Non-Destructive Fault Location on Aging Aircraft Wiring Networks
Part 1 – Cost-Optimized Solutions

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Age-related malfunctioning of wiring infrastructure in aircraft, space vehicles, trains, nuclear power plants, high speed data networks, and even the family home and car is an area of critical national and international concern. As these networks age, the wires become brittle and crack, break, or short circuit, sometimes dangerously, sometimes with annoying intermittents. Millions of man hours are spent each year trying to locate these faults, and costs from this maintenance and the associated down time run into the billions of dollars. The problem of locating the faults is notoriously frustrating. When a car will not start in the morning, is it a dead battery, corroded connector, broken battery cable, alternator, or electrical connection to the alternator? Merely debugging this very simple system will take a significant amount of time and a few cases of trial and error. Imagine when the complexity of this system is multiplied a hundred-fold, and the fault is buried deep within several miles of power distribution wire on an aircraft scheduled to depart for Chicago in twenty minutes.

This paper describes a set of cost-effective sensors that are being applied to handheld fault location meters and in situ testing systems for pre-flight fault detection and location. Three specific sensor families are described – a Frequency Domain Reflectometer, a set of Capacitance sensors, and a new class of Correlation sensors. Several advanced signal processing methods are compared for accuracy, efficiency, and applicability to realistic, noisy, ill-matched, lossy aircraft cables with complex loads. A comparison of accuracy, cost, complexity, and functionality reveals the most cost-effective solution depending on the system requirements.

These sensors and associated algorithms are tested and compared on a variety of realistic wiring platforms including the US Navy's F-18, P3, E-2C, and C2 aircraft. The system-level design considerations are included to begin to understand the most effective method of deploying an in situ network health monitoring system.