Spaceship Update – September 2023

Aidan Cowley, Alexis Paillet, Romain Charles & Spaceship Team

Spaceships – Exploration Innovation Teams

What are the Spaceship Initiatives?

- Highly motivated **innovation teams**, dedicated to enabling Exploration activities, for their locations, partners and Agencies
- **Dynamic network** of collaborators across Europe, supporting and initiating low-TRL Exploration R&D with an emphasis on **practical demonstration and skunkworks** approach (i.e., '*innovate and apply under one roof*')
- Spaceship Teams are made up of research institutes and Universities, visiting researchers, students, commercial entities, ESA and National Agency staff members

ExPeRT

E3P Programmatic Position:

'A **fundamental element of ExPeRT** *are the Spaceships, initiatives that* **develop operational concepts and low TRL technologies***…*

…Spaceship projects are emphasized to be **pragmatic, demonstration driven and innovative** *in their scope. Importantly, the initiative links with related activities within ESA and with varied stakeholders across Europe'*

Spaceship EAC – EAC, Cologne, Germany
Coordinator: Aidan Cowley

Spaceship ECSAT – ECSAT, Harwell, UK
Coordinator: Romain Charles

Spaceship France – CNES, Toulouse, France
Coordinator: Alexis Paillet

Spaceship topics

- **Advanced Manufacturing**
- **Energy**
- **Off-World Living/Crew Health**
- **Disruptive Technology (AI, VR, AR)**
- **Space Resources**
- **Robotics**

3D Printing with Regolith Composites

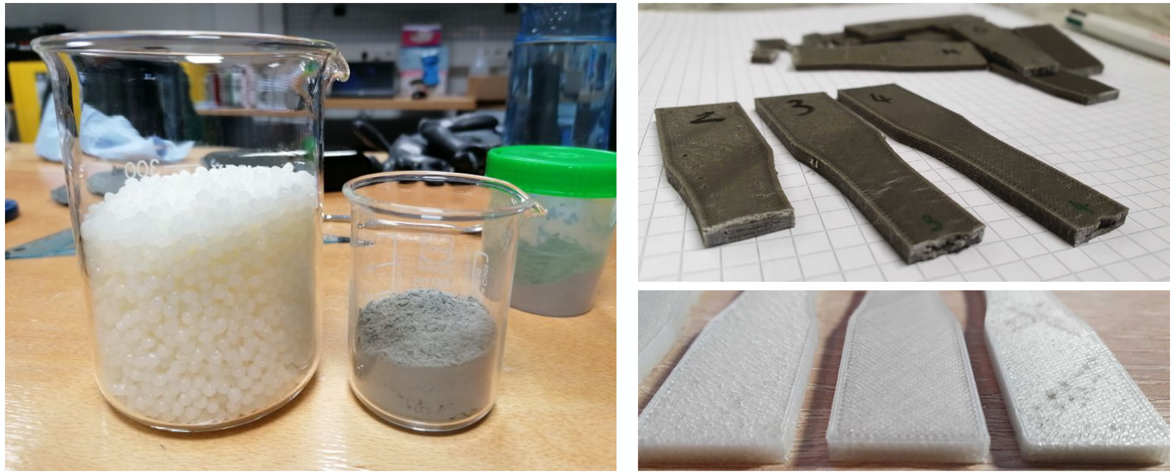
Examining different approaches and mixtures

Main objective: Defining an optimal manufacturing process to produce high-performance composites based on lunar regolith

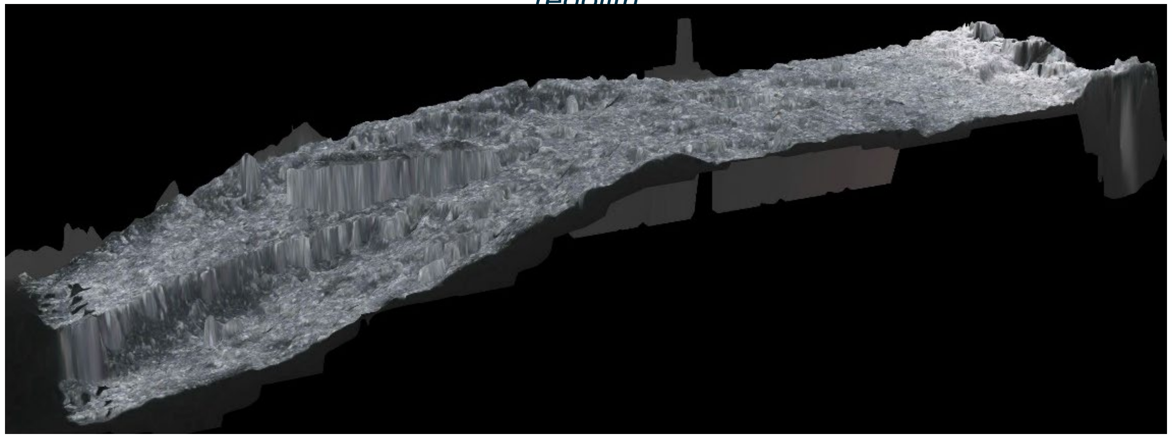
Work performed:

- Manufactured and characterized PLA/regolith composites (20 wt.% of regolith)
- Assed the recyclability of PLA/regolith composites
- Replaced the PLA with a high-performance thermoplastic – PEKK (25 wt.% of regolith)

Current work: New thermoplastic-regolith composite based on regolith (5, 15 and 25 wt.%) and three different additives: carbon, graphite, graphene.



Left: PLA pallets and EAC-1 simulant, Right: Test coupons made of PLA and regolith



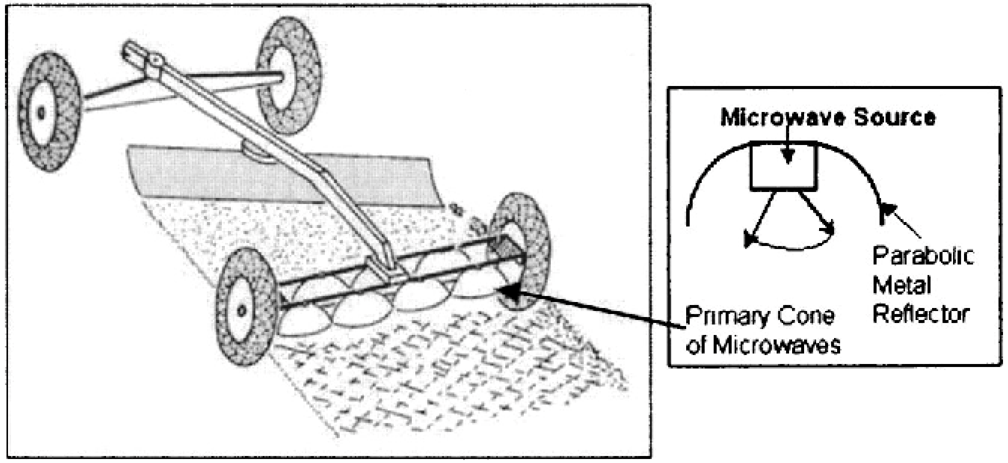
3D picture of the fracture face of sample : regolith 5%, carbon 5%, microscope x200

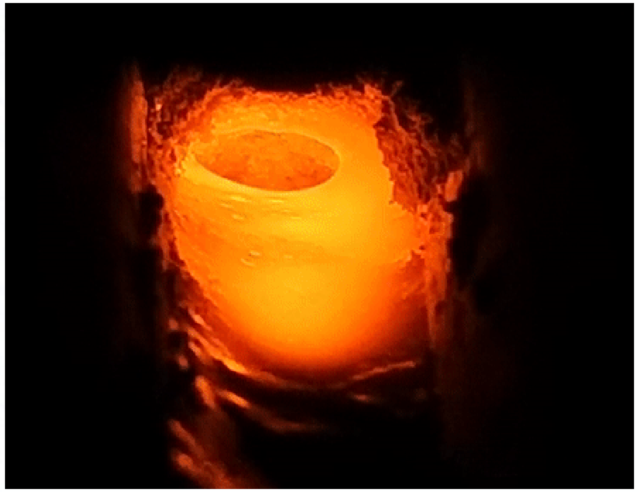
State of the Art Microwave Processing of Regolith

“MOONSTONE” project

- Custom-manufactured cavity for crucibles
- It is possible to melt a small volume of regolith inside the cavity
- Mechanically pushing the crucible allows melting a continuous line

Creating Smooth-Sintered to Glassy Surfaces on the Moon





Composite Moon Bricks – Production Process

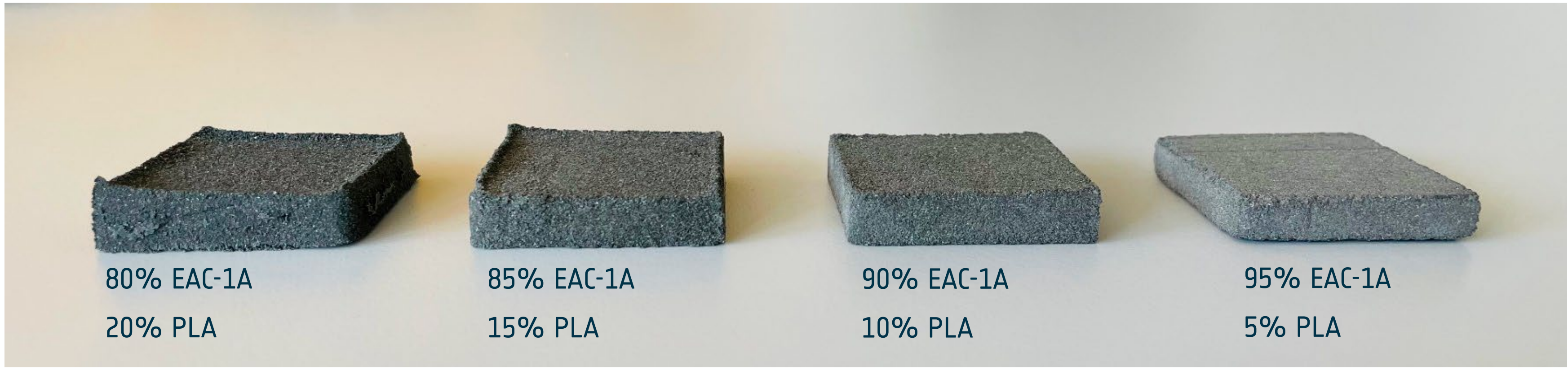
How to enable sustainable construction-scale manufacturing on the Moon?

- Simplify the manufacturing process & reduce the binder ratio
- Utilize Spaceship EAC's unique experimental research and experience for payload development

Why are standardized composite construction bricks the prime material?

- Utilizing related construction techniques and materials on Earth saves time and cost.
- Mass and volume-efficient payload to produce significant structures
- Automated production and assembly

How low can we go with the organic phase?



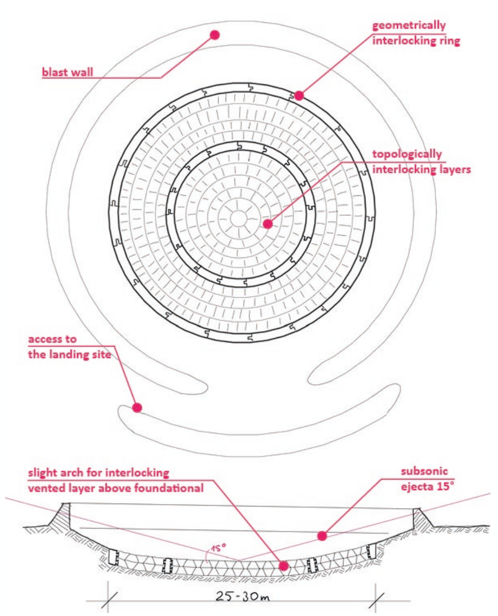
Standardized Interlocking Elements

Lunar Landing Pad – Design approach

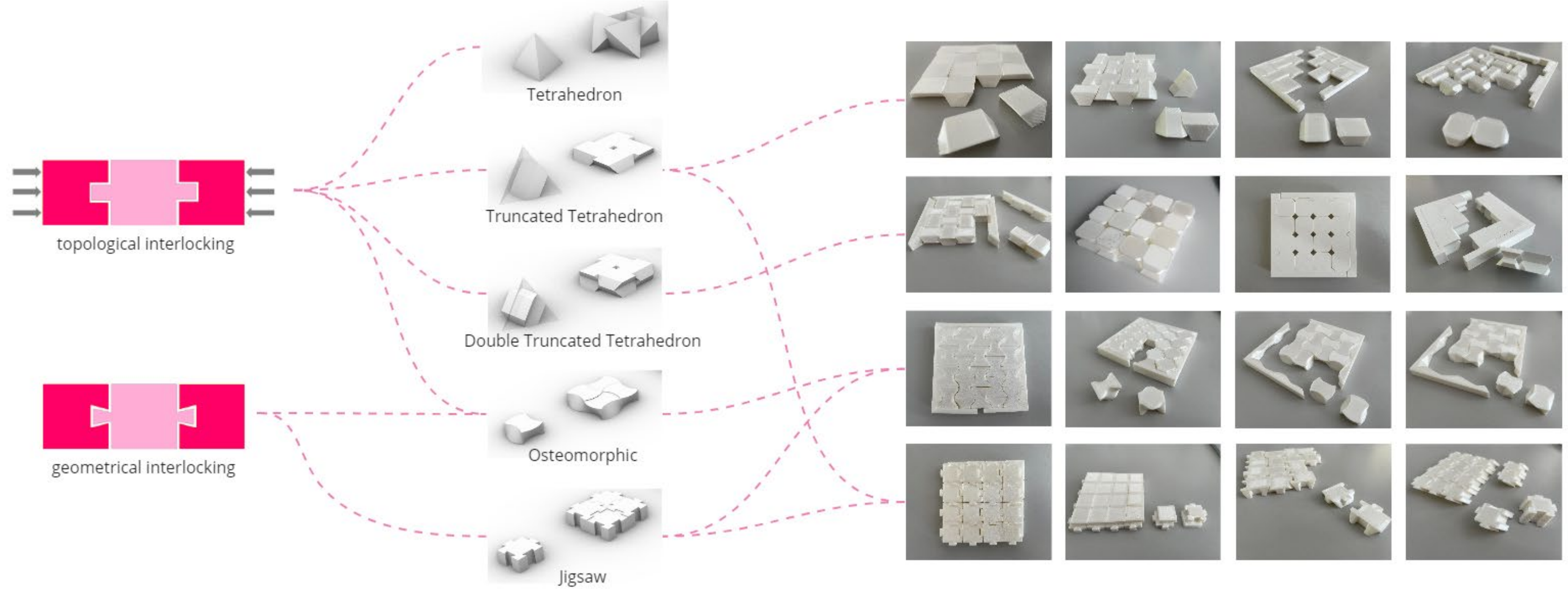
Main objective: Investigating the feasibility of using sintered and/or cast regolith bricks for lunar landing pads.
The goal is to investigate the structural capabilities of regolith bricks in terms of geometry, reliability, plume absorption and their compatibilities with future landers.

Research & Design: Exploration of vernacular designs, specifically geometrically and topologically interlocking components.
General landing pad design criteria (such as venting of exhaust plumes, blast walls and beacons for supporting lunar landing navigation)

Landing Pad Sketch



Interlocking Type | Brick Type | 3D Printed Brick Designs

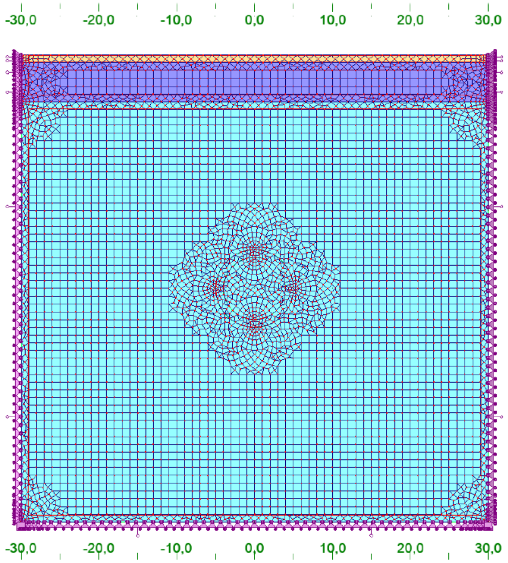


SOURCE: landing pad sketch, plan & section

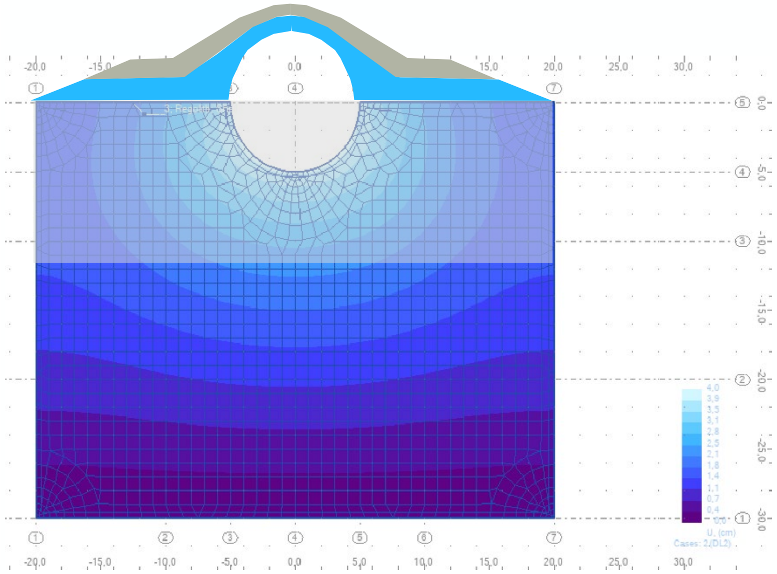
SOURCE: geometrically and topologically interlocking brick designs

Lunar Soil Mechanics – Elastic Simulations

Parametric model

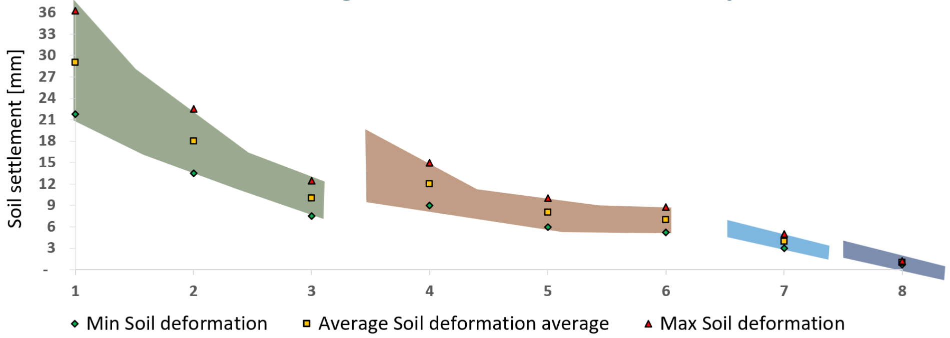


Scalability – geotechnical cases



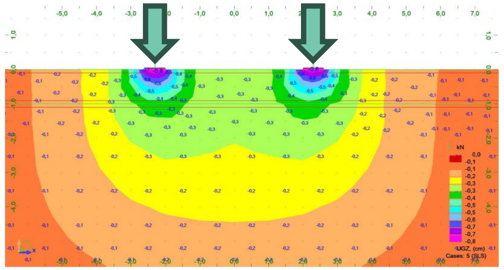
Application for landers

Estimation of regolith settlement by each scenario



Scenario - landers

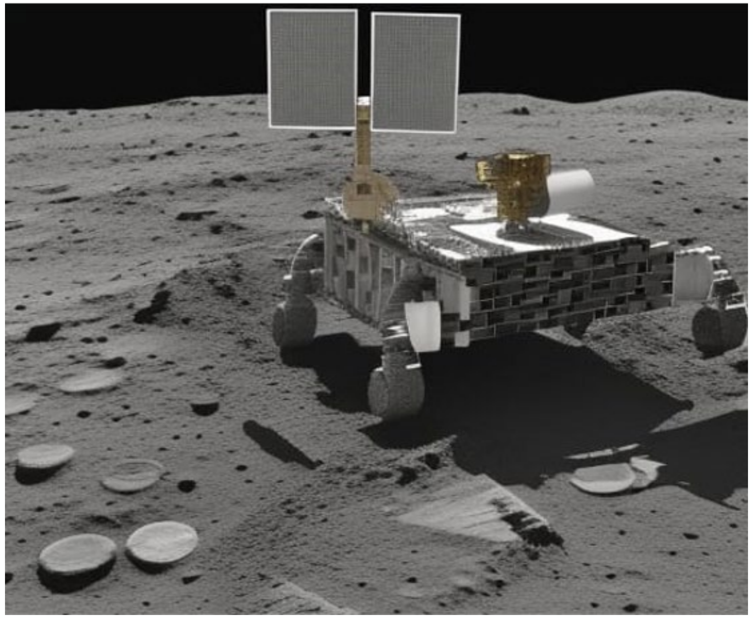
Simulation



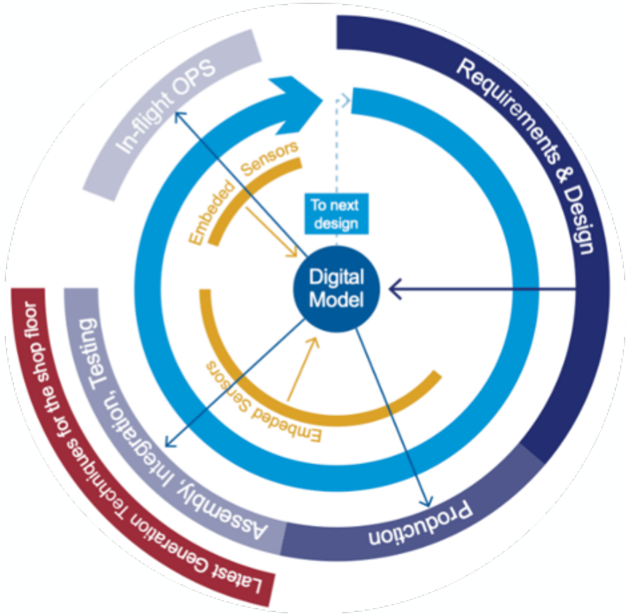
ISRU Payload – Payload Development

Mission statement: The Lunar Bricks mission shall demonstrate a reliable manufacturing system on the Moon, using lunar resources. The payload is a low-cost technology demonstration mission to verify the feasibility of sustainable ISRU manufacturing in the lunar infrastructure development.

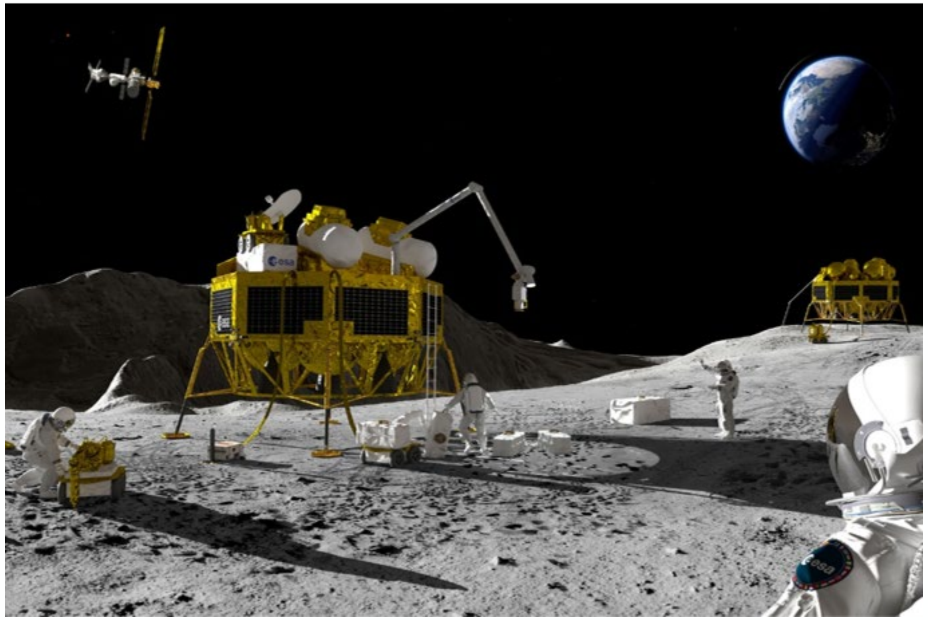
The payload is designed iteratively with simplicity and COTS solutions



Model-Based Systems Engineering saves development time and cost



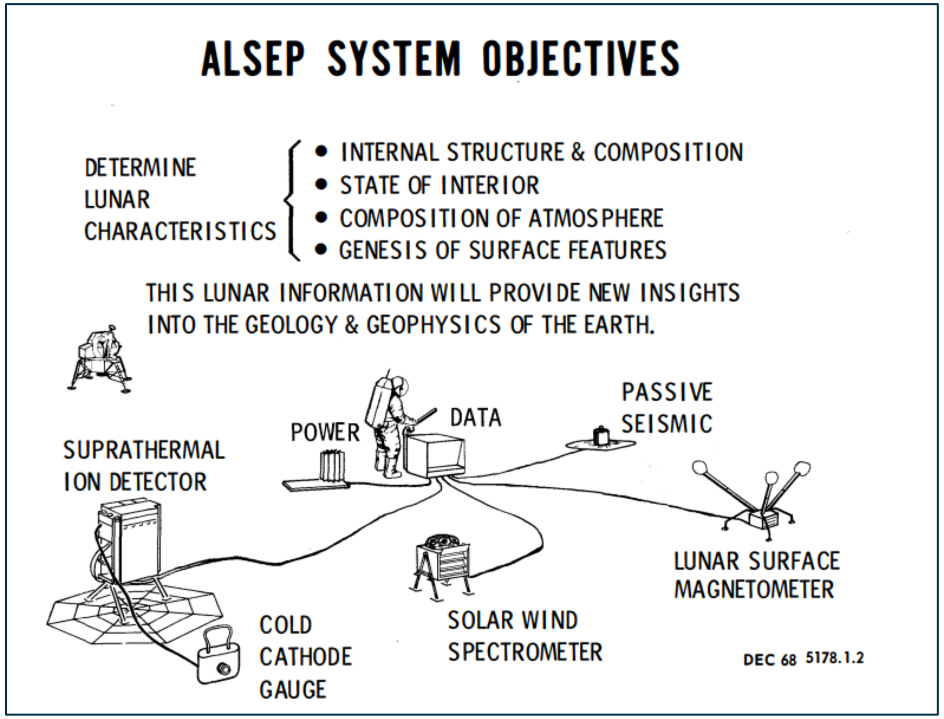
Spaceship EAC seeks to deliver the payload to a 2030+ Argonaut launch



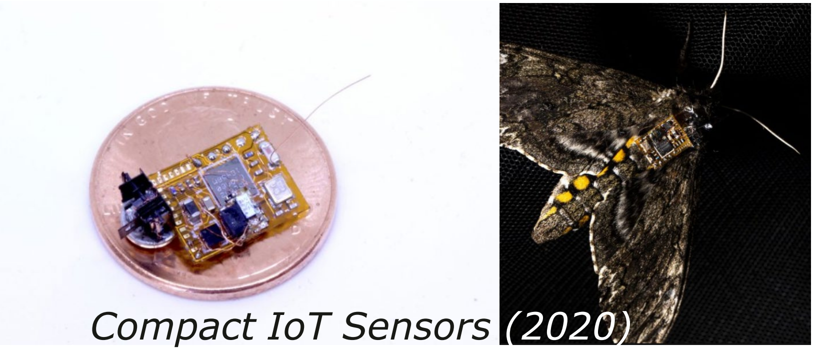
IoT Sensor Confetti for Surface Exploration

- Planetary surface exploration has been greatly limited by the area which surrounds the landing pad and areas with limited access (e.g. lunar lava tubes)
- Small sensor packages which can be deployed and communicate via long range for an extended time can help characterize these areas

- We propose a **Sensor Confetti**
  - Low power, compact IoT sensor module equipped with sensor(s) which can relay measurements via LoRa antennas
  - Connected among each other in a self-healing mesh network
  - Easy to deploy and disposable

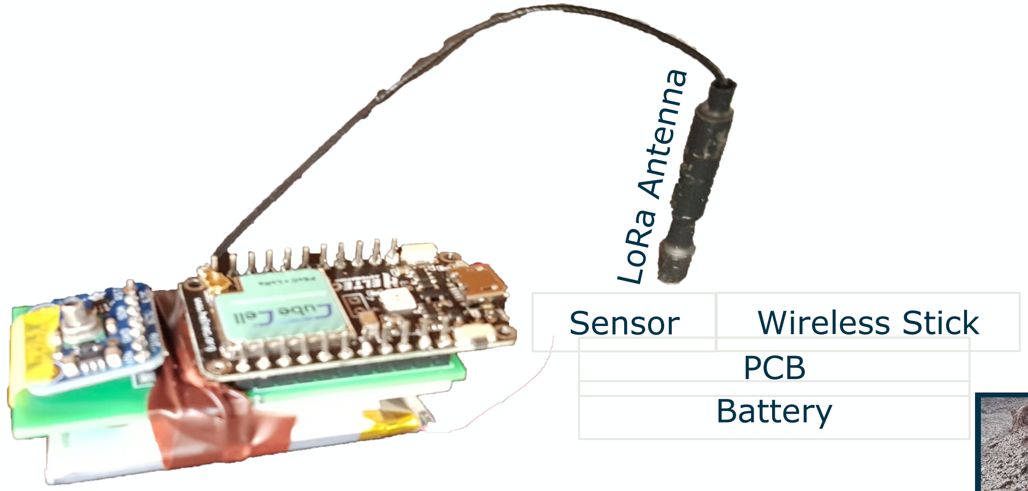


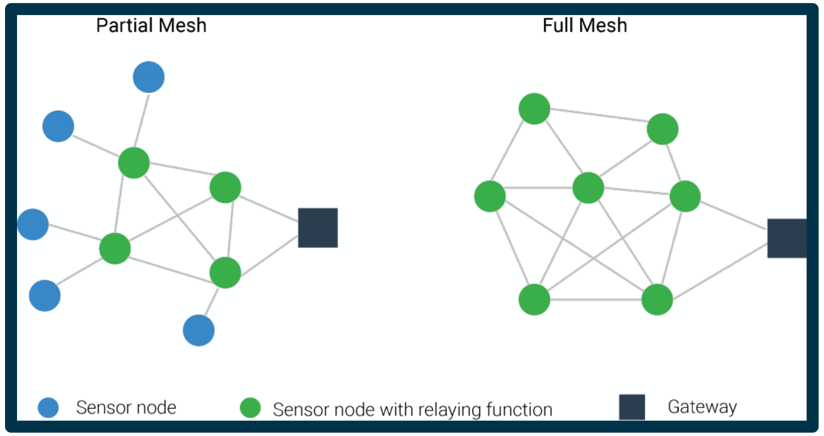
Apollo Lunar Surface Experiments Package (1968)

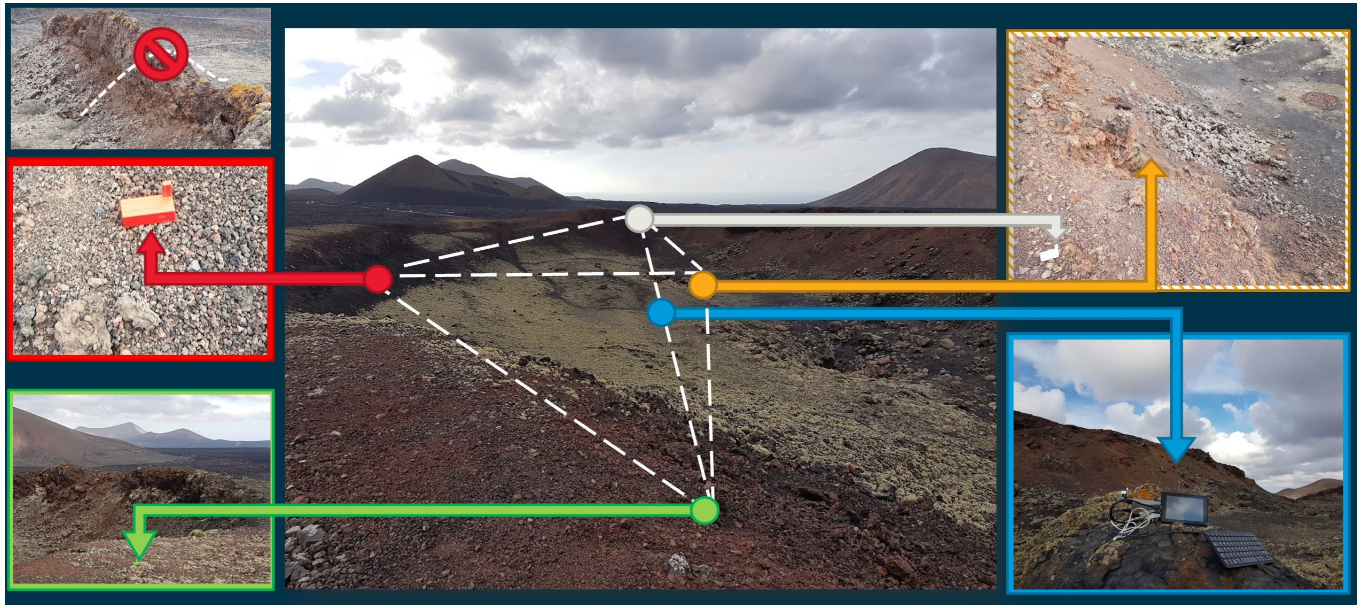


Compact IoT Sensors (2020)

IoT Sensor Confetti for Surface Exploration

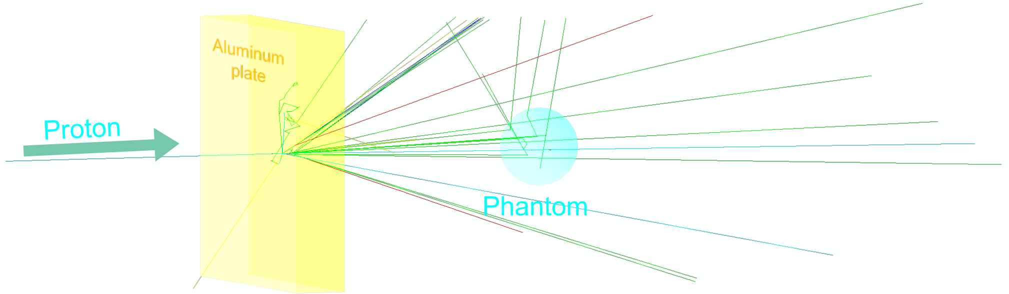


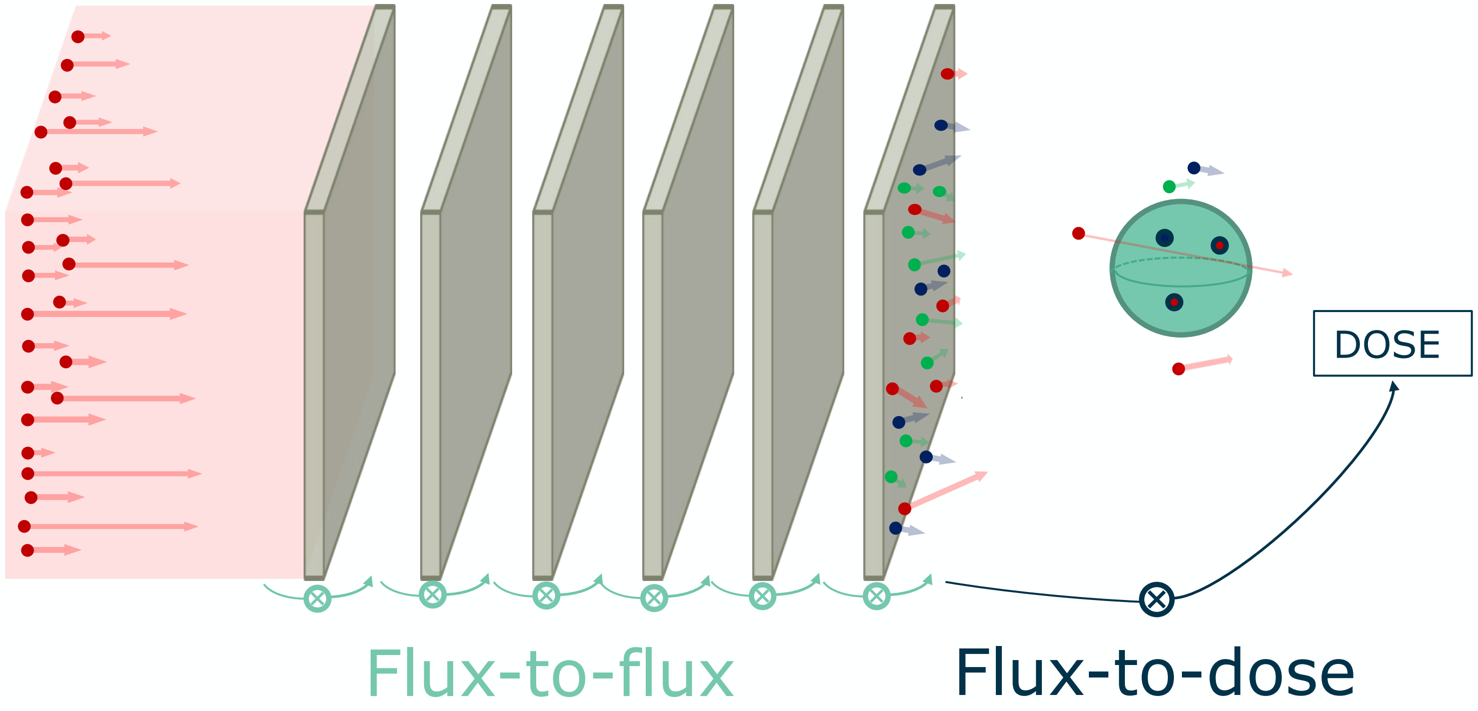




Radiation shielding on the Moon

- Propose concepts to mitigate radiations for astronauts combining innovative materials and ISRU.
- Monte Carlo simulations under Geant4





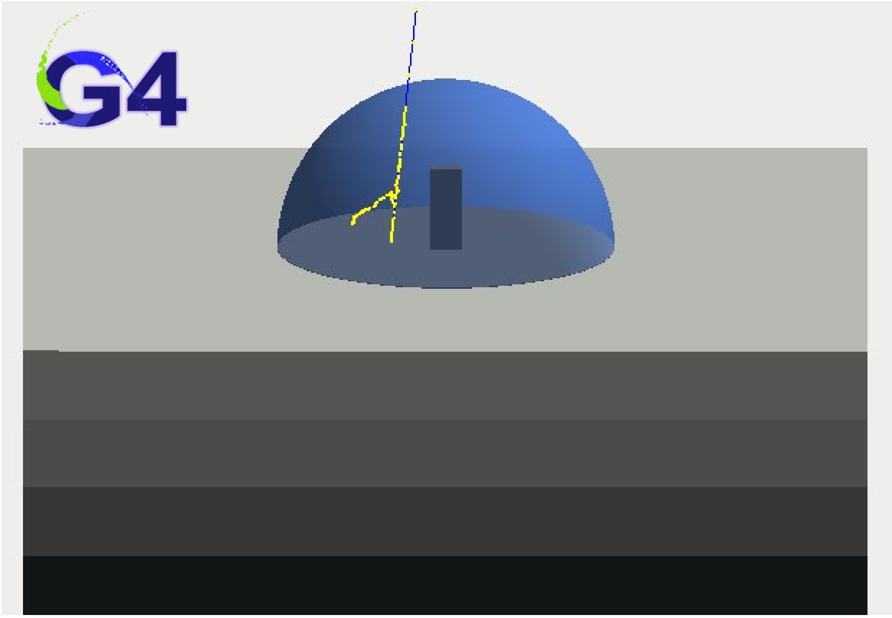
- Method computing flux by iterated convoluted layers to boost simulation time
- Future shielding material arranged in layer structure to increase shielding power
- Lunar regolith as main player

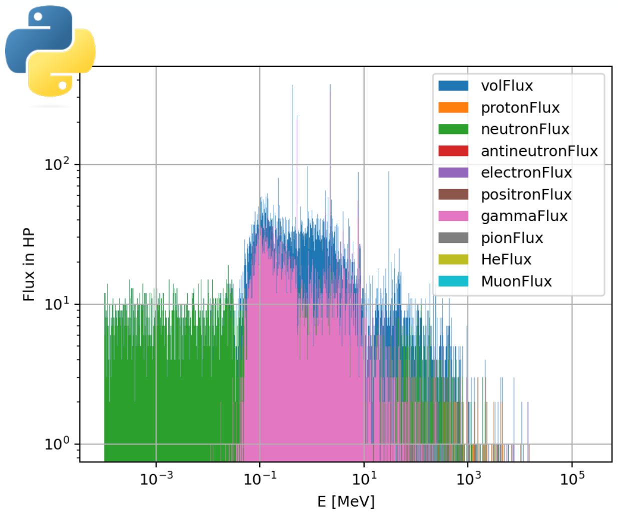
Dome Simulation with ICRP Human Phantom

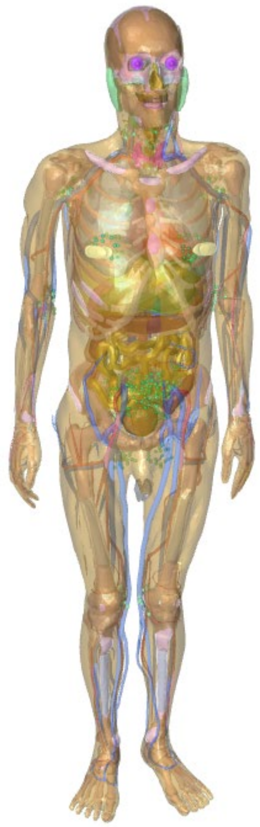
Adult Mesh-Type Reference Computational Phantoms computing dose in all important organs

Entire dome with close surroundings

- Dome made of of several layers (Aluminum + Regolith)
- Radiation field is significantly larger than the dome to include possible reflection from the ground
- Measuring the secondary particle flux inside the dome







ICRP, 2020. Adult mesh-type reference computational phantoms

Geological Classifier: Realizing in-situ lunar rock analysis

esa

Aim

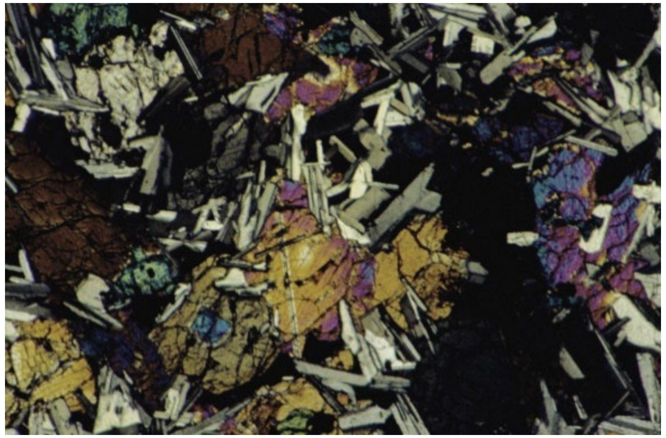
Automatically identify minerals and rock types in lunar thin section samples using Machine Learning techniques

Use Case:

- Immediate feedback on collected material
- Enable further in-situ analysis
- Create more independence of expert knowledge on earth
- Prevent sample Redundancy

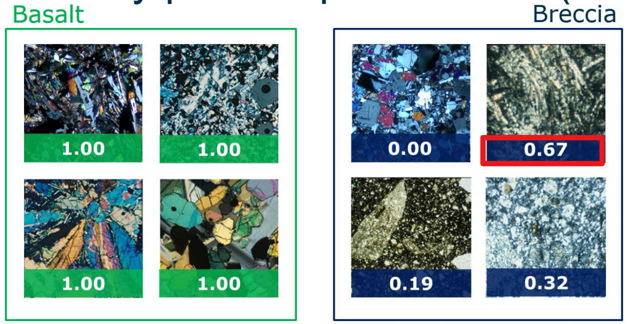
Thin section?

30µm thin semi-translucent slice of rock

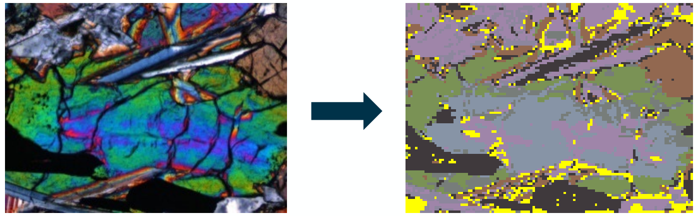


Underlying Work

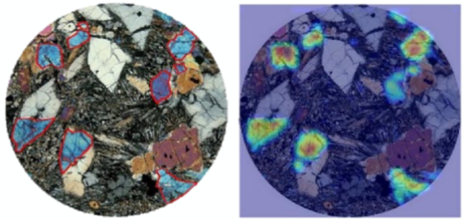
- Supervised algorithm classifying lunar rock into most common groups (Basalt or Breccia)
  Classification accuracy per sample: 99.03% (+/- 0.97)



- Unsupervised clustering algorithm to segment a thin-section image into clusters of minerals



- Weakly supervised learning to segment olivine



Ground truth Prediction

← Best results IoU[1] of 0.73, but mean IoU of 0.36

[1] IoU defines Intersection over Union i.e. the overlap of the predicted segmentation with the ground truth

NLP for Spaceship – Introducing Natalia

NATALIA

Natural Language Processing Chatbot for Spaceship's Linked Database*

Summarization and Classification

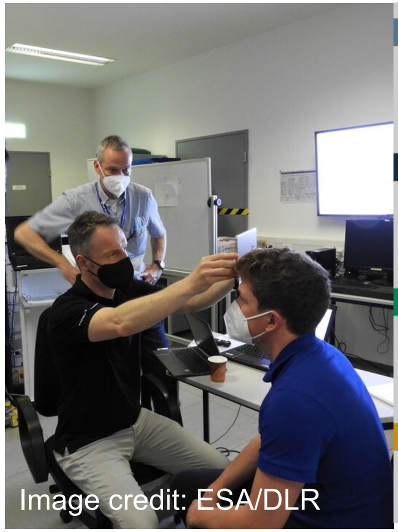
- Data Mining/Scraping and Parsing
- Document Summarization: summaries of lengthy project reports/scientific papers
- Document Classification: Clustering specific topics and themes by mathematical vectorization of documents

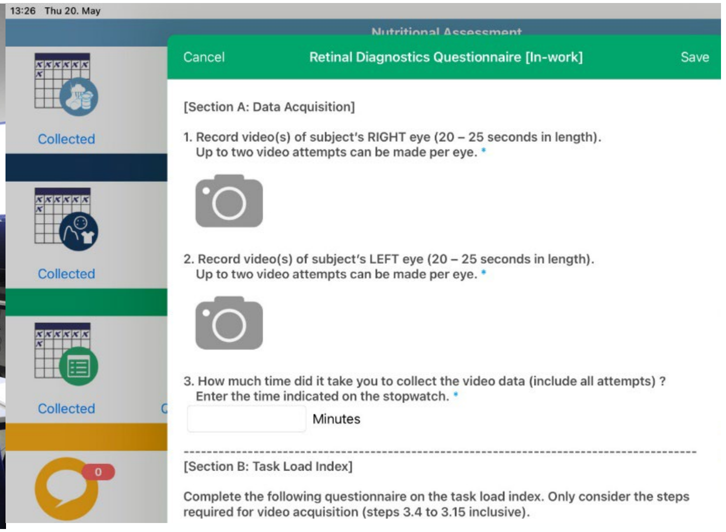
Conversational, Question Answering and Generative

- Natural Language Understanding and Contextual Understanding
- Providing accurate and contextually relevant answers based on prompt and data lake*
- Conversational Behaviour maintaining coherent and engaging dialogue

*Document Management Server housing project reports and scientific papers for Spaceship EAC

DLR-EAC Retinal Diagnostics for SANS





Spaceflight Associated Neuro-ocular Syndrome (SANS):

- Risk for long-duration flight (affects 2/3 of crew)
- Monitored by MedOps

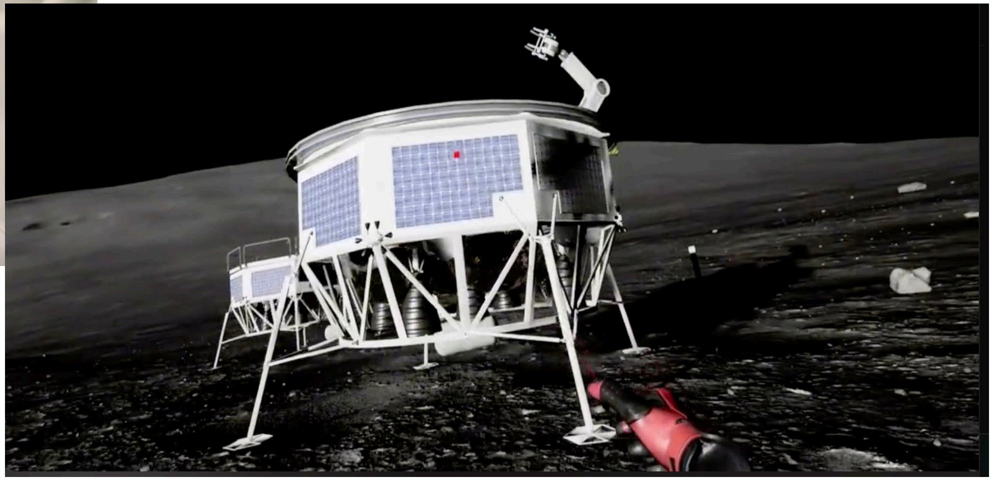
Previous ISS Inc 66 Tech Demo:

1. Uploaded 3D-printed adapter + lens
2. Attached to crew tablets (iPad Pro 2017)
3. Crew used EveryWear to video their retinas
4. Videos downlinked to train artificial intelligence models

Proposed Tech Demo Operational Overview:

1. Upload lens for new crew tablets (iPad Pro 2021)
2. Integrate our SANS-detection AI into EveryWear
3. Crew uses EveryWear to video their retinas w/ AI
4. AI models provide real-time SANS diagnosis
5. Videos and diagnosis downlinked to verify accuracy

Spaceship with the XR LAB – VR/ AR Technologies



How can we use virtual reality (VR) and augmented reality (AR) technology for astronaut training & exploration?

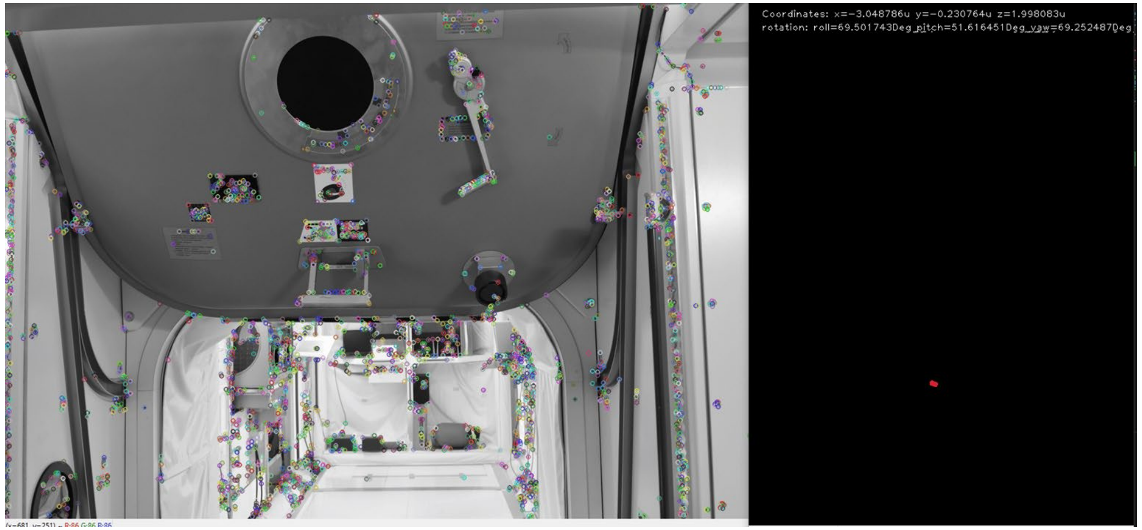
- **VR** → Cost **effective / efficient / flexible** training of astronauts through simulation of a virtual environment (e.g. ISS, lunar environments) or evaluation of design prototypes (e.g. lunar lander EL3)
- **AR** → Overlaying computer-generated (visual) information on real surroundings

Handheld Augmented Reality in 0g

Creation of a visual IMU to work around microgravity issues in AR

Real time, 6 DoF, position and orientation with a smartphone camera with combination of:

- Visual Odometry
- Visual Localisation



Working demo

What is happening ?

- Localisation in real time of the camera
- Placement of a virtual message
- The virtual message stays immobile despite movement of the camera

Human Factors for Human-Machine Interfaces

Main objective: design proposal for the European Charging Station for the Moon

Astronaut **tasks** during EVAs:

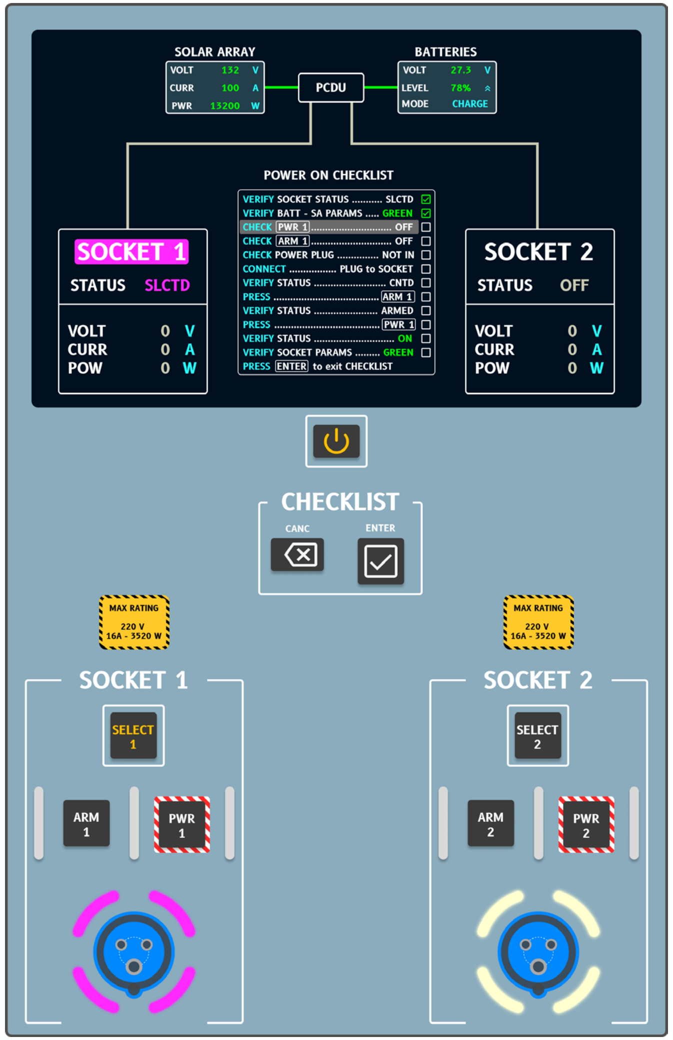
- Approach ECSM
- Operate the system with or without supervision from Mission Control
- Safely connect or disconnect utilities

Human Factors consideration:

- Environment
- Cognitive Load
- EVA **suit** (gloves and arms envelope)
- Design of the **Human-Machine Interfaces**
- Design of the **Socket & Plug system**

Challenges:

- **Apply** a Human-Centred Design approach
- **Design** a first of kind HMI
- **Validate** the initial proposal

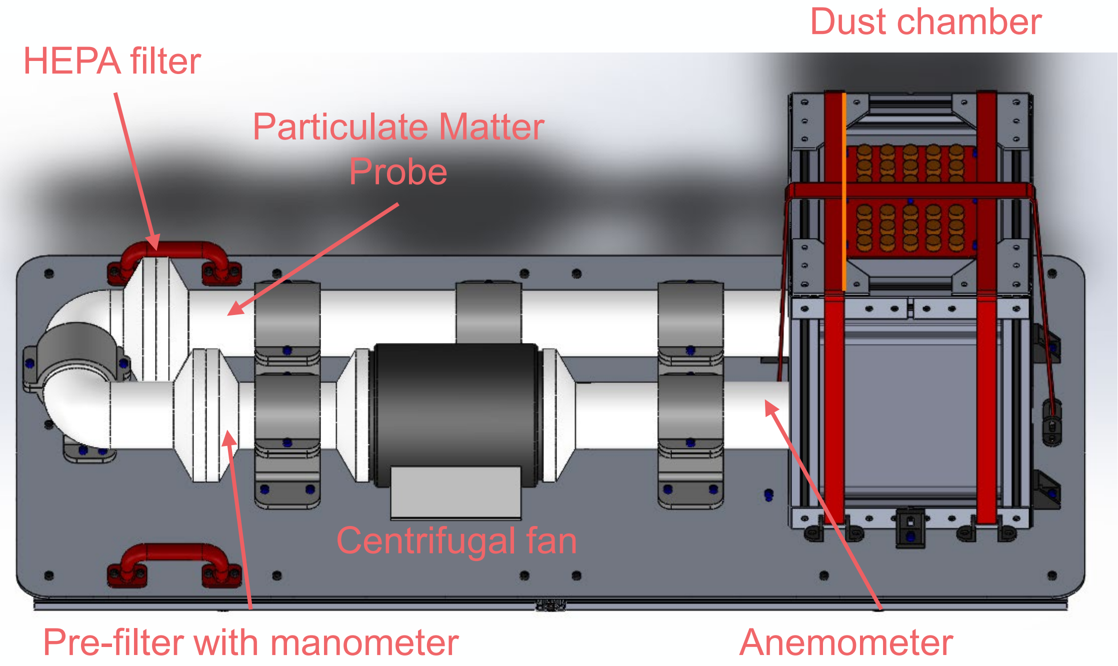


Design proposal of the interface

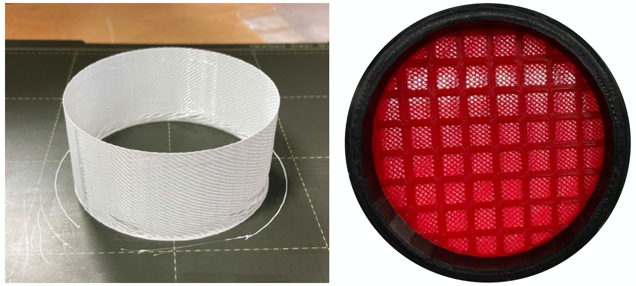
Skunkworks activities at Spaceship EAC

Lunar Facility Filtration Assessment

Main Objective: propose a multistage filtration system for lunar habitats that combines recycle prefilters prior to the high-efficiency filter and test in a **Parabolic Flight Campaign**



Flight configuration of the test setup



3D printed textiles used as pre-filters

Future work: Assess fibre dimeter and uniformity of the media, visualise the effect of layering on pore size, visualise dust loading and assess particle size that is entrapped on the layers

Spaceship ECSAT – Vision & Projects

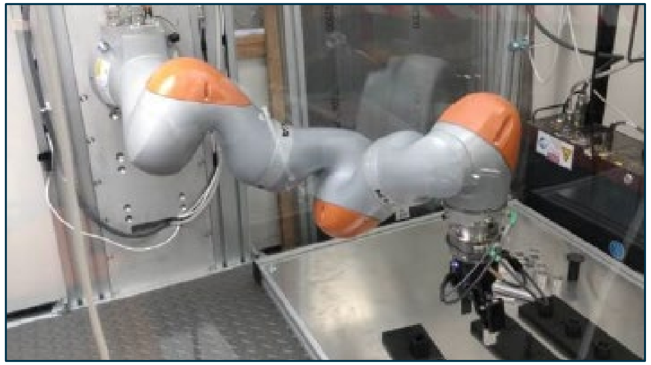
- Early 2023 – Definition of the Spaceship ECSAT Roadmap
- 3 main themes identified:

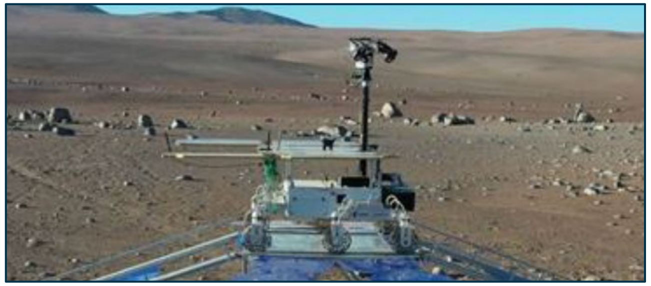
Robotics

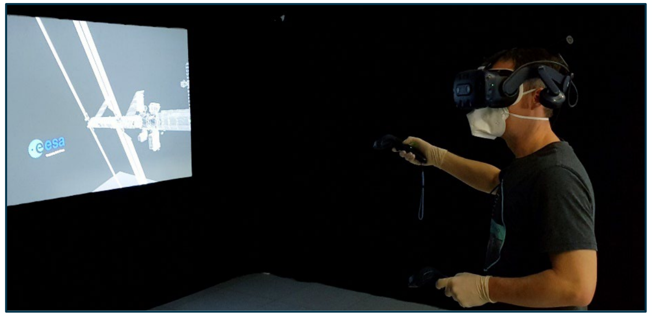
Extended Reality

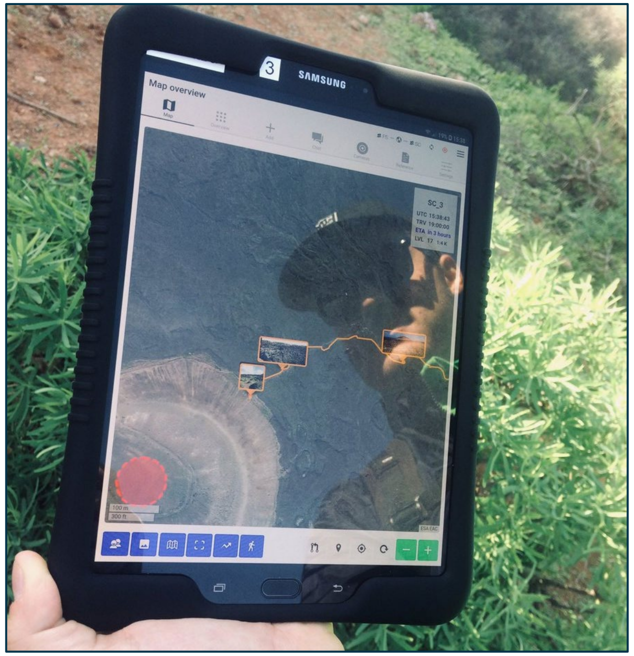
Astronauts Assistant

(Telecommunications & Navigation)









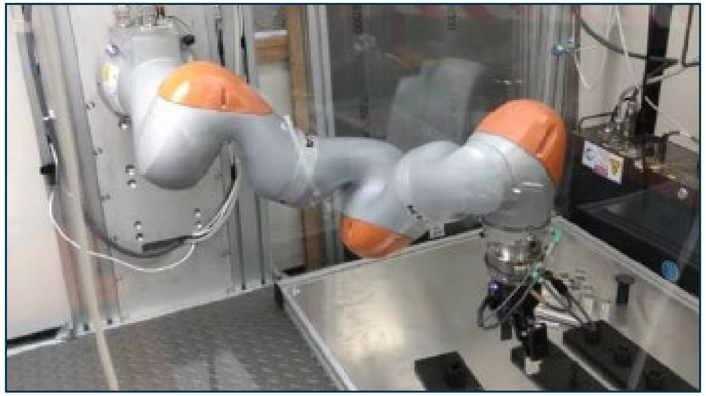
Spaceship ECSAT - Network

- Presentation of the Spaceship ECSAT roadmap and vision to stakeholders in the agency and outside
  - ESA CAVES/PANGAEA team
  - ESA Moonlight team
  - UK Space Agency
  - Catapult (Space Based Solar Power & Robotics)
  - CFMS (Center For Modelling and Simulation)
  - Ispace
  - Oxford University (Robotics lab)
  - Portsmouth University (XR lab)

Spaceship ECSAT – Start projects

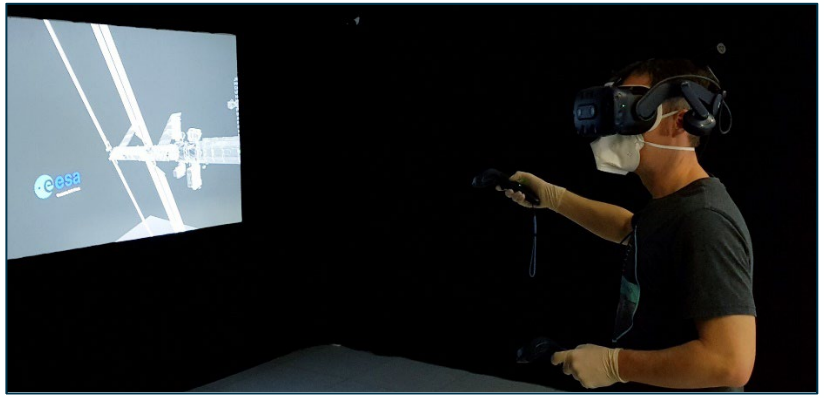
Robotics

2 internships in 2023
+
International PhD Thesis
(NET 2024)



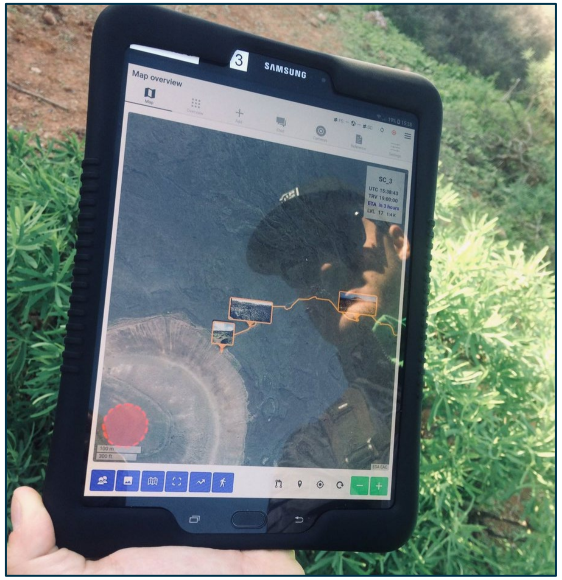
Extended Reality

1 internship in 2023



Astronauts Assistant

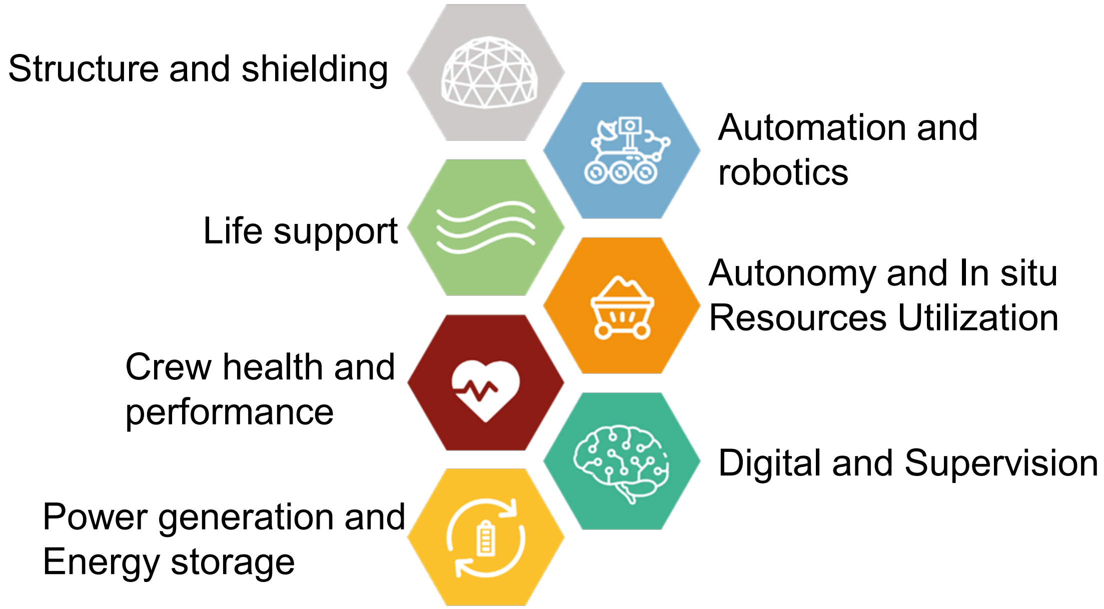
TBD with Moonlight team



Thank You!

GOAL

- **Bring French technologies on the Moon & Mars**



INTEGRATED TEAM WITH EUROPEAN PROGRAMM

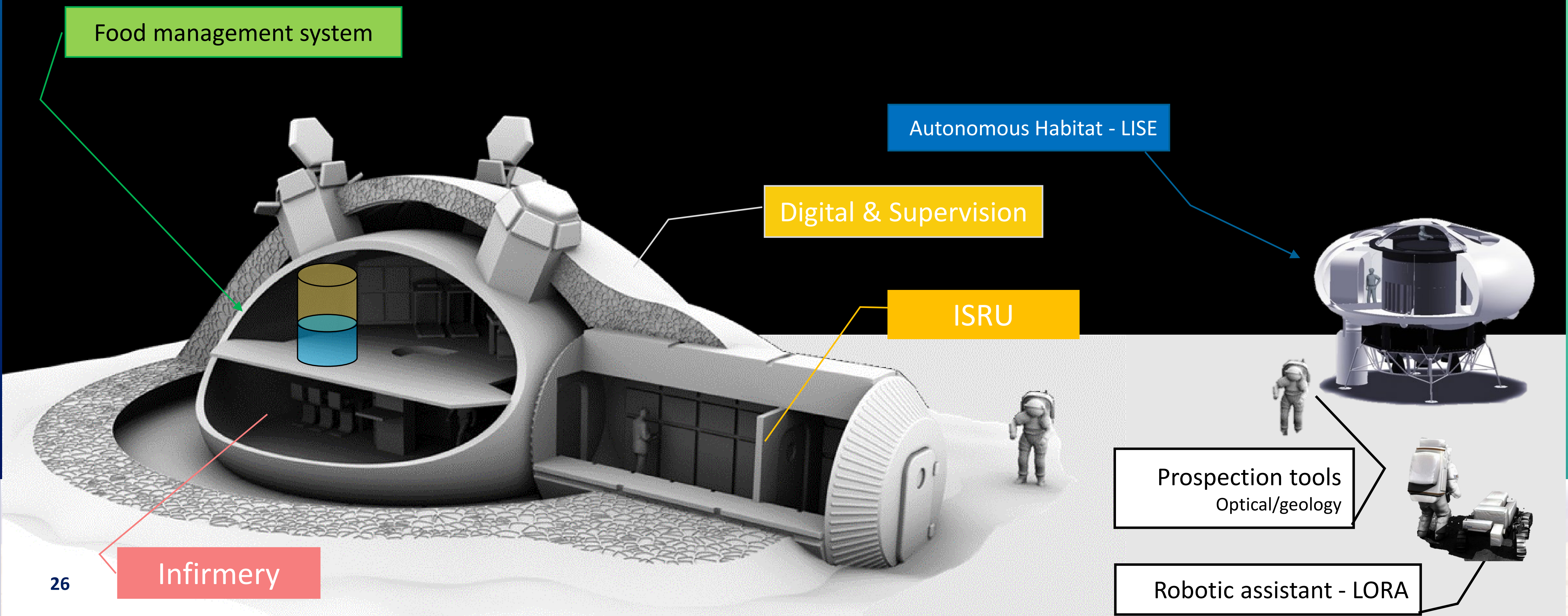
- **Spaceships Networks**
- **Synergies & partenership behind international project**

TECHNOLOGIES @ SPACESHIP FR

- **ISECG**
- **French Ecosystem**
- **Spin Off for Industrial**

FOCSE
FRENCH OPERATIONS CENTER FOR SCIENCE & EXPLORATION
cnes

Subsystems in the international outpost



SPACESHIP FR – TECHNOLOGIES & ECOSYSTEM

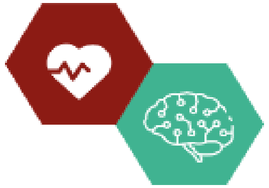
Life support system & Habitat Protection

- Life support for Habitat or pressurise r
- Supervision for habita
- Erectable frame
- µmeteorite
- Radioprotection
- Life support for Astronauts
- Energy valorisation
- Digital Twin & AI for planetary outpost
- Regenerative Fuel Cell System

Assistant for Astronaut

- Real time
- Non Organic waste recycling
- Tele-operability
- Science prospectio
- Machin / Astronauts Interface
- Equipement for ISRU
- Autonomous navigation

Crew Health & Performances



- Advanced Surgery
- Radioprotection
- Prevention
- Diagnostics
- Stress & Human factors management
- Clinical Care
- Pharmacy
- Emergency
- Digital Twin & AI for Astronauts
- Training
- contermeasures
- Multimodale & postable imagery

Food Management & Recycling

- Food managemen
- Supervision for green hou
- Food Production &Transformati
- Cooking innovation
- Organic Waste recycling
- Biosource manageme
- Digital Twin & AI for green hou

SPACESHIP FR – INSPIRE

CONFERENCE

- **Space Ressources Week /** Luxembourg - **1 Poster**
- **Space Ops /** Dubai **– 3 articles (Ground segment, astronaute assistance)**
- **Int Conf Enviromental System** / Calgary – **1 Poster, 8 Articles (Health, Life Support & Energy)**
- **Int. Conf. on Systems, Man, and Cybernetics - 1 Article (Robotics and Interaction Astronaute Rover)**

CHALLENGE

- **Digital twin for Astronaute**
- **Surface properties**

SPACESHIP FR – Communauté

CREW HEALTH & PERFORMANCES

FOCSE FRENCH OPERATIONS CENTER FOR SCIENCE & EXPLORATION · cnes · RÉPUBLIQUE FRANÇAISE Liberté Égalité Fraternité

DIGITAL TWIN OF THE ASTONAUT FOR PERSONALIZED COUNTEMEASURES (MUSCULOSKELETAL)

PHILOMEC — Franco-Canadian Startup — 2 co-founders (PhD and biomedical engineer)

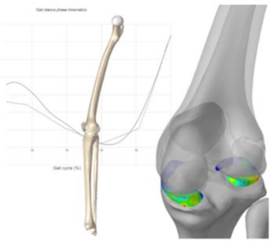
Goals:
Short term – Feasibility study for adaptation of a digital twin to spaceflight environment
Long term – Development of a tool (personalized digital twin) for preventive care of musculoskeletal deconditioning during spaceflight (countermeasures)

Strategy

1st: Literature review: musculoskeletal deconditioning during space flight and identifica countermeasures

2nd: Feasibility simulations for different exercise configurations

3rd: Sensitivity analysis for model assessment



Main Results

- Synthesis of the literature: osteoarticular alteration during spaceflight
- Discussion/validation of model strategy with space medicine expert (Vico)
- Feasibility simulation: FEM walking either under Earth gravity or during treadmill training in microgravity with spring simulated gravity – bone loss prediction

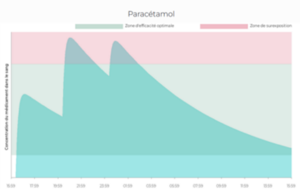
Communication

Podium presentation and publication ICES 2023 – July 2023

DIGITAL TWIN OF THE ASTRONAUT for personalized medication (Pharmakokinetik)

EXACTCURE Your Digital Twin for a Personalized Medication — Startup — 3 co-founders (PhD, pharmacist, mathematician)

Goals:
Short term – Feasibility study for adaptation of pharmacokinetic models, developed for terrestrial application, to respond to the physiological and pathological phenomena of space
Long term – Development of a tool (personalized digital twin) to give autonomy to the astronaut for his medication



Strategy

1st: Literature review: physiological functions altered during space flight and identification of molecules/areas of interest for spaceflight

2nd: Software development of a prototype model and evaluation of the model from retrospective data (bed rest simulations)

Main Results

- Synthesis of the literature: physiological functions altered during space flight
- Workshop with space medicine experts (Custeau, Pavy, Gandia, Gatacceca)
- Identification of priority molecules for spaceflight (sleep and mental health drugs cardiovascular drugs, emergency treatments (analgesics, antihistamines, antidotes)) are good candidates
- Model implementation for acetaminophen and sensitivity analysis

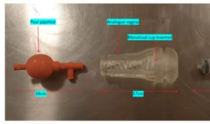
Communication

Podium presentation and publication ICES 2023 – July 2023

Design de la coupe menstruelle pour la collection adaptée au vol spatial

Claripharm LABORATOIRE — Startup bretonne — Expertise: fabrication de dispositifs médicaux brevetés destinés à l'hygiène intime

Goals: Develop a prototype of a menstrual cup adapted for blood collection in space environment



Strategy (under discussion)

- Design workshop in Toulouse in September (engineers, designer, gynecologist)
- Prototyping (medical silicone)
- Validation of the dimension with design file
- Finalization of the design by the creation of the Specifications for the mold

Main Results

- Project under discussion
- *Preliminary exchanges with tests on menstrual cup collection capacities in 0G flight*

ExoCPR - Exoskeleton for assisting chest compression maneuvers during spaceflight

Groupe Hospitalier Bretagne Sud — Hôpital
Co Work'HIT — Centre d'innovation
Plateau technique compositic Université Bretagne Sud — Laboratoire de recherche plateau technique

Goals:
Short term – Prototype of exoskeleton for assisting chest compression
Long term – Implementation of the exoskeleton in public spaces

Concept design

Strategy

1st : literature review for cardiac arrest procedure and existing devices
2nd : technical specifications required for the device and medical protocol
3rd: 3D prototype (mechanical and cinematic)

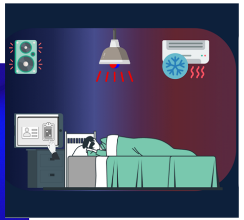
Main Results

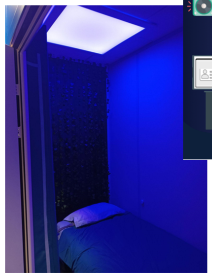
- State the art:
  - Epidemiology - cardiac arrest in space
  - Manual compressions
  - Mechanical chest compression devices (advantage/disadvantage)
- Workshop for specification definition and visit to their facilities

Sleep inertia management solution - EOS

hdg Human Design Group

Goals: Validate the efficiency of EOS on the sleep inertia of healthy subjects





Strategy (under discussion)

- Tâche 1 : État de l'art et élaboration du protocole pour le CPP (Comité de Protection des Personnes)
- Tâche 2 : Déploiement des briques technologiques à tester sur le site de l'étude (MEDES)
- Tâche 3 : Développement logiciel de contrôle des composants à tester (MEDES)

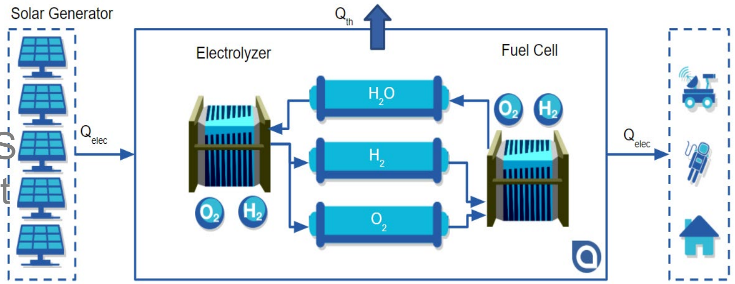
Main Results

- Project under discussion
- *Preliminary exchanges with tests on menstrual cup collection capacities in 0G flight*

ENERGY–REGENERATIVE FULL CELL –RFCS TECHNOLOGICAL

First activity: Global assessment of RFCS technology

- Task 1: Tradeoffs study of a low power (LP) RFCS
- Task 2: Investigation of a new water management solution for fuel cells
- Task 3: Predesign of a LP RFCS



2022-2023 activities: Breadboard development and start of the maturation

Task 1: Detailed design of a LP RFCS

- Assessment of RFCS architecture
- Detailed specification of main components
- Modeling and detailed performance estimation

Task 2: TRL3 Breadboard design and test

- Specification of main components (ELY, FC and tanks)
- Procurement of COTS to build a first breadboard
- **Test of H2 loop of a RFCS**

Task 3: H2/O2 Test bench for fuel cell

- Elaboration of the specification and design of the test bench
- Procurement of components
- Assembling of the test bench and first tests
- **Performance evaluation of the passive water management system on the functioning FC**

Future activities

Development of a space fuel cell

Task 1: Specification and theoretical performances

Task 2: Design of the FC

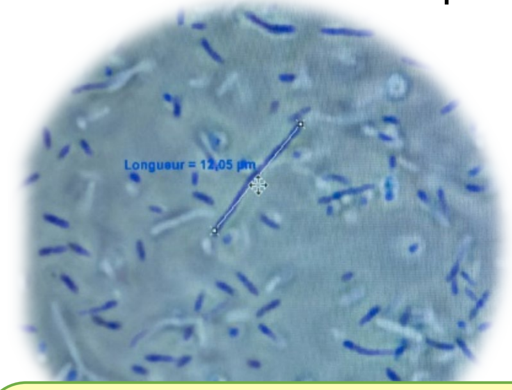
Task 3: Development of a prototype 1000W

Task 4: Tests and performance evaluation

Task 5: development plan

LIFE SUPPORT SYSTEM – ASTROPOU

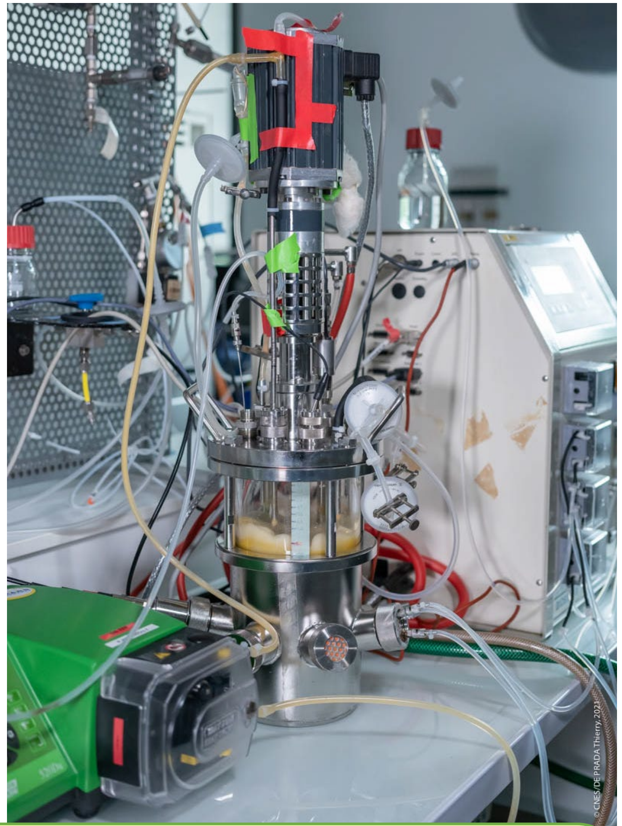
Goals: To demonstrate the ability to produce feed or food proteins and bioplastics (PHA) by bacteria from pretreated organic astronaut waste - faeces and urine-like.



Two Step strategy

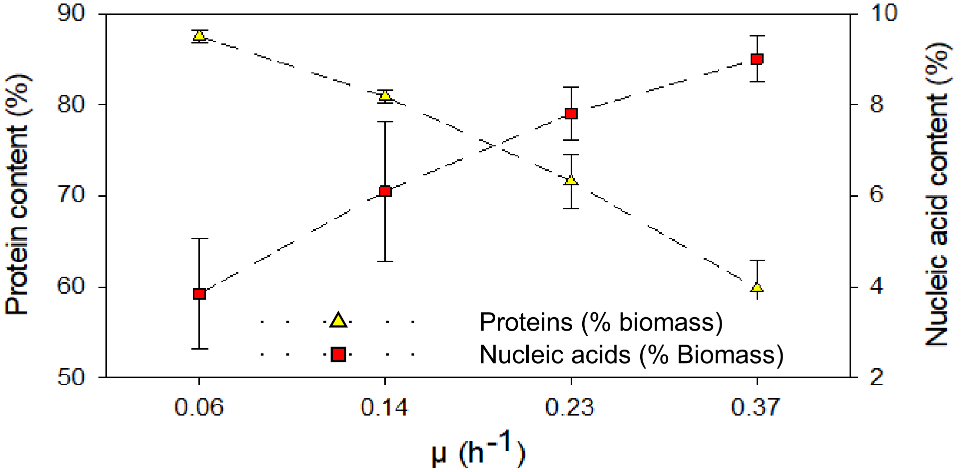
1 st : Strain screening was performed based on urea consumption ability and protein content. The bacterium *C. necator* was selected.

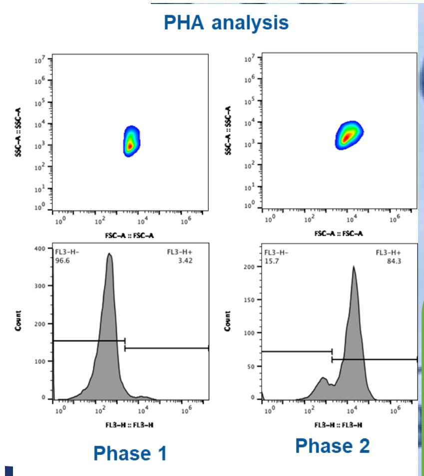
2nd : Continuous fermentation was performed in bioreactor using a synthetic medium mimicking anaerobic digestate from organic astronaut wastes. Modulation of protein/nucleic acids and bioplastic production was studied at different growth rates (µ)

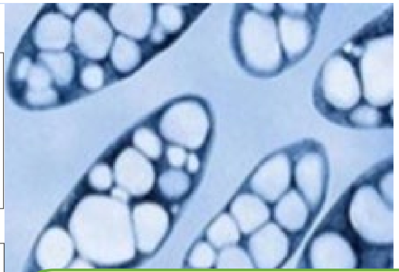


Main Results

- We demonstrated that **Urea and Volatile Fatty Acids were completely transformed** in protein or bioplastics
- A **high protein content** was reached **87%** of the dried biomass
- The **nucleic acid content can be reduced** (**< 4%**) by modulating feed rate in the biorector







Perspectives 2024

Intensification and consolidation of the concept to reach TRL 4 :

- Process optimization in terms of reactor monitoring and inlet composition
- Evaluation of the product quality

SPACESHIP FR – OTHER TOPICS

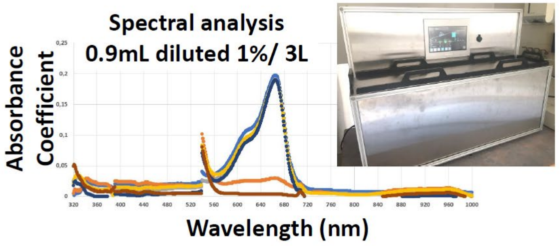
EPURA system Highlights

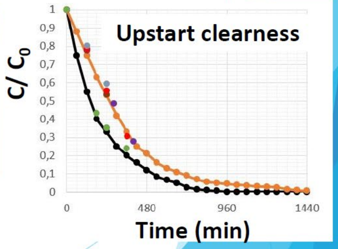
Disinfection & decontamination of the recycled water

- ✓ Light (Sun, UV) drive
- ✓ The photolysis & catalysis coupling

Water 3L → Process 24h → LED & Fluid components EPURA integration

→ **Methylene Blue decoloration Tests**





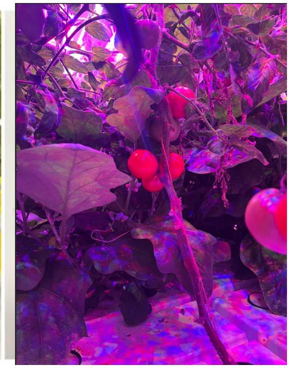
comex

Regolith as a substrate : a solution for resource-efficient, reliable fruit & vegetable production in space

Problem statement :

- Aeroponics is complex & lacks resilience
- Regolith is improper for use as plant soil *per se*

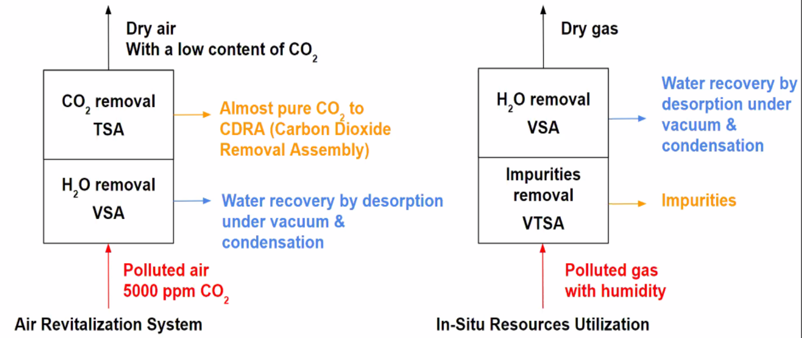
⇒ **Research on a substrate system based on regolith in porous matrix shows lunar soil has a good potential for growing plants**



Results achieved on lettuce in simulant EAC-1A :

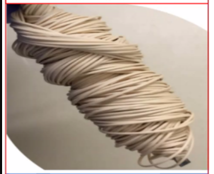
- Average germination rate (50%) to be improved
- Same yield as control for success modalities
- **22x reduction of geo-sourced matter vs. conventional substrate** (700 mg material per plant)

Applications : water capture for ARS & ISRU by adsorption



Adsorption systems using **beads** vs **solid fibers**

Solid Fibers



Beads

Adsorbent Properties	Classical purification using beads	Purification using Solid Fibers
Grain geometry	Spheres	Tunable cylinders
Average dimension	2 - 3 mm diameter	0,4 - 1 mm diameter 100 - 500 mm length
Adsorbent Packing	Dense 650 - 800 kg/m3	**Very dense** 800 - 1000 kg/m3
Kinetics	Rather Good	**Excellent**
Performance : expected gain using solid fibers	Mass reduction of the dryer (20%)	
	Volume reduction of the system (30%)	
	Average energy consumption reduction (10%)	

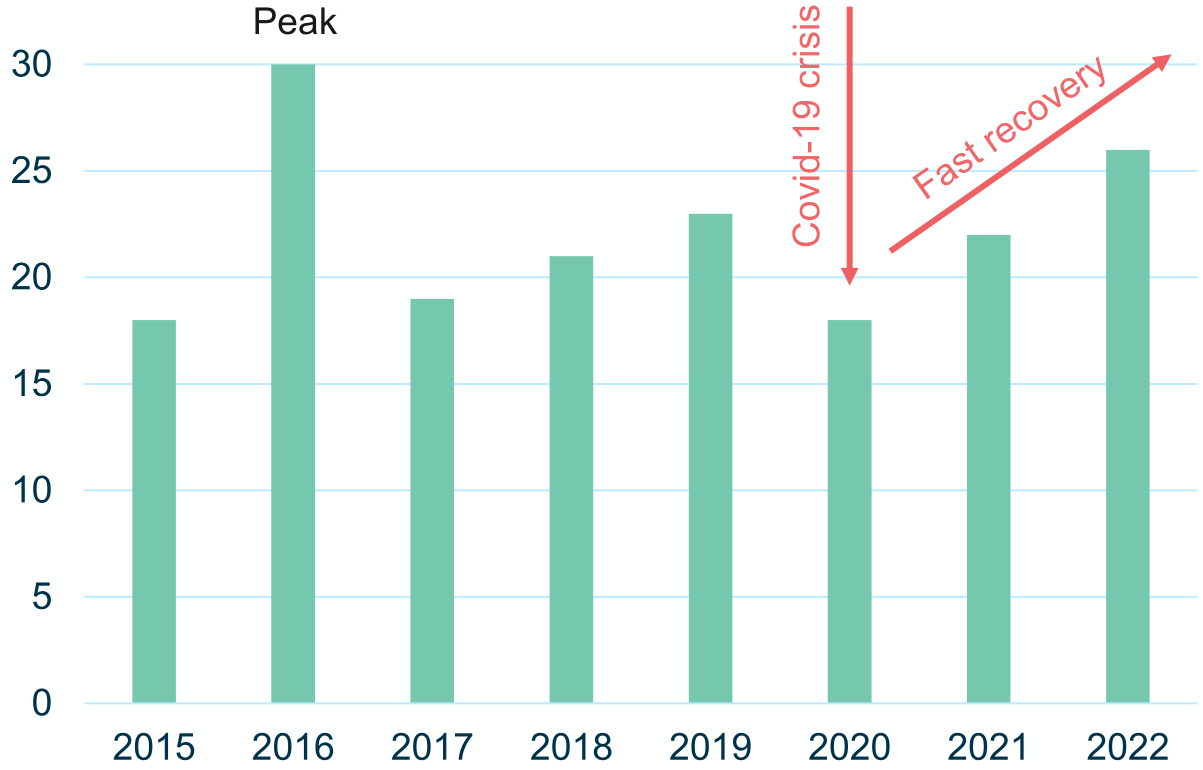

Thank you for your attention
cnes
Email to :
alexis.paillet@cnes.fr
LUNAR AND MARTIAN EXPLORATION, THE NEXT ORBITING AND SURFACE MISSIONS AT THE MOON WILL FEED FORWARD TO THE FIRST HUMAN PRESENCE ON MARS IN A SUSTAINABLE CAMPAIGN

Spaceship in numbers

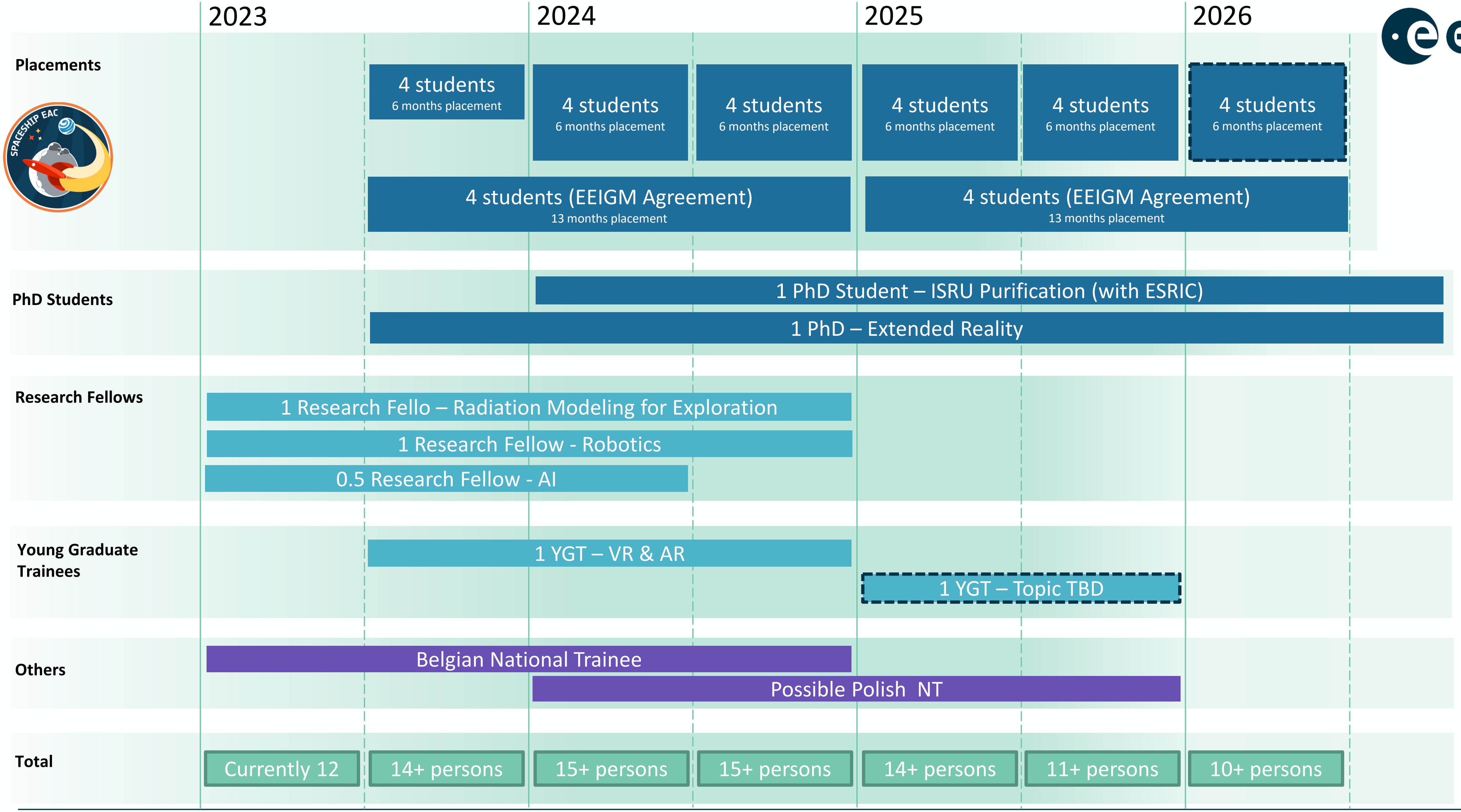
Between 2015 – 2023*, Spaceship EAC Team hosted 183 young researchers.

(*) Partial data for 2023

Distributions per year:



For 2023, until February: 4 people (1 NT, 1RF, 2 inters)


2023
2024
2025
2026
Placements
4 students
6 months placement
4 students
6 months placement
4 students
6 months placement
4 students
6 months placement
4 students
6 months placement
4 students
6 months placement
4 students (EEIGM Agreement)
13 months placement
4 students (EEIGM Agreement)
13 months placement
PhD Students
1 PhD Student – ISRU Purification (with ESRIC)
1 PhD – Extended Reality
Research Fellows
1 Research Fello – Radiation Modeling for Exploration
1 Research Fellow - Robotics
0.5 Research Fellow - AI
Young Graduate Trainees
1 YGT – VR & AR
1 YGT – Topic TBD
Others
Belgian National Trainee
Possible Polish NT
Total
Currently 12
14+ persons
15+ persons
15+ persons
14+ persons
11+ persons
10+ persons

2023 | 2024 | 2025 | 2026

esa

Placements

- 3 students – 6 months placement (2023, second half)
- 5 students – 6 months placement (2024, first half)
- 5 students – 6 months placement (2024, second half)
- 5 students – 6 months placement (2025, first half)
- 8 students – 6 months placement (2025, second half)
- 8 students – 6 months placement (2026, first half)

SPACESHIP ECSAT

PhD Students

- 1 PhD Student - Robotics (2024, second half – 2026)
- 1 PhD – Extended Reality (2025, second half – 2026)
- 1 PhD – Mechanical Engineering (2025, second half – 2026)

Research Fellows

- 1 Research Fellow - Robotics (2024 – 2025)
- 0.5 Research Fellow - Geology (2023)
- 1 RF – Topic TBD (2026)

Young Graduate Trainees

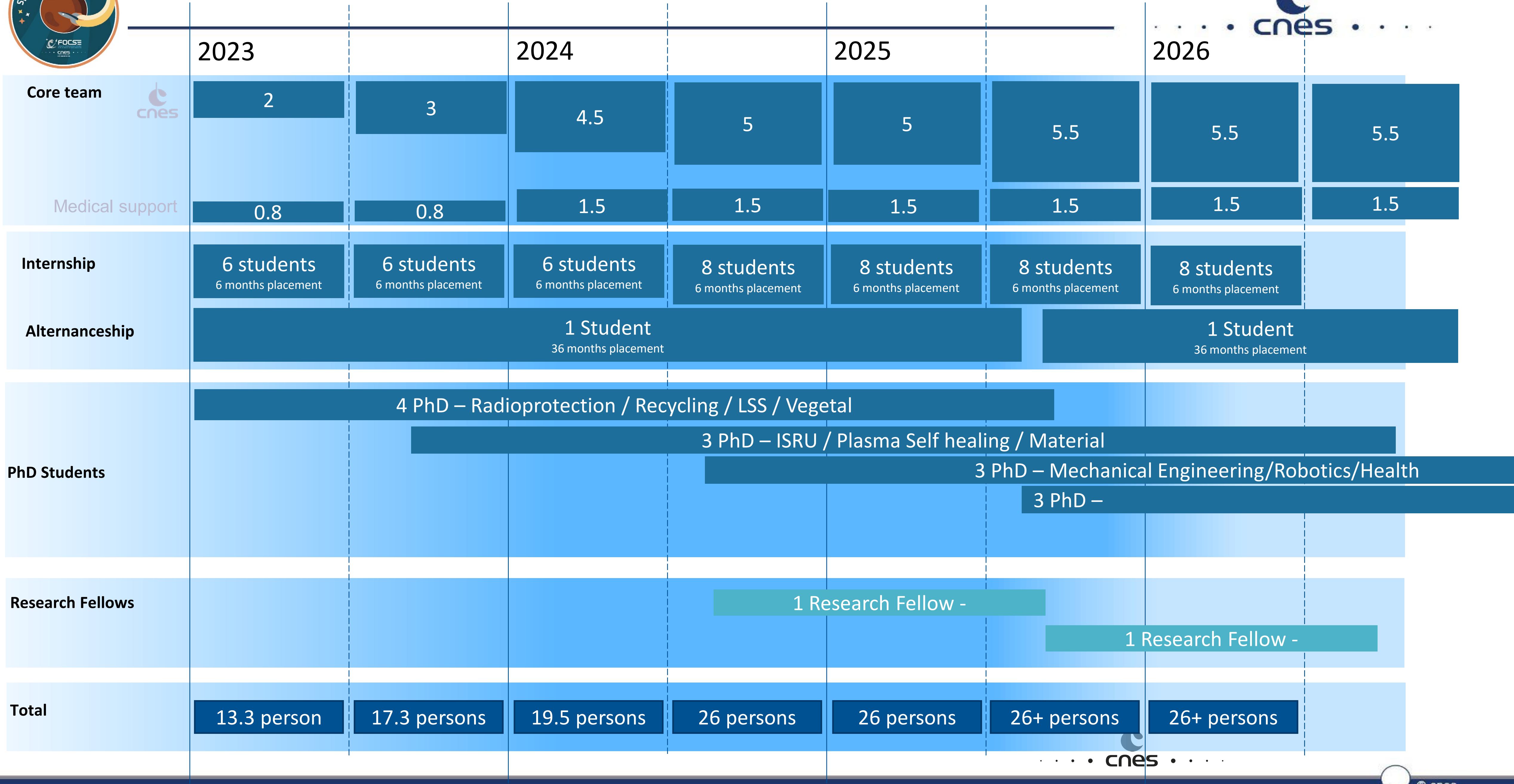
- 1 YGT – Systems Eng. (2024)
- 1 YGT – Topic TBD (2025)
- 1 YGT – Topic TBD (2026)

Others

- National Trainees? (2024)
- National Trainees? (2025)
- National Trainees? (2026)
- Other? (2024 – 2026)

Total

2023 (1st half)	2023 (2nd half)	2024 (1st half)	2024 (2nd half)	2025 (1st half)	2025 (2nd half)	2026 (1st half)
0,5 person	3+ persons	7+ persons	8+ persons	8+ persons	13+ persons	13+ persons


2023
2024
2025
2026
Core team
2
3
4.5
5
5
5.5
5.5
5.5
Medical support
0.8
0.8
1.5
1.5
1.5
1.5
1.5
1.5
Internship
6 students
6 months placement
6 students
6 months placement
6 students
6 months placement
8 students
6 months placement
8 students
6 months placement
8 students
6 months placement
8 students
6 months placement
Alternanceship
1 Student
36 months placement
1 Student
36 months placement
PhD Students
4 PhD – Radioprotection / Recycling / LSS / Vegetal
3 PhD – ISRU / Plasma Self healing / Material
3 PhD – Mechanical Engineering/Robotics/Health
3 PhD –
Research Fellows
1 Research Fellow -
1 Research Fellow -
Total
13.3 person
17.3 persons
19.5 persons
26 persons
26 persons
26+ persons
26+ persons

On behalf of all the Spaceship teams

Thank you for your support, interest & attention!