Pushing the Limits of In-Situ-Resource-Utilisation for In-Orbit Activities: Solar for Ice to Thrust - S4I2T

Barış Can Yalçın, Chiara Manfletti, Philipp Reiss,
Vanya Buchova and Miguel Olivares-Mendez

International Conference on Space Robotics (iSpaRo), Luxembourg, 24-27 June 2024

Introduction

The increasing number of satellite launches, the rise of In-Orbit Servicing (IOS), and the necessity for Active Debris Removal (ADR) services require long-term, reliable, affordable, and scalable solutions for in-space mobility. Utilizing solar energy and space resources offers the potential to create a renewable and self-sustaining mobility infrastructure, providing significant benefits for European satellite owners and enhancing the strategic autonomy of the European Union. It is crucial to identify and develop innovative Solar Electric Propulsion (SEP) systems that can effectively use advances in Solar Energy Harvesting (SEH) to reduce propellant and spacecraft mass, enhance in-space mobility, and thus lower costs. As shown in Fig. 1, these propulsion systems must be environmentally friendly and overcome the challenges associated with using in-space solar energy harvesting for innovative propulsion.

We intend to integrate this with In-Situ Resource Utilization (ISRU) technology for extracting water from the regolith of various solar system bodies, laying the groundwork for a self-sustaining circular economy in space and unlocking new economic opportunities in the following fields:

1. Solar-Electric Water Electrolysis Propulsion: Utilizing water as a propellant offers environmentally friendly, cost-effective advantages, ensuring European autonomy. In our proposed innovative Water Electrolysis Propulsion (WEP) system, it has the potential to surpass even the most advanced chemical propulsion systems currently available for in-space applications.

2. Autonomous Proximity/Docking Operations and Propellant Refilling: Water presents a straightforward solution for spacecraft refueling in orbit, as it involves the transfer of a single non-reactive liquid, simplifying the establishment of a reliable fluid connection compared to high-pressure gases like Xenon or Krypton.

3. In-Space Water Extraction and Utilization: Moreover, water stands out as one of the most readily accessible and abundant substances on other celestial bodies within the solar system, such as the Moon or Near-Earth Objects (NEOs), achievable through thermal extraction methods at relatively low temperatures.

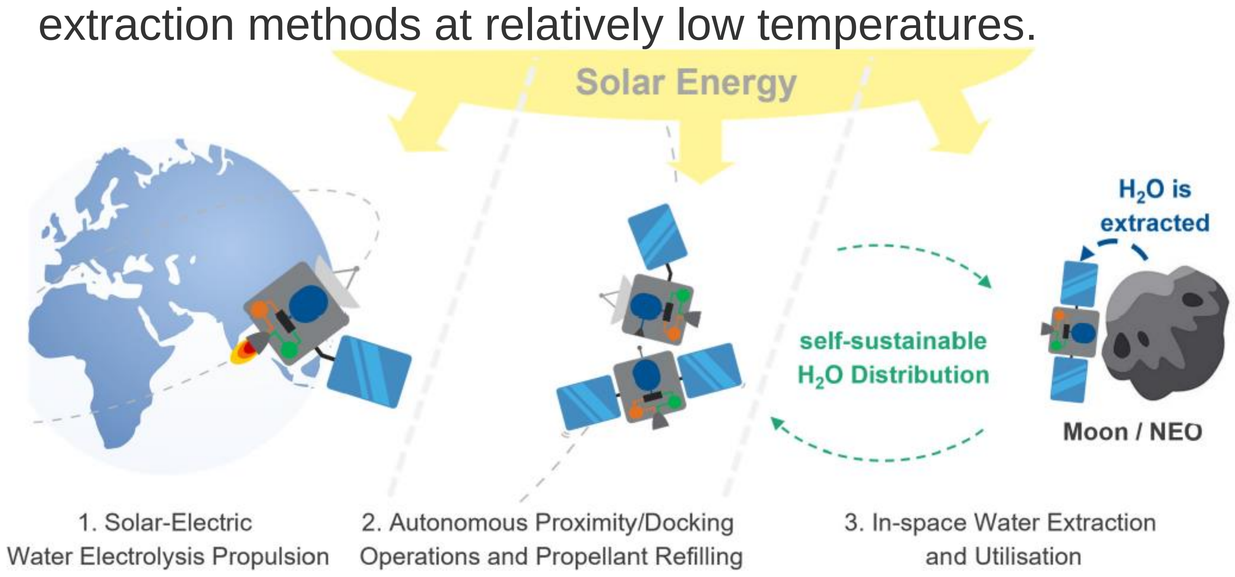

Fig. 1: S4I2T-Vision of self-staining mobility enabled by solar energy harvesting and water as propellant

1. Providing a comprehensive idea, a plan for execution, and a strategy for commercialization of a sustainable space mobility infrastructure independent of Earth.

2. Laboratory validation of the inaugural environmentally friendly, storable propulsion system surpassing traditional systems.

3. Proof-of-concept of autonomous docking and propellant refilling procedures using hardware-in-the-loop (HIL) testing, verification and validation steps.

4. Showcasing the first-ever global demonstration of an end-to-end In-Situ Resource Utilization (ISRU) technology chain under realistic conditions as described in Fig.2.

Scenario

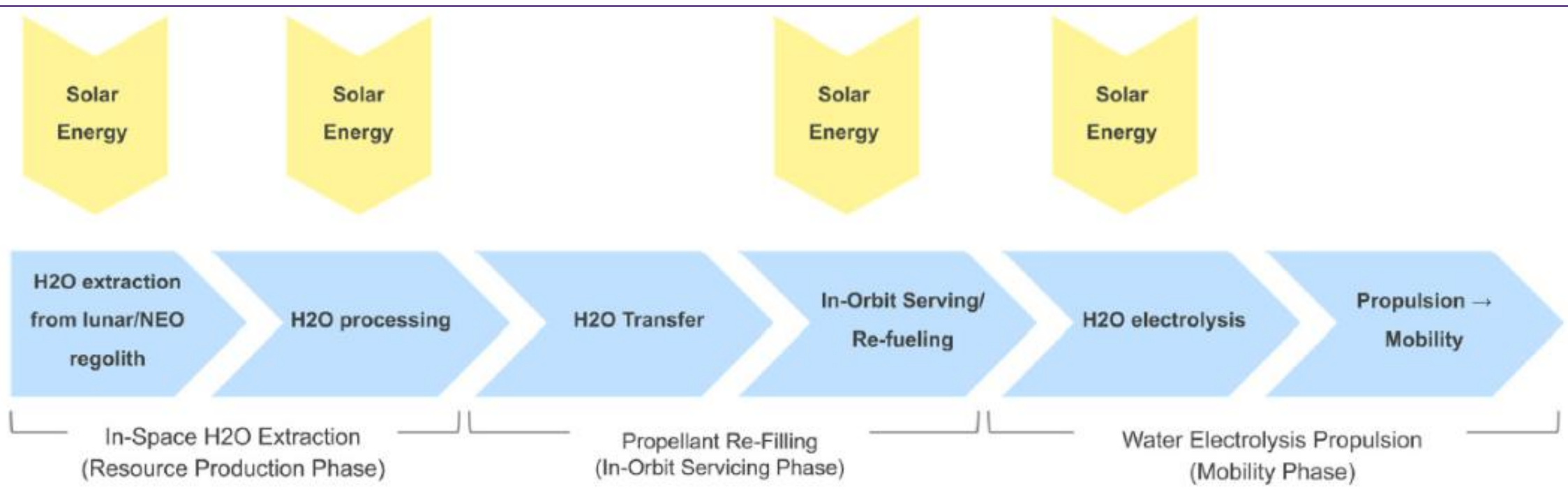

Fig. 2: S4I2T chain of processes relying on solar energy

In collaboration with: SpaceR-SnT/Uni.Lu EnduroSat Technische Universität München