SpaceShip FR's Contributions to Space Exploration and Human Spaceflight

Paillet Alexis
alexis.paillet@cnes.fr
Project manager Spaceship FR
Exploration Technologies Program Manager

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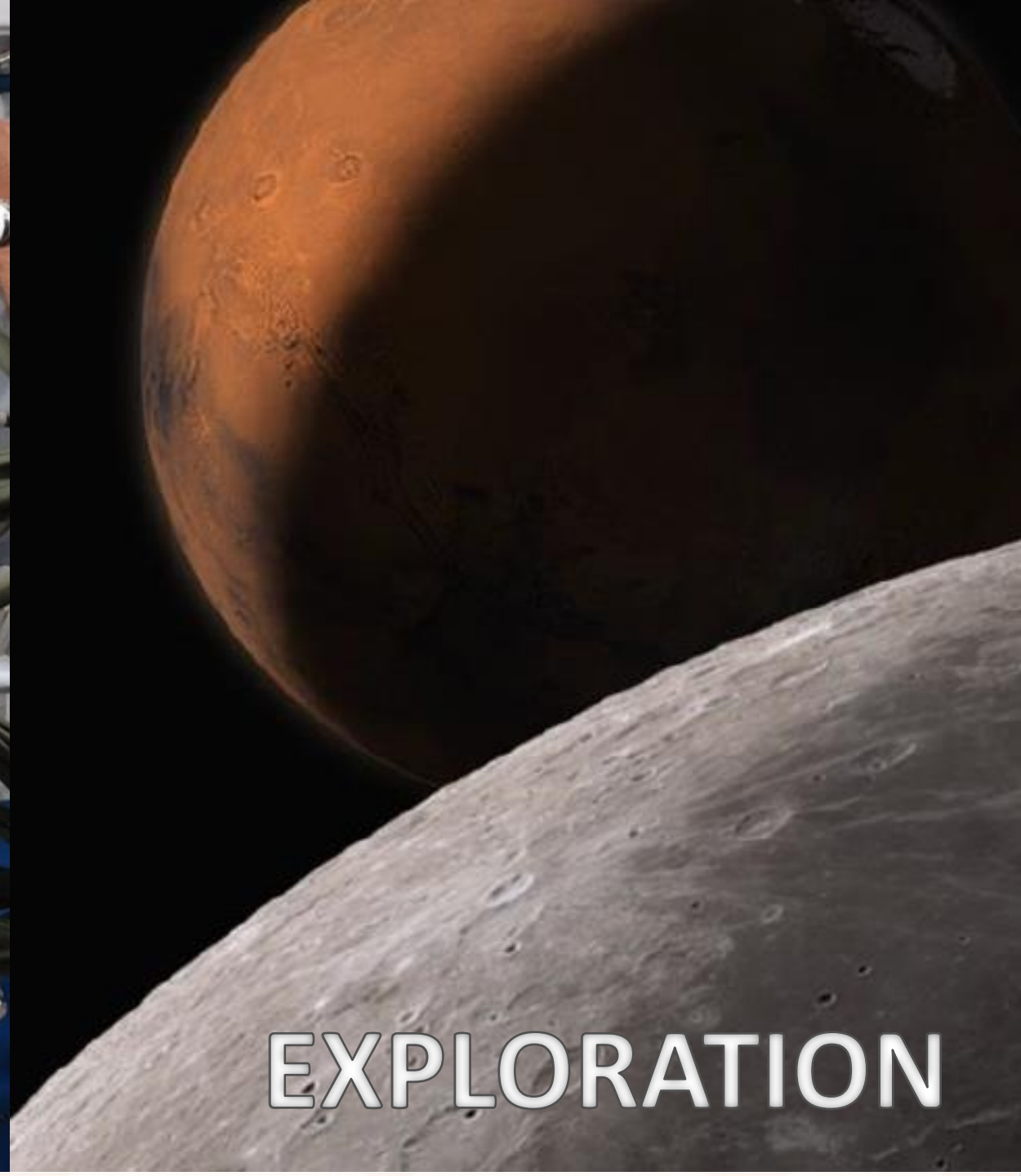
Human
SpaceFlight


EXPLORATION

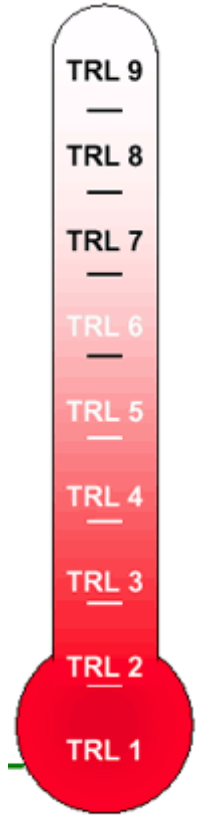
CNES Backgroung

- **Integration & Test manager for**

Chemcam instrument for Curiosity rover (2007-2012)

SEIS main instrument for Insight lander (2012-2018)

Tech demo manager on X-IFU main instrument of Athena satellite



- **2020 Project Manager for spaceship FR - innovation and application project for Exploration and Human Spaceflight**

- **2028 …**

2020 2030 2040

ON TO MARS

MARS SURFACE — Robotic Mars Sample Return

MARS ORBIT

Goal of Humans on the Martian Surface

Mars Transportation Capabilities

Mars Orbital Mission

TO THE MOON

LUNAR SURFACE — Robotic Resource Prospecting Missions

LUNAR ORBIT

IN LEO

EARTH ORBIT

Deep Space Gateway

Human Lunar Surface Exploration

Gateway Moon and Mars Mission Support Operations

Orion and SLS

Commercial Transportation Systems

Russian Crew Transportation System

International Space Station

China Space Station

Future Platforms

Spaceships – Exploration Innovation across all 3 Destinations

esa

What are the Spaceships ?

- Highly motivated **innovation teams** matched to their locations, partners and national agencies
- **Dynamic network** of collaborators across Europe, supporting and initiating low-TRL Exploration R&D with an emphasis on **practical demonstration and skunkworks** approach (*'innovate and implement under one roof'*)
- Team members include visiting researchers, students, secondees from commercial entities, national agency staff as well as ESA staff

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'

This in E3P P2 and to be continued in P3

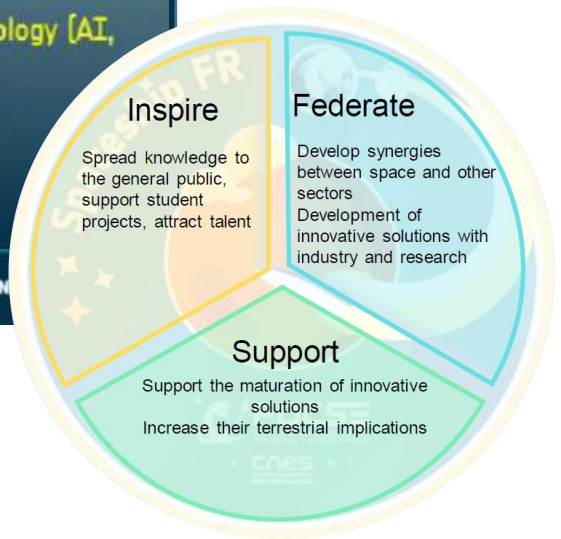
Spaceship EAC – EAC, Cologne, Germany
- Human Spaceflight and Exploration Activities
- LUNA development

Spaceship ECSAT – ECSAT, Harwell, UK
- Analogue support projects
- Sample Curation related activities

Spaceship France – CNES, Toulouse, France
- Currently developing domain areas
- Focused R&D activities with CNES & commercial partners

Thematic Areas

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

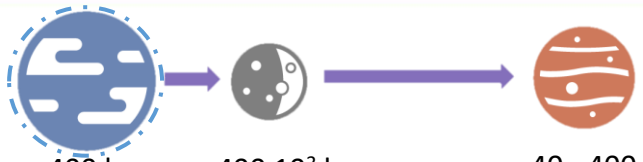


CNES: Centre National d D'Etudes Spatial
ECSAT : European Centre for Space Applications and Telecommunications
EAC : European Astronaut Center
ESA : European Space Agency

E3P: European Exploration Envelope Programme
ExPeRT: Exploration Preparation, Research and Technology
R&D : research and development
TRL: Technology Readyness Level

CONTEXT : France on the Moon, Mars

Scope for Exploration



INNOVATION	COOPERATION
COMPETITIVENESS	MULTI-DISCIPLINARY
KNOWLEDGE	PARTNERSHIP

GLOBAL EXPLORATION ROADMAP

PLANETARY OUTPOST

De-risking and pushing for the emergence of new technologies / innovative lines of research

Identify the missing technological bricks for maintaining the crew for distant exploration (lunar base, Martian base)

Animate the community of academic and industrial players of excellence to contribute to these developments

Digital & supervision

Habitat & protection
→Provide protection to the crew from extreme environment

Life Support System & habitabity
→ Provide a habitable environment to ensure the crew's survival and satisfy its basic needs.

Crew Health & performances
→ Monitoring and maintain the crew members' physical & psychological

Power generation and energy storage
→ Technologies retated to power generation,
→ Distribution and energy storage

Automation & robotics
→ Assist the crew operation through automation,
→ Help surface mobility and manipulation

Autonomy & In-Situ Resources Utilization
→ Enable the utilization of resources from the outpost environment to support the

SPACESHIP FR Technological Bricks

Power generation and energy storage
→ Technologies retated to power generation, distribution and energy storage

- Batteries
- Battery at low temperature
- Flexible Solar panel

Autonomy and In-Situ Resources Utilization
→ Enable the utilization of resources from the outpost environment to support the mission sustainability.

- Site mapping thanks to dedicated instrument
- Regolith processing
- H_20/O_2 processing
- 3D manufacturing
- Recycling

Life support system
→ Provide a habitable environment to ensure the crew's survival ar

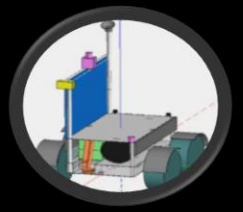
- Environmental control
- Monitoring & control
- Fire prevention detection & suppression
- Thermal control
- Dedicated Food
- Fertilizer thanks to bio-reactor
- Recycling waste

Structures and shielding
→ Provide protection to the crew from extreme environment

- deployable habitat - shelter
- Dust mitigation
- Space radiation protection
- Monitoring and control

Automation and robotics
→ Assist the crew operation through automation, surface mobility and manipulation

- Rover assistance for EVA
- Robotic assistance for habitat
- Dust mitigation
- Autonomous navigation
- "follow me"



Crew health and performance
→ Monitoring and maintain the crew members' physical & psychological health while improving its efficiency

- Medical food/pharmaceutic by using bioreactor
- Medic device : ultrasonic scan/MRI scan
- Artificial Intelligence A.I
- Health monitoring

SPACESHIP FR -- Key driver projects

Food managment system

Autonomous Habitat - **Durable Dome for Human Lunar Exploration**

Autonomous Supervision & Digital

ISR U

Tools for prospection

Geological devices

Robotic Assistant - LORA

Crew Health & performances – Medical devices

Tech area / Objectifs						
LISE Lunar Shelter Moon Base	Radioprotection Deployable structure AirLock Maintenance Repair & Overhaul	CO_2 Scrubbing Air purification Water purification Fire mgmt. Grey water	Kit 1st aids Stress mgmt. Human factors Surgery room	RFCS 1000 W Solar panel Flexible Battery @ low temperature	Supervision AI-4U Digital twin	3D printing →Alloy / Regolith PHA O_2 extraction
LORA Lunar astronaut assistant	I/F rover - Habitat		Stretcher	RFCS 100 W Solar panel Flexible Battery @ extreme Temperature[-150;100]	Autonomous rover Follow me Help astronaut for tasks Multi-sensors Multi-commanding Dust mitigation	Sensitive sensor for regolith
Food mgmt system	Green house Radioprotection	Food production CO_2 regulation Air purification	Alicaments POU		Plant robot Digital Twin nutrition AI-4U Digital twin greenhouse	Food mgmt. AI for storage
Infirmery	Radioprotection for Human	Air purification	Surgery equipments Imagery equipments Digital twin		Autonomous medical intervention Training and skills maintenance Digital twin Astronaute	Organoïd

Durable Dome for Human Lunar Exploration

What for: have a shelter to enlarge the lunar exploration area

When: before the construction of the lunar base

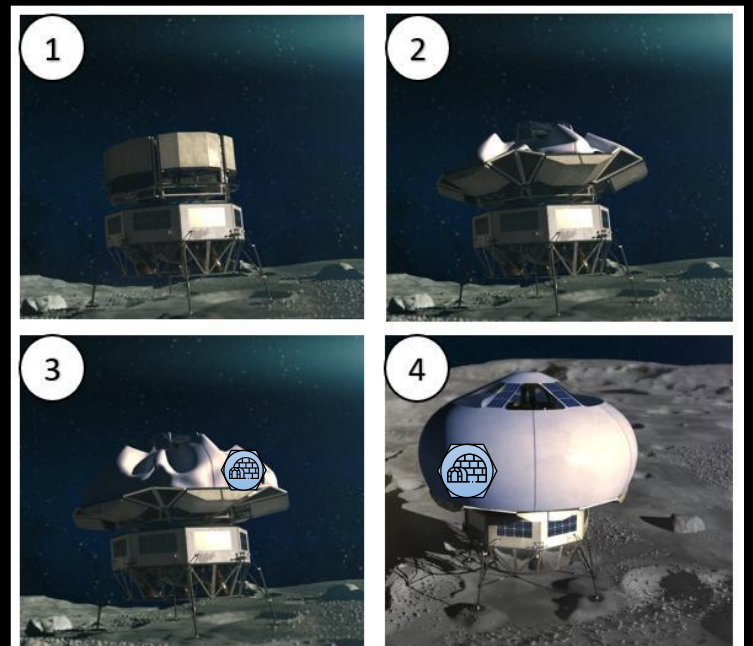
Technological devices :

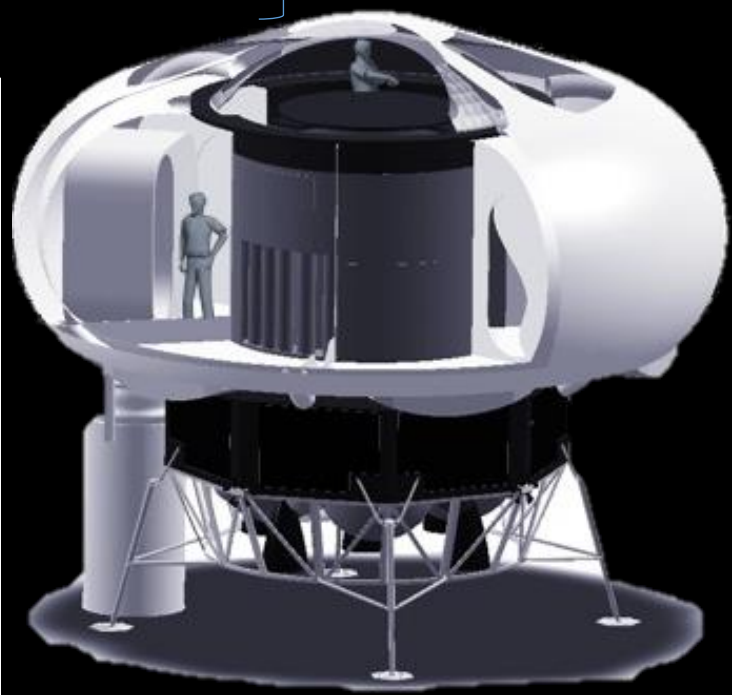
- Deployable structure, selfhealing,….
- Radiation protection
- Supervision/Communication
- Medical devices – 1st aids kit (Echographe with IA/IRM – PhysioTools-)
- Energy (RFCS/ Flexible solar panel)
- Storage (small tools, dry food, ECLSS consommable,…)
- ISRU Tools (Optical, geological,…)
- Recycling
  - Waste mgmt
  - H_2O Purification / CO_2 Traitement
  - Grey & Yellow water mgmt

Keys Words: Exploration, Reusable, Deployable

Main requirements

2 astronauts
6 - 8 consecutive days
Reusable
Frequency of reused : 28 days
Autonomous deployment
2 stand-by modes: partial and total
EL3 Payload constrainst





Robotics assistant side by side

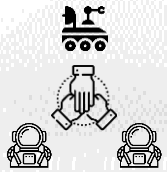
Introduction

Context: Return of mankind on the Moon (Artemis missions).

System concept: Lightweight rover aiming at ↑efficiency and ↓risks during lunar EVAs.

Mission concept: combination of three kinds of missions (*support*, *scout*, and *explore*) to maximize LORA's utility.

Navigation system : autonomous and follow me

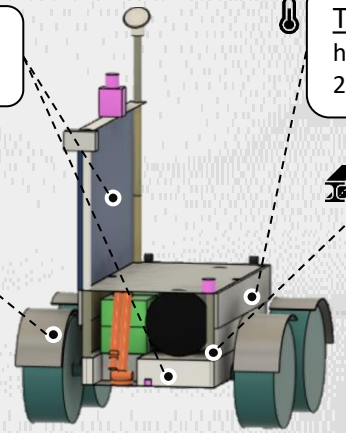


Design: platform

Electrical power: solar array 2.2 [m²], Li-ion battery 86 [kg], 594 [Ah].

Locomotion: 4 wheels, 4 driving motors, 4 steering motors, 4 suspension arms with 1 DOF.

Data-handling



Thermal control: heaters 85 [W], 2 louvers 0.5 [m²] each.

Structure: Aluminium panels and beams 43 [kg].

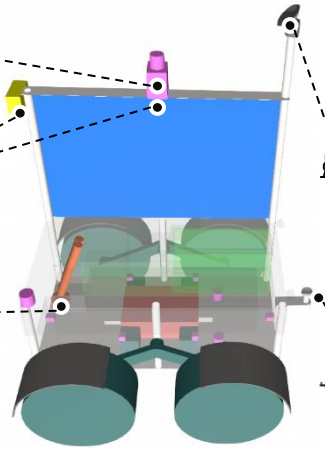
Interaction & control

Design: support functions

Imaging and mapping (purple): LiDARs, cameras, IMUs, wheel encoders.

Light (yellow): 2 light sources.

Manipulator (orange): 5 DOFs, 25 [kg], 450 [W].



Communication relay: 2 antennas (S- and Ka-band) on a mast with variable height.

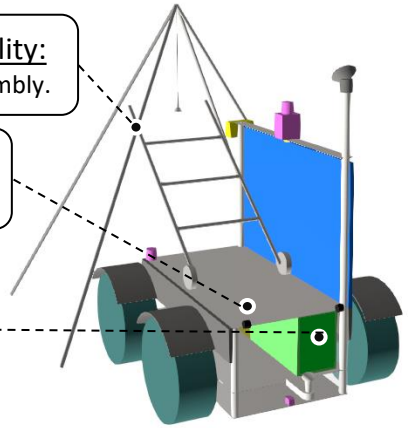
Trailer hitch

Design: support functions (cont'd)

Astronaut carrying capability: Lunar Evacuation System Assembly.

Workbench: upper board of the structure, 104 [cm].

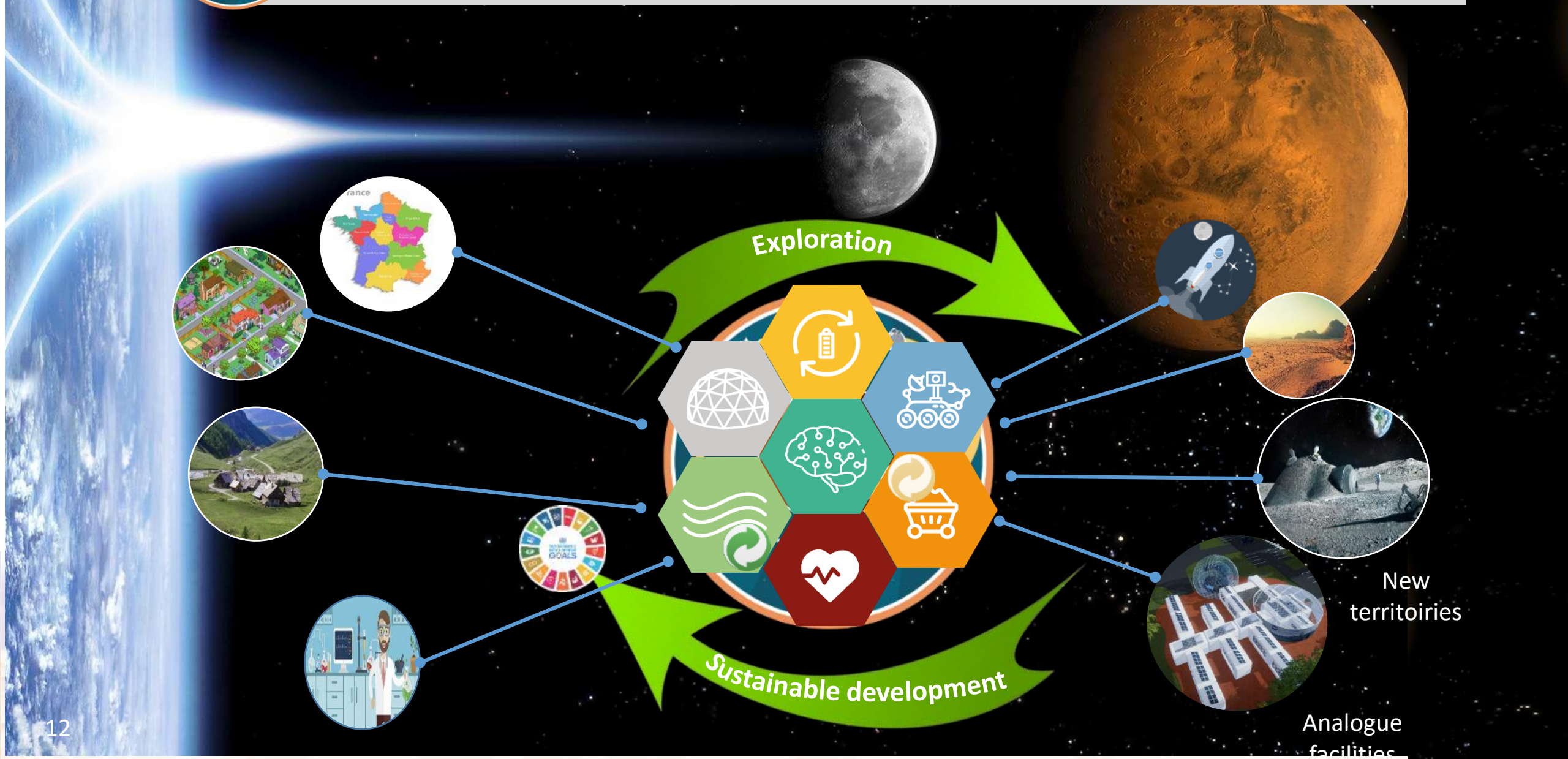
Cargo transport: Drawers to carry tools, samples, instrument packages.



Main challenges:
Autonomous navigation @ walking speed,
Lunar night survival,Dust

PARTNERS SPIN OFF COMMON CHALLENGES FOR «SUSTAINABLE TERRITORIES»

Food production, Health, Materials Waste Recycling, Smart Habitat, Radiation, Energy, Digital technologies, Air & Water regeneration, In Situ Resource Utilisation, Robotics



Thank you for your attention

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