Structural Condition Assessment during High Altitude Stratospheric Balloon Flight

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Abstract

An advent of commercial space travel has inspired engineers to rethink design and operation of space transportation systems. Structural health monitoring (SHM) is seen as a promising technology to reduce time to launch and operation costs with simultaneous improvements in the safety of commercial space vehicles. A New Mexico Tech Mechanical Engineering team has designed and successfully launched a payload to investigate performance of state-of-the-art SHM technologies during high altitude stratospheric balloon flight. Preliminary results indicate feasibility of SHM during high-altitude fight and advocate for incorporation of environmental parameters in structural characterization.

SHM Technologies and Payload Layout

Structural health monitoring is aimed at providing near real-time information of structural integrity and reporting potentially abnormal behavior. Space system SHM is unique and notably deviates from typical aircraft SHM applications because of its multi-functionality at various stages of the mission. SHM has shown utility in pre-launch diagnostics and qualification of the spacecraft.

A concept of spacecraft SHM system was implemented in a payload recently flown by NMT on a NASA FOP high-altitude balloon flight. Three SHM experiments were flown: electro-mechanical impedance diagnostics of sensors and structures during flight, wave propagation experiment for measuring structural sound speed in near-space conditions, collecting acoustic emission data, and conducting diagnosis of bolted joints and wireless sensing of strain and temperature at considerable distances. Schematics of experiments on a payload and actual payload photo is presented in Figure 1.

The university collaborated with Metis Design Corporation on active and passive embedded ultrasonic experiments and with Microstrain Corporation on wireless sensing tasked to acquire strain and temperature data for the high altitude balloon system spanning over 230 ft. Electro-mechanical impedance data was collected using measurements boards provided by Los Alamos National Laboratory's Engineering Institute.

The flight has demonstrated ability of wireless sensors not only to collect strain and temperature data, but also transmit it across considerable distance. The wave propagation experiment recorded data for wave transmission during flight and acoustic emission activity. In addition, we have conducted a bolted joint diagnostic test, in which elastic wave transmission through bolted interface was measured for healthy (tight) and damaged (partially loose) joints.

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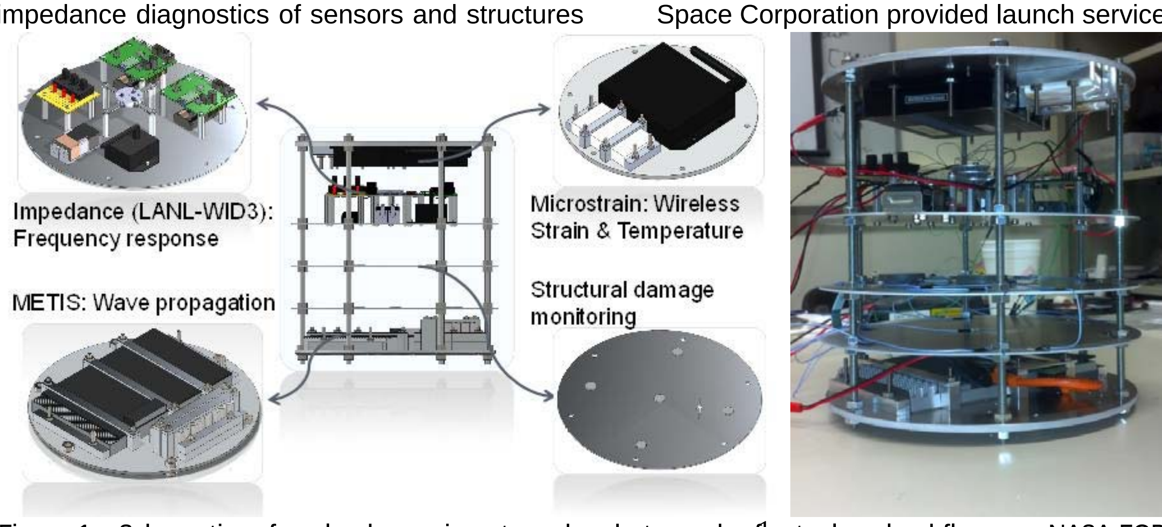

Figure 1 Schematics of payload experiments and a photograph of actual payload flown on NASA FOP.