THE MOON: FROM LABS TO TOWNS

Finance-based time scales for the Lunar Exploration

8 July, 2016

Pilar Román
Spanish Delegation to ESA
CDTI

CONTENT

1. ABOUT CDTI
2. THE EUROPEAN SPACE AGENCY
3. SPAIN IN ESA
4. THE EUROPEAN SPACE EXPLORATION PROGRAMME
   - THE INTERNATIONAL SPACE STATION
   - ROBOTIC EXPLORATION
     - ✓ EXOMARS
     - ✓ MOON EXPLORATION
5. SHORT-TERM STRATEGY
   - PILOT
   - PROJECT
   - ADDITIONAL ACTIVITIES
6. SUMMARY

What is CDTI?

Center for Industrial Technological Development

- ✓ Created in 1977
- ✓ Public Entity (Ministry of Economy and Competitiveness)
- ✓ Business innovation financing agency (LCTI)
- ✓ Focal point for the promotion of technological innovation

Enhance Spanish companies' competitiveness and internationalization through innovation

CDTI in the Space field

CDTI has been responsible for the Spanish Delegation to ESA since 1986 (up to 2008 jointly with the Ministry of Industry MINETUR)

ESA Programmes

Agreements

EUMETSAT

hisdeSAT

UE

CDTI

Bilateral Programmes

ROSCOSMOS

NASA

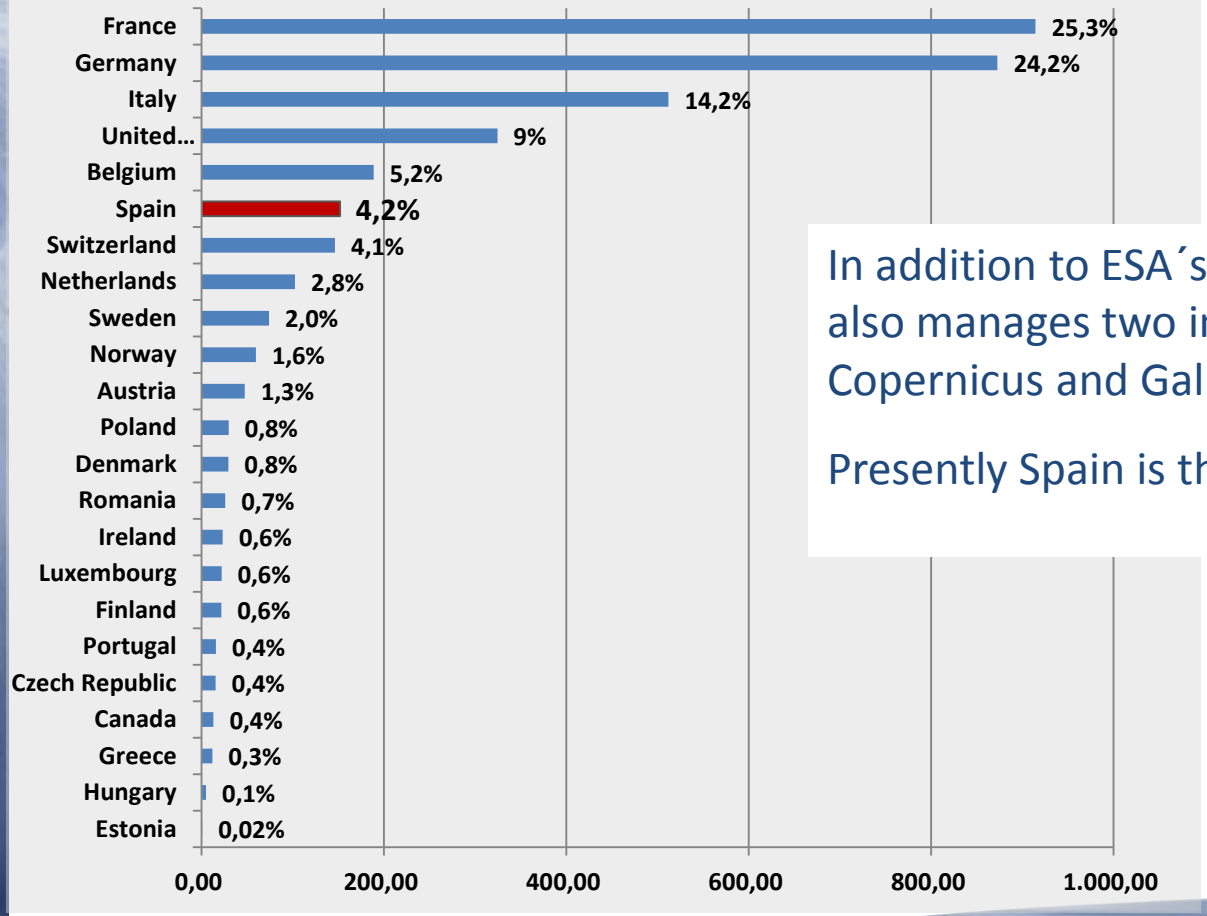
PNOT

→ THE EUROPEAN SPACE AGENCY

- ✓ Intergovernmental organization not belonging to EU
- ✓ Over 50 years of experience
- ✓ 22 Member States
- ✓ Eight sites/facilities in Europe, one of them (ESAC) in Madrid
- ✓ Current Spanish contribution: 152 M€/year

ESA budget

ESA total budget in 2016: 5.300 M€
Member States´ direct contributions: 3.600 M€ plus UE and third party activities



In addition to ESA´s own programmes , ESA also manages two important UE programmes: Copernicus and Galileo → 1.300 M€

Presently Spain is the 6th contributor (4,2%)

ESA Programmes

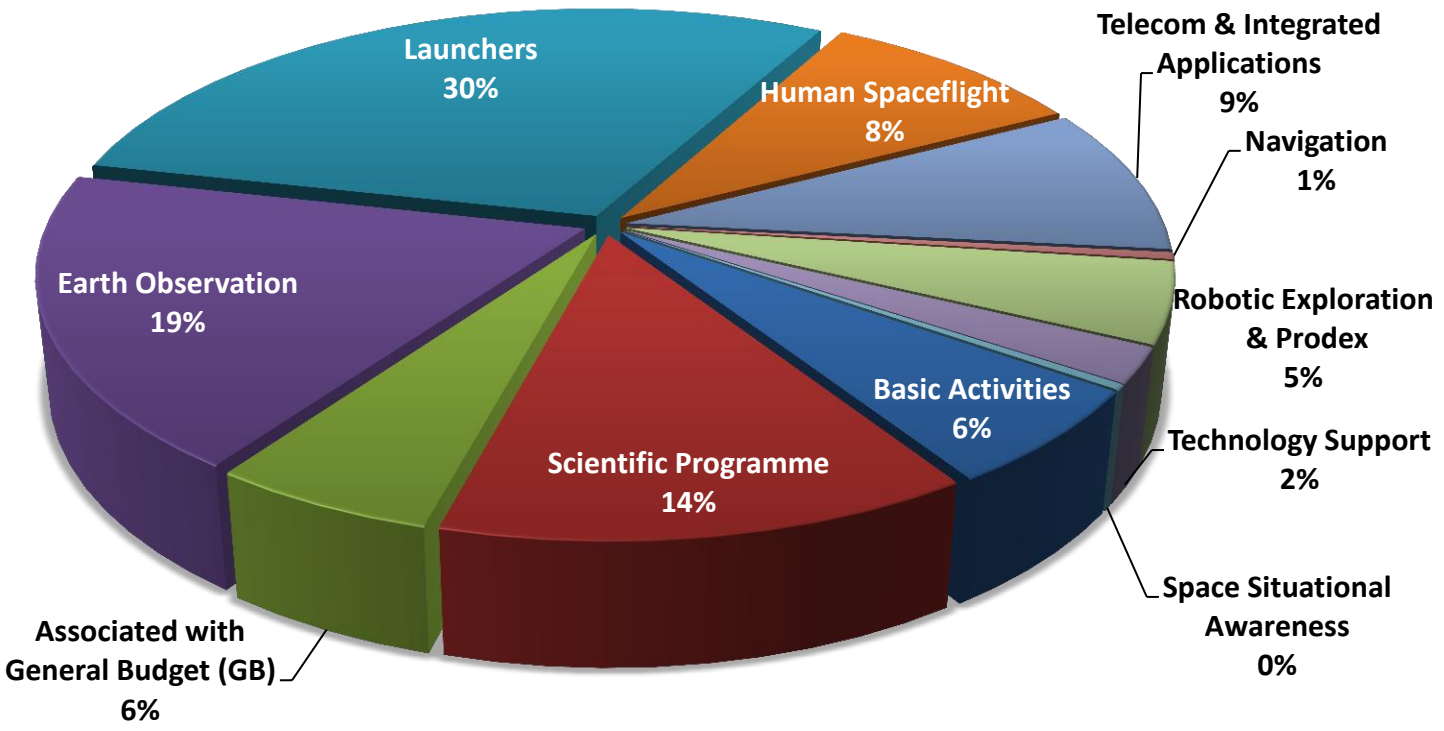
ESA develops programmes in all fields related to Space

Space science is a Mandatory programme, all Member States contribute to it according to GNP.

All other programmes are Optional, funded 'a la carte' by Participating States.

ESA´s activities

25% of the budget is dedicated to mandatory activities (Scientific Programme, Basic Activities y Associated to GB) and 75% to optional programmes.
12% to exploration activities (Human Spaceflight and Robotic Exploration)



ESA 2016

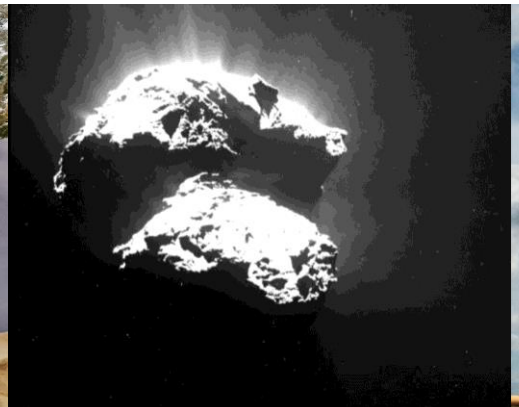
CONTENT

1. ABOUT CDTI
2. THE EUROPEAN SPACE AGENCY
3. SPAIN IN ESA
4. THE EUROPEAN SPACE EXPLORATION PROGRAMME
   - THE INTERNATIONAL SPACE STATION
   - ROBOTIC EXPLORATION
     - ✓ EXOMARS
     - ✓ MOON EXPLORATION
5. SHORT-TERM STRATEGY
   - PILOT
   - PROJECT
   - ADDITIONAL ACTIVITIES
6. SUMMARY

SPAIN in ESA

Spain has been consolidated as an important contributor to ESA programmes

- More than 1.600 M€ in contracts with the Spanish industry since 2000 with over-return.
- Spanish Space industry ranks 5th in Europe in terms of global revenue (>700 M€/year) and technological capabilities
- Significant evolution of the industry in the value chain: from building equipment to development of full missions.
- Plans to increase Spanish contribution to ESA in the next years to reach relative GNP (~ 8%) en 2020


SPAIN in ESA missions

The Spanish Industry is currently developing complete Space Missions

Missions currently led by Spain in ESA

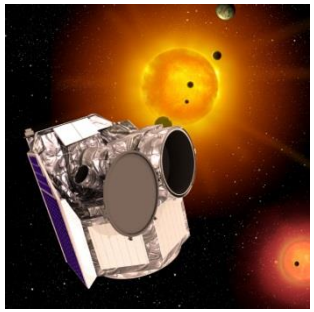
Ingenio

Earth Observation Spanish Satellite

PROBA-3

Technological mission to prove formation flying technologies

CHEOPS



Mission of the ESA scientific programme to search Exoplanets

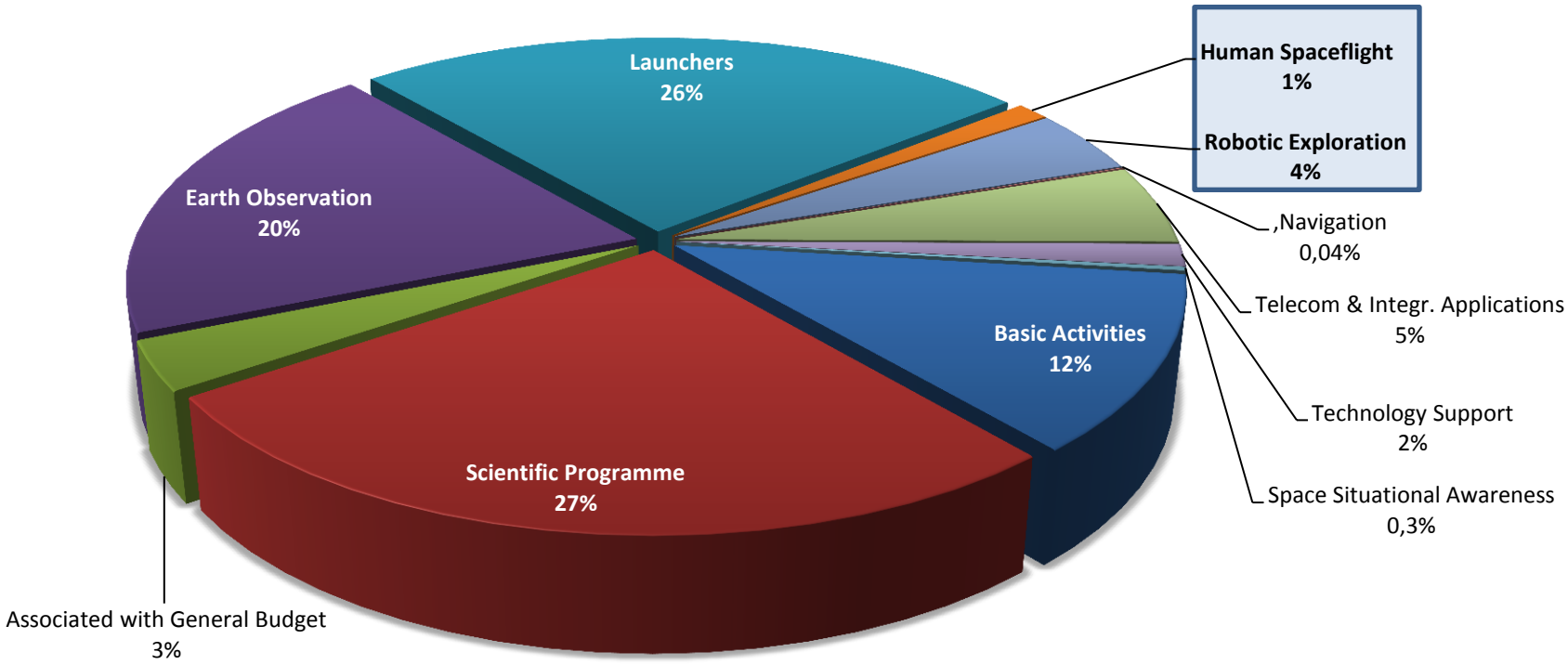
SMALL-GEO

Telecom Satellite in cooperation with Germany

Spanish´s contribution to ESA

Spain participates in all ESA programmes

Spanish´s contribution to ESA in 2016: 152 M€



CONTENT

1. ABOUT CDTI
2. THE EUROPEAN SPACE AGENCY
3. SPAIN IN ESA
4. THE EUROPEAN SPACE EXPLORATION PROGRAMME
   - THE INTERNATIONAL SPACE STATION
   - ROBOTIC EXPLORATION
     - ✓ EXOMARS
     - ✓ MOON EXPLORATION
5. SHORT-TERM STRATEGY
   - PILOT
   - PROJECT
   - ADDITIONAL ACTIVITIES
6. SUMMARY

The European Space Exploration Programme

In 2001 the Member States agreed to set space exploration as one of their priorities for the future and approved a Programme dedicated to Exploration activities: The Human Spaceflight Microgravity and Exploration Programme (HME)

The Programme sets a framework and a roadmap for extended robotic and human exploration of the Solar System

HME Programme Characteristics

Optional Programme with 3 building blocks:

H-Human Spaceflight

M- Microgravity

E- Exploration

Programme Objectives:

1. The study of scenarios for robotic and human exploration of the Solar system
2. The utilization of the International Space Station
3. The development of a policy dedicated to motivating the youth and mobilizing public support

The International Space Station - ISS

- Launched in 1998 and involving the U.S., Russia, Canada, Japan, and the participating countries of ESA, the ISS is one of the most ambitious international collaborations ever attempted
- It has been visited by astronauts from 14 Countries
- ESA has 8,5% of rights
- In CM16 ESA participants will approve the extension of the ISS from 2020 to 2024
- Spanish contribution is 2% (of ESA participation)

ESA Astronauts

ESA has 11 flight-experienced astronauts

They are currently active or on other assignment. Among them is Pedro Duque

The new generation is made up of 6 astronauts:

Luca Parmitano (IT), Alexander Gerst (DE), Samantha Cristoforetti (IT), Andreas Mogensen (DK) and Tim Peake (UK) flew to the ISS between 2013 and 2016 and Thomas Pesquet (FR) will fly in Autumn 2016.

ISS - Columbus

ISS Microgravity Laboratory

Columbus is a key European contribution to the ISS. It was launched in Feb 2008; fitted with 10 interchangeable payload racks, Columbus is a multifunction laboratory that specializes in research into fluid physics, materials science and life sciences.

It provides a substantial part of the ISS´s research capability

S122E008222

E-USOC

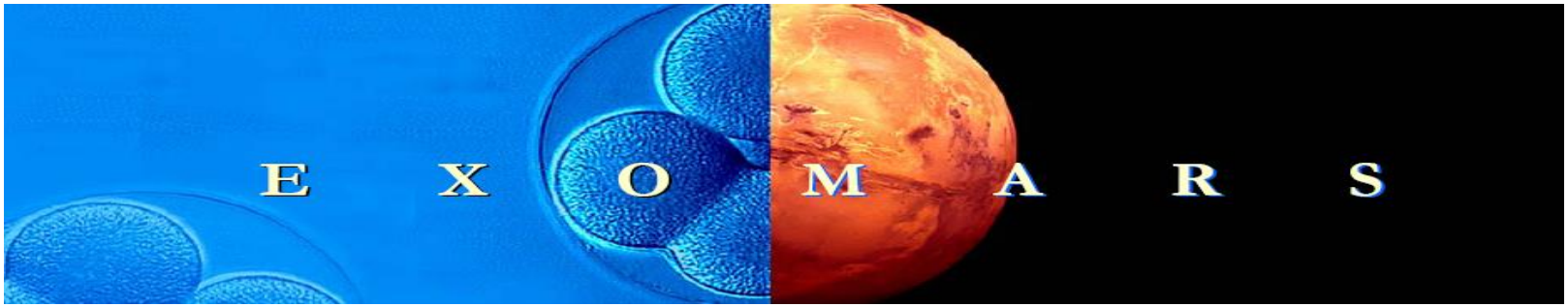
The User Support and Operation Centres, USOCs, are responsible for running and implementing European experiments in the ISS

- Astronauts are supported from Earth through USOCs
- There are 7 USOCs in Europe, organized by scientific disciplines. One of them is located in Madrid (UPM)
- **The Spanish USOC (E-USOC)**:
  - Responsible for all the experiments to be performed by ESA in MSG facility (NASA)
  - Support center for FSL (Fluid Science Laboratory (ESA)

Robotic Exploration. ExoMars

The ExoMars Programme is the first ESA robotic exploration mission to Mars

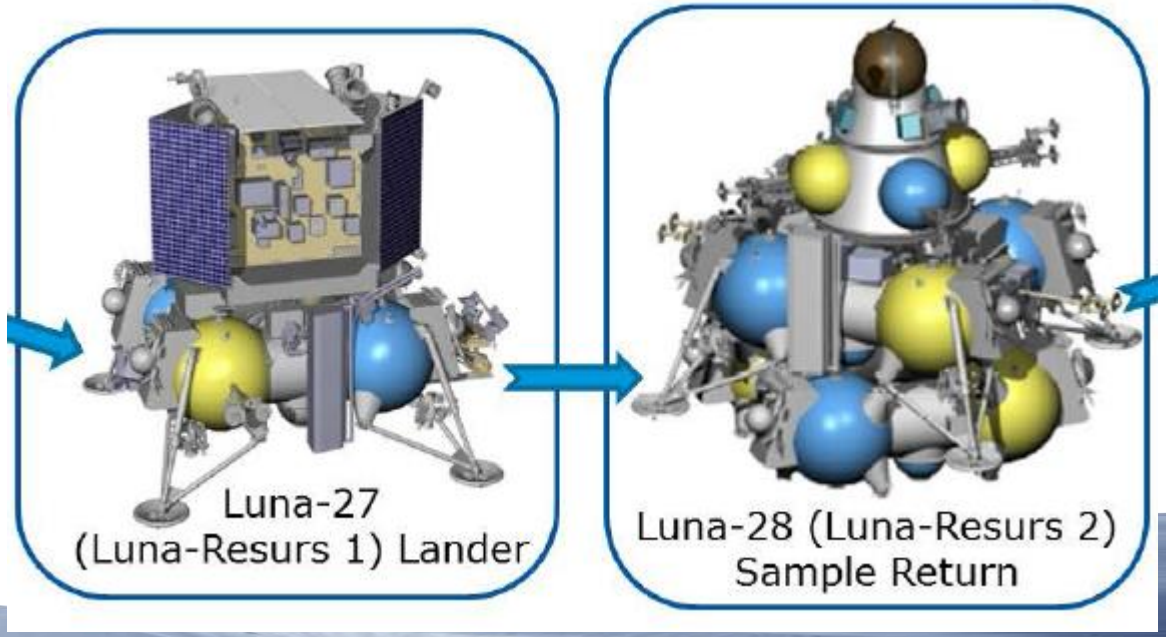
- In cooperation with Russia, two ExoMars missions (2016 and 2020) will explore Mars
- ExoMars objectives:
  - ✓ Science: Search of signs of past and present life on Mars
  - ✓ Technology: Entry, descent and landing of a rover (mobile platform) on Mars surface



Moon Exploration

Short-term objective: to achieve robotic surface access

- ESA is in discussion with Russia with a view to establishing a joint Lunar exploration programme, built on the existing ExoMars cooperation
- Main focus of proposed ESA-ROSCOSMOS Lunar cooperation is:
  - ✓ Luna-27 (Luna-Resurs 1) Lander. mission to send a lander to the South Pole, an unexplored area of the Moon, and targeting frozen volatiles in the sub surface
  - ✓ Luna-28 (Luna-Resurs 2) Sample Return. It will bring soil samples back to Earth.



CONTENT

1. ABOUT CDTI
2. THE EUROPEAN SPACE AGENCY
3. SPAIN IN ESA
4. THE EUROPEAN SPACE EXPLORATION PROGRAMME
   - THE INTERNATIONAL SPACE STATION
   - ROBOTIC EXPLORATION
     - ✓ EXOMARS
     - ✓ MOON EXPLORATION
5. SHORT-TERM STRATEGY
   - PILOT
   - PROJECT
   - ADDITIONAL ACTIVITIES
6. SUMMARY

2016 Ministerial Conference

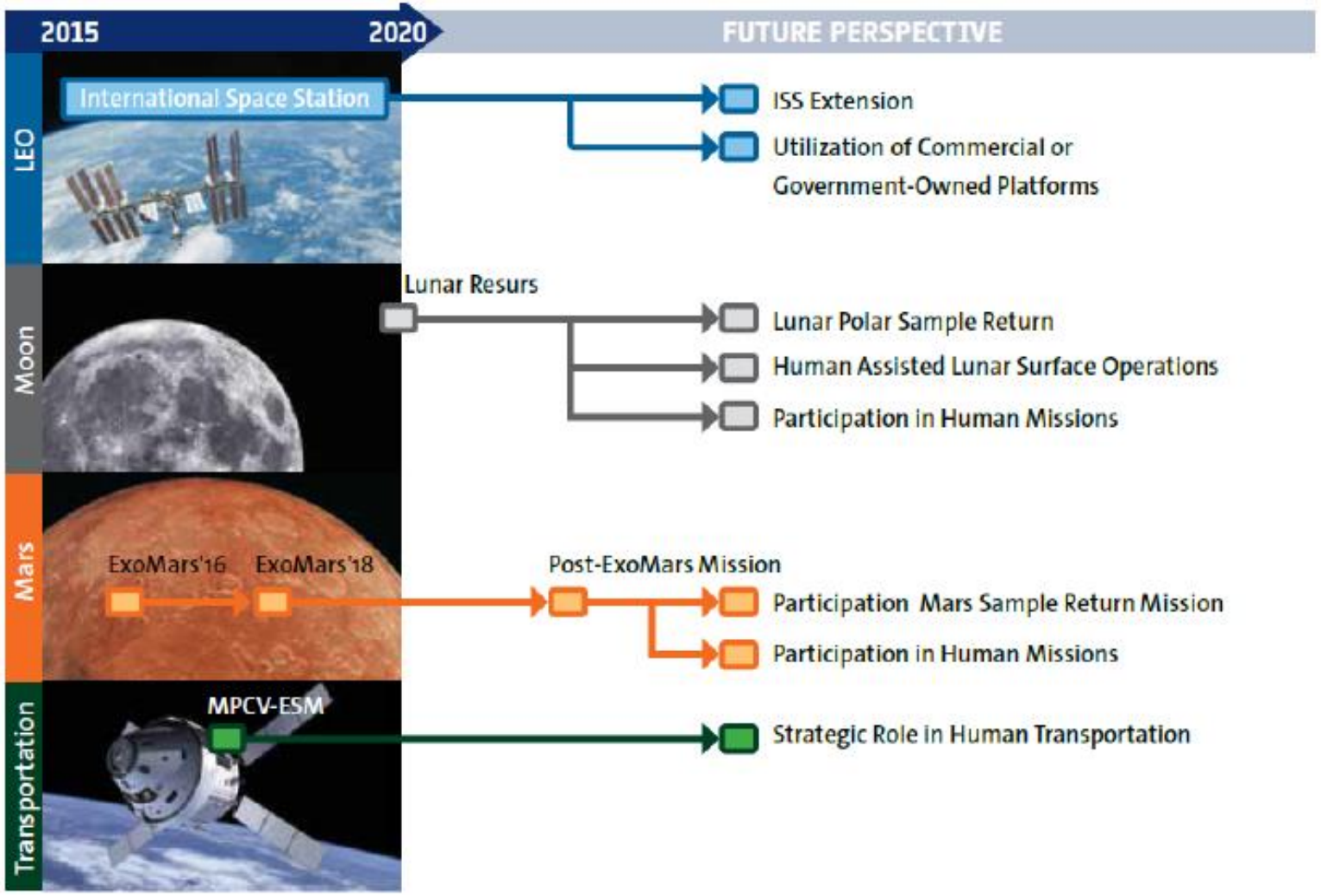
- Next Ministerial Conference: Switzerland December 2016
- Chaired by the Spanish Minister with competences in Space
- 2019 Ministerial Conference to be held in Spain
- Objectives of the Conferences -> to approve:
  - New optional programmes
  - The budget of the Scientific Programme

CM16 Proposal Exploration

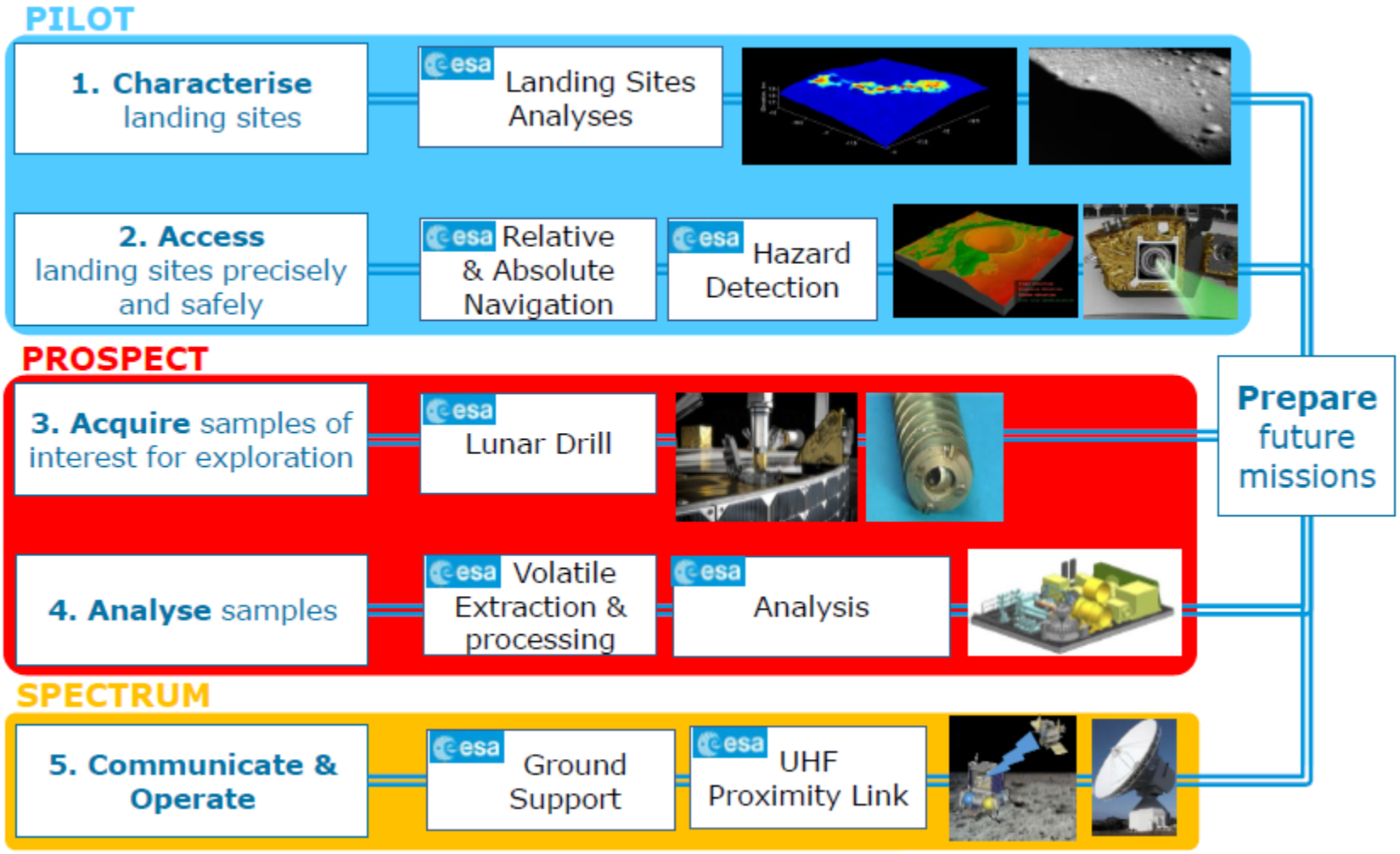
Line of Activity	Budget (M€)
ISS	890
ExoMars	300
Science in Microgravity	300
Technology preparation	95
Luna-Resurs Lander	65
TOTAL	**1650**

Missions Roadmap

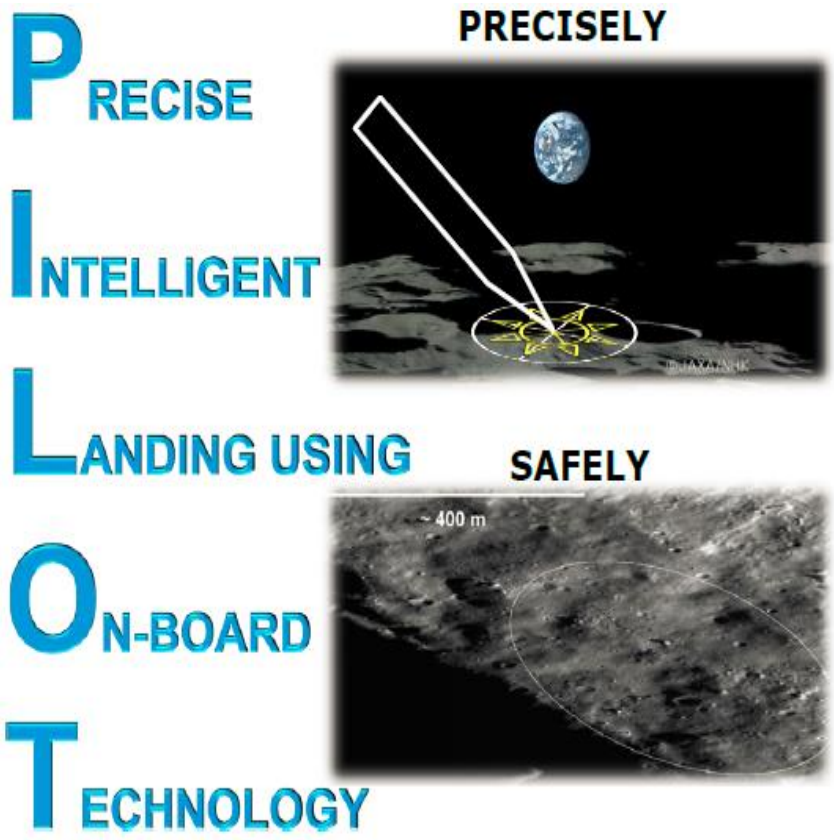
Three destinations: LEO, Moon and Mars



Moon: Core European Products and Services



PILOT



- PILOT provides accurate Navigation and Hazard Detection and Avoidance in Orbital and Lunar Landing scenarios
- Using PILOT, it will be possible to land safely on the Lunar surface with an accuracy of ~200 meters
- The Vision Based Technologies have reached the actual Readiness Level also thanks to CDTI support
- **GMV participates in PILOT developing the 2 core vision based technologies (RelNav & AbsNav) of the Navigation system**

FUTURE OPPORTUNITIES

PILOT will be the first Space on-board navigation system using vision based technology in GNC closed loop **completely autonomously** (no ground intervention)

PILOT will include the key technology for future lunar colonization since it will be the only Navigation system which can provide the needed accuracy

GMV: A GLOBAL TECHNOLOGY GROUP

Multinational technology group

Headquarters in Spain (Madrid)

Over 1,100 employees

Aeronautics, Space, Defense, Security, Transportation, Healthcare, Banking & finances, and ICT industries.

Private capital

Subsidiaries in 10 countries

Roots tied to the Space and Defence industry

Engineering, development and integration of systems, software, hardware, specialized products and services

Founded in

1984

PROSPECT

PLATFORM FOR

RESOURCE

OBSERVATION AND IN-

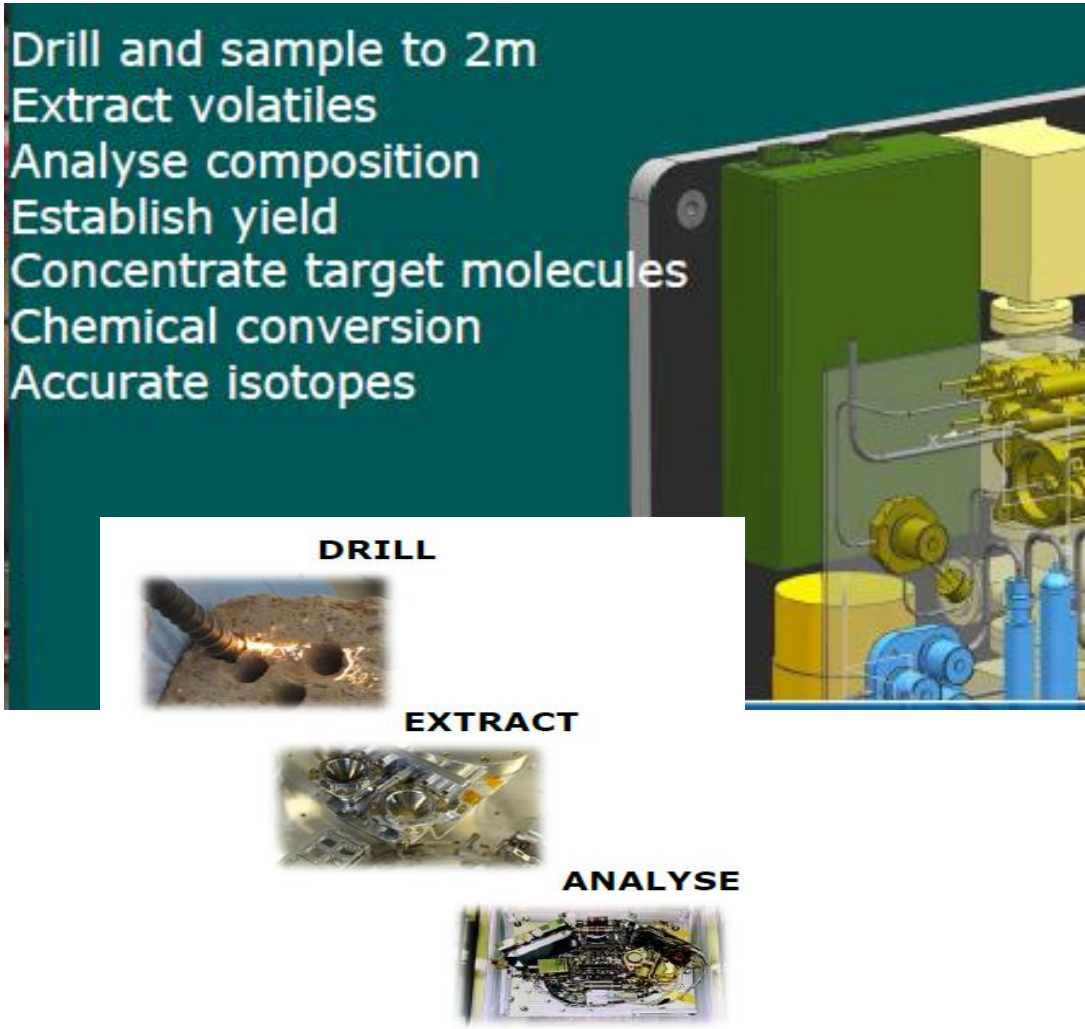
SITU

PROSPECTING IN SUPPORT OF

EXPLORATION,

COMMERCIAL EXPLOITATION &

TRANSPORTATION



PROSPECT

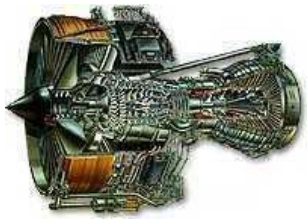
PROSPECT is focused on volatiles investigations through drilling and sample analysis.

It is made up of two elements:

- Excavation and Extraction drill
- Sample analysis instrument

SENER, based on the knowledge acquired with ExoMars 2020, will be responsible for some of the mechanisms for the Drill, enabling drilling of the lunar soil to a depth of two meters

About SENER...



Aeronautics

GAS TURBINES

ITP (53,125 %)

- Turbines engineering and technology
- Manufacturing of components and module integration
- In Service Support

MARKETS

- Large civil aircraft
- Defense
- Industrial turbines
- Small civil aircraft
- Helicopters

AFFILIATES AND PARTICIPATIONS

- ITP ENGINES UK (100 %)
- TURBORREACTORES (100 %)
- AEROMARITIME GROUP (100 %)
- ITA (100 %)
- PRECICAST BILBAO (80 %)

Engineering & Construction

SENER INGENIERÍA Y SISTEMAS

BUSINESS UNITS

- Aerospace
- Infrastructures and Transport
- Power and Process
- Marine

LOCATIONS

- Bilbao
- Madrid
- Barcelona
- Valencia
- Lisbon
- Mexico City
- Buenos Aires
- Algiers
- Warsaw
- Abu Dhabi
- Okayama
- San Francisco
- São Paulo
- Busan
- New Delhi
- Shanghai
- Bogota
- Santiago de Chile

AFFILIATES AND PARTICIPATIONS

- III (100 %)
- ENGIVIA (100 %)
- NTE-SENER (100 %)
- HISDESAT (5 %)
- EXEN (100 %)
- SETEPLA (48 %)
- EIPSA (80 %)

Energy & Environment

MUNICIPAL WASTE TO ENERGY

ZABALGARBI (30 %)

FARM WASTE TREATMENT

- TRACJUSA (42 %)
- VALPUREN COMATUR (95 %)
- VALPUREN BAÑUELO (93 %)

CONCENTRATED SOLAR POWER

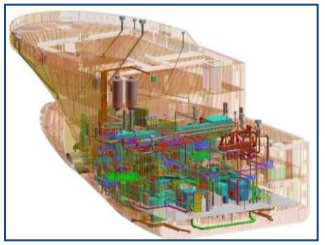
TORRESOL ENERGY (60 %)

- GEMASOLAR (100 %)
- ARCOSOL (Valle 1) (100 %)
- TERMESOL (Valle 2) (100 %)

BIOMASS AND USED OIL REREFINING

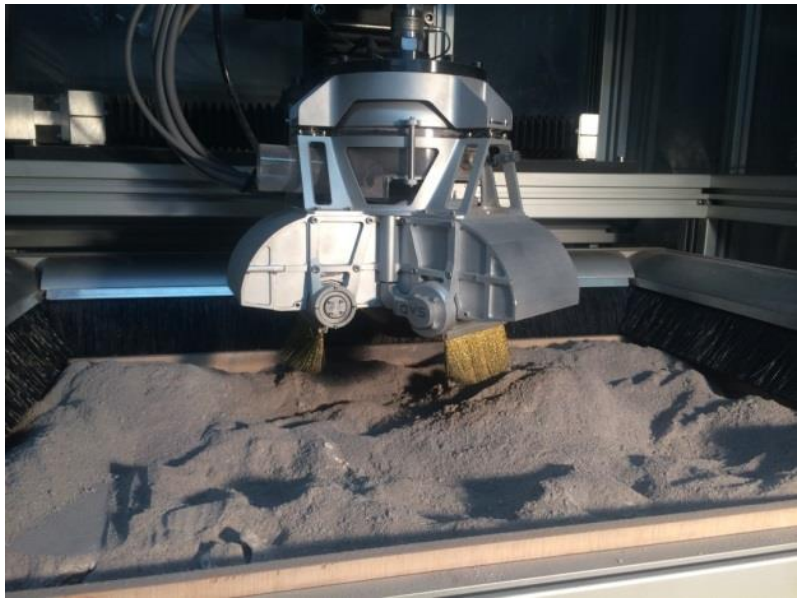
RRF (80 %)

KEY Operative Construction



Additional Activities: sampling tool mechanism for low gravity bodies

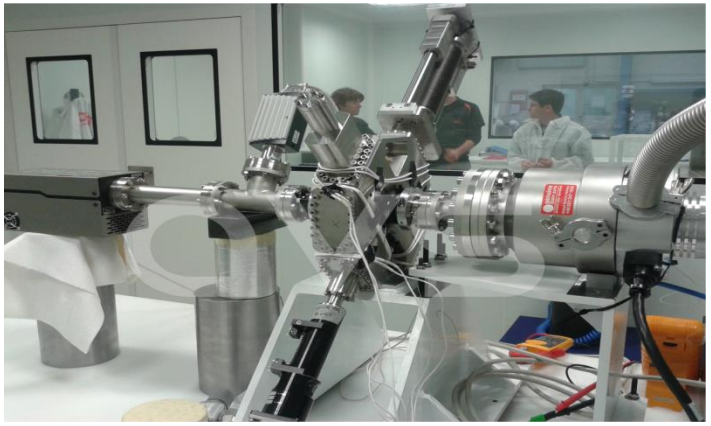
- **AVS** (Bilbao) has developed a breadboard of a fully functional sampling mechanism for touch and go sampling on a low-gravity body
- Tested under ambient conditions using an asteroid regolith simulant
- And tested inside a parabolic flight campaign, in microgravity environment.



- Next steps: Sample return missions to asteroids, moons and planets of our solar system are the next logical step of robotic exploration beyond Earth to study evolution of the solar system.

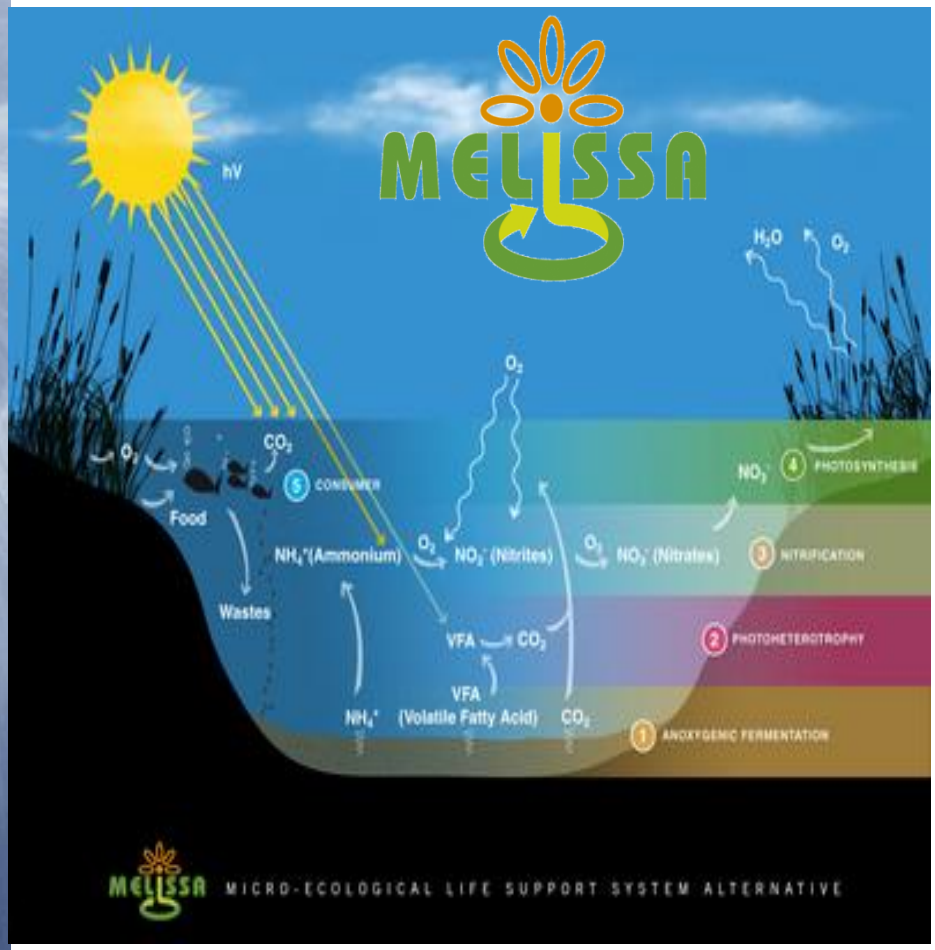
AVS was found in 2006. It is an SME with high qualified personnel (80% engineers and physicist) 3000 m2 of moderns facilities including in-site workshop and clean room.

Design, analysis, manufacturing, assembly, integration and test under ISO9001/EN9100



www.a-v-s.es

Additional Activities: MELISSA (Life support system)



MELISSA (Micro-Ecological Life Support System Alternative)

The objective is the recovering of food, water and oxygen from waste (faeces, urine), carbon dioxide and minerals. It is based on the principle of an "aquatic" ecosystem.

It is intended as a tool for the development of a future regenerative life support system for long term manned space missions as a lunar base or a mission to Mars

Melissa is located at Barcelona

Summary

- CDTI is the focal point for Spanish space industrial activities
- ESA has 22 Member States and an annual budget of 3.600 M€ (direct contributions)
- Spain is the 6th contributor with an investment of 152 M€/year
- Spain participates in all ESA programmes and its industry is highly competitive
- ESA exploration programme is developed thorough 3 main lines: human exploration and microgravity (ISS) and robotic exploration (Moon and Mars)
- The short-term objective for Moon exploration is to achieve robotic surface access
- Cooperation with Russia is under discussion
- The European participation will be oriented to accurate navigation (PILOT) and sample analysis through drilling (PROSPECT)
- Spain is actively participating in these areas (GMV, SENER) and in sampling tools (AVS) and life support systems (UB) for future robotic and human missions

Thank you!

mariadelpilar.roman@cdti.es
www.cdti.es
@CDTIoficial