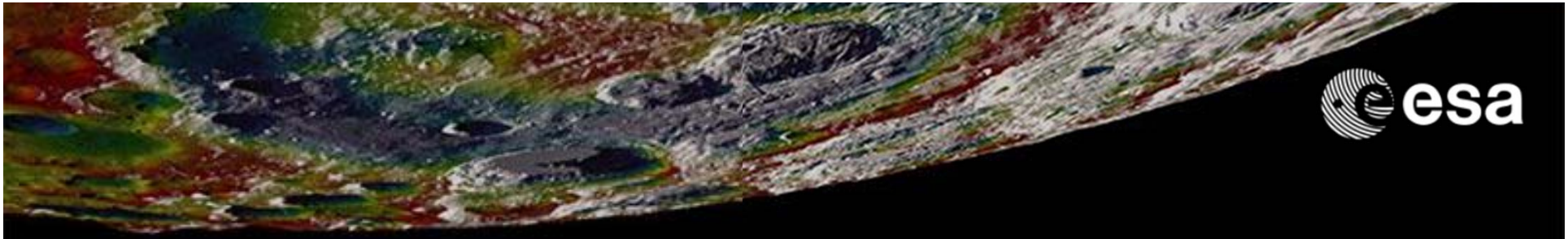

MOON 2020-2030
A new era of human and robotic exploration

SAMPLE ACQUISITION, PROCESSING AND CONTAINMENT SYSTEMS (SAPCS)

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ESA/ESTEC Noordwijk
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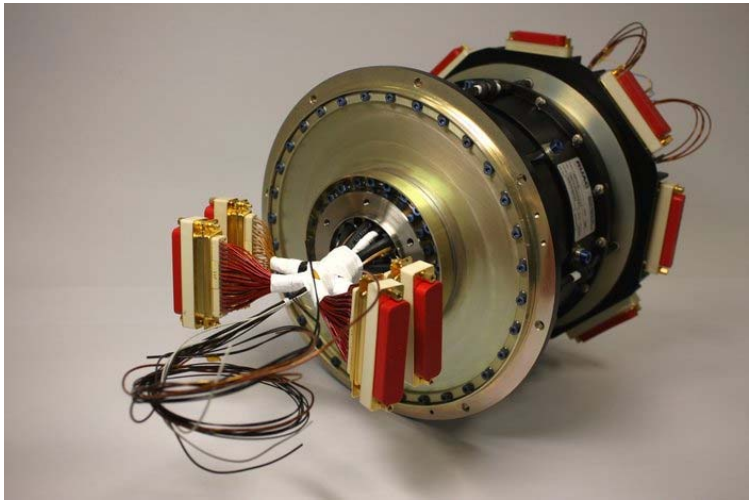
European Space Agency

AVAILABLE MECHANISMS FOR MOON MISSIONS

- Large range of rotary actuators available for drive trains, solar array drives, antenna pointing …
- Specific mechanisms under development into the frame of the MREP program,
- The European knowledge is in place to upgrade those products for the Moon missions.



SADM – Courtesy of RUAG (CH)

High detent rotary actuator – Courtesy of Sener

SAPCS FOR MOON SCIENTIFIC NEEDS (PROSPECT) - INTRODUCTION

- Sampling, processing, transporting the Moon resource (regolith) is useful for :
  - Scientific analysis (cross contamination is an additional requirement),
  - In situ construction at longer term.
- Containment is necessary for sending back the samples for a later analysis.
- The range of mechanisms needed is very large and faces technological challenges :
  - The dust moon is very abrasive (more than 50% of the Apollo mechanisms failed due to dust jamming),
  - Useful building blocks : sealed gearbox, magnetic gear, …
  - For robotic functions and in-situ construction, the required torque can be significant,
  - Close to the moon poles, the temperature may be around 120 K and limit the number of dry lubricants.
- **This presentation provides a status of existing MREP developments and identifies further developments.**

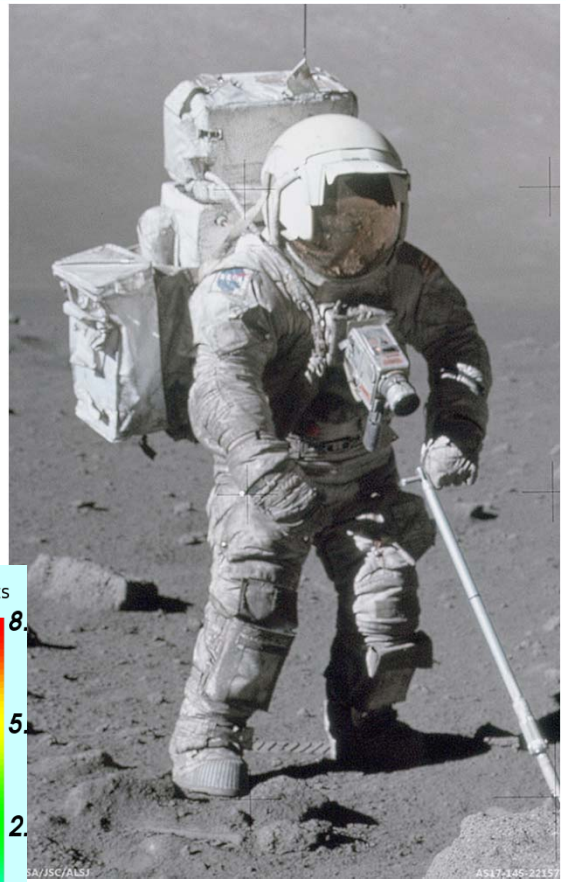
SAPCS FOR MOON SCIENTIFIC NEEDS (PROSPECT) - TD4 SPACE ENVIRONMENTS AND EFFECTS

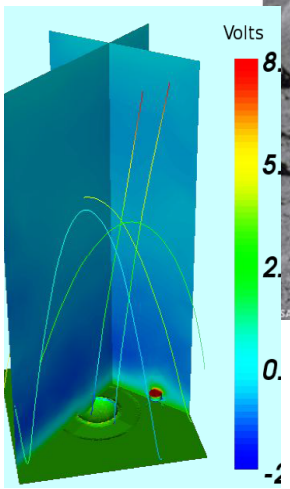
In the context BB6 Sample Acquisition, Processing, Containment :

- Dust & electrostatic charging effects
- Very fine lunar dust is a hazard for mechanisms, contaminates surfaces through
- Dust transport and contamination
- Interactions with fields and plasmas

R&D work started on:

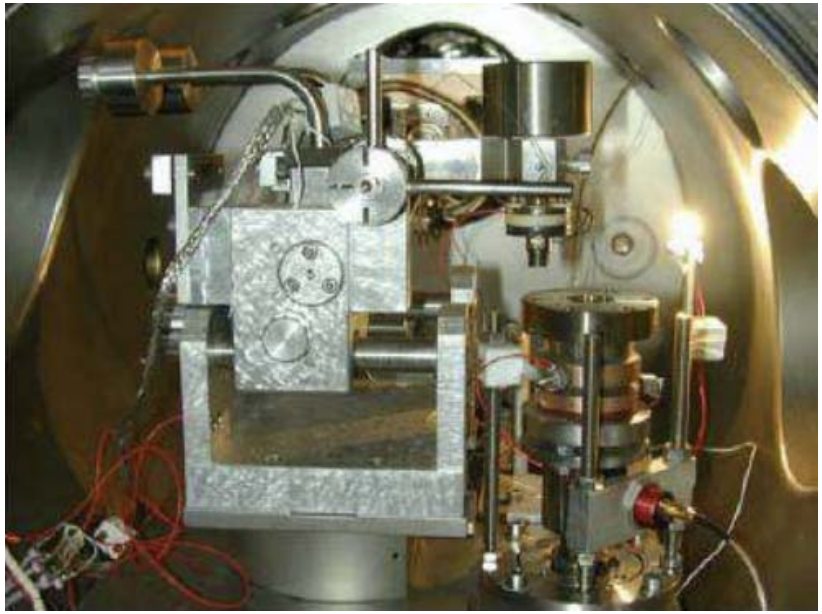
- Simulation tools for charging & interactions of dust
- Dust environment and transport
- Vehicle/hab charging & dust interactions (e.g. SPIS-Dust)





SAPCS FOR MOON SCIENTIFIC NEEDS (PROSPECT) LUBRICATION

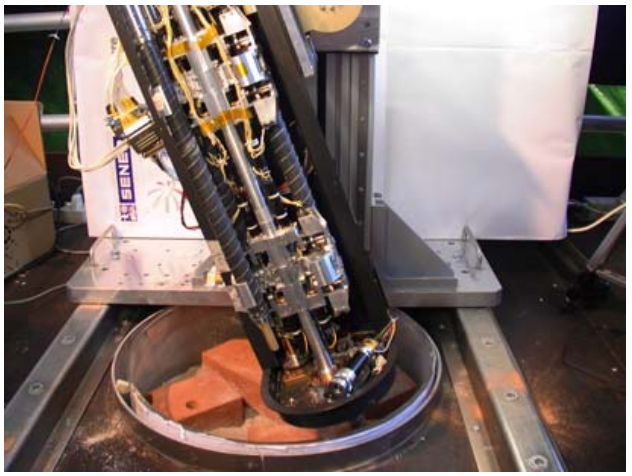
- Potential re-use of the MREP results “Cold-efficient lightweight mechanisms”
- For Mars, the emphasis is put on the CO2 atmosphere and its effect on the tribology,
- Some additional tests will have to be done again for the Moon to confirm the best option found so far.



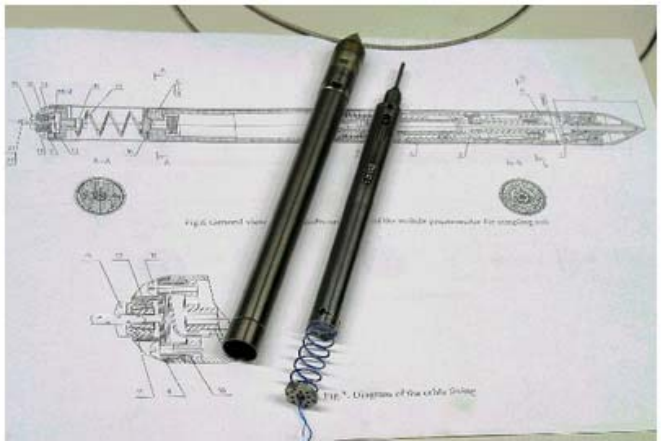
Tribometer (courtesy of AAC (AT))

SAPCS FOR MOON SCIENTIFIC NEEDS (PROSPECT) DRILLING

- Several drilling / sampling mechanisms have been designed / flown for Rosetta, ExoMars, …
- Deep Drilling (2 meters) in the regolith at 120 K is more difficult due to the compactness of the regolith and may require :
  - Percussive drilling (various methods have been investigated : electromagnet, cam + spring, ultrasonic, …),
  - Dry lubrication



ExoMars drill : courtesy of Selex



Sampling mole & hammering mechanism

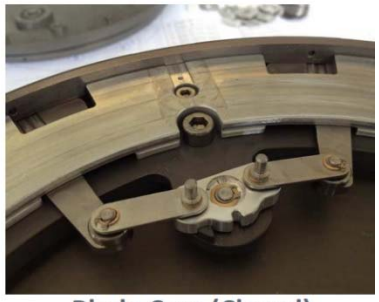
SAPCS FOR MOON SCIENTIFIC NEEDS - CONTAINMENT

- Ice volatiles : for scientific needs, it is requested not to heat the samples by more than 10 degrees :
  - During sampling acquisition, during transport & processing,
  - Detailed thermal analysis and design needed,
- Sample processing :
  - Sieving : various methods (vibrating, centrifugal, …)
- Bio-sealing :
  - Is needed to send back the sample on Earth.

Container (simplified)

Lid

Lid (with Blade Cam Open)

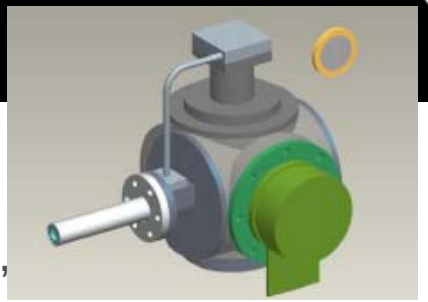


Blade Cam (Closed)

Bio-sealing breadboard : courtesy of Selex

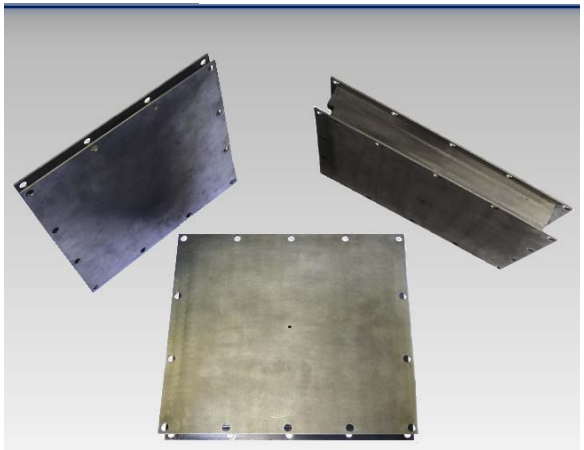
SAPCS FOR MOON SCIENTIFIC NEEDS (PROSPECT) THERMAL ASPECTS

- Thermal drivers:
  - Depending on the nature of the samples, it might be necessary to acquire them at cryogenic temperature (120K), and to store them below ambient temperatures (-20degC) until retrieval
- Potential technologies:
  - TRP: *Microcooler for Miniaturised Space Experiments* which aims at adapting / developing a miniaturised, efficient and low cost European cryocooler
  - Phase Change Material: Can be used to thermally control the samples after their acquisition. 2 activities on the subject in TEC-MT since 2010



Up - Concept of Small Scale Cooler (RAL)

Right – Non Space Thales Cryogenics Microcooler



Breadboard PCM developed in the frame of a TRP (Walopt)

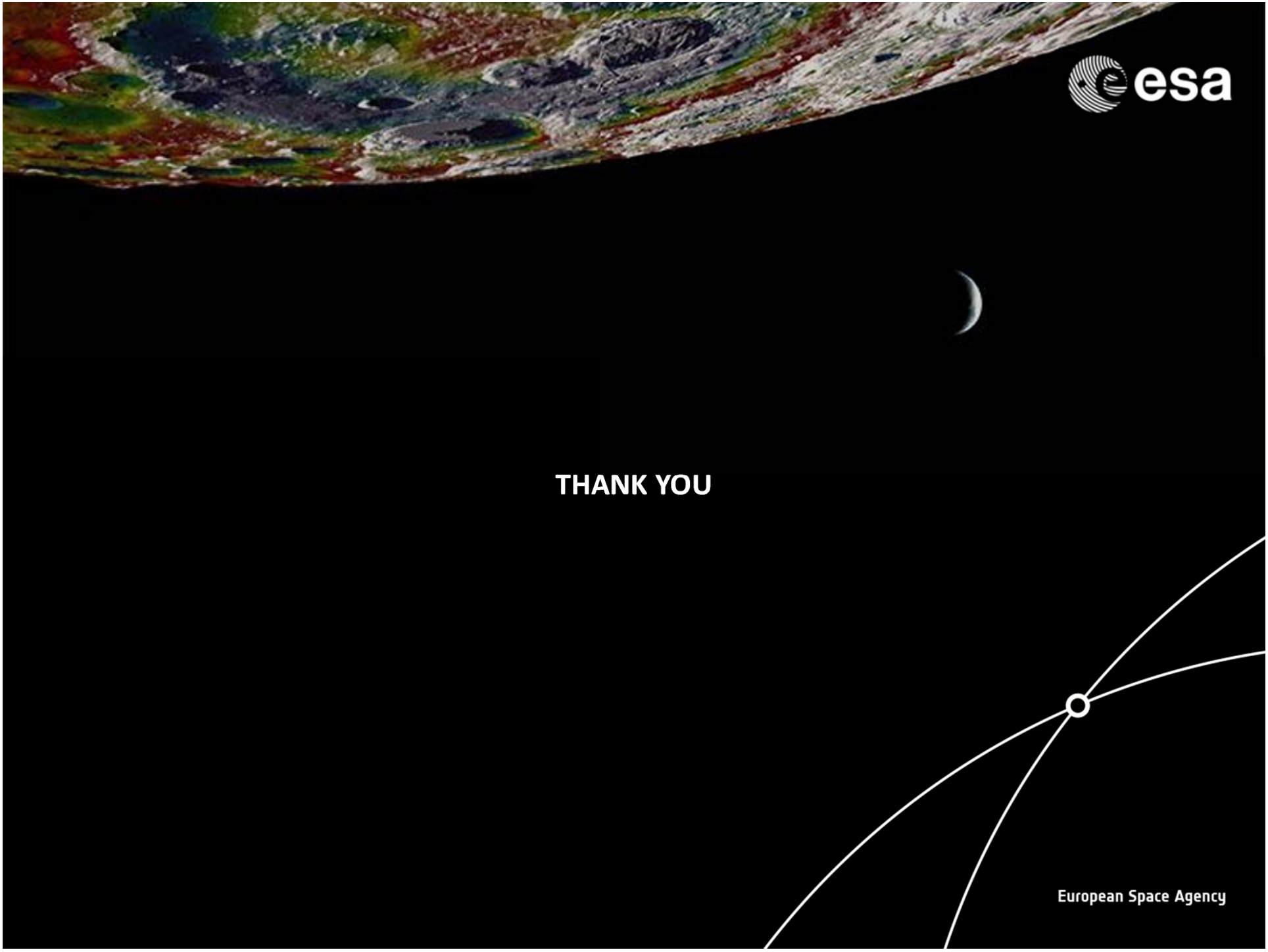
SAPCS FOR MOON SCIENTIFIC NEEDS - CAPTURING

- Rendezvous and capture mechanisms,
- MREP Capturing of the Bio-container (CGS)
  - On-board on the moon orbiter,
  - Cooperating with the AOCS,
  - Capturing the bio-container.
- Need for a fast & robust mechanisms
- Tested at TRL5 by CGS (IT) through the MREP program.

Courtesy of CGS (IT)

OUTLINE - CONCLUSION

- The Sample, Acquisition, Processing and Containment System (SAPCS) is a sub-system requiring various mechanisms,
- The European industry has a valuable experience through past & on-going missions (Rosetta, ExoMars, …),
- Some scenarios requiring new mechanisms (e.g. containment) have been bread boarded through the MREP program,
- The Moon environment (e.g. dust, cryo-temperatures) will trigger new delta-developments for mechanisms within the European industry :
    - Drilling (hard soil, no increase of temperature),
    - Dust mitigation,
    - Lubrication optimization for cold mechanisms (120 K),
    - High power mechanisms.


esa
THANK YOU
European Space Agency