Self-Healing Reconfigurable Manifolds

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Conventionally, spacecraft wiring harnesses are built with architectures that are fixed at manufacture. They must therefore be designed to endure the lifetime of the mission with a very high probability, though the necessary redundant duplication of signals has significant implications for mass. At a launch cost in excess of $30,000 per kg, reducing the mass of a spacecraft's wiring harness without compromising reliability is highly desirable. As a motivating example, the network cabling in the International Space Station (ISS) is known to mass more than 10 metric tonnes.

Recent advances in MEMS-based switching [2] have made it possible to consider constructing *reconfigurable manifolds* – essentially, wiring harnesses that behave like macroscopic FPGA routing networks. Redundant wiring can be shared between many signals, thereby significantly reducing the total amount of cable required. Reconfigurability has a significant further benefit, in that it also allows adaptation to mission requirements that change over time.

We present an algorithm that allows such a reconfigurable manifold to be dynamically tested in-situ, such that signals are automatically rerouted around non-functioning wires and switches as soon as faults are detected. Break-before-make switching is used in order to achieve transparency from the point of view of subsystems that are interconnected by the manifold, whilst also making it possible to achieve near-100% testability.

A *self-healing reconfigurable manifold* will behave identically electrically to a conventional fixed architecture wiring harness from the point of view of the subsystems that it interconnects, though with significantly enhanced reliability and flexibility.

Current Status. The project is presented at an early stage as work-in-progress.

Related Work. Jason Lohn's group at NASA Ames [1] have demonstrated an ability to work around cosmic ray induced permanent latch-up damage to FPGAs with genetic algorithms; the authors have demonstrated a similar (though provably correct) capability based on SAT solvers [3].

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References

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[3] THOMPSON, S., MYCROFT, A., BRAT, G., AND VENET, A. Automatic in-flight repair of FPGA cosmic ray damage. In *Proc. 1st Disruption in Space Symposium* (July 2005).