Pioneer Force WSL TOKYO DENKI UNIVERSITY

衛星構体内ワイヤレス通信を目指したUWB伝送の実験的評価

- Spacecrafts UWB -

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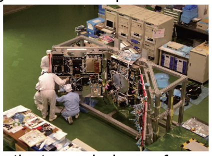
Background

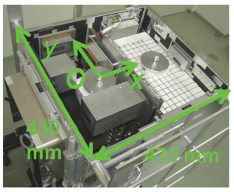
- Adoption of wireless technologies within the spacecrafts:
  - Reduction of cable weight (and launching cost as a result)
  - More flexibility in layout of spacecraft subsystems
  - Reliable connections at rotary, moving, and sliding joints



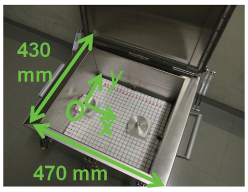
- Multipath propagation affecting the transmission performance
  → Applying UWB technology is a solution
- The propagation study [1] has been followed up with experimental evaluation of UWB link throughput within spacecrafts

[1] A. Matsubara, et al., "Measurements and characterization of ultra wideband propagation within spacecrafts," in Proc. 2009 Loughborough Antennas and Propagat Conf. (LAPC 2009), Loughborough, UK, Nov. 2009.

Measurement Setup (1/3)



a mechanical test model (MTM) of a small scientific satellite



a shield box with use of a radio absorber

Measurement Setup (2/3)

■ Antennas: low VSWR (< 1.3) UWB volcano-smoke

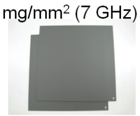
■ Frequency: 4.2 - 4.8 GHz (low-band UWB)
7.3 - 7.9 GHz (high-band UWB)

■ The UWB propagation gain

$$= -10\log\left(\frac{1}{f_H - f_L}\int_{f_L}^{f_H} 10^{\frac{|S_{21}|[\mathrm{dB}]}{10}}\, df\right) \quad [\mathrm{dB}]$$

Measurement Setup (3/3)

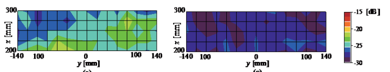
■ Radio absorber
- ✓Attenuated radiowave reflection by 20 dB at 4 and 7 GHz, and by 10 dB within a 1.5-GHz bandwidth
- ✓Thickness: 2.3 mm (4 GHz) / 1.8 mm(7 GHz)
- ✓Weight: 9.0 mg/mm² (4 GHz) / 6.4 mg/mm² (7 GHz)
- ✓Usable in vacuum



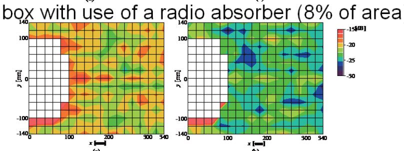
■ Commercial UWB device
- ✓Multiband-OFDM (4.2 - 4.8 GHz, 7.3 - 7.9 GHz)
- ✓Guard Interval length: 60.61 ns
- ✓Nominal throughput: 72 Mb/s

Distributions of Propagation Gain

MTM



Shield box with use of a radio absorber (8% of area)

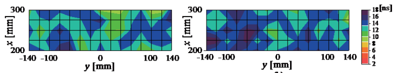


(a) low-band UWB (b) high-band UWB

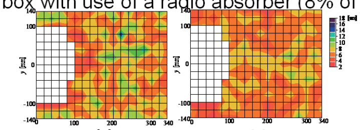
	low-band UWB	high-band UWB
MTM	-28 - -21 dB	-30 - -26 dB
Shield box	-25 - -15 dB	-29 - -19 dB

Distributions of Delay Spread

MTM



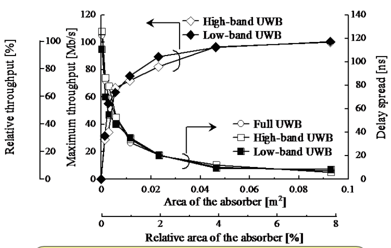
Shield box with use of a radio absorber (8% of area)



(a) low-band UWB (b) high-band UWB

	low-band UWB	high-band UWB
MTM	8.8 - 17 ns	7.7 - 18 ns
Shield box	2.3 - 16 ns	2.4 - 11 ns

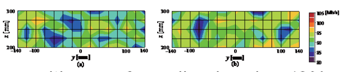
Delay Spread and Throughput Versus Area of the Absorber



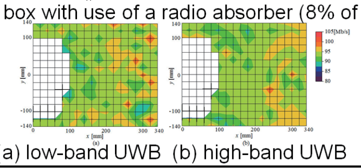
Delay spread smaller ➡ Throughput higher

Distributions of Throughput

MTM



Shield box with use of a radio absorber (8% of area)



(a) low-band UWB (b) high-band UWB

	low-band UWB	high-band UWB
MTM	82 - 97 Mb/s	80 - 97 Mb/s
Shield box	88 - 102 Mb/s	88 - 100 Mb/s

Conclusions

- The delay spreads can be suppressed with the use of a small patch of radio absorber.
- Commercial, off-the-shelf WiMedia devices can be used to accommodate up to around 100-Mb/s data buses within the spacecrafts, as long as the delay spread is suppressed below 10 ns. No significant difference was observed between the low- and the high-band UWB.