Hot Structure Control Surface Progress for X-37 Technology Development Program
(P.G. Valentine, 21 Jul 04; edited by Dave Meyer and Holly Snow, July 23, 2004)

The NASA Marshall Space Flight Center (MSFC) has been leading the development of technologies that will enable the development, fabrication, and flight of the automated X-37 Orbital Vehicle (OV). With the Administration's recent announcement of the Vision for Space Exploration, NASA placed the X-37 OV design on hold while developing detailed requirements for a Crew Exploration Vehicle, but has continued funding the development of high-risk, critical technologies for potential future space exploration vehicle applications. Hot Structure Control Surfaces (HSCS) technology development is one of the high-priority areas being funded at this time.

The goal of HSCS research is to mitigate risk by qualifying the lightest possible components that meet the stringent X-37 OV weight and performance requirements, including Shuttle-type reentry environments with peak temperatures of 2800 °F. The small size of the X-37 OV (25.7-feet long and 14.9-foot wingspan) drives the need for advanced HSCS because the vehicle's two primary aerodynamic surfaces, the flaperons and ruddervators (Fig. 1), have thicknesses ranging from approximately 5 in. down to 1 in. Traditional metallic or polymer-matrix composites covered with tile or blanket thermal protection system (TPS) materials cannot be used as there is insufficient volume to fabricate such multi-component structures. Therefore, carbon-carbon (C-C) and carbon/silicon-carbide (C-SiC) composite HSCS structures are being developed in parallel by two teams supporting the X-37 prime contractor (The Boeing Company).

The Science Applications International Corp. (SAIC) and Carbon-Carbon Advanced Technologies, Inc. (C-CAT) team is developing the C-C HSCS, while the General Electric Energy Power Systems Composites (GE-PSC) and Materials Research and Design (MRD) team is developing the C-SiC HSCS. These two teams were selected to reduce the high level of risk associated with developing advanced control surface components. They have continued HSCS development work as part of the X-37 critical technology development contract.

The SAIC/C-CAT team is using Advanced Carbon-Carbon (ACC) because its fabrication is very similar to the process used for Space Shuttle Reinforced Carbon-Carbon fabrication, including the SiC-based pack cementation conversion coating systems using with both materials. ACC was selected over RCC because it has much higher tension and compressions strengths, and because T-300 fiber is readily available, whereas RCC rayon fiber is no longer manufactured. The GE-PSC/MRD team is using a T-300 fiber-reinforced SiC matrix composite material densified by chemical vapor infiltration. The C-SiC material has an SiC-based environmental barrier coating.

Major accomplishments have been made over the past year by both HSCS teams. C-C and C-SiC flaperon subcomponents (Fig. 2), which are truncated full-scale versions of flight hardware, have been fabricated and are undergoing testing at the NASA Dryden Flight Research Center (Fig. 3), NASA Langley Research Center, and U.S. Air Force Research Laboratory. By the end of 2004, ruddervator subcomponents also will be delivered and tested.

As NASA moves forward in realizing the Vision for Space Exploration, it will continue to invest in advanced research and development aimed at making new generations of spacecraft safer, more reliable, and more affordable. The X-37 HSCS effort ultimately will benefit the Agency's vision and mission.

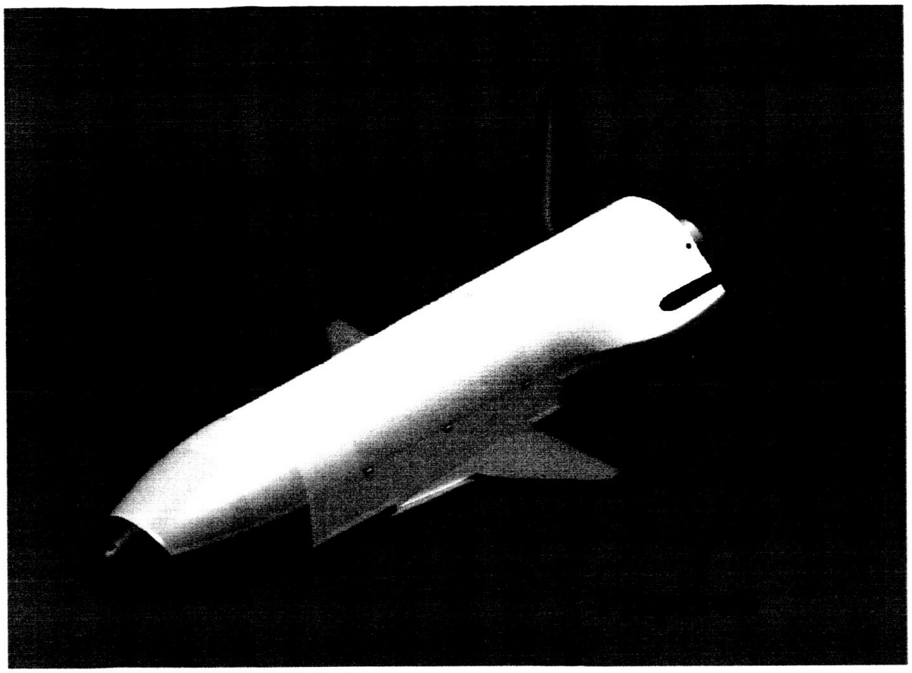

Fig. 1: X-37 OV concept showing the location of the hot structure aerodynamic control surfaces (flaperons and ruddervators).

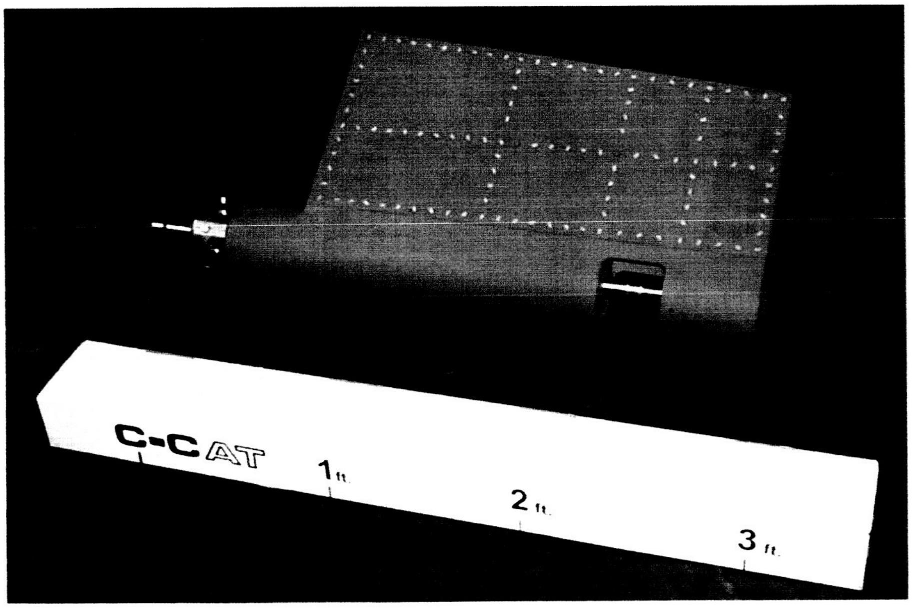

Fig. 2: C-C flaperon subcomponent test article is about half that of the actual flight hardware (nominally 5 ft.), with cord length and constituent component dimensions that are approximately the same as the flight component dimensions. This top view shows the removable bolt-on top-skin.

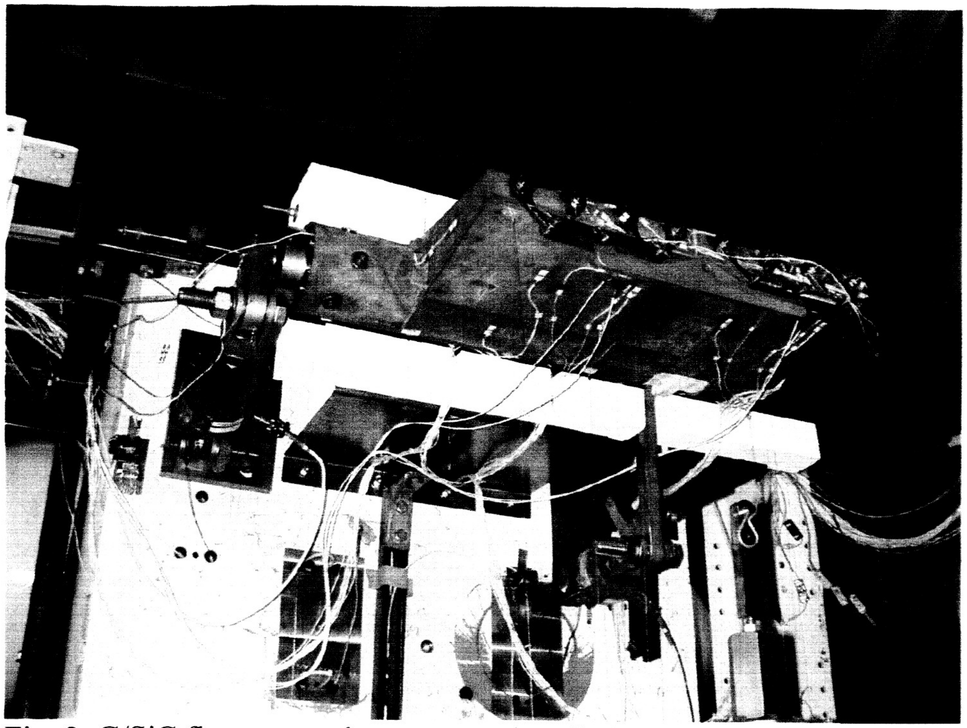

Fig. 3: C/SiC flapperon subcomponent installed in the test setup at NASA Dryden.