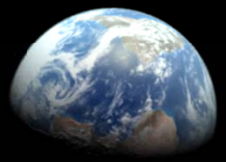
THE EUROPEAN ASTRONAUT CENTRE – AN OPERATIONAL ECOSYSTEM FOR FUTURE LUNAR EXPLORATION SCENARIOS



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14/12/2015

OVERVIEW

- Future challenges & EAC
- The ESA exploration roadmap
- Exploration focused ESA/EAC studies
- What is the aim of Spaceship EAC?
- Current projects
- Summary and outlook

ESA'S ASTRONAUT CENTRE

- Established in 1990
- Home base of ESA astronauts (*)
- Training Centre for ESA flight elements and payloads of the International Space Station
- Space Medicine Centre for astronaut medical support
- Training Centre for ground controllers

(*) since 1998 there are no European "national" astronauts anymore -> ESA Astronaut Corps

THE EAC TEAM

100 EXPERTS

ASTRONAUTS

MEDICAL OPERATIONS

CREW OPERATION TASKS

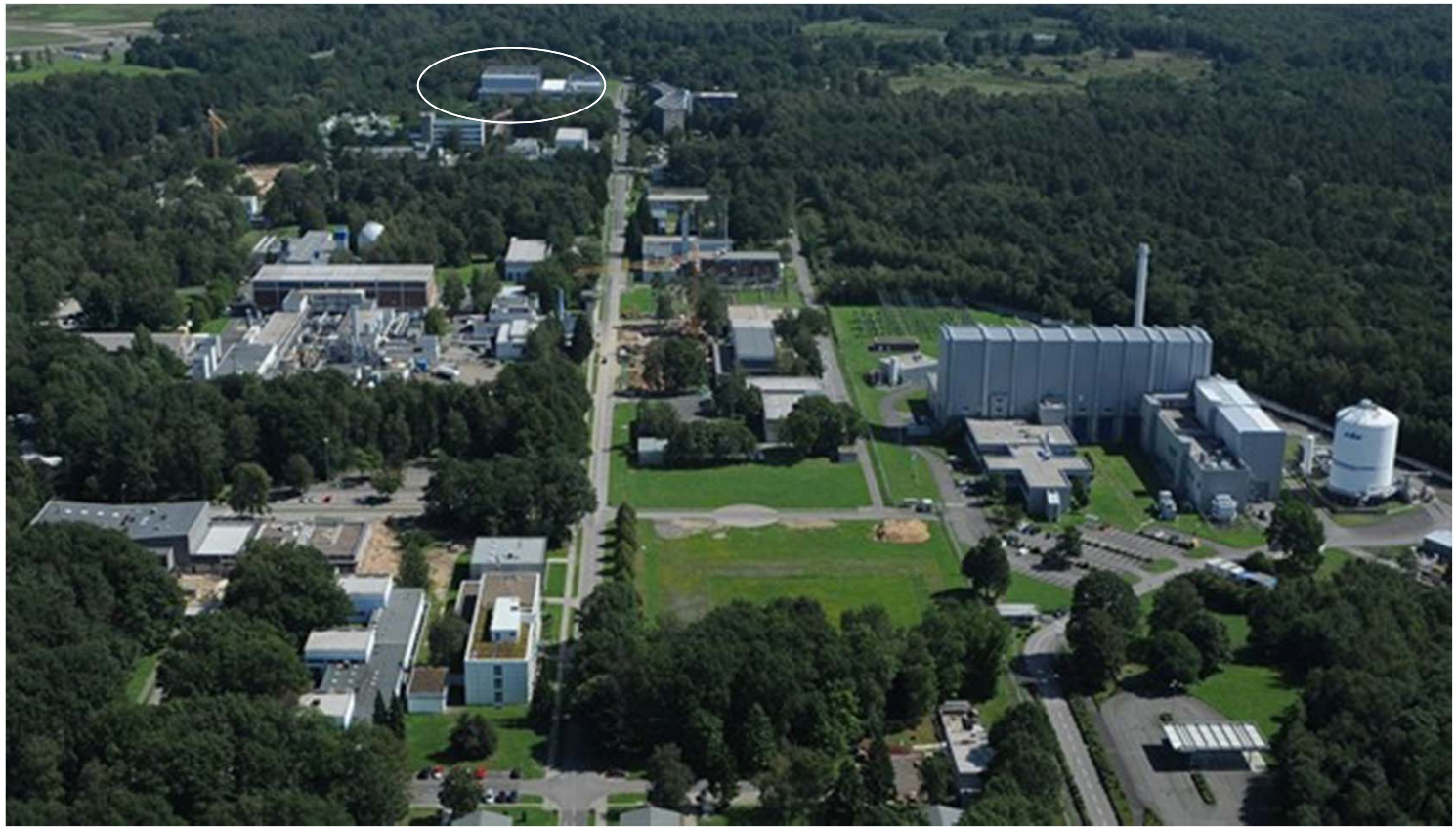
ASTRONAUT TRAINING

ASTRONAUT SUPPORT

PROCEDURE MANAGEMENT

PUBLIC RELATIONS & OUTREACH

LOCATION



FUTURE CHALLENGES

1. Future of space sector:

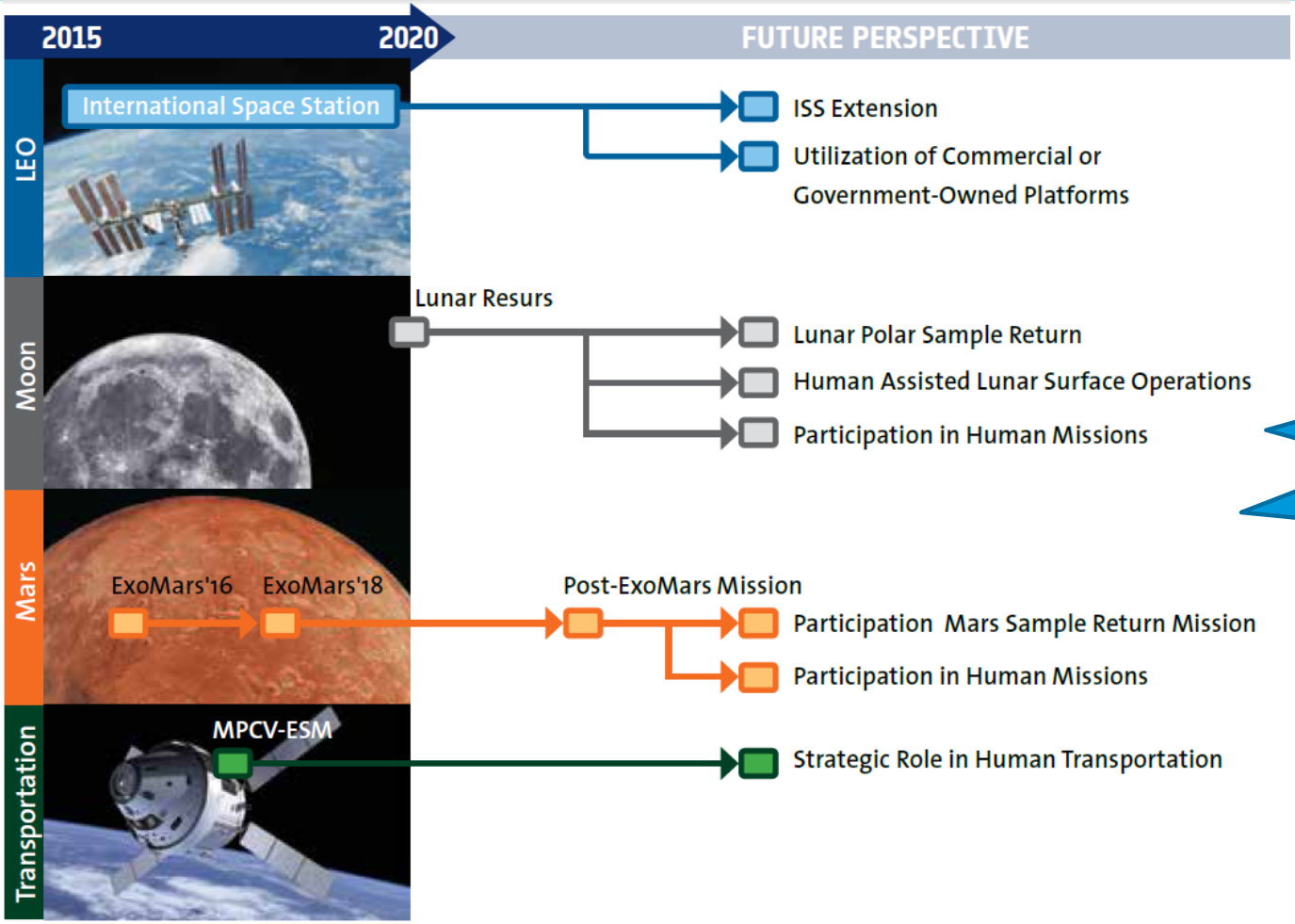
(ESA Agenda 2015)

“ESA shall provide solutions for future challenges of humanity: climate change, limited resources (water, food), global health, energy”

2. Evolution of European Astronaut Centre

with increased visibility and expertise in human spaceflight & exploration **ISS & beyond**

THE ESA EXPLORATION ROADMAP



New Technologies & Operations!

EVOLVING TO MEET EXPLORATION CHALLENGES

Human Spaceflight Exploration technologies to demonstrate:

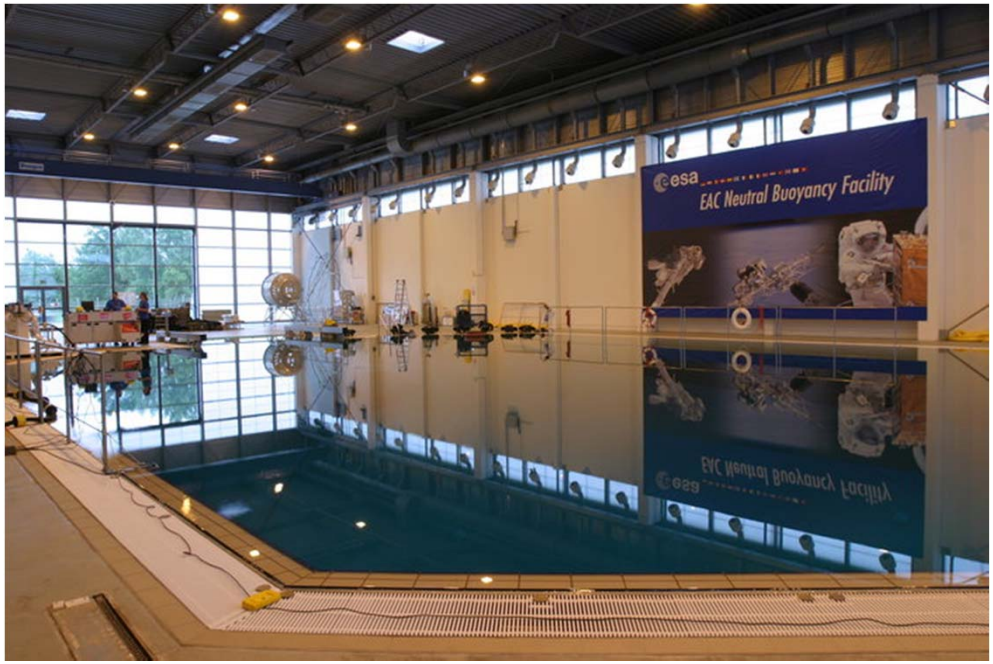
- Need for resource management and recycling
- Closed loop system (air, water, energy…)
- In Situ Resource Utilisation (new mission paradigm)
- Crew wellbeing (e.g. clean air, non toxic materials, quality food and water, space medicine, etc.)
- Operational know-how, procedures and protocols

→ Habitation Challenges

Human Spaceflight Exploration activities:

- Build capability at EAC
- Enhancing EAC capability as an Analogue location
- Spaceship EAC initiative

EXISTING ASSETS AT EAC



Neutral Buoyancy Facility (NBF)

Training hall and ISS mockups

EAC ACTIVITIES: GSP & GSTP STUDIES

GSP: "Analogues for preparing robotic and human exploration of the Moon – need and concepts"

- Aim: Identification of an analogue that could be located at EAC
  (based on needs, regarding existing analogues, benefitting from synergies within EAC and DLR campus)
  Status: KO: October 2014; FP: end 2015;

See talk on 'Analogues for preparing robotic and human exploration on the moon', Tom Hoppenbrouwers

GSP: "Use of NBF beyond ISS? NBF as tool to prepare EVAs during extra-terrestrial exploration missions"

- Aim: Development of a concept to use NBF for training/preparing EVA Operations within Extra-terrestrial Surface Explorations
  Status: KO: May 2015; FP in May 2016

EAC ACTIVITIES: GSP & GSTP STUDIES

GSTP: "Additive Manufacturing with Lunar Regolith" (run by DLR)

Aim: Investigates the feasibility of 3D printing by using directly the heat from the sun (on-site solar furnace). The intended first result is a brick-size model building block of a lunar base outer shell

- Status: KO: early 2015; FP: end 2017;
  See talk on 'Granular Matter in low and zero-g', M. Sperl, and poster by Alexandre Meurisse

GSP: "Research & Development of Astronaut Aptitude and Performance Testing for Manual Robotics & Docking Skills (APT)" study

- Aim: The objectives of this study focuses on R&D of aptitude testing for astronaut selection. Specific emphasis is placed on manual robotics and docking operations.
  Status: KO: March 2015; FP: March 2016;

WHAT IS THE AIM OF SPACESHIP EAC ?

"foster EXPLORATION activities in ESA"

- EAC involvement in triggering **R&D** of new HSF **technologies** will accelerate exploration and improve quality of results.
- virtual lunar base / lunar analogue will be inspiring for researchers, mission planners and astronauts

"OPERATE: Showcase & technology incubation platform"

- EAC as **operational test bed** for future technologies (space and earth applications); Demonstrate processes or technology at a **low TRL**

"support exploration relevant RESEARCH"

- Support science department in **Networking** with external researchers across EU to bridge the gap between research and operations;

"INSPIRE"

- Inspire students by offering **internships** in EAC and networking with universities; inspire the public by active **outreach**;
- Inspire ESA / agencies by **networking**

SPACESHIP EAC SCOPE

Cross disciplinary scope:

- Building operational knowledge across these domains
- Want to drive activity in these areas as relevant to human spaceflight
- EAC can act as a demonstration platform for these technologies

SPACESHIP EAC PROJECT AREAS OVERVIEW

Energy

- Lunar based Fuel Cell system, system level simulation (Polytechnic Turin)
- Thermal energy storage / energy creation using ISRU/Lunar Regolith
- ISRU produced Flywheel for energy storage
- Other energy storage concepts with ISRU

ISRU, Materials & Additive Manufacturing (3D printing)

- Behaviour of Regolith material (DLR)
- Processing & sintering of lunar Regolith (via solar, microwave or laser)
- Application of AM to on-orbit activities (tools, spare parts, medical)
- AM combined with ISRU (e.g. solar furnace @ DLR)

Water

- Hydroponics (DLR)

PROJECT AREAS OVERVIEW

Simulation

- Develop a virtual lunar base, simulating different aspects of its metabolism (initial focus on energy – collaboration with ESOC)
- Develop virtual lunar EVA's for robotic / human mission planners, scientists and outreach

Architecture/Habitability

- Iterate on baseline 'habitat' concepts for modelling activities (such as the thermal study, construction concepts, etc)
- Lunar dust mitigation research

SPACESHIP EAC – PROJECTS, NETWORKING AND OUTREACH ACTIVITIES

Aidan Cowley (Research Fellow)

Samantha Cristoforetti (Astronaut)

Leo Teeney (YGT)

Matthias Maurer (Head of EAC management)

Brainforce: Internships at EAC

EEIGM, France: 7 x Internship Positions

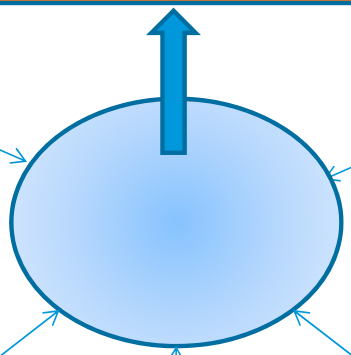
Heriot Watt, Edinburgh:
Input to Final Year Projects, M.Sc. Projects

University College Dublin, Ireland: 1 x

Haute Ecole Libre Mosane, Belgium: 1 x

ISU Strasbourg, France: 2 x Space master

Feed-in to Spaceship EAC



Universities & external experts:
- Politechnico di Torino, Italy
- Open University, UK (Lunar research)
- Aachen University (AM)

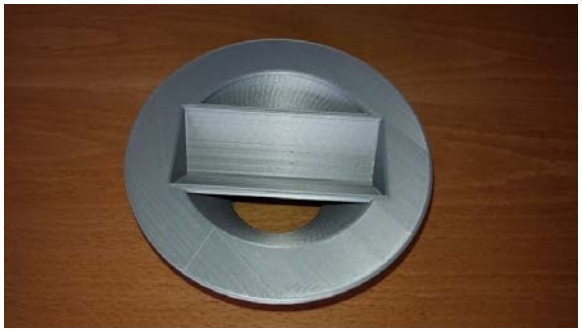
Network

ESA:
- Input & coordination with ESTEC (HSO: lunar exploration, TEC: additive manufacturing, power systems, etc)

DLR:
- Sintered Regolith for construction using solar furnace *(GSTP programme)*
- *Sintered Regolith for Lunar Habitat (*
- Hydroponics & ISRU Water Purification Project *(started)*
- Dust mitigation
- Thermoelectrics
- Combination of AM & ISRU

3D PRINTING – AN EXPLORATION ENABLING TECHNOLOGY

Objective: „made in space“ – expertise for EAC

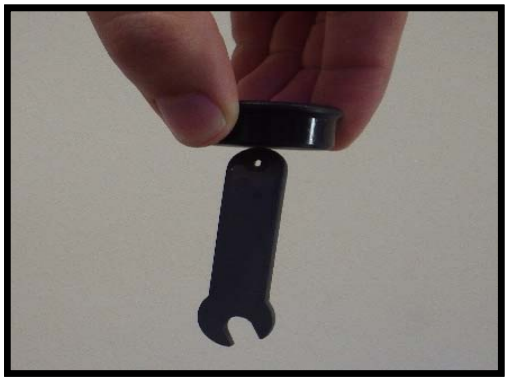


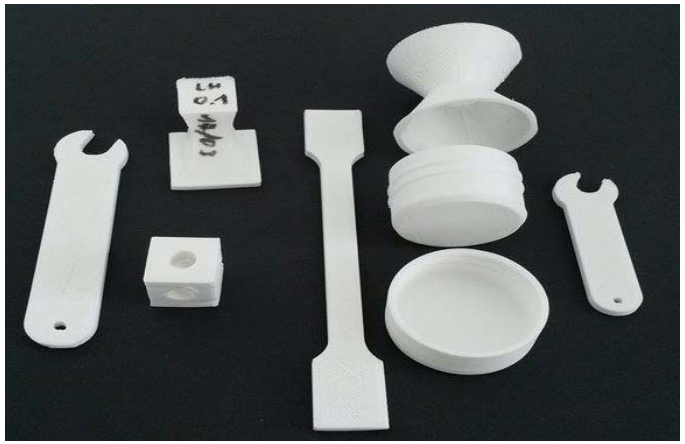
Process:

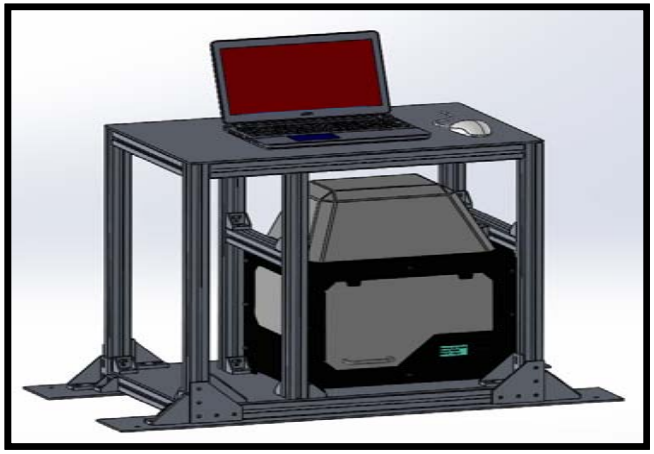
AM of tools, structures, mechanical test specimen, ISS Components

Materials:

Magnetic iron PLA, CNT ABS: Conductive filament, Stainless steel PLA







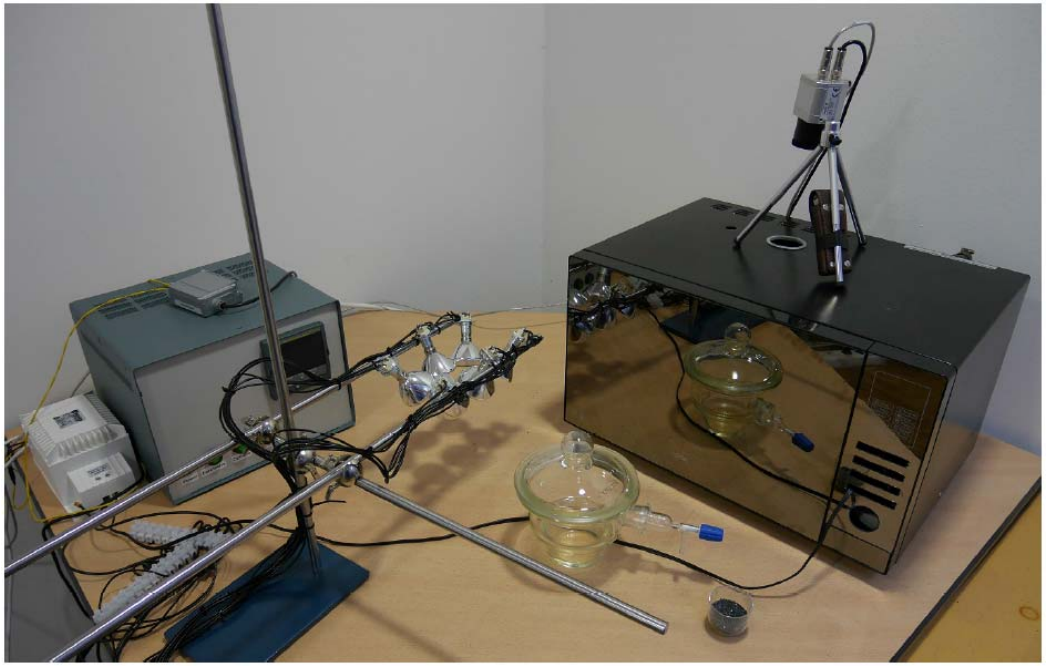
SPACESHIP EAC: HYDROPONICS EXPERIMENT WITH DLR

Objective: Water regeneration

- scientific experiment (with research outputs) and demonstrator as part of Spaceship EAC
- PI: Dr. Jens Hauslage (DLR)
- Commission and run in 2015

EXAMPLE PROJECT - MICROWAVE SINTERING OF REGOLITH

- Commercial off-the-shelf kitchen microwave model "LOGIK L25MDM14". The nominal microwave output power is 850 - 900 watts
- Control electronics have been replaced by an external Eurotherm 3504 PID-Controller
- Infrared camera model "Optris PI 1M“ mounted on top access port
- 6 x IR lamps provide preheating of samples
- MW Mode-stirrer also modified into MW cavity

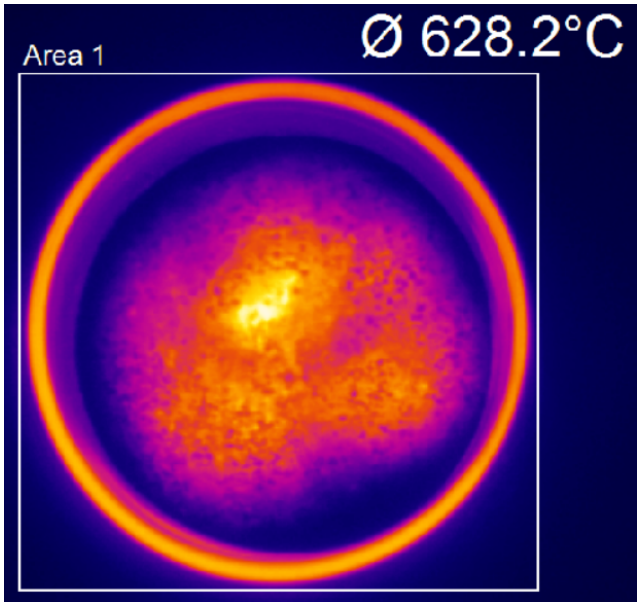


MICROWAVE SINTERING – BLIND HEATING

- Microwave (900w), regolith JSC-1a mixed with 10% wt Illmenite powder, 200 seconds
- Crucibles are pre-heated by IR lamps prior to MW exposure

(a) Sample in the oven

(b) Sample as it left the oven



- We observed significantly faster sintering of samples where Ilmenite powder was mixed
- Same test with no Ilmenite resulted in no sintering after 9 minutes
- Good agreement with our COMSOL simulations, both with and without preheating
- At present, with weak control, only achieving melted samples (thermal runaway)

SUMMARY & OUTLOOK

1. EAC is adapting to help address future exploration challenges

Spaceship EAC is one activity in this area

1. Evolution of European Astronaut Centre

with increased visibility, leveraging our expertise in human spaceflight

Aiming to build a network of experts that can work together on implementing exploration relevant systems and procedures

2. EAC wants to engage with actors in these areas!

Networking within ESA and without is one of our objectives


THANK YOU
European Space Agency