Green Space Propulsion: For a Sustainable Space Era

Amir S. Gohardani and Omid Gohardani

In the early days of flight, the need for sustainable air travel was not listed among the top aviation priorities. On the contrary, the sole vision of flying between two locations enabled the nearly impossible of overcoming the technical challenges of flight. Today, it is possible to track a number of similarities between commercial aviation and some of the current plans for commercial spaceflight.

If stringent demands are posed for the foundation of an environmentally sustainable space era, enabling a comprehensive tool set of sustainable space solutions appears as an important choice. However, sustainability is a broad term within this context. Achievement of environmental sustainability by human societies is an interesting debate topic, particularly as the validity of indefinite growth in a closed system is questioned in light of environmental degradation due to human activities. Hence, a simplification of the term "sustainability" for air and space travel is crudely characterized as "air and space travel with minimal environmental impact."

In commercial aviation, technology development programs have independently driven the sustainable agenda. A distinct example of this has been the significant advancements in turbofan engines. The substance of sustainable aviation only recently has been transformed to tangible visions for years 2020-2050, more than a century after the first controlled, powered and sustained heavier-than-air human flight by the Wright brothers. This statement is broadly based on efforts to initiate distinct noise and emission reductions, among others, as presented by the Advisory Council for Aeronautics Research in Europe in its Vision 2020 and Flightpath 2050 reports, which provide a visionary road map for aviation research, development and innovation through a comprehensive, strategic agenda.

In the United States, NASA has served as one of the inspirational organizations with specific goals and visions for air and space activities. NASA's Environmentally Responsible Aviation Project and Fundamental Aeronautics: Subsonic Fixed Wing Project are examples of visions where NASA N+1 to N+4 activities have been considered along with future concepts and technologies. In the past century, technical contributions to sustainable aviation were continuously recorded even without as detailed of a road map as Vision 2020. These include the vital solar-powered-aircraft era and the combined research endeavors that enabled more-robust aircraft design processes and other means of propulsion including all-electric and hydrogen-powered aircraft.

The space community already has set a number of definite visions for space endeavors. However, lessons learned from the younger aviation industry are beneficial. One of these points to the notion that an increasing level of transportation activities is likely to impart a larger environmental impact unless more sustainable options are considered throughout the introductory product stages. Although a learning curve for the technical comprehension and implications of new technologies is expected, a more sustainability-aware approach is favorable.

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Reusability of rockets and spacecraft for future missions is indeed a step in the right direction. A more comprehensive approach, however, would be to look beyond reusability and to revisit the current propellants for spaceflight. This is rather similar to flying with biofuels in aviation. NASA, the U.S. Defense Advanced Research Projects Agency and other governmental/commercial/private entities have investigated green propellants. Green space propulsion is an important element of a sustainable era. Further advances, ranging from green propellants to propellant-less options for space propulsion, are likely to result in sustainable solutions to reach low Earth orbit and beyond with minimal environmental impact.

In a recent collaboration between our organization and OHB-Sweden, ECAPS, the Swedish Defense Research Agency and the Swedish National Space Board, a selected number of promising green space propellants were reviewed and identified for various space missions. Findings from this study suggest that green propellants are constantly gaining interest for future space applications.

In Sweden — similar to concurrent efforts by NASA, the European Space Agency and a handful of aerospace companies worldwide — the green propulsion research was initiated in order to find a less-hazardous and lower-cost alternative to traditional monopropellant systems using hydrazine, with the goal of meeting new requirements for small-satellite missions.

Even though current employment of green space propulsion seems promising and green propellants are constantly explored, many emerging technologies also support the overall removal of propellants. Nonetheless, before such drastic changes are introduced, it is crucial that all the advantages and disadvantages of new technologies are considered in light of state-of-the-art technologies that currently provide the space industry with alternative means of sustainable green propulsion.

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