ICE Cubes

A Fast –Track, Low-Cost Service for Small Experiments to The ISS

1st Symposium on Space Educational Activities

Padova

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Outline of the Presentation

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- System Overview
- Service Characteristics
- Programmatic Information
- Scientific Opportunities and Possible Users
- Socio-Economic Benefits
- Potential Research Instruments in Experiment Cubes

Motivation & Objectives 1/

- The **International Commercial Experiment Cubes (ICE Cubes) Service** will provide rapid, simplified, low-cost access to the International Space Station (ISS), offering the opportunity to increase its use for the remaining lifetime.

- The service, created and managed by Space Applications Services, will enable any organization, public or private entities or individual, such as universities, academic programs, high schools and research centres or companies to perform experiments on board the ISS.

- Space Applications Services is currently developing, supported by the European Union, the ICE Cubes on-orbit facility and the relevant ground infrastructure, aiming at a launch to and installation in the ISS towards the end of 2017.

This project has received funding from the European Commission's H2020 Framework Program for research, technological development and demonstration under grant agreement No. 666815.

Motivation & Objectives 2/

One of the ICE Cubes service's objectives is to increase the possibilities of access to the ISS for experiments selected, developed and operated outside the typical scientific programs established by the Space Agencies (e.g. the ESA ELIPS).

The absence of a peer review allows for a fast track approach.

The characteristics of "plug and play" and end-to-end service are very attractive, especially for universities and research centres from the "developing space-faring nations".

The ICE Cubes service is particularly suited for:

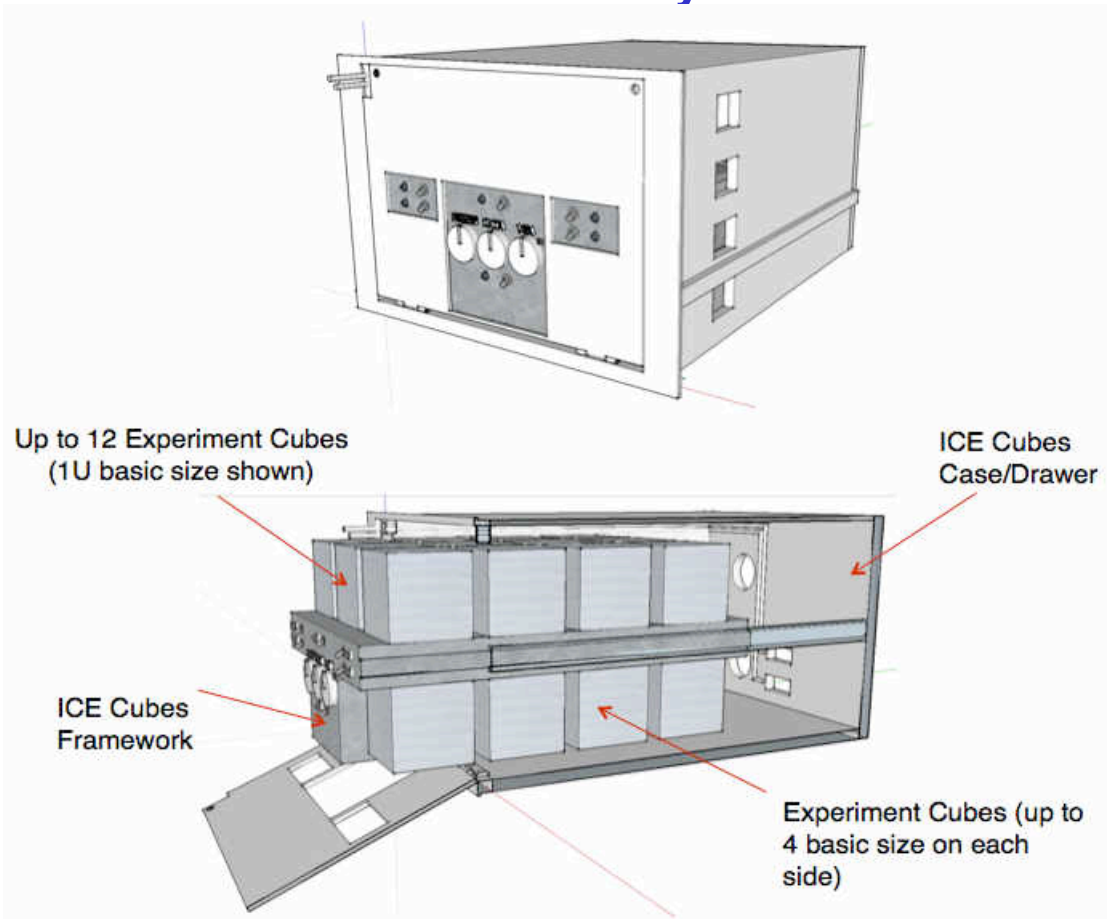
- Experiment Cubes belonging to the general 'low gravity research and educational' area
- Experiment Cubes characterized by higher power needs, focusing on technological development and TRL rising of spacecraft components and technology

System Overview 1/

The system on board the ISS will consist of a multipurpose facility composed of:

- **Framework:** hosting up to 20 locations for Experiment Cubes and providing power, data connectivity and overall facility management.
- **Experiment Cubes:** standardized plug-and-play research modules (1U = 10cmx10cmx10cm) or modular combinations of that basic size.
- **Case/Drawer:** An independent case or rack drawer containing the Framework and the Cubes and interfacing to the ISS infrastructure.

System Overview 2/



ICE Cubes facility

Experiment Cubes in launch configuration (concept)

System Overview 3/

Resources allowable for the Experiment Cubes

Power: Scenario of multiple power profiles delivered via a single connector, e.g.

5V @ 2.0 A, 10 W
12V @ 3.0 A, 36 W

Actual scenario to be finalized in the preliminary design phase

Heat sink/removal: Constraints, as related to the dimension of the Cubes, are under definition in the frame of the preliminary design phase.

Command/Data: LAN connection to ISS infrastructure

Near real-time telemetry/telecommand (TM/TC) and deferred data downlink/ download

Operations: Facility monitored and operated from ground

Experiment Cubes operated directly from user's home base

System Overview 4/

Key Elements of the ICE Cubes approach

The Framework:

- Developed according to criteria of long-duration mission and qualified according to standard approaches.
- Parts manufacturing will use only qualified materials and qualified processes.
- No critical technologies envisaged.

The Experiment Cubes:

- They may be equipped with commercial off-the-shelf (COTS) components, which significantly reduce the cost and duration of development and allow for the utilization of the latest technologies.
- Users will develop their own Experiment Cubes according to a specific set of interface and safety requirements documents released by Space Applications Services.
- Users will be responsible of the reliability and performance of their own Cubes.

Service Characteristics 1/

The **ICE Cubes service** will be set up and maintained by Space Applications Services, with the following characteristics:

- **Fast-track, low-cost:** ICE Cubes engineering services will be provided to interface with the Agency and Launch Authorities from the moment a user signs the contract until the launch. Standard service will be provided at a fixed cost.

- **Complete 'End-to-end Service':** Space Applications Services will further ease the process by providing operations services to handle and monitor the on-board operations and to take care of the scientific data and/or experiment retrieval.

Service Characteristics 2/

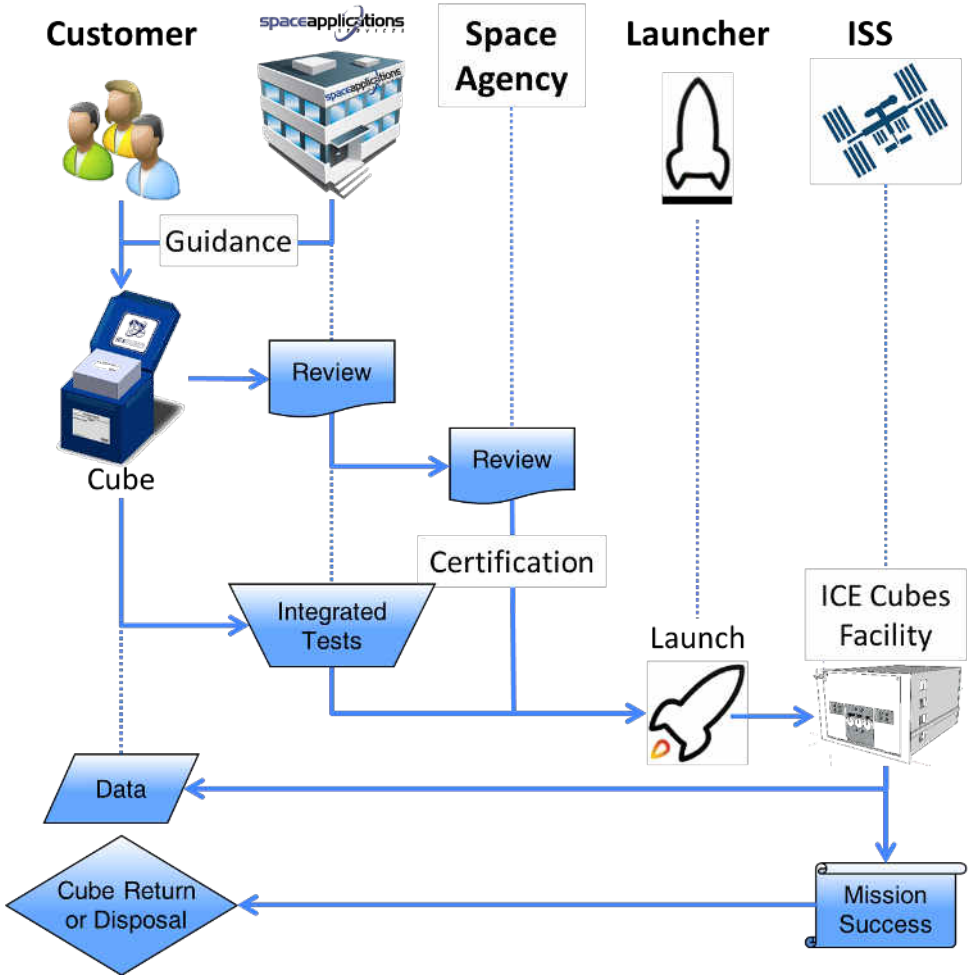
To support the ICE Cubes Service, Space Applications will develop:

- An Engineering Service
- An Operations Service
- A Sales Service

Service Characteristics 3/

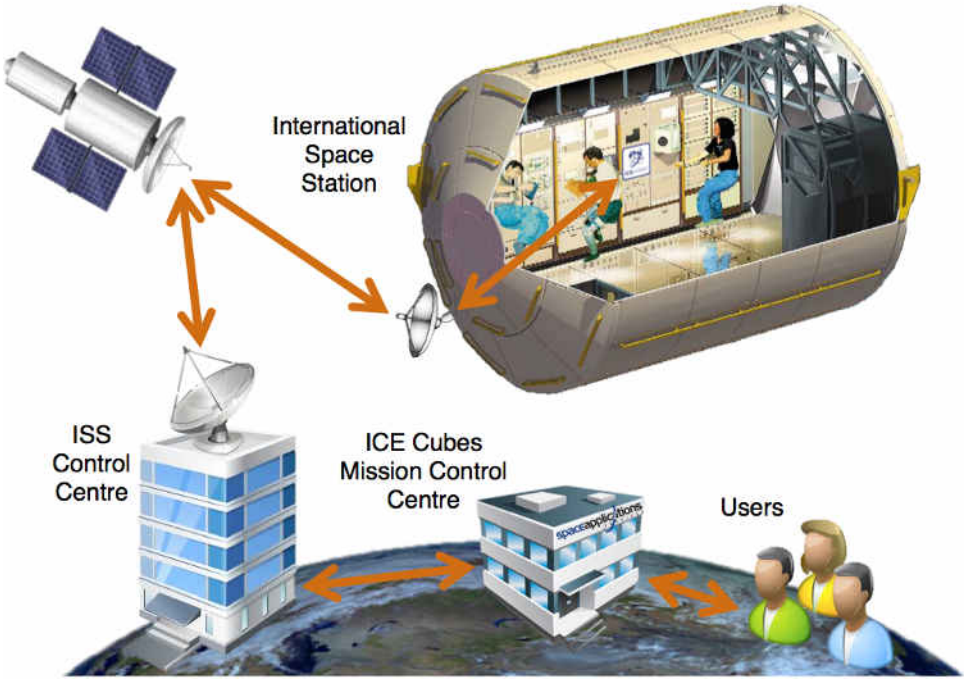
- **Engineering Service: (Preparation & Implementation Phase)**
  - Engineering assistance to Experiment Cubes developers/integrators
  - Handling contacts with Space Agency and Launcher Authorities
  - Generation of Interface Control Document (ICD) and Safety Data Package (SDP)
  - Handling of Safety Reviews
  - Assistance in the preparation of the payload operations concept
  - Ensuring/booking uplink and downlink capabilities
  - Ensuring/booking Crew time for installation / de-installation and data retrieval
  - Handling disposal or booking hardware download capability as requested
  - Maintenance of a Web catalog of miniaturized space-proven/qualified COTS electronics parts and instruments

Service Characteristics 4/



Service Characteristics 5/

- **Operations Service:**
  - Running payload operations from ground (near real-time TM/TC)
  - Receiving and distributing data to the various customers home bases (via a dedicated open source Mission Control Software deployed by Space Applications Services)



Service Characteristics 6/

Time from contract signature to readiness for launch	• 12 months (initial) • 9 months (target)
Cubes delivery for launch	Late access approach possible
Launch	Soft stowed in foam/Nomex® containers
Typical lifetime of each experiment on-board ISS	1 month
Data transfer	• Near real-time • Postponed downlink • Physical download (e.g. via USB supports)

Prices list will be established considering parameters like: mass, needed resources, duration, additional requested services (e.g. level of engineering support)

Programmatic Information

The program has started on June 1st, 2015 and is composed of the following phases:

Phase	Period	Status
Initial Development Program	2015 - 2017	Funded
Commercial Service	2018 - onward	Established on commercial basis
Follow-on development of additional capabilities	2018 - onward	Established on commercial basis

Scientific Opportunities and Possible Users

Up to now, ICE Cubes has received Letter of Interest (LoIs) from 10 universities (7 European, 1 South African, 2 South American) in the fields of physics, astronomy, aerospace / mechanical engineering etc., as well as from the European Low Gravity Research Association (ELGRA).

The International Space University (ISU) agreed to provide the first Experiment Cube as pilot user of the ICE Cubes facility and service.

Socio-Economic Benefits 1/

ICE Cubes service will increase the possibilities for the science and industrial community to fly small experiments to the ISS as part of –or complementing– the programs already established by the various Agencies.

The ‘plug-and-play’ Experiment Cubes can be very attractive to and can act as a catalyst for universities, high schools and research centres, also from ‘developing space-faring nations’.

The ICE Cubes service fits perfectly well in the frame of STEM (science, technology, engineering, and mathematics) education activities, in this way supporting hands-on activities, so important in the preparation of the next generation of space scientists and engineers.

Enabling space on-orbit experimentation to become part of the standard curriculum for M.Sc. & Ph.D. will engender a significant increase in interest and participation in space.

The emphasis on low-mass, low-energy devices needed for space will also drive forward development in the areas of MEMS, micro-technologies, etc., which will also have direct terrestrial benefits.

Socio-Economic Benefits 2/

Possible Users

Microgravity

- Fluid science
- Materials science
- Plasma physics
- Human physiology
- Plant biology
- Cell and molecular biology
- Biotechnology
- Microbiology

Space environment

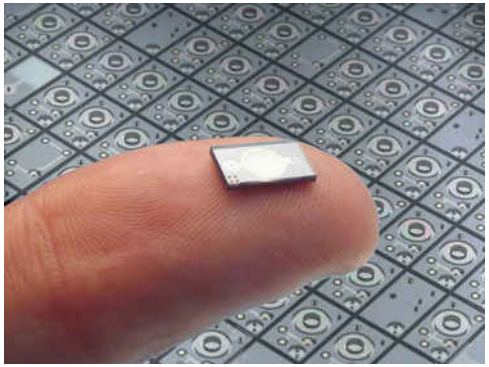
- Radiation measurement
- RF studies
- Magnetic fields studies

Technology demonstrations

- 3D Printing / Tools manufacturing
- In-space testing of components
- In-space testing of systems
- Receivers / Transmitters
- Sensing / actuating devices
- Robotics
- Chip-scale atomic clock

Potential Research Instruments in Experiment Cubes 1/

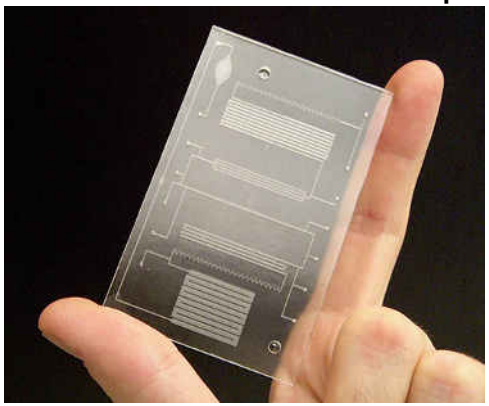
Micro Electro Mechanical Systems (MEMS)



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
- Precision accelerometer
- Interferometers
- Switches for laser signals

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

Potential Research Instruments in Experiment Cubes 2/

Microscopes:

Different types for different purposes:

- Optical
- Electron
- Fluorescence
- Confocal
- Scanning probe (e.g. atomic force microscope)

Micro interferometer:

Chip-Scale Atomic Clock (CSAC)

ICE Cubes

Fast-Track, Low-Cost Service For Small Experiments To The ISS

For more information and to assess the flight possibilities of your next experiment, please contact:

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www.icecubesservice.com

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