Accessing, Drilling and Operating at the Lunar South Pole: Status of European Plans and Activities

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[5] OHB System AG, Munich, Germany

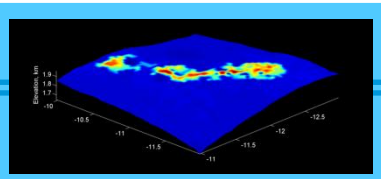
ASTRA 2015

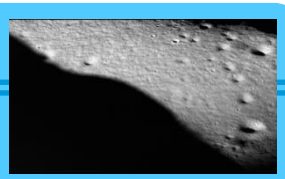
Lunar Exploration Programme: European Products

PILOT

1. Characterise landing sites

Landing Sites Analyses

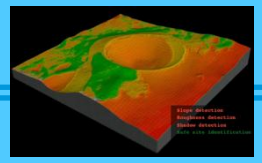


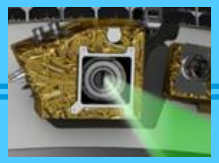


2. Access landing sites precisely and safely

Relative & Absolute Navigation

Hazard Avoidance



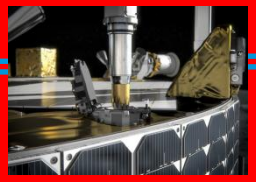


PROSPECT

3. Acquire samples of interest for exploration

Lunar Drill

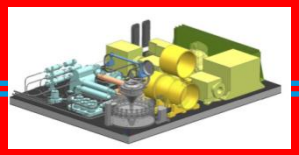
Sample Handling



4. Analyse samples

Volatile Extraction & Analysis

IR Spectrometer

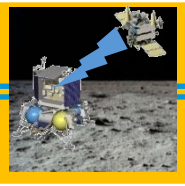


SPECTRUM

5. Communicate & Operate

Ground Support

UHF Proximity Link



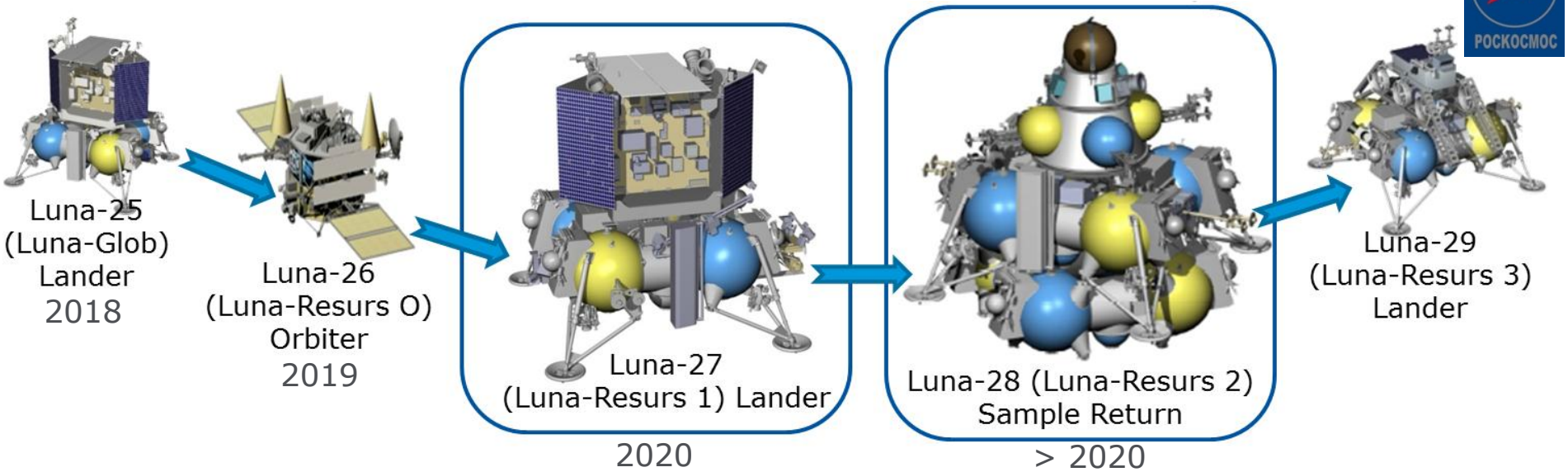
Prepare future missions

PROSPECT Goals

- Establish and demonstrate European competence in key areas for future international missions in the areas of:
  - Drilling
  - Sampling
  - Sample handling and processing
  - Sample analysis
- Generating knowledge which address unknowns for resource utilisation and fundamental scientific questions
- Engage and increase public and stakeholder interest and understanding of lunar exploration and its benefits
- Provide a drill that meets Russian requirements and expectations and ensure that Europe benefits from the provision of that drill

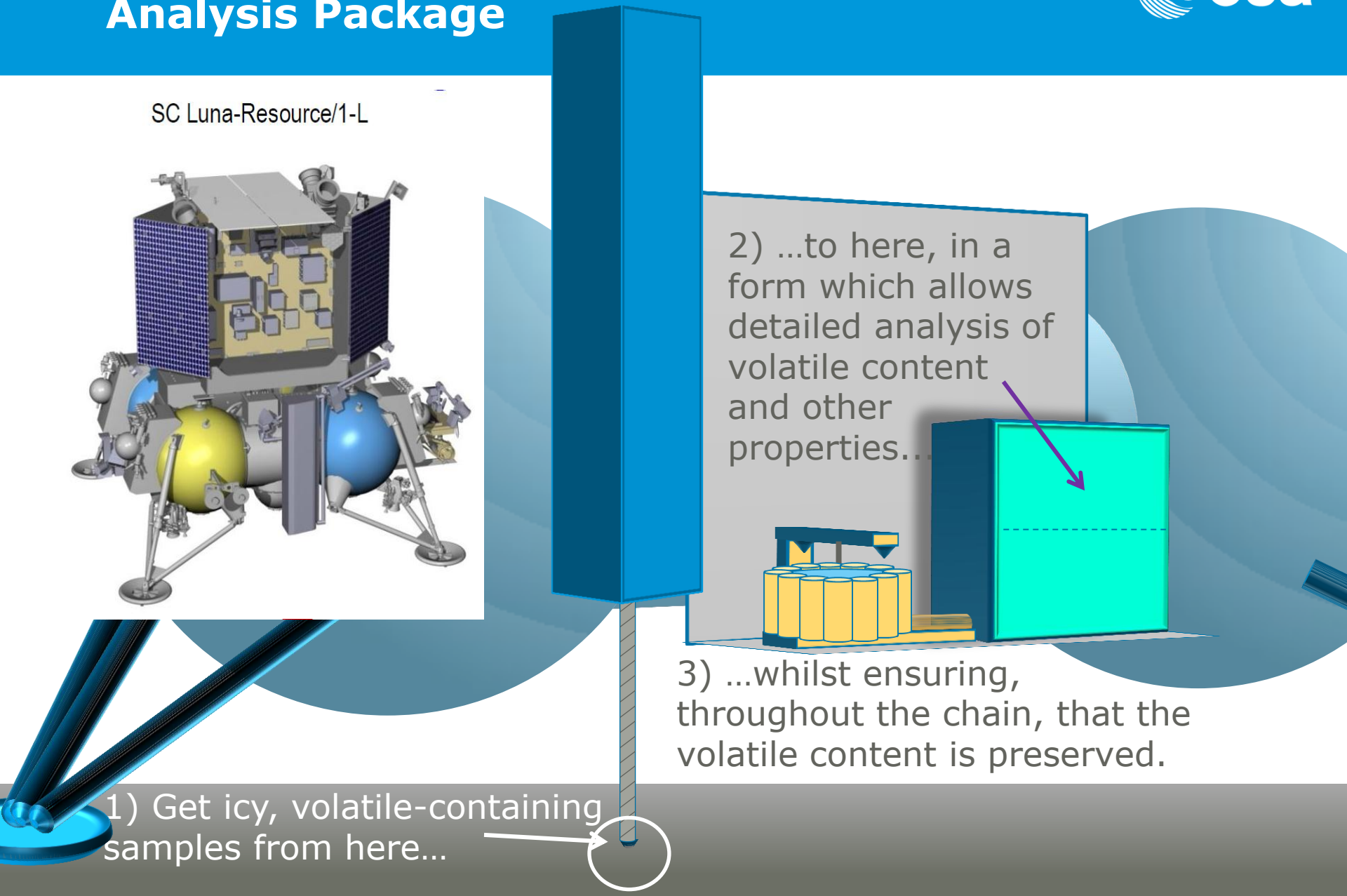
Robotic Precursor Phase of Lunar Exploration: Russia as the First Partner

- Lunar exploration is major goal of Russian exploration programme
- Compatible and complementary interests between ESA & Roscosmos identified, both in technology and science
- Detailed investigation, in-situ and by sample return, of volatiles in the polar regions plus complementary science at the poles



- **Principle of product based approach is to have elements and capabilities which are also available for cooperation with other partners**

PROSPECT: Sampling & Sample Analysis Package



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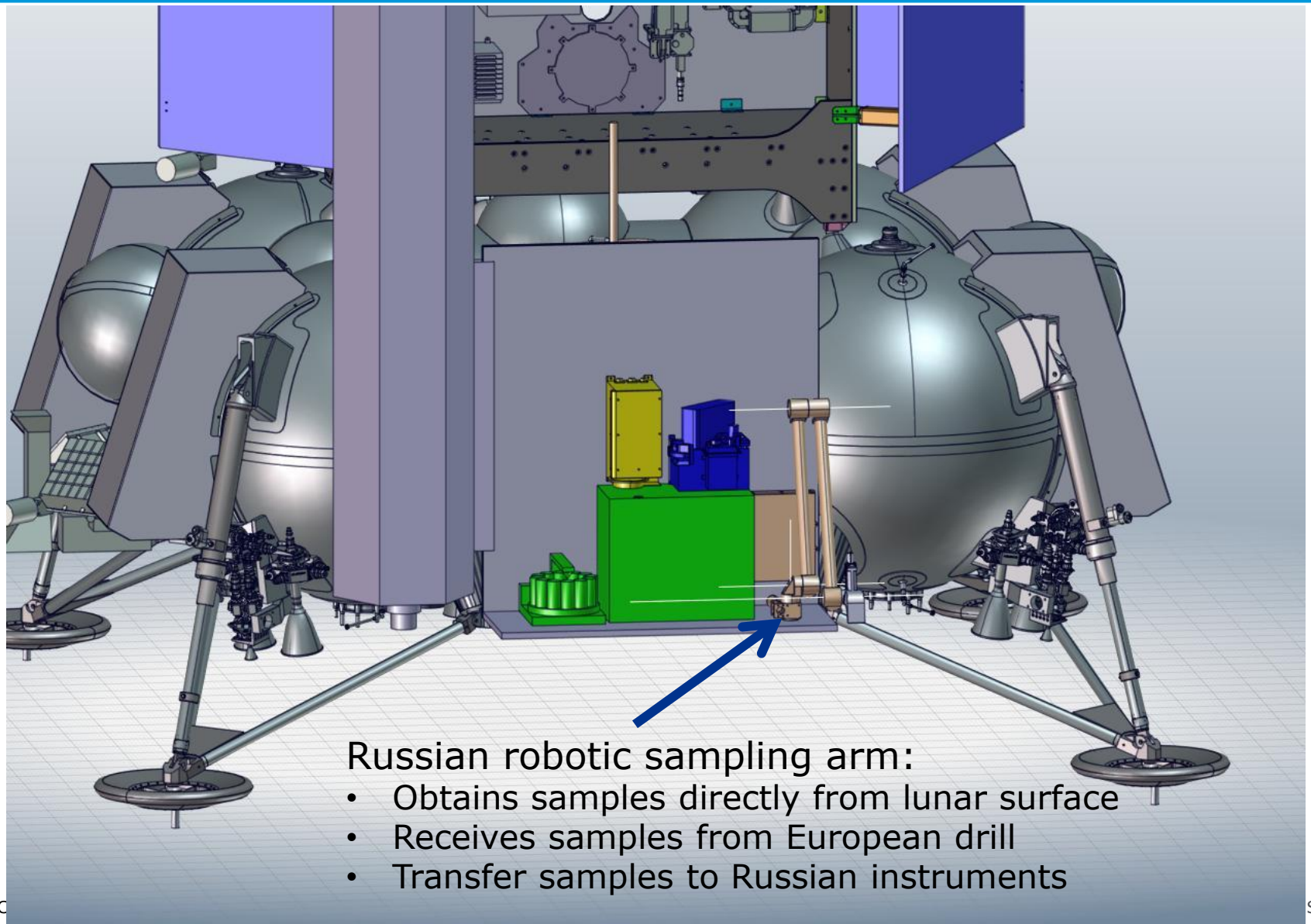


PROSPECT: Key challenges

OBJECTIVE: drill 2m into lunar surface at the poles, extract samples, preserve volatiles/ices , chemical extraction, chemical analysis

- ENVIRONMENT: COLD (~120K; shadowed side of the lander)
- MATERIAL: Highland regolith?, Icy? [0%, ppm, 5%, saturated, ice lenses…?]
- ICES/VOLATILES: behaviour in vacuum, loss mechanisms?
- TECHNOLOGY: some heritage, new combinations, new applications

MATERIAL

?

Dry, loose, powdery, easily lost but also 'sticky'

Saturated, hard, stronger than reinforced concrete

ICE LOSSES

?

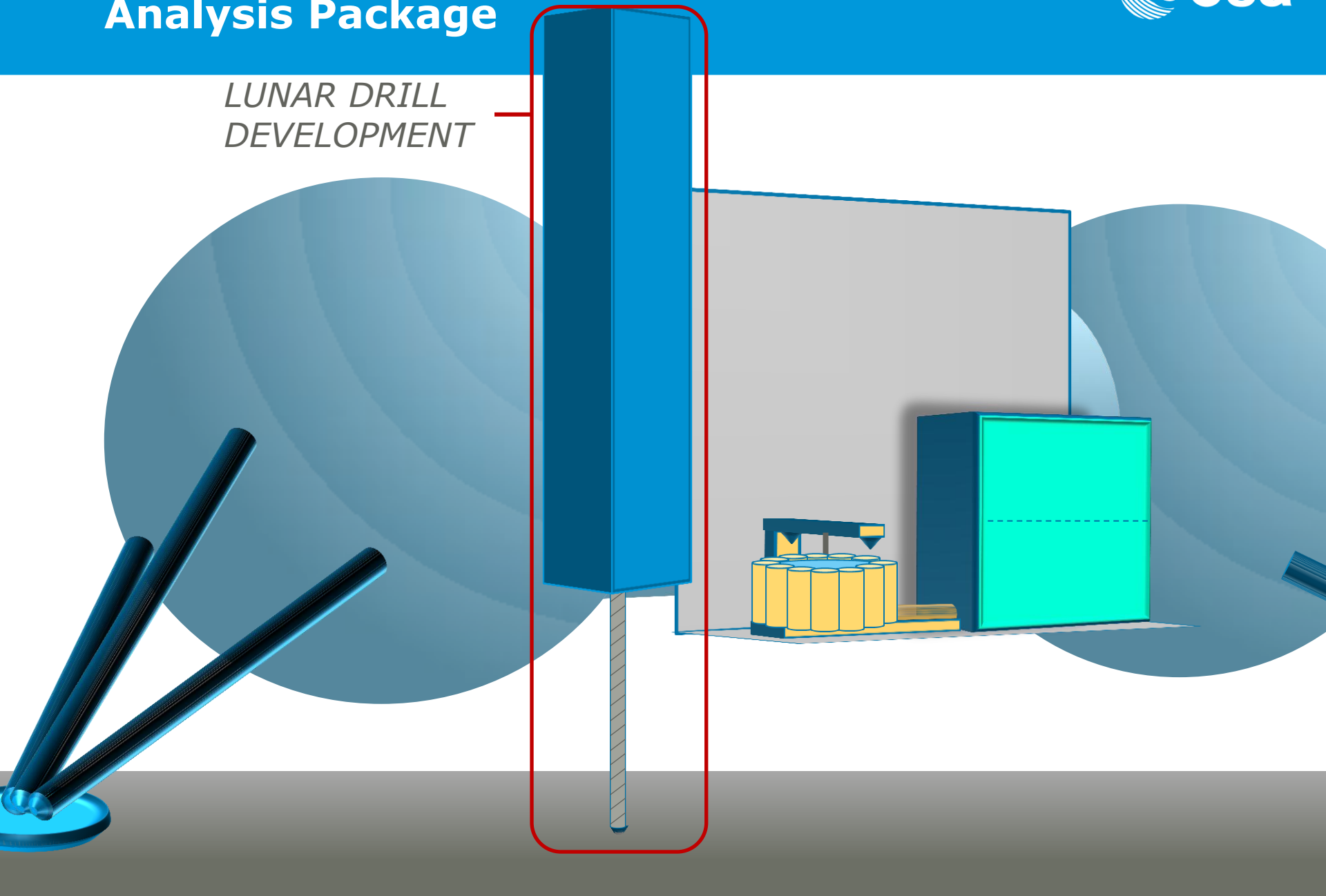
Rapid, highly temperature dependent loss of ALL icy material

Slower, less temperature dependent loss, strongly influenced by sample size/nature

Delicate frost

Dirty snowball

PROSPECT: Sampling & Sample Analysis Package



LUNAR DRILL DEVELOPMENT

Kickoff: 01 September 2014
End date: 30 September 2015

PRIME: **SELEX-ES (I)**
Sub-cos: Maxon Motors (CH)
Astronika (PL)
Pol. di Milano (I)

esa

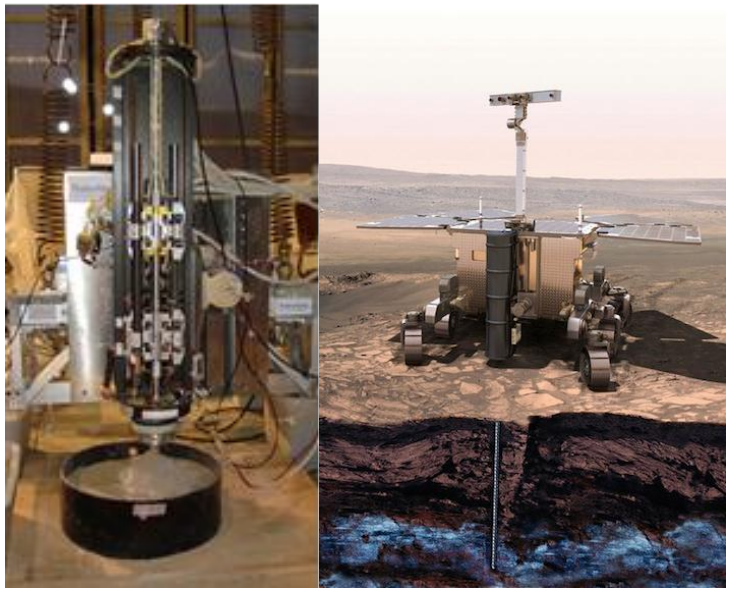
HERITAGE

- ROSETTA-PHILAE (low temperature drilling and sample handling)
- EXOMARS (extensive development & testing, incl. components)
- R&D: DeeDri, Downhole Hammering Mechanism, ExoMars Motor Env. Testing

ACTIVITY FOCUS

- Access samples from potentially very high strength material (cold, icy)
- Ensure preservation of sample volatile content (maintain low temp.)
- Establish operational approach compatible with minimal resources

SD2 onboard Philae



ExoMars drill

LUNAR DRILL DEVELOPMENT

Kickoff: 01 September 2014
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PRIME: **SELEX-ES (I)**
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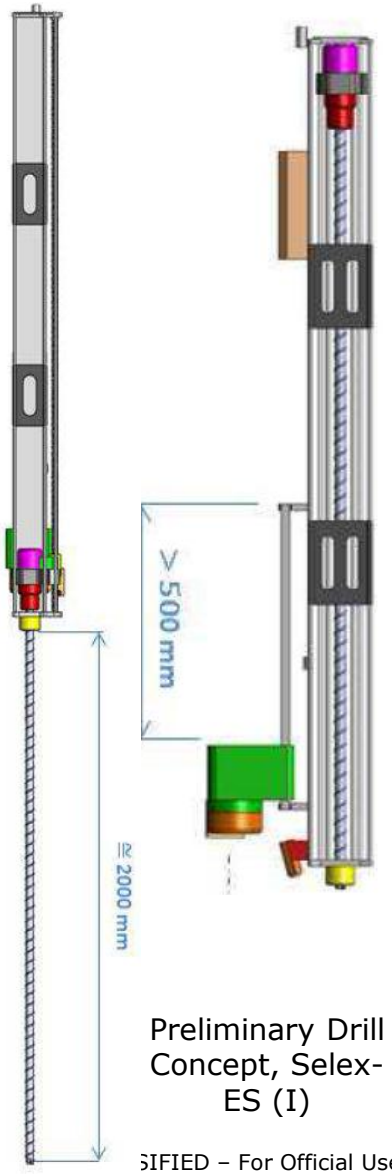
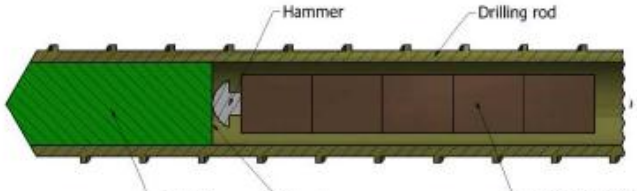
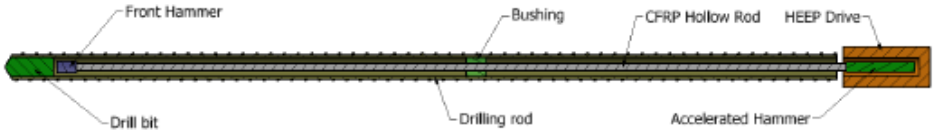


Preliminary Drill Concept, Selex-ES (I)

KEY TECHNICAL AREAS

- Single rod rotary drilling system
- Integrated hammering device with electromagnetic drive
- Drill translation & positioning system
- Thermal preservation of samples during drilling and sample transfer
- Environmental testing of motor/gearbox combinations
- Flexible operational control
- In-situ measurement capabilities (e.g. temp, permittivity, IR-spectra)



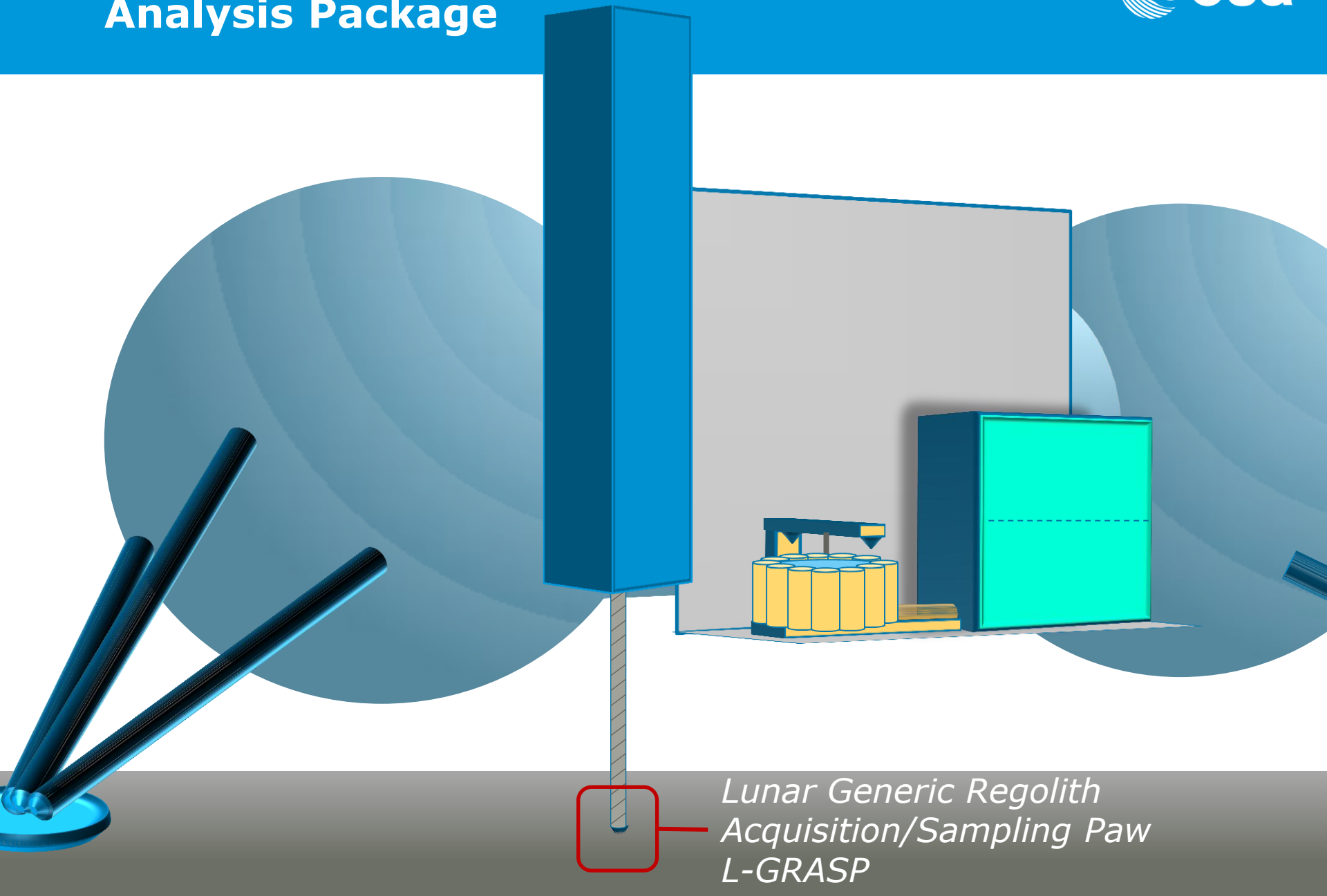


Options for hammer-device location, Selex-ES, Astronika (I)

MUPUS comet penetrator Rosetta – Philae CBK-PAN (PL)

Drill test HW available for concept tests – Selex-ES (I)

PROSPECT: Sampling & Sample Analysis Package



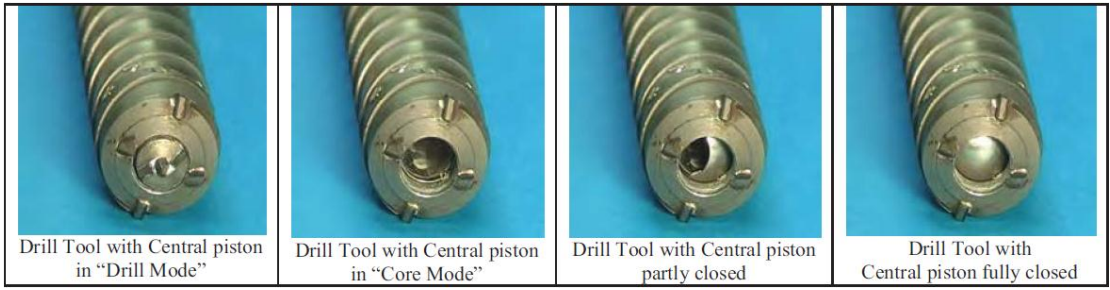
L-GRASP

Kickoff: 08 May 2013
End date: Early 2015

PRIME: **SELEX-ES (I)**
Sub-cos: OHB-Munich (DE)
Uni. of Leeds (UK)
Support: TU Graz (A)

HERITAGE

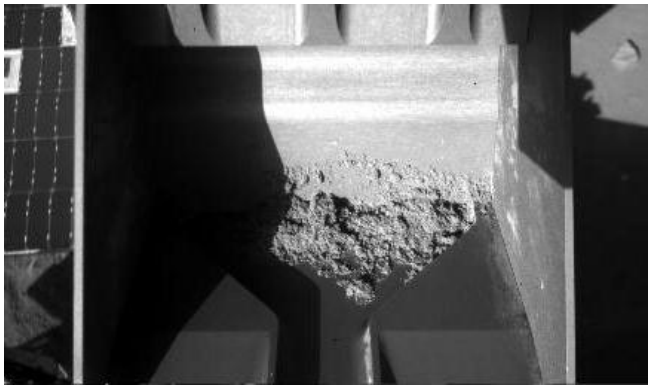
- ROSETTA SD2 development
- ExoMars Drill tool development



ExoMars and Rosetta-Philae SD2 drill tip configurations – Selex-ES (I)

ACTIVITY FOCUS

- Review of current knowledge of icy sample properties, state-of-the-art in lunar regolith simulants and experimental approaches
- Evaluation of sample acquisition <u>and</u> ejection tools for icy lunar samples, focusing on robustness to range of icy sample properties
- Assessment of sampling tool concepts by review, and by concept breadboarding and testing



Phoenix's scoop after it had been inverted and a motor in the scoop had been run to jar the sample of icy dirt loose. The image, taken on July 28, shows that much of the sample remained stuck inside the scoop.

Credit: NASA/JPL-Caltech/University of Arizona/Max Planck Institute

L-GRASP

Kickoff: 08 May 2013
End date: Early 2015

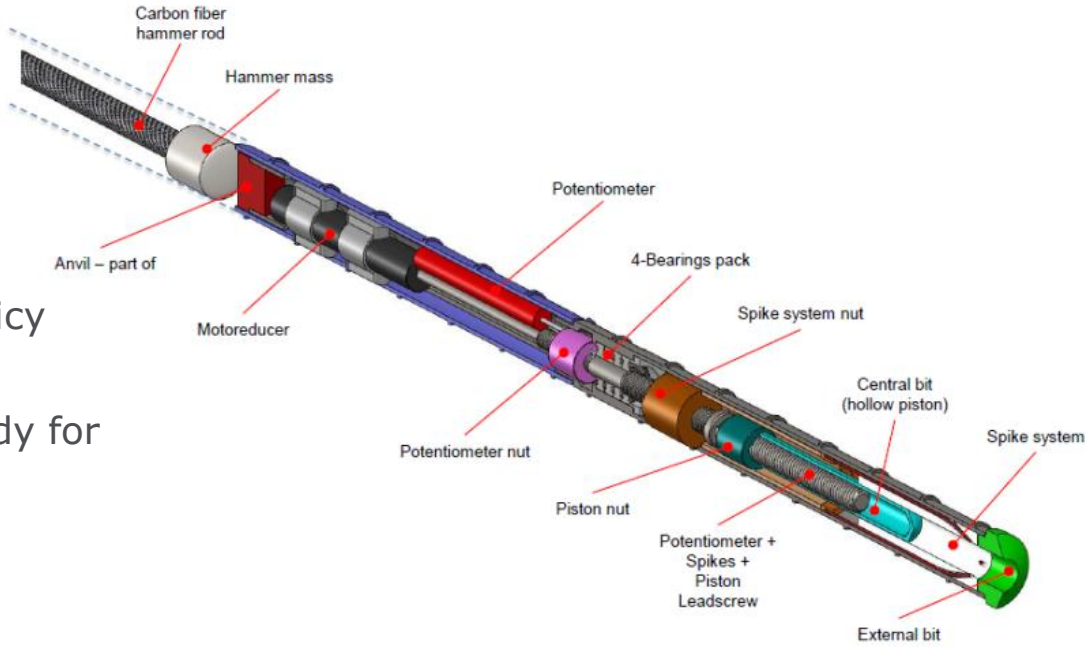
PRIME: **SELEX-ES (I)**
Sub-cos: OHB-Munich (DE)
Uni. of Leeds (UK)
Support: TU Graz (A)

KEY TECHNICAL AREAS

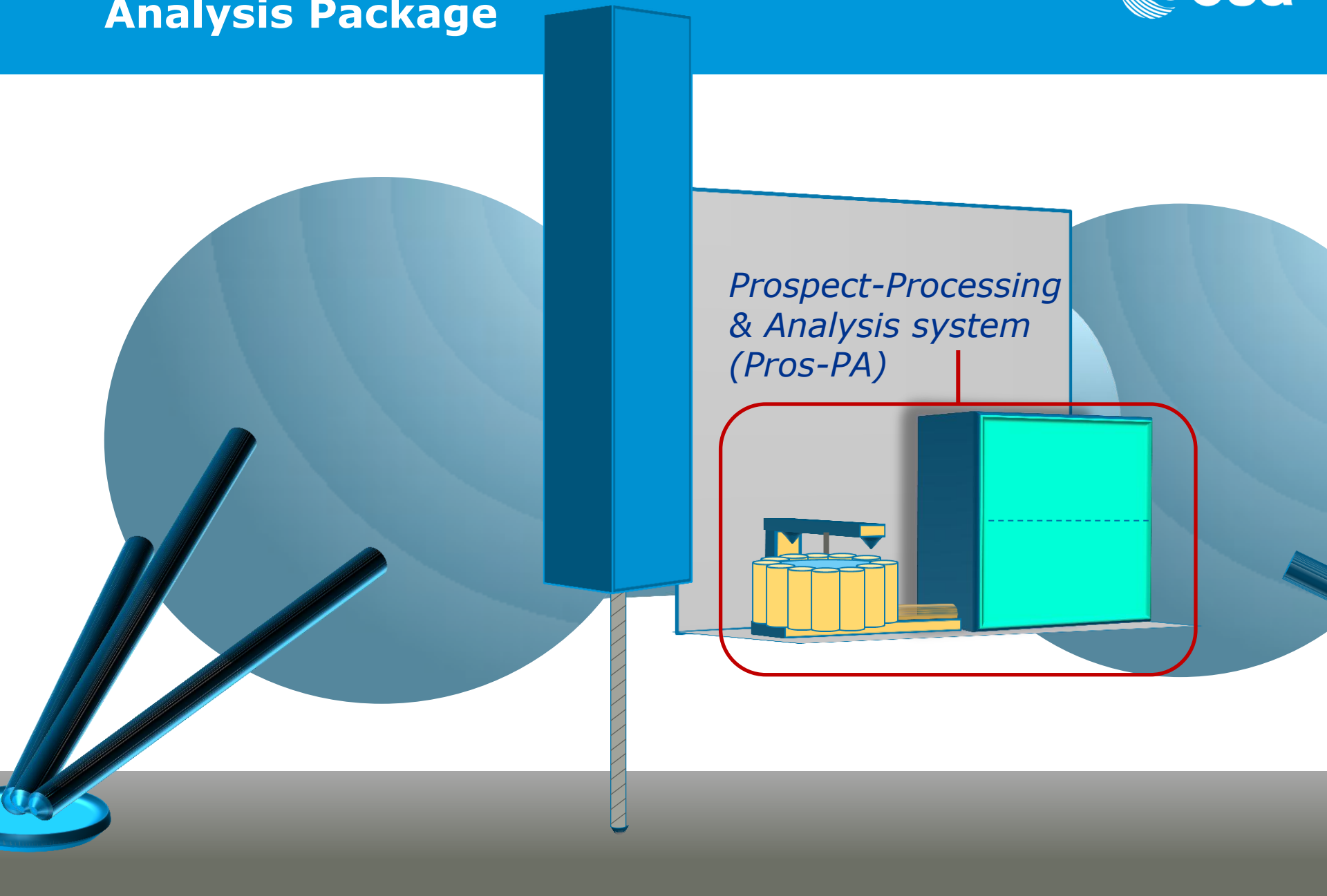
- Establishment of icy regolith simulant specification and preparation approach, with support of international simulant/lunar materials experts (Workshop in ESTEC: October 2013)
- Sample tool concept breadboarding and test campaign in icy regolith simulant (bottom right)

ACTIVITY OUTPUT

- Established test setup and icy regolith preparation procedure, <u>and</u> hands on European experience with icy samples
- Test data on nature and behaviour of icy regolith when sampling
- Preliminary sampling tool concept ready for integration in drill design, already subjected to initial test campaign



PROSPECT: Sampling & Sample Analysis Package



PROCESSING AND ANALYSIS

Kickoff: 01 September 2014
End date: 04 June 2015

PRIME: **Open University (UK)**
Sub-cos: OHB (DE), TU. Munich (DE) RAL Space (UK)
Consult.: Selex-ES (I), Airbus DS Ltd. (UK)

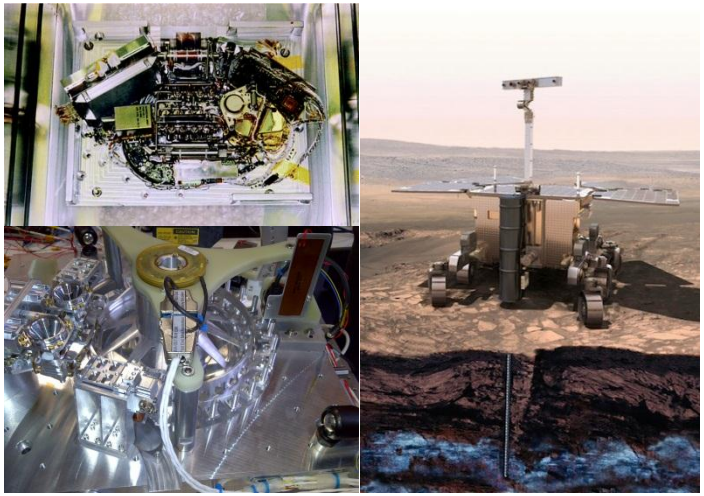
HERITAGE

- Cometary, Martian, Lunar chemical processing and analysis laboratories
    - ROSETTA-Ptolemy,
    - Beagle 2-GAP,
    - Lunar Lander L-VRAP
- Volatile sample handling heating and gas extraction
    - ROSETTA-SD2
    - EXOMARS-SPDS

ACTIVITY FOCUS

- Handle, contain and heat potentially icy regolith samples
- Thermochemical extraction of resource relevant chemistry
- Gas chemical processing and analysis of composition and isotopes

SD2 oven, Ptolemy onboard Philae and a lab setup including a mass spectrometer



ExoMars SPDS and B2 GAP

PROCESSING AND ANALYSIS

Kickoff: 01 September 2014
End date: 04 June 2015

PRIME: **Open University (UK)**
Sub-cos: OHB (DE), TU. Munich (DE) RAL Space (UK)
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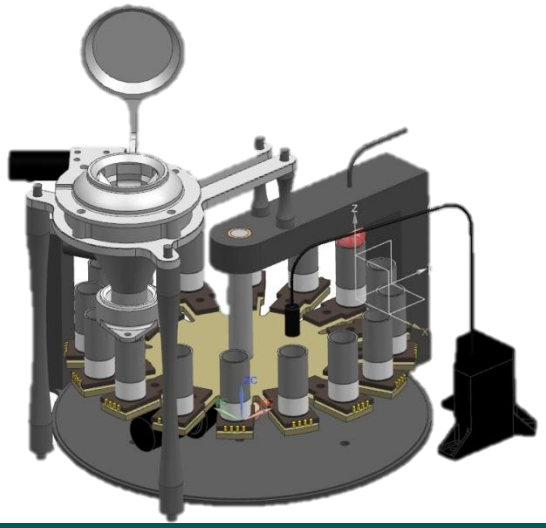
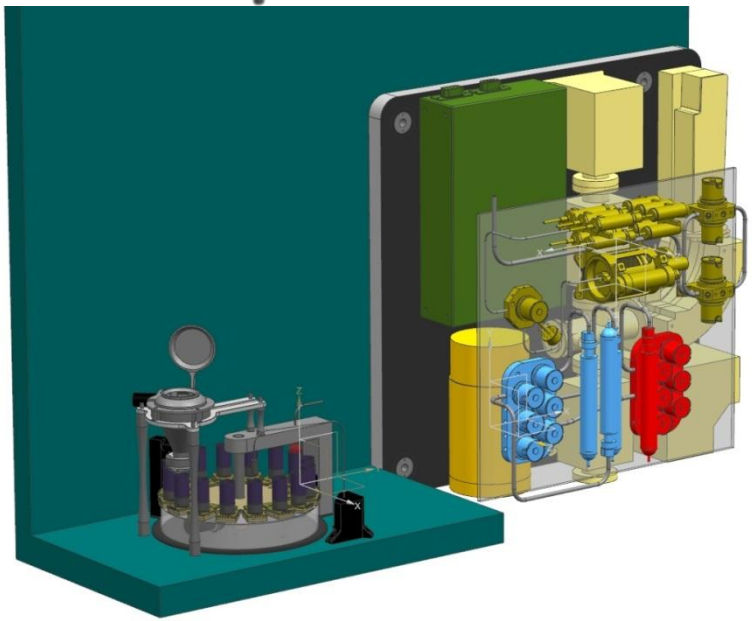
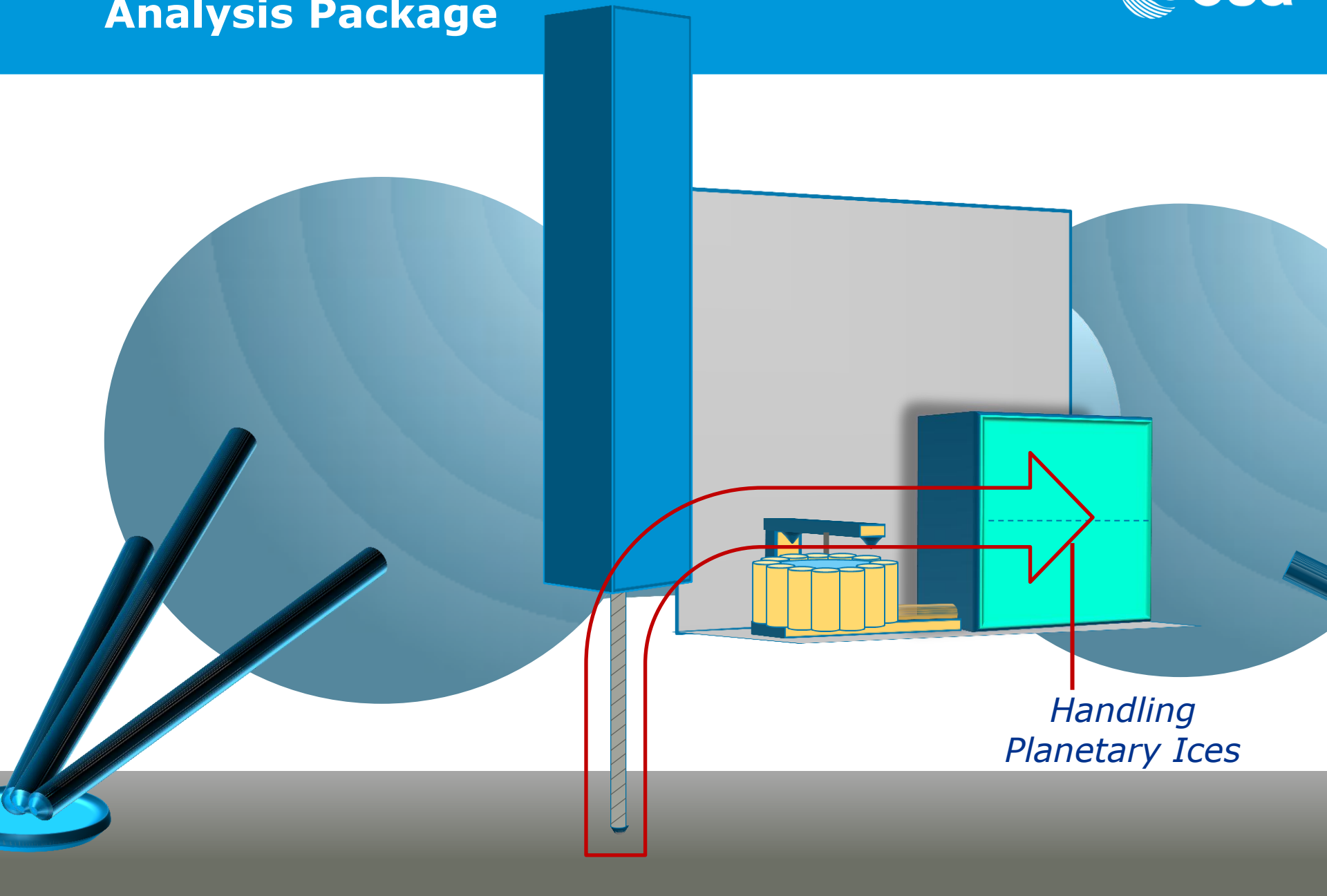




KEY TECHNICAL AREAS

- Diagnostic/context sample measurements (imaging/IR)
- High temperature ovens
- Reactants for thermochemical extraction
- Chemical yield determination (pressure / composition)
- Ion trap MS for composition and yield of extracted chemicals
- Chemical reactors for evolved gas alteration (e.g. to remove isobaric interferences)
- Gas separation thermal manifolds for gas separation
- Reference standard gasses (allowing lab quality measurements)
- Accurate and precise isotopic measurements (Magnetic Sector MS)

PROSPECT: Sampling & Sample Analysis Package



HANDLING PLANETARY ICES

Kickoff: 18 March 2014
End date: 2nd half 2015

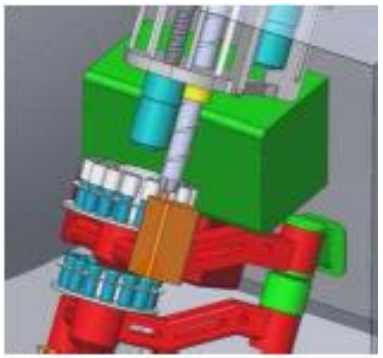
PRIME: **Selex-ES (I)**
Sub-cos: Open University (UK)
Airbus DS Ltd. (UK)

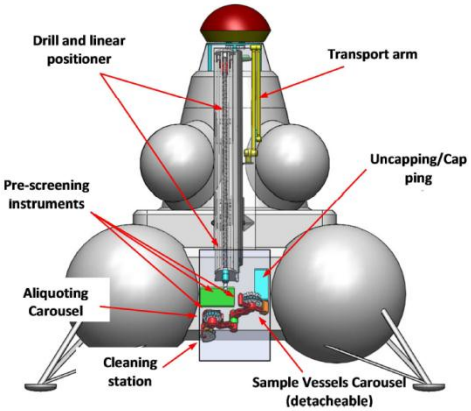
HERITAGE

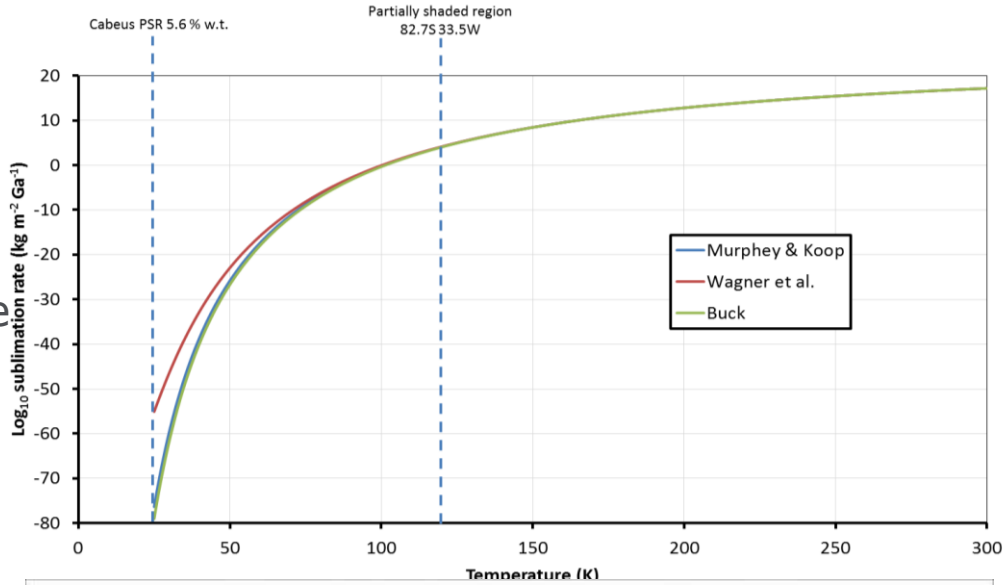
- Laboratory and modelling experience, Rosetta

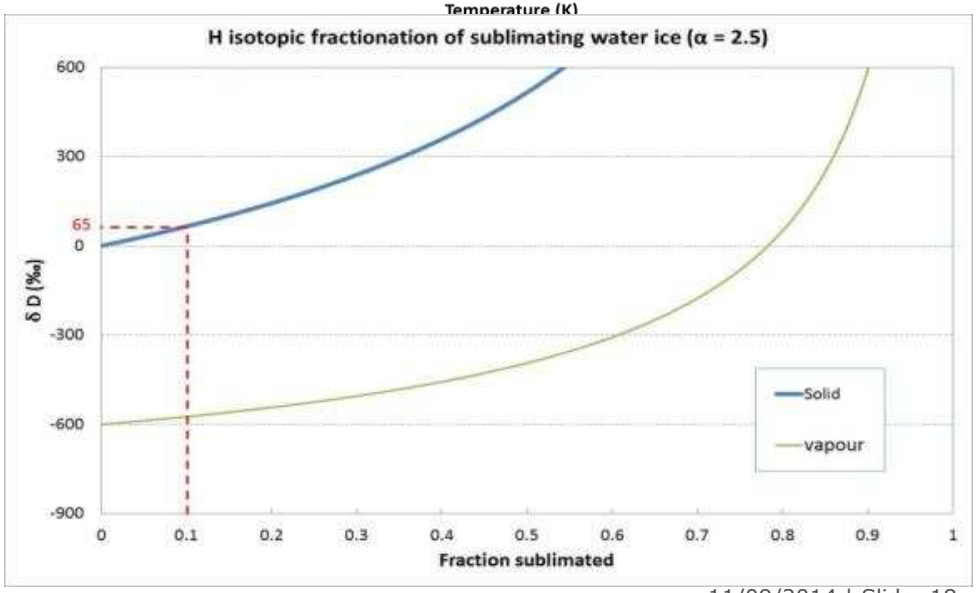
ACTIVITY FOCUS

- Understand the effects of temperature and handling of ice in vacuum and measurement implications.
- Apply this to develop sample handling concepts (in-situ & LPSR)
- Allow the application of models and lessons learned to hardware development







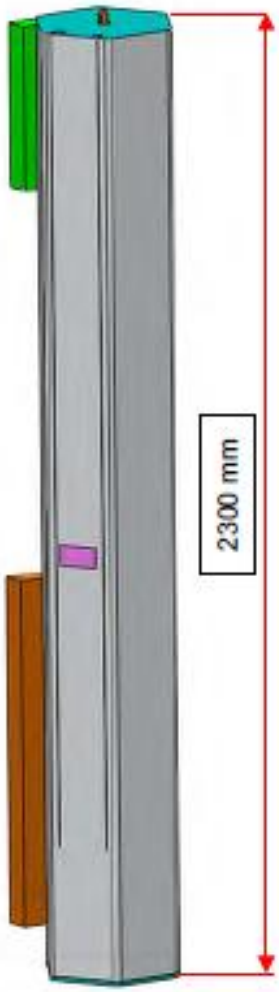


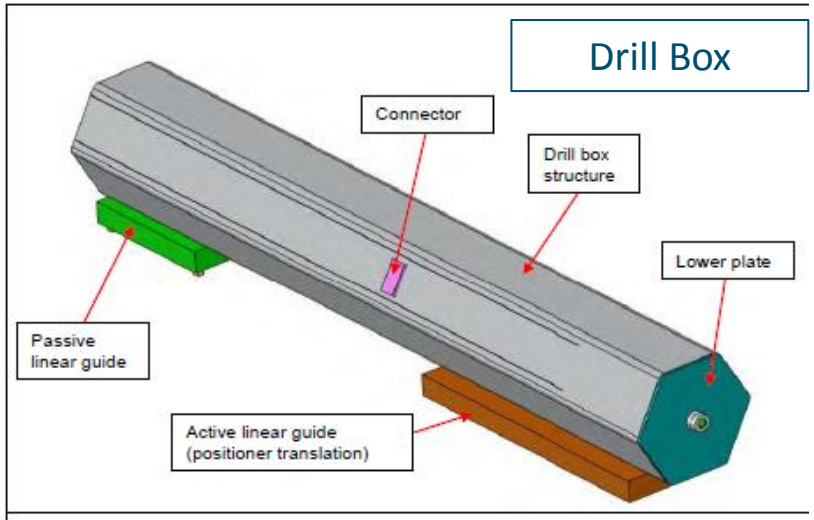
PROSPECT: Element breakdown for next steps

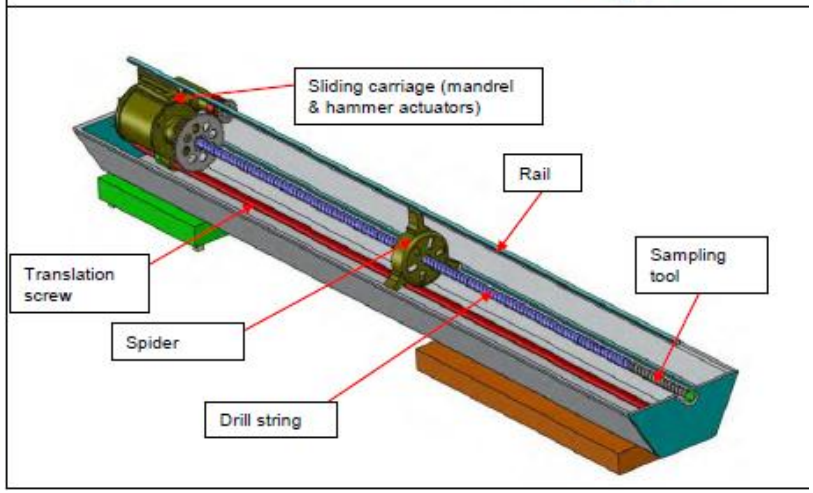
ProsEED: PROSPECT Excavation and Extraction Drill

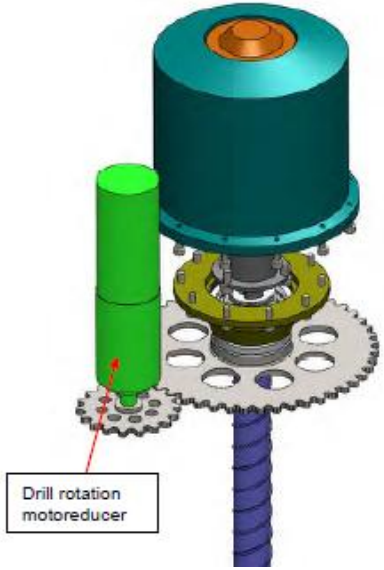
ProsPA: PROSPECT Processing and Analysis

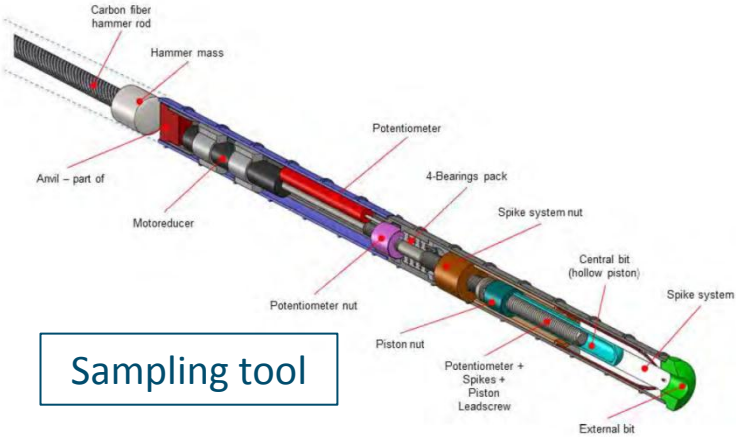
ProsEED: PROSPECT Excavation & Extraction Drill – *Current Architecture*



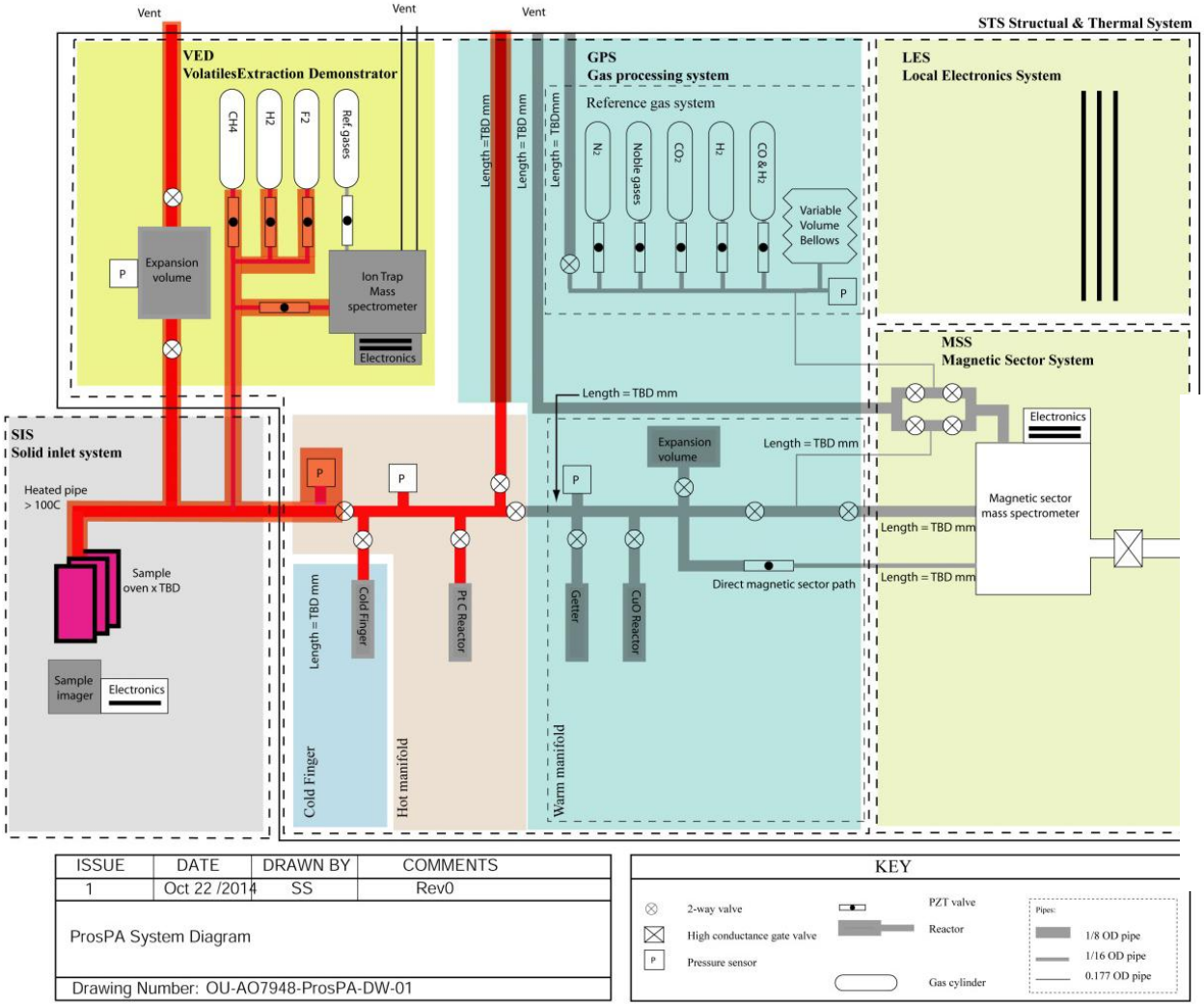


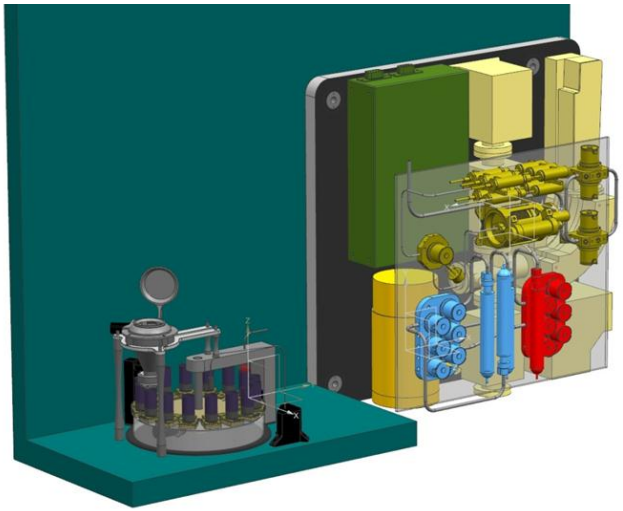






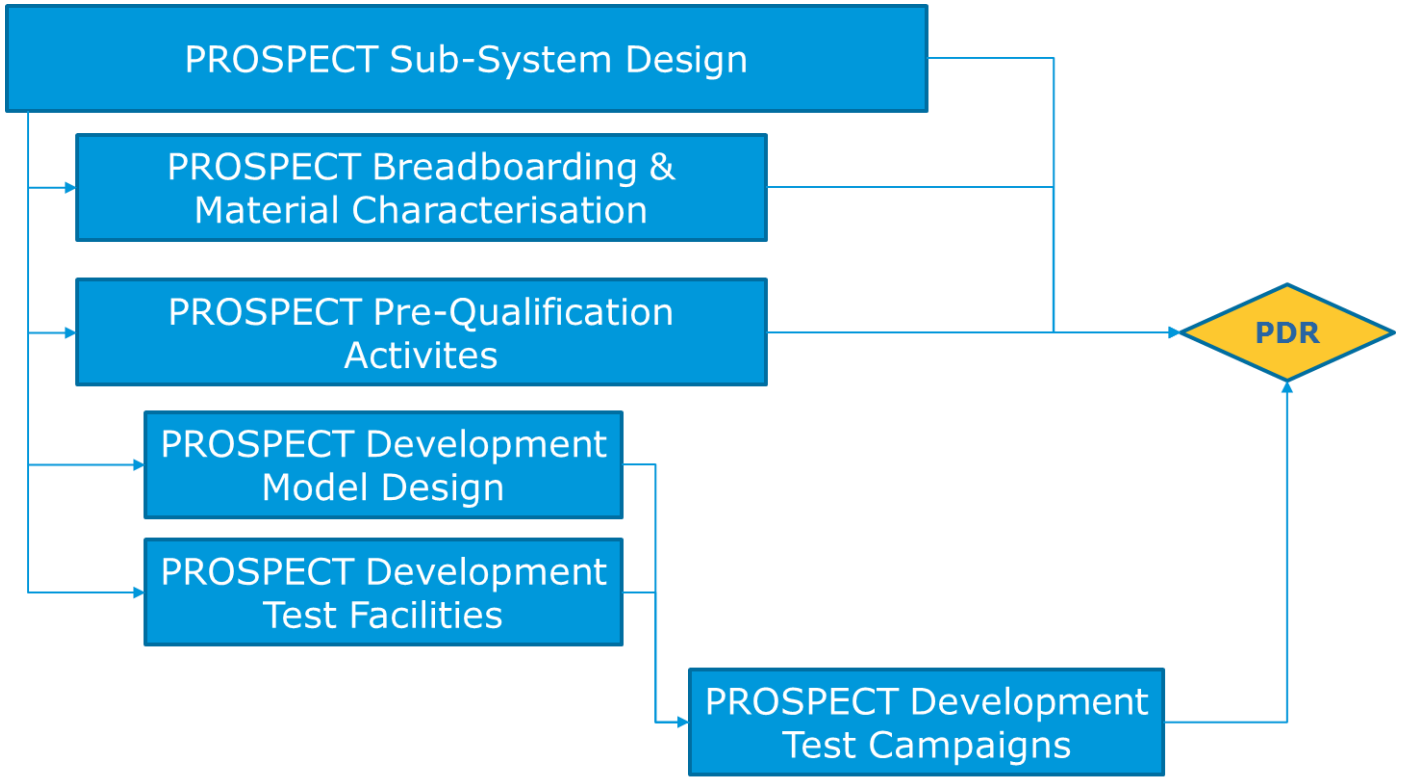
ProsPA: PROSPECT Processing and Analysis Package – *Current Architecture*





PROSPECT: Next Steps

- CMin2014: successfully integrated Lunar exploration activities, including PROSPECT development, within overall ISS programmatic framework as next step for exploration
- Pre-development/Phase A activities due to be completed by mid 2015
- Next step is Phase B+ to mature PROSPECT up to PDR (end 2016), with work starting in 4Q2015
- Following Phase C/D/E shall take PROSPECT up to flight and operations in 2020



Next Steps: Breadboarding, Material Characterisation & Pre-Qualification

Low-T Component Pre-Qual

Sample sealing

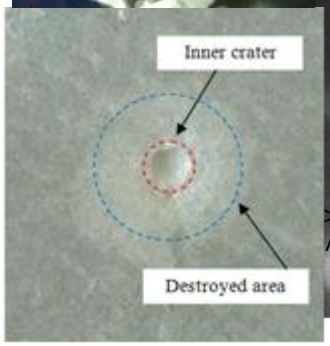
Material strength tests

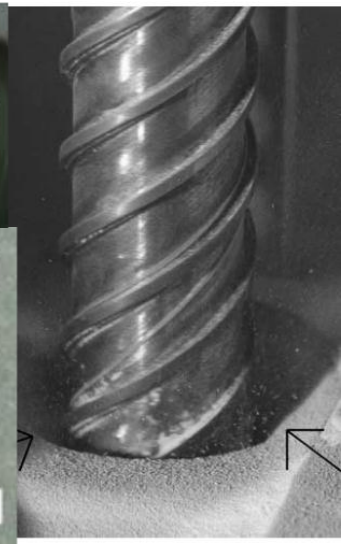
Volatile preser-vation

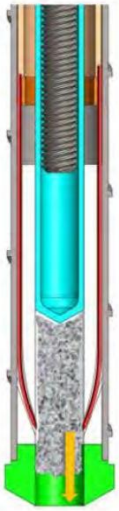
Thermo-chemical extraction

Drilling efficiency tests

Sample extraction tests



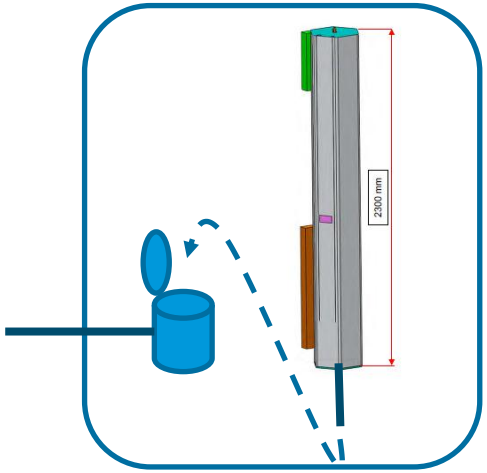


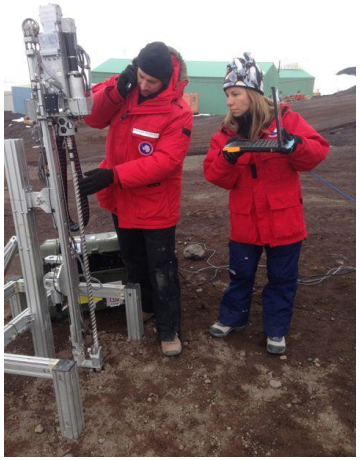


- Many activities have been initiated via Phase A/TRP
- Phase B will extend the use of existing HW, and where needed establish dedicated breadboard tests to address specific issues

Next Steps: Development Model(s) & Test Facilities

Instrument hardware and operational development	End-to-end requirements verification & validation in representative environment	Assessment of design robustness
ProsPA Functional Dev Model	ProsPA LAB DM (Front End) / DRILL LAB DM	DRILL FIELD DM
On the bench	*In the chamber*	*In the field*





ProsPA Func. DM test environment	PROSPECT LAB DM test chamber "Lunar Polar Simulator"	ProsEED Field Test Facility & Logistics

User Group

- A call will be released in the coming weeks for members of the PROSPECT User Group, which shall represent the future User community for PROSPECT
- User Group activities will include:
  - Review and update the PROSPECT science and other user objectives and requirements
  - Validate science and other user requirements and advise on verification approaches
  - Provide user support to Development Model test campaigns
  - Support the establishment of operational scenarios at the lunar surface
  - Represent a broad User Community for the data products that will be produced
- Users will include the scientific community, but also those preparing technologies for future missions

Conclusion

- European priority on specific exploration 'products' focuses resources on developing hardware and experience
- Russia represents our first partner for using these products, with complementary mission plans, objectives and capabilities
- Products can be considered for cooperation with multiple international partners
- PROSPECT
    - Builds on existing heritage
    - Provides Europe with a key lunar exploration capability
    - Answers fundamental exploration and scientific questions
- Development approach targets early HW testing
    - Providing test data for PDR
    - Creating foundation of expertise and facilities
    - Supporting involvement of product Users
- *INVITATION: to industries & institutes with relevant experience, facilities and/or interests in the PROSPECT product*