HARPIA

Team Name	Aerospace Team Graz
Rocket Name	HARPIA
Category	L9 (9 km liquid SRAD)
University	Graz University of Technology
Country	Austria
Team ID	01

Introduction and Project Goals

Following five previous rockets, the Aerospace Team Graz presents HARPIA, its sixth rocket and the team's first liquid-propellant launch vehicle. Building on the experience gained from previous EuRoC campaigns, HARPIA represents a major step forward.

The project's main objectives are:

- Develop a liquid-propellant propulsion system.
- Reach an apogee of 9 km with a nominal launch and recovery.
- Produce comprehensive technical documentation to support knowledge transfer and future projects.
- Compete for a top-five result at EuRoC 2026.

Hard Facts

- length 3940 mm
- wet mass 58.4 kg
- diameter 182.4 mm
- dry mass 34.0 kg
- max. velocity 2200 km/h
- burn time 8.0 s
- total impulse 39.2 kNs
- total flight time 6 min
- telemetry range 30 km
- thrust 4.9 kN
- max. acceleration 9.1 g

Aerostructure Subsystem

The airframe is divided into seven sections, including the two structural tanks and wound carbon fiber reinforced polymer segments connected using RADAX connectors. Due to the SRAD patch antennas, only the nosecone is made from glass fiber for RF-transparency.

On top, the pitot static probe measures the dynamic and static pressure for airspeed and altitude calculations.

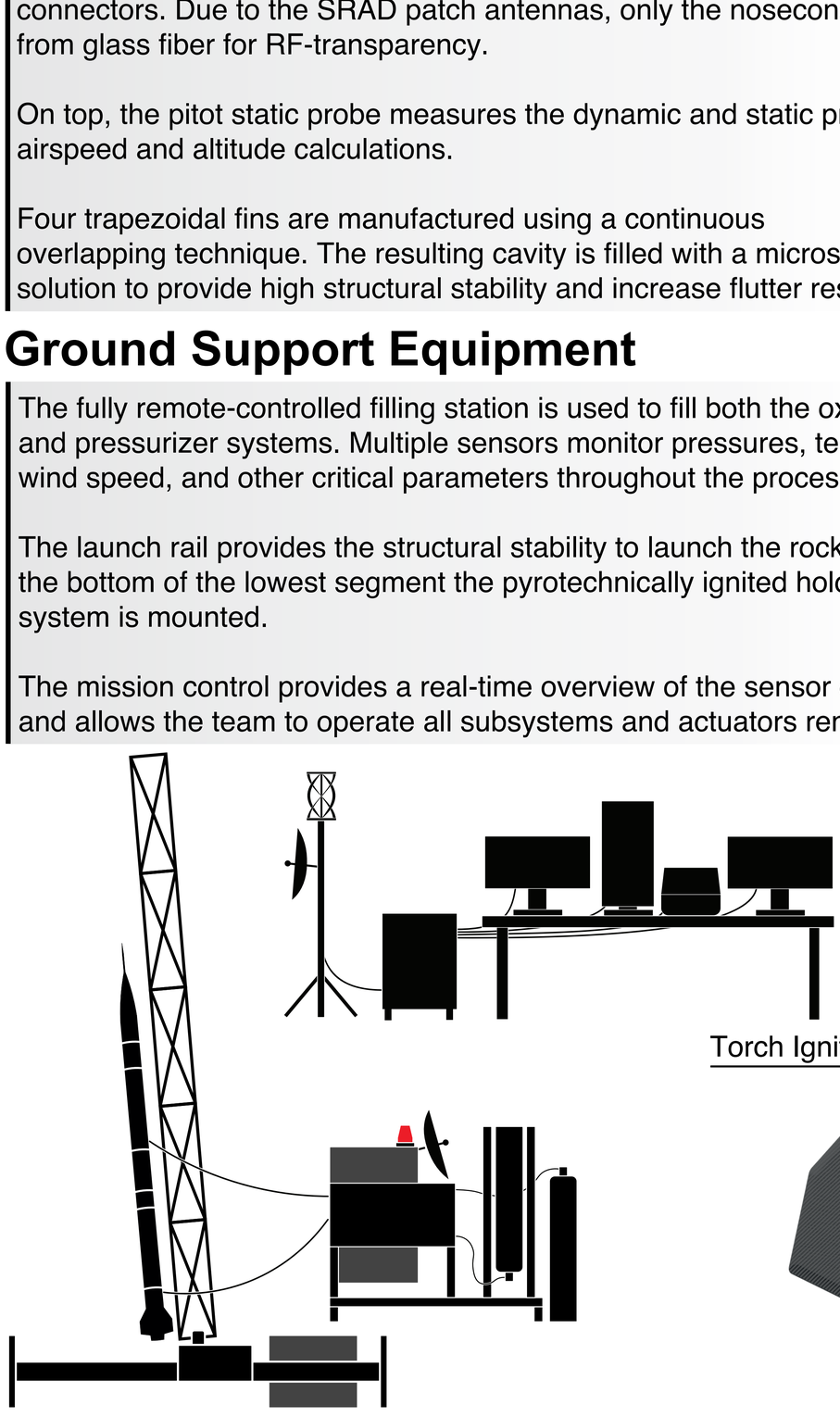
Four trapezoidal fins are manufactured using a continuous overlapping technique. The resulting cavity is filled with a microsphere-resin solution to provide high structural stability and increase flutter resistance.

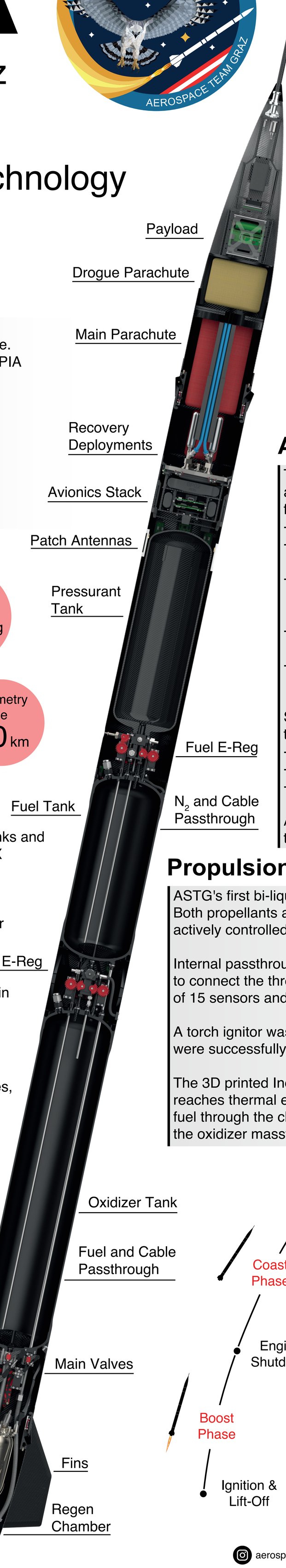
Ground Support Equipment

The fully remote-controlled filling station is used to fill both the oxidizer and pressurizer systems. Multiple sensors monitor pressures, temperatures, wind speed, and other critical parameters throughout the process.

The launch rail provides the structural stability to launch the rocket. At the bottom of the lowest segment the pyrotechnically ignited holddown system is mounted.

The mission control provides a real-time overview of the sensor data and allows the team to operate all subsystems and actuators remotely.





Recovery Subsystem

The recovery system relies on a dual-deployment, two-parachute design with electrical and mechanical cross-redundancy.

1st Deployment: At apogee, an argon-actuated nosecone separation system releases the cross-shaped aramid drogue parachute. SRAD shock absorbers dampen the resulting deployment loads by dissipating energy through the controlled tearing of sewn Dyneema bands. A newly developed simulation tool models deployment dynamics and line behaviour, its results are currently being validated through testing.

2nd Deployment: A pyrotechnically actuated pin-release mechanism deploys the elliptical ripstop nylon main parachute. The main parachute is anchored by an SRAD titanium eyebolt, which achieves 80% weight reduction.

Avionics Subsystem

The avionics system combines in-house hardware, telemetry, a custom operating system and algorithms to provide reliable flight control:
- Hardware: 63 self-designed and assembled PCBs.
- Software: an SRAD real-time operating system with a modular and flexible architecture.
- Communication: decentralized sensor and control nodes connected via CAN bus communicate via an SRAD protocol.
- Interfaces: USB-C umbilical for on-pad power supply and reset capabilities.
- Navigation: An extended Kalman filter fuses 11 sensors to produce a precise altitude and attitude estimation.

Self-developed antenna and telemetry systems, consisting of two patch antenna rings on the outside of the rocket:
- GNSS patch antennas for location tracking.
- 2.4 GHz patch antennas for data and command transmission.
- QFH antenna ground station for continuous monitoring and control via the mission control.

A bidirectional LoRa wireless link with transmitting power up to 1.5 W ensures robust communication.

Propulsion Subsystem

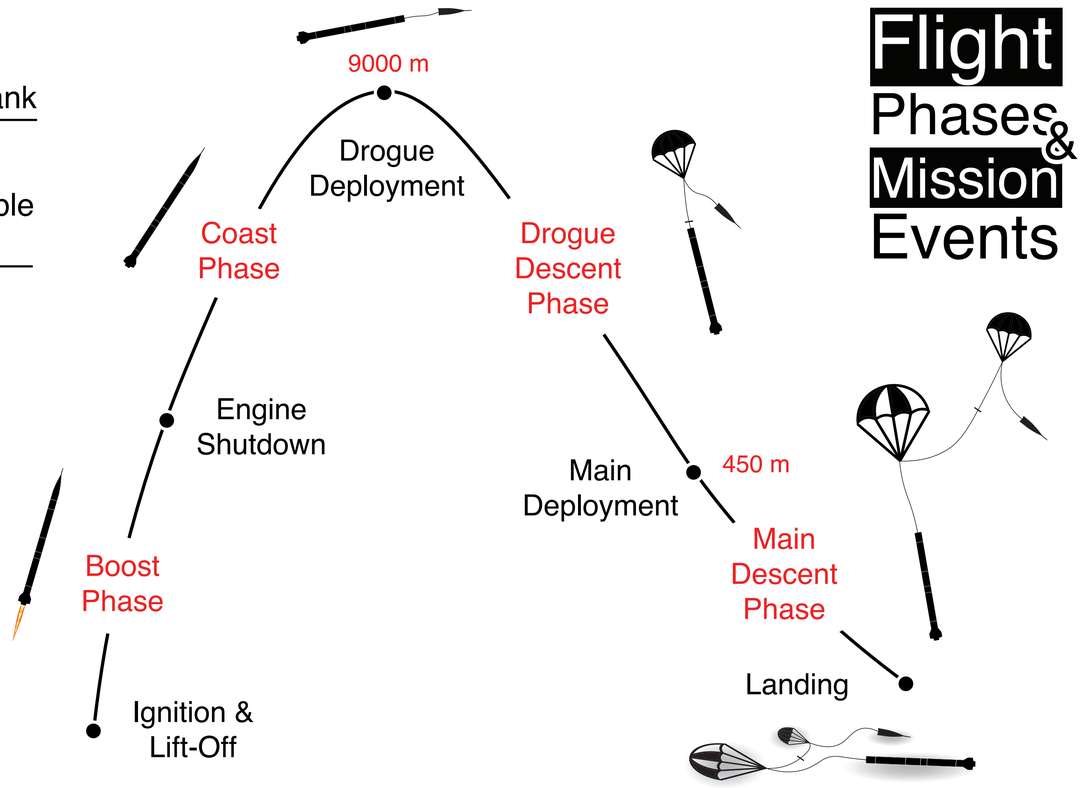
ASTG's first bi-liquid propulsion system utilizes isopropanol and nitrous oxide. Both propellants are pressurized by 300 bar nitrogen using E-Regs. The actively controlled ball valves stabilize the tank pressures during the burn.

Internal passthroughs lead cables, pressurant gas and fuel through the tanks to connect the three fluid systems. Four CANaries read out and control a total of 15 sensors and 12 valves.

A torch ignitor was extensively tested with 3 iterative versions, all of which were successfully fired at different O/Fs for up to 18 seconds at a time.

The 3D printed Inconel 718 combustion chamber is regeneratively cooled and reaches thermal equilibrium after 3 seconds. 66 twisted cooling channels lead fuel through the chamber wall to the pintle injector. A cavitating venturi restricts the oxidizer massflow for an O/F of around 2.7 and 26 bar chamber pressure.

Flight Phases & Mission Events



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