UNIVERSITÀ DEGLI STUDI DI PADOVA

Advanced technologies for carbon capture and biohydrogen production

Alessandro Crescenzi - 40th Cycle

Supervisor: Prof. Francesco Picano

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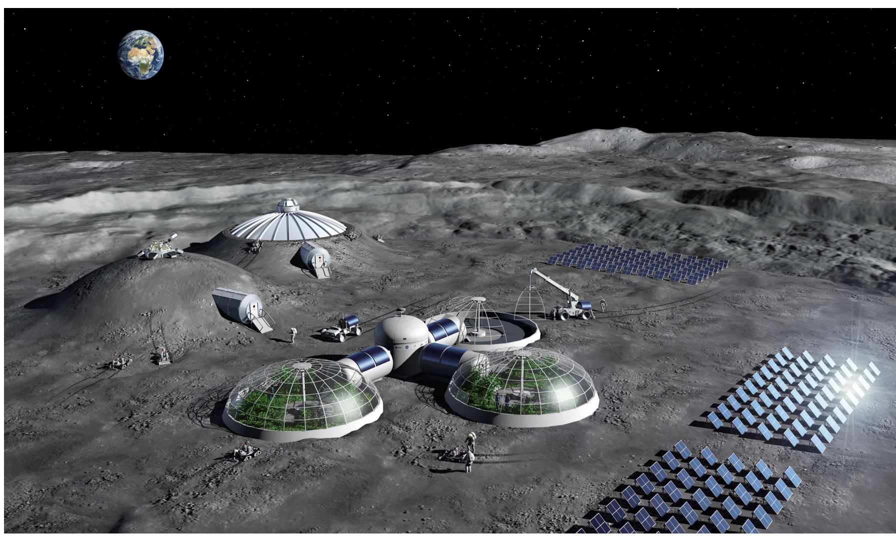
Project Motivations

Space exploration: waste management and supply issue

- Aim to **longer missions** and to establish extraterrestrial **human settlements**
- Crew needs to carry along all the supplies needed during the mission
- Every missions produces **enourmous quantities of waste** that goes unrecycled



Project Motivations

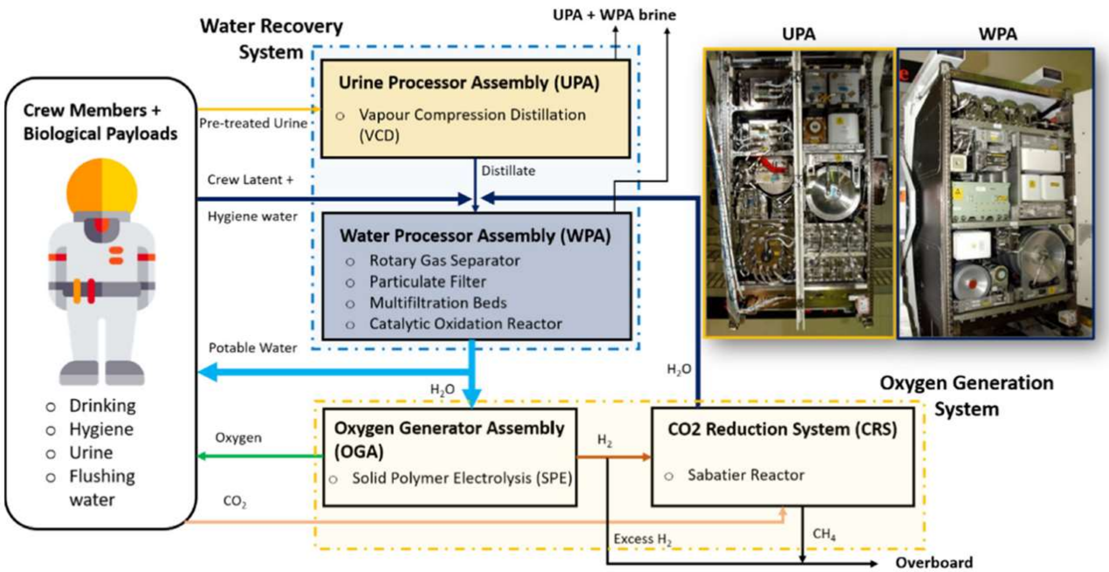
- Currently the ISS is equipped with an Environmental Control and Life Support System (ECLSS), comprised of six sub-systems.

- The **Water and Recovery Management (WRM)** system is responsible of "waste management".

- Through **chemical and physical processes**, the UPA and WPA are able to produce **potable water**, used for drinking, hygiene and flushing water

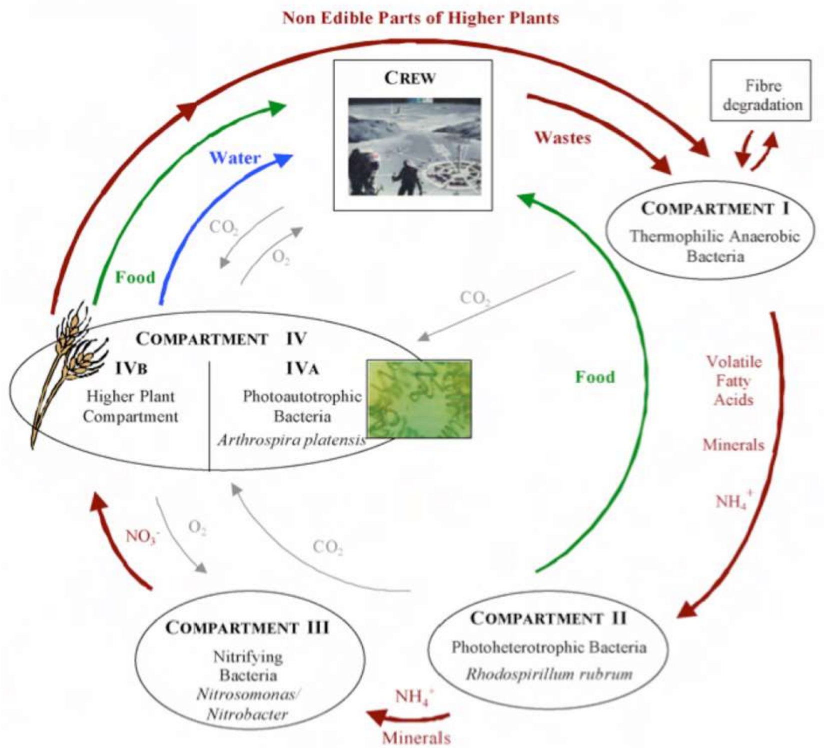
- **Total mean waste** for every single mission is estimated to be of around **6 tons of CO2**, **8 tons of urine** and **13 tons of H2O**

- Still, solid waste is not taken in consideration at all



Closing the loop: MELiSSA (Micro-Ecological Life Support System Alternative)

- For decades, attempts have been made to close the loop, using organic waste to produce crew supplements
- At the moment **MELiSSA**, using five different organisms in five separate compartments **(bioreactors)**, **produces all the nutrients to grow superior plants**
- The system has been proven to work, but is **particularly complex to deploy** profitably in orbit, currently

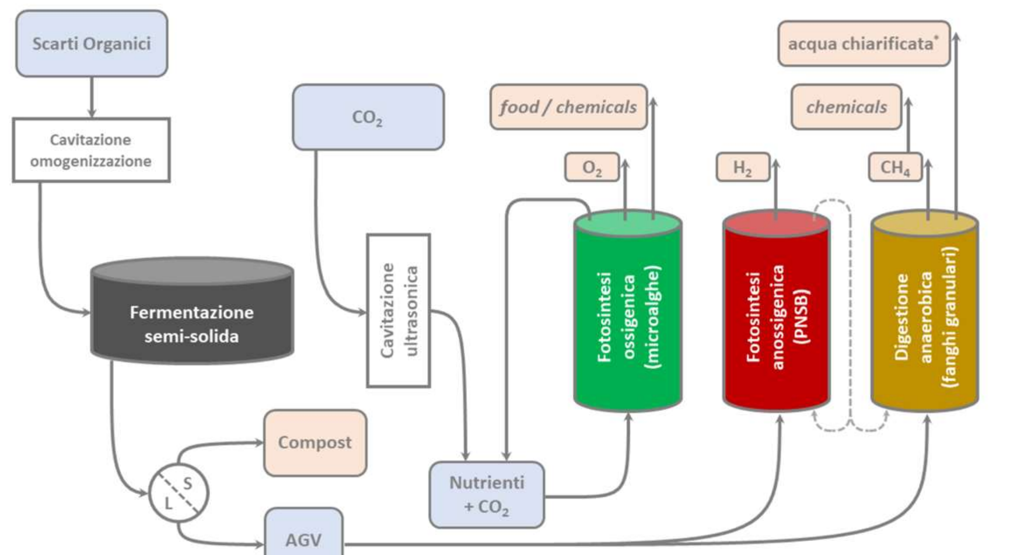


Lasseur, Christophe. (2008). Melissa: The European project of a closed life support system.

Background: BioMOON

A different take on Life Support Systems

- Project developed by **Veritas S.p.A.**, commissioned by the **Agenzia Spaziale Italiana** (ASI)
- Less complex than MELiSSA, simpler actual deployment
- Three distinct biological systems, three different organisms: **microalgae**, **non-sulphuric red bacteria (PNSB)**, and a granular sludge of **methanogenic bacteria**
- These microorganism will be positioned in **bio/polymeric matrices**, to achieve **better water utilisation**



* acqua chiarificata a basso contenuto di AGV, da inviare a processi di **ultrafiltrazione** per la disinfezione e depurazione

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Task #1: Experiments at Veritas

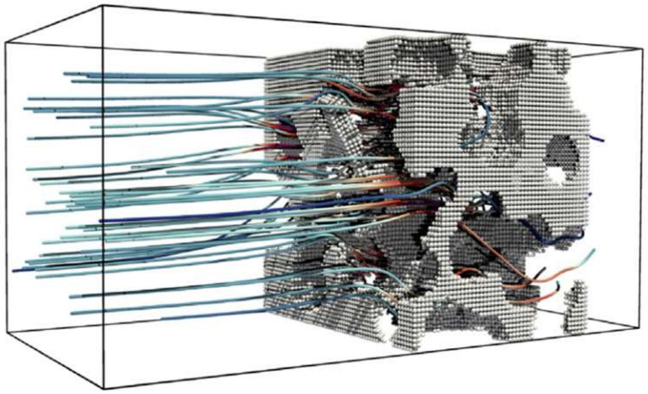
Producing data from actual experiments

- Collaboration with **Green Propulsion Laboratory** (Veritas S.p.A., Fusina)
- Study of the behaviour of the flow through parts of the system
- Investigation on the **effects** of the introduction of **porous matrices** as **culture medium**
- Performance analysis of **different bioreactors shapes**
- Overall **data collection** to be used in computational **model validation**

Task #2: CFD Development

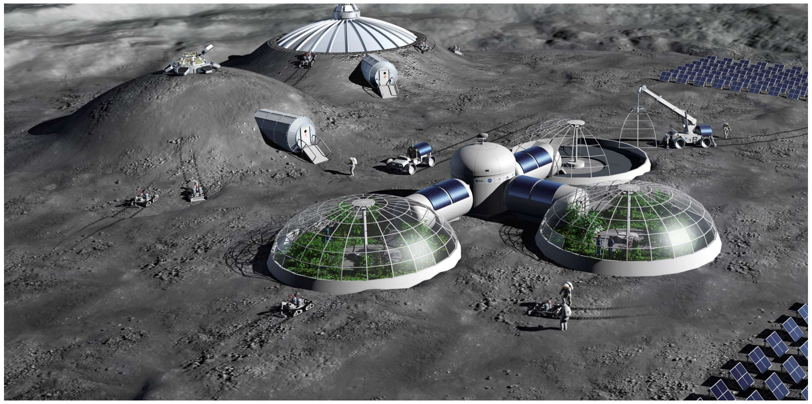
CFD models based on previous data:

- Development of a **macroscopic model** to study the motion of **bubbles within the reactor** using commercial software
- Development of a **macroscopic model** to study the motion of bubbles within the reactor using in-house software
- Development of a **microscopic model** (of **micro-cavities** and the **exchange of liquid and gas** across the matrix surface)
- The model will be applied to all three reactor types studied and will allow **optimisation of reactor geometry and size**



Task #3: Gravity Effect

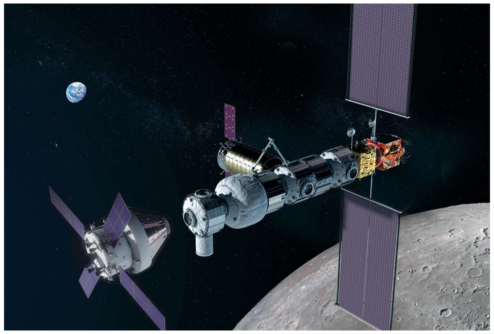
Moon/Mars settlement and orbit environment



Open questions:

- How well do bioreactors work in these conditions?
- Are new setups or approaches needed?

New experiments are to be done, possibily in simulated **microgravity environments**.
Computational models will be updated and validated.



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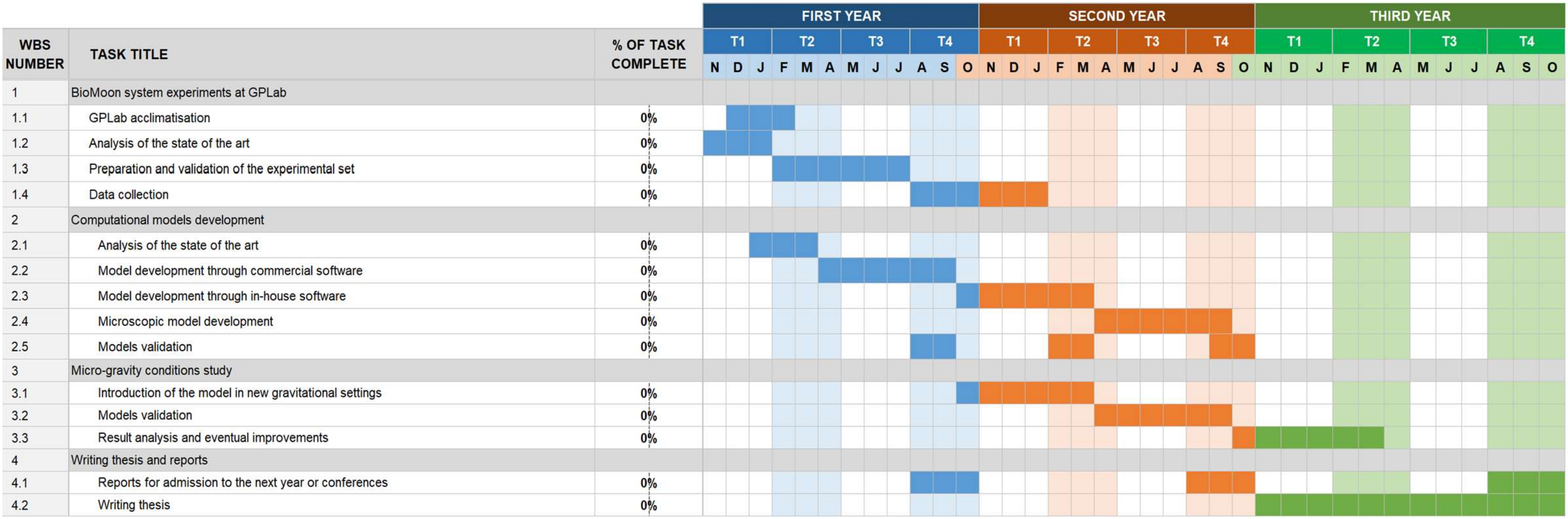
GANTT Chart



Thanks for the attention

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