VISPA

Versatile In-Space and Planetary Arm

DEFENCE AND SPACE

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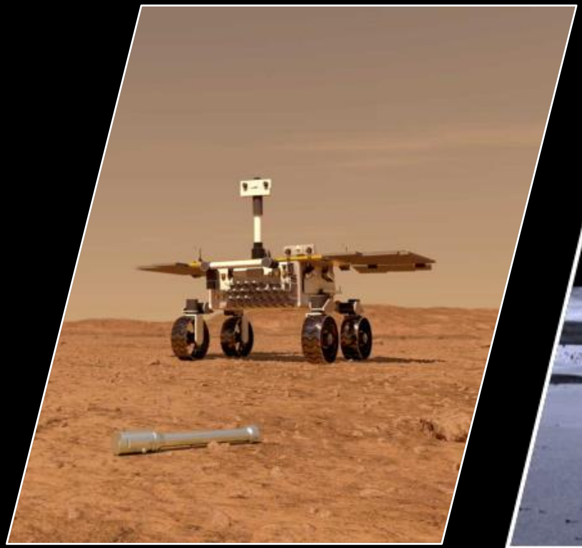
Space Robotics: an evolving landscape

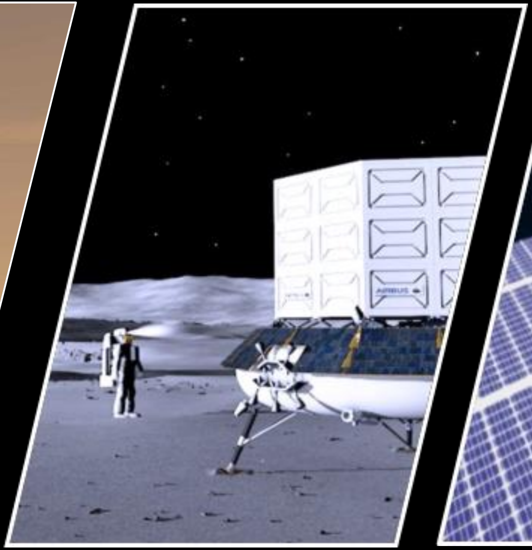
- Convergence of mission concept, technologies and vision
- Supported by an acceleration of developments

Planetary

In-Orbit

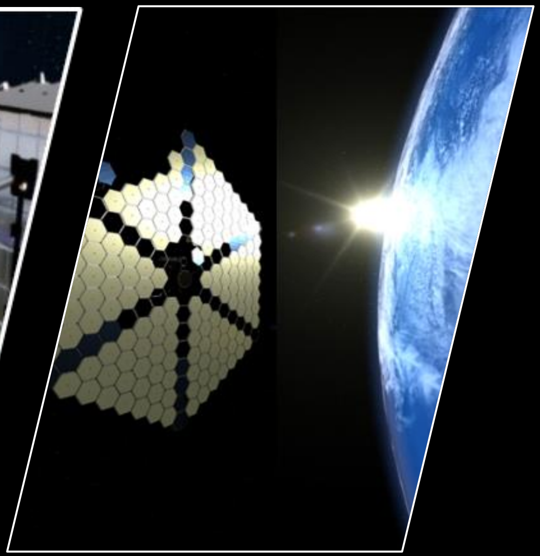


Mars



Moon

In-Orbit Services



In-Space Manufacturing and Assembly

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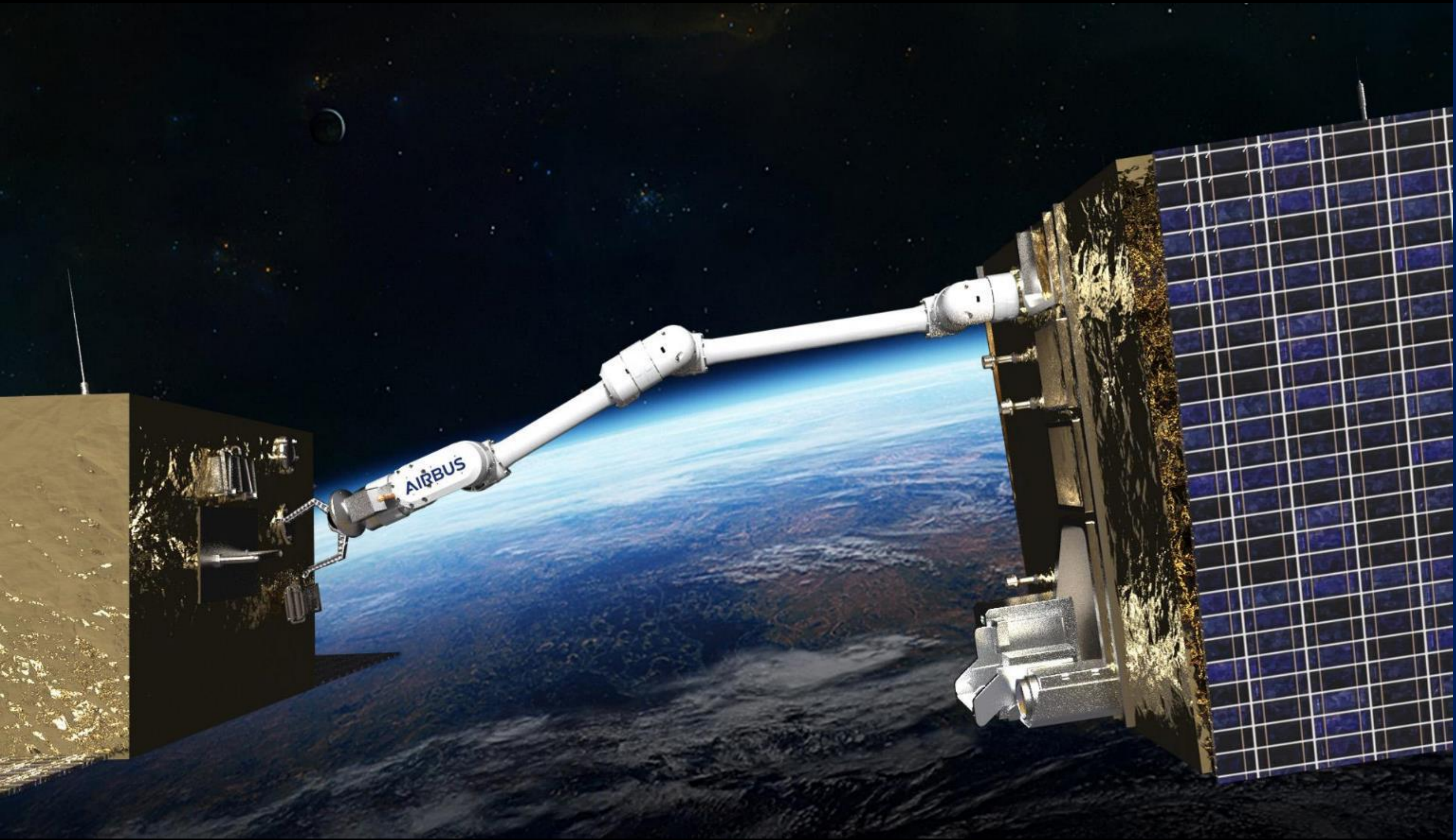
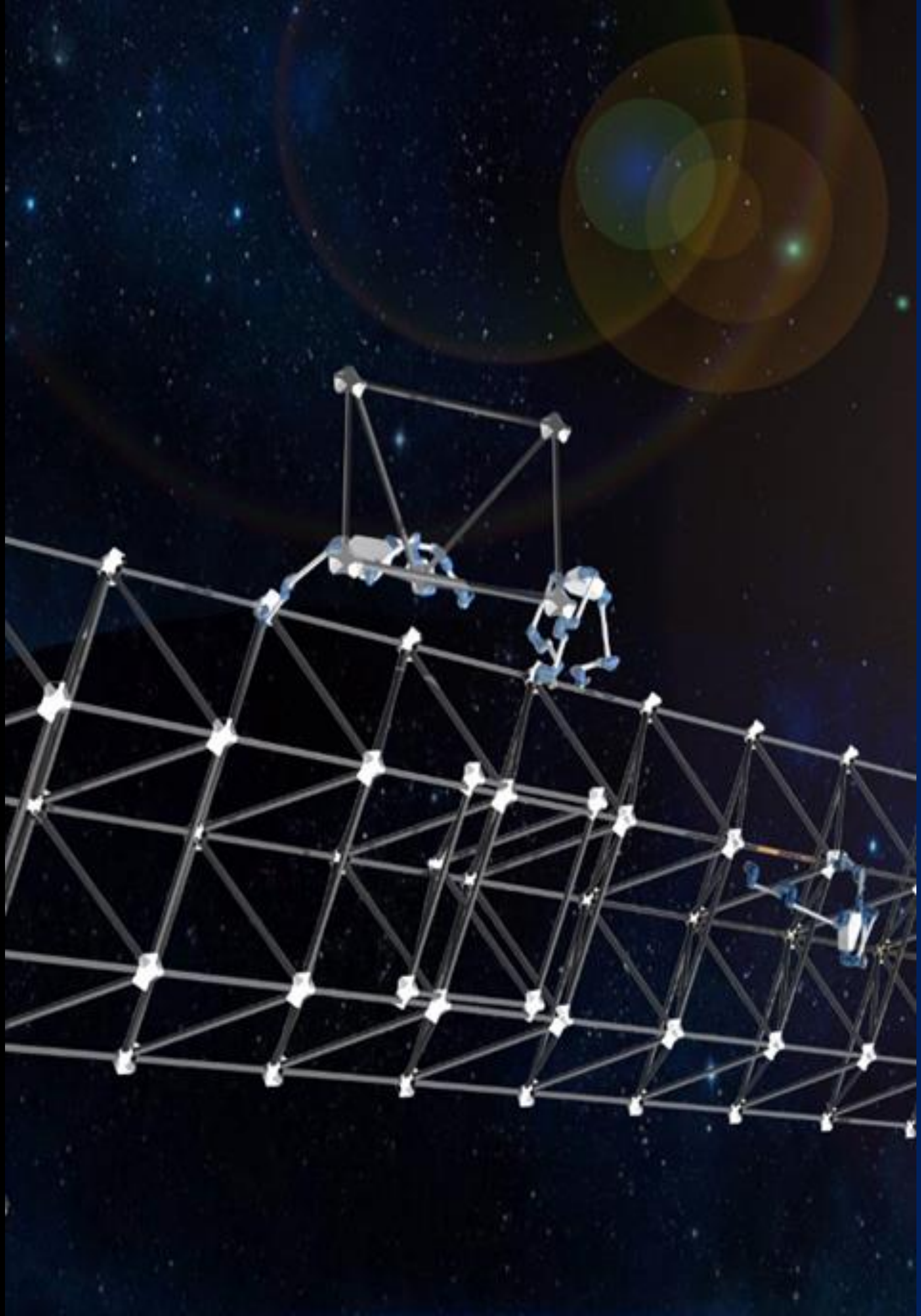


In-Orbit Services

- Active Debris Removal
  - Prevent collision
  - Clear orbits
- In-Orbit Servicing
  - Maintain
  - Refuel
  - Upgrade

→ All part of an emerging ecosystem

Multi-Arm Robots In-Space Assembly



Payload/ Spacecraft Clustering

Multiple systems co-located on single structure

Payload

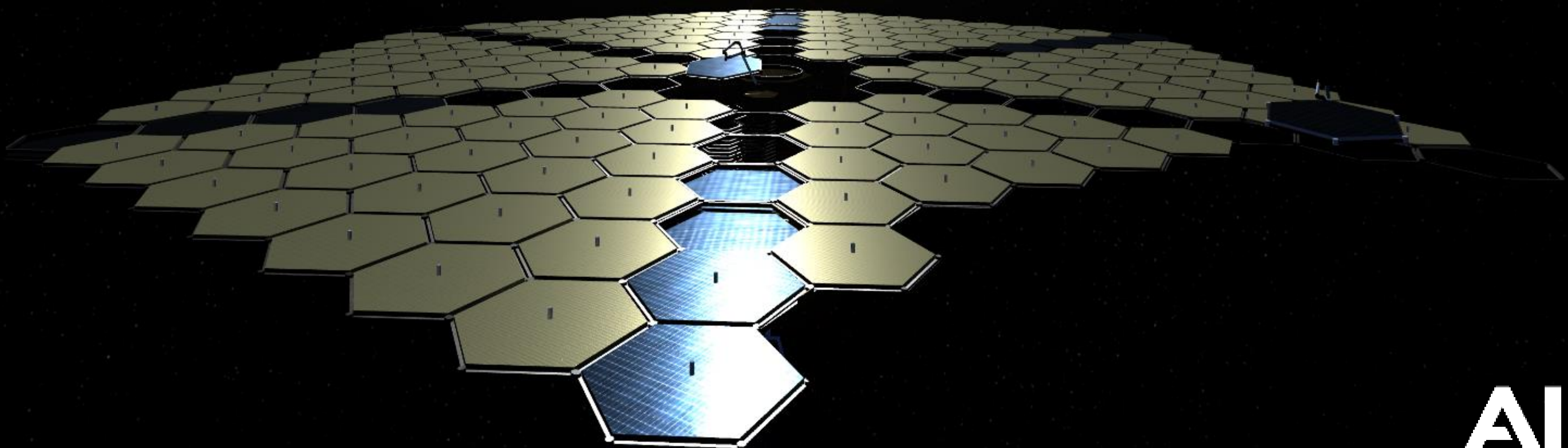
- Need fewer spacecraft
- Cheaper Access to space
- Manage obsolescence

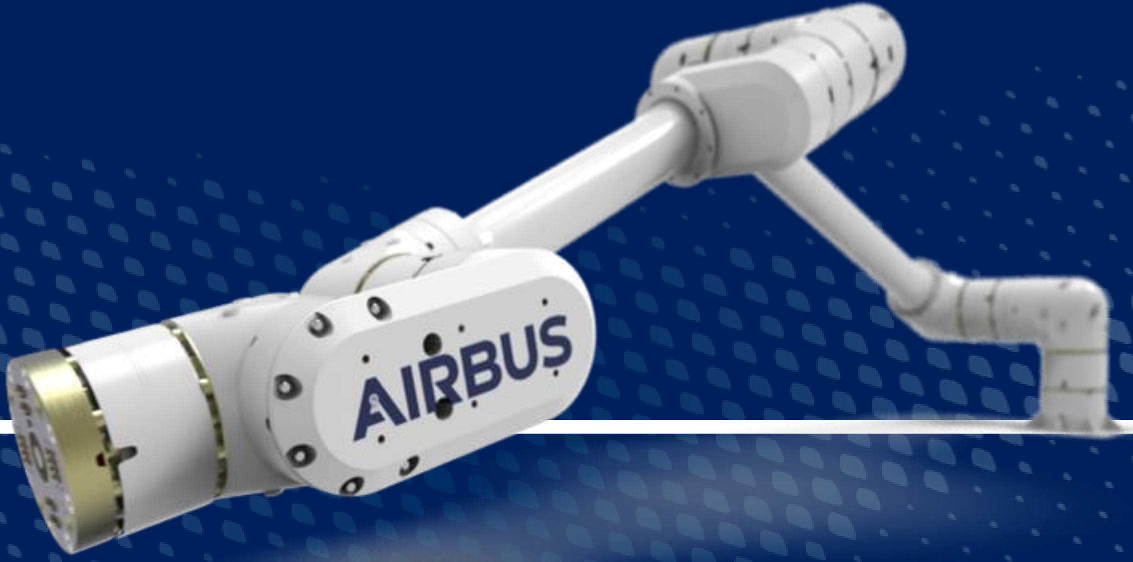
Spacecraft clustering

- Removal of failed spacecraft
- Sustainability

Larger Infrastructures to address new needs and services

Telecom, SBSP





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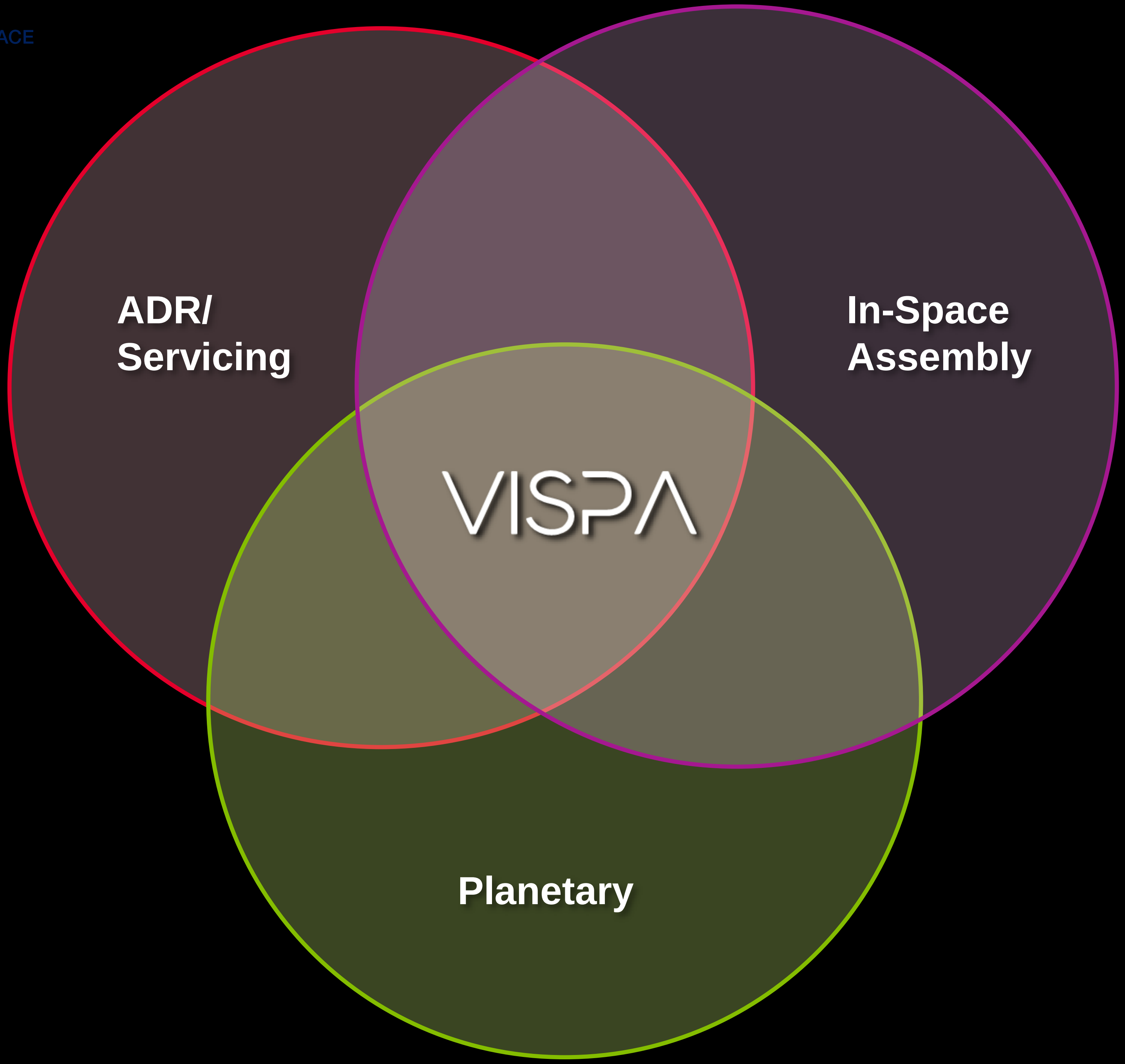

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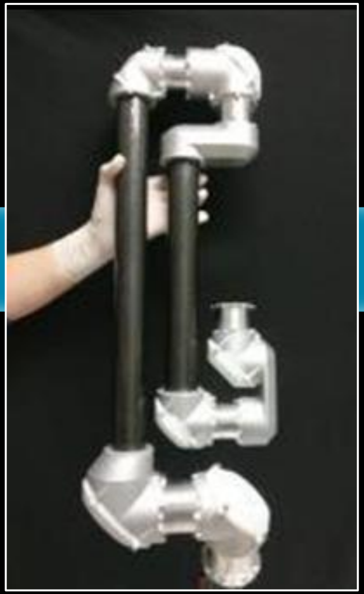
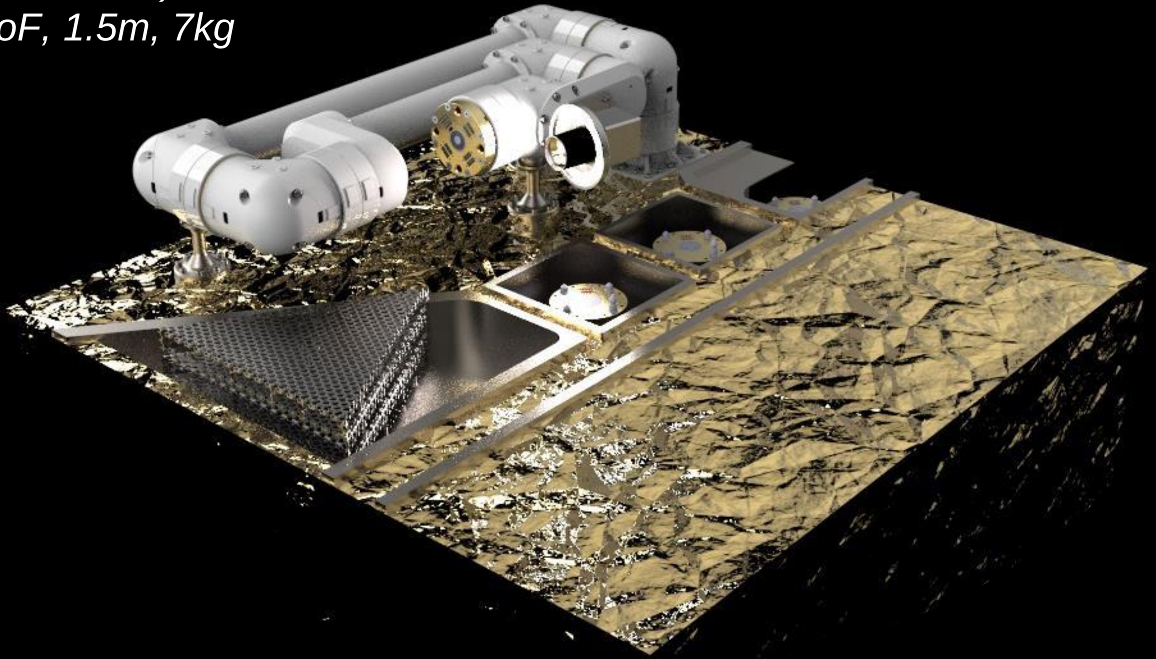
Versatile In-Space and Planetary Arm

- Reach
- Environment (Thermal, rad, dust)
- Payload capability
- 1g Testability
- Stowed volume
- Mass

LARAD
(UKSA)
6DOF, 2.2m, 16kg



RISMA
(InnovateUK)
6DoF, 1.5m, 7kg



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Versatile In-Space and Planetary Arm

- Builds upon past developments
- Target the design of a disruptive cost-efficient space manipulator

→ *Simple to integrate*

→ *Platform agnostic*

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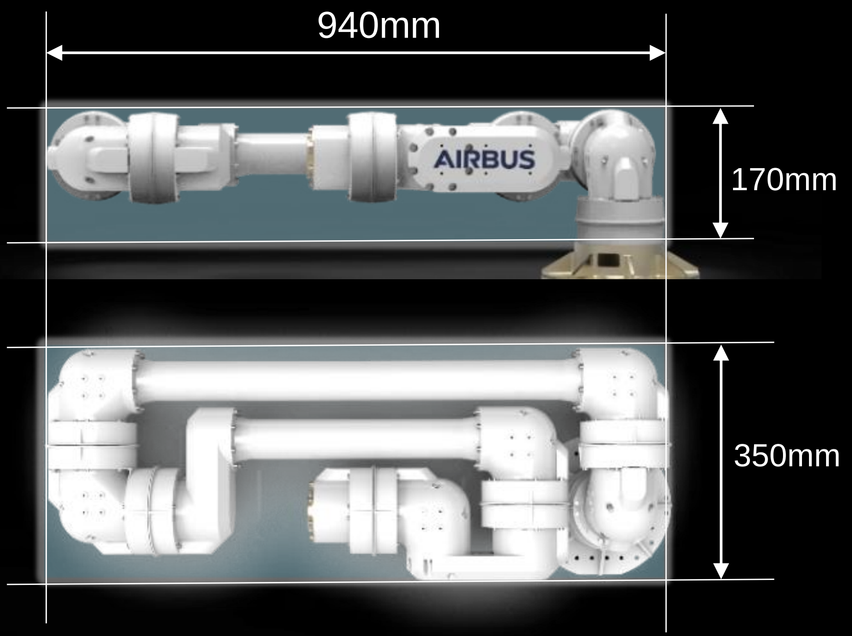
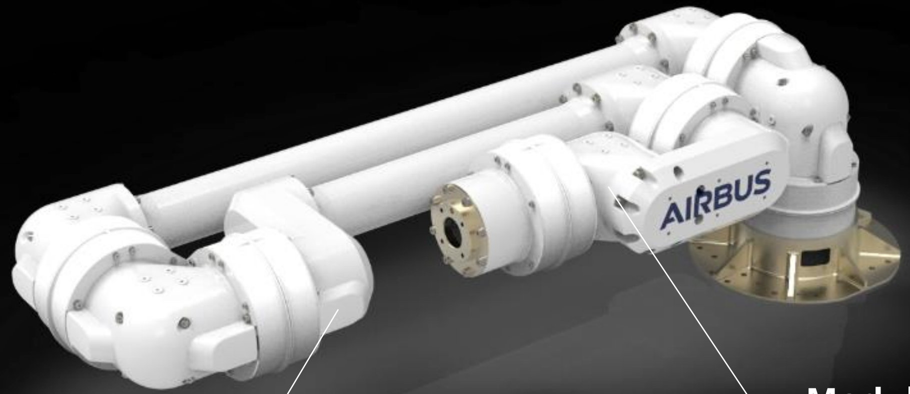
Configuration Overview



Self contained robotic joints
- Compact transmission
- In-joint motor control electronics
- 6 identical joints



Modular lightweight Mechanical structure
- Scalmalloy ALM

Modular configuration
- Slender design
- Compact stowage
- With/without spherical wrist
- Various DoF options

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Versatile In-Space and Planetary Arm

- Reach: ~1955cm long at tool interface
- Compact stowage
- Modular architecture and design
- Scalable family of joints
- 17kg

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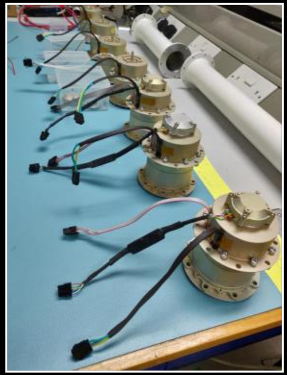
Versatile In-Space and Planetary Arm

- Identification of several functional use-cases and testing opportunities

→ to feed back into design

Sustained development through short iterative design cycles

2019 – Q4 - TRL4 DM integration and testing



2021 - Q2 – TRL5 Joint TVAC

2023 – TRL6 EM Integration and testing

2020 – DM v1

2021-Q2 DM v2 (TRL5 joint design)

2021-Q4 – TRL6 EM design

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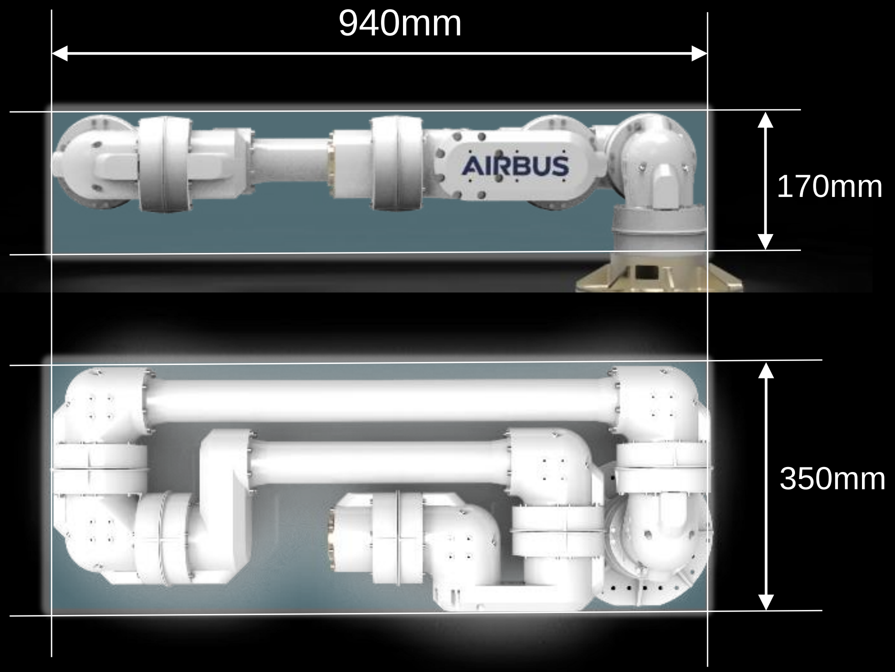
Versatile In-Space and Planetary Arm

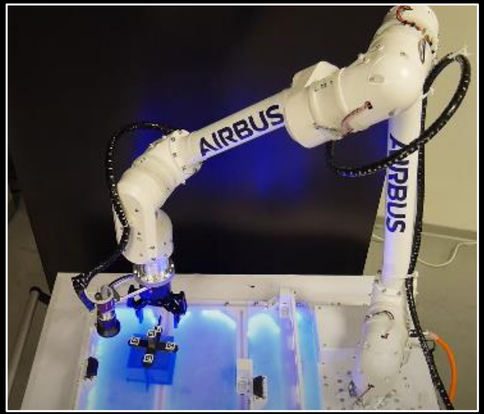
DM Performance over calibrated workspace in 1g

Configuration	VISPA	Unit
Manipulator		
Degrees-of Freedom	6	
Full extension reach (exc tool)	1955	mm
Mass	16.1	kg
End-effector Repeatability	0.171mm / 0.049deg	
End-effector Accuracy	<5mm/0.25deg	
Visual Servoing – End-Effector Accuracy	**~0.6mm**	mm
Joints x 6		
Max velocity	>1RPM	
Range of motion	+/-175	deg
Electrical		
Power bus	Redundant 48V	
Data bus	Redundant CANbus	



EM / Flight unit target performance

Configuration	VISPA	Unit
Manipulator		
Degrees-of Freedom	6	
Full extension reach (exc tool)	1955	mm
Mass	<20	kg
End-effector Repeatability	<0.2mm / <0.05deg	
End-effector Accuracy	<3mm/ <0.3deg	
Joints x 6		
Max velocity	>1RPM	
Range of motion	+360 ; -220	deg
Electrical		
Power bus	Redundant 24-48V	
Data bus	Redundant CANbus	
End-effector bus option	SpW/Ethercat	



DM visual servoing → 0.6mm end-effector accuracy across whole arm workspace

- DM used as development platform for use-case testing and advanced control options including visual servoing and impedance control
- EM model integration and testing ongoing

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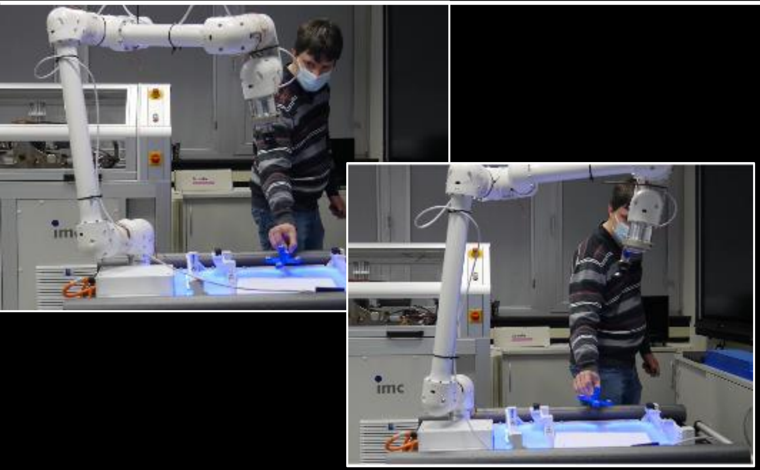
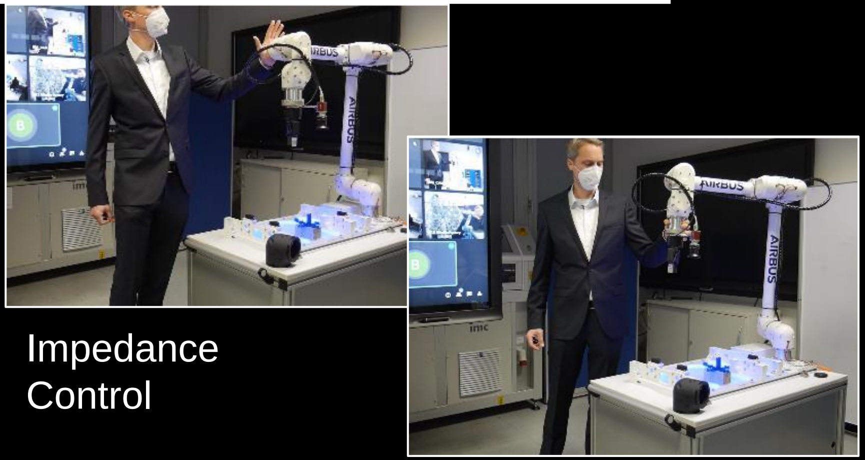
Manipulator Control



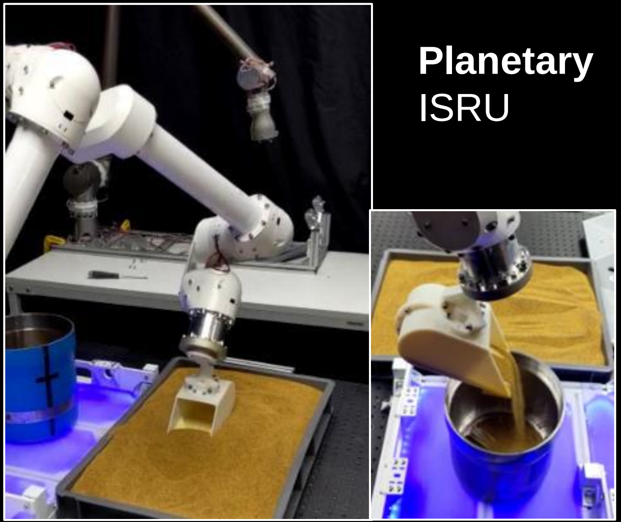
Visual
Servoing



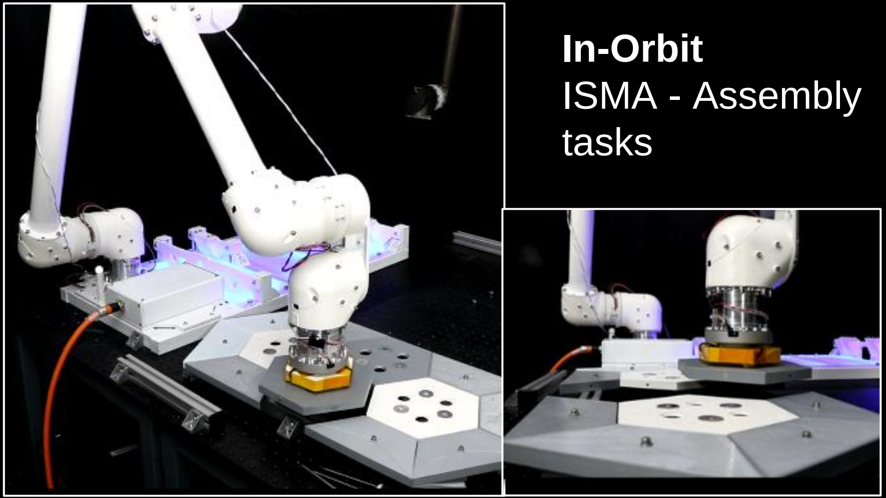
Impedance
Control

Admittance control

Use Cases



Planetary
ISRU



In-Orbit
ISMA - Assembly
tasks

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Versatile In-Space and Planetary Arm

- **Ongoing developments and demonstration of range of control scenarios and use-cases**

→ Strong UK opportunity to capitalise on maturity of the system

- **UK technology block** supporting range of valuable scenarios
- **Feeds into IOD opportunities to federate development and UK supply chain**
  - Components
  - Tools
  - Control

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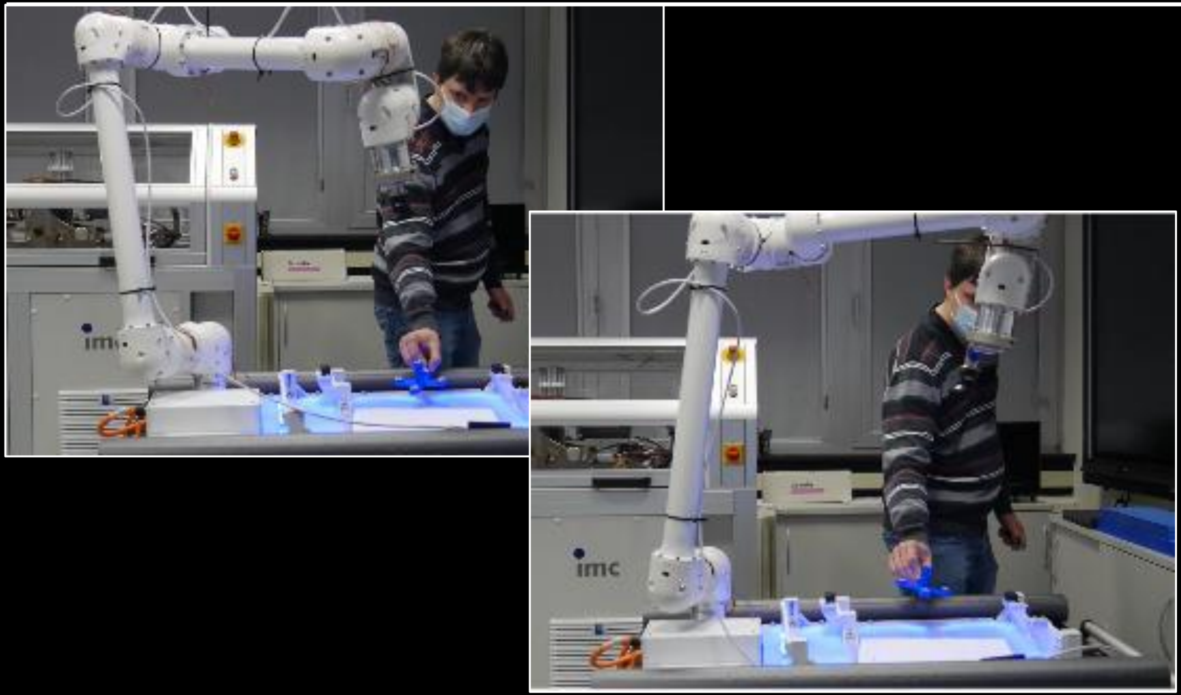
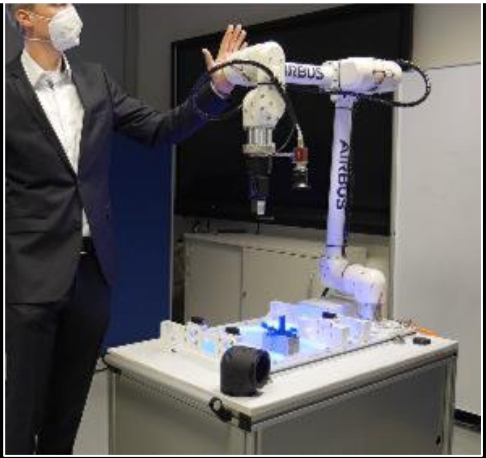
Manipulator Control

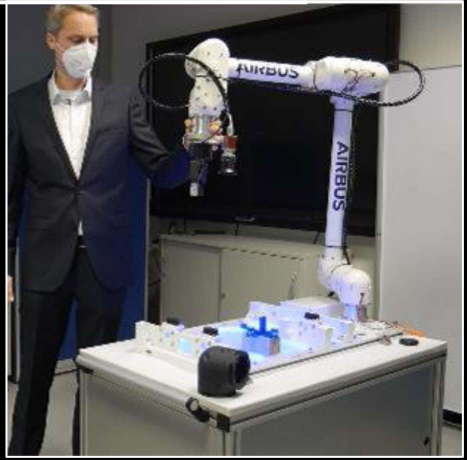


Visual Servoing
- Tracking moving targets
- Improving final tool placement
- Adapt to changing environment

Sensorless Impedance Control
- Collision detection
- Soft contact

Admittance Control
- Robot teaching





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Versatile In-Space and Planetary Arm

- Development of high level control modes:

- Visual Servoing

  See Ingo Arnhs Poster

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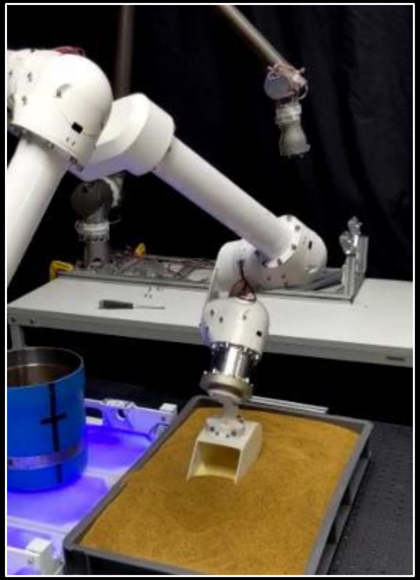
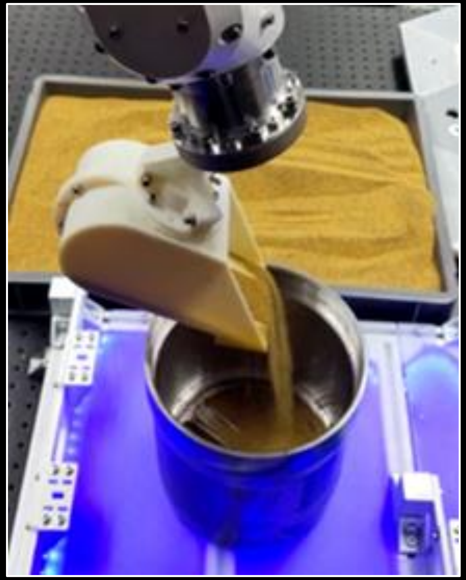
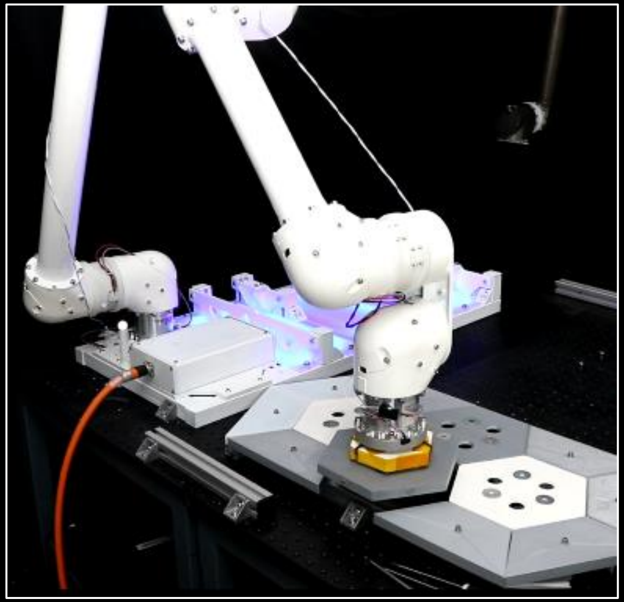
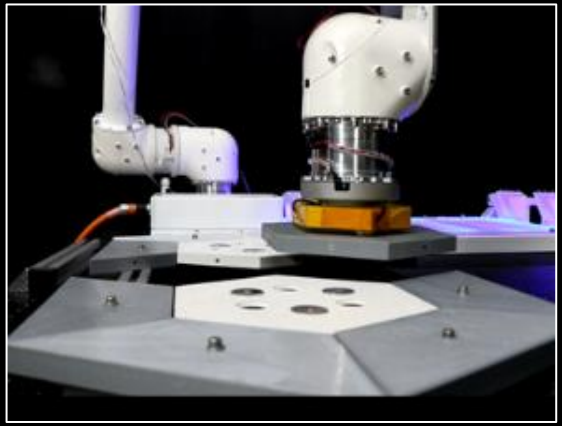
Use-cases and testing activities

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Versatile In-Space and Planetary Arm

- Assembly of modular elements → Antenna and structure building
- Trenching/Regolith sampling → ISRU

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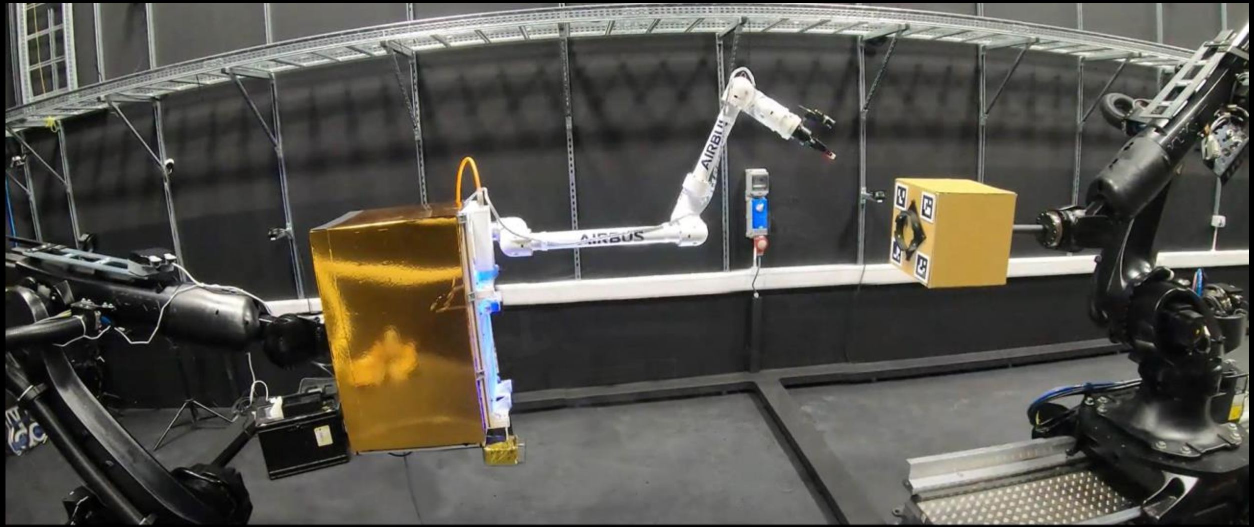
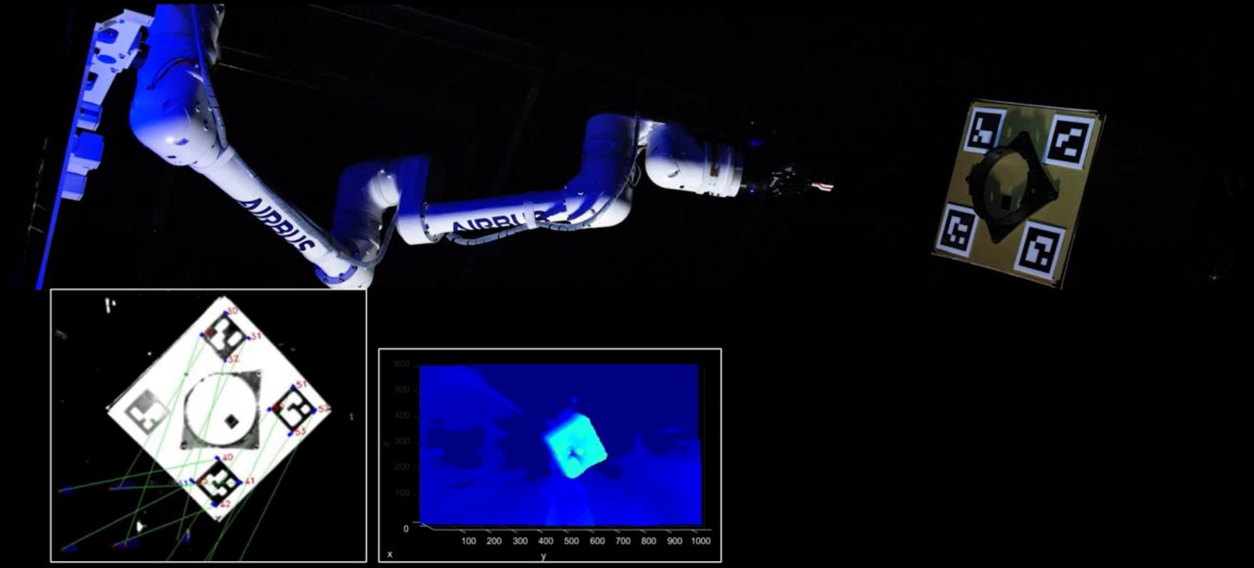
ADR/Servicing scenario testing at SatApps Catapult in Wescott





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Versatile In-Space and Planetary Arm

ADR/Servicing test scenario

- Chaser /target setup
- Inspection of target
- Approach, imaging and capture
- Target release

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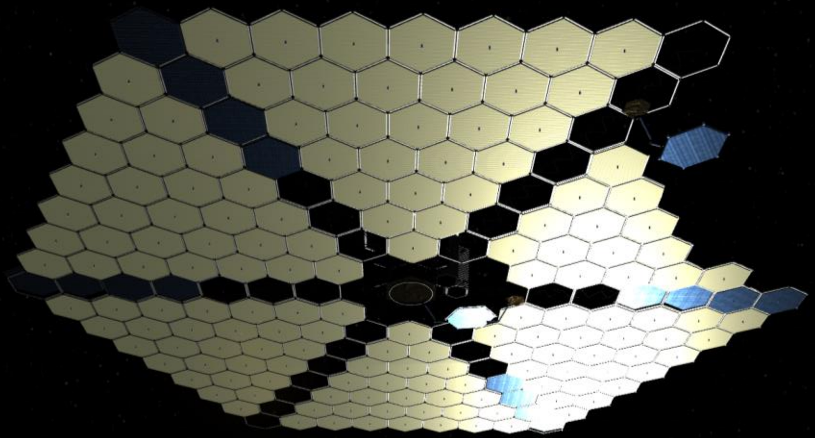

Building such large structures

will require thousands of hours of continuous operation

Robotics will fail

…and It's OK…

…if you plan for it

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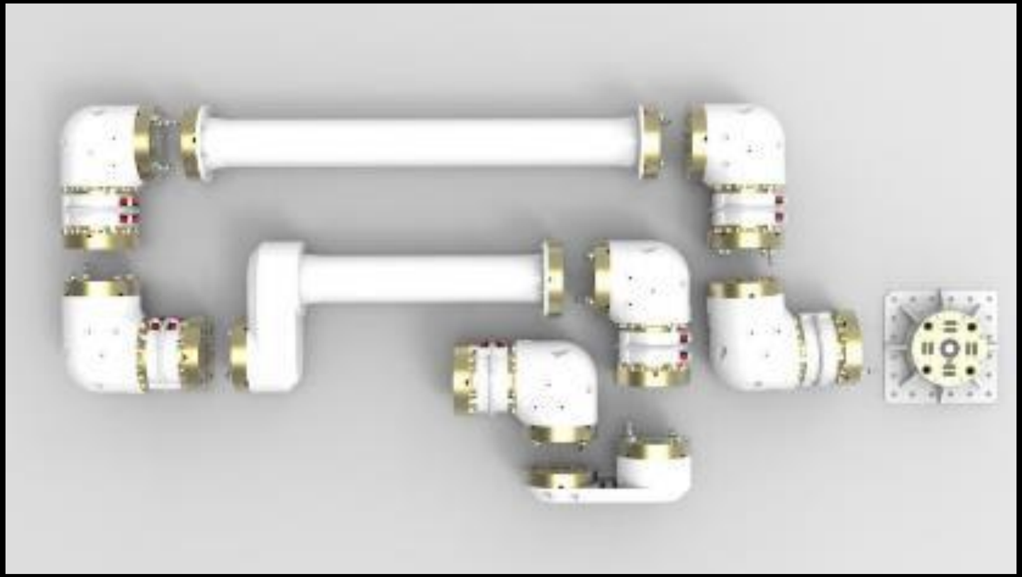
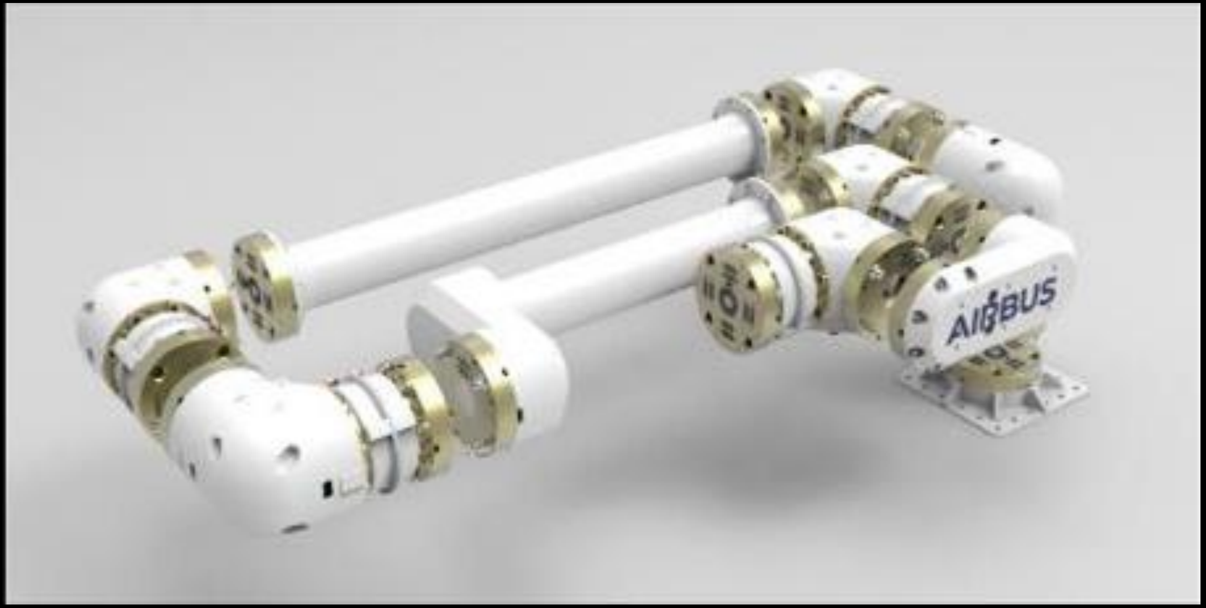
In-space serviceable – A new paradigm





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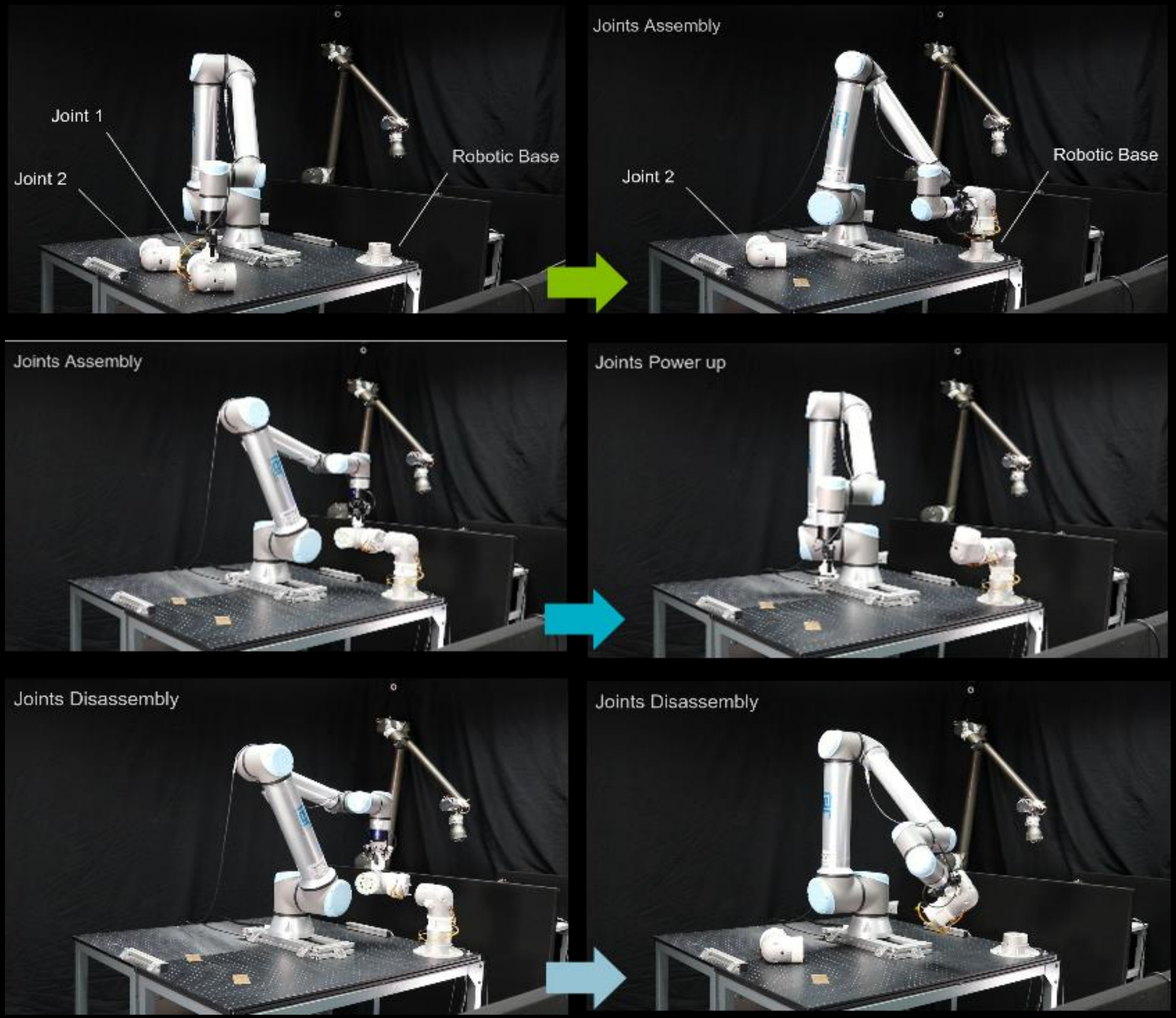
Versatile In-Space and Planetary Arm

- Target High-duty cycles
- Designed to manage failures
- Joint Swapping design
- To reconfigure and service manipulator in-space
- Opportunity to review testing regime and part selection
- Economy of scale

→ lower cost

→ Robotics as consumable

In-space serviceable – A new paradigm – Testing



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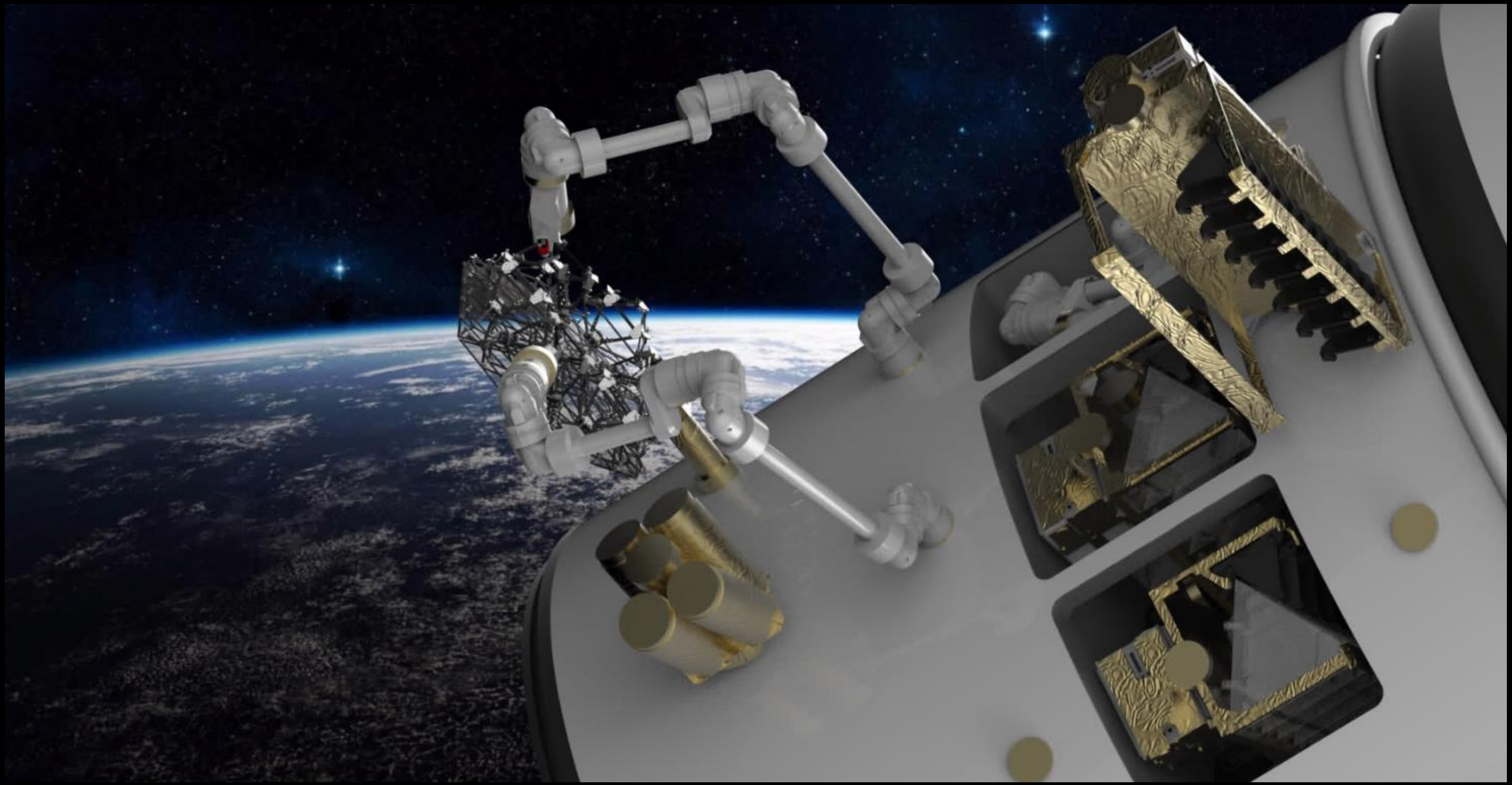
DEMARLUS



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In-Space Assembly IOD

See poster in Foyer

- Scoping of IOD mission
- Assembly of a modular reflector and a small spacecraft
- Antenna performance tests
- Release of s/c
- 2x VISPA manipulators
- Joint swapping demo

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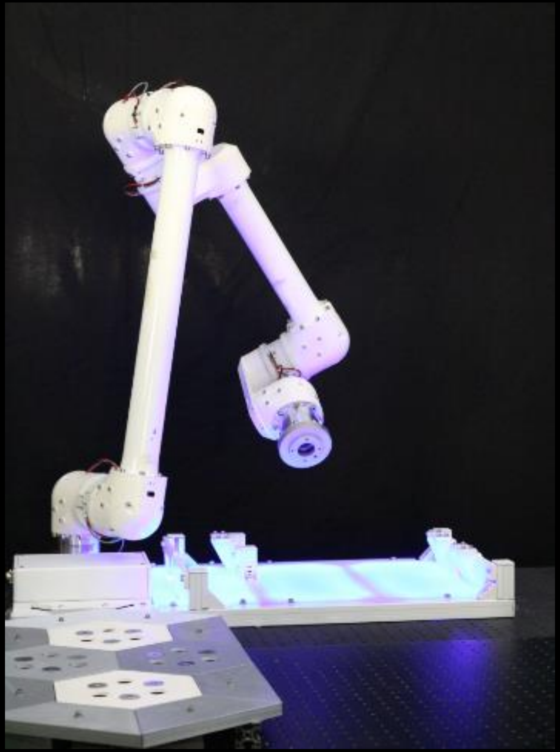
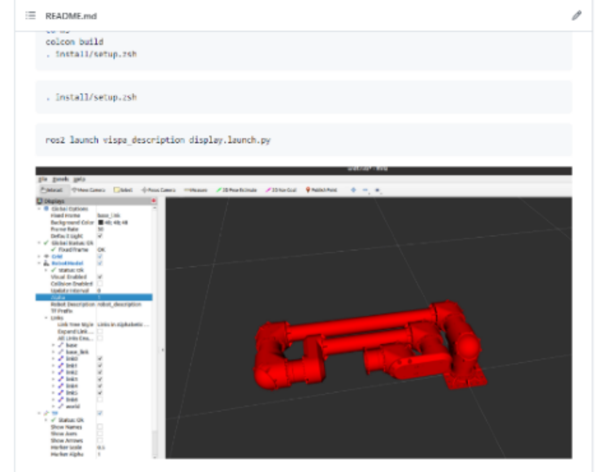
Ecosystem Building and Outreach

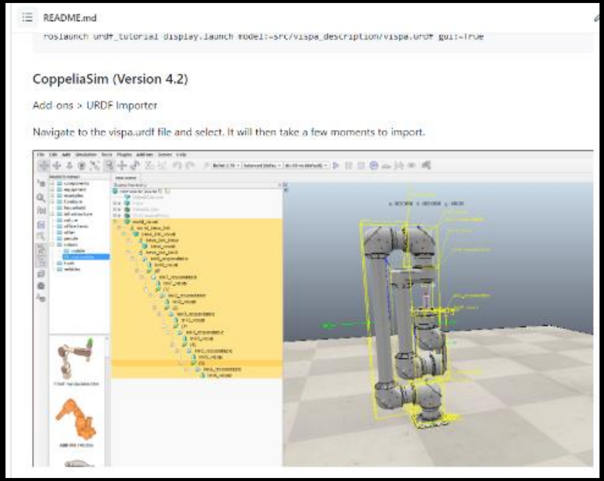
VISPA URDF

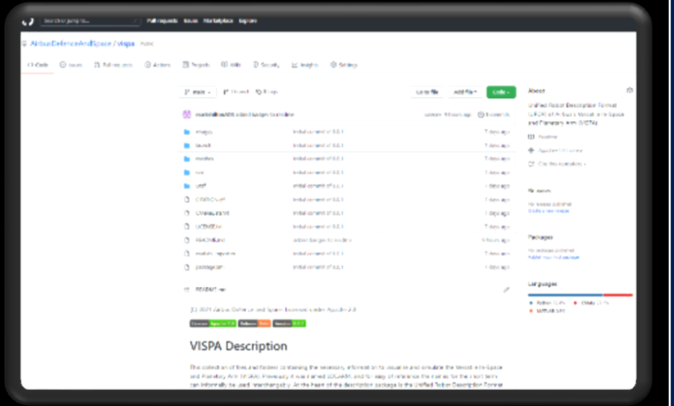
- To support the development of complementary building blocks, mission concepts and actors, Airbus released the **VISPA Unified Robot Description Format**
- Publicly available
- Currently in Beta release.
- Ready to use in ROS, CoppeliaSim, etc

→ https://github.com/AirbusDefenceAndSpace/vispa









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Versatile In-Space and Planetary Arm

The future of space activities relies on the development of a nascent IOSM ecosystem

- Currently used by a number of EU and National projects
- Used by University projects and student competitions related to IOSM
- Used by SMEs to test planning and control systems

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Conclusion

- **Space Robotics is an enabler**, a tool, that will become ubiquitous **IF** it can be made economical over its lifetime
- **VISPA** is being developed as a cost-effective solution to address a range of use-cases, with a longer term view towards future assembly activities, but with shorter term application to ADR and IOS
- The **space landscape is evolving rapidly** and **VISPA** is being put forward as a technology block **to enable new mission** to take shape in this emerging ecosystem

VISPA 2023 finalist for:
- Robotic Innovation in Extreme Environment

VISPA 2023 Winner of the
- Robotic Innovation in Aerospace

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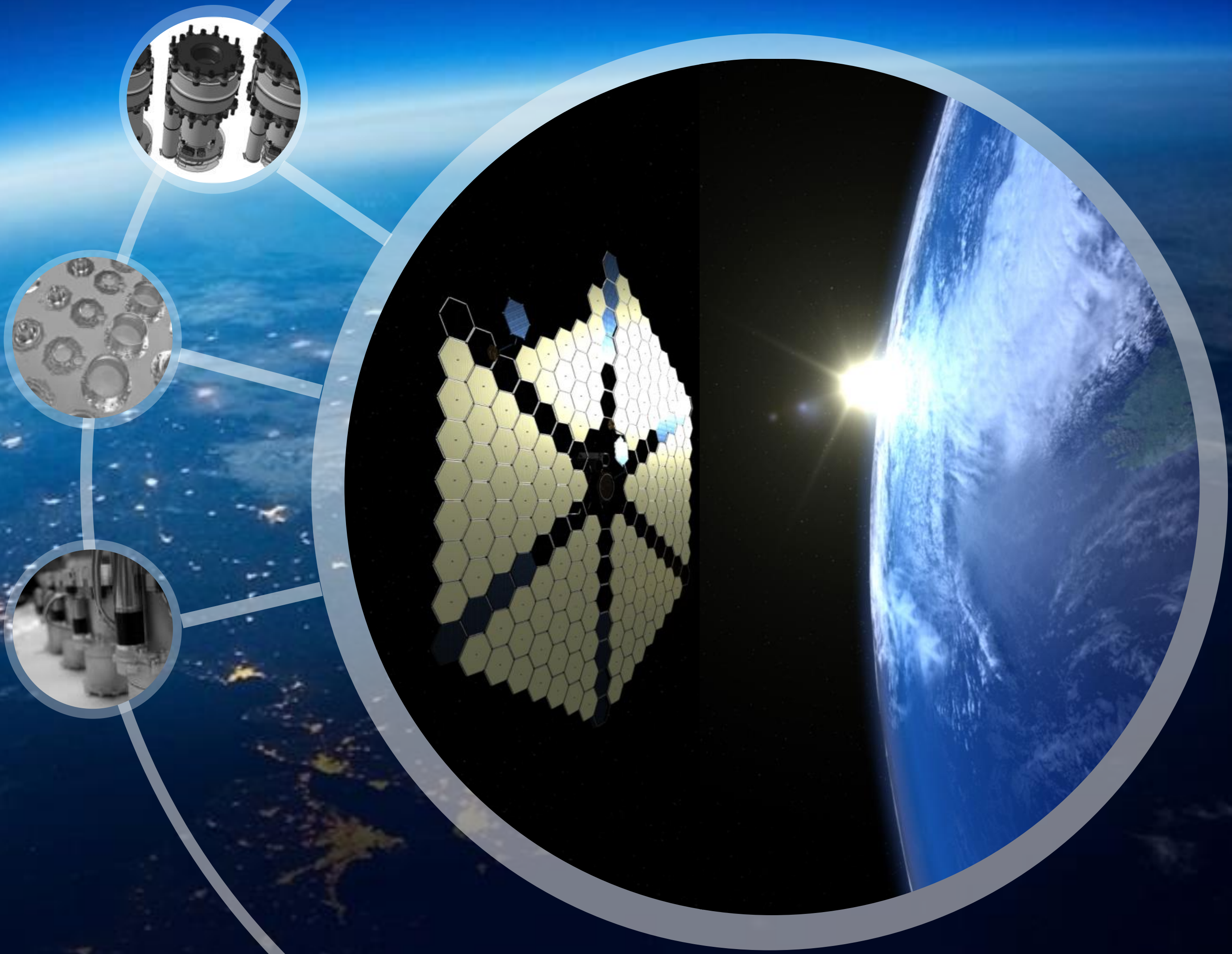
Versatile In-Space and Planetary Arm



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