SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS (D2)
Future Space Transportation Systems Technologies (5)

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HIGH THRUST ENGINE DEMONSTRATIONS

Abstract

Europe is currently preparing the future of space transportation for the upcoming next decades, anticipating Ariane 5 replacement by a new generation launcher, or a major evolution expected by 2020-2025. To this end, a general trade-off at launcher system level has been initiated over the past few years in both national and European frameworks. Among these, the Future Launcher Preparatory Programme (FLPP) was initiated in 2005 under ESA funding to prepare Europe for the decision on its Next Generation Launcher (NGL).

The purpose is to identify the most promising vehicle configurations together with the most relevant propulsion systems, following a progressive down-selection approach, and to guide the propulsion technology work.

Regarding high thrust applications, different propulsion systems options are competing for powering a new main stage pending on the propellant combination (LOX/LH2 or LOX/LCH4), engine system scheme (gas generator or staged combustion) and possible demanding reusability requirements. The required thrust level also appears to be a key element of the trade-off, since impacting the cycle and determining the number of engines to be accommodated on the launcher, hence the cost.

Snecma has been helping the launchers trade-off by providing a support on liquid rocket engine systems considering all the above mentioned alternatives. The down-selection is under progress but taking into account the wide investigation range and scenario possibilities, a clear status or decision on the final high thrust engine is not expected soon.

Nonetheless, the preparation of new high thrust engines has started with – in parallel to the system studies – different technological demonstrations going on in Europe. Snecma is involved in these demonstrations under national French funding as well as under the ESA European FLPP program.

These demonstrations are presently mainly centered at subsystems levels and focus on key enabling technologies with a wide range of applications, following a progressive TRL increase approach. On the Turbopump field, fluid bearings, open impellers and blisk turbine have been tested at subscale level on BCLH2 bench during the TP Tech program, and then integrated at Vulcain 2 scale in the TPX demonstrator which is currently being tested on PF52 bench. Following this important milestone, the application of the TPX technologies and design methodology on a staged-combustion LH2 turbopump is

envisaged with a further application on an engine Demonstrator. On the Combustion devices field, the tri-coaxial technology has been matured through two successive programs: at first a Vulcain 2 gas generator equipped with six tri-coaxial injection elements has been successfully tested on P8 bench (DLR), then the tri-coaxial technology has been associated with innovative architecture features in the GGPX, a low cost Vulcain 2 scale gas generator that has been tested on PF52 bench in 2009. The tricoaxial injector is now the Snecma reference injection technology for gas generator and preburner. As far as Nozzle extension is concerned, the Sandwich technology is considered as very promising. A full-scale demonstration of a sandwich nozzle has been successfully performed on Vulcain 2 ARTA 8 campaign at the end 2009.

In parallel, of the above mentioned wide range of application technology maturation activities, some more specific key technologies dedicated to staged-combustion engine are studied within the FLPP program. A subscale staged combustion pathfinder has been tested in 2008 at P8 bench (DLR). It consisted of a preburner coupled with a main combustion chamber, whose main objectives were the mastering of the ignition an shut-off transient sequences design and the verification of the stability, the characterization of preburner tri-coaxial injectors in high pressure conditions, and the evaluation of Main Combustion Chamber heat transfer evolution and combustion efficiency.

Although LOX/LH2 propellants are the main propellants involved in the demonstrations, LOX/LCH4 is also considered. The subscale staged combustion pathfinder has been tested in Methane configuration at the end of 2008 with specifics preburner and main combustion chamber injection elements.

All of these current demonstrations conducted by all the companies involved in the Ariane program will be beneficial to the European propulsion industry competences. This technology maturation process is seen as a necessary step towards a possible demonstration at engine level.