URSI Commission C

Measurements and Physical-layer Modelling of Transmission Loss for Gas Turbine Engine Sensor Networks

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Wireless sensor network technology offers a potential step change in gas turbine engine testing and monitoring by alleviating significant disadvantages including lengthy, complicated and expensive wiring harnesses, complex set up processes and instrumentation, design in-flexibility, and inefficient data gathering. Wireless sensor kits for test measurements are currently being assessed by the aerospace industry.

The aim of this study is to extract a physical-layer wireless channel model from a set of channel measurements, in support of the wider, collaborative, WIDAGATE project to assess the potential of wireless sensor networks for the condition monitoring of gas turbine engines. The collaborative partners in WIDAGATE are Rolls-Royce, Selex and University College London. The resulting model is being incorporated into a complete system protocol stack as part of the wider project. The physical layer channel model incorporates interference [1] and noise in addition to signal transmission characteristics.

ISM-band and UWB-band frequency response measurements between pairs of points distributed on a grid over the cylindrical surface of a Gnome gas turbine engine have been made. The measurements, covering the range 2.4 - 2.5 GHz for ISM-band [2] and 3 - 11 GHz for UWB-band [3], have been made without (set 1), and with (set 2), an engine cowling. The corresponding measurement databases form the basis of an empirical transmission gain model.

Analysis of the measurement database has been undertaken and the best-fit first-degree polynomial, $As + B\kappa + C\overline{G}_T + D = 0$, where $\overline{G}_T$ is mean transmission gain in dB (< 0), has been derived. The difference between the measured data and the first-degree model, $\varepsilon_{dB} = G_{Tmeasured} - G_{T\,mod\,el}$, has been modelled in the same way as the original data.

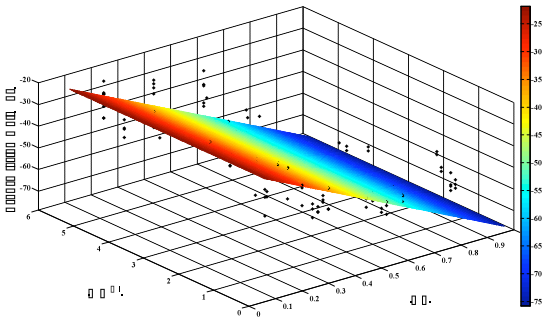

Figure 1 – Example of best-fit first-degree polynomial surface.

Mean transmission gain $\overline{G}_T$ is sensitively dependant on the path length *s* but relatively insensitive to path curvature κ.

[1] EUROCAE ED-14E *"A Joint EUROCAE RTCA Achievement"* [Sections 19-21]. The European Organisation for Civil Aviation Equipment, March 2005.

[2] K. Sasloglou, I. A. Glover, P. Dutta, R. Atkinson, I. Andonovic, and G. Whyte. "*A Channel Model for Wireless Sensor Networks in Gas Turbine Engines"*. In Loughborough Antennas & Propagation Conference (LAPC) 2009, 16-17 Nov. 2009, Loughborough, UK.

[3] K. Sasloglou, I. A. Glover, P. Dutta, R. Atkinson, I. Andonovic, and G. Whyte. "*Empirical Modelling and Simulation of Transmission Loss between Wireless Sensor Nodes in Gas Turbine Engines"*. In The 7th International Conference on Information, Communications and Signal Processing (ICICS 2009), 7-10 Dec. 2009, Macau.