Off the Shelf Wireless Bridges Interfacing to SpaceWire: Possibilities, Practicalities and Opportunities

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Background

- The paper is based on work performed by SEA under the ESA contract for "RF Wireless for Intra-Spacecraft Communications" which, among other activities included:

- High Speed EGSE/AIT wireless support:
  - Assessment and demonstration of SpaceWire-WiFi bridge concept
- Medium Speed EGSE/AIT wireless support:
  - Assessment and demonstration of CAN-BT bridge concept

Wireless in Spacecraft AIV

Wireless offers the following benefits:

1. Reduction in EGSE – Spacecraft bespoke harnesses
2. Simplification of computer interfaces
3. Better isolation in bio-containment programmes
4. Simplification of interfaces into test chambers such as thermal vacuum

1. Reduction in EGSE – Spacecraft bespoke harnesses

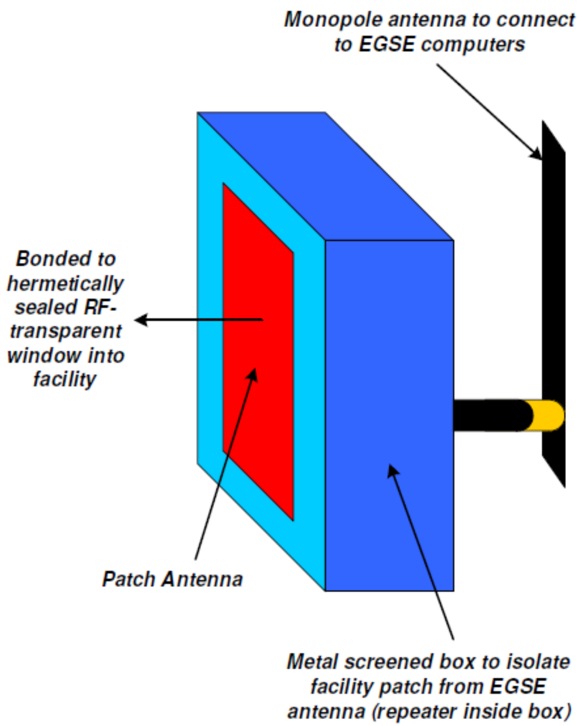
- In spacecraft test, the harness between the spacecraft and EGSE is not only complex but expensive
- At the end of the programme the harness is generally discarded
- Substituting a wireless link for a data handling harness potentially saves cost and waste
- However wireless has limitations in terms of line of sight, and range

2. Simplification of computer interfaces

- The bespoke AIT harness connecting the spacecraft to the EGSE requires that the EGSE computer implement special to type interfaces
- Most wireless systems will interface with standard personal computers
- Use of wireless in AIT simplifies the computer equipments themselves, meaning that if there is a problem on a computer it can be quickly replaced with one bought locally
- Data on wireless WiFi links is also compatible with internet connection

3. Better isolation in bio-containment programmes

- Sample return missions require physical isolation to protect the sample from contamination and for planetary protection
- Interface connectors that perforate the containment barrier risk introducing a contamination path
- Wireless links can operate directly in and out of the containment vessel, or by relay connection through a window



4. Simplification of interfaces into test chambers

- Thermal vacuum test chambers require hermetic interfaces, often new connector panels often need to be designed and made, adding to costs
- tend to be metal and the spacecraft bespoke EGSE Wireless systems could not operate directly into the chamber
- However a series of interfaces in the same band could be carried through by one semi-rigid coaxial connection with antennas at each end, so a lot of data interfaces could be relayed by one connection.

Available Wireless Interfaces

- 802.11 series are LAN based and offer rates from 54Mbps (802.11g) to 300Mbps (802.11n)
- Ethernet has already been interfaced to SpaceWire so this is a possibility to interface with a WiFi bridge
- The alternative at similar rates is “Wireless USB” potentially offering rates at up to 480Mbps
- SpaceWire has also been interfaced to USB so this is a possibility to interface with a Wireless USB

802.11 Tests on SpaceWire Interfaces

SEA tests on interfacing SpaceWire to 802.11 wireless have been demonstrated but we need to take account of:

- The difference between quoted “data rate” and data throughput
- The overlying TCP/IP protocol which assumes a wired guaranteed delivery interface

802.11 Data Throughput

- 802.11g quotes a data rate of 54Mbps
- In reality the actual unidirectional data throughput is less than 24Mbps
- 802.11n increases this rate by:
  - Reducing the guard interval between media access (54Mbps → 75Mbps)
  - Doubling the channel bandwidth, 20MHz → 40MHz, 75Mbps → 150Mbps
- But a 150Mbps 802.11n link typically only gives a unidirectional single channel throughput of 67Mbps

Effect of TCP/IP

- TCP/IP is designed to operate on a wired network with interconnecting routers where a data packet should always reach its destination
- The protocol assumes that if data has not arrived, the network routers are congested and the buffers overflowing
- The wireless protocol compensates for this by slowing down or stopping the data transfer to allow the router buffers to clear then increasing the rate to normal again
- Wireless transfer is statistical in nature so uses retries, which are seen by as network congestion.

Tested 802.11n Throughput

- In tests with a dual channel 802.11n system and a small bespoke Ethernet interface, with an expected throughput of 67Mbps:
- At 30Mbps transfer was consistent.
- At 50Mbps transfer worked at intervals of about 3 minutes at full rate then the rate slowed to a stop and started again.
- It is believed this was a combination of the Ethernet interface, the TCP/IP protocol and the effect of retries on the wireless link.
- This indicates that the wireless should work consistently at 50% loading on the throughput rate. This would allow 120Mbps on a full MIMO (4 stream) 802.11n

Wireless USB Testing

- COTS cable replacement USB wireless was available for a short period but has almost disappeared from the market
- One set tested by SEA gave only 7Mbps data rate against the expected 480Mbps USB2 promises
- This was checked by benchmark software that achieved over 36 Mbps on a wired USB2
- Other commercial reviewers have found the same
- Tests showed its range was limited to about 7m which is likely to be inadequate for Spacecraft AIT
- COTS USB used Ultra Wide Band (UWB) RF and this is likely to cause EMC problems with sensitive RF equipment

Conclusions

- Wireless connection to a spacecraft data system has advantages in AIT
- This is particularly true for biocontainment or planetary protection
- 802.11n is feasible for SpaceWire connection at 30Mbps per temporal stream i.e. a maximum 120Mbps continuous over a 4 channel MIMO
- UWB USB does not seem functional in COTS assemblies and has issues in terms of interference