STARDUST

PUSHING THE BOUNDARIES OF
SPACE RESEARCH TO SAVE OUR FUTURE

MARIE CURIE ACTIONS

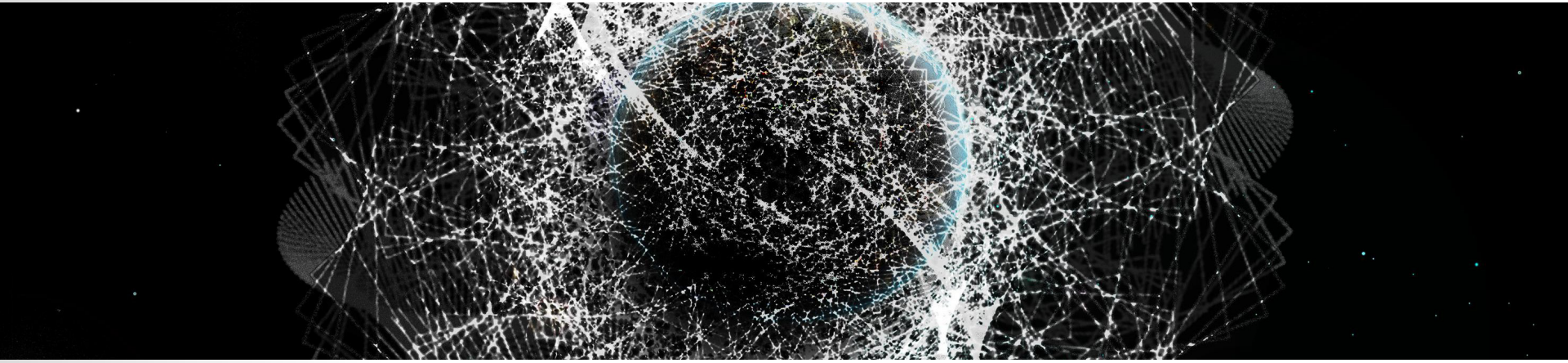

*Image credit: Peter McGinty, University of Strathclyde*

# Stardust Reloaded (Stardust-R)

## Marie Sklodowska-Curie Actions Space Debris and Asteroid Research Network

**Marko Jankovic, MSc.**
Robotics Innovation Center – DFKI GmbH, Bremen & University of Bremen

Universität Bremen

# Outline

- Stardust-R Overview
  - Stardust-R in numbers
  - Who are we
  - Key research areas
  - Overview of the research program
- Stardust-R Project in DFKI Robotics Innovation Center
  - Robotic capture of non-cooperative targets
  - Project overview
  - Related projects in DFKI RIC

Overview of the Stardust-R ETN

# STARDUST-R EUROPEAN TRAINING NETWORK (ETN)

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*Image credit: Peter McGinty, University of Strathclyde*

**Stardust-R** is a €3.9M research and training network supported by the European Commission H2020 to focus on **asteroid and space debris issues on a global scale**. Continuation of the €4.1M **FP7 ITN Stardust**

4 year program started on **01 January 2019** & ending on **31 December 2022**

**Strathclyde University** is the lead coordinator

**15 Early Stage Researchers** (ESRs) to be **recruited**

8 major training and outreach events to be organized by the network

**20** European partners (13 beneficiaries, 12 associate partners)
**4** Overseas affiliated partners

17 universities,
3 companies,
3 space agencies,
3 research centers.

- Who's who in the network?
- Where are they in the world?



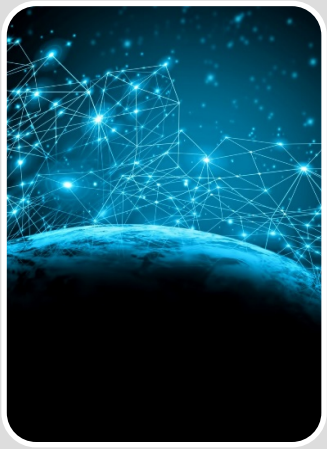

*Map image credit: Wikimedia Commons*

- Who's who in the network?
- Where are they in the world?



*Map image credit: Wikimedia Commons*

# Stardust-R: Key Research Areas



## Space Traffic Management (STM)

- Artificial Intelligence in support of STM
- Improved impact risk prediction
- Data-driven anomaly prediction
- Analysis of the long term stability and chaotic evolution of the space environment
- New approach to on-orbit servicing
- Advanced disposal strategies using natural dynamics
- Design for demise and re-entry prediction


## Nano-Exploration of Minor Bodies

- Development of a criticality index for small asteroids
- Low-cost exploration with nanosatellites and nanolanders
- Improved impact risk prediction



*Images credit: Massimiliano Vasile, University of Strathclyde*

# Stardust-R: Research Program 1


### COMPUTATIONAL INTELLIGENCE AND THE QUANTIFICATION OF UNCERTAINTY

WP1 will combine mathematical modelling with artificial and computational intelligence to quantify uncertainty in orbital mechanics, predict and correlate rare events, anomalies and singularities, and support decision making and operation planning. It will cover the computation of the probability of impacts and collisions, with single objects and clouds of fragments, including resonant returns and keyholes, and the quantification of uncertainty during re-entry.


### THE ART OF DEMISE

WP2 will cover all activities related to the re-entry of space objects and their possible demise. It includes all multi-fidelity and multi-physics simulations, the possible design of these objects and their effect on the pollution of our planet.


### THE DYNAMICS OF CHAOS AND THE DISPOSAL OF SPACE DEBRIS

WP3 will cover all activities related to dynamic modelling, resonances and long term evolution of space objects in different orbital regimes and how this can be exploited to dispose of space debris. It will include the coupling of natural dynamics with passive and/or active disposal strategies.


### THE LINKAGE PROBLEM

WP4 will cover all activities related to Initial Orbit Determination (IOD) and the use of observational data and measurements both optical and radar for both asteroids and space debris. It will introduce techniques to process large databases and link spatially and temporally distant data sets.



*Images credit: Massimiliano Vasile, University of Strathclyde*

# Stardust-R: Research Program II

**WP5**

### THE CRITICALITY OF SMALL ASTEROIDS

WP5 will extend the distribution of near Earth objects to include asteroids of small dimensions down to few tens of meters and covering regions still poorly known. WP5 will define a criticality index that provides a measure of how easy the asteroid is to deflect with a given deflection method, and how interesting the asteroid is to explore and to exploit.

**WP6**

### THE MANIPULATION OF NON-COOPERATIVE TARGETS AND ON ORBIT SERVICING

WP6 will cover all activities related to robotics and the required autonomy to perform rendezvous, docking, on orbit servicing, repair and disposal. It will include the use of specific removal technologies that require and interaction between a cooperative and a non-cooperative object.

**Work package led by DFKI RIC**

**WP7**

### EXPLORATION AND EXPLOITATION OF MINOR BODIES

WP7 will cover all activities related to exploration, and exploitation of asteroids and comets. It will investigate the use of small platforms to characterize asteroids, binary systems, and will develop technologies for close proximity navigation and landing on minor bodies.

**WP8**

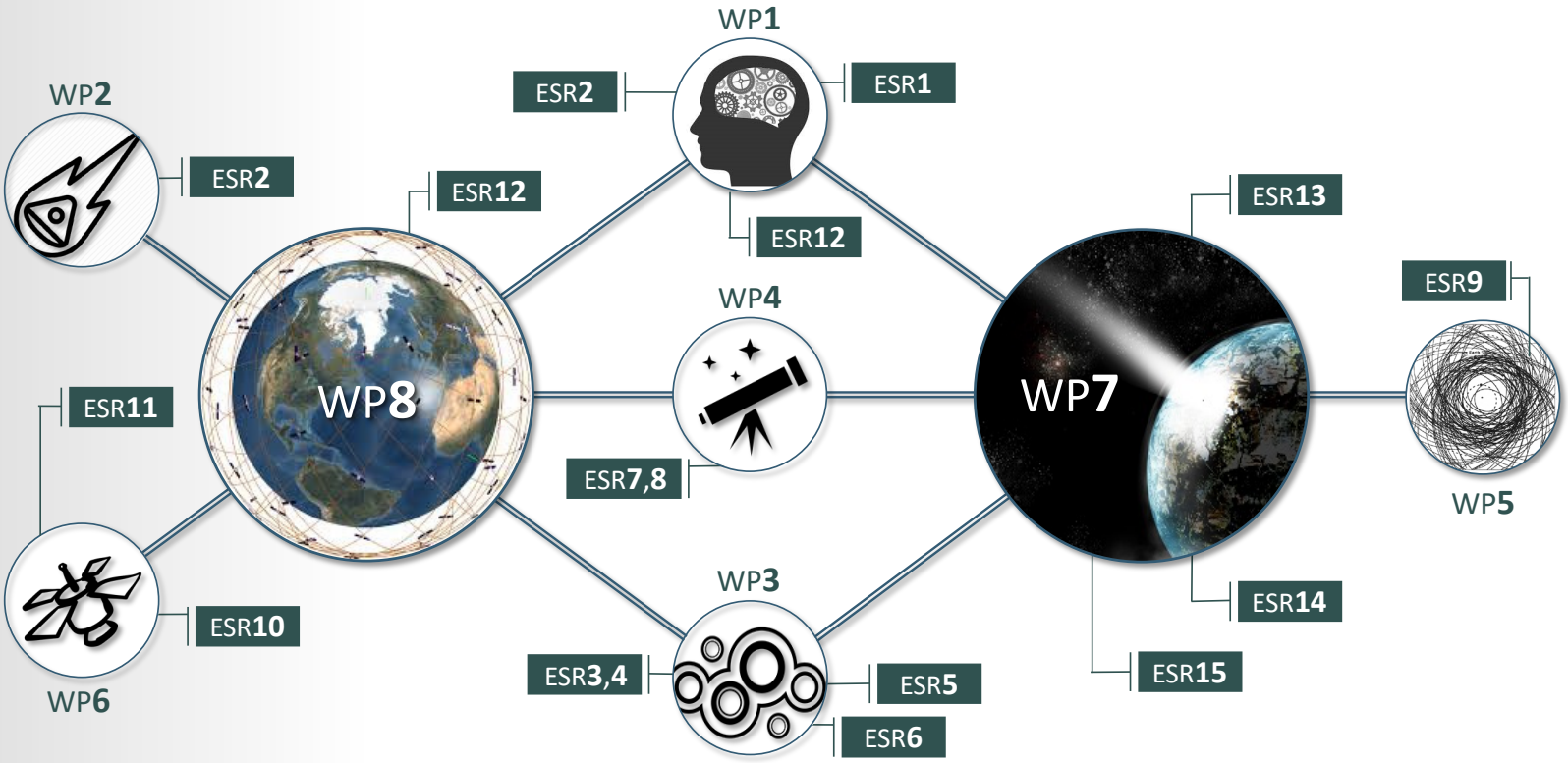
### SPACE TRAFFIC MANAGEMENT AND THE RESILIENT SPACE ENVIRONMENT

WP8 will cover all activities related to the future evolution of the space environment, the required change in operations, the problem of planning and executing collision avoidance maneuvers and the deployment and dispose of future constellations.



*Images credit: Massimiliano Vasile, University of Strathclyde*

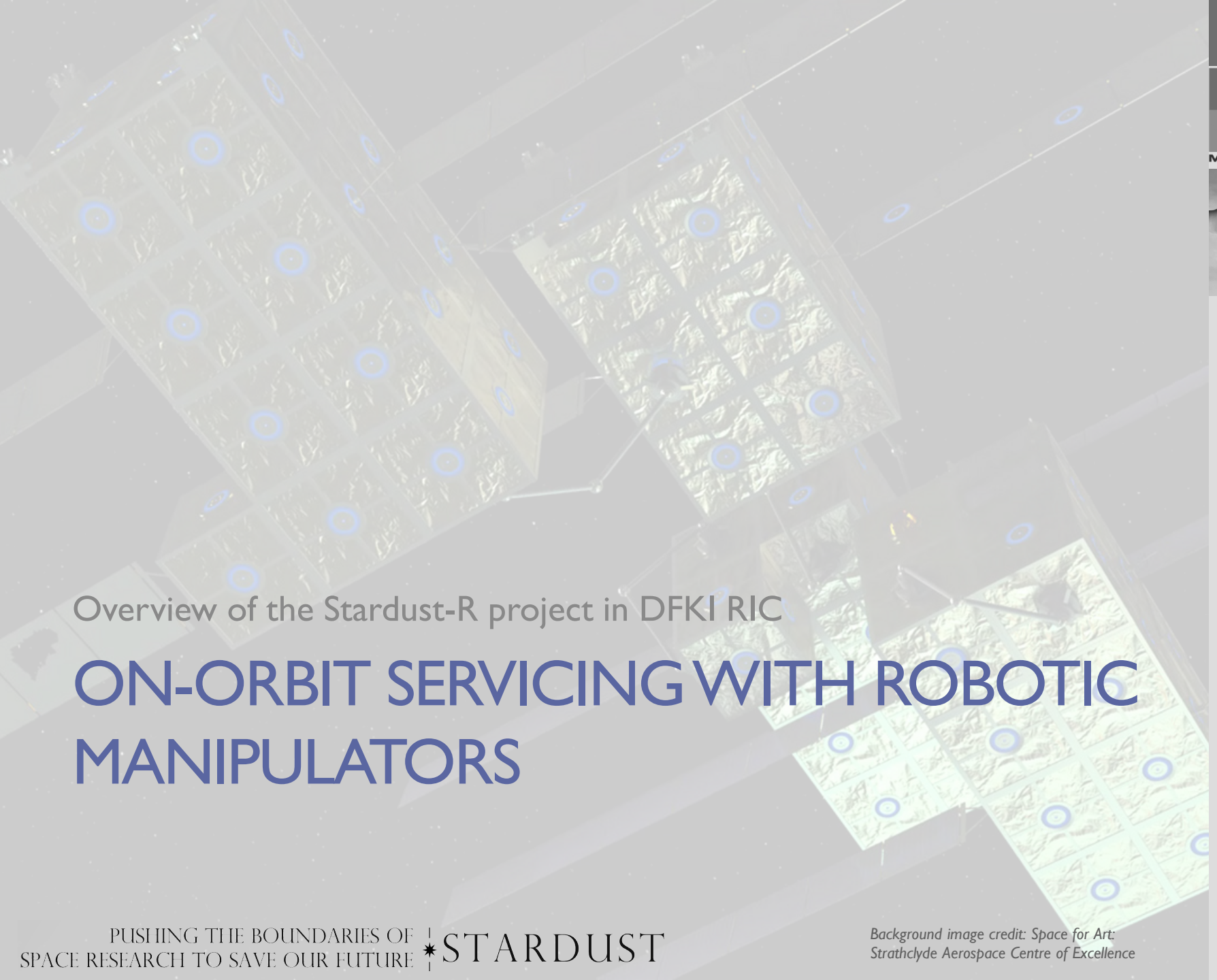
# Stardust-R: Research Program Overview




More info @: http://www.stardust-network.eu/



*Image credit: Massimiliano Vasile, University of Strathclyde*



Overview of the Stardust-R project in DFKI RIC

# ON-ORBIT SERVICING WITH ROBOTIC MANIPULATORS

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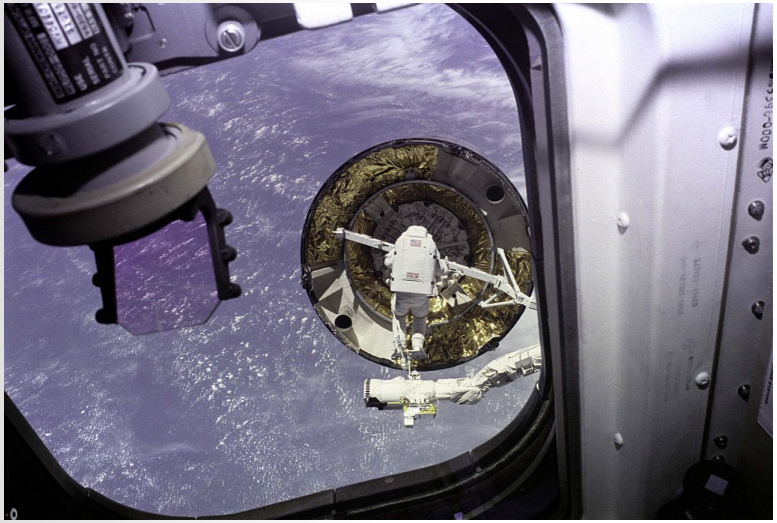
*Background image credit: Space for Art: Strathclyde Aerospace Centre of Excellence*

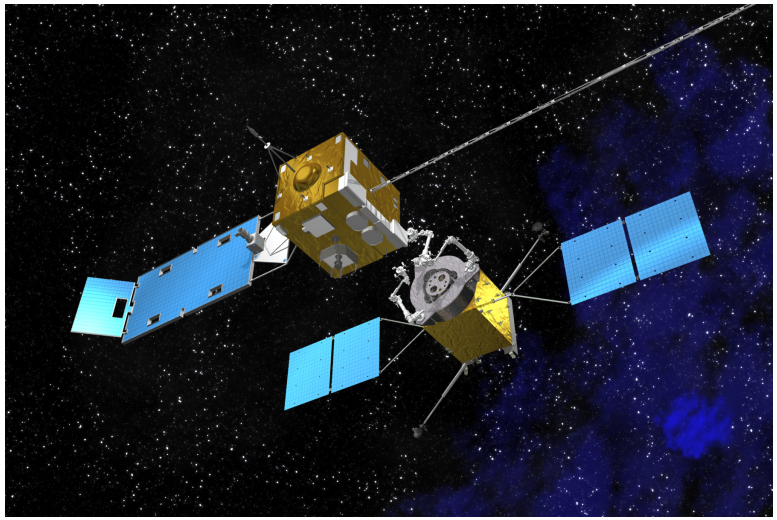
# Robotic Capture of Non-Cooperative Targets

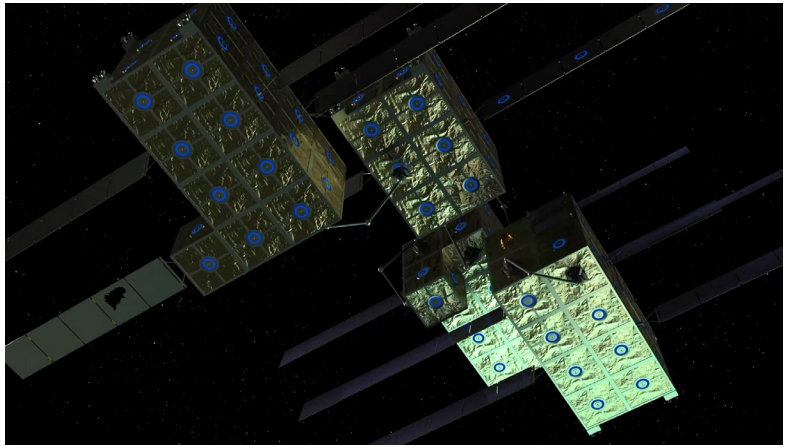


- Mission type: Intelsat VI repair
- Operator: NASA
- Launched: May 1992
- Records:
  - First EVA involving **3 astronouts**
  - **3 rendezvous** with an orbiting satelite
  - Attachement of a live rocket motor to an orbiting satellite

# On-Orbit Servicing with Robotic Manipulators

- **Project objectives**:
  - Development of **on-orbit servicing** and **active debris removal** disposal **solutions**.
  - Development of a **real-time control system** for a free-floating space manipulator.
  - Development of **control strategies to deal with contact interactions** in microgravity and their evaluation using an underwater vehicle.
  - **Test** final concepts on the flat-floor of the orbital robotics lab of **ESA-ESTEC**.
- **Project deliverables**:
  - Public wiki page
  - Book chapter on the Manipulation of Non-Cooperative Targets and On-Orbit Servicing
- More info @ https://goo.gl/xjRzQH



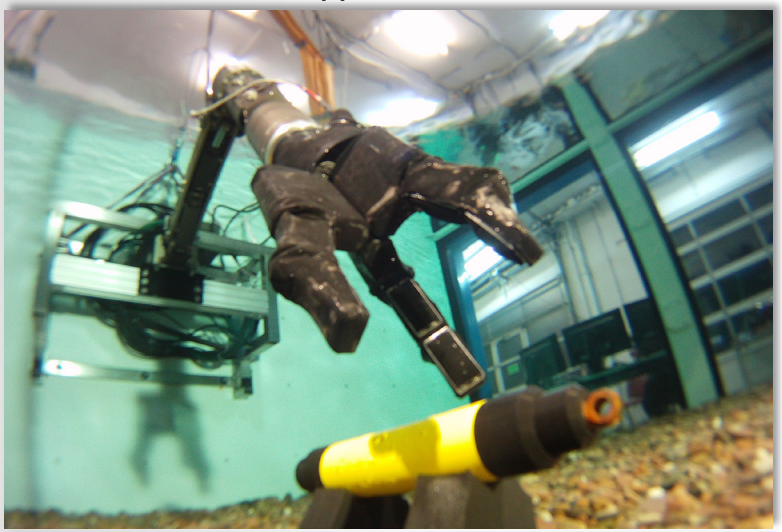


*Images credit: NASA (top) & Space for Art: Strathclyde Aerospace Centre of Excellence (bottom)*

# DFKI RIC Related Projects

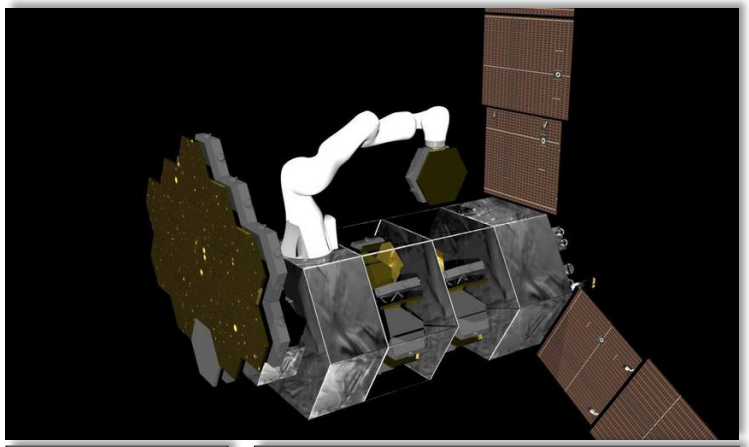
**Mare-IT**

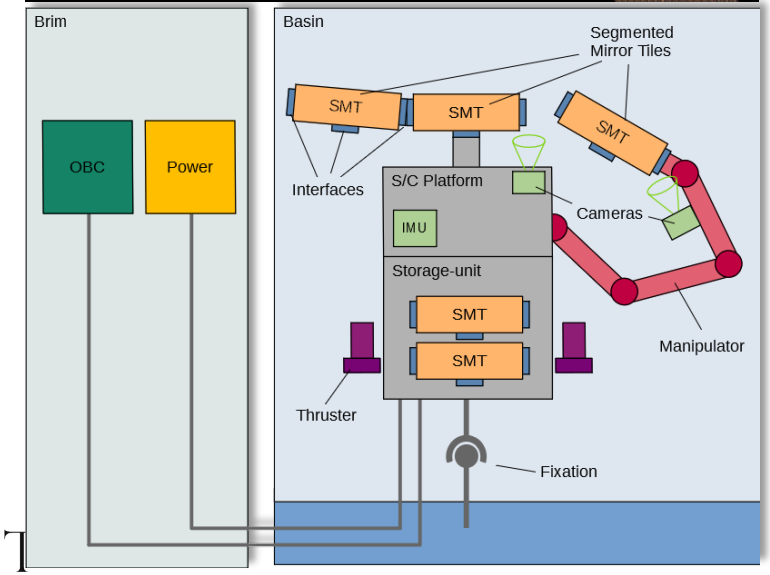
Information Technology for Maritime Applications



**H2020 PULSAR**

Prototype of an Ultra Large Structure Assembly Robot





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## Thank you for your attention!
## Any questions?

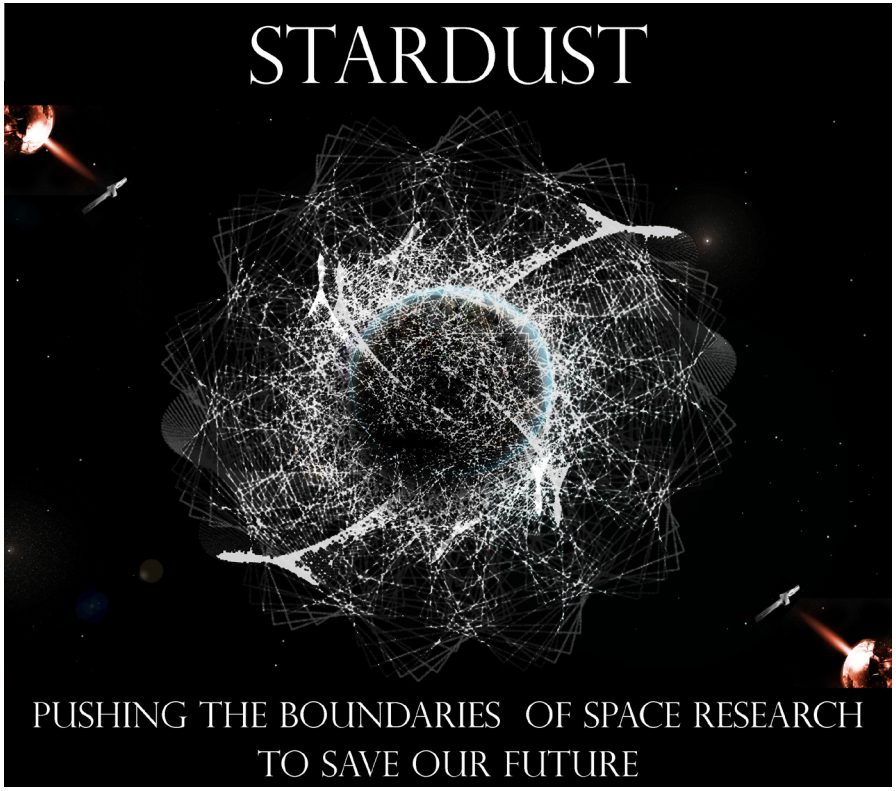


*Image credit: Peter McGinty, University of Strathclyde*

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