

IAF Committee Briefs

November 2021

IAF SPACE TRANSPORTATION COMMITTEE

1. Introduction

The objective of the IAF Space Transportation Committee is to address worldwide space transportation solutions and innovations. In particular the goals are:

- To foster understanding and cooperation amongst space business academicians and practitioners, through the creation, diffusion, and adoption of new knowledge and lessons learned
- To build a world-wide network of communication and relationships
- To encourage, promote, and assist the development of newer members of the space community through IAC participation

The corresponding activities are devoted to different types of space transportation missions, systems (launch vehicle system and/or the propulsion stages, expendable or reusable, manned or unmanned) and to their safety and support operations.

2. Summary

The major highlight in 2021 was the achievements in commercial human space transportation with successful flights of Virgin Galactic, Blue Origin and SpaceX.

Another interesting development is the race between tenths of companies related to the development of a cheap launch service based on a small launch vehicle with a high launch rate

3. Highlights

HORIZON 2020

Air-breathing hypersonic vehicle concepts may act both as first stage of future reusable two stage to orbit

vehicles, able to take-off and land horizontally, and as high-speed civil passengers transport aircraft. Within the framework of the Horizon 2020 Project STRATOFly (Stratospheric Flying Opportunities for High-Speed Propulsion Concepts), significant results have been achieved at mission, system and subsystems level for a vehicle concept that flies at Mach 8 at 35 km of altitude exploiting liquid hydrogen as propellant. At mission and system level the following achievements can be highlighted:

- Complete aero-propulsive characterization for all speed regimes through high-fidelity simulations for wave rider configurations
- Enhancement of the scientific understanding of atmospheric processes has revealed that the higher is the stratospheric altitude of the water vapour emissions, the longer is the perturbation lifetime of the emitted water vapour, thus resulting in higher climate impact
- Jet-noise test campaigns coupled with high-fidelity simulations have allowed to get reliable acoustic data to make observations about the noise mechanism and to derive an adapted semi-empirical noise prediction tool for the nozzle of fair-breathing high-speed engines. Strategies for noise reduction potentials have thus been defined.

At subsystems level the following achievements can be highlighted:

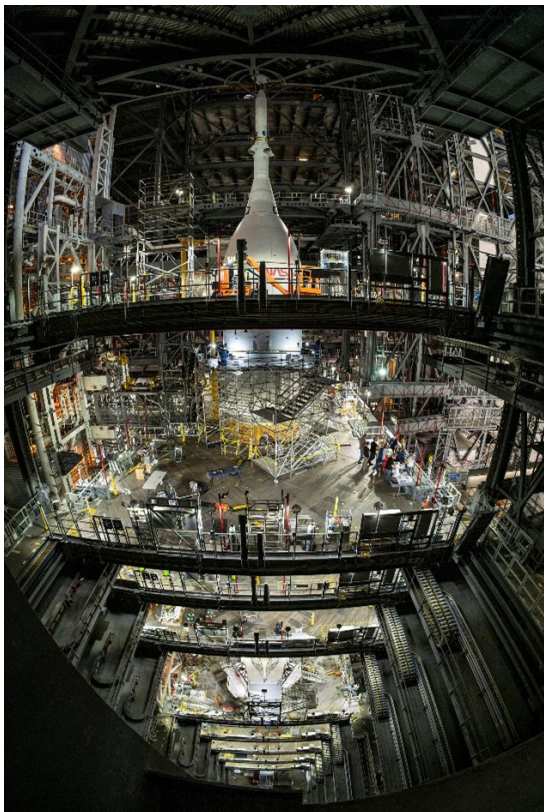
- Redesign of the dual mode ramjet combustor guarantees a reduction of the 80% in NOx levels emissions in cruise at Mach 8, with respect to the initial baseline
- Validation of LES high-fidelity models of high-speed combustion through combustion test campaign
- Performance assessment of the multidisciplinary and multi-functional Thermal and Energy

Management System that exploits liquid hydrogen for multiple integrated purposes: heat rejection, thermal control (as coolant mean of heat exchangers) and high electric power generation through turbine expansion for on-board subsystems

NASA Update

NASA's Commercial Crew Program safely returned their second crew from the International Space Station after 199 days in orbit in November 2021. The next crewed launch, Crew-3, is preparing for launch aboard a SpaceX Crew Dragon in November.

NASA has completed stacking of the Artemis I Space Launch System rocket and Orion spacecraft in the Vehicle Assembly Building (VAB) at the Kennedy Space Center in Florida. The ground team also recently completed their Underway Recovery Test 9 (URT-9) certifying that NASA's Landing and Recovery team is ready for the Artemis I recovery. A series of tests are now underway in the VAB before the wet dress rehearsal in January and a targeted launch in February 2022. This first test flight paves the way for NASA's first crewed flight of Orion and the SLS, planned for 2024 on Artemis II.



A view of the fully stacked Orion and SLS in the Vehicle Assembly Building



U.S. Navy divers from Explosive Ordnance Disposal (EOD) Expeditionary Support Unit 1, attach tending lines to a mock Orion capsule during Day 2 of Underway Recovery Test 9 (URT-9) aboard the USS John P. Murtha. During the weeklong test, NASA's Landing and Recovery team completed their final mission certification ahead of Artemis I.

Newest Development of China's Space Transportation

Chang'e-5 has accomplished China's first Lunar sample return mission. Chang'e-5's mission profile is very similar to Apollo program, although it is unmanned. The probe is consisted of an Ascender, a lander, a return capsule and an orbiter. The Ascender/Lander combination is similar to Apollo's Lunar Module and return capsule/Orbiter is similar to CSM. During the mission, the world's first unmanned Lunar orbit rendezvous and docking with an orbiter was conducted.

After a test launch in 2020, China used its Long March-5B rocket to take its space station into orbit. This version is the world's only one and a half stage launch vehicle in service. It has four boosters with two YF-100 kerosene/liquid oxygen engines each. The total thrust of the boosters are more than 960 tons. It took Tianhe-1 core module of China's space station to a 41.5 degree inclined orbit. The core module is the first of the world that adopted hall effect engines to raise its orbit.

China tested its new launch vehicle, Long March-8 on 22 December 2020. This launch vehicle has a similar first stage like Long March-7 but with only two boosters. The second stage of this rocket is a derivative of the third stage of Long March-3A, which uses liquid hydrogen/liquid oxygen engines. Long March-8 rocket is developed for commercial market and hope to test recover and reusable technologies in the future.

After a failure on its maiden flight of Long March-7A in March 2020, the second flight was a success in March 2021. The rocket is based on Long March-7, which is a two and a half stage mid-sized launch vehicle. Long March-7A added a third stage, which is based on the

third stage of Long March-3A. With this improvement, the GTO capability can reach to 7 tons.

Beijing Interstellar Glory Co. Ltd, which is the first private company in China that achieved an orbital launch in 2019, suffered two failures in its second and third orbital launch attempt. Galactic Energy, another private company accomplished its first orbital launch in November 2020. Both company's launchers are small four-stage solid-rocket boosters.

4. Future Outlook

As an outlook into the future, it will be interesting to see in the next years, which company will be able to successfully develop, qualify and operate a small launch vehicle out of the many currently running projects.

Also, one must watch carefully how the commercial human space flight will develop after the first successful missions this year into low earth orbit with a short visit to a space station respectively into suborbital altitude.

Finally, 2022 will hopefully mark the return to human lunar missions with the first flight of the SLS launch vehicle and the Orion spacecraft.

5. Committee activities

Two new activities are planned by the IAF Space Transportation Committee up to the next committee meeting in March 2022:

- To organize a virtual session on small launch vehicles latest developments
- To propose special sessions and keynotes for the IAC 2022 in Paris. For example, a special session on the climate impact of future launchers (either reusable or not), imagining a higher launch rate for large constellations