ME – MTech(Res) Thesis Colloquium

Crew supervisory guidance scheme for manned spacecraft atmospheric re-entry applications

Angad Pratap, M.Tech.(Research), Department of Mechanical Engineering, IISc,Bengaluru

April 20, 2026 at 10:00AM

Venue – A.R Auditorium, ME@IISc (join online)

ABSTRACT

The study investigates the feasibility of incorporating a bank-angle-based crew supervisory control scheme for a lifting-ballistic type manned space capsule during atmospheric reentry to Earth. Crew supervisory mode is proposed as an additional backup to the existing multiple (yet identical) automated modes of re-entry control in scenarios of (i) the flight profile exceeding predefined operational envelopes, (ii) identical failures of the guidance scheme across all automated control chains, or (iii) to address and mitigate unforeseen errors while adhering to existing manned spacecraft standards borne out of lessons from manned spaceflight history. The crew supervisory control scheme is explored from the standpoint of implementing a manual guidance scheme starting from a predefined re-entry altitude to the parachute opening altitude (120-10 km). In particular, the control problem is solved by employing a 6-DOF (degree-of-freedom) model consisting of the translational and rotational dynamics of a representative manned spacecraft. Hard constraints such as the vehicle's tolerance to heat flux, human tolerance to transverse acceleration, and peak dynamic pressure loads are used for shaping the allowable reentry corridor. The tuning of PID (Proportional-Integral-Derivative) controller gains is used to achieve dynamic stability to perturbations in the angle of attack and sideslip, while roll angle regulation is used for bank-angle control. This approach helps maintain the spacecraft within the desired operational envelope during the re-entry phase, thus ensuring adherence to the planned terminal position of parachute deployment at the end of the re-entry phase. Moreover, it is shown that the proposed intermittent manual guidance scheme under degraded feedback helps achieve supervisory control of the vehicle during this descent process without leading to a significant increase in cognitive workloads. Clearly then, incorporating this additional degree of crew supervisory redundancy holds promise for a significant enhancement of mission reliability, thus meeting a key benchmark of planned future manned spacecraft missions.

ABOUT THE SPEAKER

Angad Pratap is a MTech(R) student in the Department of Mechanical Engineering at the Indian Institute of Science, Bengaluru, working with Dr. Jishnu Keshavan. He is also an astronaut at the Human Space Flight Centre, ISRO and is associated with projects related to the upcoming Gaganyaan and Chandrayaan missions.