# AEROSPACE ENGINEERING

## 117-LifeCycle Cost Analysis of Life Support Systems for SpaceExploration: sustainable management of vital resources for harsh environmental conditions

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| **Context of the research activity** | This proposal puts forth the development of methodologies and tools supporting space systems developers and operators in the selection of the most affordable and sustainable solutions for providing vital resources in long duration human space exploration missions, analyzing the different phases, costs and development time of life support systems and technologies. The methodologies and tools will incorporate Life Cycle Costs (LCC) analysis to assess the total costs associated with each phase, including initial research and development costs, manufacturing and assembly costs and operational costs, with associated potential savings over time. It will also consider sustainability aspects, such as resource utilization, waste management, and environmental impacts, to ensure that the system aligns with long-term sustainability goals, minimizing ecological footprints and promoting eco-friendly practices. Moreover, to mitigate the development risks of sustainable and cost-effective bioregenerative systems, the feasibility of utilizing existing and even commercial technologies will be evaluated, as well as collaborations with terrestrial agriculture research centers to leverage expertise and reduce complexity in the system components, processes, and management requirements, thereby optimizing operational efficiency and minimizing costs. In conclusion, the proposed methodologies and tools aim to support the development of a robust, economically viable, and environmentally responsible system to meet the sustainable exploration needs of astronauts during extended space missions by integrating LCC analysis, sustainability considerations, and complexity reduction<br><br>Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23001970004 |

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| **Objectives** | As human space exploration ventures extend beyond short-term missions to long-duration expeditions, the need for a bioregenerative system becomes critical for their sustainability. However, the development of such systems is often hindered by high developmental costs, long schedules and complex operational requirements. This proposal puts forth the development of methodologies and tools supporting space systems developers and operators in the selection of the most affordable and sustainable solutions for providing vital resources in long duration human space exploration missions, analyzing the different phases, costs and development time of life support systems and technologies. The methodologies and tools will incorporate Life Cycle Costs (LCC) analysis to assess the total costs associated with each phase, including initial research and development costs, manufacturing and assembly costs and operational costs, with associated potential savings over time. It will also consider sustainability aspects, such as resource utilization, waste management, and environmental impacts, to ensure that the system aligns with long-term sustainability goals, minimizing ecological footprints and promoting eco-friendly practices. Moreover, to mitigate the development risks of sustainable and cost-effective bioregenerative systems, the feasibility of utilizing existing and even commercial technologies will be evaluated, as well as collaborations with terrestrial agriculture research centers to leverage expertise and reduce complexity in the system components, processes, and management requirements, thereby optimizing operational efficiency and minimizing costs. In conclusion, the proposed methodologies and tools aim to support the development of a robust, economically viable, and environmentally responsible system to meet the sustainable exploration needs of astronauts during extended space missions by integrating LCC analysis, sustainability considerations, and complexity reduction.<br>In turn, the developed approach will apply to circular economy addressing terrestrial systems supporting human life in presence of limited vital resources.<br>The proposed topic perfectly fits with PNRR Mission 4C2 “Dalla Ricerca all’Impresa (From Research to Industry)”, Investment 3.3 (Innovative PhDs with enterprises), as it addresses key industrial needs for human space exploration. Moreover, the proposed topic is in line with PNRR Mission 1 “Digitalization, innovation and competitiveness in the productive system”, as it strengthens the development of the space economy. Finally, the proposed research spins-off to Mission 2 (Green Revolution and Ecological Transition) objectives, as to the development of methods and tools to quantify and strengthen circularity and sustainability.<br>The proposed topic will be dealt with in collaboration with Thales Alenia Space, as industrial partner. |

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| **Skills and competencies for the development of the activity** | Human space exploration missions and systems. Environmental control and life support systems. Life cycle costs analysis. |