

**european
space technology
harmonisation**

Automation and Robotics

2017 Cycle #2 Mapping Meetings

POLAND Presentation
Ministry of Economic Development, PL,

Main actors:

- Space Research Centre, Polish Academy of Science (*MUPUS penetrometer for PHILAE lander in ROSETTA mission and others: KRET 1 i KRET 2, HEEP, CHOMIK instrument for PHOBOS-GRUNT mission*)
- PIAP/PIAP Space
- SENER PL (*IBDM, e.Deorbit – clamping mechanism, Umbilical Release Mechanism ExoMars 2020*)
- Astronika
- SKA-Polska
- ABM Space,
- Robotics inventions,
- Creotech Instruments
- GMV (*software for GNC and robotics, e.Deorbit*)
- AGH University of Science and Technology,
- Sybilla Technologies,
- Cilium Engineering,

Past Activities from Poland

Title	Short Description	Prog	Remark	Date	
				Start	End
Packmoon	Sampling device dedicated to low gravity bodies.	MREP	Company: CBK PAN	1.2015	4.2017
Air bearing table upgrade	Air bearing table dedicated to tests orbital maneuvers of space robot as well lander operations on low gravity bodies.	MREP, TRP	Company: CBK PAN In the frame of REST, SAMPLER and e.Deorbit Phase B1 projects	5.2015	12.2016
Lemur manipulator upgrade	Lemur manipulator tests done at GMV facility. Allow to upgrade the control system and build interface with S/C control system.	TRP	Company: CBK PAN Activity done in the frame of ORCO project (Startiger program)	11.2015	11.2016
Clamping Mechanism	The mechanism has to assure rigid connection between the chaser and follower. Clamping mechanism is able to adapt to the encountered obstacles, clamping in a different	GSTP	Company: SENER PL (sub);	09/2015	12/2016

Past activities from Poland

Title	Short Description	Prog	Remark	Date	
				Start	End
Hammering Mechanism for the HP3 mole type penetrator	As part of this project, Astronika developed and delivered seven models of the drive unit for DLR's heat probe instrument which is part of NASA's InSight mission to Mars planned for launch in 2018. The Hammering Mechanism created by Astronika is a drive system of the HP3 penetrator whose purpose is to transport thermal sensors below the surface of Mars.	Contract DLR	Company: Astronika	01/2014	03/2017
			Company: CBK PAN (sub) - manufacturing		
Lunar Drill Development - Phase A	The Lunar Drill, developed by the European consortium, will aid the mission's aim of examining the surface and subsurface distribution of volatiles across the Moon and of investigating the feasibility of utilizing lunar regolith in future human exploration by extracting subsurface samples from the depth of up to 2m. The Lunar Drill will be equipped with a torsional drive and a percussion module which enhance the conventional drilling process, and Astronika's expertise is particularly relevant to the instrument's hammering function.	GSTP	Company: Astronika	01/2015	05/2016

On-going and future activities from Poland

Title	Short Description	Prog	Remark	Date	
				Start	End
ADRexp: Active debris removal demonstration in laboratory condition	- Development two Breadboard Models of robotic grippers for Launch Adapter Ring capture	TRP	Company: PIAP Space (prime)	01/2015	05/2017
COMRADE: Control and Management of Robotics Active Debris Removal	Software Model of the robotic gripper & Launch Adapter Ring. Contact dynamics simulations of the gripper and Lanch Adapter Ring	TRP	Company: PIAP Space (subcontractor)	04/2017	12/2019
LAR gripper MGSE	Motorized MGSE to test LAR capturing by a gripper under vacuum thermal conditions	TRP	Company: PIAP Space (prime)	04/2017	01/2018
I3DS: Development of a modular high- level Inspection Sensor Suite	Torque/force sensors development	H2020	Company: PIAP Space (subcontractor)	11/2016	12/2018

On-going and future activities from Poland

Title	Short Description	Status	Prog	Remark	Date	
					Start	End
Elastic joint development based on cycloidal gear and direct drive	Development of elastic joint dedicated for robotic arm which reduce the arm vibration by using special cycloid gear head, direct drive and elastic components.	On-going	PIS / Slovak space program	Company: CBK PAN	6/2018	6/2020
Air bearing table upgrade to tests S/C GNC systems	Upgrade of air bearing table by special spherical air bearing to be able to tests S/C GNC systems	On-going	TRP	Company: CBK PAN	1/2018	10/2019
Mathematical model of contact process while landing on small celestial bodies	Mathematical model development of the contact process based on observations, laboratory testing and numerical simulation (Project ESA LOOP – Landing Once On Phobos)	On-going	PLIIS	Company: CBK PAN	2017	2019
Clamping mechanism	The mechanism has to assure rigid connection between the chaser and follower. Clamping mechanism is able to adapt to the encountered obstacles, clamping in a different position.	On-going	TRP	Company: SENER PL; under e.Deorbit Mission Phase B1	TBD	TBD+12m
Mechanisms and elements for International Berthing and Docking	developing standarised berthing and docking system to International Space Station (ISS)	On-going	GSTP/PLIIS	Company: SENER PL	2015	2018

On-going and future activities from Poland



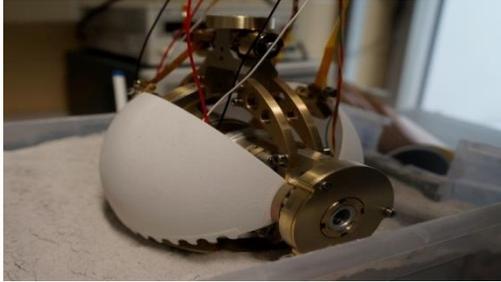
Title	Short Description	Status	Prog	Remark	Date	
					Start	End
PROSPECT Development for Lunar Exploration	This project is a continuation of the Lunar Drill development. A comparison between the two leading solutions is being performed: one based on an electromagnetic principle of operation and another propelled by a DC motor.	In progress	GSTP	Company: Astronika	11/2016	05/2018
Series of HDR actuators based on thermal cutting	The main objective s to develop a reliable, simple, lightweight, compact and cost effective type of serial Hold Down & Release Actuators (HDRA), understood as off-the-Shelf Building Blocks and suitable for future space mission needs.	In progress	PLIIS	Company: Astronika	04/2014	06/2019
HDRM for the EUROSTAR 3000 Deployable Reflector Assembly	The main objective to develop a reliable and cost effective non-explosive Hold Down & Release Mechanism (HDRM) suitable for the Eurostar 3000 platform Deployable Reflector Assembly (DRA).	In progress	PLIIS	Company: Astronika	11/2015	06/2019
RadCube boom system for RadMag instrument	To develop the boom for the RadMag instrument onboard the hungarian RadCube satellite. The boom shall position the RadMag magnetometer, developed by MTA EK, at a distance away from the satellite's body in order to avoid interferences from the RadCube on measurements.	In progress	GSTP	Company: Astronika	04/2017	11/2019
S-Heep – Planetary penetrator with soil collecting system for Luna-	As part of the Luna-Resurs mission. The aim is to develop, integrate and test a device which will drive into the ground and make measurements of the thermal properties and heat changes.	In progress	National funds	Company: CBK PAN -leading	01/2017	



CBK PAN involvement in space robotics development



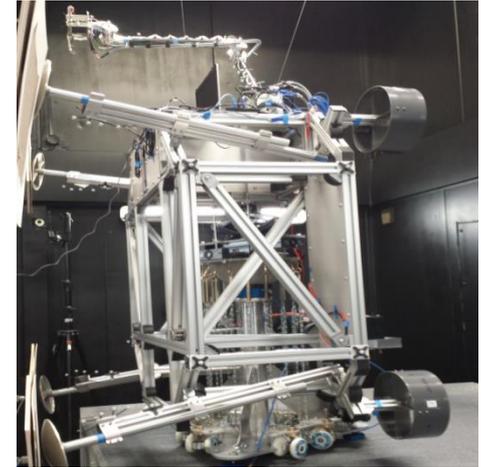
1. CBK PAN is a Polish research Institute fully focused on space sciences, technology development and applications
2. Space Mechatronics and Robotics Lab (LMRS) is focused on technical sciences and technology development in aerospace field
3. For ESA we are realizing number of projects related to future space debris removal and exploratory missions (edeorbit, Phootprint, Lunar missions)
4. We are cooperating with other worldwide partners like JPL/NASA, ROSKOSMOS and ChSA
5. Many projects are done by realization PhD thesis which allows to growth aerospace engineering community



PACKMOON sampling tool and drill development (ESA TASK FORCE and national projects)



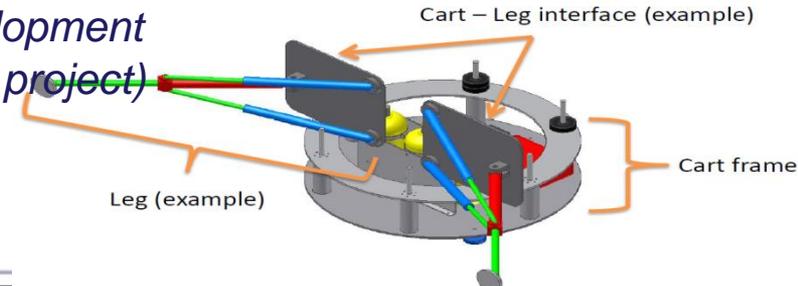
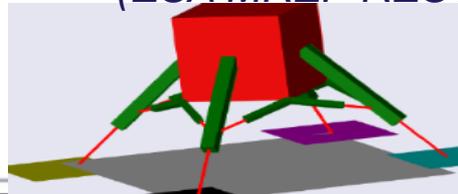
Air bearing facility at CBK PAN.



Testing sampling tool interaction with lander (ESA



Landing gear development (ESA MREP REST project)

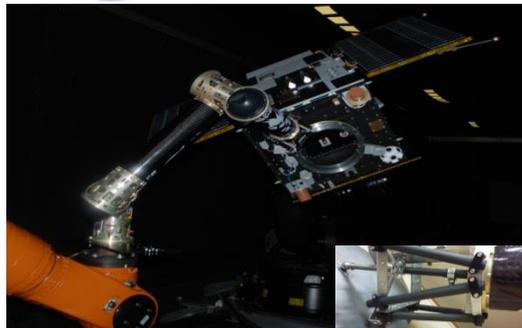


Cart – Leg interface (example)

Leg (example)

Cart frame

On - orbit robotics at CBK

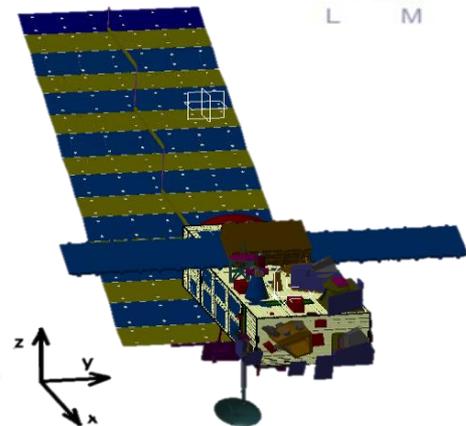


Robotic arm LEMUR control system development (ESA ORCO pr.)

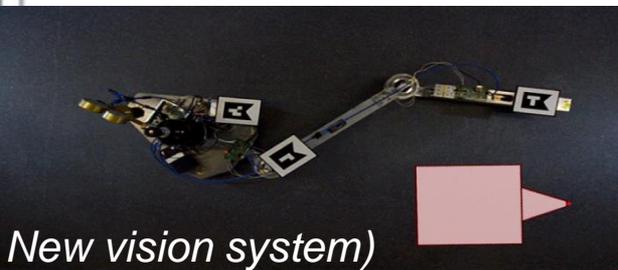
New platforms development (2 national scientific projects)



Air bearing facility at CBK PAN.



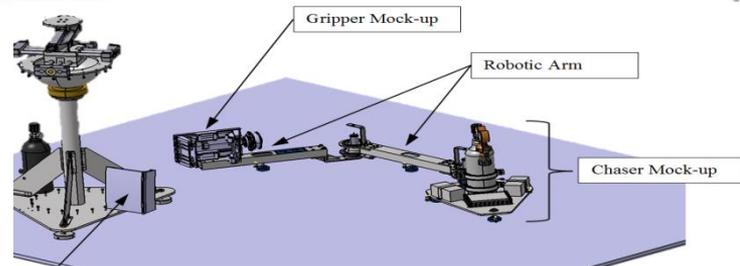
Simulating and testing grippers operations for ESA edeorbit mission



New vision system)



New platforms with thrusters



Future plans

1. Increase of TRL level of Packmoon device and its application for Lunar missions
2. Further air bearing facility upgrade -> qualification process would be important to certify results obtained on the system
3. Towards robotic cubesat mission which might be cost effective way to test some of robotic technologies
4. Development of low gravity model of regolith based on the tests in low gravity platforms
5. Extensive gripper testing on air bearing table

References to be added:

[1] Seweryn K., The new concept of sampling device driven by rotary hammering actions, IEEE/ASME Transactions on Mechatronic systems, VOL. 21, NO. 5, 2016

PIAP

INDUSTRIAL RESEARCH
INSTITUTE FOR AUTOMATION
AND MEASUREMENTS

PIAP

OBRUSN
INDUSTRIAL
AUTOMATION

PIAP SPACE

PIAP

SCIEN-TECH
TECHNOLOGY
TRANSFER

PIAP GROUP:

SPECIALISATION AREAS: ROBOTICS, AUTOMATION, MECHATRONICS

EXPERIENCE: 50 YEARS OF MARKET ACTIVITIES

STAFF: 320 (60% ENGINEERS)

TURNOVER: 15 MLN EURO/YEAR

PRODUCTS: 9 UGVs MODELS

SERVICES: 100+ INDUSTRIAL ROBOTS UNIT INSTALED

WORLD PRESENCE: 20+ COUNTRIES, 4 CONTINENT

PIAP SPACE:

SPECIALISATION AREAS: ROBOTICS, MGSE, MECHANISMS

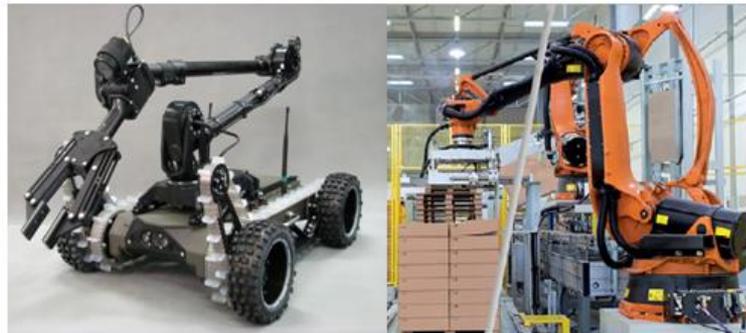
AMBITION: BECOME TIER-2 FOR ROBOTICS

ACTIONS: MEMBER OF SRC ROBOTICS, LEADING SPACE ROBOTICS ADVISORY GROUP IN POLAND, MEMBER OF POLISH SPACE MINING GROUP

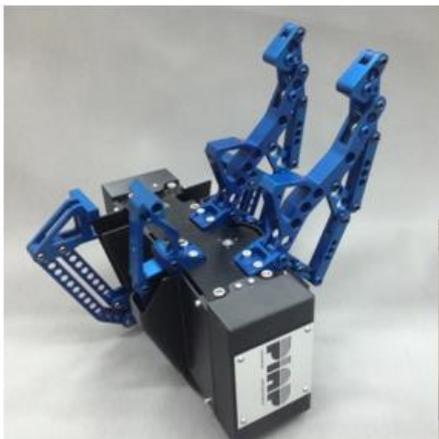
ROBOTIC MISSIONS: SPACE TUG, ADR, ON-ORBIT SERVICING, REFUELLING & ASSEMBLING, ASTEROID MINING

ROBOTIC ELEMENTS: GRASPING & HOLDING, END-EFFECTOR TOOLS, LIGHT-WEIGHT ARM, MOBILE PLATFORMS, PERCEPTION, ROBOT - USER INTERFACING

ADDITION ROLE: TRANSFERRING TO TERRESTIAL



1. LAR GRIPPERS FOR LAUNCH ADAPTER RING CAPTURING



- TRL 4
- FOR ADR & OOSS APPLICATIONS
- TWO GRIPPERS, 2 LAR MODELS
- VALIDATED ON AIR TEST BENCHES AND RANDEVOUS TEST BENCH (CLOSE & OPEN LOOPS)

KEY PERFORMANCE:

- ENCLOSING THE TARGET
- HIGH CAPTURE ENVELOPE
- SHORT CLOSING TIME
- HIGH GRIPPING FORCE

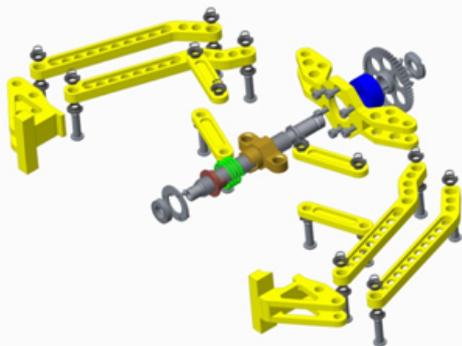
2. SUPPORTIVE ACTIVITIES FOR GRASPING SUBSYSTEM DEVELOPMENT:

3DS: INTEGRATED 3D SENSORS

- TORQUE/FORCE SENSORS DEVELOPMENT
- TACTILE SENSORS DEVELOPMENT

APPLICABILITY:

- GRIPPER FINGERS / CLAMPING MECHANISM JAWS
- DOCKING MECHANISMS
- ROBOTIC ARM WRISTS / JOINTS

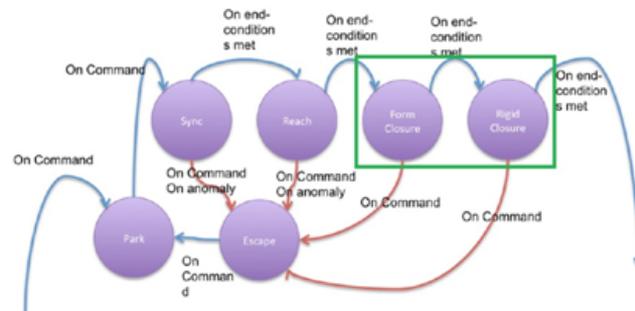


COMRADE: CONTROL AND MANAGEMENT OF ROBOTICS ACTIVE DEBRIS REMOVAL

- DEVELOPMENT SOFTWARE MODEL OF THE GRIPPER & LAR (MATLAB)

APPLICABILITY:

- SIMULATIONS OF THE LAR CAPTURING PHASE



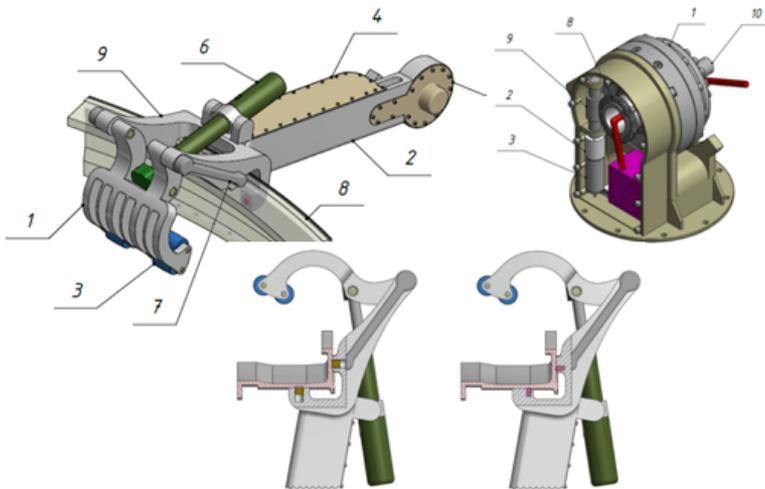
Green frame shows which operation sub-phases will be covered by PIAP model

3. ASSOCIATED ACTIVITIES FOR GRASPING SUBSYSTEM DEVELOPMENT:

CLAMPING MECHANISM CONCEPTUAL DESIGN (INTERNAL STUDY)

APPLICABILITY:

- ADR MISSIONS: HOLDING LAR OF THE HEAVY CLASS SATELLITE DURING DE-ORBITATION BOOSTS

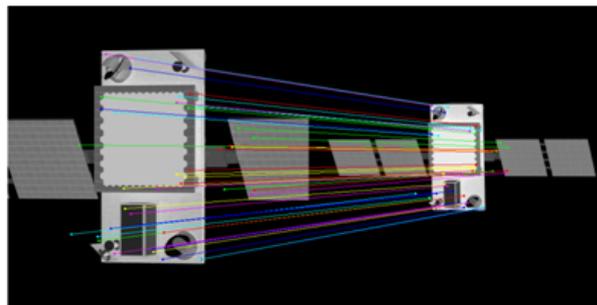


OBSERVER: ROBUST, UNSUPERVISED VISUAL MOTION RECOGNITION OF NON-COOPERATIVE SATELLITE FOR ON-ORBIT CAPTURE

- FUNCTIONAL MODEL OF THE NAVIGATION CAMERA
- ALGORITHMS FOR IMAGE RECOGNITION

APPLICABILITY:

- SERVICING MISSION OF THE IRIDIUM SATELLITE



Involvement of Astronika in areas covered by Dossier:

4.5.1.1 Manipulations systems:

- Four LP-PWI Langmuir probes are to be mounted on the JUICE spacecraft in order to gather crucial information about the surrounding bulk plasma in Jupiter's magnetosphere. The main goal of **the mechanism** developed by Astronika's engineers **is to position the Langmuir Probes at the desired angle of 135° and 3 m from the interface hinge.**
- Boom system for the RadMag instrument on the RadCube satellite

Development a boom system for the Hungarian RadCube space mission based on a beryllium tape developed under the ESA project **Tubular antenna system for satellite applications**, which shall extend by 1m. The main application of the boom is to position in orbit the RadMag instrument developed by the MTA Centre for Energy Research in Budapest. This mission would enable Astronika to raise the technology level of beryllium tape systems up to TRL9.

4.5.1.2 Mobility Systems:

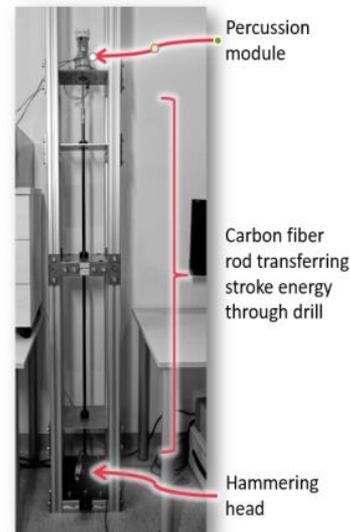
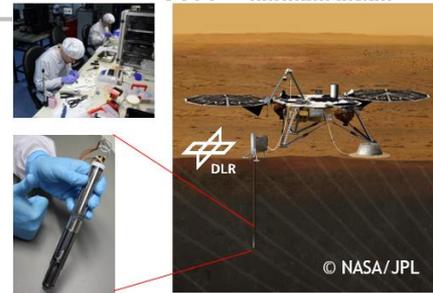
- **Hammering Mechanism (HM)
for the HP3 mole type penetrator**

the drive unit of DLR's heat probe instrument for NASA's InSight mission to be launched in 2018.

- Lunar drill for Roskosmos-led Luna-Resurs (Luna-27) mission (phase B+; end: Q1 2018 at TRL 6)
- HOPTER platform (ev. to be added to 4.7.2.2)

4.5.2.3 Motion and Actuation

- **Oscillatory motor** is an active/passive damper which cooperates with the spring driven hinges for deployments of solar panels, masts, booms, antennas, etc.

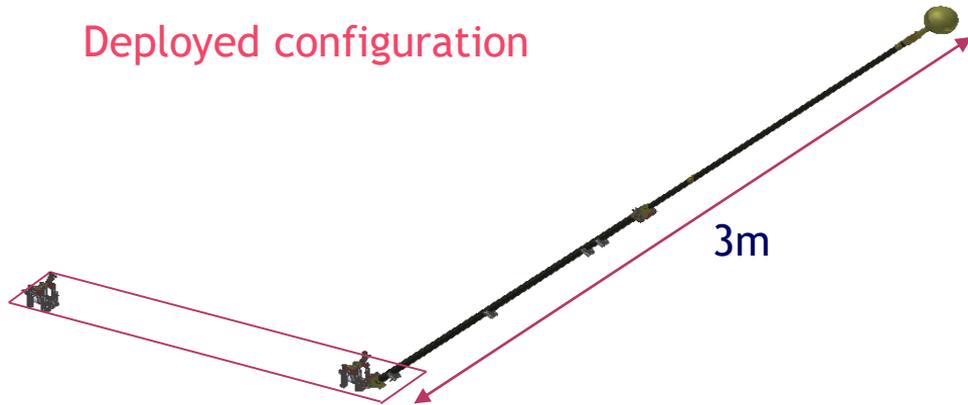


LP-PWI - Langmuir Probe & Plasma Wave Instrument

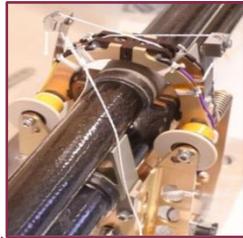
Deployed configuration

LP-PWI overview

LP-PWI is a part of the instrument group RPWI (Radio & Plasma Waves Investigation) on JUICE (Jupiter Icy Moon Explorer) mission. 4 LP-PWI will be measured plasma and electric field. Astronika together with IRFU is responsible for development Langmuir Probe instrument



HDRM#2



Central hinge



Base hinge+ HDRM#1

Stowed configuration

LP-PWI - Langmuir Probe & Plasma Wave Instrument

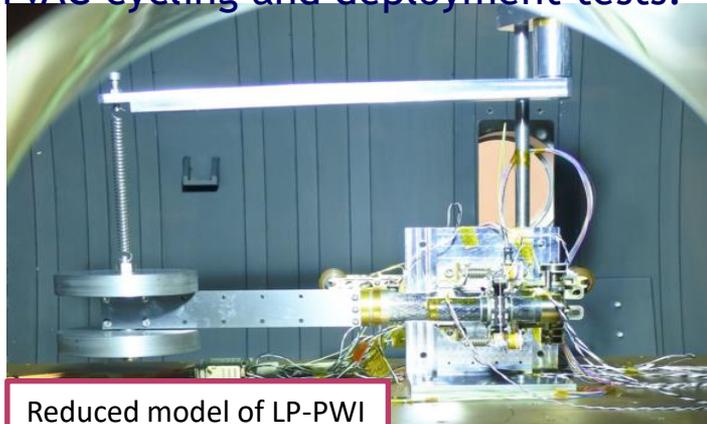
LP-PWI successfully passed breadboarded test campaign

Deployment test in simulated -0g environment:



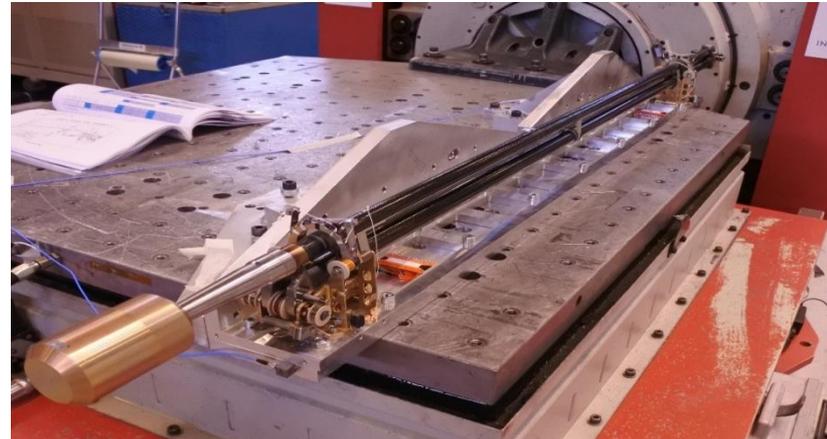
Test performed on the epoxy floor, using Miniature Ball Transfer Units (BTU)- 0g facility

TVAC cycling and deployment tests:



Reduced model of LP-PWI

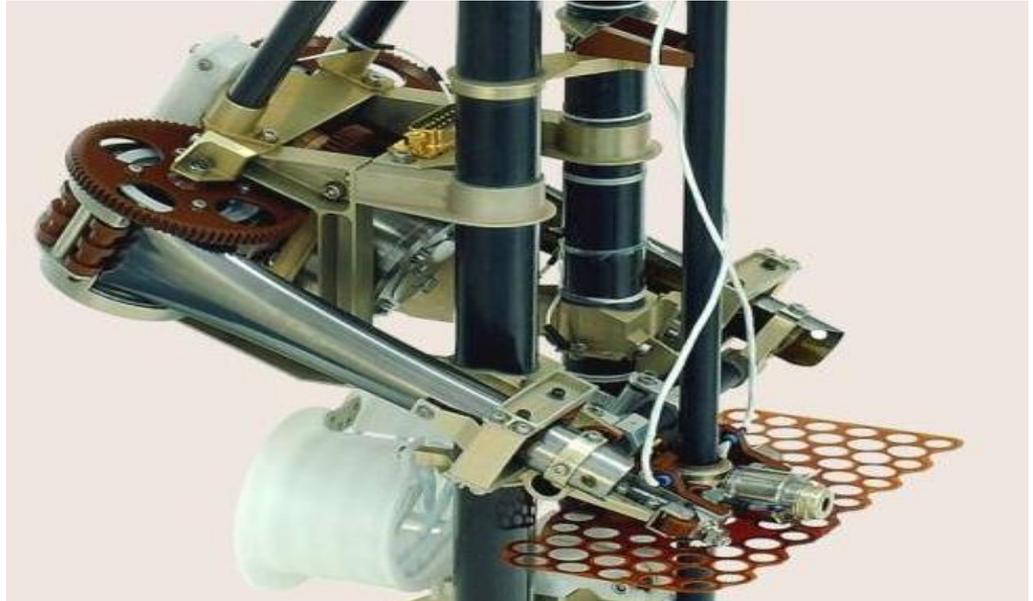
Vibration tests:



Over the years (since 1993) Astronika's engineers have developed numerous instruments based on the tubular boom technology, most of which were developed under the auspices of CBK PAN or in private engineering entities contracted by foreign space companies.

The tubular boom technology perfectly fits into specificity of deployable single-shot antennas, both monopoles and dipoles as well as ultra-light manipulators.

The functional principle is based on a tubular boom mechanism. The tubular boom strip is stored on a reel in stowed configuration. When deployed it forms cylindrical tube of given length.



HOPTER - Novel Planetary Exploration Platform



Unique Highland Terrain Hopper HOPTER



Visualization of HOPTER on Martian terrain

Astronika promotes R&D activities

Beside involvement in space industrial sector, it is of interest of Astronika to cover also research activities in niche domain of scientific instruments and mechanisms with especially nonstandard and demanding environmental requirements.

Highland Terrain Hopper

In cooperation with CBK PAN (SRC PAS) and ING PAN (IGS PAS) Astronika develops a cutting-edge Highland Terrain Hopper (HOPTER) as a novel exploration platform for exceptional mobility on celestial bodies with low- and micro-gravity (Mars, moons, asteroids). Astronika proposed an original system architecture of a hopping robot capable of traversing undulated terrain with obstacles much higher than the robot itself where conventional rovers and landers can no longer operate.