Chapter 1 – INTRODUCTION

A new technology has emerged in recent years that has the potential to dramatically improve the design and efficient operation of aerospace vehicles throughout their entire life cycle, from initial design to final retirement. This new technology, often referred in the literature as Fiber Optic "Smart" or "Sensory" Structures (FOSS), began in the early 1980s with breakthroughs in the miniaturization of sensors and actuators, along with advances made in the field of composite materials. The FOSS concept, as originally envisaged, involved the distribution of advanced sensor networks, such as fiber optic sensors, that could be integrated within, and adhered to the surface of load-bearing composite structures. The vision was that these sensors could be distributed in vast networks analogous to the nervous system in the human body. Information from these sensory networks could be fed-back to on-board or central processing computers, serving as the brain, which in turn could provide instructive information to pilots, maintenance crews, or other key decision makers responsible for ensuring vehicle performance over the vehicle's life cycle. Stresses, structural instabilities, temperature distributions, and a plethora of other engineering measurands could be monitored in real time with a single fiber optic based instrumentation system. Such a system could offer an unparalleled amount of valid engineering data indicating the structure and sub-system health with almost no weight penalty.

While an increasing number of FOSS technologies are emerging from the research laboratory, many technological barriers still exist that impede its acceptance by the aerospace community. This acceptance is especially challenging because of strict vehicle performance requirements, coupled with highly aggressive project schedules that compete against the implementation of what is viewed by many as "high risk" technologies. Much of that risk comes from a lack of understanding of the accuracy and performance of embedded sensors in large-scale FOSS components. This area must be addressed and the integration risk reduced by thoroughly validating the new technology using universally accepted industrial standards. A greater emphasis on large-scale sensor validation is required before FOSS components can gain full acceptance by the mainstream engineering community and placed into service.

While some of the barriers toward FOSS application are technical, many of these barriers are cultural. As with any new technology, the fear of change from what works, no matter how antiquated, to what could be involves a cultural paradigm shift from conventional thinking. Without these cultural changes, realizing the benefits of FOSS technologies could have the real consequence of limiting the efficiency and performance of future aircraft vehicle designs. Or far worse, a failure to embrace the advantages of new promising technologies, such as FOSS could impair competitiveness in combat or impact economic competiveness in the global marketplace.

To address these barriers, this paper first presents work that has been conducted at the National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (Edwards, California) to clear some of the FOSS technical barriers to large-scale application. After a brief overview of conventional and fiber optic sensor technology, an overview of the research and development that has been conducted using fiber optic sensors at all vehicle phases will be discussed. Lastly, to help overcome the cultural resistance, the FOSS vision is presented and its potential benefits in aerospace vehicle design throughout the life cycle are presented.