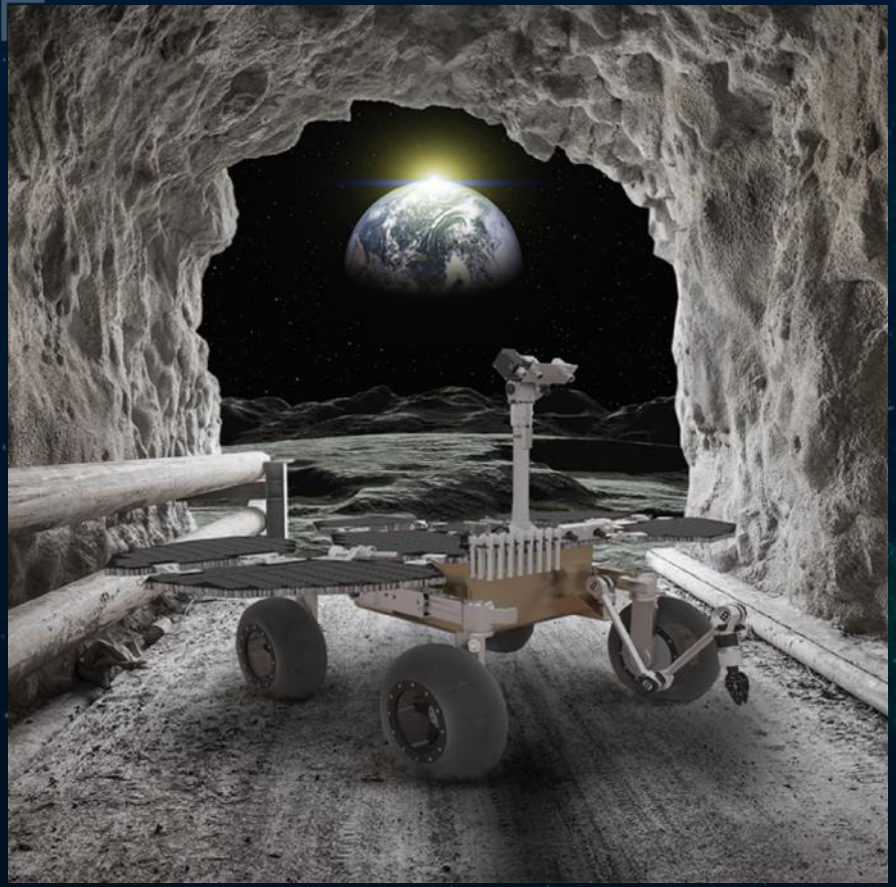


esa space solutions

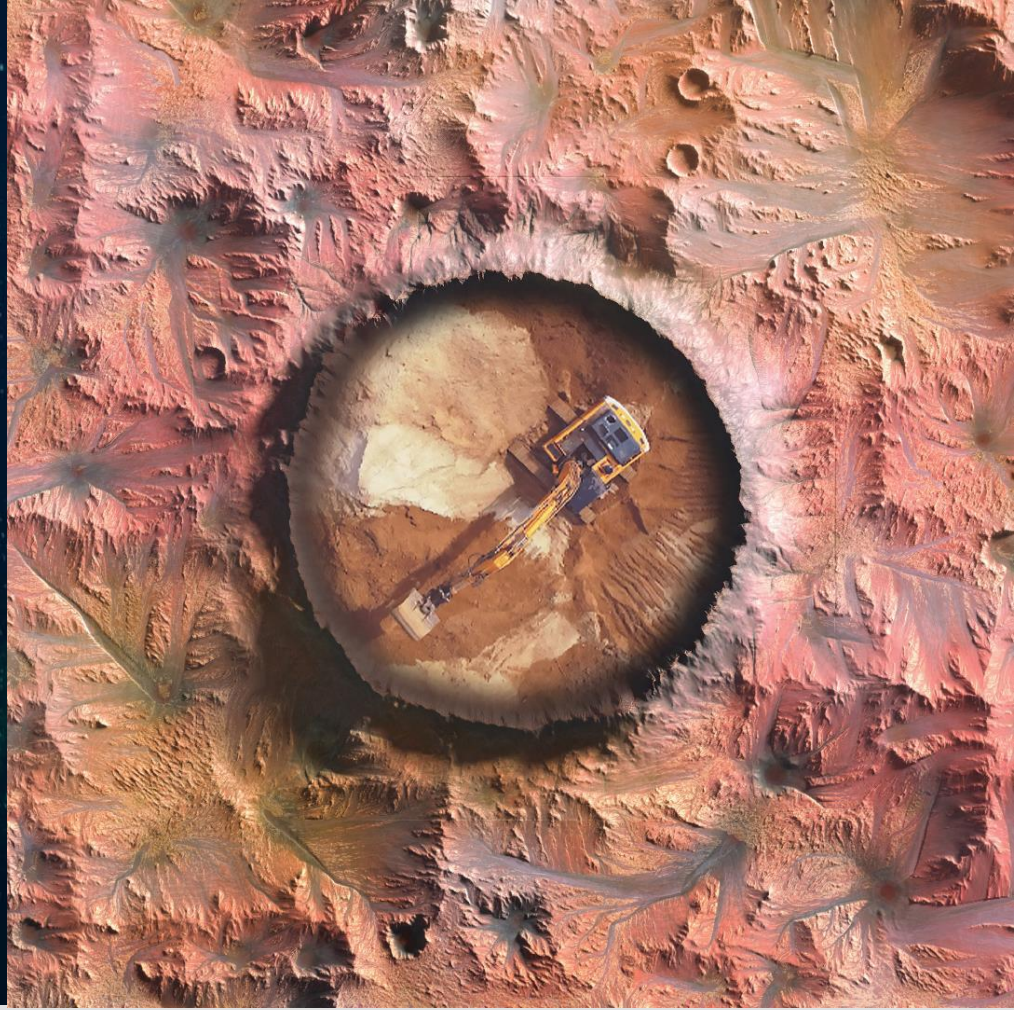
SPACE RESOURCES WEBINAR

Christian.Walter@esa.int Liz.Barrow@esa.int

Welcome to the Webinar!

Before we start...

- Please keep your microphones muted during the webinar and make sure your webcam is switched off.
- You can use the conversation function anytime to submit your questions. They will be addressed during the Q&A at the end of the webinar



Agenda

ESA Welcome and Introduction

About ESA's Space Resources Competition

Mining in Space by Guest Speaker Gavin Gillet, Rio Tinto

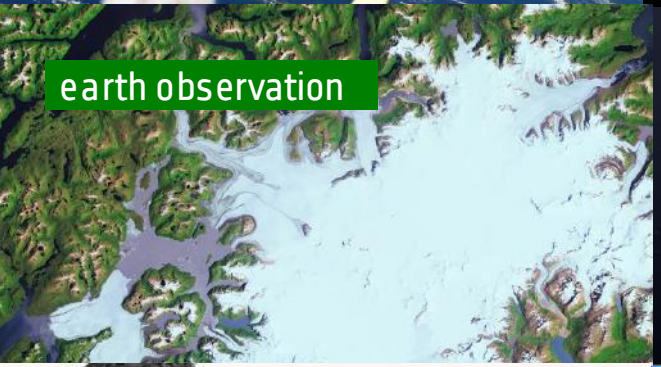
How to Apply to the Space Resources Competition

Q&A Session


space transportation


science


human spaceflight


earth observation

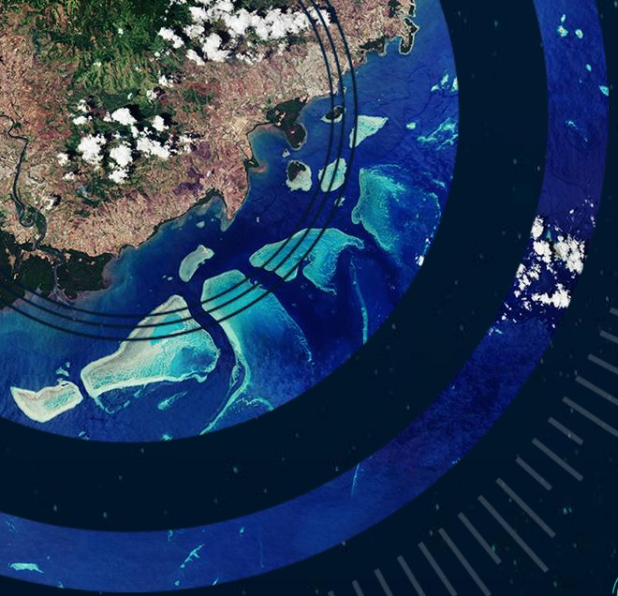

telecommunications
and applications


navigation


exploration


operations


technology



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MARITIME

HEALTHCARE

TRANSPORT

ENVIRONMENT

AGRICULTURE

MEDIA

ENERGY

EDUCATION

AVIATION

FINANCIAL

SPACE WEATHER

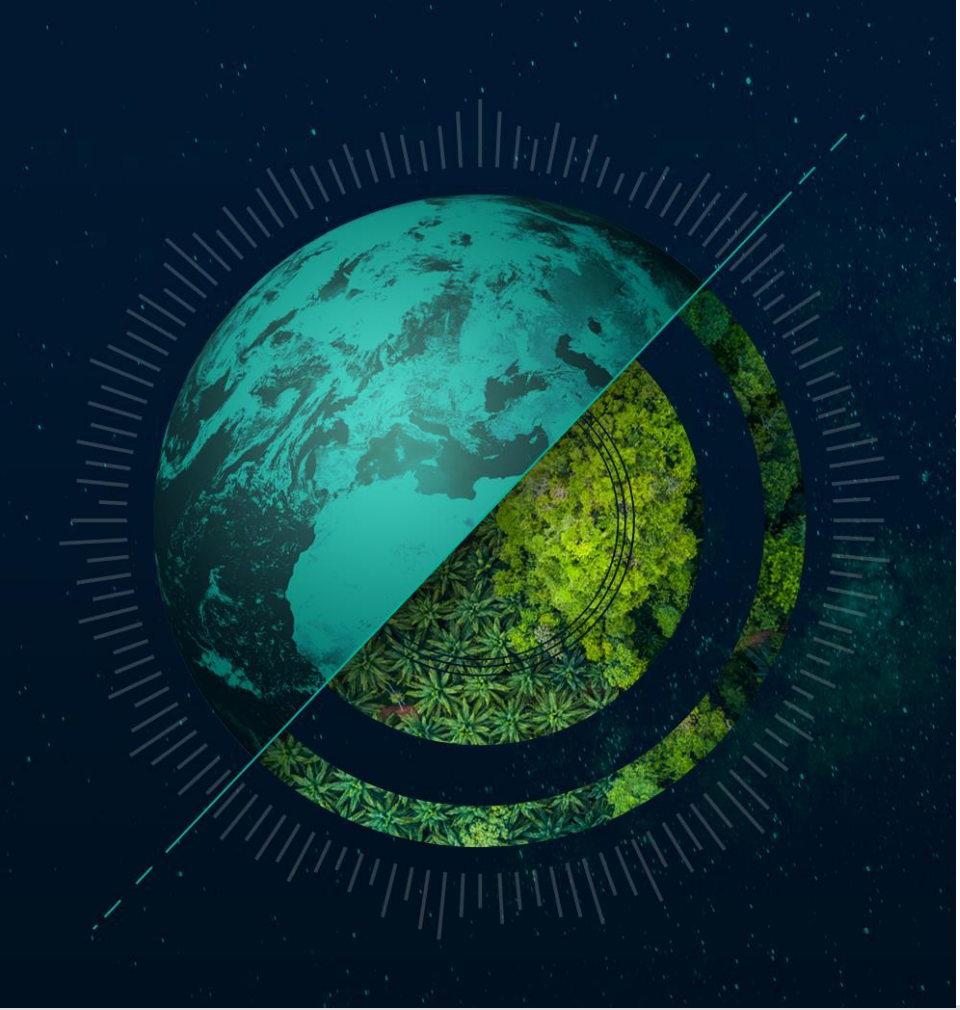
EARTH OBSERVATION

SATELLITE NAVIGATION

SATELLITE COMMUNICATION

HUMAN SPACEFLIGHT TECHNOLOGIES

Supporting the Development of Products and Services on Earth that Involve Space



ESA SPACE SOLUTIONS

- Zero-equity funding (from €50k to €2M+ per activity)
- A personalised ESA consultant
- Technical support and commercial guidance
- Tailored project management support
- Access to our international network of ESA and partners
- Access to our network of investors
- Credibility of the ESA brand

SPACE RESOURCES
ESA Competition for Studies

ESA Space Solutions is supporting the development of products and services that are relevant to industries on Earth today but have potential for future application in space

Background

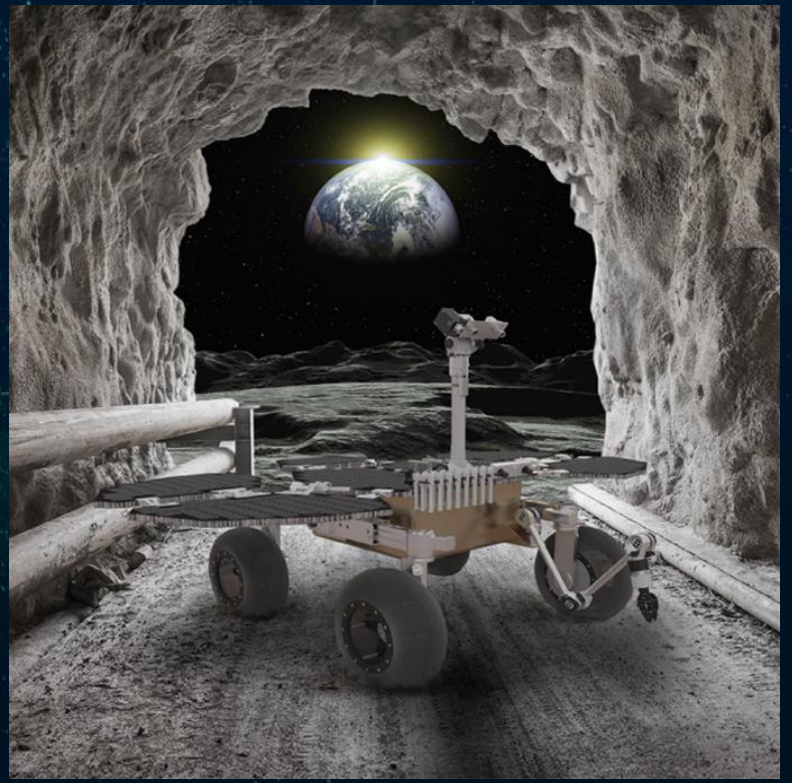
- The future of space exploration depends on humanity's ability to extract resources in space.

...But why is this relevant to sectors on Earth?

- In-situ resources utilisation (ISRU) is a futuristic concept, but it has great potential for creating new opportunities on Earth.

- It can encourage development of technologies that improve sustainability, tackle resource scarcity, and address the Sustainable Development Goals on Earth.

About The ESA Space Resources Competition



- Successful Teams will receive funding an support to run a year-long study
- The aim of the study is to assess the technical feasibility and commercial viability of a product or service that can be applied on Earth today and is relevant to future operations in Space. The product or service must meet the needs of paying customers and other relevant stakeholders.

..... So, which topics are relevant to Earth today and Space resources in the future?

1. Reducing water usage in mining operations
2. Effective Energy generation and storage
3. Remote and autonomous operations
4. Agile and precise mining operations
5. 3D printing, additive manufacturing and other specialised services

Relevant Topics to Consider

#1 Reducing the Use of Water in Mining

On Earth

- Mining operations typically use considerable amounts of water.
- This can create tensions with local communities, cause pollution to local water bodies, and reduce levels of ground water.
- Reducing water usage is a key sustainability challenge for mining operations around the globe

Relevant Topics to Consider

#1 Reducing the Use of Water in Mining

In Space

- Reducing water usage is also a key challenge for future ISRU
- Water is a highly sought-after resource in space but is not easy to access.
- Space mining equipment cannot be reliant on large amounts of water.

Relevant Topics to Consider

#2 Energy Generation and Storage

On Earth

- Mining operations have high energy demands but often take place in remote locations, where it is expensive to connect to power grids.
- Solar energy could offer mining companies a more attractive and sustainable method of generating power.
- However, major challenges still exist for renewable energy at off-grid mines e.g. unstable energy generation of PV plants.

Relevant Topics to Consider

#2 Energy Generation and Storage

In Space

- Mining machinery in space will likely be solar powered, to reduce the need for fuel that would have to be hauled into space.
- Future solar arrays should be manoeuvrable, efficient, light and robust.
- Ideally, future solar panels could be manufactured in space using safe, readily available in-situ materials.

Relevant Topics to Consider

#3 Remote and Autonomous Operations

On Earth

- Remote operations involve monitoring and controlling equipment over considerable distances, often in high-risk environments.
- Autonomous operations can help to make systems safer, more efficient and reliable, and more cost-effective.
- Challenges with automation and remote operations do exist e.g. inability to react to changing scenarios in time.

Relevant Topics to Consider

#3 Remote and Autonomous Operations

In Space

- Autonomous off-Earth mining systems requiring limited human oversight would be instrumental for advancing space mining.
- Exploration and initial sampling in space will likely be carried out by autonomous robots.
- Autonomous equipment would face additional challenges in Space e.g. radiation

Relevant Topics to Consider

#4 Agile and Precise Mining Operations

On Earth

- Mining often involves large machinery, which can be inefficient and wasteful, disrupting the surrounding environment.
- The mining sector intends to change this with low footprint, precision mining, supported by intelligence in mapping, remote sensing and tracking.
- The future of mining could rely on swarms of small, agile mining machines capable of autonomously detecting and extracting the pure deposit.

Relevant Topics to Consider

#4 Agile and Precise Mining Operations

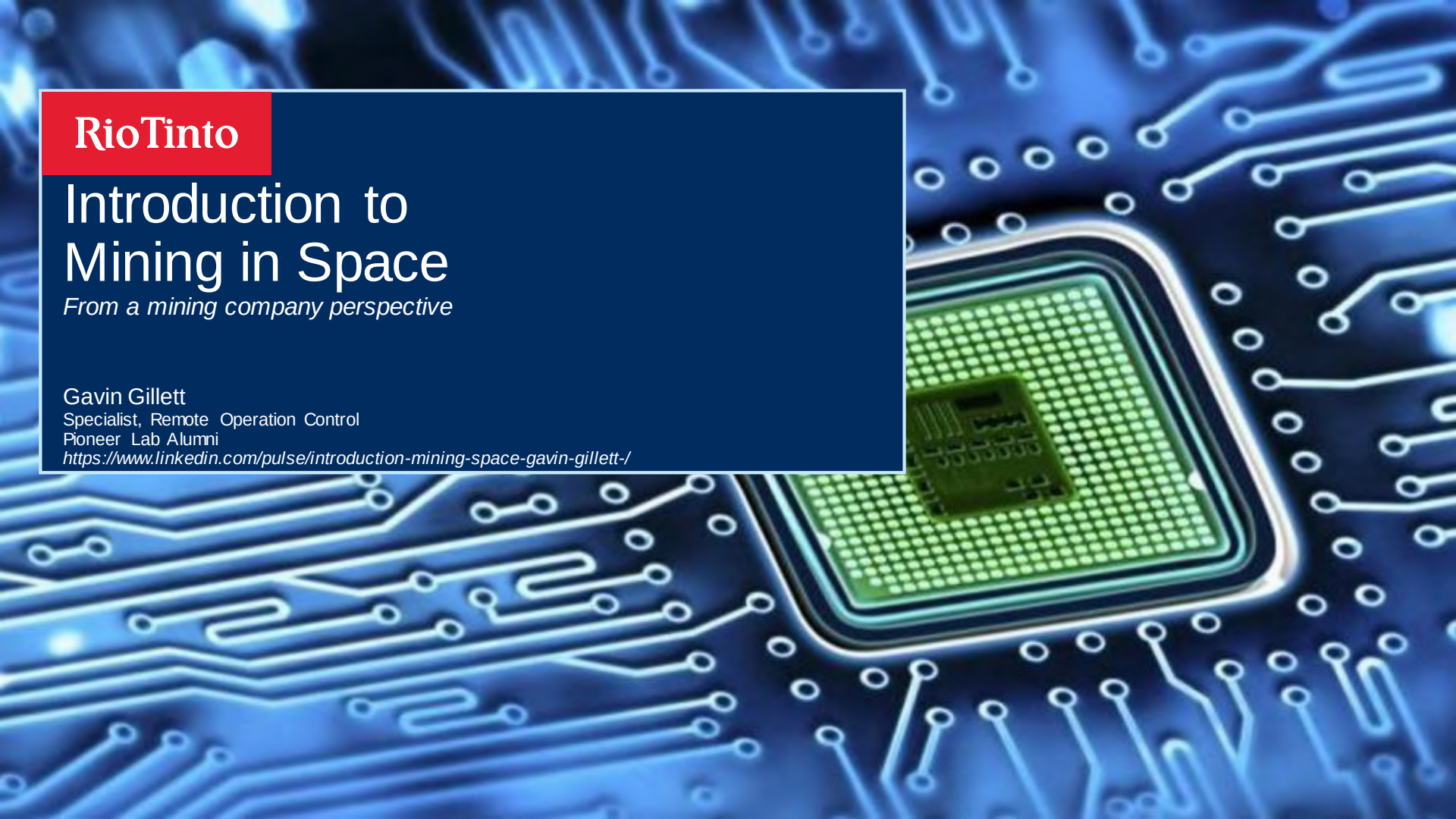
In Space

- High launch costs make transporting large and heavy fleets of equipment into space practically impossible.
- Light, robust equipment capable of operating in the unique space environment are needed e.g. equipment capable of capturing valuable material in spite of low gravity.
- Innovative drilling, mining, tunnelling and water extraction systems developed on Earth could be modified for use in Space.

Relevant Topics to Consider

#5 3D Printing, Additive Manufacturing and Other Specialised Services

- 3D printing could transform manufacturing on Earth and the future of space resources.
- 3D printing could lead to sustainability in space, as it would eliminate the need for equipment to be built and launched from Earth, thereby reducing costs and risks.
- Standardised interfaces, compact instruments, or self-cleaning and dust-proof equipment would be beneficial to mining operations on Earth and in Space.



RioTinto

Introduction to Mining in Space

From a mining company perspective

Gavin Gillett
Specialist, Remote Operation Control
Pioneer Lab Alumni
https://www.linkedin.com/pulse/introduction-mining-space-gavin-gillett-/


06D63

Standard normal distribution

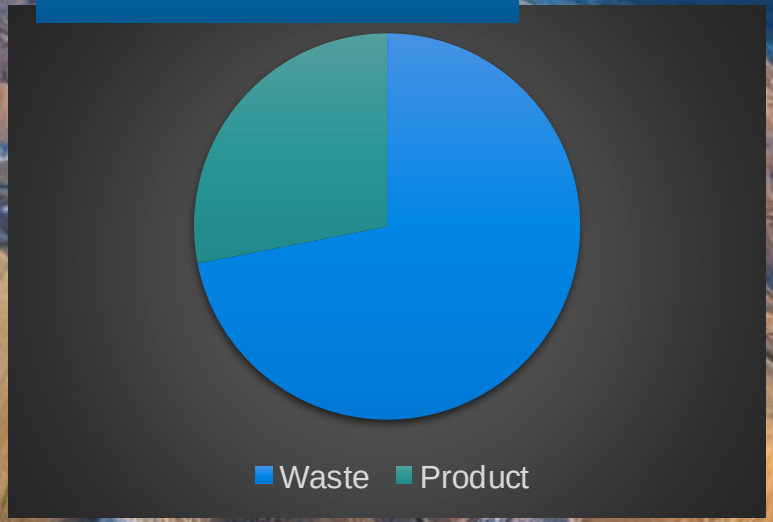
Probability density

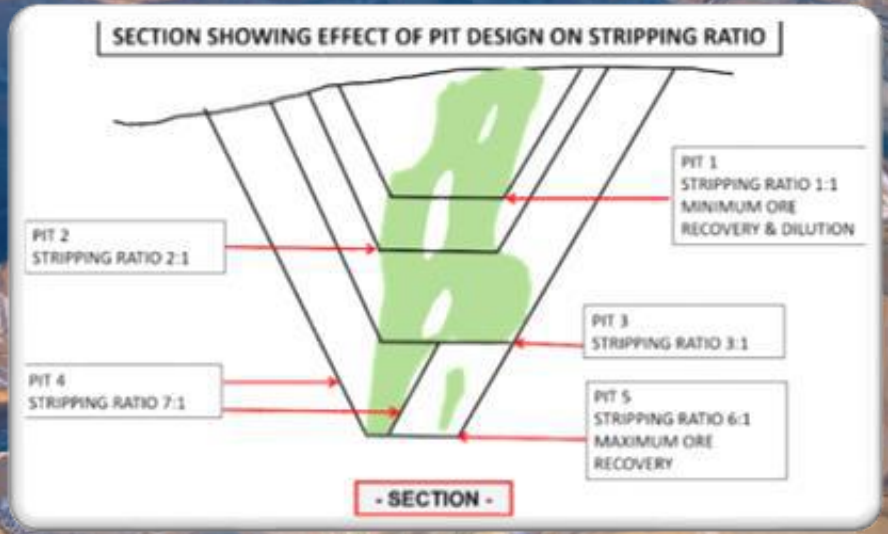
0.4
0.3
0.2
0.1
0.0

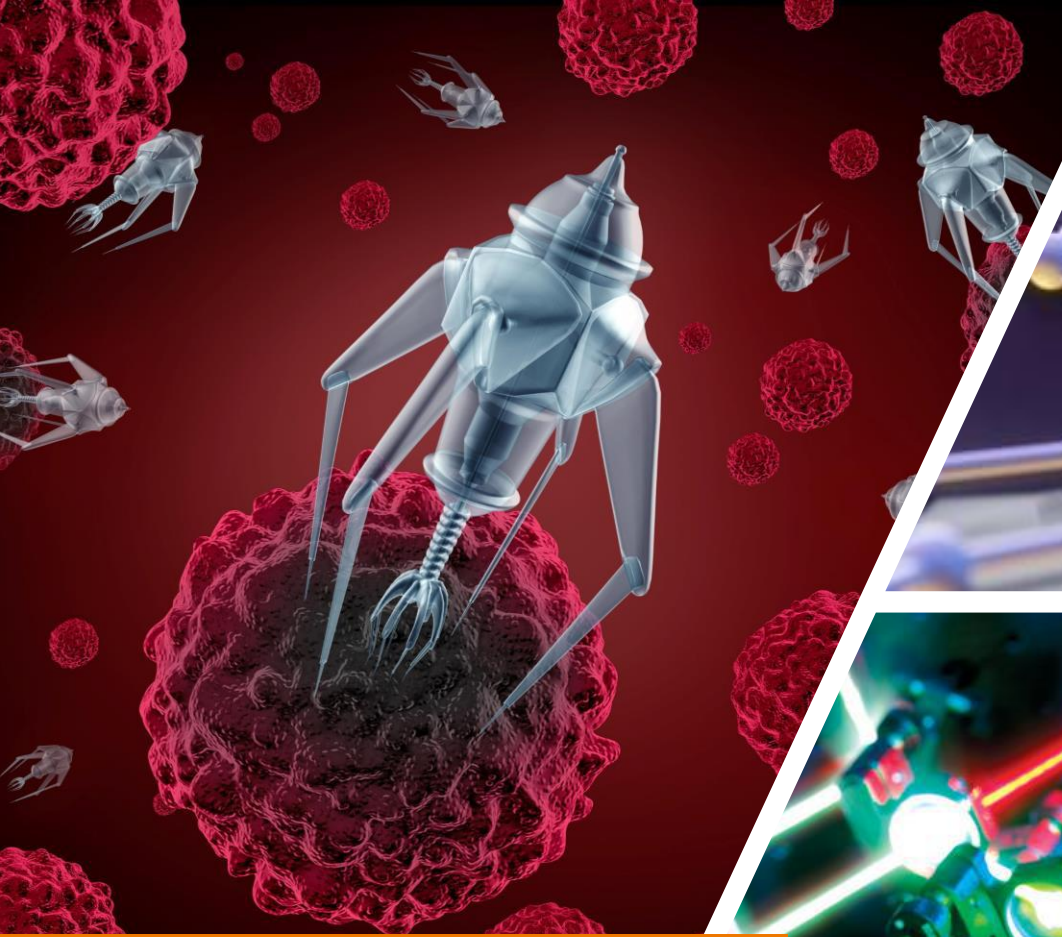
-3 -2 -1 0 1 2 3

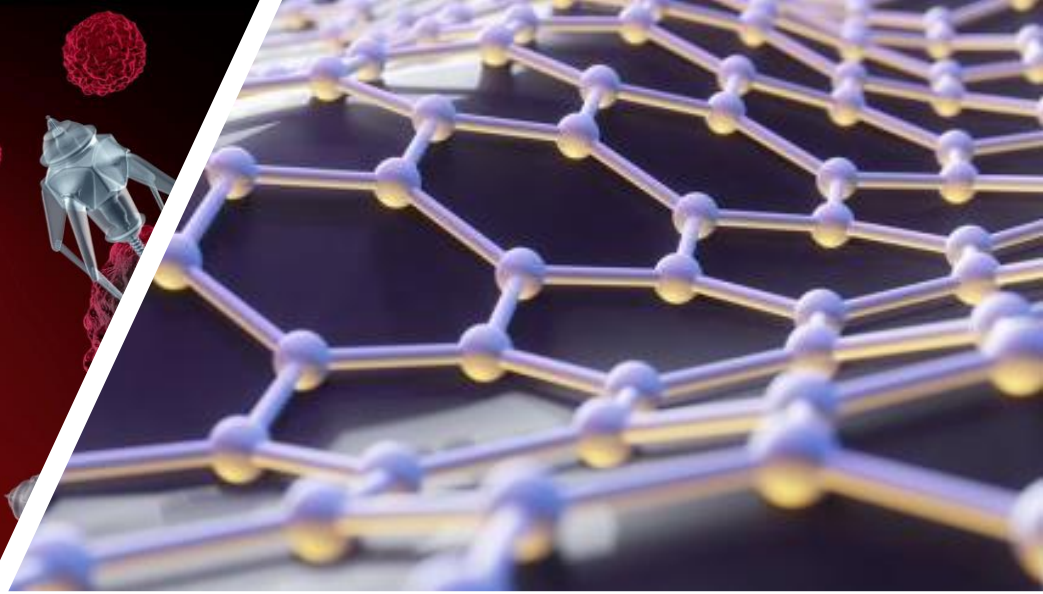
z-score

Tackling the WASTE

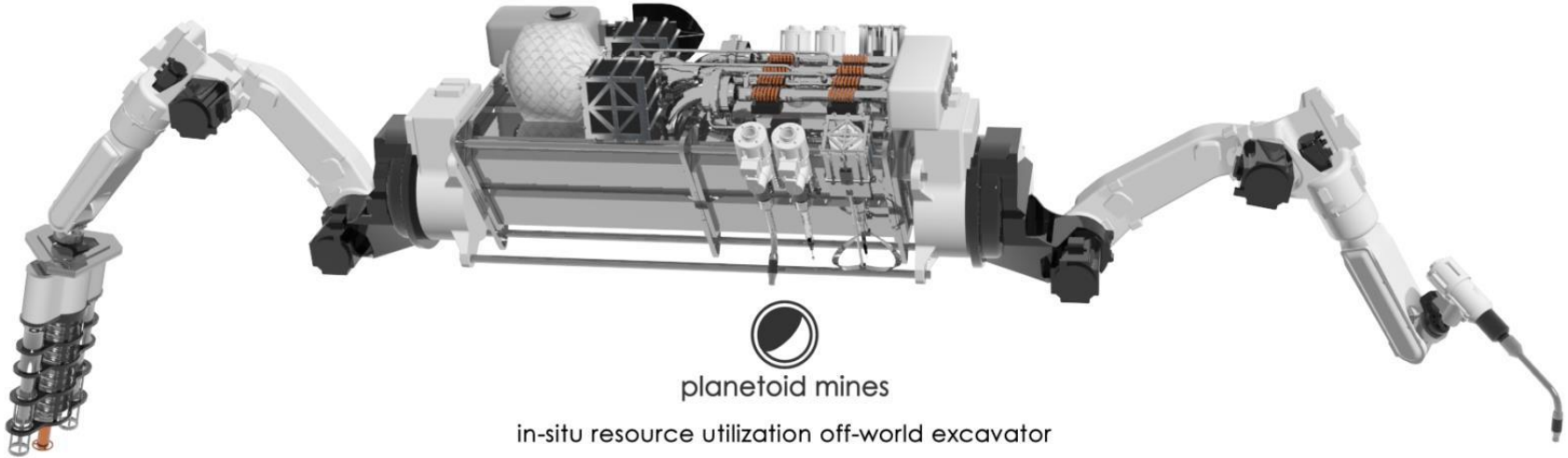








Perfect Mining?



planetoid mines

in-situ resource utilization off-world excavator

Six Core Areas of RT4.0 Development

RT4.0 leverages digital and physical technology to enhance safety and business value

Automation & Robotics

- Autonomous equipment
- Process automation
- Additive manufacturing

Big Data & Analytics

- Analysis and optimisation
- Predictive and prescriptive models
- Artificial intelligence

Digital Enablers

- Data capture and management
- IT infrastructure and architecture
- People and processes

Augmented Workforce

- Remotely operated vehicles
- Wearables and work aids
- Virtual and augmented reality

Integration & Platforms

- Integrated and remote operations
- Virtual integrated value chains
- Platform interactions

Environment & Social

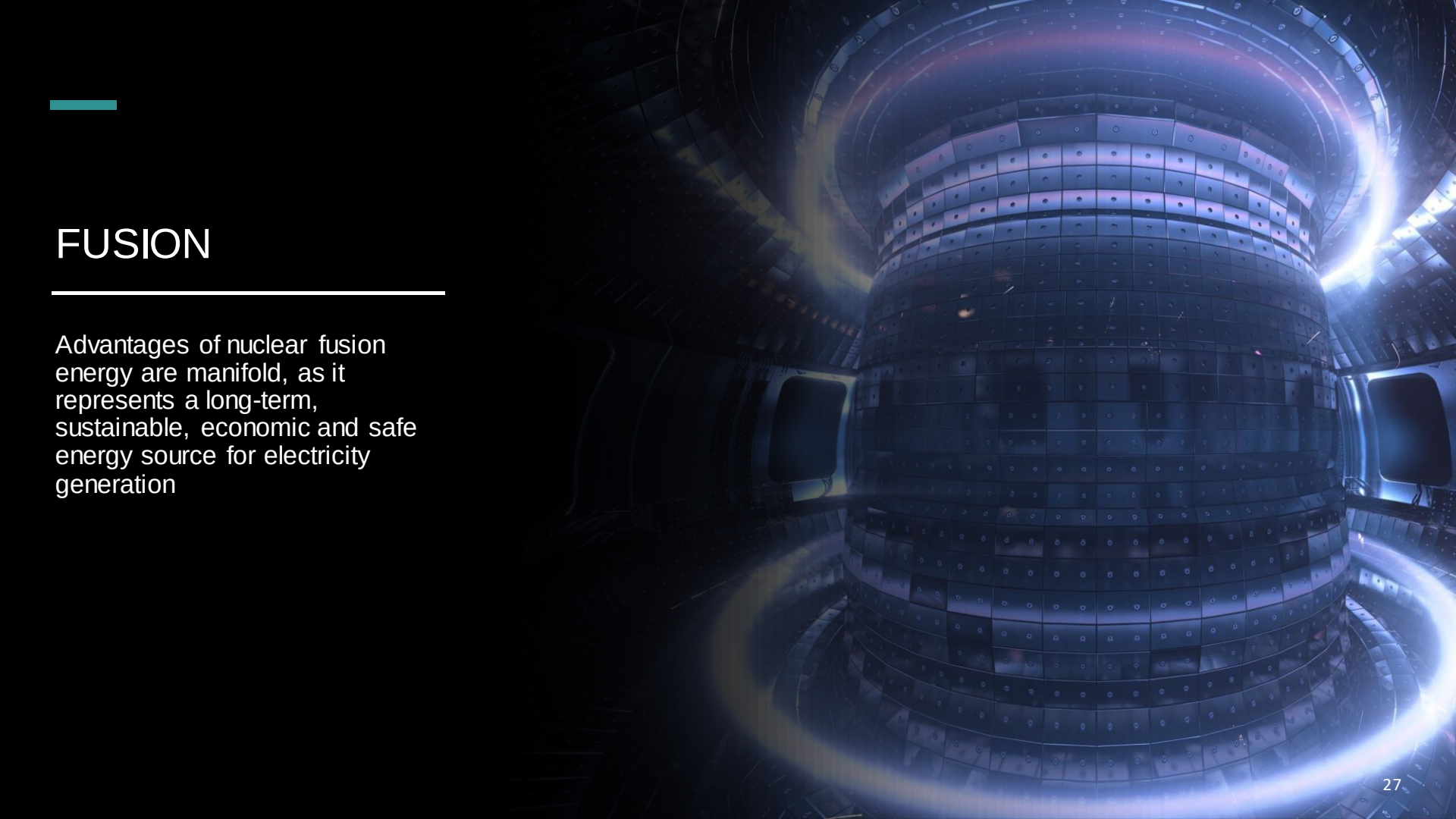
- Renewable energy sources
- Reduced emissions
- Waste management

There are many examples of RT4.0 already creating value across the business…

…but we've only just begun

FUSION

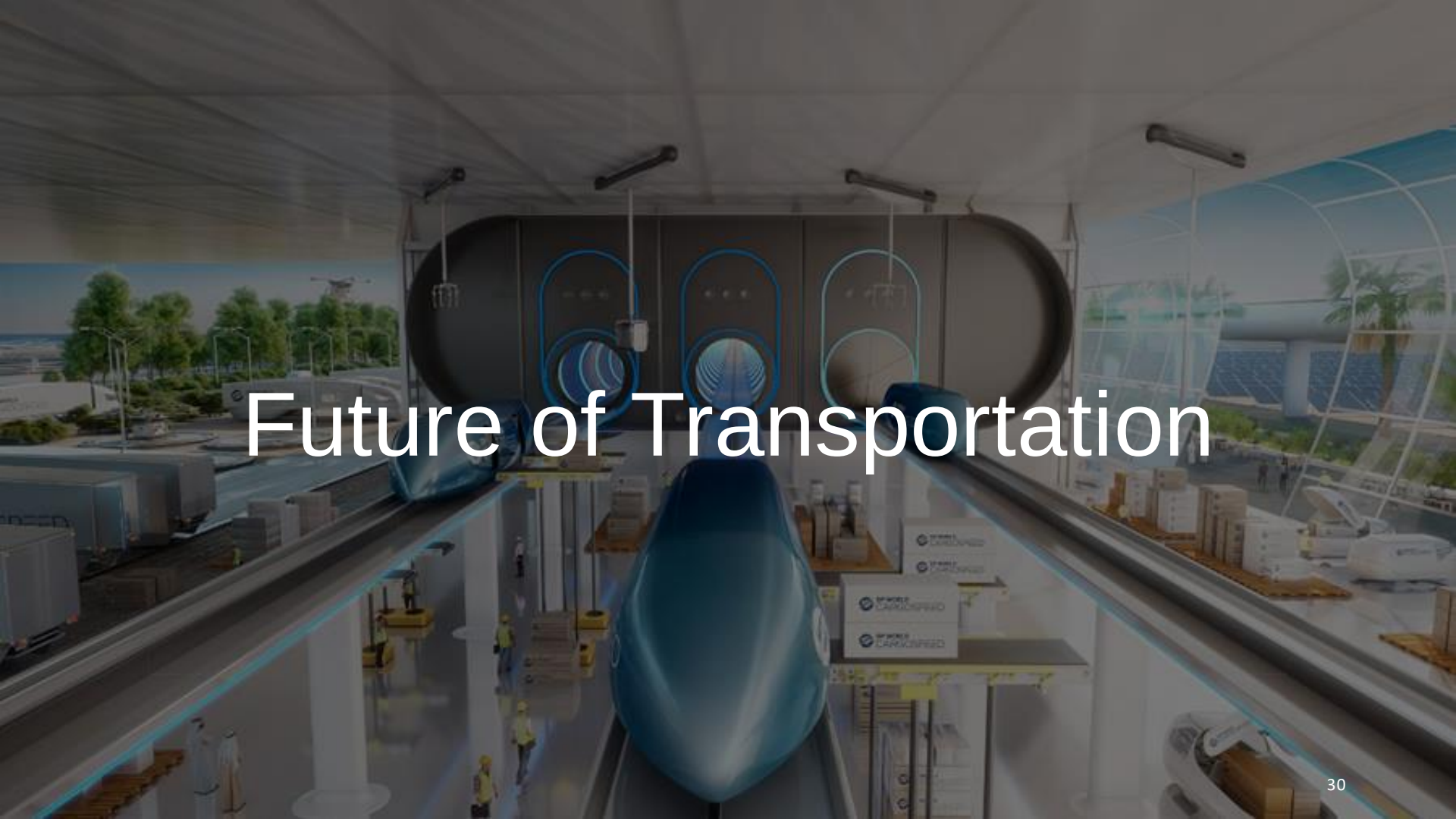
Advantages of nuclear fusion energy are manifold, as it represents a long-term, sustainable, economic and safe energy source for electricity generation



Mirror World
Digital Environments

Accurate simulations of the living world

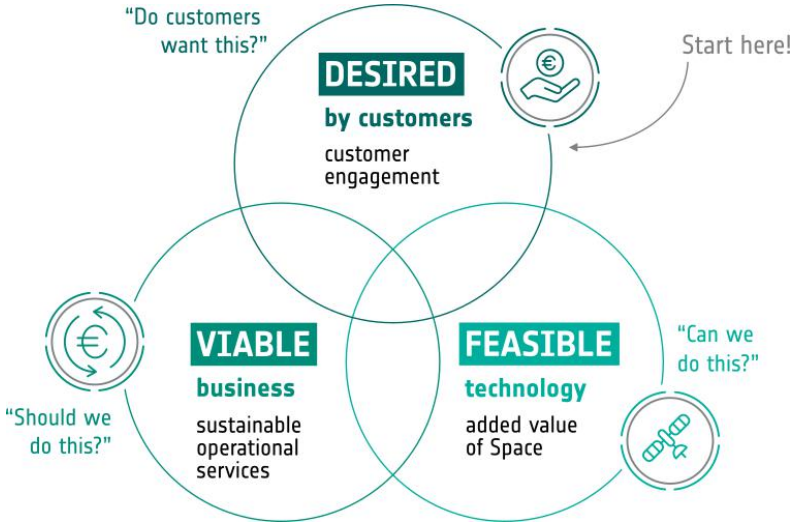

TO
EARNING


Future of Transportation


Energy Transfer Graph
Atacamite Deposit
Mass: 6240.65
Beryl 4.68%
Taranite 0.82%
1.43 Instability
0.35 Resistance
Cargo Capacity
Fracturing Sensor 0%
Overcharge Sensor 0.00%
Fracture Mode

About The ESA Space Resources Competition

- Successful Teams will receive funding an support to run a year-long study
- The aim of the study is to assess the technical feasibility and commercial viability of a product or service that can be applied on Earth today and is relevant to future operations in Space. The product or service must meet the needs of paying customers and other relevant stakeholders.
- The ESA Space Resources Competition opens on 19 April 2021 and closes on 30 June 2021.
- Successful teams will each receive 100% funding of up to €200K to run a 12 month study to:
  1. Engage with users/customers
  2. Assess the technical feasibility
  3. Develop a business model and plan
  4. Propose a roadmap, demonstrating how the service/product will be used in space, following successful roll out on Earth



Who Can Apply?

- ESA Space Solutions can provide funding to teams based in the following member states:

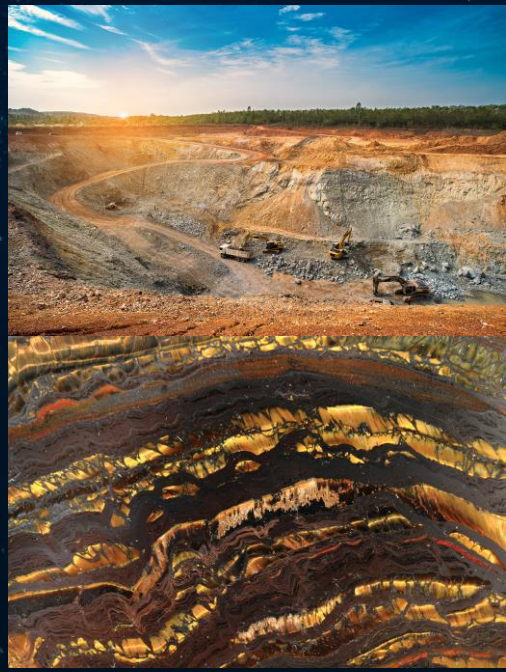
  Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden and Switzerland.

- Please note that teams based in the UK are not eligible for funding through this opportunity.

- Consortia are welcome

- Teams can involve non-European entities, but their contribution to the study cannot be funded by ESA.

- If you are considering applying, you must inform your National Delegation to obtain a letter of authorisation allowing the funding of the proposed activity. Contact details of each National Delegate can be found here: https://business.esa.int/national-delegations-0



How to Apply

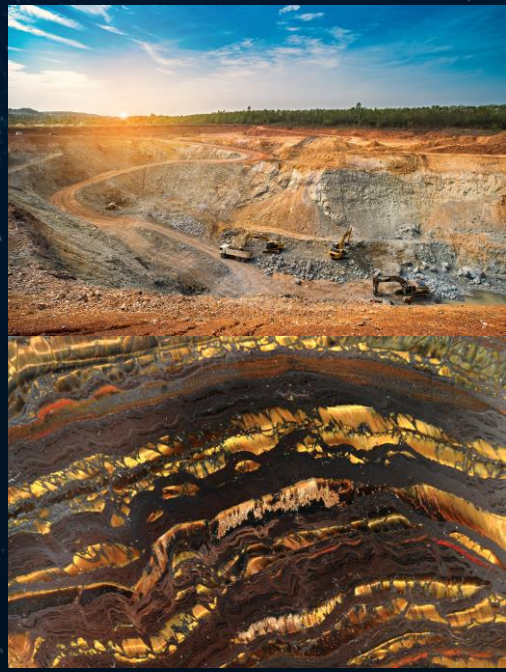
1. Register your team on esa-star Registration today! If your team is made up of more than one company or organisation, each entity will need to register.
   https://esastar-emr.sso.esa.int

2. When the Tender launches on 19 April 2021, visit esa-star Publication and search for this Space Resources opportunity to download the official documents. The official documents will include a statement of work, a proposal template, a draft contract, and additional information about this opportunity.
   https://esastar-publication.sso.esa.int

3. Use the official documents to prepare your proposal

4. Reach out to your National Delegate to request a Letter of Authorisation. Contact details of each National Delegate can be found here: https://business.esa.int/national-delegations-0

5. Submit your proposal via esa-star Tendering by 30 June 2021 at 12:00 CEST.
   https://esastar.sso.esa.int



Proposal Template

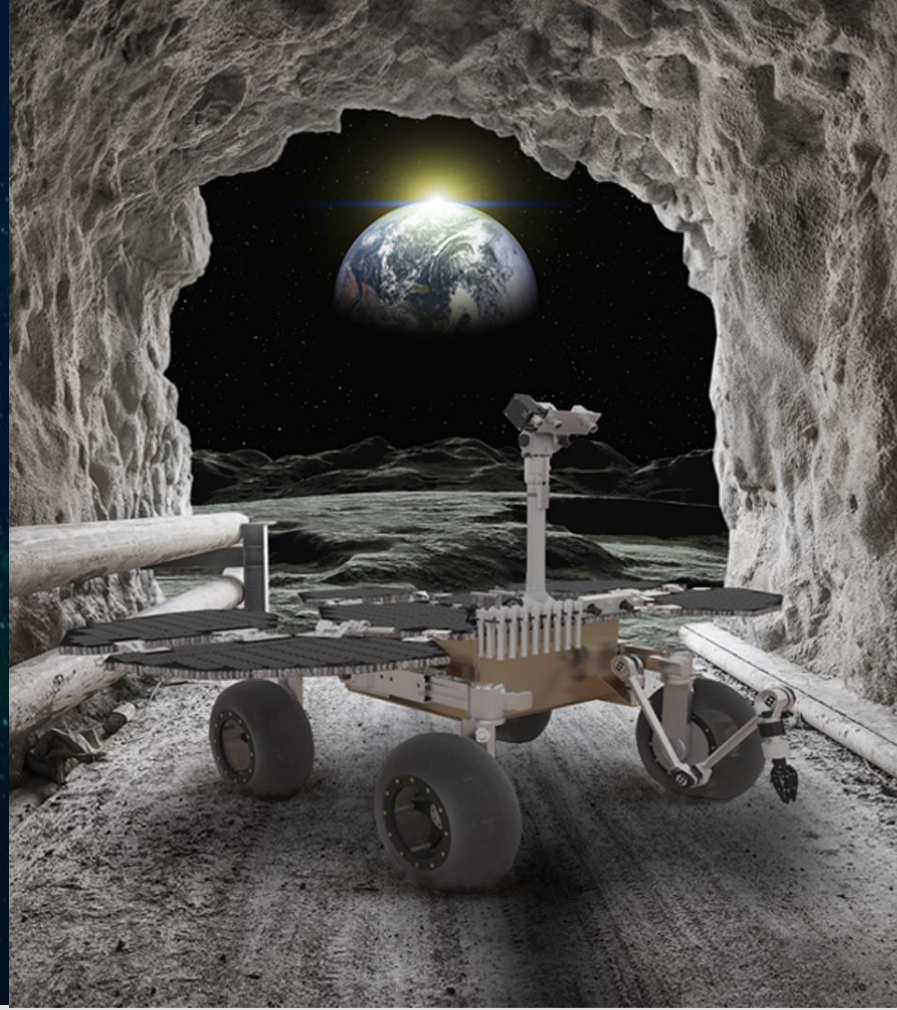
Your Proposal should include the following information:

1. Service Description
2. Business Potential including letters of interest from potential users/customers
3. Technical Potential
4. Work Plan
5. Team
6. Financials

Checklist

Before applying, check that:

1. Your team is proposing a product / service that could become operational on Earth in the near future (1-4 years)
2. Your idea is relevant to future operations in Space.
3. Your team is eligible for funding and has attained a letter of authorisation from the National Delegate.
4. Your proposal covers technical and business aspects, as well as a roadmap for the service rollout in Space.
5. There is a market for your service on Earth and potential users/customers will be involved in the study
6. The proposed study is not a pure research and technology development activity.



Q&A Session

We are very happy to take your questions. Please type them in the chat box now!

.... Continue the conversation later by joining the "Space Resources and ISRU" group on LinkedIn: linkedin.com/groups/9019547

For more information, visit: https://business.esa.int/funding/invitation-to-tender/space-resources

ESRIC Space Resources Week

Join us at ESRIC Space Resources Week!

Registration open until 15 April 2021:

https://www.spaceresourcesweek.lu/registration

Registration is free.

Additional Slide: Value of Space

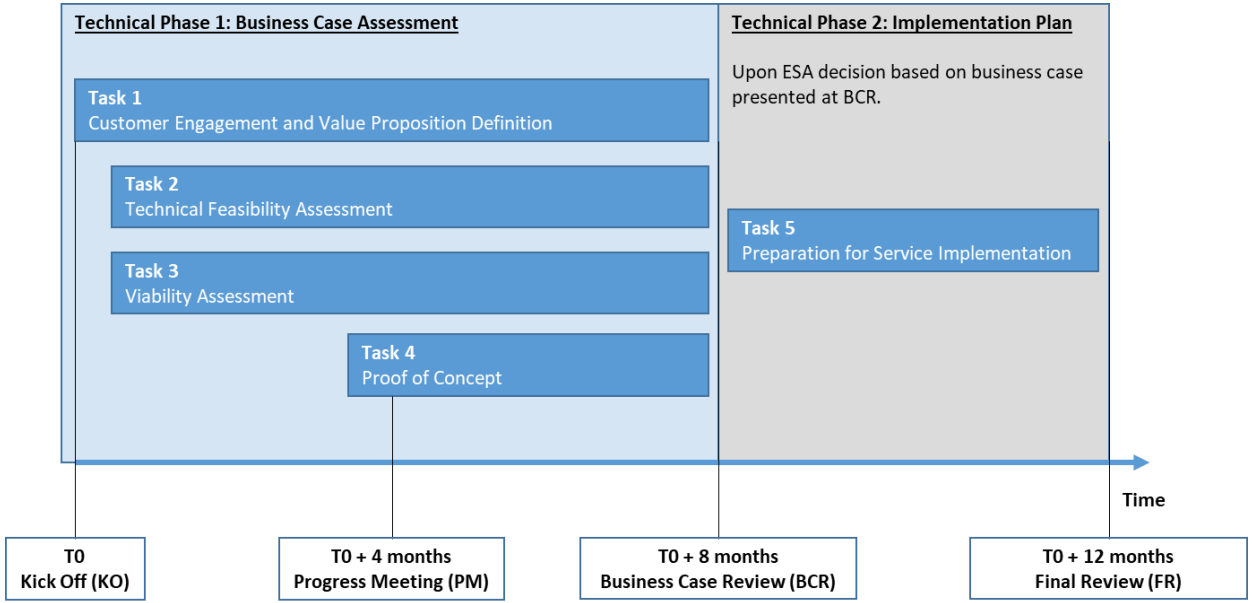
The proposed services must have potential for future application in Space. However, these services may also leverage existing space assets like satellite navigation, communication, Earth observation, or human spaceflight technologies and/or technologies that were derived in space. The space assets do not need to be limited to ESA's or European space assets.

Satellite Earth Observation (SatEO) can provide information to aid the mining process, such as feature extraction, elevation models, change detection, subsidence monitoring and hazard mapping. SatEO can also be used to monitor the natural environment, water resources, and rehabilitation of the land.

Satellite Navigation (SatNav) and augmented Global Navigation Satellite Systems (GNSS) technologies are increasingly important in geospatial systems for the mining and oil & gas industries. Most applications, like mine site surveying, autonomous operation of machinery, machine guidance, environmental surveys, and tracking materials require accuracies of around the centimetre to 10 centimetre level. SatNav can therefore be used to improve precision, efficiency and safety.

Satellite Communication (SatCom): Robust methods to communicate across vast distances without extensive delay are key to coordinating operations on Earth and in Space. In remote areas – like offshore oil rigs and isolated mining sites – and where terrestrial networks are insufficient, satellite communications can provide secure connectivity for data, video and voice communications.

Additional Slide: Work Logic



Additional Slide: Overall Aim