

IAF SPACE PROPULSION SYMPOSIUM (C4)  
Solid and Hybrid Propulsion (2) (4)

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KEYNOTE: HYBRID PROPULSION SYSTEM PRACTICES AND SAFETY CONSIDERATIONS  
BOTH FOR LAUNCH VEHICLES AND IN-SPACE MISSIONS

**Abstract**

Advances in rocket technologies using new manufacturing techniques and cost effective/safe propulsion systems unlock the potential of hybrid rockets to be used in both launch vehicles and in-space missions. In addition, safety aspects and functionality of the hybrid rocket motors are also designed for the Moon or Mars Ascent Vehicle concepts using in-situ resources by practitioners in the field. Therefore, the objective of this keynote is to summarize engineering practices of hybrid rocket motor combustion, manufacturing and applications such as launch vehicle systems, Mars Ascent Vehicle concept using carbon dioxide as the oxidizer and the in-space missions for deep space exploration. Furthermore, this keynote will provide insight of safety considerations of the propellant manufacturing, handling and launch operations. Engineering practices of the hybrid motors include following topics, (i) oxidizer handling and safety issues, (ii) internal ballistics improvements using mixing devices, (iii) propellant manufacturing and additives and (iv) nozzle erosion for high burn time applications. Oxidizer handling will focus on liquid oxygen (cryogenic) and nitrous oxide. Mixing devices using silico phenolic material will be emphasized. Metal powder addition to the paraffin-based fuels are the topic of the propellant manufacturing. Nozzle materials and prevention of erosion rate is another topic of this keynote for burn times over 100 seconds. Mission practices will be explained using current literature for the Mars/Moon exploration using in-situ resources such as Metal/CO<sub>2</sub> combustion results. Also, mission practices will cover how to develop an effective sounding rocket using hybrid propulsion system to reduce the cost. Defense applications for supersonic drone is another topic that will be mentioned. This keynote will also summarize ‘global projects with hybrid rockets’ to create better understanding of existing and future missions by various of countries, governments and the private sectors.