



Development of a LAR gripper and the associated MGSE equipment

Clean Space Industry Days 2017

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PIAP SPACE

PIAP
INSTITUTE

PIAP
OBRUSN
INDUSTRIAL
AUTOMATION

PIAP
SPACE

PIAP
SCIEN-TECH
TECHNOLOGY
TRANSFER



PIAP GROUP:

**SPECIALISATION AREAS: MOBILE & INDUSTRIAL
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 CONTINENTS







**Przemysłowy Instytut
Automatyki i Pomiarów PIAP**



PIAP SPACE – COMPANY DEDICATED FOR SPACE ACTIVITIES

OWNER:

**PIAP INSTITUTE, GOVERNMENTAL INVESTOR
- INDUSTRIAL DEVELOPMENT AGENCY**

SPECIALISATION AREAS:

ROBOTICS, MGSE, MECHANISMS

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,
AUTOMATIZED INTEGRATION & INSPECTION OF
SATELLITES & LAUNCHER ELEMENTS**

IMPORTANT ROLE:

TRANSFERRING TO TERRESTRIAL



Rationale & technology need



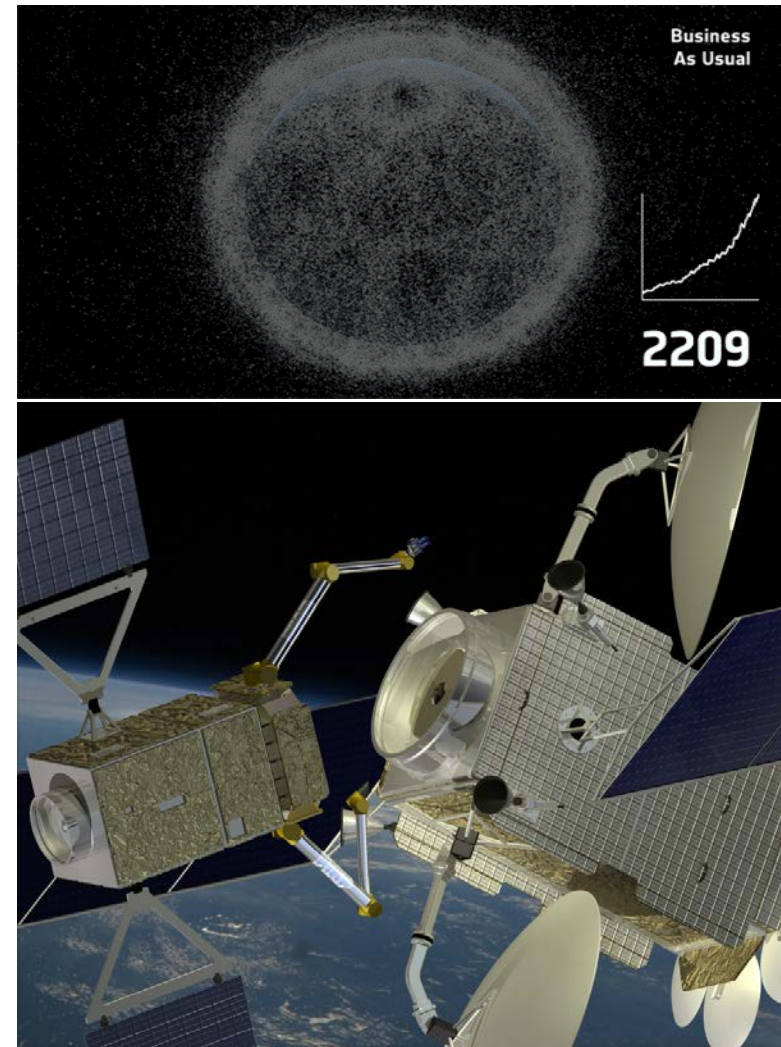
Market areas:

- Active Debris Removal
- On-Orbit Satellite Servicing
- On-Orbit Satellite Refuelling
- Space Tug concept

Similarities:

- Prepared & unprepared client satellite
- Minimal modification of existing satellite buses
- Launch Adapter Ring as a grasping point.

Technology gap in the area of grasping devices.

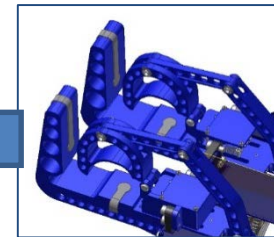
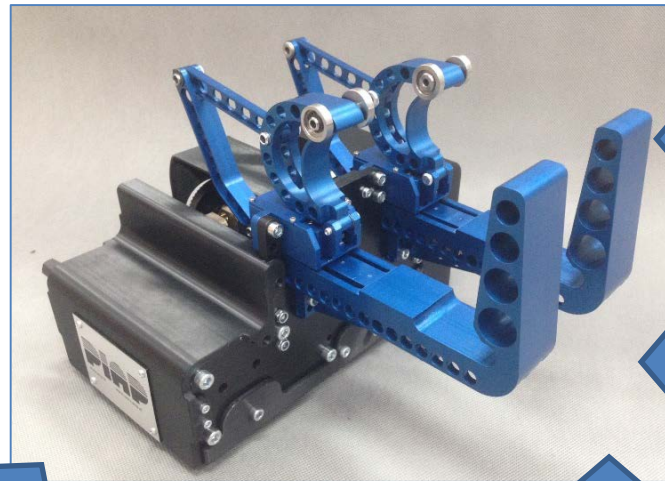


LAR Grippers – technology building blocks



ADReXP (TRP):

- Grippers B/B development (mechanism)
- HIL close-loop tests

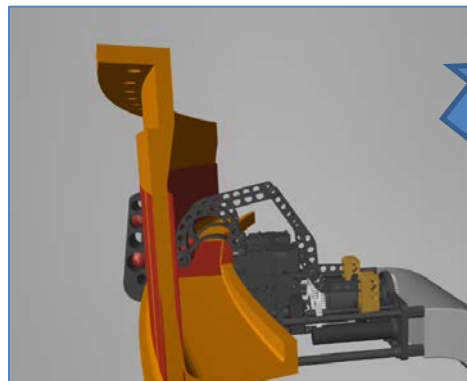
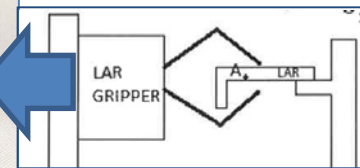


Polish study:

- Sensors to monitor jaws configuration

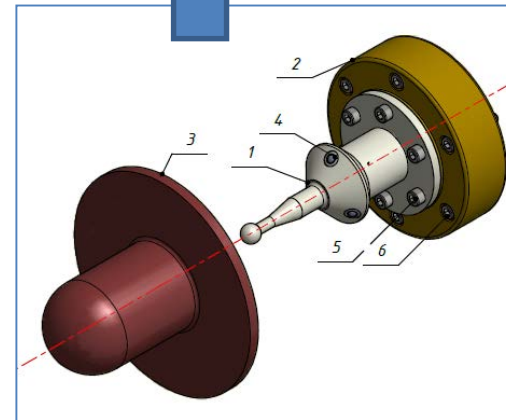
MGSE (TRP)

- Functional, quality & environmental tests



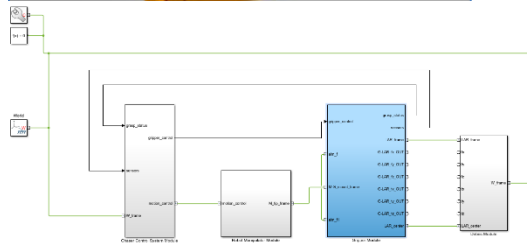
COMRADE (TRP):

- Gripper SW model
- Contact dynamics simulations



I3DS (OG4):

- Tactile sensors
- Force / Torque sensors



Key requirements



1. Launch Adapter Ring compatibility

Particular model or several similar.

2. Capture time

Decreasing risk that object would fly away, decrease requirements for capture window.

3. Capture envelope

Static and dynamic misalignments of the target.

4. Loads transfer

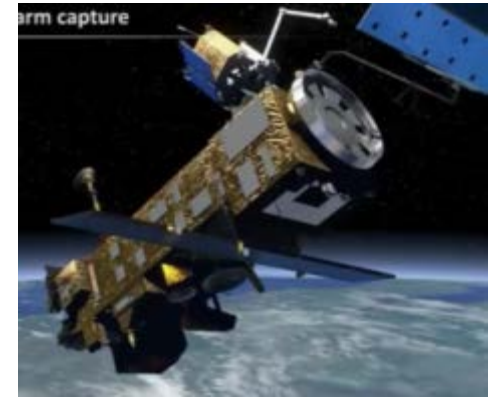
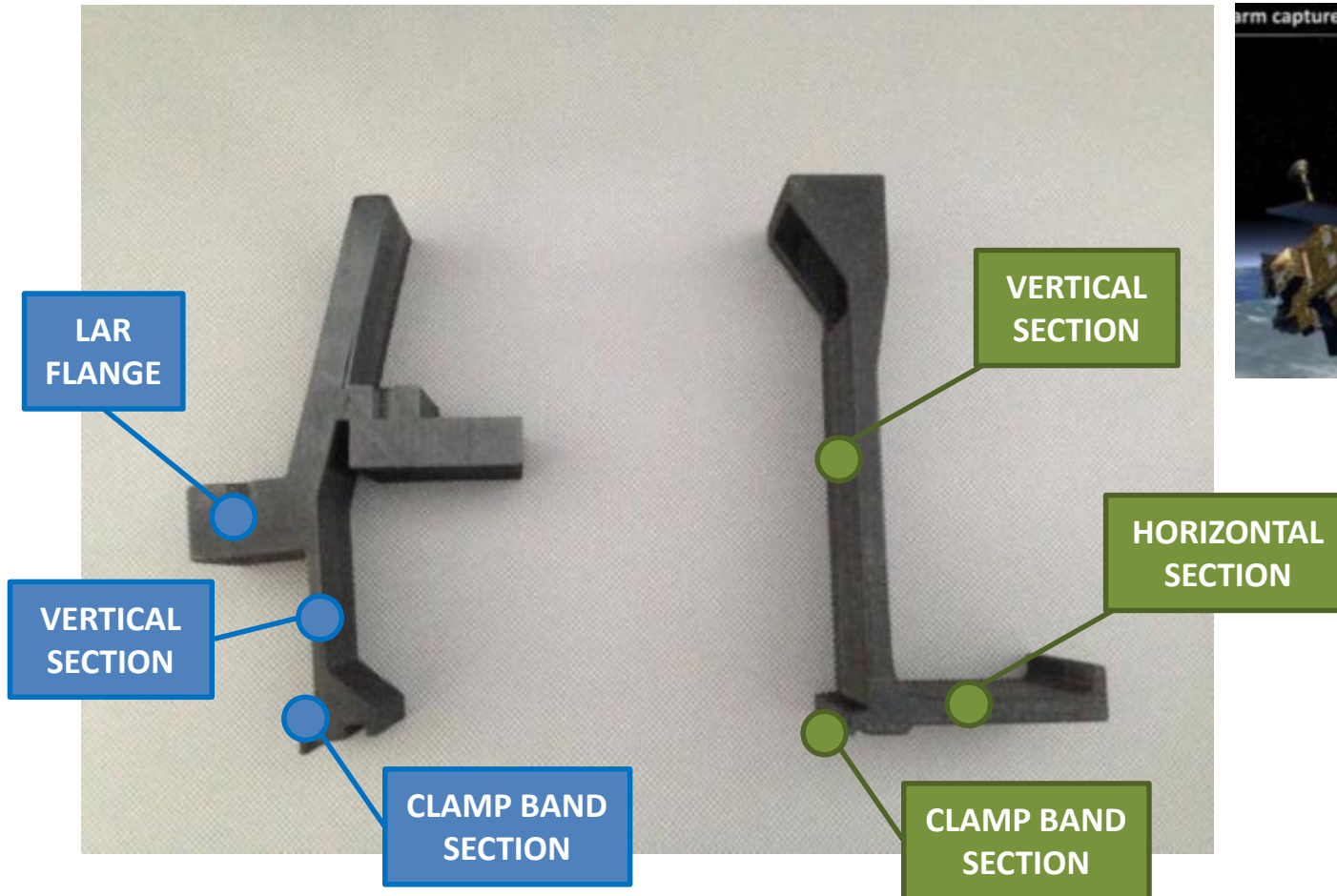
Allowing different operations: robotic arm and chaser reorientation, detumbling, orbit change (including deorbitation).

5. Autonomy & automatisisation

6. I/F with servicing satellite

Robotic arm or directly structure of the chaser.

Targets

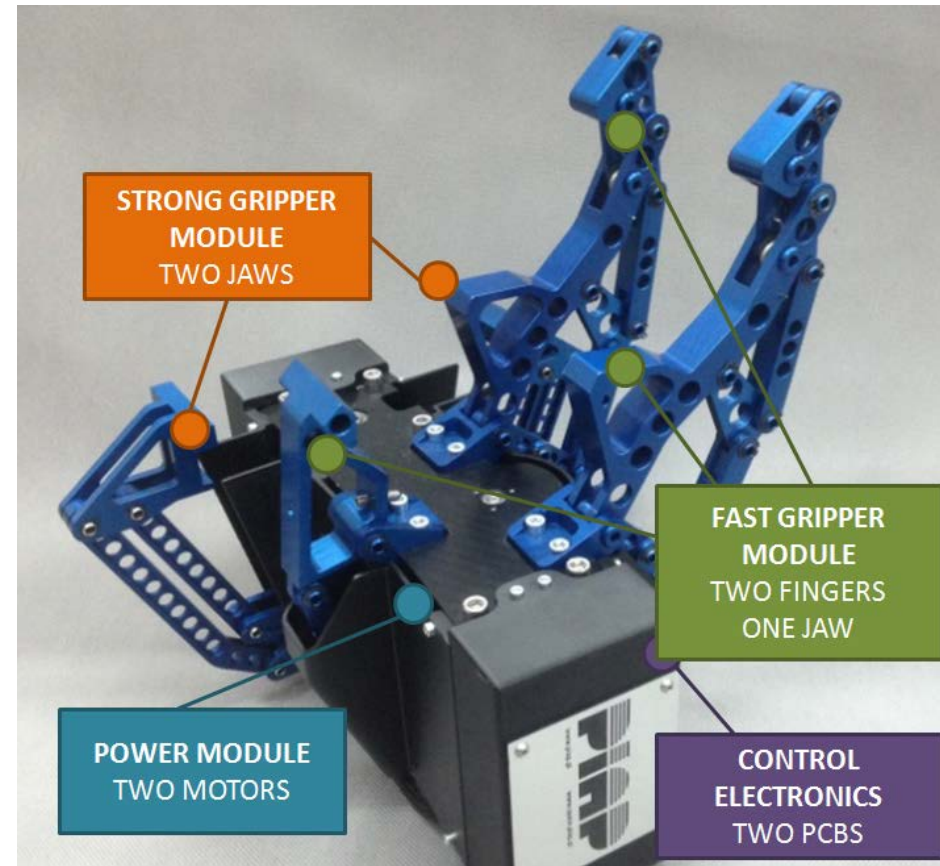
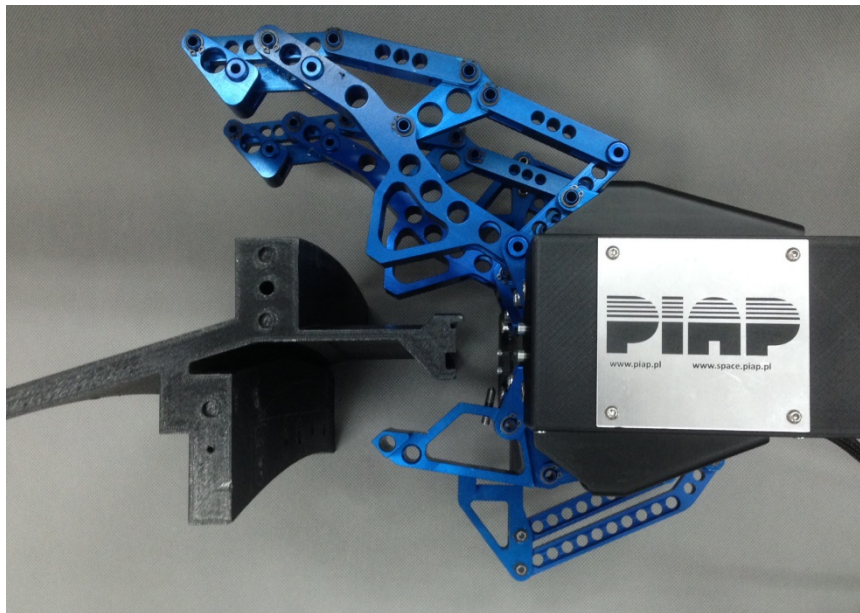


Gripper #1 design overview

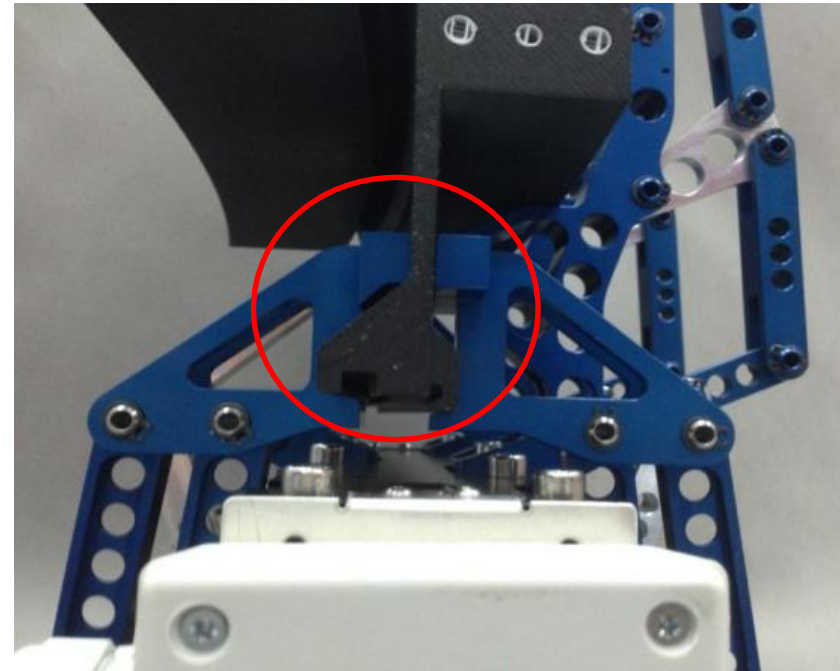
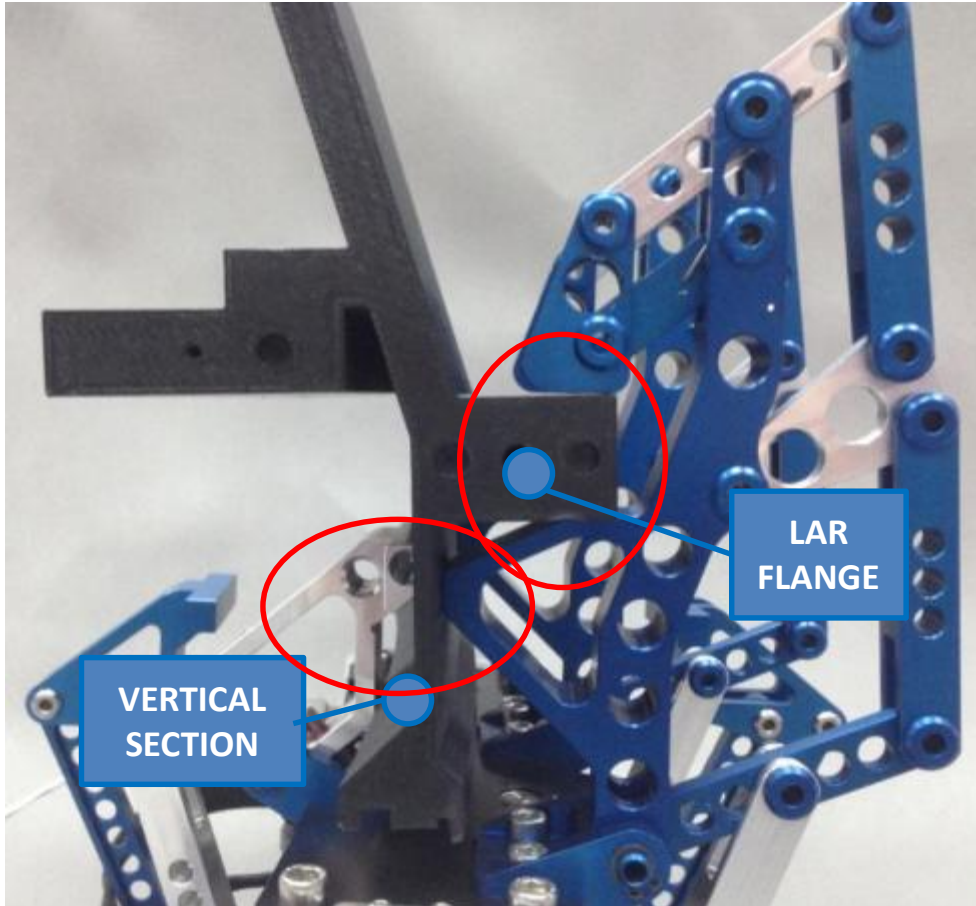


Operations divided between two grippers:

- Antropomorfic: enclosing, soft capture and handling misalignments
- Strong gripper: increasing capabilities of loads transfer
- Each gripper driven by separate motor



Gripper #1 design overview

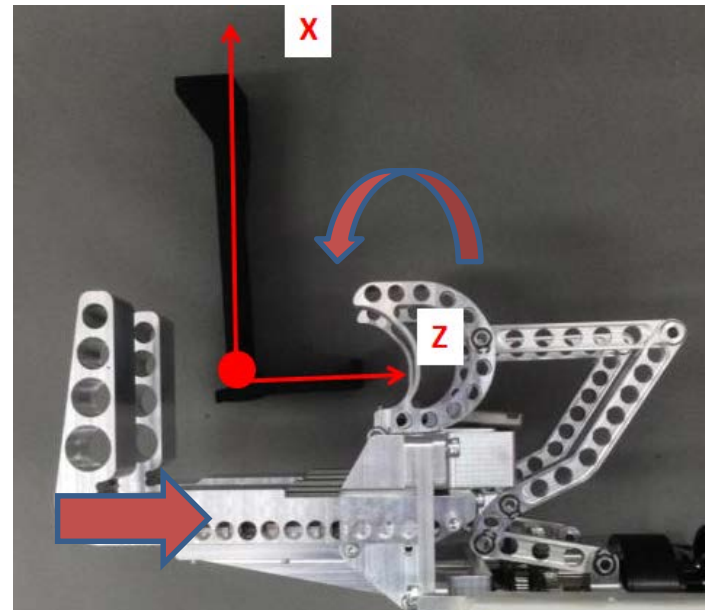
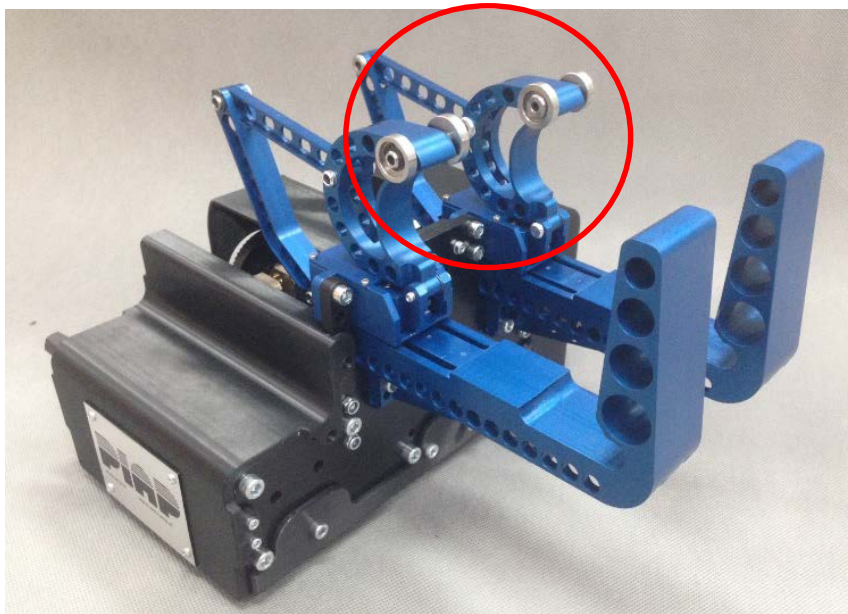


Gripper #2 design overview



Operations divided between two grippers:

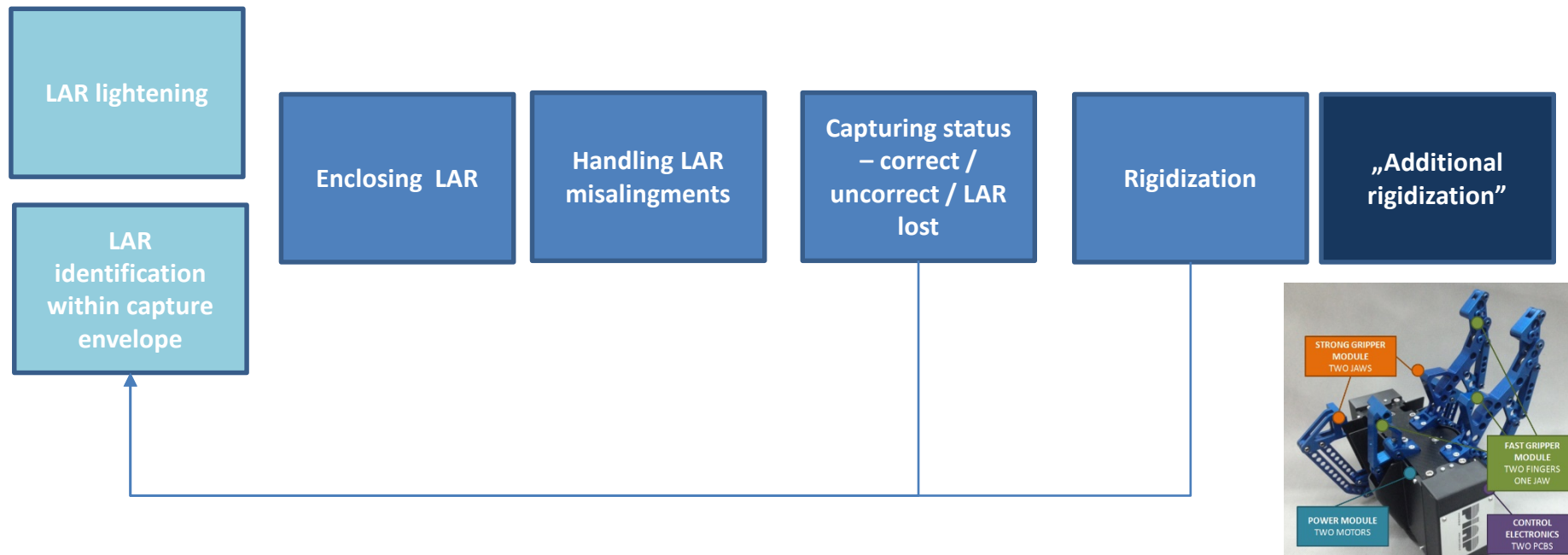
- Antropomorphic: enclosing, soft capture and handling misalignments
- Strong gripper: increasing capabilities of loads transfer
- Jaws rotational movement to enclose LAR, linear to increase gripping force
- Rolls to decrease friction impact



Grippers #2 operations



Grippers performance



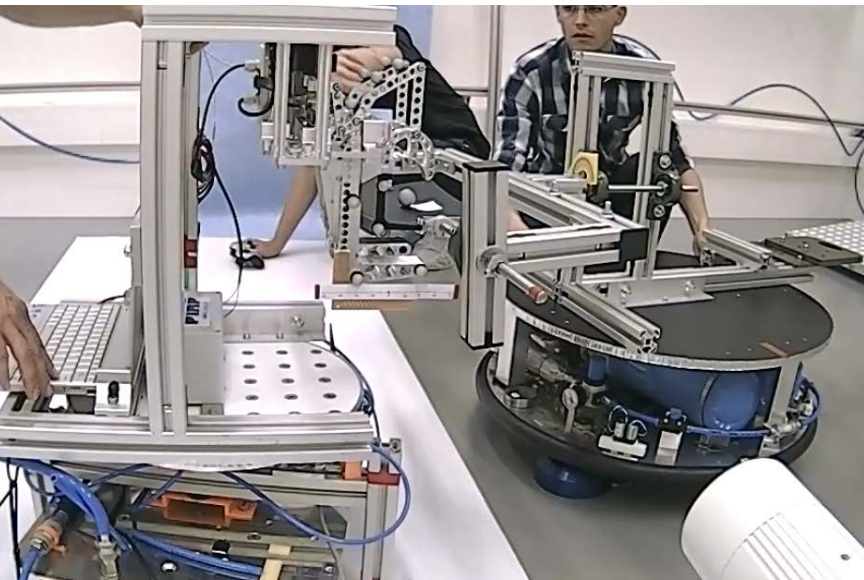
VALIDATION



AIR TEST BENCH

VALIDATION

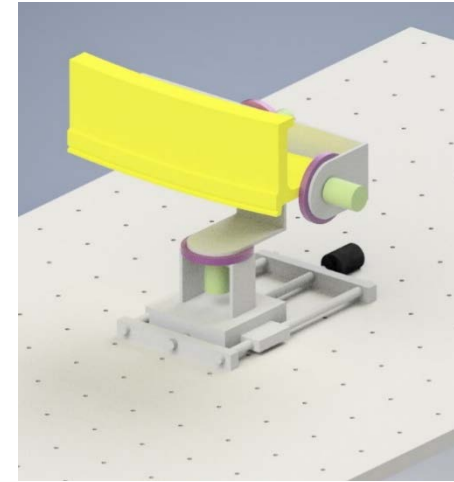
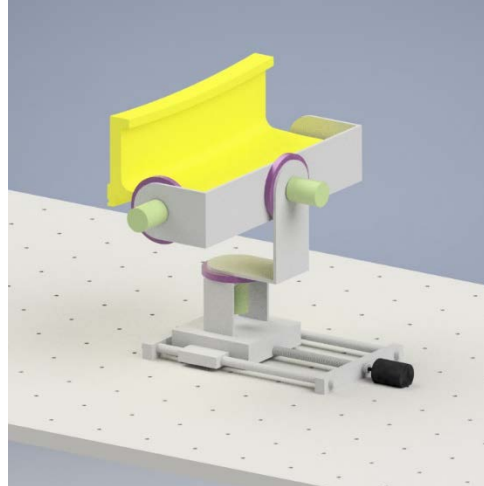
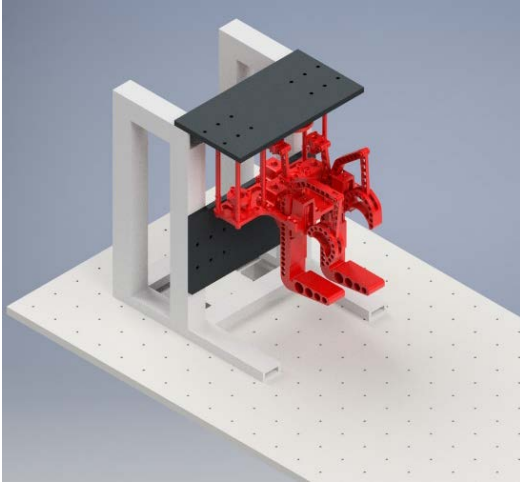
**ROBOTICS
RENDEZVOUS
TEST BENCH**



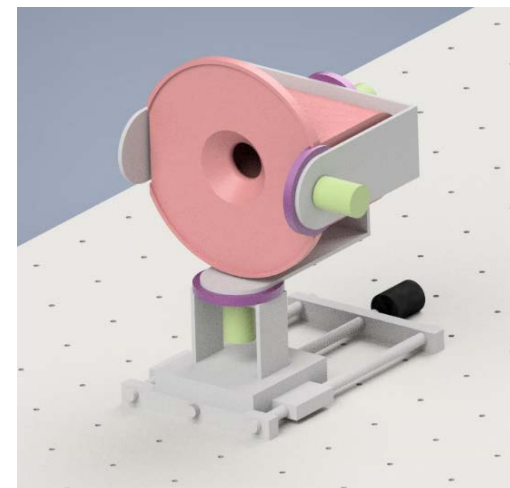
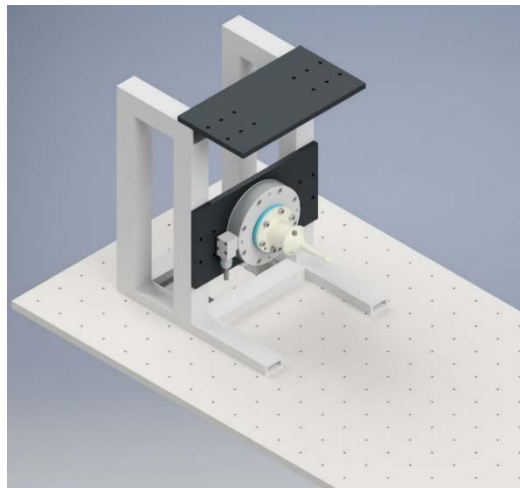




LAR Gripper MGSE for TVAC validation



LAR gripper



ASSIST

GRASPED OBJECT ALWAYS MUST BE ENCLOSED FIRST

- WIDTH OF THE FINGERS IS THE MAIN LIMITATION TO REACH HIGHER MISALIGNMENTS – „WALL” CONCEPT
- THE HIGHER WIDTH FINGERS HAVE THAN THE GRIPPER BETTER HANDLE ALFA MISALIGNMENTS AND ALFA AND BETA TORQUE LOADS
- IN CASE OF NOT FULLY CORRECT HOLDING USING SECOND GRIPPER ALLOW ITERATIVELY REACH CORRECT HOLDING
- FOR SOME CASES CONTROLLING EACH FINGER SEPARATELY IS USEFUL
- FOR SOME CASES INSTALLING ROLLERS ON THE TIPS MIGHT BE USEFUL
- WORTH TO APPLY ADDITIONAL „STRONG GRIPPER”, „LOW COST”, LOADS TRANSFER SIGNIFICANTLY INCREASING

Gripper translation from ADR to Space Tug?

Launch service providers



- ArianeSpace – Ariane 5, Soyuz (Starsem 2001r. manual as well), Vega
- ULA – Atlas V, Delta IV, Delta II
- SpaceX – Falcon 9, Falcon Heavy
- EUROCKOT – Rockot
- ILS –Proton
- CASC – Long March 3
- MHI Launch Services – HII-A
- SeaLaunch – Zenit
- LM – Athena
- Orbital ATK – Antares, Pegasus
- Kosmotras - Dnepr



Launch statistics (29.12.2015)



220/231
Ariane
family

469/582
Atlas family

Launch Vehicle	Successes	Tries
Delta 2	151	153
Delta IV	29	30
Soyuz	859	884
Ariane 5	57	58
Atlas V	59	60
Proton	78	89
Zenit	38	47
Falcon 9	14	15
Rockot	23	25
Vega	5	5
LM-3	78	83
H-2A	28	29
Dnepr	21	22
Pegasus	37	42

Max. payload mass



LV	LEO [t]	SSO [t]	GTO [t]	GEO [t]
Delta 2	3.470	-	2.190	-
Delta IV	28.370	-	13.810	-
Soyuz	4.850	4.400	3.250	1.440
Ariane 5	20.000	10.000	9.500	-
Atlas V	18.850	-	8.900	-
Proton	23.000	-	6.930	3.300
Zenit	13.740	-	6.160	4.200
Falcon 9	22.800	-	8.300	-
Rocket	2.140	1.300	-	-
Vega	2.300, 1.430 (polar 700 km)	1.260 (800 km)	-	-
LM-3	11.500	-	5.500	-
H-IIB	16.500	-	8.000	-
Dnepr	3.200	1.800	-	-
Pegasus	0.400	-	-	-
Angara	24.500	-	6.600	-

Launch service providers' data, www.spacelaunchreport.com

Launch adapter providers



- RUAG (Saab Ericsson Space)
- EADS Casa Espacio (CASA)
- MOOG
- BLS - Boeing Launch Services
- **Yuzhnoe SDO**



Launch service providers



- ArianeSpace – Ariane 5 (**RUAG**, **EADS CASA**), Soyuz (**SAAB**, **CASA**), Vega(**EADS**)
- ULA – Atlas V (ULA, **RUAG?**), Delta IV (ULA), Delta II (Boeing)
- SpaceX – Falcon 9, Falcon Heavy (**RUAG**, **EADS**)
- EUROCKOT – Rockot (**EADS**)
- ILS –Proton (**RUAG**, **EADS**)
- CASC – Long March 3A (**RUAG**)
- MHI Launch Services – HII-A
- SeaLaunch – Zenit
- LM – Athena (**RUAG**)
- Orbital ATK – Antares (**RUAG** optional), Pegasus
- Kosmotras - Dnepr

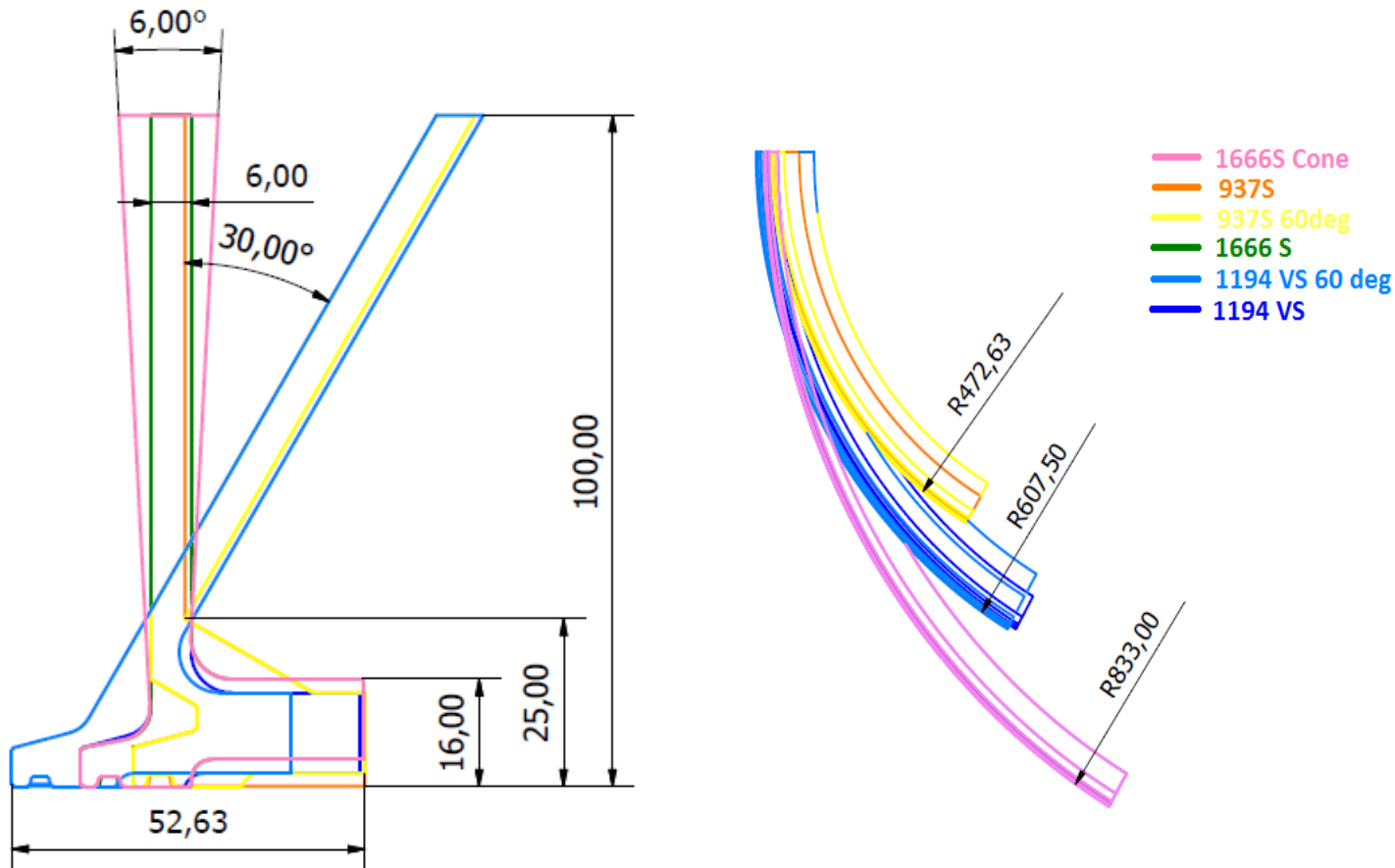
Similarities:


- **The majority are RUAG and EADS CASA**
- **3 main diameters – 937, 1194, 1666 mm**
- The occurrence of groove
- The occurrence of outer surfaces' slope
- Material –Al. alloy
- Coating:
 - Contact surface: MIL-C-5541 – cl. 3, resistance <10 Ohm
 - beyond: chromic acid anodizing
- Roughness: 1.6-3.2 (63 inna norma)

Differences:

- The width for cross sections for different LAR diameters
- The slope of outer surfaces:
 - Contact with sep. System <9,11,15,20> st.
 - Upper surface: 90 deg. +/- 30
- The groove position and its dimensions – differences of about 1-2 mm
- The depth of cut-outs, range (0 – 5.08 mm)
- Sometimes chamfered edges of the cut-outs (47 st.)
- Some tolerances vary
- Unique cross sections may vary significantly

Gripper translation from ADR to Space Tug



A composite image of space. The top half shows a large, detailed Earth with blue oceans and white clouds, partially obscured by a smaller, grey, cratered Moon. A bright, colorful lens flare emanates from the point where the Moon's edge meets the Earth's horizon. The bottom half of the image shows a view of Earth from space, with a thin, glowing blue and white atmospheric layer curving over a dark, textured surface.

THANK YOU Q & A

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More:

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