Overview of the DLR M3 test field for component testing for cryogenic propulsion

Michael BOERNER[1], Tobias TRAUDT[1], Sebastian KLEIN[1], Justin HARDI[1]

[1]*Institute of Space Propulsion, German Aerospace Center (DLR), Hardthausen, Germany*
michael.boerner@dlr.de, https://www.dlr.de/ra/en/raketenantriebstechnologie

Abstract:
The M3 test field at DLR Lampoldshausen has been in service for research and technology development for cryogenic rocket propulsion for more than 30 years. Fundamental processes in rocket combustion chambers and supply systems, in particular propellant conditioning and transient flow, injection, ignition, and combustion, are investigated. The operating conditions that can be realized at the test field correspond to those in orbital engines and, in individual aspects, to those of launcher engines.

Research topics currently investigated at M3 include:

- Analysis of dynamic processes in feedlines like water-hammer effects
- Investigation of the spray during the injection of liquid fuels
- Investigation of ignition and flame stabilization in combustion chambers

Technology tests include:

- Component tests for turbopumps
- Injector element characterization
- Ignition transients
- Nozzle plume interaction with structural components like landing gear

The M3 test field currently houses three active test positions (M3.1, M3.3, M3.5) for tests with cryogenic media liquid oxygen and liquid nitrogen, and gaseous hydrogen or hydrocarbon fuels on a laboratory scale and feed-line pressures of up to 40 bar.

The test bench M3.1 is designed for injection, ignition and combustion testing. An altitude simulation system facilitates in-space, launch pad and toss-back conditions within the combustion chamber before injection to verify ignition transients for various mission profiles. The combustion chambers available for injector screening have optical access to the combustion chamber volume. This allows high-speed imaging of the injection and ignition processes in combination with schlieren diagnostics and chemiluminescence measurements.
At test bench M3.3, the injection of liquid nitrogen and liquid oxygen under in-space (vacuum) conditions is studied.
The test bench M3.5 is designed for the investigation of transient cryogenic flows through supply lines and engine components, where in particular phenomena such as cavitation, two-phase flow, and water hammer are studied.

The talk will detail the test capabilities and show selected test activities from recent projects.