UNOOSA WEBINAR SERIES

TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY

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WHO AM I ?

Leuven, Belgium
MSc Mathematics / Physics
PhD Plasma-Astrophysics

Started with Space Applications Services, Brussels in 1999

Supported EADS (Airbus) on ATV spacecraft
Coordinated operations ISS science payloads

ESA Mission Science Office cross-agency coordination ISS research & technology & edu

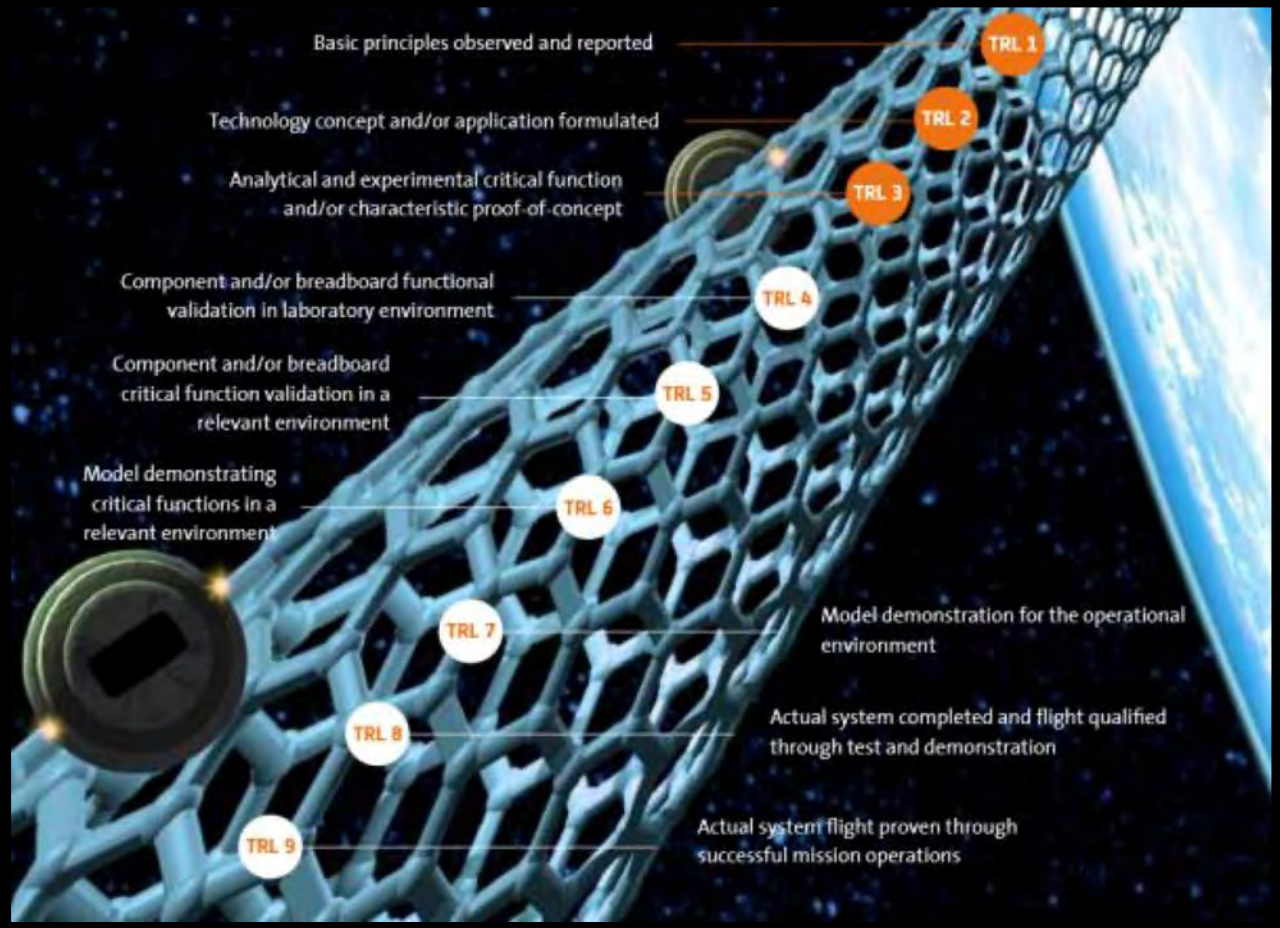
ICE Cubes space access service for research, technology & education

WHY TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY ?

- Demonstration / validation of technologies, processes and systems in relevant space environment
- Validation of space technologies for satellites, for spacecraft, …
- Technology readiness level (TRL) raising
- Proof-of-Concept of operations, training, crew interfaces, logistics
- Obtain operational knowledge in a relevant environment
- De-risking
- In-space engineering research
- Capacity building and support of education activities in engineering curricula
- Technology market creation & development

TECHNOLOGY DEMONSTRATION - TERMINOLOGY

- Technology Readiness Level (TRL)
- In-Orbit Demonstration / Validation (IOD/IOV)
- Proof-of-Concept
- Commercial-off-the-shelf technology (COTS)



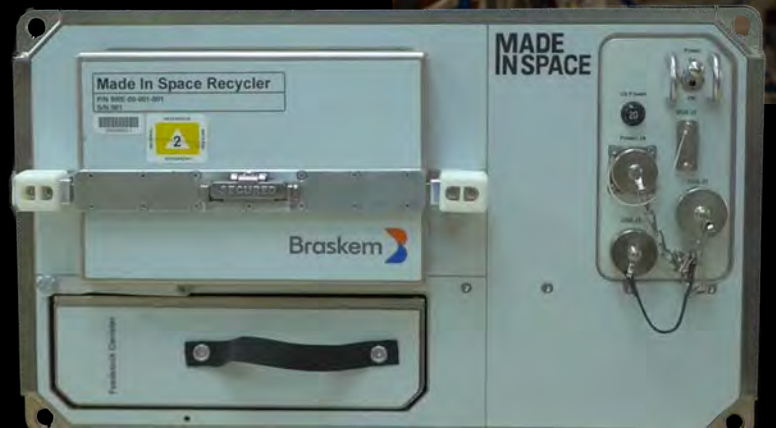
Credit: ESA

WHAT TECHNOLOGY DEMONSTRATION ?

3D PRINTING, ADDITIVE MANUFACTURING, RECYCLING, SOLDERING

- TOWARDS SUSTAINABLE, FLEXIBLE SPACE MISSIONS
- ON-DEMAND FABRICATION, REPAIR AND RECYCLING
- MODULAR ARCHITECTURE / INFRASTRUCTURE
- IN-SITU RESOURCES UTILIZATION
- REDUCE COST OF MISSION
- EXTENDING MISSION LIFE
- INCREASE FEASIBILITY AND SELF-SUFFICIENCY
- PROFOUNDLY CHANGE SPACE EXPLORATION

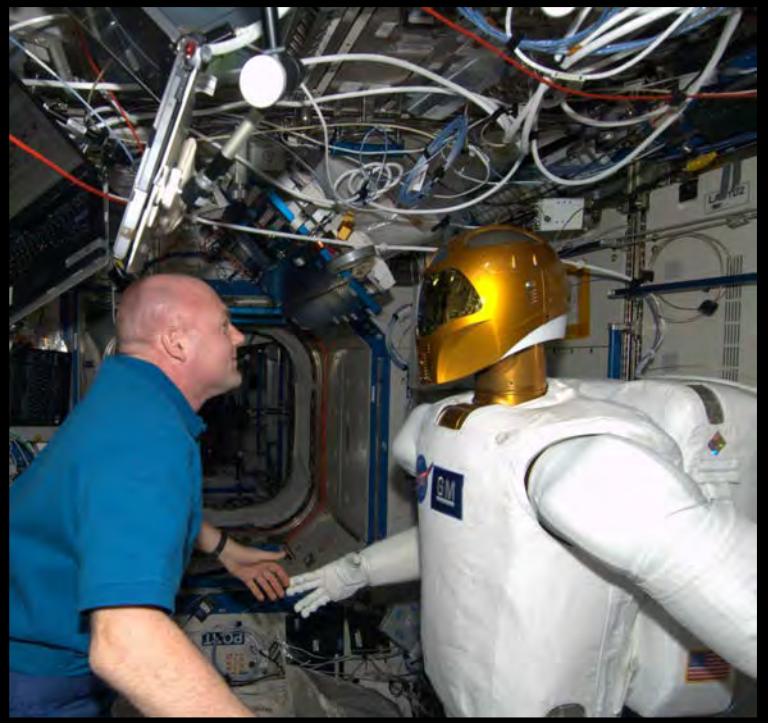
3D PRINTING IN ZERO-G – MADE IN SPACE



COMMERCIAL POLYMER RECYCLING FACILITY – MADE IN SPACE

Robotics, Tele-Robotics and Autonomous Systems

- Dynamic response of the system, cannot replicate on earth
- Performance and operational concepts of (tele-)robotic systems
- Training and exposure of AI / robotic systems
- Upstream activities
- Possible spin-offs

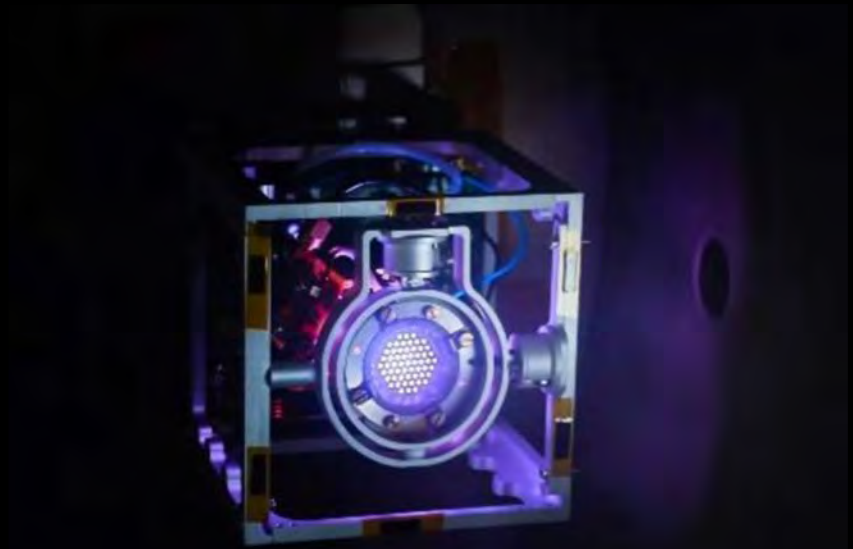


Robonaut - NASA

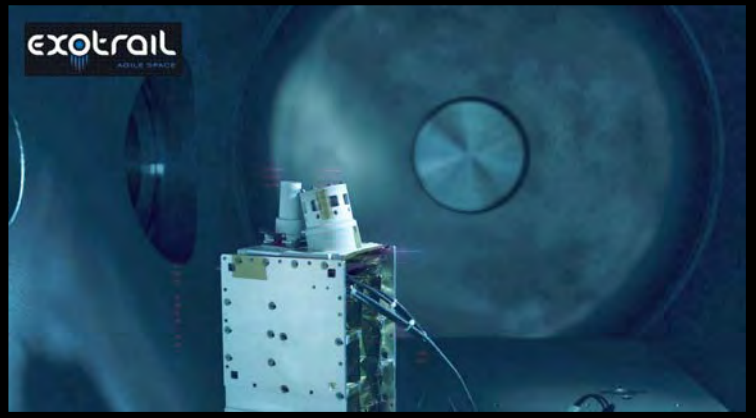
GITAI – J-SPARC - BISHOP

In-Space Propulsion

- Electric, chemical, hybrid, waste gas, nuclear or propellant-less propulsion systems
- Spacecraft reliability and lifetime
- Reducing the cost of long-duration missions
- Gaining operational run time in the microgravity, vacuum and thermal environments of space
- Gaining experience in fuel flow management and performance
- Linking to in-space refueling



Thrustme – Spacety- Iodone-propelled



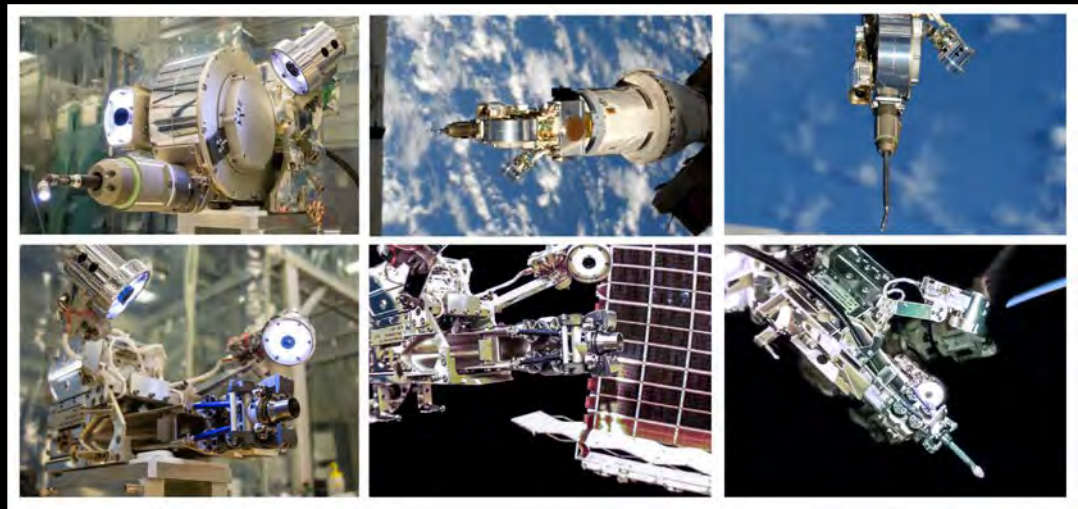
Exotrail – ExoMG Hall-effect electric propulsion

Satellite servicing / refueling

- Activities spanning fixing, improving, and reviving satellites
- Refuel, repair, replace or augment an existing asset in space
- Allows for satellite life-extension and upgradability
- Assembling massive life-seeking telescopes in space, refueling and repairing spacecraft on journeys to distant locations, …
- Demonstrating the foundational capabilities in orbit
- Context of space debris mitigation / reduction

Furphy – Orbit Fab

Robotic Refueling mission 3 – NASA

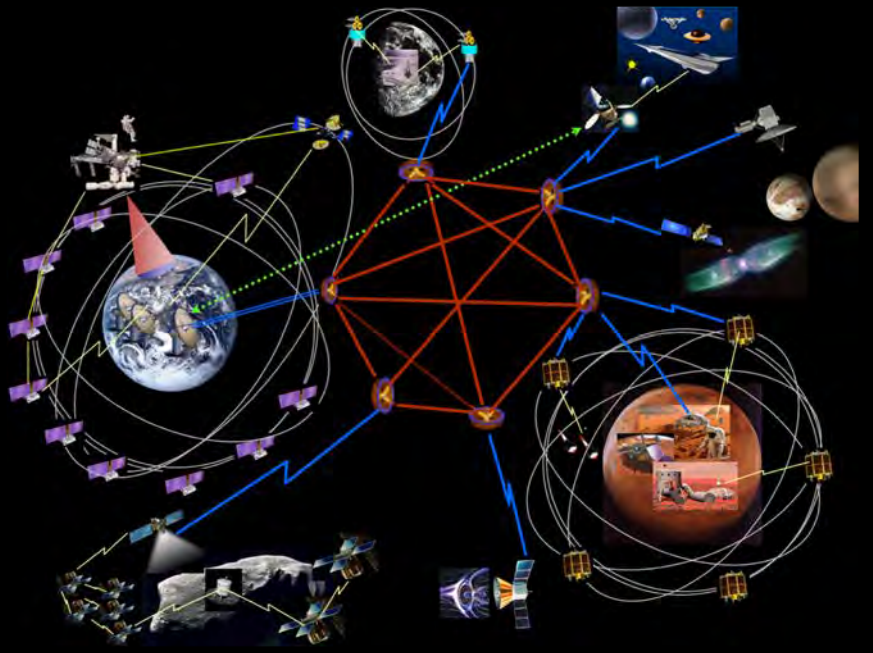


Communication and Navigation

- Navigation systems demo, advanced or automated RDV and docking demo
- Communication delay tolerance, elimination of space communication architecture bottlenecks, thus increasing throughput of the integrated systems
- Testbed for deployable antennas, optical cross-links, characterize on-orbit performance

Spheres ReSwarm – NASA MIT

Delay/Disruption Tolerant Networking (DTN) - NASA



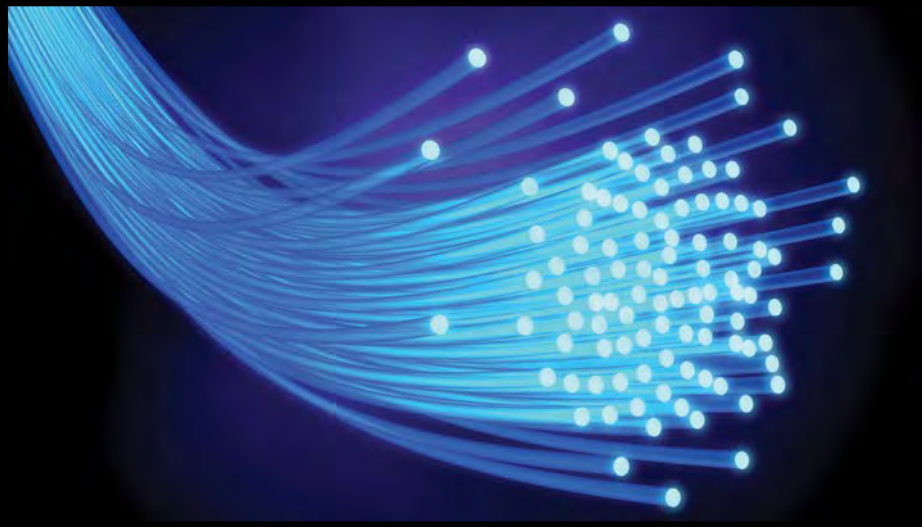
THERMAL CONTROL

- TRANSPORT, STORAGE, AND REFRIGERATION DEVICES , RADIATORS, AND INSULATION
- LONG-TERM EFFECTS OF THE SPACE ENVIRONMENT ON THERMAL CONTROL COMPONENTS
- RE-ENTRY THERMAL PROTECTION
- SPACECRAFT THERMAL TECHNOLOGIES TO MAINTAIN CRYOGENIC SYSTEMS AND THERMAL CONTROL OF A SPACECRAFT'S SYSTEMS AND INTERNAL ENVIRONMENT

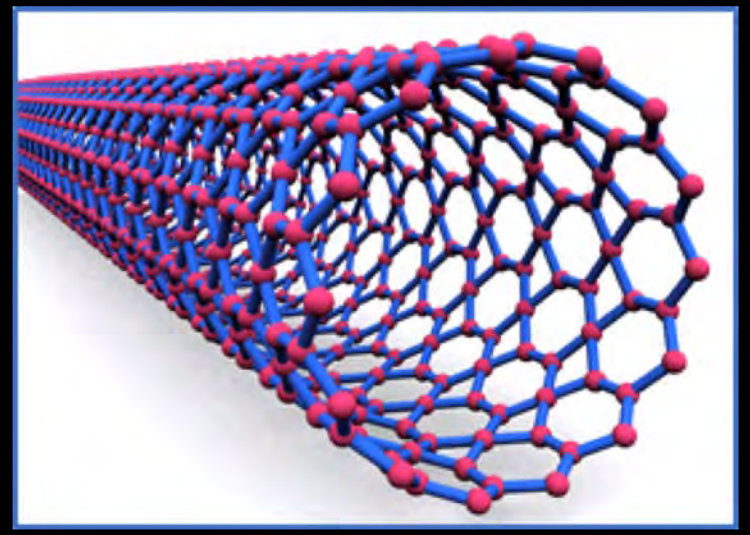
SPACE TEST PROGRAM - HOUSTON 3 - NASA

Materials, Structures and Manufacturing

- Use of materials in harsh environment of space
- Return vehicles sample materials exposure
- Effects of microgravity and other assets for manufacturing of goods



ZBLAN Optical Fiber – Made in Space - FOMS



Carbon Nanotubes - DexMat

LIFE SUPPORT & HABITATION

ENVIRONMENTAL TECHNOLOGIES

- STABLE, SELF-CONTAINED MICRO-ENVIRONMENT
- REVITALIZING THE AIR, COLLECTING AND PROCESSING WASTEWATER STREAMS, PROVIDE SAFE DRINKING AND HYGIENE WATER FOR THE CREW, MANAGING SOLID WASTES
- INCREASE OPERATIONAL AVAILABILITY AND REDUCE SYSTEM MASS, CONSUMABLES AND POWER NEEDS

AMINE SWINGBED - NASA

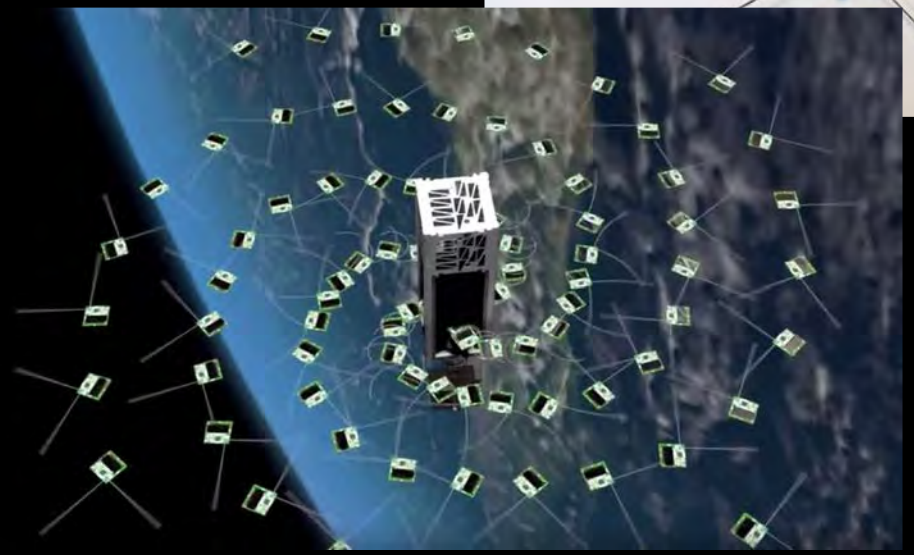
EXPLORATION DESTINATION SYSTEMS

PLATFORMS OF THE FUTURE

- TEST BED TO DEMONSTRATE OPERATIONAL TECHNIQUES AND CAPABILITIES
- BENEFIT HUMAN AND ROBOTIC EXPLORATION BEYOND LEO
- RELATED TO EVA, SPACEWALKS, HABITATION, …
- BENEFIT FROM MICROGRAVITY ENVIRONMENT

LOCAD-PTS

SPACECRAFT-ON-A-CHIP EXPERIMENT PLATFORM – SPRITE – CORNELL UNIV



AR / VR

Artificial intelligence

- AR / VR in flight simulations, in surgical training, operational support
- AR's range increases as computing power grows
- Artificial Intelligence technologies of high relevance to space applications

Juxtopia Context-Aware Mobile Mixed Assistive Device (CAMMRAD)

Cimon-2 – DLR, Airbus, IBM

Space power and energy	Fuel Cells, Energy generation, capture, storage, solar cells and arrays	E.G. Testing TiSi2 Nanonet Based Lithium Ion Batteries for Safety in Outer Space
Computing	Electronics Avionics	E.G. SG100 Cloud Computing Payload, Hewlett Packard Spaceborne Computer
Science Instruments	Science and sensor systems, prototypes, evaluation	E.g. Reducing Signal Interruption from Cosmic Ray Background in Neutron Detectors
Clothing / Textiles		E.g. Active Deployment of first Aerospace Electronic Textile - MISSE
Operational processes and procedures	Evolving and maturing towards exploration missions	E.g. Supervision of Autonomous and Teleoperated Satellites - Interact (SATS-Interact)

HOW TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY ?

- Agencies: NASA, ESA, JAXA, CSA, SANSA, …
- Agencies educational / capacity building programs
- Through challenges or competitions
- ISS US national lab
- Commercial access services

WHERE TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY ?

- Terrestrial-based platforms (Parabolic Flights. Drop towers, sail planes or gliders, neutral buoyancy)
- Sub-orbital
- ISS
  - Internal
  - External
  - Airlocks
- Cubesats: hosted or deployed
- Rideshares
- Spacecraft serving as technology demonstration platform for more experiments

WHERE TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY ?

- TERRESTRIAL-BASED PLATFORMS (PARABOLIC FLIGHTS. DROP TOWERS, SAIL PLANES OR GLIDERS, NEUTRAL BUOYANCY)
- SUB-ORBITAL
- ISS
  - INTERNAL
  - EXTERNAL
  - AIRLOCKS
- CUBESATS: HOSTED OR DEPLOYED
- RIDESHARES
- SPACECRAFT SERVING AS TECHNOLOGY DEMONSTRATION PLATFORM FOR MORE EXPERIMENTS

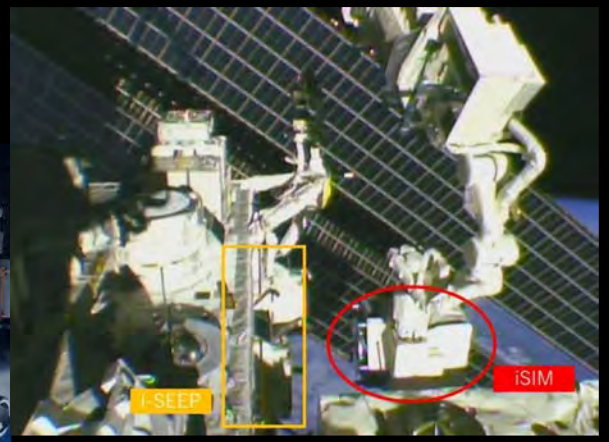
Category	#	Criteria	
Platform Environment	1	Duration	Short (8 minutes or less)
	2		Medium (8 mins - 1 week)
	3		Long (1 week - 3+ months)
	4	High Quality Microgravity (> 10^{-3})	
	5	Low Mechanical / G-load Forces	
Payload Accomodation	6	Mass	Small (< 5 kg)
	7		Medium (5 - 20 kg)
	8		Large (20 - > 100 kg)
	9	Volume	Small (< 0.2 m^3)
	10		Medium (0.2 - 0.5 m^3)
	11		Large (0.5 - > 1 m^3)
	12	Space Access / Satellite Deployment	
	13	Hazardous Material Permitted	
Human Interaction	14	Resarcher Accompanied Payload	
	15	Test Subject Involvement	
	16	Observation / Maintenance Personnel	
Monitoring & Control	17	Real-time Data / Monitoring	
	18	Remote Commanding / Control	
Platform Accessibility	29	Frequent Access	
	20	Access Interval (weeks to months)	
	21	Late / Early Payload Access	

Identification of User Needs and Possible Platforms for Future Microgravity and Space Experimentation
C.Boggs, andV.Dhiri , Telespazio

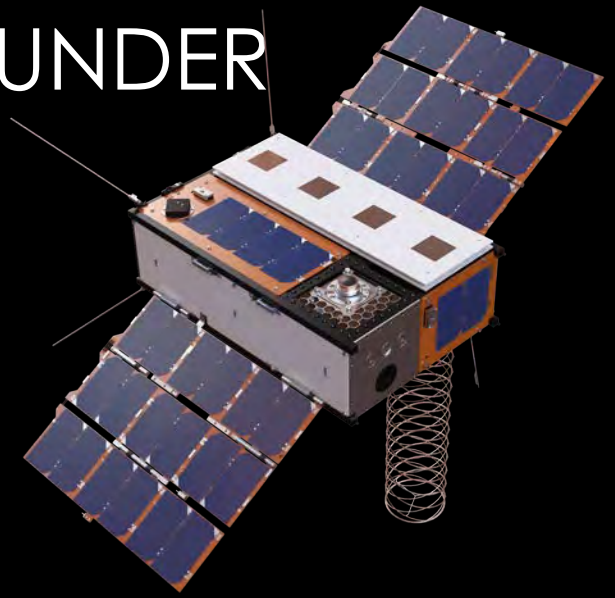
WHERE TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY ?

BISHOP AIRLOCK NANORACKS

BARTOLOMEO AIRBUS



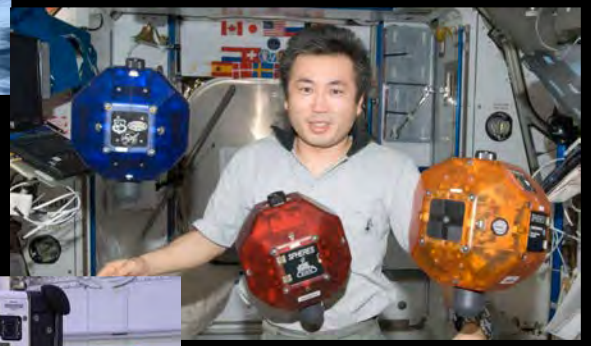
I-SEEP SPACEBD



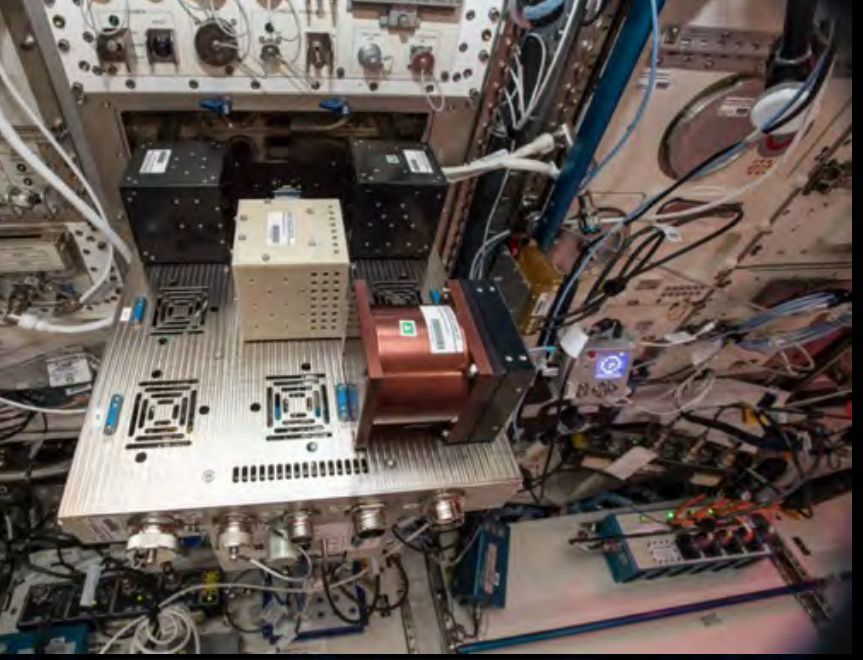
FARADAY – INSPACE MISSIONS

MISSE ALPHA-SPACE

SPHERES-ASTROBEE – NASA - MIT



EXOPOD - EXOLAUNCH



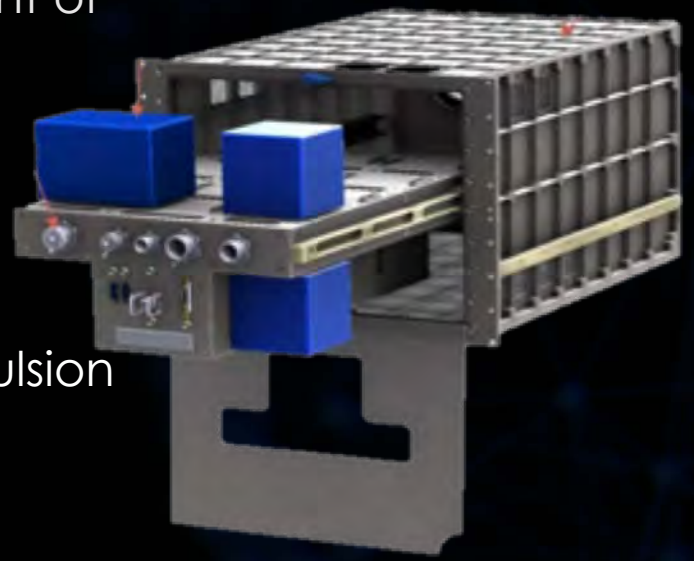
ICE Cubes platform

- Own facility inside space station
- Fast-track regular access
- Front connector – isle payload
- WiFi payloads
- Unique real-time interaction capability
  - Via internet / IP protocols
  - From your home location ~24/7Power / data

ICE Cubes use cases

Wired Experiments:

- Detection and recovery from Single Event Upsets for electronic hardware
- Proof of concept for material manufacturing
- Heat Pipes / micro-fabricated heat pipes used for thermal management of detectors
- Sloshing Analysis/Demonstration
- Proof of concept for miniaturized mechanisms and robotic systems
- Demonstration of alternative propulsion concepts (e.g. micro and nano thrusters)

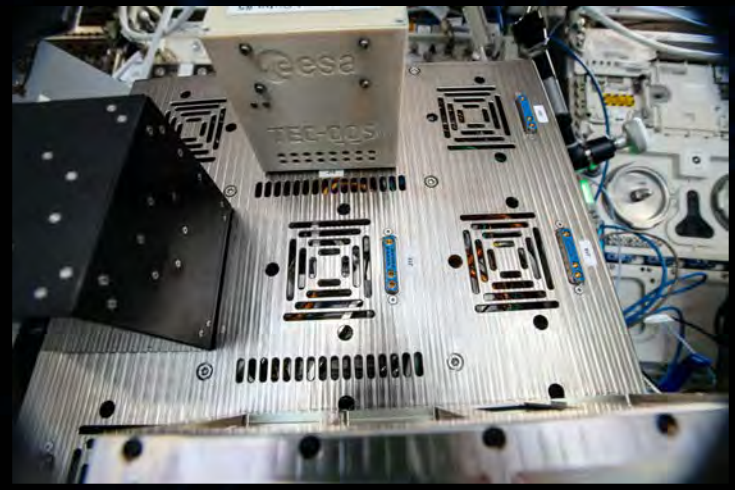


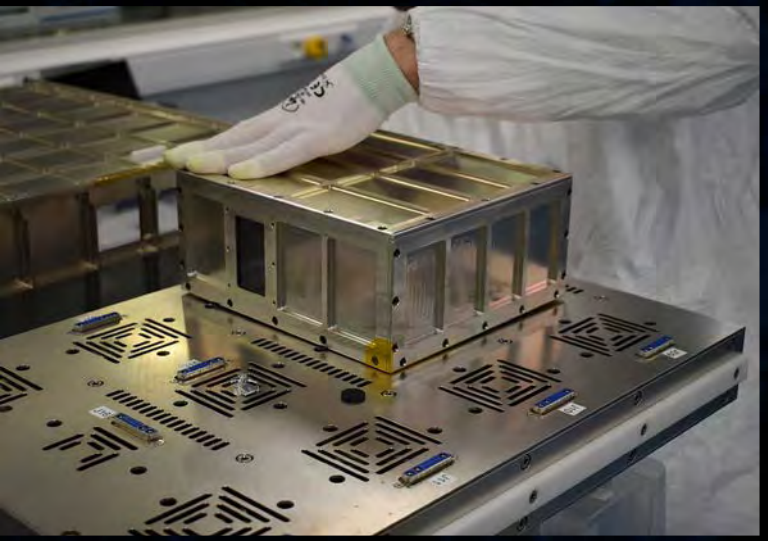
Wireless controlled experiments :

- Testing guidance and navigation algorithms / strategies, in areas of autonomous technologies in formation flying, collision avoidance,
- Proof of concept for miniaturized docking / berthing / capturing subsystems
- Test of life support technologies for monitoring and analysis of crew vital performances (e.g. supported by AI and supervised from ground)

ICE Cubes example cases

- Cybersecurity: testing technological solutions to make encryption-based secure communication feasible for even the smallest of space missions
- http://www.esa.int/ESA_Multimedia/Images/2019/07/Cryptography_ICE_Cube_experiment





- UV/VIS Spectrometer precursor technology demonstrator for future Exobiology mission
- https://www.ohb.de/en/news/2019/iss-to-ohb-technology-demonstrator-spectrodemo-transmits-first-data-set-to-earth

- OscarQube diamond magnetometer

CONCLUSION TECHNOLOGY DEMONSTRATION UNDER MICROGRAVITY / HYPERGRAVITY

- WHY? VALIDATION IN TRUE SPACE ENVIRONMENT, TRL RAISING
- WHAT? TYPES / SCOPES / USE CASES
- HOW? DIFFERENT ROUTES
- WHERE? WHICH TYPES OF PLATFORMS

- OPPORTUNITIES
- NETWORK AND COLLABORATE

THANK YOU

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