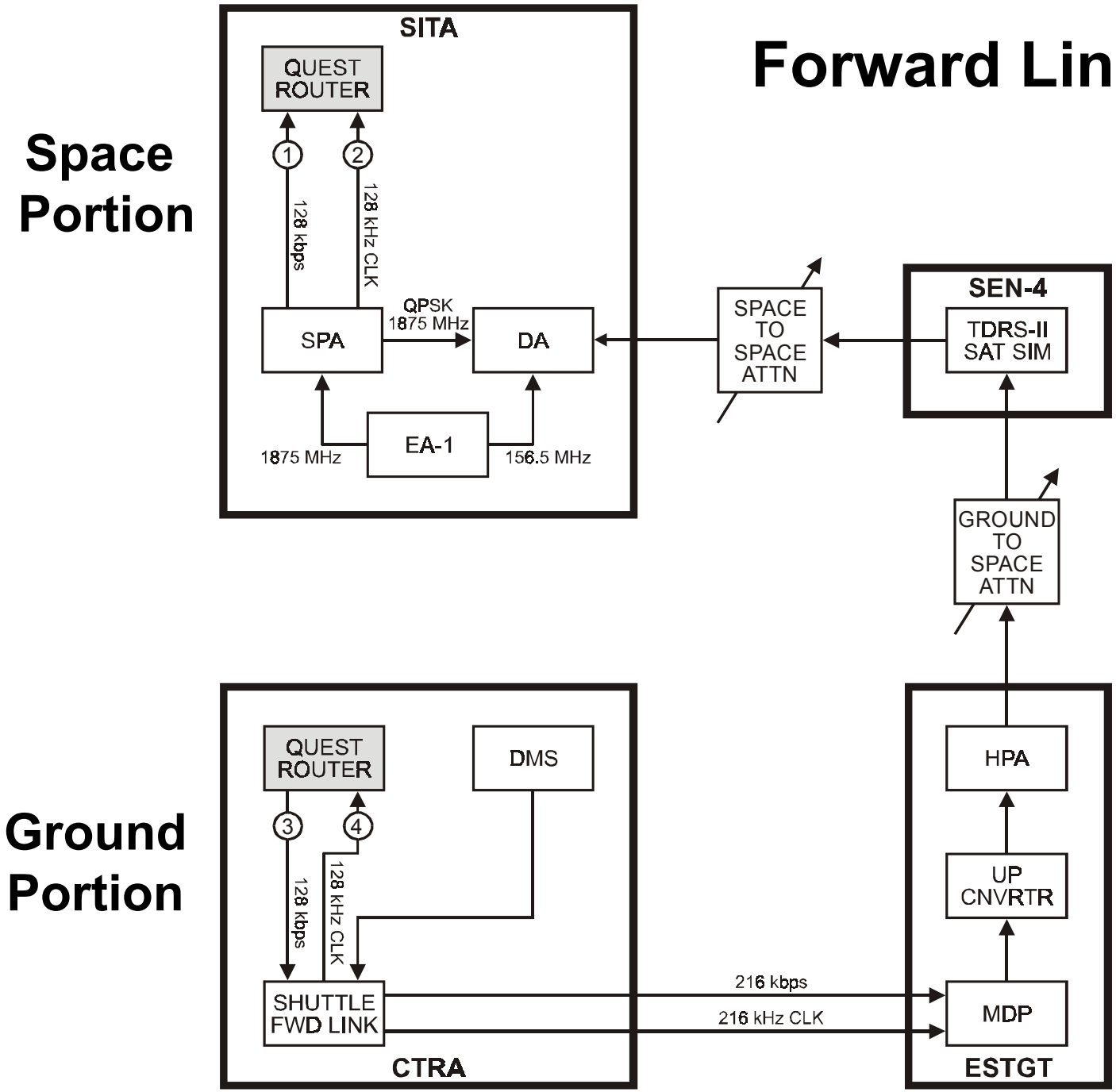
NOTE 1:
HIGH STATE: 2.5v (+1.0v, -0.5v) SIGNAL LINE TO SIGNAL GROUND
0.0v (+0.5v, -0.0v) SIGNAL RETURN LINE TO SIGNAL GROUND

LOW STATE: 0.0v (+0.5v, -0.0v) SIGNAL LINE TO SIGNAL GROUND
2.5v (+1.0v, -0.5v) SIGNAL RETURN LINE TO SIGNAL GROUND

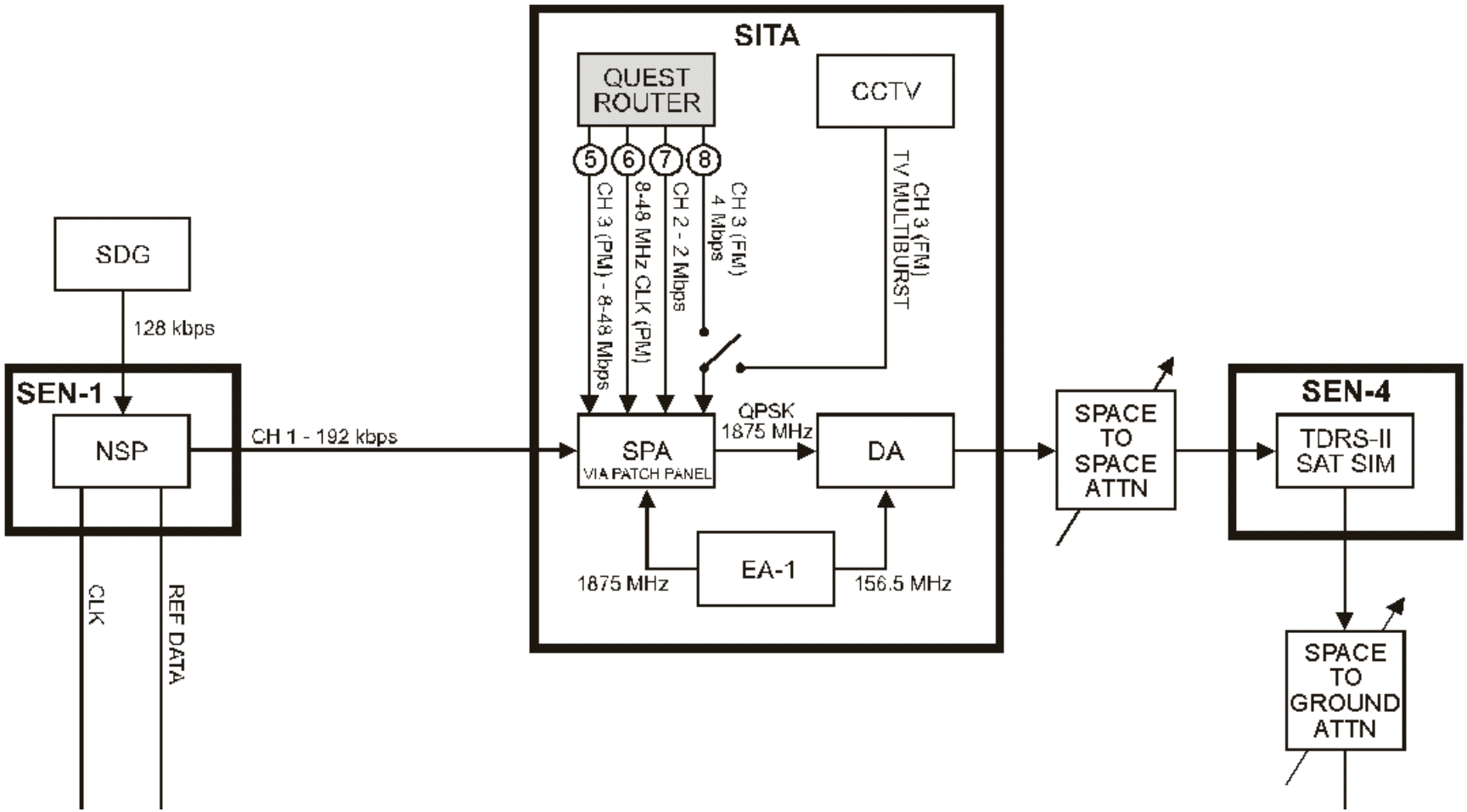
NOTE 2:
DATA LOGIC 1: +4.5v to +6.5v DATA LOGIC 0: -0.5v to +0.5v
CLOCK LOGIC 1: +3.7v to +6.5v CLOCK LOGIC 0: -0.5v to +1.5v

NOTE 3:
BALANCED SIGNAL COMES FROM TWO SEPARATE CABLES THAT PROVIDE THE (+) AND (-) SIGNALS

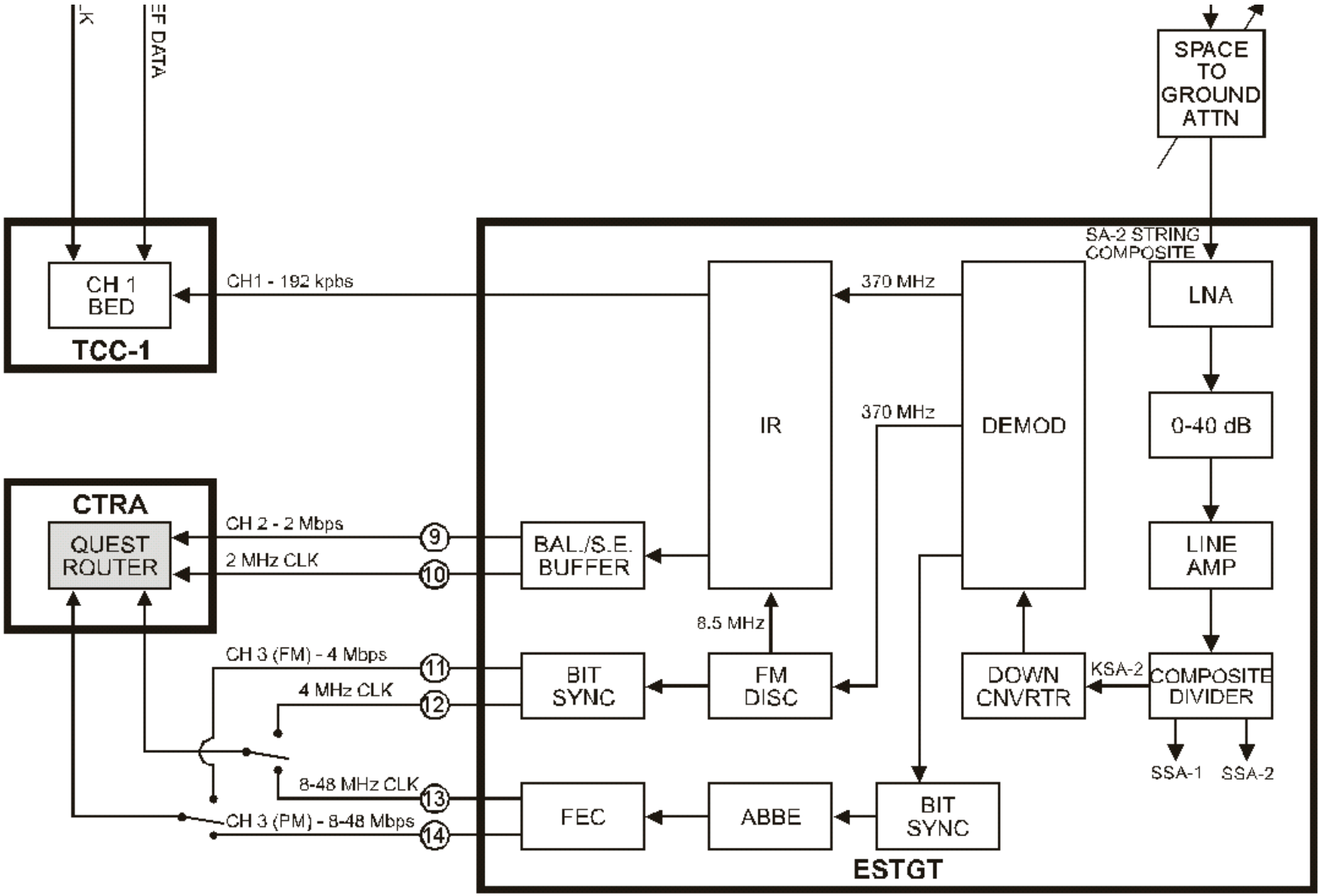
Forward Link



Return Link (Space Portion)



Return Link (Ground Portion)



Preliminary Test Results (All testing was with 1.2 sec RTT)

- TCP works fine error free (12+Mbyte file) using:

  ttcp -t -l1440 -b300,000 10.0.2.54 < file

- TCP does not work efficiently with 1E-6 over 1.2 sec delay (Obviously)
- UDP packet transfers worked fine 2 Mbps error-free
- UDP lost 70% at 1E-6 (why???)
  - TCP did not show this phenomena

Preliminary Test Results (All testing was with 1.2 sec RTT)

- VOIP work fine error free
- VOIP appeared to work even at 1E-5 including call setup (This was a very limited test.)
- Telnet work even at 1E-6

Preliminary Test Results (All testing was with 1.2 sec RTT)

- **Used browser to control the Aironet wireless access point over the link.**
  - **Worked error free, didn't try with errors.**
- **We tried IPTV briefly, but ran out of time. IPTV would have demonstrated multicast over simplex links.**
  - **We can try this back at GRC.**

Conclusions

- **IP will work over long delays (1.2 sec RTT) on near error free links.**
  - **No news here. We tested this may times in the lab with even greater delays.**
- **VOIP with G729.R8 compression appears to be very error tolerant.**

Recommendations

- **Use COTS standard interfaces such as RS422.**
- **Provide duplex links if possible**

  - At least one duplex link (even a low rate link) enable UDLR. Then one doesn't have to do static routing and all the other goofy commands.
- **Fix the radio link - only once.**

Did You Know?

- **Service Module of the International Space Station (the Russian Module) uses the following:**
  - **Ethernet LAN running 100Base-TX**
  - **Cabletron SmartSwitch router**
  - **Module is wired with shielded cat-5 type cable**
  - **3Com 3C589D, or Intel Pro/100 PCMCIA Ethernet cards**
  - **Using VPN's**
  - **All of the module's flight control systems as well as the operational and payload data systems are connected to the same LAN**