Making access for space
experiments
FAST
SIMPLE
ATTRACTIVE
and AFFORDABLE
to allow for capacity building

International Commercial
Experiments Service

www.ICECubesservice.com
ICECubes@spaceapplications.com
@ICECubesService

Dr Hilde Stenuit
Hilde.Stenuit@spaceapplications.com

spaceapplications SERVICES

Outline of the Presentation

- ICE Cubes Introduction
- ICE Cubes facility and experiment cubes
- ICE Cubes service characteristics
- ICE Cubes service future developments
- ICE Cubes service in the context of capacity building
- ICE Cubes potential example usage areas

The development phase of this project has received funding from the European Commission's H2020 Framework Programme for research, technological development and demonstration under grant agreement No. 666815.

ICE Cubes Introduction

The International Space Station (ISS) is a great international achievement, designed as a flexible laboratory able to support research in a wide range of disciplines.

However making use of the ISS is still not attractive / accessible for a large number of potential users, due to the burden of complex rules, procedures and the cost & duration associated.

Yet, things are now changing in this commonly-recognized new era…..

Based on a public–private partnership agreement with the European Space Agency (ESA), the **International Commercial Experiment Cubes (ICE Cubes) service** is now providing for **a commercial access service** to the International Space Station.

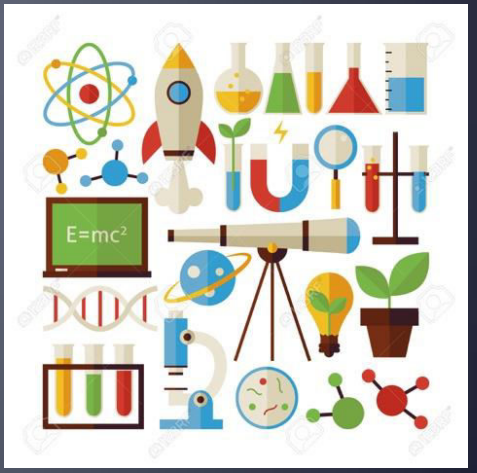
ICE Cubes is providing **fast, simple and affordable access for experiments** to the ISS, creating capacity-building opportunities in space research and exploration **for any country or any entity / user**.

ICE Cubes Introduction

The launch of the ICE Cubes internal facility is planned in **January 2018** and with that the real start of the service and its operations. The agreement with ESA allows to ensure committed & recurring **launches three times a year up to 2024** with extensions possible.

The ICE Cubes service is suitable for many uses:

- fundamental and applied research in space / microgravity
- educational experiments and demonstrations in the science, technology, engineering and mathematics (STEM) areas for inspiration of the new generation of space scientist
- technological / industrial activity

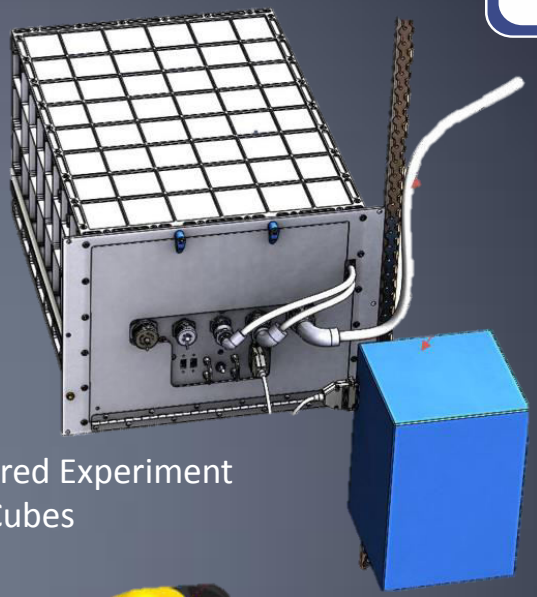


ICE Cubes Introduction

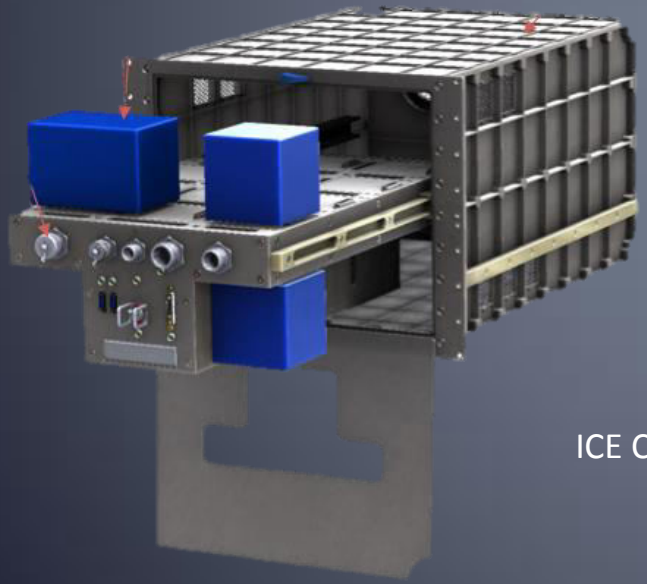
ICE Cubes service allows any country, any institute or any entity to directly develop and conduct their experiment on the International Space Station, the only laboratory in space.

Users can develop their own Experiment Cubes according to a specific set of interface and safety requirement documents. They will remain owners of their experiments and results.

ICE Cubes Facility and Experiment Cubes



External Wired Experiment Cubes

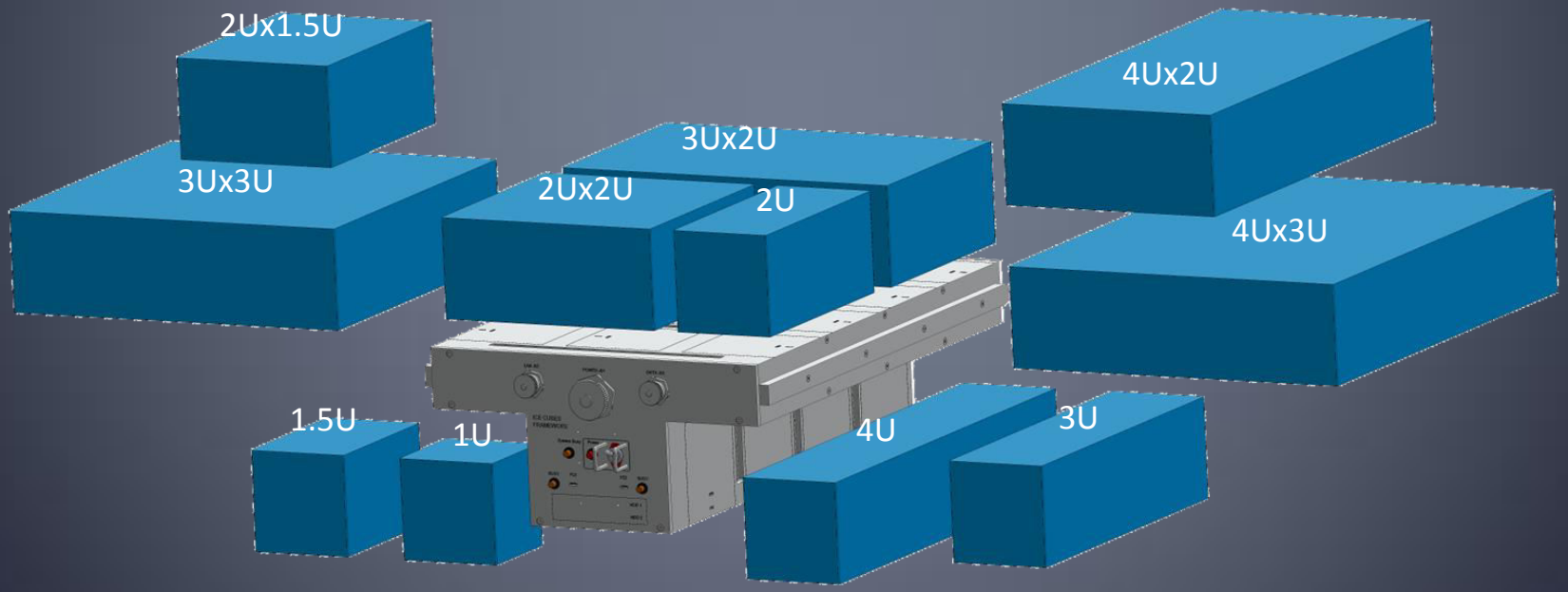


ICE Cubes Facility (ICF)

External Wireless Experiment Cubes (images courtesy ESA-NASA)

ICE Cubes Facility and Experiment Cubes

- Size of the Experiment Cubes set to mimic the CubeSat standard, i.e. 10x10x10cm (1 litre) for a 1U Cube, 20x10x10cm for a 2U Cube, etc with a max of ~45 x ~35 x ~11cm.
- Experiment Cubes using one single connector for both power and data



Experiment Cube Standard Form Factors

ICE Cubes Service characteristics

Time from agreement signature to launch	12 Month (typ)
Launch / return frequency	Every 4 months from beg 2018

Standard Service includes:

- basic Experiment Cube development guidance,
- interface testing,
- arranging experiment certification,
- launch,
- on-orbit installation,
- standard type operations support,
- as well as disposal after operation.

Additional Service can include:

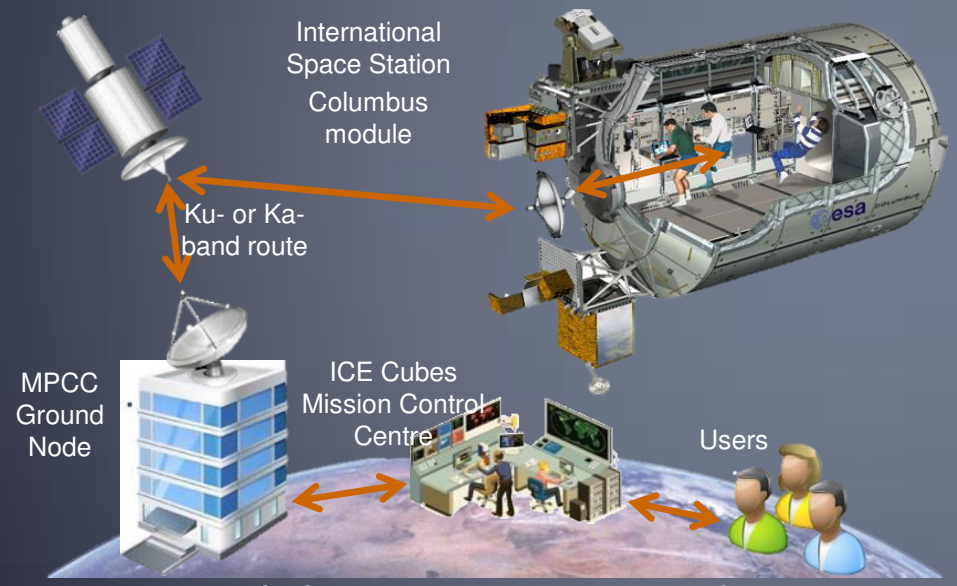
- engineering support for development
- conditioned stowage
- late access to launch vehicle
- return of the hardware
- early access to return vehicle
- dedicated crew activities
- ....

Standard Service:

Price is between 1 and 2 orders of magnitude less than current traditional launchers.

ICE Cubes Service characteristics

- Payload operations from ground, i.e. near real-time telemetry and telecommand
- Data reception and distribution directly to the various user home bases



- To control their Experiment Cubes, users will be provided with an out-of-the-box software suite composed of VPN client, FTP client, Web browser, Mission Control System client and User manual.

ICE Cubes Impact

Affected areas	With ICE Cubes
Socio-Economics	Allows for capacity building
	Spin-in opportunities
	Spin-offs generations
Industry – Non Space	Prompt access to space and microgravity environment
Industry – Space	De-risk innovation and accelerate development
Future Space Exploration	Enabling (private) endeavour and participation to explore

Source: (c) ESA

ICE Cubes Service Future Evolution

ICE Cubes in the context of capacity building

The ICE Cubes service can help to address simultaneous goals in this context:

1. Offer the **opportunity to address research goals** related to sustainable development and to be informed on its potential in space / microgravity.
2. Offer **capacity building opportunity specifically in R&D experiment development and execution**: The setup of the ICE Cubes service is such that it can provide ad-hoc fine-tuned support for the experiment development according to the need / desire / existing capacities.
3. Allow **to position in the economic LEO ecosystem**: Given the current wave of Low Earth Orbit (LEO) commercialization steps, a new LEO ecosystem of organizations / (academic) institutes / companies / … is currently being established. This is the right time for any country / entity to be integrated.
4. Offer a **platform of appropriate / affordable size to be used for start-ups / pilot projects / university projects**.
5. Allow for **match-making collaborations**.

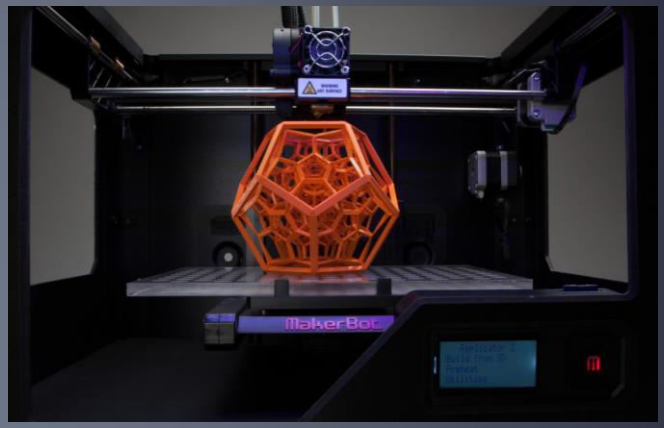
ICE Cubes in the context of capacity building

- Lower cost enables to lower the entry barrier for many more users than before and this **grows the community** nationally and globally.
- Lower cost enables establishing **ecosystems of users** with similar objectives and encourages partnerships. Matching partnerships seems key.
- **Short cycle time from signing flight agreement to receiving results** - fits within the academic year for educational users, enables quicker ROI of results for industry users.
- The service is willing to help not experienced organizations/countries, a.o. by arranging info days and workshops in situ. We would be happy to introduce ICE Cubes to the Regional Centres for Space Science and Technology Education.
- Allows to build a whole campaign of events around your own space experiment.

ICE Cubes potential example usage areas

This platform allows for space research in areas relevant to sustainable development, (beyond Earth observation / telecommunications). Some examples:

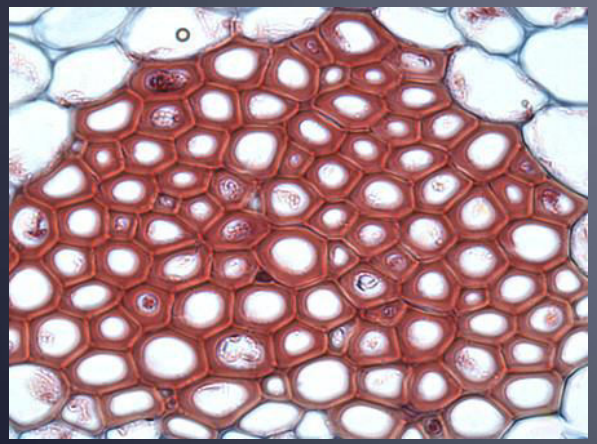
- **in-situ resource utilization / additive manufacturing**
- 3D (bio-)printing to allow to cut down on prototyping, waste, and transportation



- investigation of **food production & processes** for increasingly harsh environments given climate change
- investigation and refinement of microalgae culturing
- increased understanding of plants and micro cultivation systems behaviour in space to increase production / improve quality of food on Earth

ICE Cubes potential example usage areas

- generation of **biotech materials and processes** for therapies and eco-environmental interventions (e.g. waste recycling, pollution control and abatement)
- re-cycling system for water previously used for washing or food preparation



- **drugs R&D optimisation and testing**
- monitoring system for rapid response to contamination, ensuring safety of sterile pharmaceutical products
- microfluidic lab on a chip applications in cell, molecular, plant biology / microbiology, pharmaco-chemical research

Conclusion

- Through this way, the ICE Cubes service allows any entity **to stimulate their capability to achieve research, social & economic goals and nurture innovative solutions**.
- Similar as the cubesat boost, this new ICE Cubes service allows any country / agency / organization / university / private entity to access space / space research and increase the capacity on space experiment development now for **the internal environment of the International Space Station.**
- This could allow for technological leap-frogging for emerging countries.
- As such the ICE Cubes service provides for a very appealing **key technological solution and innovative approach for capacity building** by providing access to space for the broad community.

If you have an idea or want to discuss, come & see us or contact us!

Back-up slides

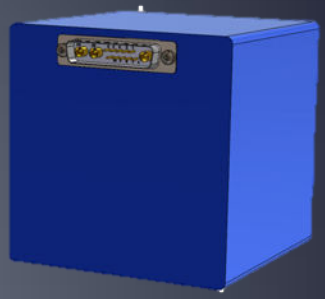
ICE Cubes Service Characteristics

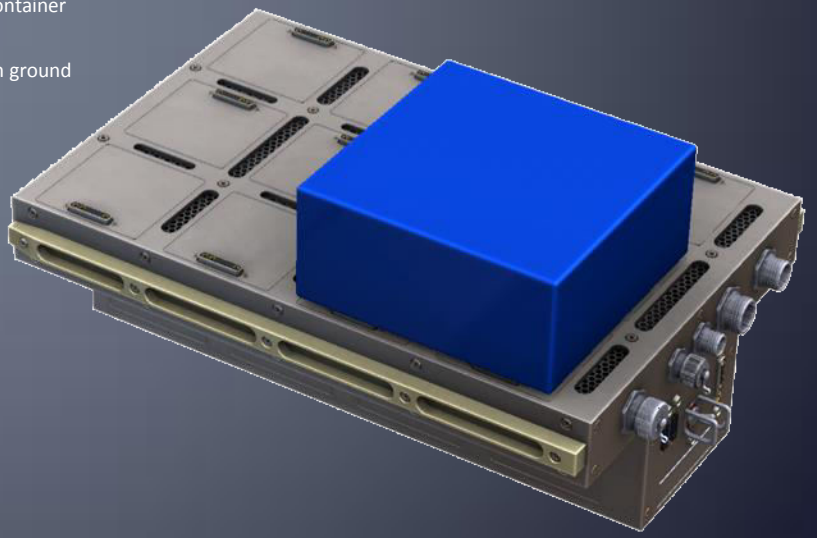
The ICE Cubes programme will establish:

- A permanent multipurpose facility (**ICE Cubes Facility**) on board the International Space Station allowing for the accommodation and exploitation of small payloads and experiments (**Experiment Cubes**)
- A set of special-purpose or repeated-use multi-unit Experiment Cube which can be used by multiple users (e.g. fluorescent microscope special cube)
- The ground infrastructure for the management of the ICE Cubes Facility and the Experiment Cubes
- The end-to-end service allowing utilization of the ICE Cubes Facility and of the aforementioned multi-unit Experiment Cube
- Ad-hoc engineering services (e.g. design, development, assembly, testing), as needed / desired.

ICE Cubes Facility and Experiment Cubes

ICE Cubes Facility Framework





ICE Cubes Facility and Experiment Cubes

Experiment Cubes characteristics

- Power profiles: 5V and 12 V, 10W per liter, up to 40.5 W max per Cube
- Thermal cooling: Forced air ventilation
- Operations: Real-time telemetry/telecommand to/from ground
- Data: Downlink up to 4 Mbps
  Uplink up to 0.5 Mbps
- Communications: standard internet protocols (IPs)

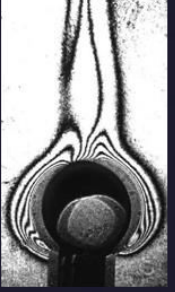
ICE Cubes special diagnostic cubes

In the frame of the ICE Cubes Service special purpose Experiment Cubes will be developed provided with diagnostics to support different areas or research. The special cubes will remain on board the ISS and will temporary host replaceable experiment containers/cartridges. This approach aims at providing solutions for Cube level mini-facilities that may reduce cost of the development and launch of the various branches of experiments.

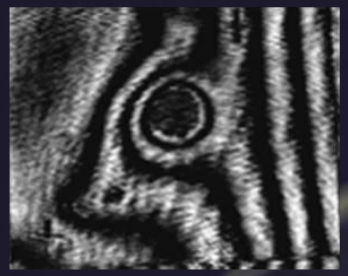
Currently undergoing a survey of the possible interests/requests by the potential users or at start of development are:

- Fluorescent microscope
- X-Ray diffractometer
- Organ-on-a-chip technology testbed
- Others under investigation

Scientific Opportunities and Possible Areas of Usage - Fluids



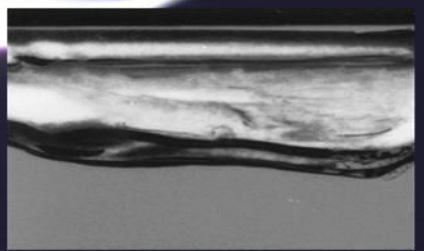
Credits: ULISSE / Medes



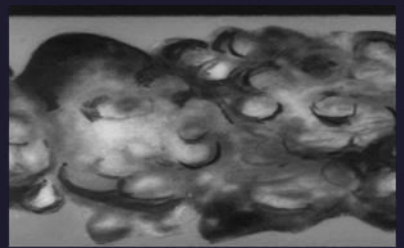
Credits: NASA

Credits: ALTECSPACE

Credits: ULISSE / Medes



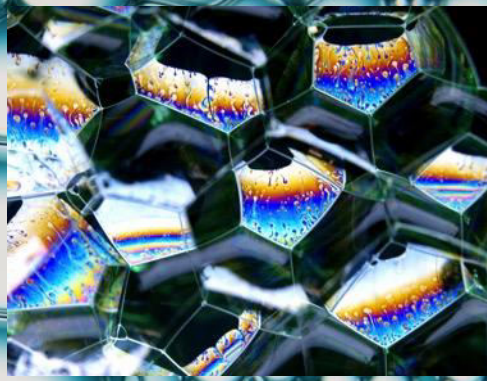
Credits: ULISSE / Medes



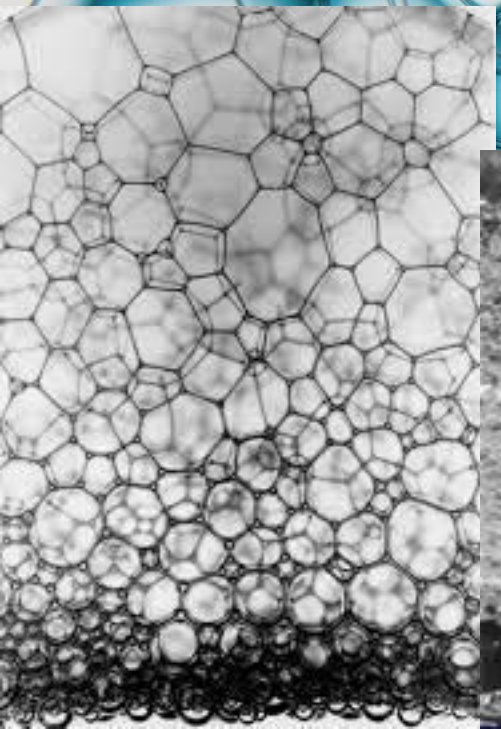
Scientific Opportunities and Possible Areas of Usage
Foams

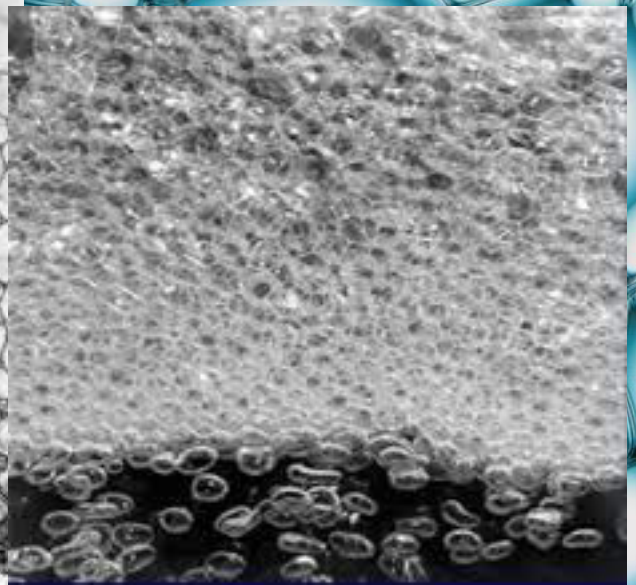
Credits: foams@aber

Credits: NASA/ ESA

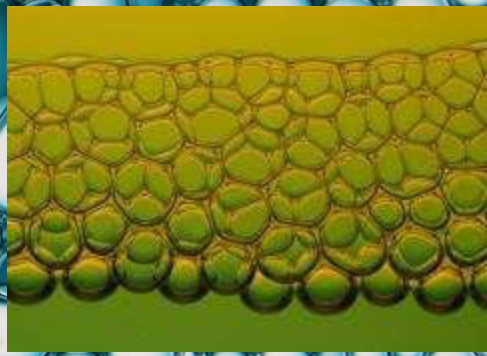


Credits: LPS, Universite de Paris



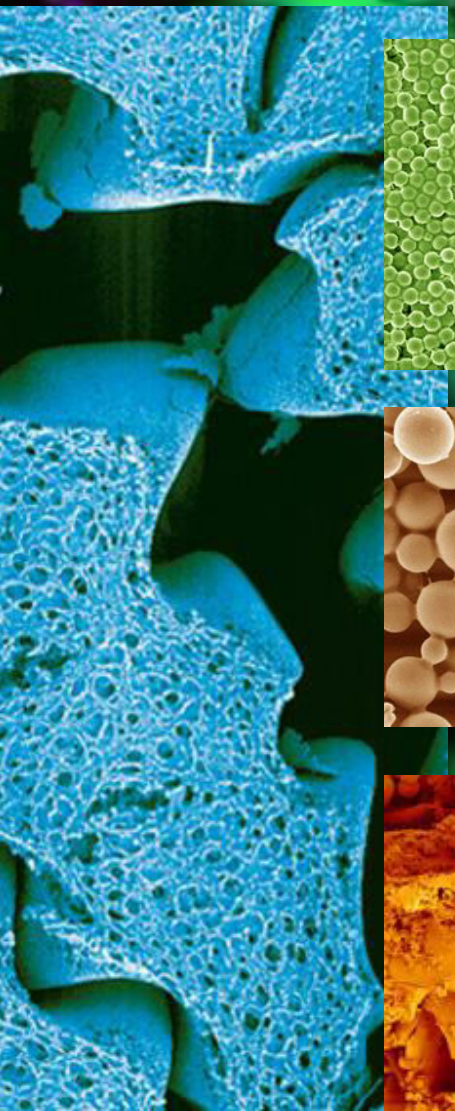


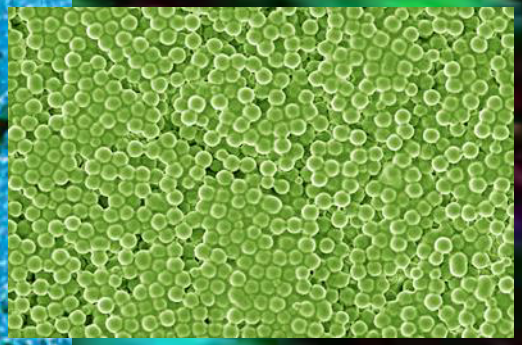
Credits: GRASP, ULG

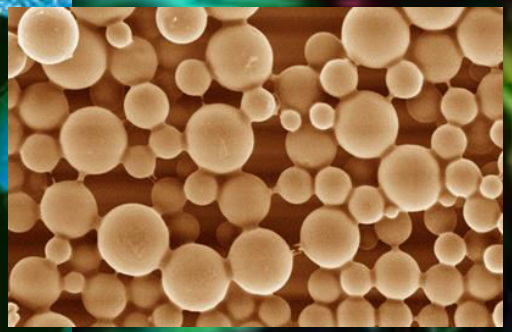


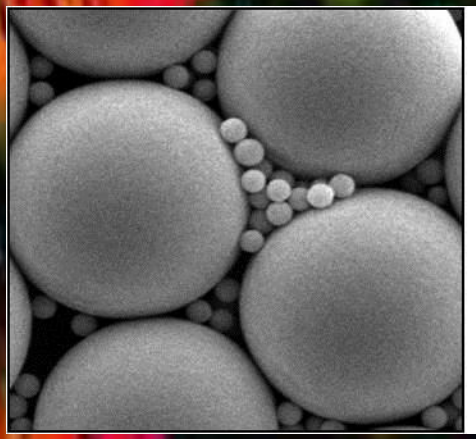
Credits: MPI of colloids and interfa

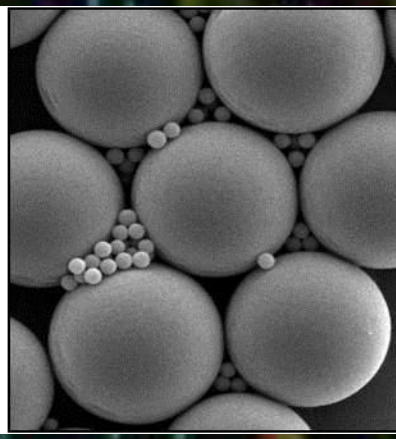
Scientific Opportunities and Possible Areas of Usage
Colloidal chemistry / Nanoparticles



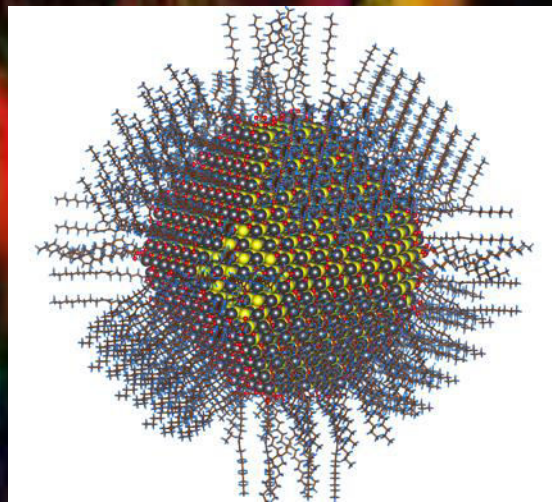






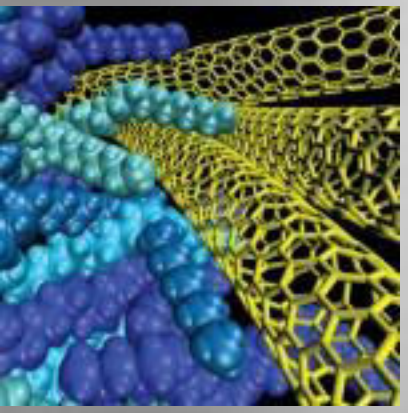


Credits: P.M. Chaikin and A.D. Hollingsworth, New York University

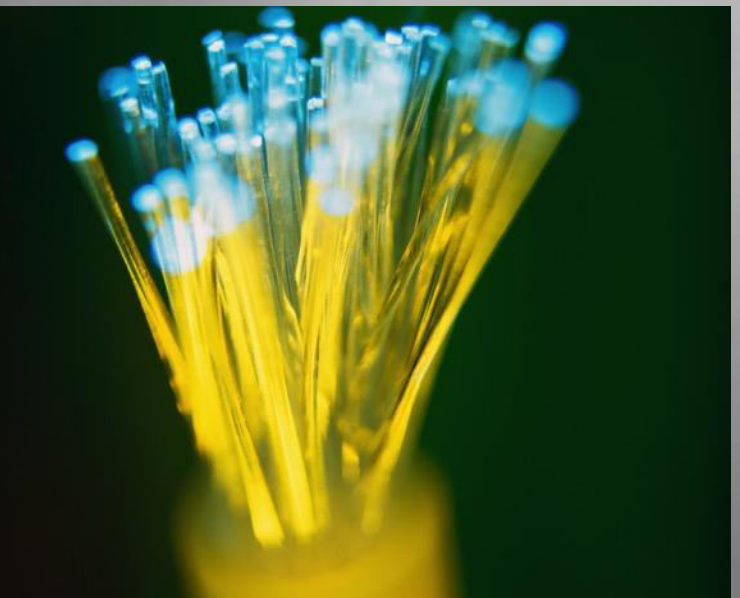


Scientific Opportunities and Possible Areas of Usage
Materials

Credits: JAXA



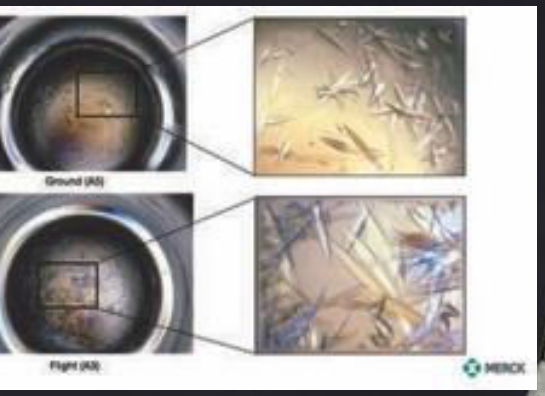
Credits: ALTECSPACE



Credits: ESA

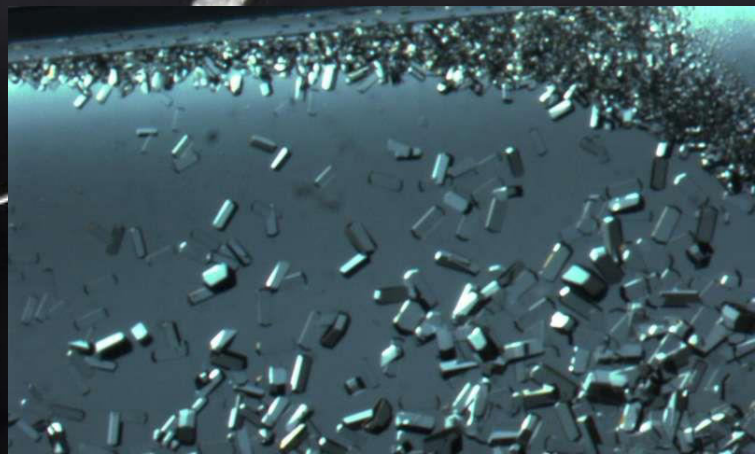
Scientific Opportunities and Possible Areas of Usage
Proteins crystallization

Credits: NASA@aber



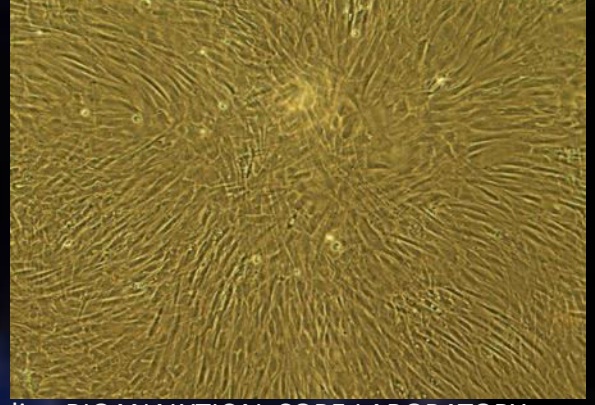
Credits: MERCK

Credits: NASA

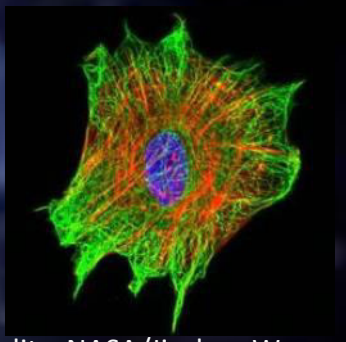


Credits: Lawrence DeLucas

Scientific Opportunities and Possible Areas of Usage
Radiation / Radiation Biology



Credits: BIOANALYTICAL CORE LABORATORY



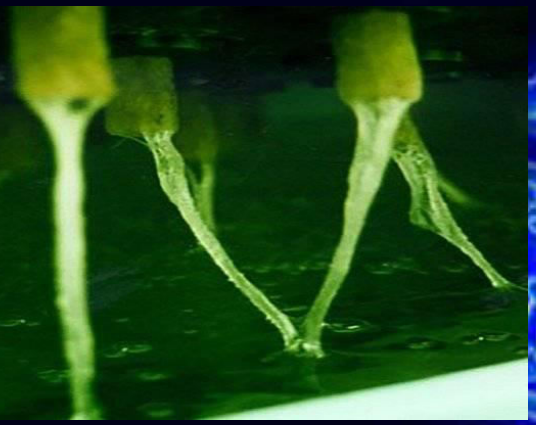
Credits: NASA/Jiashan Wang

Credits: NASA

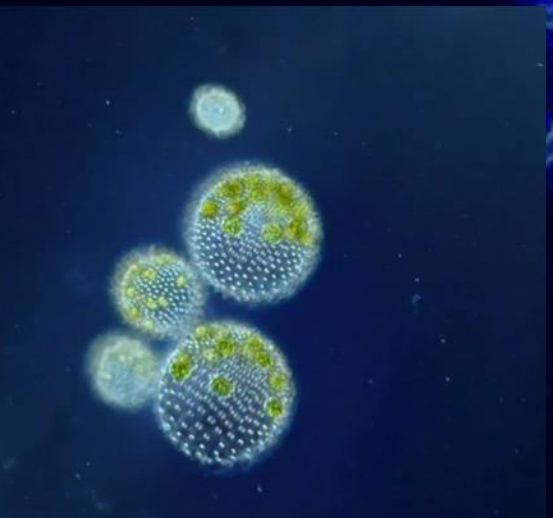
Credits: NASA@aber

Scientific Opportunities and Possible Areas of Usage
Space Biology / Microbiology / Cell Biology / Plants

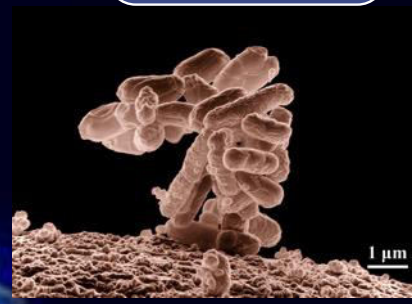
ICECUBES



Credits: ESA

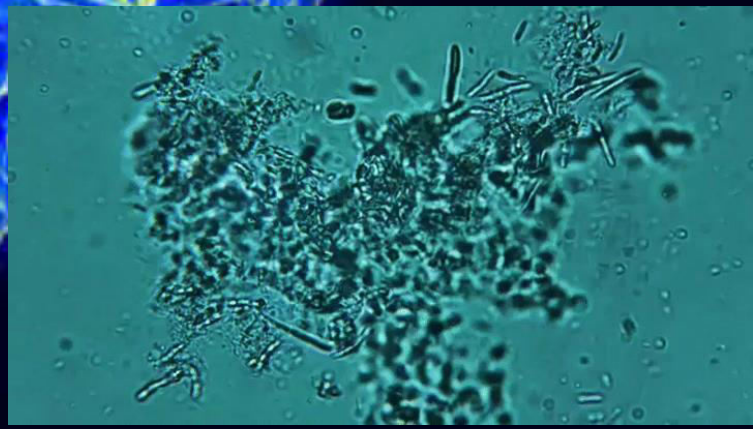


Credits: NASA Genelab



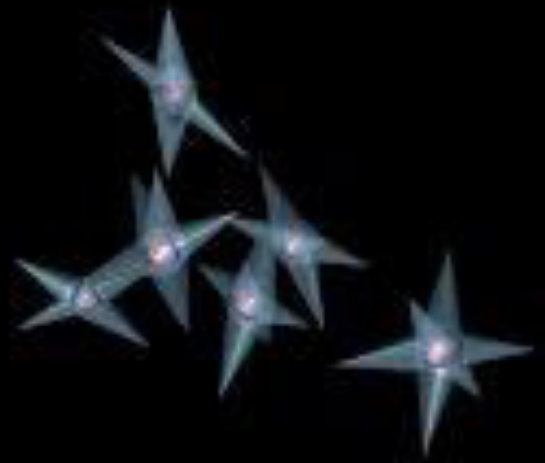
Credits: Eric Erbe, Wikimedia

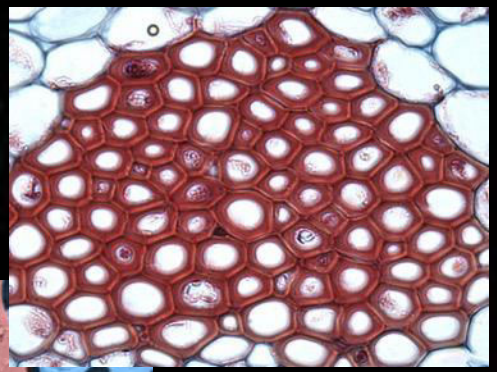
Credits: NASA

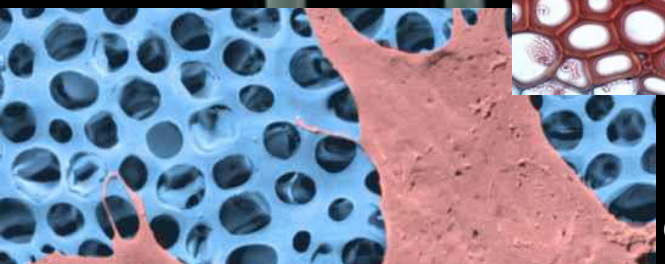


Credits: NIH / NIBIB

Scientific Opportunities and Possible Areas of Usage
Stem Cell Research / Regenerative Medicine / 3D tissue Engineering







Credits: Swansea Univ

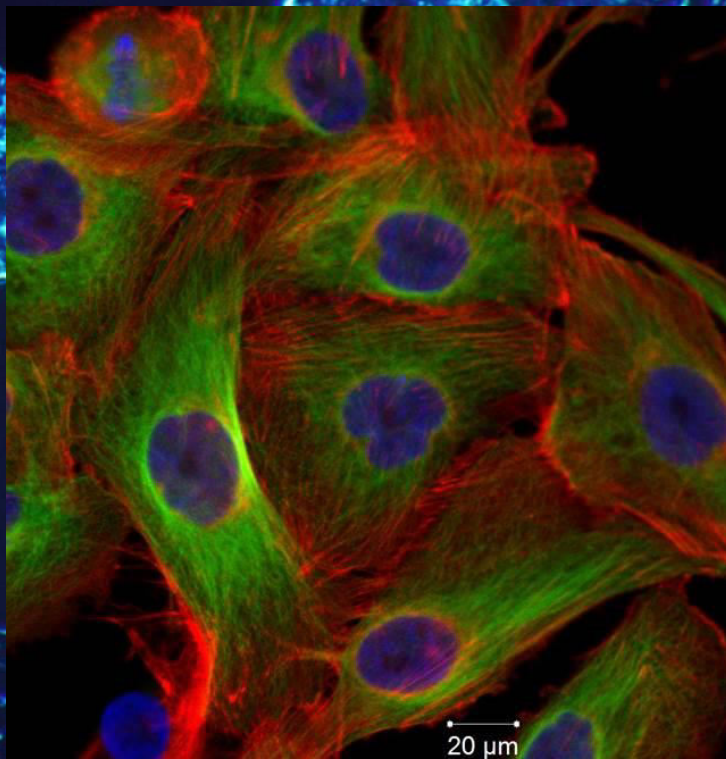
Credits: MyMicrogravity

Scientific Opportunities and Possible Areas of Usage
Cancer research / pre-clinical testing

Credits: Emulates

Credits: NASA

Credits: NASA



Scientific Opportunities and Possible Areas of Usage

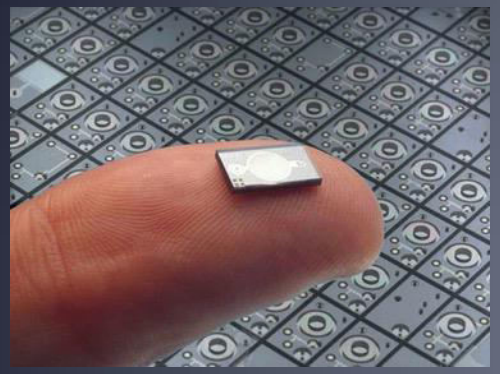
Examples of devices that can be used inside the Experiment Cubes or that can be subject of technological development and qualification activity:

Micro sensors	
Liquid capacitive inclinometers	Capacitance
Infra-red sensor	Resistance
Electro-optical sensor	Camera
Spectrophotometer	Oscilloscope
Biosensor	Gyroscope
Electro-chemical sensor	Pressure sensor
Temperature sensor	RF sensor
Humidity sensor	Magnetic

Micro actuators	
Magnetic motor	Solenoid
Piezoelectric	Thermal
Capacitive	Speaker
LEDs / LCDs	Galvanometer
Valves	Fans
Heater	Peltier cooler

Scientific Opportunities and Possible Areas of Usage

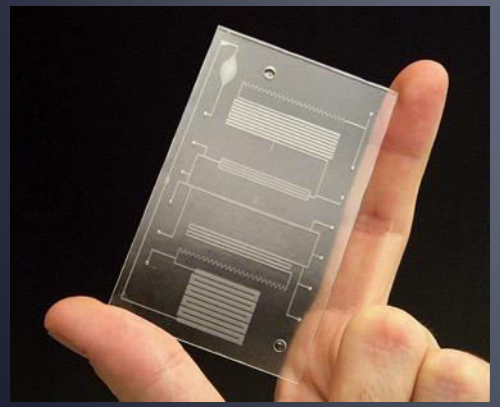
Micro Electro Mechanical Systems (MEMS)



Applications in opto-electronics, micro-electronics, chemistry, biotechnology / bioengineering, tools manufacturing etc.:

- Blood pressure sensors
- Bio-MEMS
- Fluid accelerations such as for micro-cooling
- Micro-scale energy harvesting
- Piezoelectric Micromachined Ultrasonic Transducers (PMUT)
- Optical switching for data communications
- MEMS gyroscopes

Microfluidic lab-on-a-chip



Applications in cell, molecular, plant biology / microbiology, pharmaco-chemical research etc.:

- Biomaterial processing (e.g. blood samples preparation, nucleic acids extraction)
- Real-time Polymerase Chain Reaction (PCR)
- Biochemical assays (e.g. fluorescent immunoassays)
- Microarrays
- Protein crystal growth
- Tissues analysis
- Plant on-a-chip (e.g. characterizing *A. Thaliana* pollen tube guidance)
- Dielectrophoresis
- Ion channel screening
- Testing the safety and efficacy of new drugs
- Organ-on-a-chip

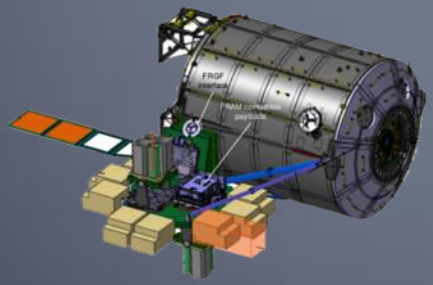
ICE Cubes Service Future Evolution

Internal ISS Experiments

- Specialized sub-facility labs with diagnostic capabilities
- Crew interaction applications

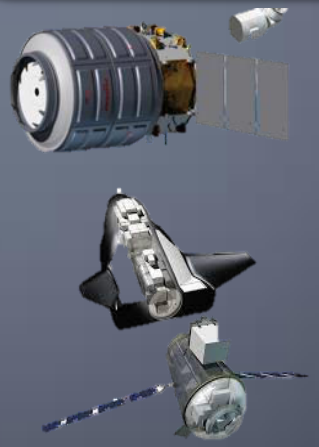
External ISS Experiments

- Facility for deployment of external payloads through ISS Airlock(s)



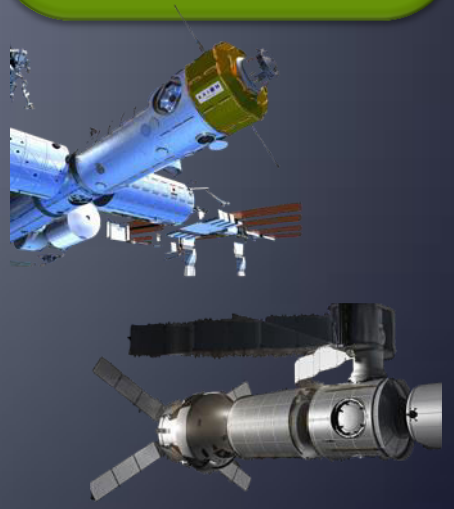
Free flying and sub-orbital Experiments

- Facility for pressurized payloads in e.g. Orbital Cygnus, Dream Chaser, Space Rider
- Facility for utilization in balloons and/or Sounding Rockets



Post ISS and beyond LEO

- Possible collaborations with commercial platforms
- Possible commercial exploitation of a Cis-lunar Station



About Space Applications Services

Space Applications Services NV/SA is an independent Belgian company founded in 1987, with a subsidiary in Houston, USA and an office in The Netherlands. Staff of 90, and growing.

Our aim is to research and develop innovative technology, solutions and services for the aerospace and security markets and related industries:

- Research and develop technologies for specific domains or subsystems which may be used stand alone or integrated within an overall system.
- Services to design, develop and integrate scientific and technology payloads, mission critical systems, facilities and command and control centres. Including laboratory, workshop and clean room.
- Services to operate facilities and command and control centres and to train persons to perform operations.

The company capabilities cover system, software and operations engineering and our activities include manned and unmanned spacecraft, launch/re-entry vehicles, monitor and control, robotics and information systems.

www.spaceapplications.com

European Space Research and Technology Centre
Noordwijk, The Netherlands

Space Applications Services Noordwijk Office, The Netherlands

European Astronaut Centre
Cologne, Germany

aerospace applications

Aerospace Applications North America Inc., Houston, USA

spaceapplications SERVICES

Space Applications Services NV HQ, Zaventem, Belgium

Belgian Institute for Space Aeronomy
Brussels, Belgium