*July 2021*

# IAF SPACE PROPULSION TECHNICAL COMMITTEE

## 1. Introduction/Summary

The Space Propulsion Committee addresses sub-orbital, earth to orbit, and in-space propulsion. The general areas considered include both chemical and non-chemical rocket propulsion, and air-breathing propulsion. Typical specific propulsion categories of interest are liquid, solid and hybrid rocket systems, electric, nuclear, solar and other advanced rocket systems, ramjet, scramjet, and various combinations of air-breathing and rocket propulsion.

The Committee deals with component technologies, propulsion system aspects, the implementation and application of overall propulsion systems and dedicated test facilities. The Committee is also examining the feasibility of new missions made possible by new propulsion systems and how combinations of propulsion technologies, such as chemical and electrical technologies, can be optimized for this purpose.

## 2. Latest Developments

Right now, all over the world, a lot of new launchers are appearing with new engines, with first flights just completed or planned for this year or in the next few years.

This means that a lot of activities are on-going to complete the development and qualification of the associated propulsion systems.

Let start with the very well-known and already flight tested Starship of SpaceX and its Raptor engines, the first large reusable liquid rocket engine with liquid oxygen and liquid methane as propellants used in flight. It uses full-flow staged combustion cycle.


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In China, a project of heavy-lift launch vehicle, for future important missions such as deep-space exploration and manned landing on the Moon, has been carried out. A 500 ton- thrust-class LOX/kerosene rocket engine will be used for the first stage and boosters of the launch vehicle, which is also the next generation of large thrust rocket engine in China. The engine employs oxidizer-rich staged-combustion cycle system and after-pump gimbal configuration. The first engine has been manufactured and the sub-systems have been successfully hot-fire tested.

On the coming first flights, we can underline the arrival of the Japanese H3 launch vehicle with its LE-9 (most powerful expander bleed cycle) and LE-5B-3 cryogenic rocket engines, the European Ariane 6 launch vehicle with its Vulcain 2.1 and Vinci cryogenic rocket engines and its P120C solid rocket boosters (largest and most powerful, one-piece, composite case Solid Rocket Motor), the US Vulcan and New Glenn launch vehicles with their BE-4 in the first stage (liquid oxygen / liquid methane propellants), and the US SLS with its RS-25 (upgrade of the well-known SSME) and upgrade SRB.
On the launch vehicle domain, we can also underline the “effervescence” of start-up that create their own micro-launchers and associated propulsion systems.

In terms of electric propulsion, NASA, along with Maxar Technologies and Busek Co., successfully completed the first ground test of the 6-kW solar electric propulsion subsystem destined for the Gateway Power and Propulsion Element (PPE). Several of these 6-kW thrusters will later be combined with other higher-power thrusters to complete the PPE's 50-kW electric propulsion system. This system will make the Gateway the most powerful electric propulsion spacecraft ever flown, and it will manoeuvre Gateway around the Moon, opening more of the lunar surface for human exploration than ever before.

In Europe, Ariane Group is continuing its development of the RIT-2X gridded ion thruster, which is foreseen to be used on the Earth Return Orbiter (ERO) within the Mars Sample Return Program (MSR). As next step, the lifetime qualification test campaign will be started for this flagship program of another outstanding US-European cooperation.

The micro-propulsion domain is particularly dynamic, especially in response to the increasing demand coming from the rapid flourishing of small satellite missions and concepts. These missions, ranging from commercial to exploration spacecraft, and from Earth-orbiting to interplanetary ones, are consequently in demand for a full range of flight-qualified propulsion systems covering all potentially expected mission needs. As examples of innovative micro-propulsion systems currently under development for specific missions, we can mention: the 8-thrusters high-performance mono-propellant system for the NASA CAPSTONE CubeSat; the 4-thrusters green mono-propellant for the NASA Lunar Flashlight CubeSat; the miniaturized ion thruster for the ESA M-ARGO CubeSat; and the AQUARIUS water micro-resistojet for the JAXA EQUULEUS CubeSat.

## 3. Breakthroughs

Even though it has been known for a few years, Additive Layer Manufacturing shows real interesting applications in space propulsion with enormous possibilities for design, simplification of manufacture and reduction of lead times. Particularly impressive in this respect are the achievements obtained by the team at NASA Marshall Space Flight Center, who has recently demonstrated the manufacturing in 90 days of a 5 ft diameter, 6 ft height metallic nozzle with fully integral cooling channels.
The Electric Propulsion continues to extend its application on satellites, regardless of their size, and space probes.

At the launch vehicle level, reusability and methane seem to become a new reference for future systems.
Reaction Engines Limited has successfully validated and demonstrated the engine remarkable precooler technology at inlet airflow temperature conditions representing Mach 5.

The space propulsion industry is addressing a number of promising areas of development. One of them is the use of detonation combustion of fuels. The continuous rotating detonation engine (RDE) receives more attention due to the simpler structure of the chamber, as well as the possibility of obtaining higher operating frequencies. Numerical simulations and experiments have been carried out extensively. Understandings for the mechanism of continuous detonation process have been improved greatly.

## 4. Action plan for the year

This year 2021 will be marked by the change of Chair and Co-Chairs of our committee, with the votes on-going.

*In addition, we are working on an improvement of our IAF website area with new pages dedicated to:*

- *Main technologies used for the different types of space propulsion (Solid Propulsion, Liquid Propulsion, electric Propulsion, Hybrid Propulsion, Nuclear Propulsion, Hypersonic and Combined Cycle Propulsion etc…)*
- *Last News in the field of Space Propulsion*
- *Specific topics such as Propulsion for Smallsats*
- *And also webinar on different topics, the main actors in the field …*