EVTM (Ethernet-viaTelemetry):

Get Ethernet Packetized Data Directly From Your Test Article

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Presentation Outline

- System Theory of Operation
  - System description
  - Encapsulation Protocol
  - First Article Hardware
- First Article Evaluation and Flight Testing
  - Lab Testing at NASA AFRC (Take 1)
  - Lab Testing at NASA AFRC (Take 2)
  - Live Flight at Redstone Arsenal
- Lessons Learned/Future Development
  - Data Throughput Evaluation
  - Live Flight Observations
  - Next Generation Improvements

System Theory of Operation

- Additional data translation layer
  - Ethernet to serial data and back
- Physical layer hardware is standard telemetry RF link
- Encapsulation is IP protocol neutral
  - Works with TCP/IP and UDP
- Protocol offered for IRIG inclusion
  - RCC-TG
  - Submitted 4/2014

System Theory of Operation -System Description-

- Ethernet enabled devices at both ends of link
- Standard serial streaming telemetry SST RF hardware
  - Any modulation, any advanced techniques
    - LDPC, Space Time Coding, etc.
- Data rate is set for both directions and is constant
  - User-settable
  - Can be differing data rates in each direction
  - HDLC idle patterns are sent when no information is being transferred
- Data rate set on transmitter defines buffer empty rate

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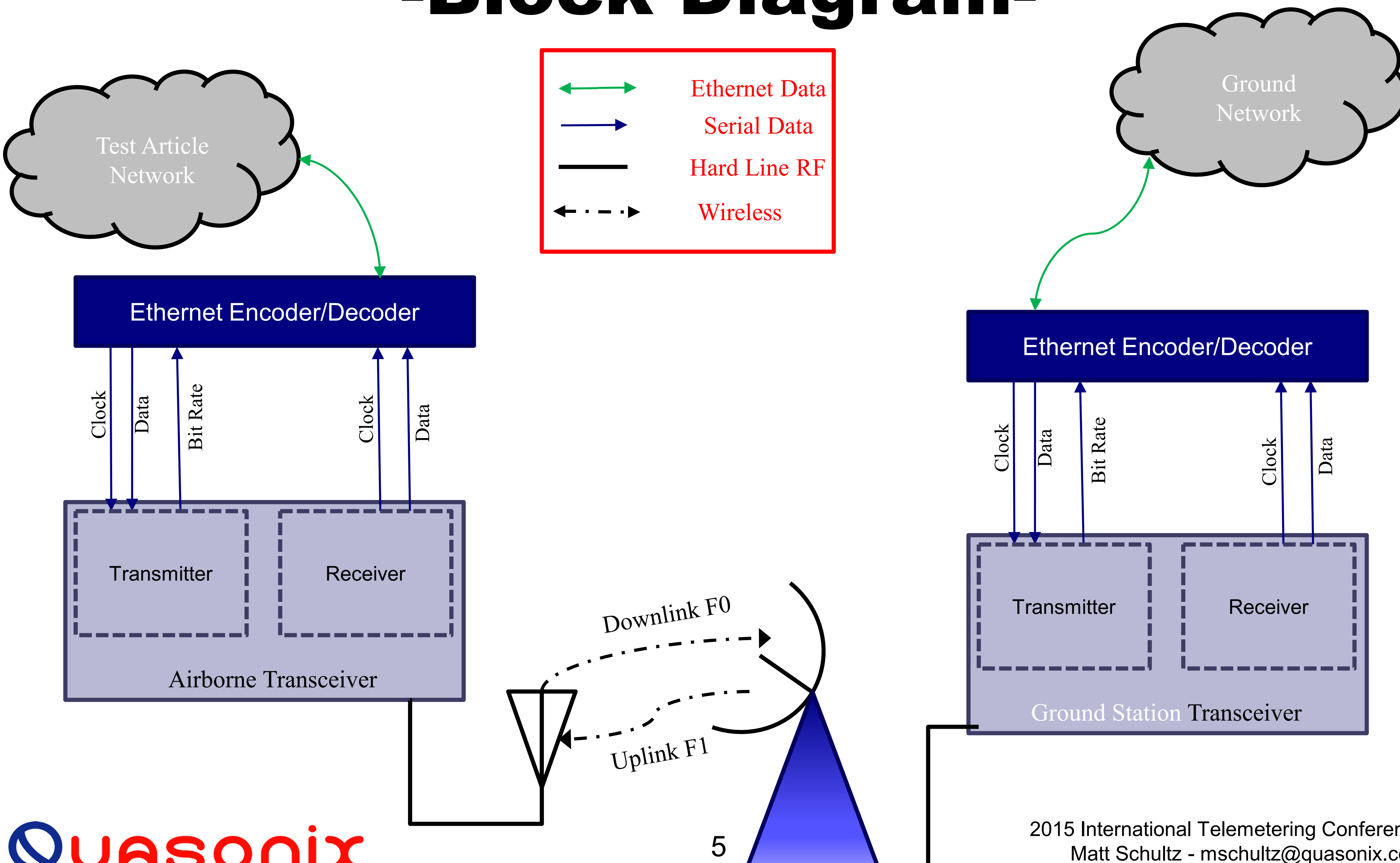
System Theory of Operation -Block Diagram-

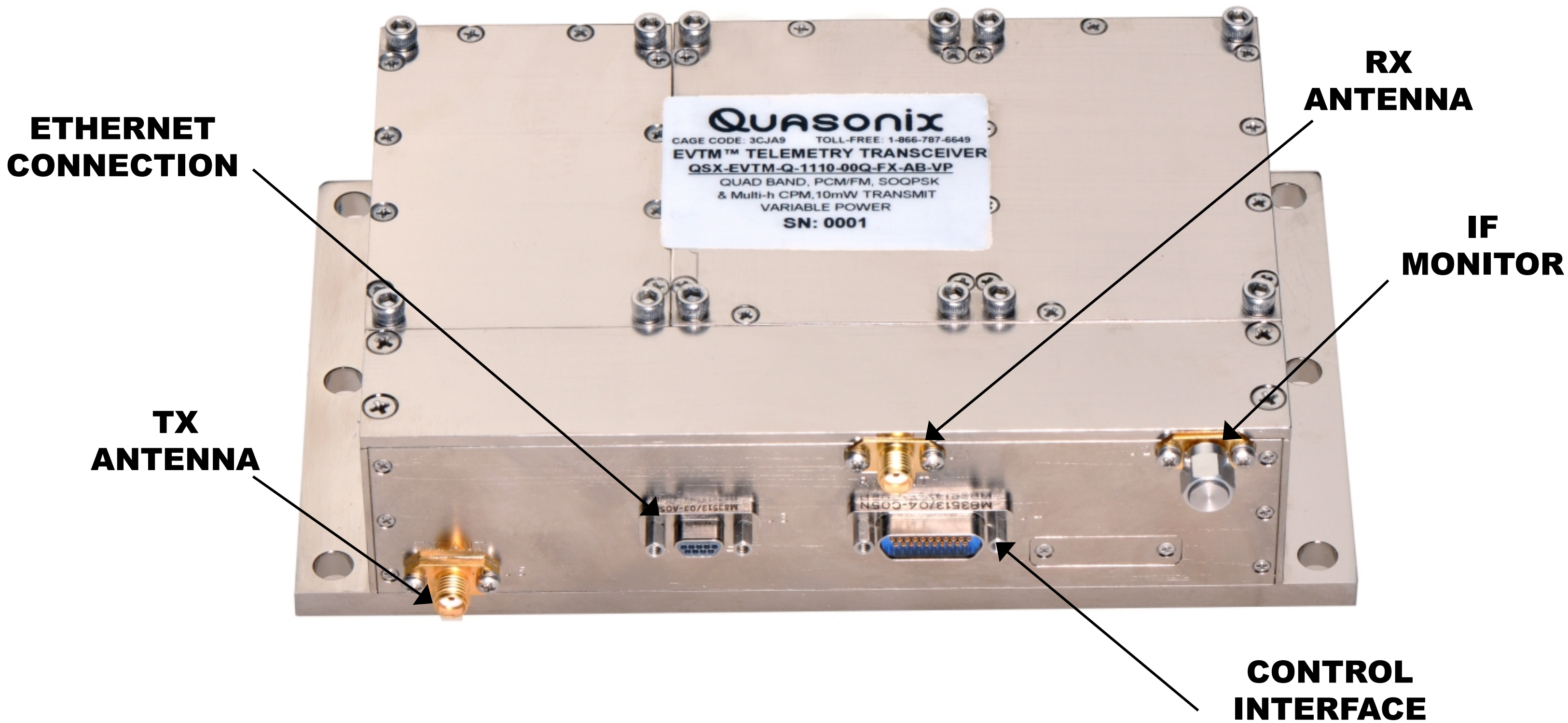


System Theory of Operation -Encapsulation Protocol-

- HDLC Standard
  - <FLAG>< Data Frame (60 to 1514 bytes)><FCS><FLAG>
- Data frame bit stuffing
  - Used to prevent duplicating frame delimiting flag
- Frame check sequence
  - CRC-32 polynomial
    - $X^{32}+X^{26}+X^{23}+X^{22}+X^{16}+X^{12}+X^{11}+X^{10}+X^{8}+X^{7}+X^{5}+X^{4}+X^{2}+X$
- Data transmitted un-encoded in order received

System Theory of Operation -First Article Hardware-

- Compact airborne hardware
  - RS-232 serial control interface



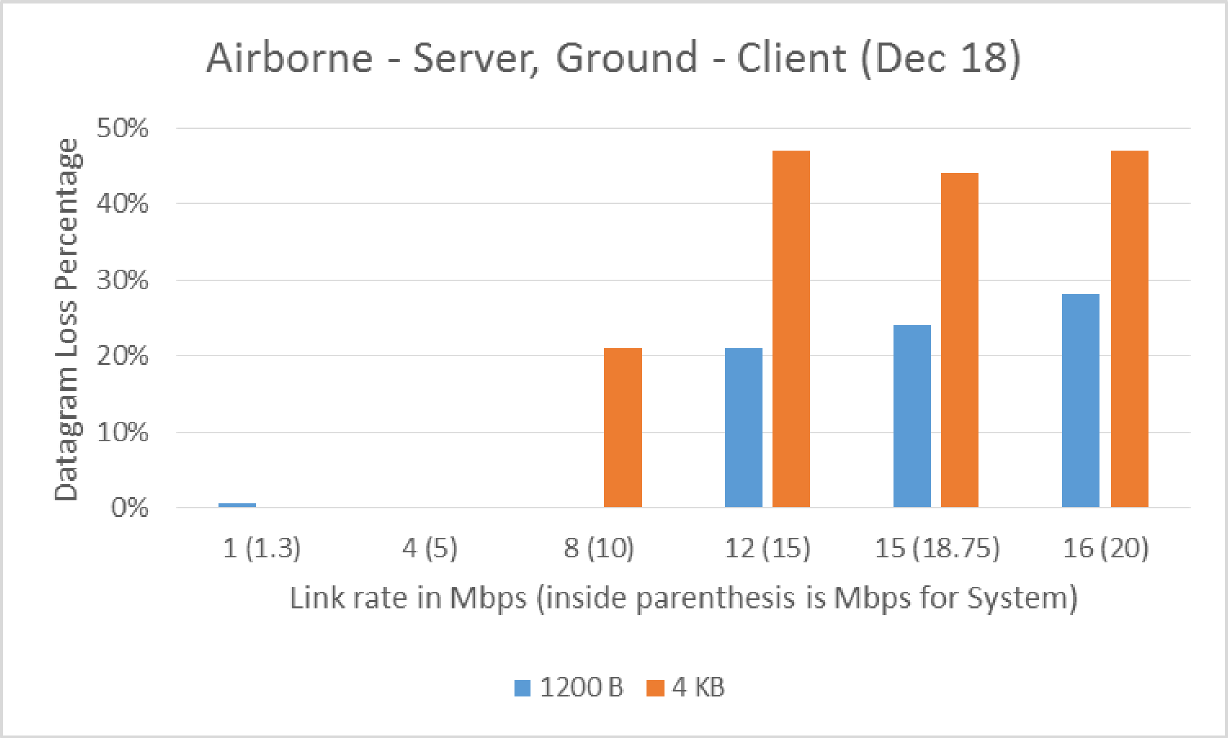
System Theory of Operation -First Article Hardware-

- Rack mount ground station
  - Push button control
  - Graphical feedback

First Article Evaluation and Flight Testing
-Lab Testing @ NASA AFRC Take 1-

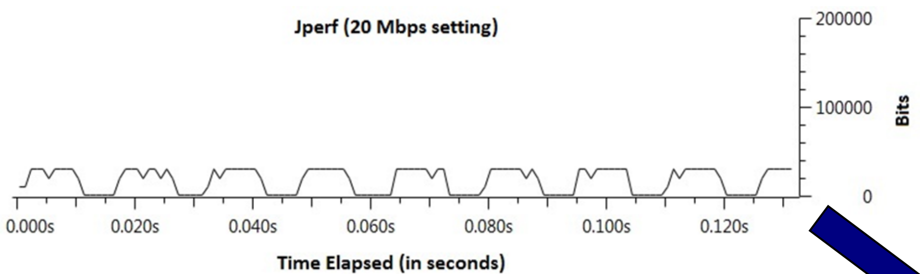
- Hard-wired link
  - Downlink 1750.0 MHz, SOQPSK-TG
  - Uplink 2217.5 MHz, SOQPSK-TG
- Tested at multiple data rates from 1- 20 Mbps
  - 1200B and 4kB packet sizes
  - Network traffic data rates higher than 5 Mbps initially showed significant packet loss
- Discovered buffer overrun issue
  - Adapted serial telemetry hardware had limited receive buffering to withstand high rate burst on wired interface
  - Reallocated limited buffering to maximize buffering on wired Ethernet receive path to extend possible with first generation hardware

First Article Evaluation and Flight Testing
-Lab Testing @ NASA AFRC Take 1-

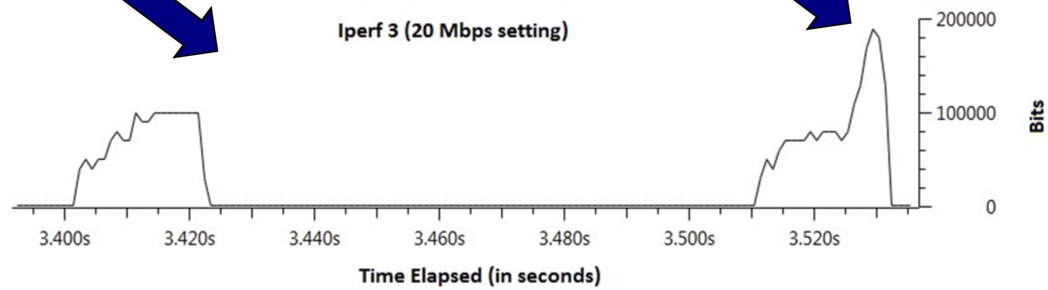


First Article Evaluation and Flight Testing
-Lab Testing @ NASA AFRC Take 2-

- The switch from jperf to iperf3 PC network test software subjected the Ethernet receive to even higher burst rates and buffer over-runs
- Recommend use of flow control to limit packet burst buffing requirements

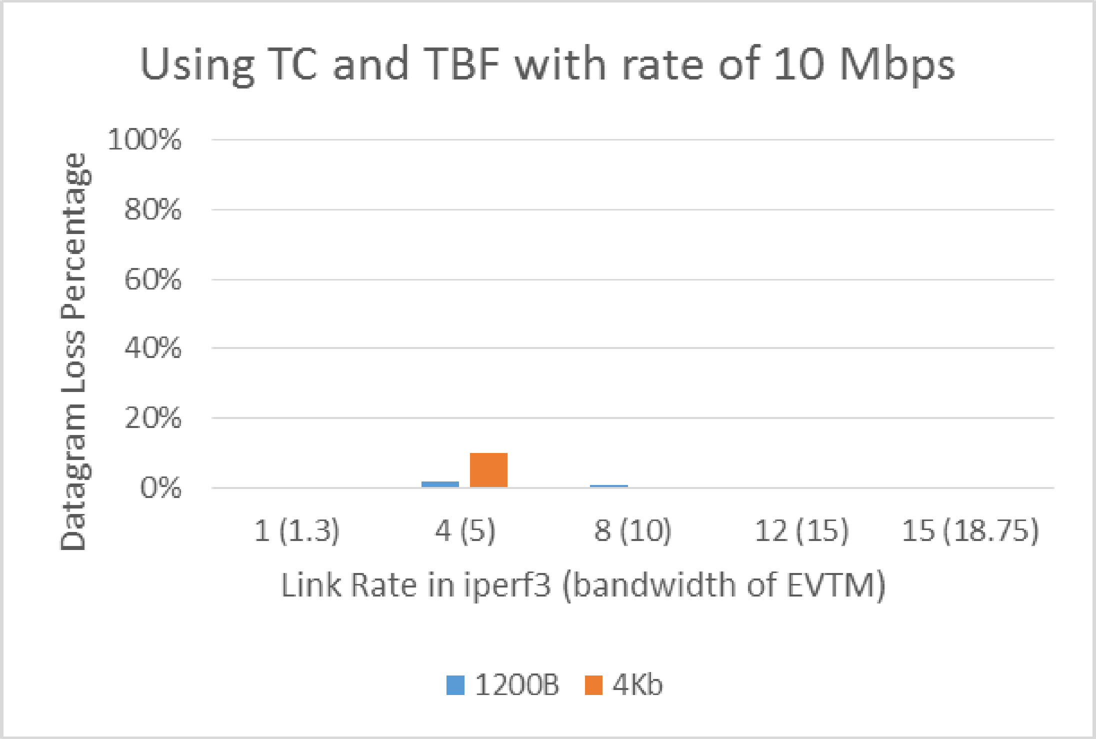


Higher peak burst rates from iperf3 test setup



First Article Evaluation and Flight Testing
-Lab Testing @ NASA AFRC Take 2-

- Loss rates after additional wired Ethernet receive buffering and network flow control



First Article Evaluation and Flight Testing
-Live Flight @ Redstone Arsenal-

- 9.0 Mbps SOQPSK @ S-Band
- Encrypted link (Ethernet encryption)
- Non-steerable antennas
  - Omni on test article, directional on ground
- Link distances of 4 km and 8 km
  - Peak transfer speed of 9 Mbps

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Lessons Learned/Future Development

- Data throughput evaluation
  - Coding overhead approximately 10%
  - Flow control necessary to avoid buffer overrun
  - Buffer size insufficient
- Live flight observation
  - Unit handles encrypted TCP/IP traffic well
  - Ease of integration
- Next generation improvements
  - Increase buffer size
  - Integrate with diversity combined ground station
  - Investigate unidirectional data transfer capability

Questions/Comments