Stratospheric Projectile Experiment of Entry Dynamics (SPEED) Avionics and Instrumentation

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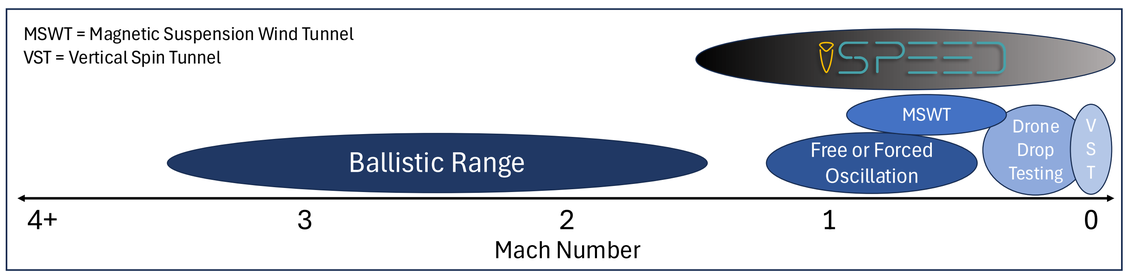
SPEED Overview

SPEED is a low-cost and data-rich approach for capturing free-flight dynamics data for entry capsules.

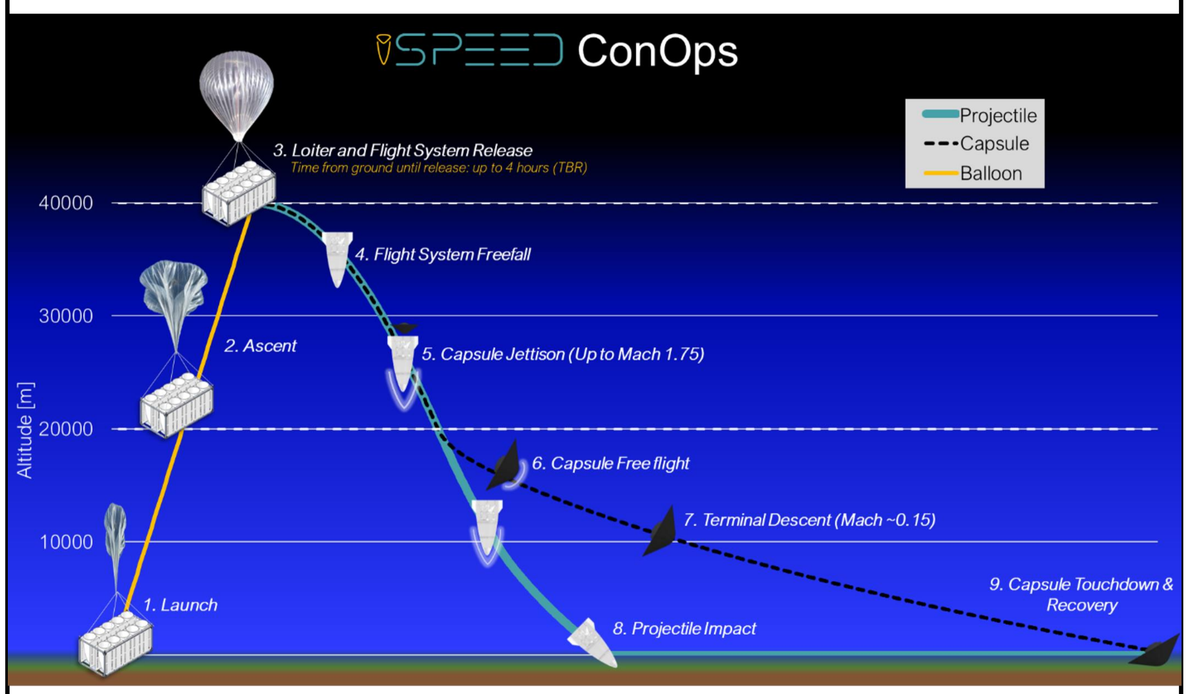
Traditional methods to characterize dynamic stability are limited:

- Few operational ground test facilities in the U.S.
- Complexity of data collection and analysis leads to high uncertainties in calculating stability parameters like the pitch damping coefficient
- Validation of computational methods is difficult due to the scarcity of flight-like experimental data



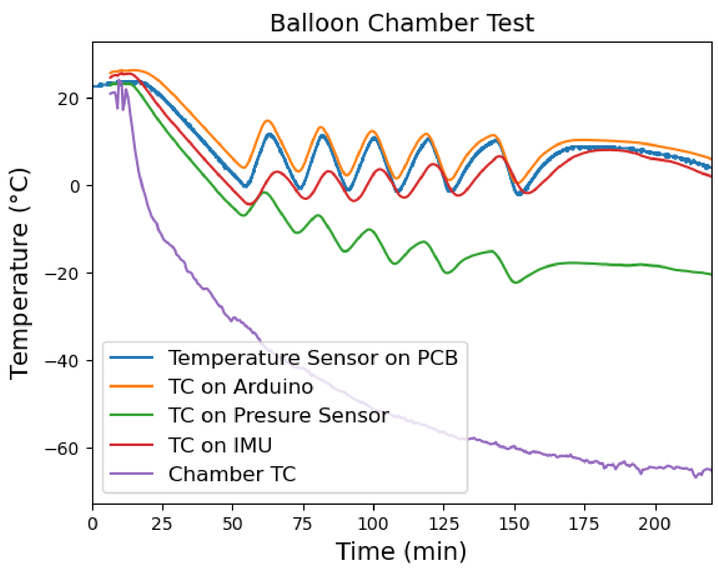
SPEED is a test architecture that employs a stratospheric balloon and a two-stage descent phase to achieve flight-like supersonic conditions

- Can be tailored to meet scaling requirements for most missions (Titan, Mars, Earth) by changing capsule size, mass and starting altitude



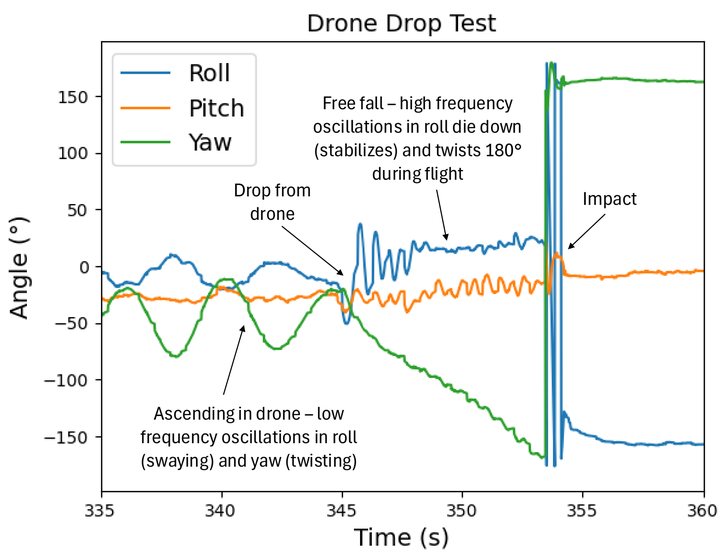
A robust avionics system and comprehensive instrumentation package are critical to releasing entry capsules at the right time and capturing high-fidelity data throughout flight.

Testing/Validation



- Thermal testing in atmospheric chamber (up to 60,000 ft) to verify heater control and avionics lifetime
- Lifetime and freezer testing for IMU

- Drone drop testing for IMU and capsule data collection and ejection validation
- Helicopter drop testing for all three avionics systems

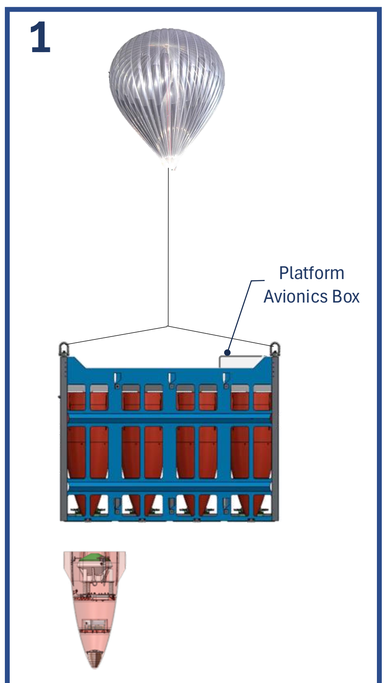


Avionics Systems

Three avionics systems to trigger events and collect data:

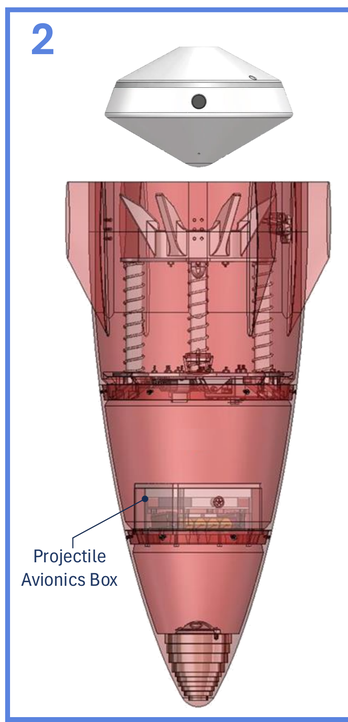
1. Release projectiles sequentially from **drop platform**
2. Eject the capsule from the **projectile**
3. Collect data on the **capsule** during free fall

1



- Receive trigger signal
- Release payloads sequentially
- Closed-loop temperature control

2



- Sense free fall
- Eject capsule at specified time
- Closed-loop temperature control

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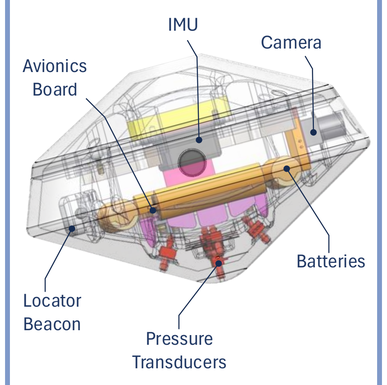
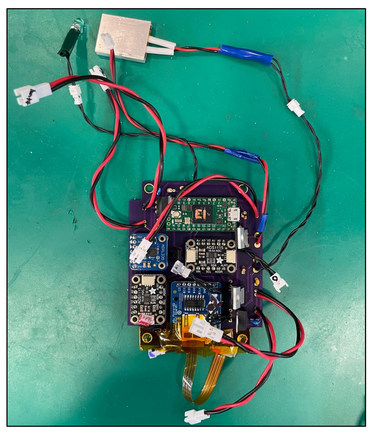


- Record instrumentation data
- Capture video
- Closed-loop temperature control

Major Component	Avionics System	Function	Model	Key Specs
IMU	C	Collect/record orientation data	Yost 3-Space Data Logger x-io Tech x-IMU3	Accel: ±24-200g, 12-16 bit Gyro: 1000-2000 °/s, 16 bit Mag: ±1.3=2.5 Ga, 12 bit Sample rate: 200-400 Hz
Camera	C	Record horizon video during flight	OpenMV Cam H7 (OV7725 Image Sensor)	640x480, 60 fps
Differential pressure sensor	C	Collect pressure data off-center	Honeywell Dual Ax Diff (HSCSAAN001PDAA5)	-1 to 1 psi, 1% accuracy
Absolute pressure sensor	P, C	Sense ejection altitude (P), collect pressure data on nose (C)	Honeywell Single Ax Abs (HSCSANN015PAAA5)	15 psi, 0.25% accuracy
3-axis accelerometer	P, C	Sense free fall to trigger capsule ejection (P) and video recording (C)	ADXL335	±3g, 16-bit (breakout board)
Temperature sensor	P, C, D	Sense temperature for heater control	LMT87LP	-50 to 150°C, 0.4-2.7°C accuracy
PTC Heater	P, C, D	Maintain operating temperature	DFRobot FIT0845	100°C, 5V, 4-8 W

*C = Capsule, P = Projectile, D = Drop Platform



Challenges and Next Steps

Balloon flight has been delayed due to FAA approvals, weather on the ground, and stratospheric winds / flight path.

Upcoming launch window: August 4-8, 2025!
Launch location: Artesia, NM
Drop location: Spaceport America / White Sands

Various projects and companies are interested in future SPEED flights. Further work to improve the avionics and instrumentation includes:

- Environmental testing at more accurate temperature and pressure profiles
- Increase battery life of IMU to increase launch opportunities (i.e., enable trajectories with slower stratospheric winds)
- Redesign PCBs to make various improvements