WELCOME,

THE WEBINAR WILL START SHORTLY

Space for the Agrifood Sector

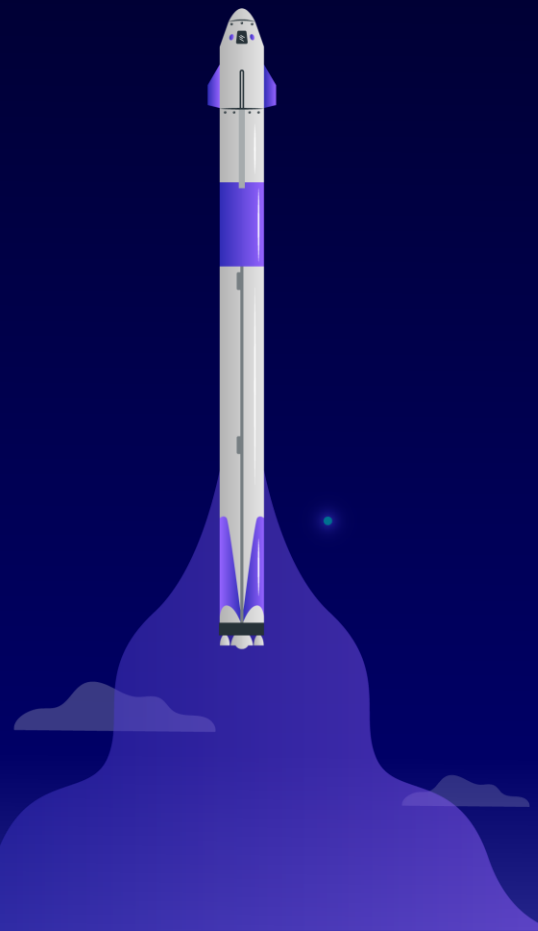
13/10/2022

Space Cooperative Europe SCE²

The Co-Innovation Space Hub

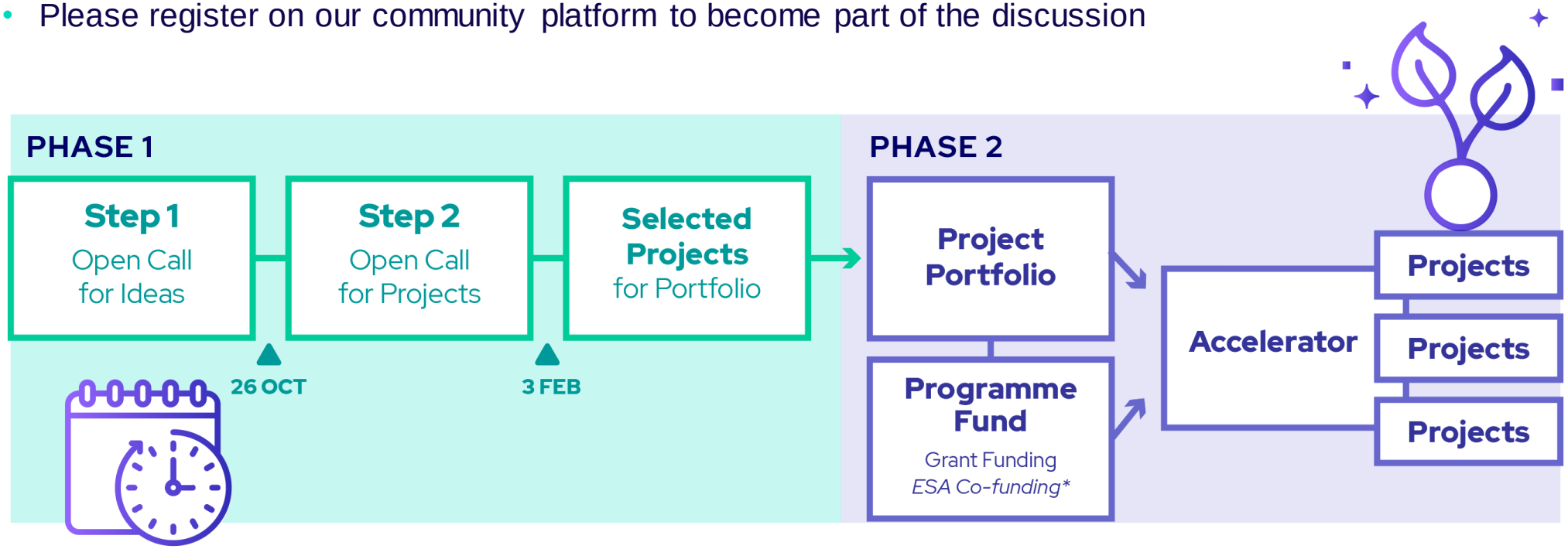
Agenda

- **Welcome** • 4:00 - 4:05
- **Markus Haüser - Introduction** • 4:05 - 4:08
- **Why AgriFood in Space** • 4:08 - 4:25
  - Cynthia Bouthot – Why Space for Agriculture and Food
  - Dr. Jonathan Volk - Supporting Science
  - Cynthia Bouthot and Dr. Jonathan Volk - Case Studies
- **Martijn Leinweber - The Open Call for Ideas Process** • 4:25 - 4:30
- **Panel** • 4:30 - 4:50
  - ICE Cubes
  - Kayser Italia
  - Airbus Bartolomeo
  - Yuri Microgravity
- **Q&A** • 4:50 - 5:00



Why are we here and the High Level Process

- BSGN Industry Accelerator is presenting a NEW OPPORTUNITY
- Why is Space Relevant and Beneficial for your Terrestrial Agriculture and Food Operations?
- To Participate you need to submit a simple STEP 1 Proposal + LOI no later than 26 October
- Please register on our community platform to become part of the discussion



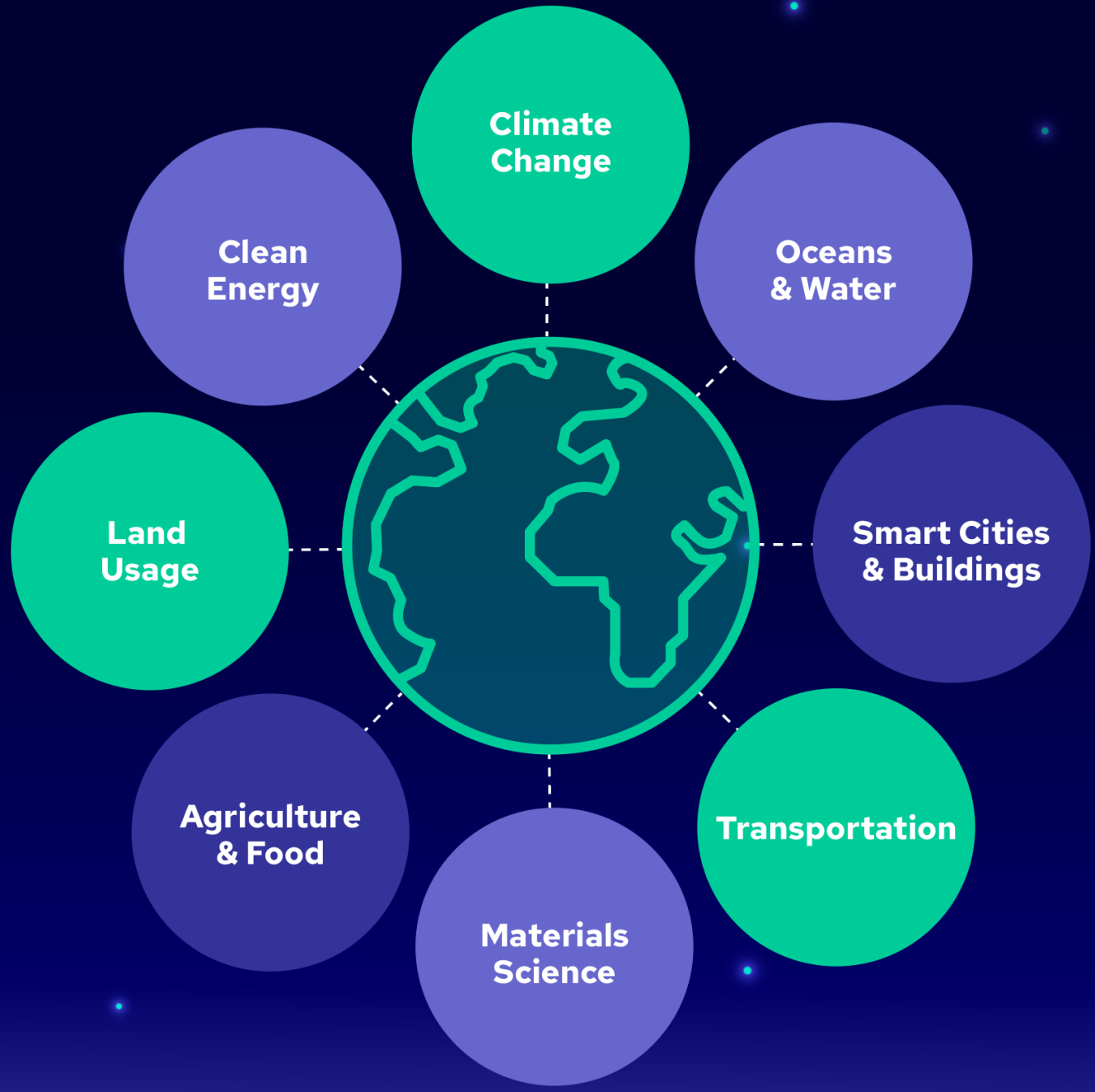
ESA’s Focus on Commercialization

- Dr Josef Aschbacher, ESA DG published **commercialization as one of the top 5 priorities on the ESA Agenda 2025**
  - Established a new Commercialization Directorate with Géraldine Naja as the inaugural director
- **ESA Business in Space Growth Network**
  - Biomanufacturing
  - Sustainable AgriFood
  - Advanced Materials and Manufacturing

I certainly consider it to be the one that makes or breaks the whole Agenda 2025 or rather, the whole European space sector. It is the one that if we don’t get widespread buy-in and risk-tolerance fast, then the other priorities become quite irrelevant.

ASCHBACHER

We are going off our Planet to solve Major Terrestrial Problems



There has been traditional focus on supply side in space

SpaceX

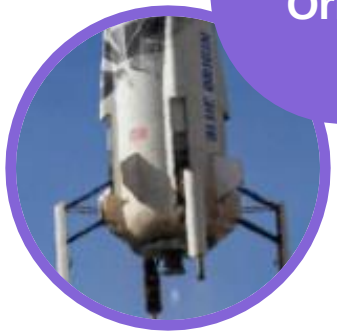
Northrop Grumman

Axiom

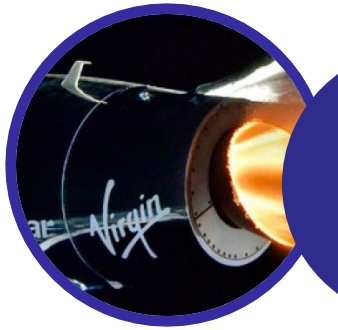
Sierra Nevada

Boeing

Blue Origin



Virgin Galactic



But what about the Demand-Side?

There has also been Extensive Commercial and Scientific LEO Activity for Terrestrial Benefit

Life Science & Crop Science

- Drug Discovery & Development
- Cellular Biology
- Regenerative Medicine
- Accelerated Disease Models
- Manufacturing & Process Optimization

Consumer Products & Industrial

- In Orbit Manufacturing
- Accelerated Degradation
- Material Synthesis
- Combustion
- Transport Phenomena
- Interfacial Phenomena

Technology & Communications

- VR/AR/AI
- Optics/Photonics
- Robotics
- Autonomous Systems
- Data Imagery
- IOT

Sustainability

- Climate Change
- CO_2 Sequestration
- Ocean Health
- Water Efficiency
- Energy
- Mobility

SANOFI AstraZeneca Lilly TARGET GOODYEAR P&G Honeywell MOREHEAD STATE UNIVERSITY Microsoft IBM

MERCK Be well BAYER Baylor College of Medicine BASF We create chemistry HOUSTON Methodist LEADING MEDICINE NALCO Champion An Ecolab Company hp VISIDYNE DELTA Google

And it’s not Just the ISS Anymore!

We are Seeing Record Levels of Investment into New Space Stations, Terrestrially-Friendly Facilities, & Space Factories

Private investment in space companies in 2020 set a new annual record with $8.9 billion, according to Space Capital.

“Despite expectations that space Infrastructure would be hardest hit by the pandemic, 2020 turned out to be a record for investment”.

SPACE CAPITAL MANAGING PARTNER CHAD ANDERSON

ZIN Technologies joins founding leadership team establishing a science park in Low Earth Orbit: The Starlab George Washington Carver Science Park

The total estimated award amount for all three funded Space Act Agreements is $415.6 million. The companies that received awards are:

- Blue Origin for $130 million
- Nanoracks for $160 million
- Northrop Grumman Systems for $125.6 million

UPDATES FROM THE TEAM

SPACE FORGE SECURE £600K IN FUNDING TO BUILD A REUSABLE MANUFACTURING SATELLITE

By SpaceForgeUsr | 29th June 2020

Space Forge has secured a £600k of funding package from the Development Bank of Wales, alongside Bristol Private Equity Club and Innovate UK. This funding will help us continue developing a reusable manufacturing satellite, ramp up our capability in Newport, Wales and Bristol and build upon UK and European partnership schemes. Space Forge's vision is to harness the power of Space by manufacturing high-performance products impossible to produce on Earth, which work to decrease energy consumption and carbon dioxide emissions....

WASHINGTON — Made In Space, a pioneer of in-space manufacturing and assembly technologies, is being acquired by Redwire, a new venture that is rolling up a number of smaller space companies.

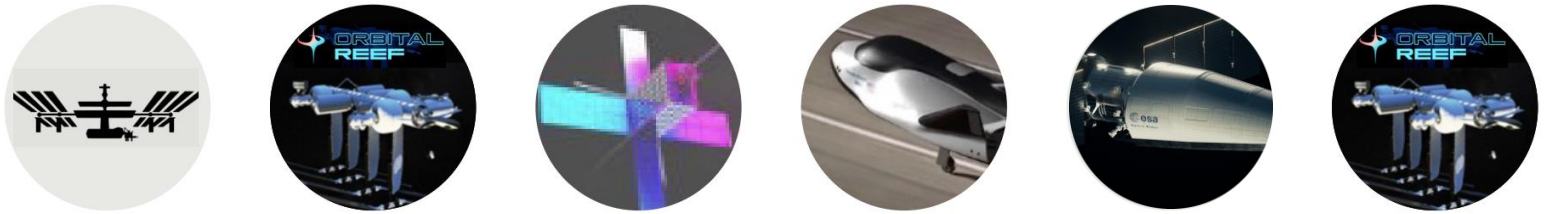
Dec 8, 2020 - Science

Varda Space raises $9 million for manufacturing in space

NASA has picked Private Partners to build the Next-Gen International Space Station

The Time is Now

New Investment and Transportation Systems with Return Capability will enable Terrestrial Markets to use Space as an Outsource Marketplace.



SPACE-BASED CONTINUUM	Proof of Concept R&D		Small-Scale Manufacturing		Full-Scale Manufacturing	
	↕	↕	↕ translation ↕		↕	↕
TERRESTRIAL PRODUCT DEVELOPMENT	Basic Research	Validation	Prototype	Small Scale Production	Demonstration	Commercial Application

Why Space for Sustainable Agriculture and Food?

VALUE PROPOSITIONS

Value Impact of Conducting Agriculture and Food R&D and Manufacturing in Space

AGRICULTURE

- Increasing crop yield
- Creating more stress tolerant plants
- Finding Improvements in vertical agriculture
- Decreasing water usage
- Decreasing chemical uses
- Help to prevent catastrophic crop losses

FOOD

- Creating longer lasting foods
- Creating more shelf-stable foods
- Creating longer lasting Preservative and Stabilizers
- More Sustainable manufacturing processes
- Preventing and removing disease causing biofilms
- Creating more sustainable packaging

Seeds and plant nutrition

Sub-Topic Areas	Agriculture and Food Terrestrial Propositions	Why Space	Markets
Plant Genetics are the regulations of the plants' genes	• Drought Tolerance • Extreme Rain Tolerance • Salinity Tolerance • Heat Tolerance • Cold Tolerance	In microgravity, we see changes in a plant's gene expression that leads to plants that are more tolerant to various extreme weather conditions and even salinity levels	• Production of Seeds • Genetically Modified Seeds • Hybrid Seeds • Stress Resistant Seeds • Water Management Technologies
Gravitropism is the response of the plant to gravity whereby the shoot of the plant grows up out of the ground and the roots grown down towards the water and nutrients in the soil	• Root Structure • Shoot Structure	Microgravity allows us to better understand the effects of gravity on shoot and root growth in plants which could help create better technologies for traditional farming and vertical agriculture	
Soil Health and the relationship of nutrients for the plant and microbes that improve plant-soil relationship	• Soil Health • Plant-Microbe Interactions	Microgravity changes the behaviour of microbes, in some cases making them more active, and could help us find microbes that are more beneficial to plant and soil health	• Soil Treatments • Regenerative Soil • Water Management
Disease Treatment and pest management including fewer pests and invasive undesired plants as well as better and friendlier fertilizers	• Fertilizers • Fungicides • Herbicides • Insecticides	The lack of sedimentation and convection in microgravity allow for larger more regularly shaped crystals with fewer defects to form	• Fertilizers • Fungicides • Herbicides • Insecticides • Bio/Organic Fertilizers

Crop Monitoring and Management

Subtopics	Why Space	Markets	Market Applications
GPS on Equipment	Earth observation/remote sensing via specific radio frequencies	• Farm Equipment and Management • Farming Aps • Precision Agriculture • Weather Observation	Improving crop management leading to better crop yield
Soil Health Monitoring	Earth observation/remote sensing • Visible – specific soil detection • IR – soil differentiation, classification, surface temperatures		Preventing over/under watering and monitoring nutrients in the soil for sustainability and better crop yield
Crop Health Monitoring	Earth observation/remote sensing • Visible – vegetation discrimination, normalized vegetation index • IR – classification, healthy vs. disease crops, chlorophyll content, moisture content, crop water stress level		Understanding issues on a large scale to prevent issues from spreading or stopping them leading to increased crop yield
Weather Monitoring & Prediction	Earth observation/remote sensing • IR - Drought events, severe weather, smoke monitoring		Preparation for preventing crop loss if weather events threaten crops
Pest Tracking	Earth observation/remote sensing using visible and IR		Preparing for and preventing the spread of pests that effect crop health and yield

Food Behavior, Formulation and Packaging

Sub-Topic Areas	Agriculture & Food Terrestrial Propositions	Why Space	Markets
Food Behavior & Formulations	• Flow Profiles • Product Stability and Shelf Life • Separations • Formulations • Mixing & Emulsifying • Crystallization • Raw Materials	• Removing the lens of gravity to understand the forces that effect the synthesis of the material – emulsions, active agents – and texture of material • Using microgravity to look at forces other than gravity that effect the mixing and emulsification process • Microgravity minimizes the forces that create material defects during the crystallization process to produce better materials • Use microgravity to develop better raw materials via synthetic biology	• Food Blenders & Mixers • Food Emulsifiers • Agricultural Biologics • Shelf-Life Testing • Global Liquid Fertilizer • Fluid Dispensing Systems • Hydroponics
Packaging	• Biofilms • Green Packaging	Formulating better or novel materials in microgravity can be done due to the lack of convection, sedimentation, and buoyancy not effecting the formulation of the new, novel materials Due to the change in behaviour of microorganisms we see biofilms that are thicker and more resistant to treatments in microgravity than terrestrially. Understanding how to prevent and combat biofilms in microgravity can lead to better biofilm prevention and treatment terrestrially	SProtective Packaging Plastic Packaging Materials Fluid Dispensing Systems Biofilm Treatment

Scientific Benefits of Low Earth Orbit

WHY ON EARTH WOULD YOU DO SOMETHING UP THERE?

Microgravity

Microgravity, weightlessness, alters observable phenomenon within the physical and life sciences.

Microgravity influences cell behavior, organism health, fluid physics, combustion and various processes across the physical and life science.

Extreme Conditions

Extreme Environmental Conditions of space include extreme thermal cycling, atomic oxygen, ultra-high vacuum, debris impacts and high energy radiation.

Vantage Point

The ISS offers a unique vantage point at about 400 km overhead in Low Earth Orbit (LEO).

The orbital path of the ISS covers about 90% of the Earth's population every few days and provides unique spatial resolution and variable light conditions.

Scientific Behavior in Space

Rethink your science - In space lack of:

- Gravity
- Convection
- Buoyancy
- Sedimentation

All these forces present on Earth are minimized.

Crystallization

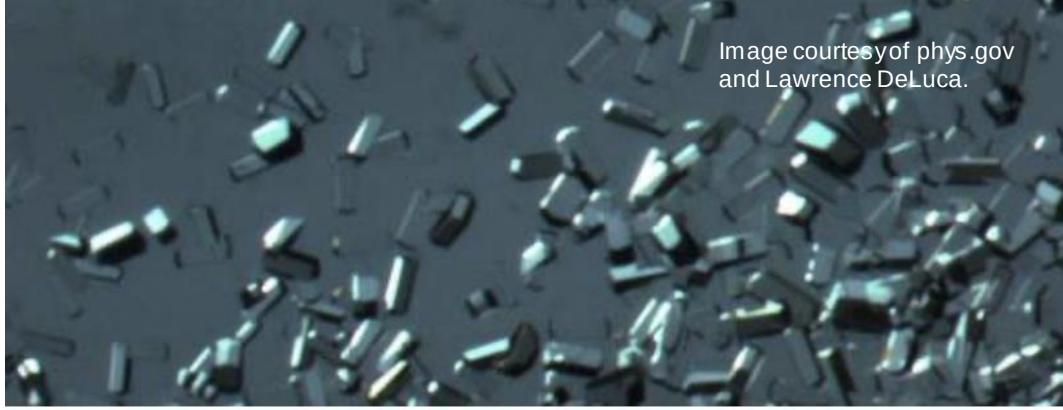


Image courtesy of phys.gov and Lawrence DeLuca.

Larger more ordered structures can be obtained in microgravity:

- Microgravity Molecular Crystal Growth (MMCG)
- Fertilizers
- Precision Farming
- Water-Soluble Products

Water-soluble fertilizers: it's crystal clear!

Crystallisation, as a powerful separation technology and production process, is helping the fertilizer industry diversify its product mix, improve profitability and enhance sustainability, as **Sana Boulablar** and **Matias Navarro**, of Veolia Water Technologies North America, explain.

As with most sectors of the economy, the agricultural value chain has been disrupted by the shock of the Covid-19 pandemic. Adding to existing trade tensions, fertilizer producers have been hit by labour shortages, plant closures, logistics delays and bottlenecks.

Fertilizer producers have been put to the test during this crisis by having to meet urgent and immediate farming needs. Admirably, producers have stepped up their role in ensuring the flow of essential fertilizers to farmers. Supporting agriculture and food availability and affordability is as vital as ever, particularly in a situation of growing food insecurity.

But as lockdown restrictions ease and transportation and distribution start to return to normality, it will be time to think again about the challenges affecting the fertilizer industry in the long run – namely sustainability, resource-efficiency, and economic and environmental viability.

Priorities will undoubtedly shift. This will be a matter of 'when' not 'if'. Greater


PHOTO: VEOLIA

Veolia crystalliser units, Dead Sea Works, Israel.

extracting a purge stream from the crystalliser. This prevents their co-precipitation with the desired fertilizer crystals. Other process techniques can be combined with the initial crystallisation step to further upgrade and purify the product. A second crystallisation step, for example, minimises the waste purge and delivers higher production yields. It also makes it possible to consume lower grade raw materials yet still produce higher value fertilizer products.

From waste to value

The ability to turn waste into a marketable product is another desirable attribute of crystallisation technology. Being able to adapt to different feedstock grades or sources such as waste streams is one of the technology's greatest advantages. Not only does crystallisation help control manufacturing costs, by delivering higher recoveries, it also enhances sustainability through better waste management.

This is most evident in the production

Cell Biology

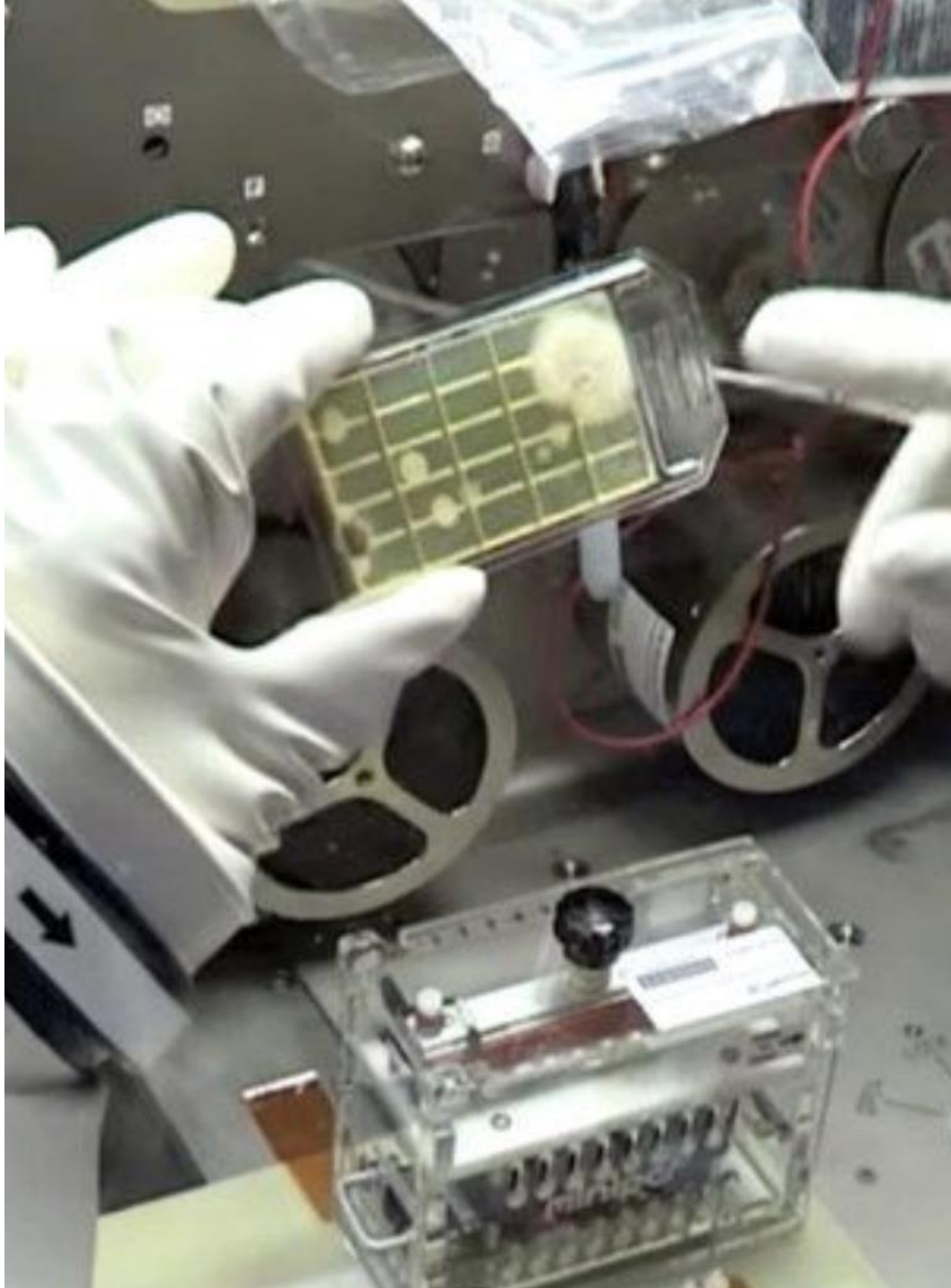
Microgravity effects cell's behavior, gene expression and allows 3D structures to form without the use of a scaffolding or matrix:

- Cellular agriculture; producing animal products from cell culture, rather than animals.
- Biotechnology
- Tissue Engineering
- Molecular Biology
- Synthetic Biology

Microorganisms

The diffusion driven environment of space induces changes in the behavior and virulence of microorganisms:

- Bacteria
- Fungus
- Viruses
- Biofilms



Plant Science

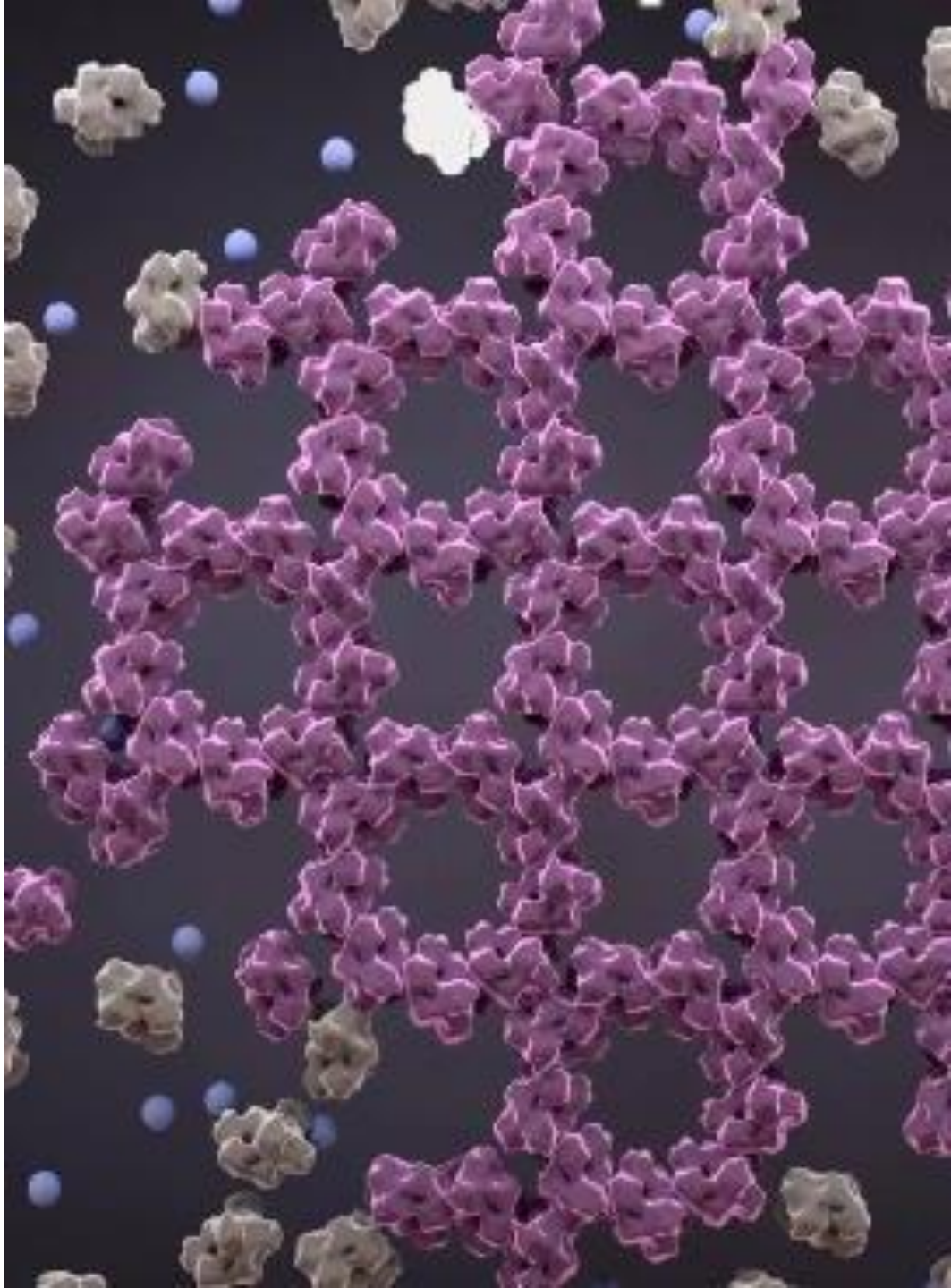
Microgravity can be used to probe mechanisms to understand how terrestrial plants respond to gravity and activates stress response in plants:

- Plant growth
- Plant stress
- Plant/microbe interaction
- Crop monitoring
- Water monitoring

Materials Synthesis

More ordered material structures can be developed in microgravity:

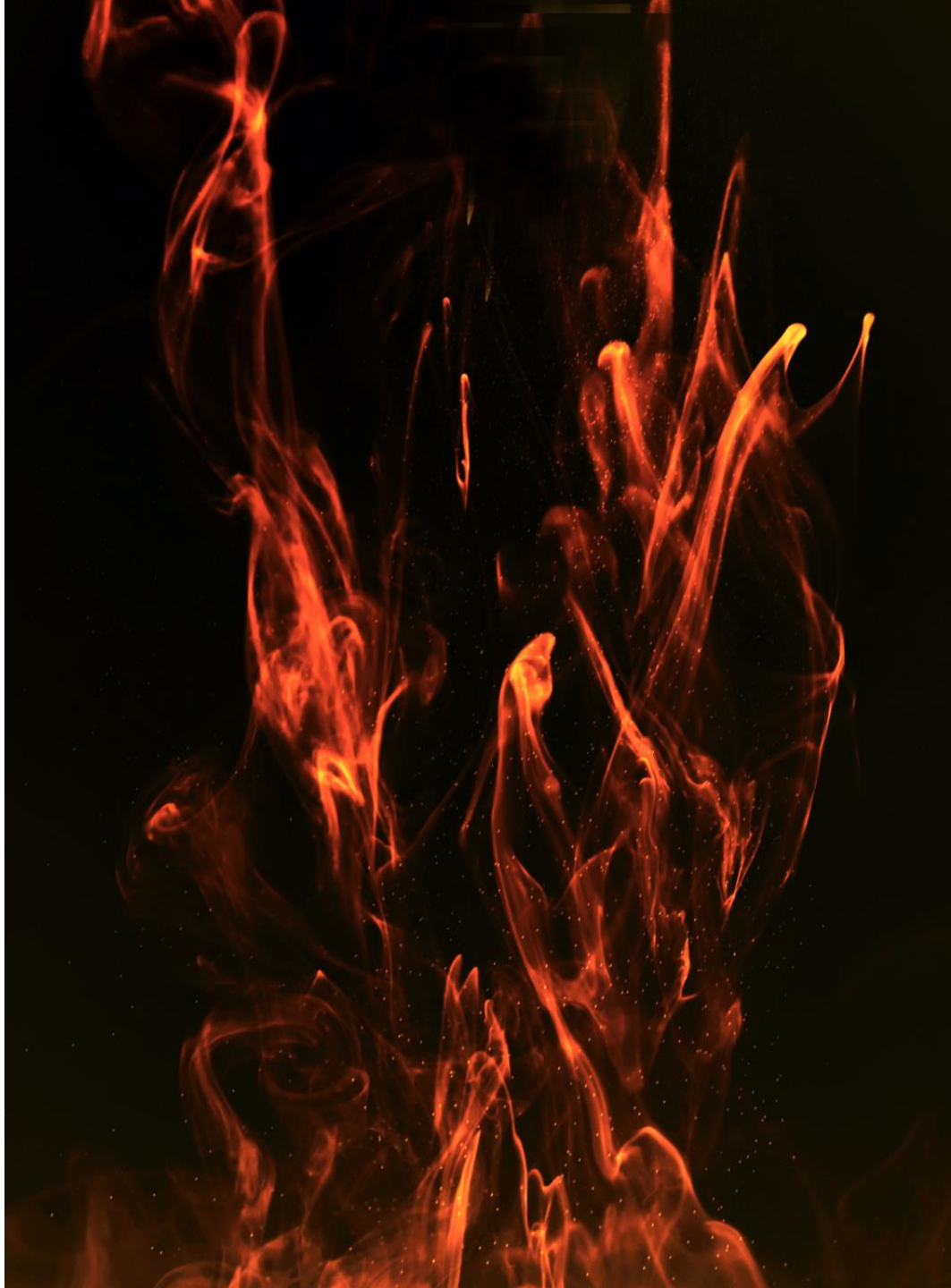
- Polymers
- Biomaterials
- Composites
- Ceramics
- Metals
- Semiconductors



Property Measurements & Behavior

Critical properties of materials and systems can be measured more accurately in microgravity leading to more exact design models:

- Thermophysical Properties
- Transport & Modeling Coefficients
- Phase Transitions



Fluid Dynamics & Transport Phenomena

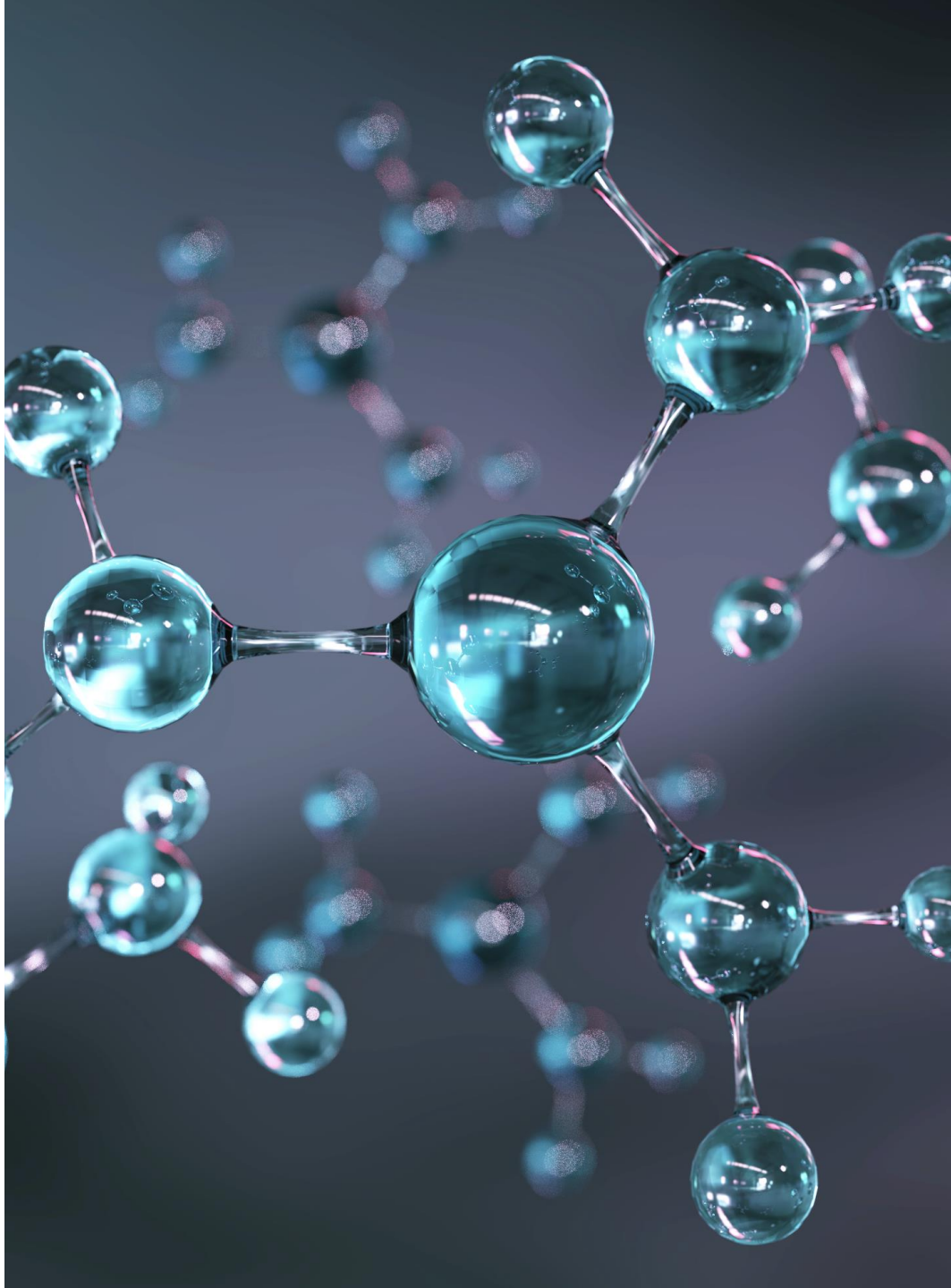
Unique fluid behavior in microgravity can allow for easier studies of:

- Multiphase Flows
- Capillary Flow
- Diffusion
- Surface Tension
- Separation and Agglomeration
- Interfacial Behavior

Reaction Chemistry

Lack of gravitational forces can influence:

- Chemical Product Formulation
    - Flow
    - Batch
- Mixing Behavior
- Combustion

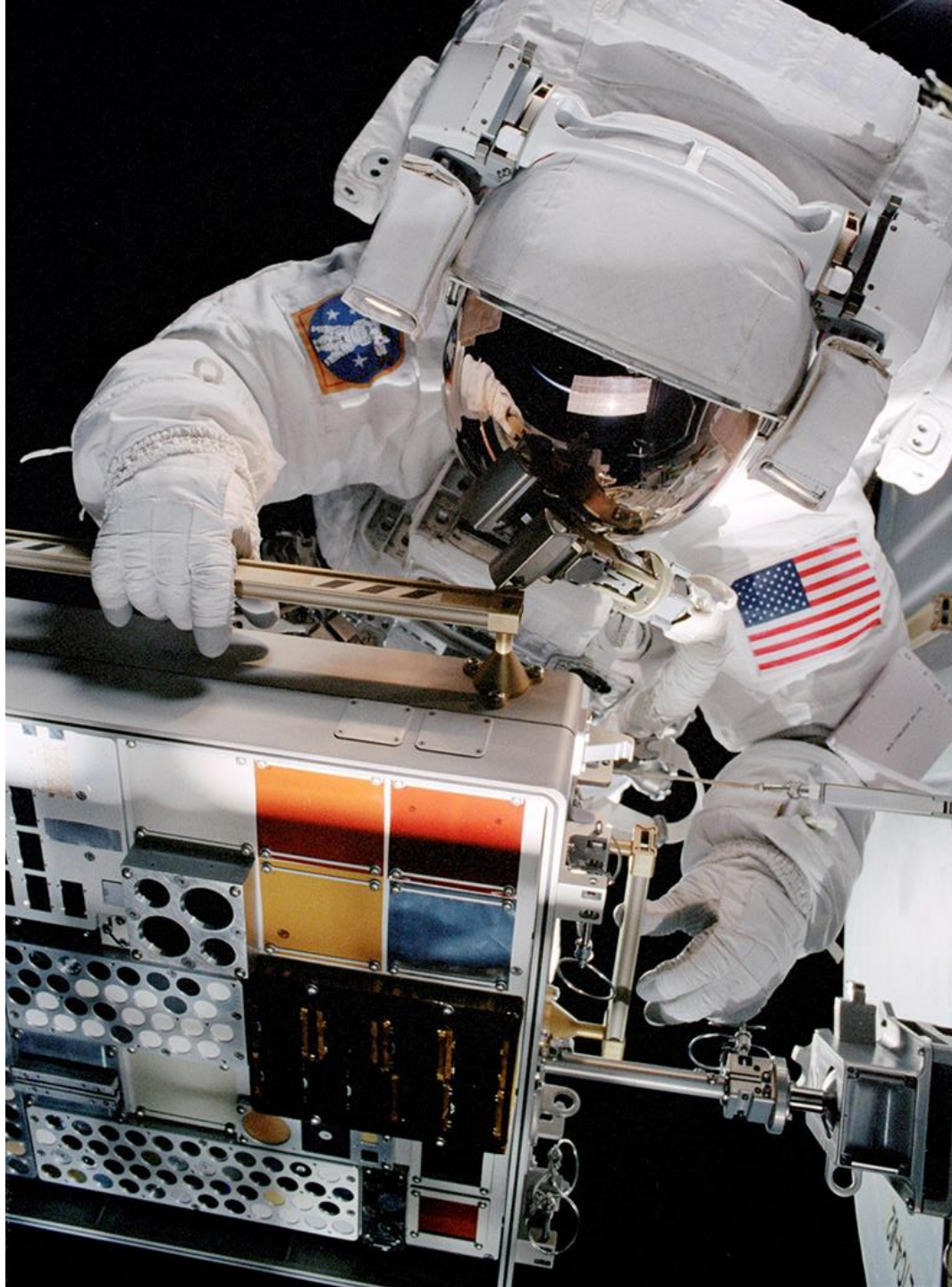


External Materials Testing

The extreme conditions of space provide the ultimate platform for materials testing:

- Degradation
- Corrosion
- Other Failure Modes

Degradation Process occurs orders of magnitude faster than on Earth

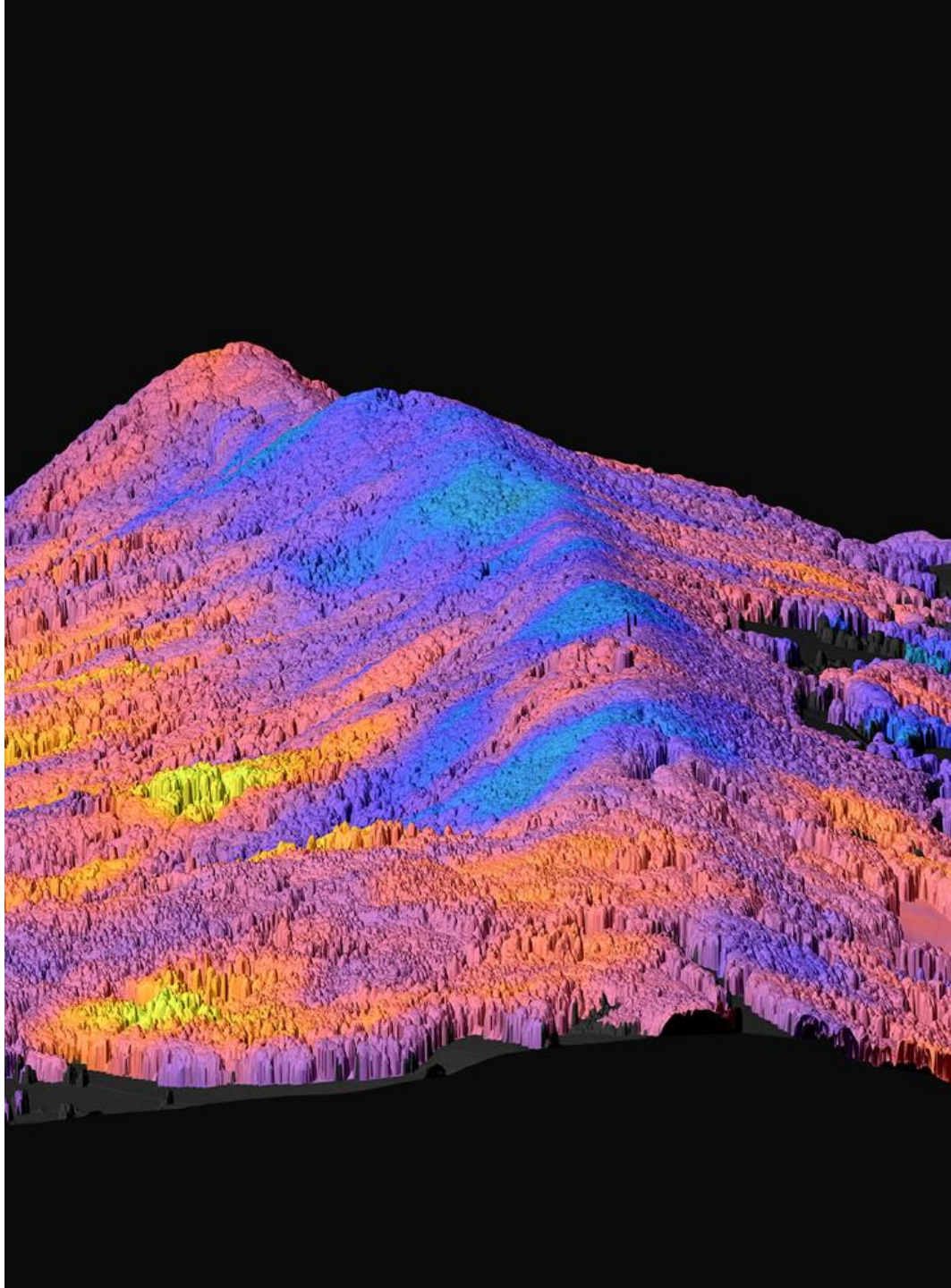


Remote Sensing

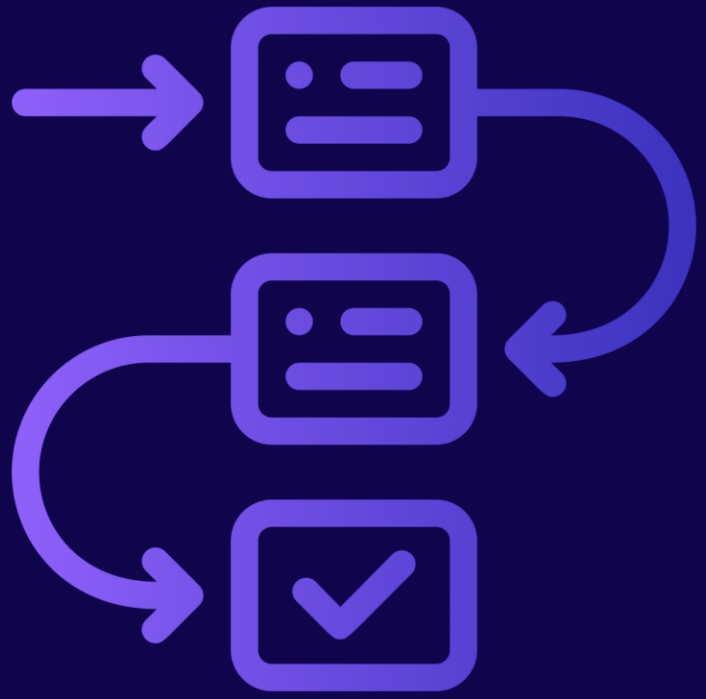
- Vantage point of ISS provides opportunity to collect important data sets (regional, continental, global).

- Sensing Options:
  - Visible/Hyperspectral
  - Infrared
  - RADAR
  - RF

- Data Applications:
  - Sustainability
  - Climate Change
  - Planet Health
  - Raw Materials
  - Mapping



Use cases



Cotton Crop Sustainability • Target

3 PROJECTS SELECTED

Targeting the Roots of Cotton Sustainability

Simon Gilroy, University of Wisconsin (Madison, WI)

Roots play a central role in a host of plant functions that are critical to plant survival. The ability of cotton plants to produce cotton bolls and survive stress requires that their root systems provide water and nutrients. Cotton plants that overexpress the AVP1 gene show increased resistance to stressors such as higher salinity and drought and yield 20% more cotton fiber under these conditions, which normally limit cotton productivity. These stress-resistant features have been tentatively linked to an enhanced root system that can explore a wider and deeper volume of soil for water and nutrients. Such exploration patterns are inextricably linked to gravity, which directs the growth of main and lateral roots. This experiment will assess the degree to which root system architecture influences stress resilience, water-use efficiency, and carbon sequestration during the critical phase of seedling establishment.

Unlocking the Cotton Genome to Precision Genetics

Christopher Saski, Clemson University (Clemson, SC)

This project proposes to use the tools of genetic sequencing to examine gene expression, DNA methylation patterns, and genome sequences of three different cotton cultivars using embryogenic callus material (plant embryos that are formed from somatic plant cells not normally involved in plant embryogenesis and development). In the absence of gravity, the differences between cotton cultivars during the process of regeneration—and their ability to grow from embryogenic callus material—may be affected and could reveal new insights into the genetics of plant growth and regeneration. A better understanding of these processes (and differences between cultivars) will advance fundamental biological knowledge and could improve our ability to grow cotton plants that more efficiently use water and adapt to changing environments.

Field Scale, Aggregated Best Management Practice Verification and Monitoring

Marshall Moutenot, Upstream Tech (Alameda, CA)

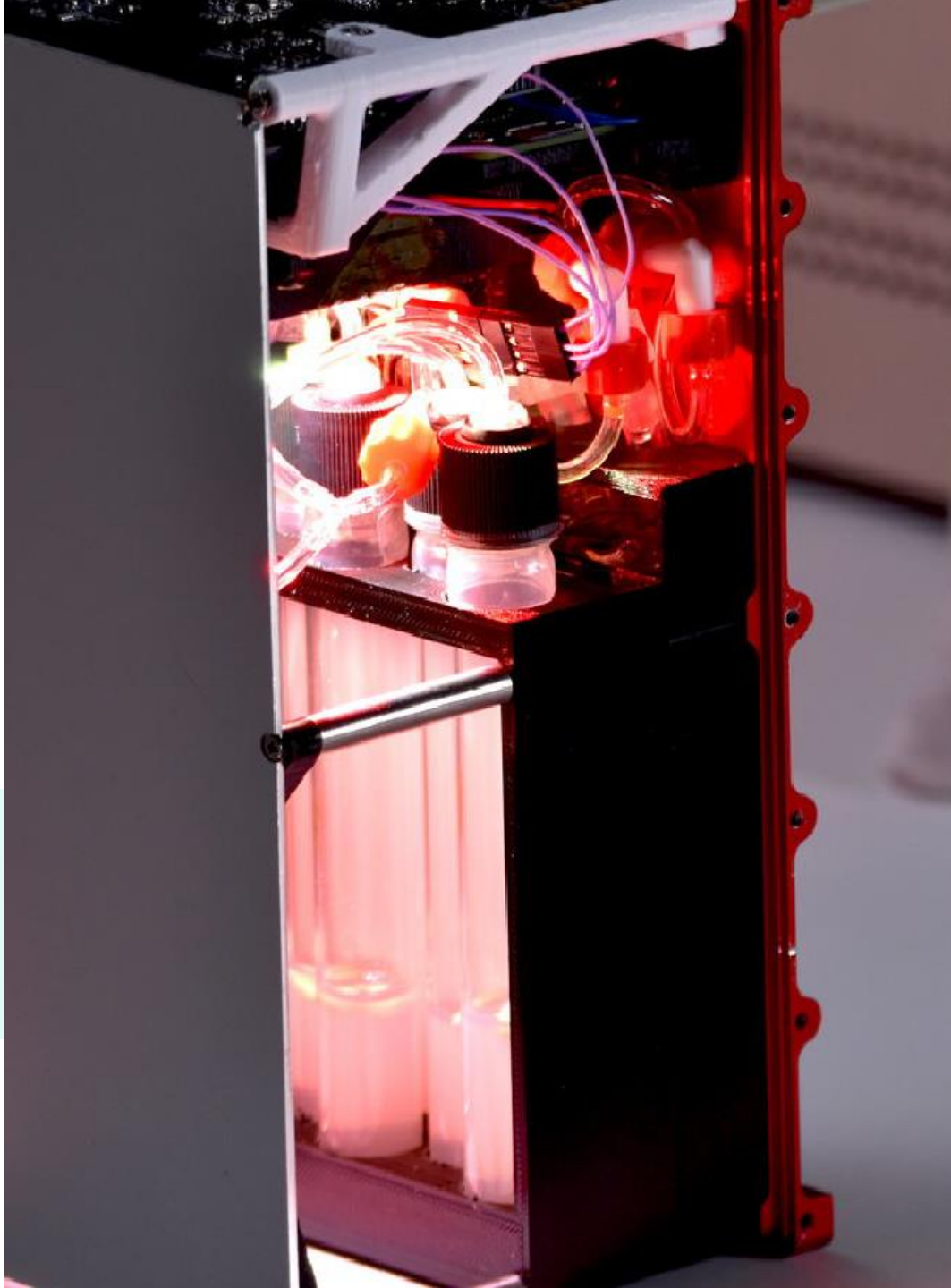
Upstream is a public benefit corporation with the mission to create economic forces that drive environmental conservation.. Upstream proposes to leverage ISS remote sensing imagery to expand the capabilities of its “Best Management Practice Assessment and Real-time Monitoring” platform to enable the automated monitoring and analysis of cotton agriculture and inform Target’s production-related water use goals for sustainable cotton production.

Target sponsored a $ 1M challenge open to a non-traditional space community to find ways to grow more sustainable cotton

Barley Seed Germination
Large Food and Beverage Company

Plant growth in microgravity gives clues towards plant growth under various stresses on Earth
The lack of gravitational forces influences growth mechanisms and could lead to a better structured strand of barley

Impact: *Influence how barley and other raw materials should be grown/developed on the ground and aid in creating more stress resistant strains of core crops*



Plant Science • Syngenta

Microgravity can be used to probe mechanisms to understand how terrestrial plants respond to gravity.

Microgravity activates stress response in plants
Areas of Focus:

- Plant growth
- Plant stress
- Plant/microbe interaction
- Crop monitoring
- Water monitoring

Impact: *Better understand stress mechanisms of plants, leading to varieties that are more resistant to climate change and better vertical agriculture techniques.*

Biofilm Thickness & Corrosion

Nalco Champion

- Microbiologically Influenced Corrosion (MIC) causes $ 0.5-1.5T in damages and lost revenue annually, mostly in oil & gas industries
- Driving forces behind MIC risk are: number of cells, total mass, and thickness of film
- The microgravity environment enables these factors to increase in biofilms
- Can determine if these thicker films lead to more corrosion in carbon steel

Why Space: *Biofilms grow in size significantly faster and larger in microgravity, compared to what can be grown on Earth. This provides a much better platform to determine the extent of biofilm growth on surfaces.*

Value Impact: *Reduction of damaged oil & gas pipelines, lessening the risk of leaks/spills, potentially saving billions of dollars in damages*

Droplet Formation
Delta Faucet

Looking to understand droplet formation in microgravity (where surface forces can be isolated and studied) out of a patented shower head design

How do you make less water feel like more due to droplet size and velocity?

Why Space: *Space eliminates gravitational forces, making it easier to study how surface forces impact droplet formation out of a shower head, which can help improve future head design*

Value Impact: *More efficient showering, ultimately helping water conservation (less water needed during shower) and energy conservation (less heat needed during shower)*

Colloidal Stability
Procter & Gamble

Phase separation is significant issue in the reduction of shelf life for consumer products (foods, cleansers, etc.)

Sedimentation, driven by gravity, is not the only driver of phase separation

Why Space: *Non-gravitational factors contribute to phase separation of colloids, but these factors can only be clearly studied in microgravity since sedimentation is nullified.*

Value Impact: *Increased shelf life and formula stability of various household products.*

Agricultural Camera

University of North Dakota

An infrared and visible light camera that takes pictures focusing on the North American Great Plains.

Given to farmers and ranchers within 1 to 2 days - faster than previous cameras.

Used to help inform drainage and irrigation planning, fertilizer and pesticide application or livestock forage/grazing plans. Also used to take pictures worldwide of melting glaciers, deforestation, and natural disasters.

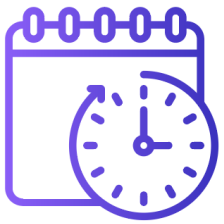
Why LEO: *Provides the vantage point to capture accurate data over a specific large geographical region.*

Value Impact: *Farmers making informed decisions for large scale agriculture as well as data available for recording and modeling climate change.*

Florida West Coastal Region. ISSAC
Image courtesy UND UMAC.

Open Call Information

Timeline



2022

September 19
Public launch

October 26
Step 1 (idea proposal)

November 11
Step 1 (idea selection)

December 16
Step 2 (project proposal)

2023

February 3
Step 2 (project selection)

February
Programme Go/No Go Decision

For a successful application, please follow the indications described below

1. Register to the **BSGN AgriFood Community**
2. Get support from experts on **BSGN AgriFood Community Platform**
3. Fill in the **online** **Application Form (Step 1)** before October 26th, 2022 at 23:59 CET
4. Then we will confirm your application
5. You will hear if you got selected for Step 2 or not
6. READY TO GO!

From idea proposal to project proposal

If you are selected,you will receive guidance to turn your idea proposal into a concrete project proposal.

- Business
- Technical (a.o. service provider)
- Financial aspect

Concrete project proposal needs to be submitted before the 16th of December.

Panel of Experts with the Facilities and Capability to Support Your In-Space Activity

ICECUBES
BY SPACE APPLICATIONS SERVICES

BIOREACTOR
EXPRESS

YURI

Thank you for your attention

- To Participate you need to submit a simple STEP – 1 Proposal + LOI no later than October 26th
- Please register on our community platform to become part of the discussion
- For more information about the Accelerator and the Call for Ideas, please contact: José Salgado • jose.salgado@spacecoop.eu
- Or visit: https://bsgn.spacecoop.eu/opencall/

Space Cooperative Europe SCE²

The Co-Innovation Space Hub