Fluid-structure Interaction Simulations of Supersonic Parachutes using Large-eddy Simulation and Thin Shells

Thursday, September 28, 2017 | 4:00 p.m. | 202 Reed McDonald

Abstract

Computational fluid dynamics (CFD) simulations are undertaken to examine the fluid-structure interaction (FSI) of supersonic flow around decelerators used in planetary exploration missions. These decelerators are composed of some rigid objects, generally an aeroshell, accompanied by light flexible structures intended to increase the overall drag when deployed. Large-eddy simulation (LES) using a structured adaptive mesh refinement (AMR) framework interfaces with a large-amplitude thin-shell solver to investigate the behavior of these devices. The fluid solver is based on three-dimensional conservative finite-differences with low numerical dissipation and it is capable of simulating turbulence using LES and moderately strong shocks. The fabrics are modeled using the finite-element method (FEM) using Kirchhoff-Love theory for thin shells, capable of handling large deformations and small strains. The fluid-structure interaction is modeled only near the interface of the fluid-solid regions using a loosely coupled approach. The simulations of two typical devices will be discussed, a supersonic disk-gap-band (DGB) parachute and an inflatable tension cone aeroshell (ITC). Supersonic parachutes have been used as aerodynamic decelerators during entry and decent into low-density atmospheres in most extraterrestrial space missions (to Mars). The deployment of such parachutes, at supersonic speeds, constitutes a complex phenomenon in FSI research. It involves bluff body and porous aerodynamics, nonlinear structural dynamics and fully coupled interaction between the compressible fluid flow and the thin-fabric of the parachute. In August 2012, the Mars Science Laboratory (MSL) deployed the next generation exploration robot to the surface of Mars (Curiosity). The delivery of this payload is partly accomplished using a new DGB supersonic parachute similar to that used in the Viking missions. This is the largest supersonic parachute NASA has designed for the deployment conditions in the atmosphere of Mars. In the second part of the talk I will discuss the ITC concept, that is not yet a certified technology but it has the potential to provide stable and effective deceleration for missions with heavy payloads, possibly including humans. I will discuss our approach, results, shortcomings, and conclusions using the computational methodology discussed above focusing on the fluid dynamical aspects of the interactions.

Carlos Pantano received his Bachelor degree in Industrial Engineering with specialization in Electrical Engineering from the University of Sevilla in Spain. He received a Masters in Applied Mathematics from Ecole Centrale Paris in France, and a Masters and PhD in Mechanical and Aerospace Engineering from the University of California San Diego. He was a Senior Postdoctoral Engineering from 2000 to 2001 at the Office National d’Etudes et de Recherches Aerospatiales in France and then moved to the California Institute of Technology as a senior post-doctoral associate and later as a senior research scientist until 2006. Currently, he holds the rank of Professor in Mechanical Engineering at Illinois. Professor Pantano received the Presidential Early Career Awards for Scientists and Engineering (PECASE) in 2006. He is currently an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and member of American Physical Society (APS), Society for Industrial and Applied Mathematics (SIAM), and the Combustion Institute.

Refreshments served at 3:45 p.m.