ADAPTIVE GRIPPER FOR LAUNCH ADAPTER RING CAPTURE

CLEAN SPACE INDUSTRIAL DAYS 2016

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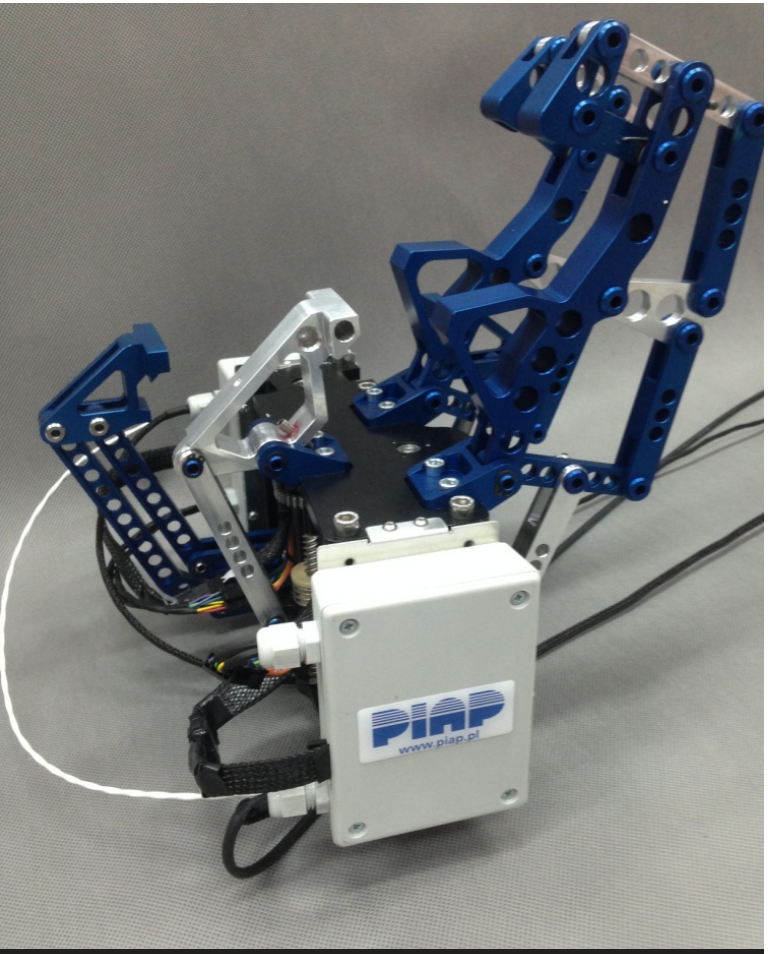
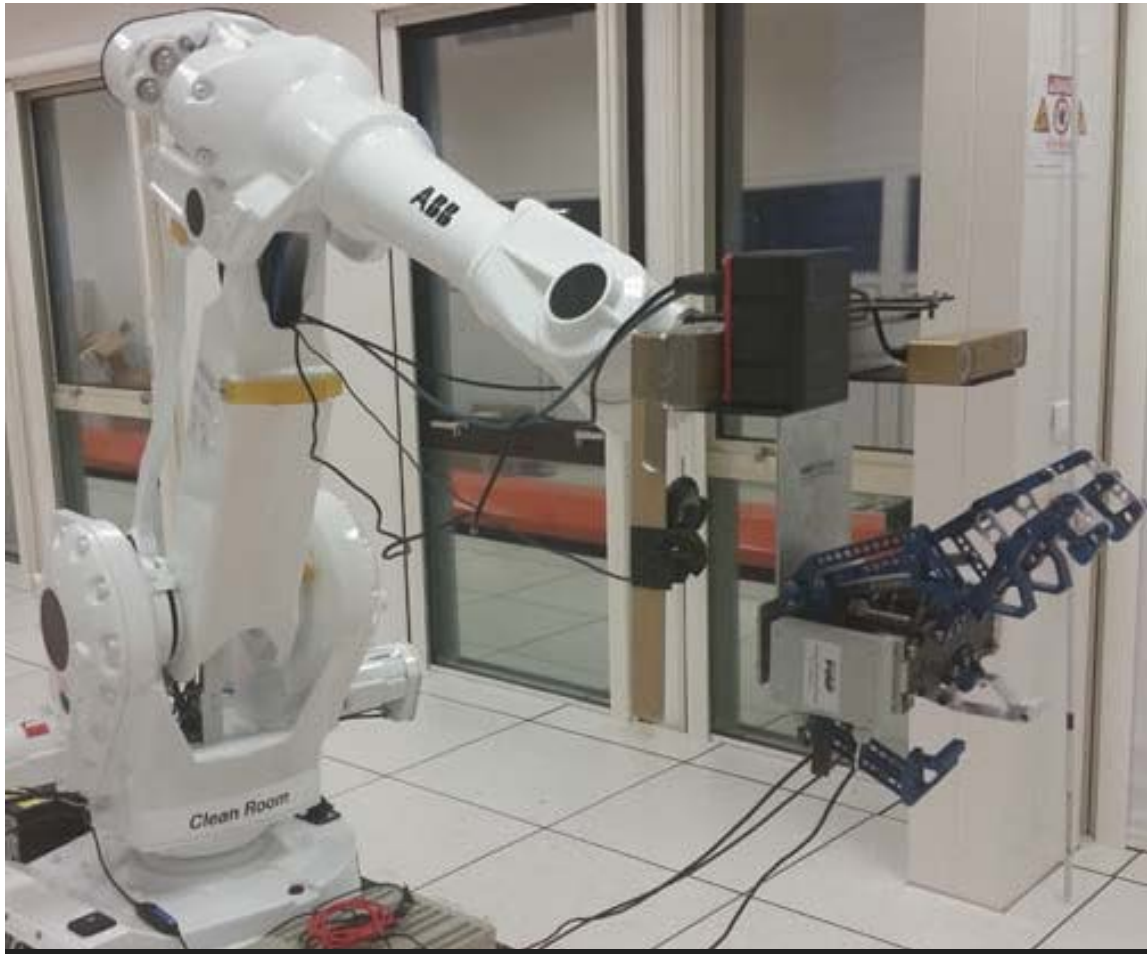
PIAP SPACE

1. OVERVIEW

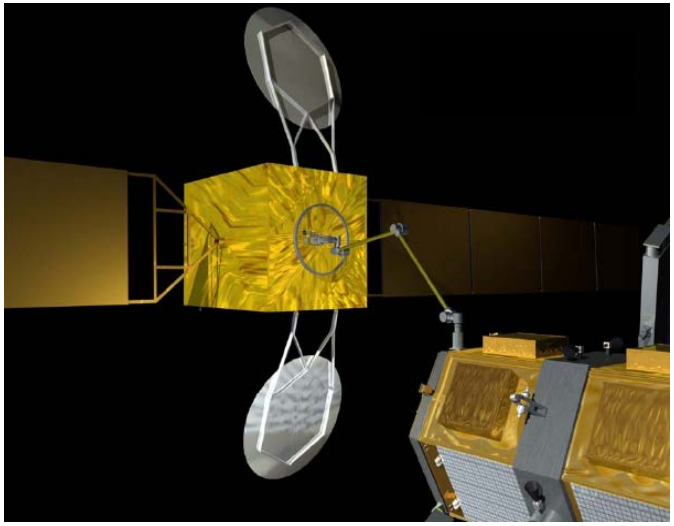


BREADBOARD MODEL OF THE GRIPPER



GRIPPER DURING TESTS ON THE RANDEVOUS TEST BENCH (TAS-F)

2. APPLICABILITY



REFERENCE MISSION:

- ACTIVE DEBRIS REMOVAL

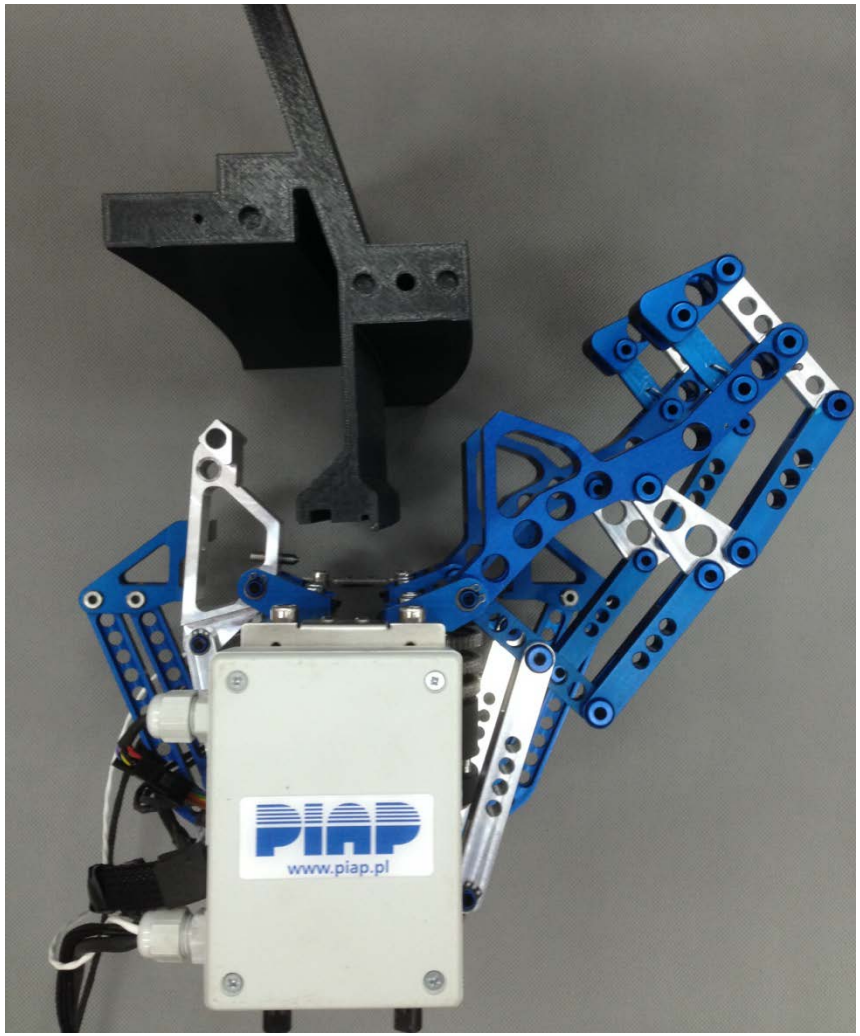
PHASES:

- OBJECT CAPTURE VIA LAR
- ROBOTIC ARM RE-ORIENTATION
- CHASER RECONFIGURATION
- TARGET DE-TUMBLING
- DE-ORBITATION / RE-ORBITATION BOOST

ADDITIONAL MISSION:

- ON ORBIT SATELLITE SERVICING

3. CHALLENGES / REQUIREMENTS

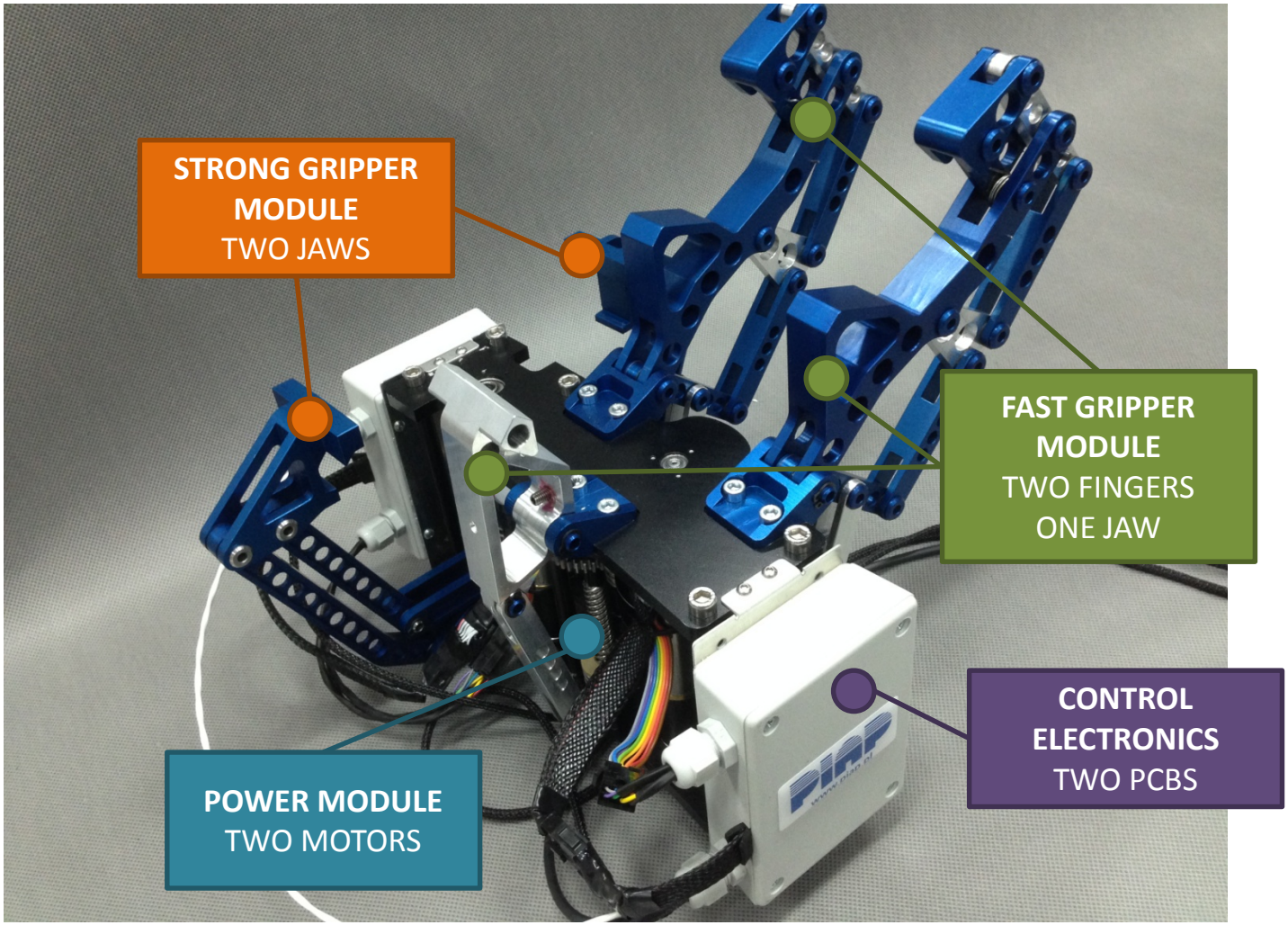


- ENCLOSING THE TARGET FIRST
- SHORT CLOSING TIME
- HIGH CAPTURE ENVELOPE
- HIGH GRIPPING FORCE
- PROVISION OF REPETABILITY
- KEEPING SIMPLE DESIGN
- SMALL MASS

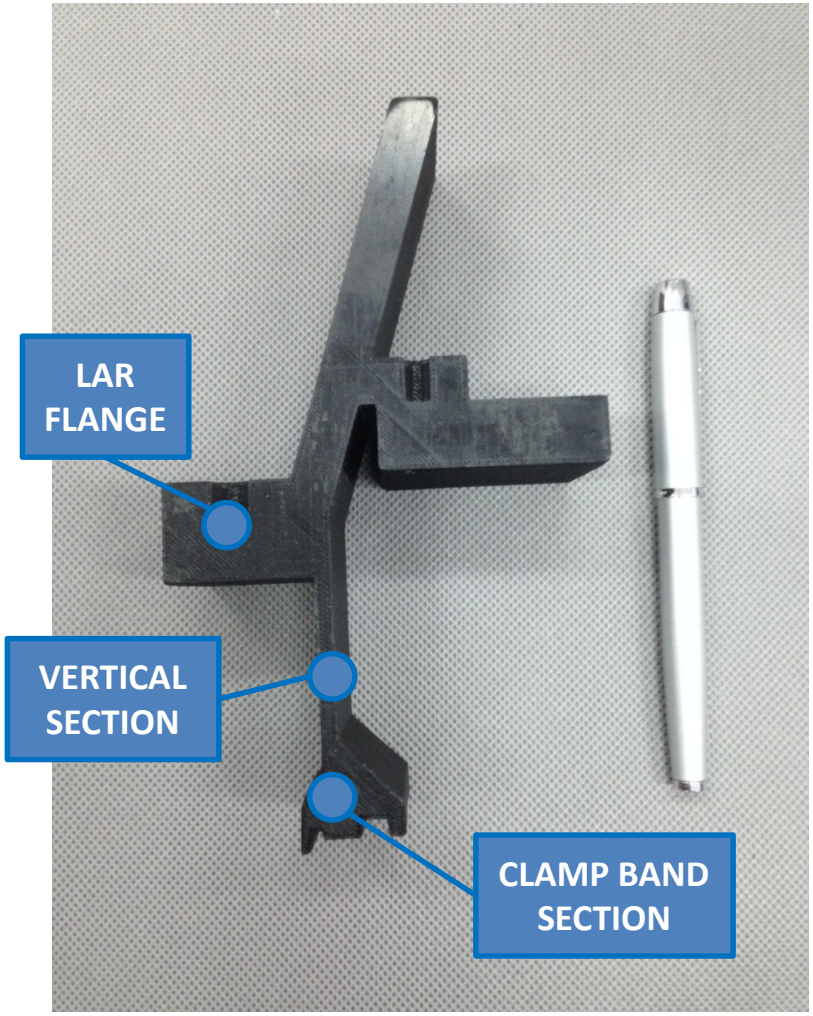
4. CAPABILITES

TARGET:	LAUNCH ADAPTER RING (ONE MODEL)
ARCHITECTURE:	TWO SEPARATE GRIPPERS: FAST GRIPPER & STRONG GRIPPER
CAPTURING PHASES:	SOFT CAPTURE (3sec) & RIGID PHASE (20sec)
TORQUE TRANSFER:	FAST (40 Nm) & STRONG (200 Nm)
CAPTURE ENVELOPE:	SHOWN LATER
OPERATION:	TELEOPERATION OR AUTONOMOUSLY
MASS:	3KG
CURRENT STATUS:	TESTED ON AIR TEST BENCH AND RANDEVOUS TEST BENCH
TRL:	3/4

5. GRIPPER DESIGN



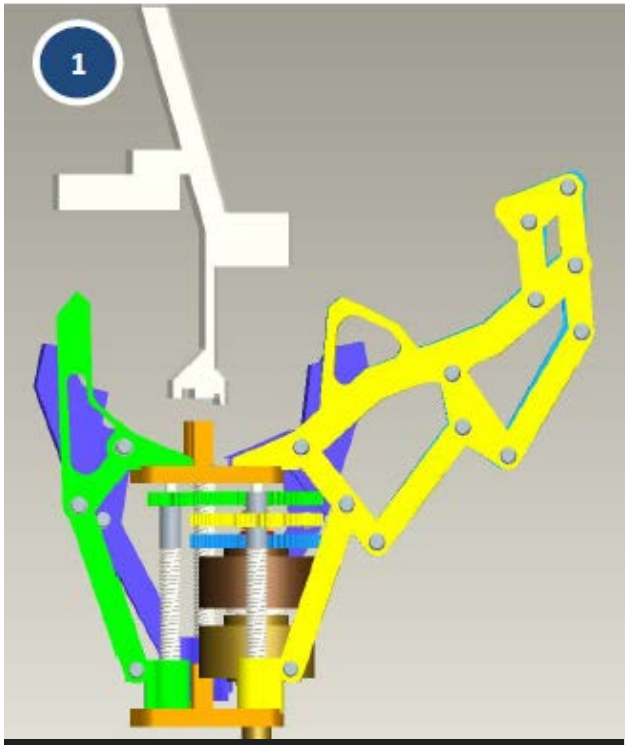
6. MODEL OF THE LAR



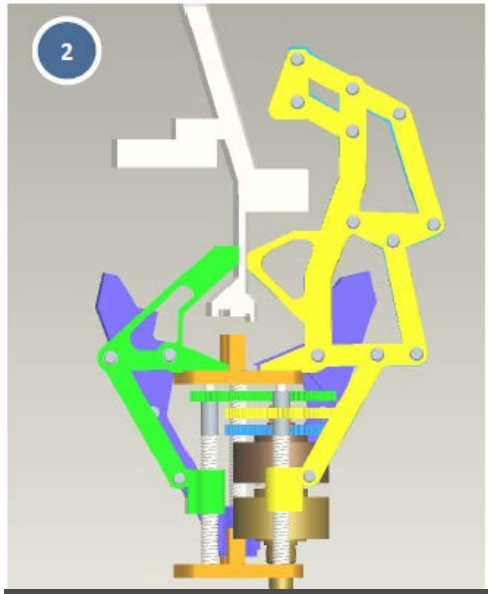
- 30 MM OF FLAT HORIZONTAL SURFACE
- 40 MM OF FLAT VERTICAL SURFACE
- POSSIBILITY TO GRAB IN TWO PERPENDICULAR AXES AND SET UP LAR TO THE REQUIRED POSITION

7. CAPTURING PHASES

FAST GRIPPER – SOFT CAPTURE PHASE



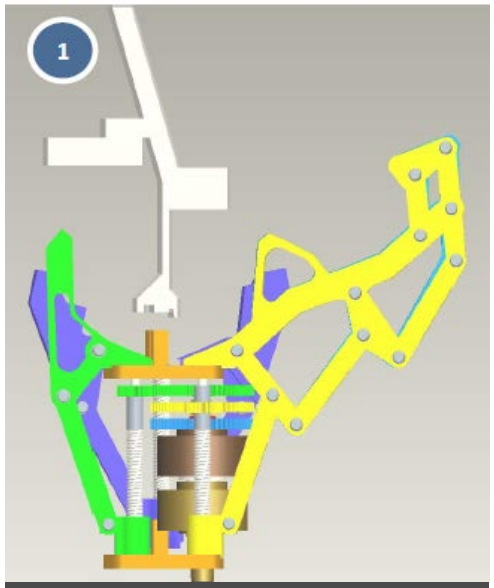
1. STARTING POSITION:
SOFT GRIPPER IS WIDELY OPEN,
LAR IS LOCATED IN CAPTURE ENVELOPE



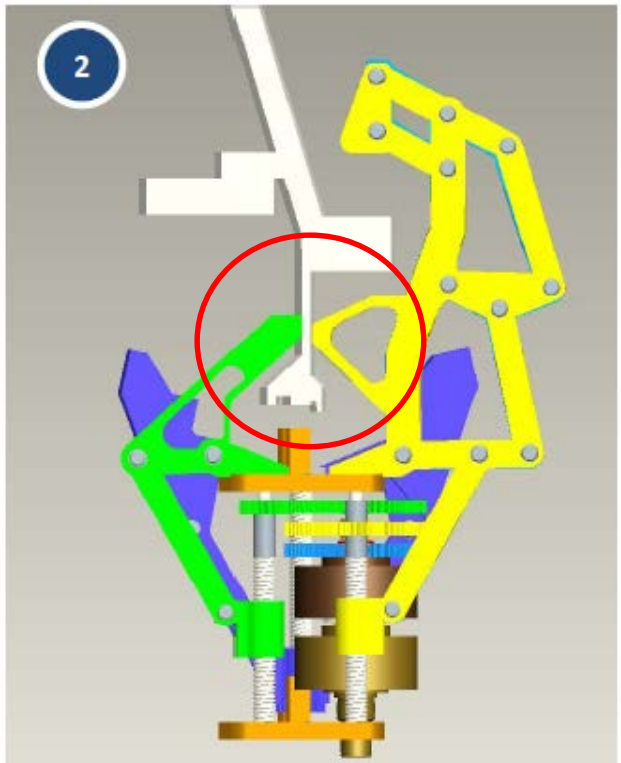
NEXT PHASE

7. CAPTURING PHASES

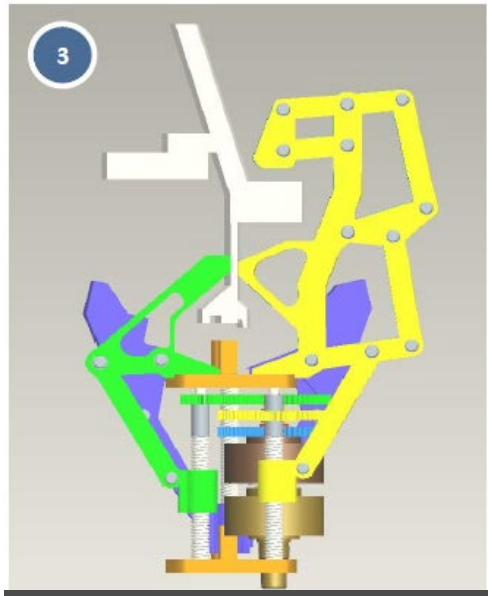
FAST GRIPPER – SOFT CAPTURE PHASE



PREVIOUS PHASE



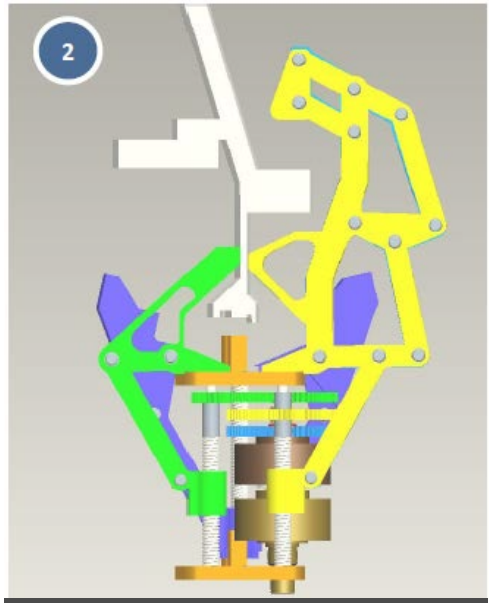
2. INITIAL CONTACT
INTERNAL JAW AND LOWER PHALANGES OF FINGERSS TIGHTEN AT VERTICAL PART OF THE LAR (RED).



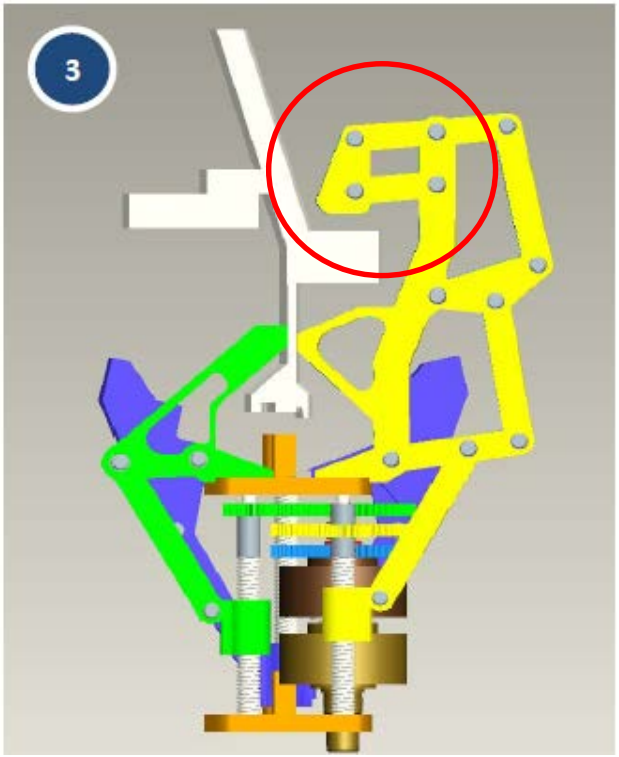
NEXT PHASE

7. CAPTURING PHASES

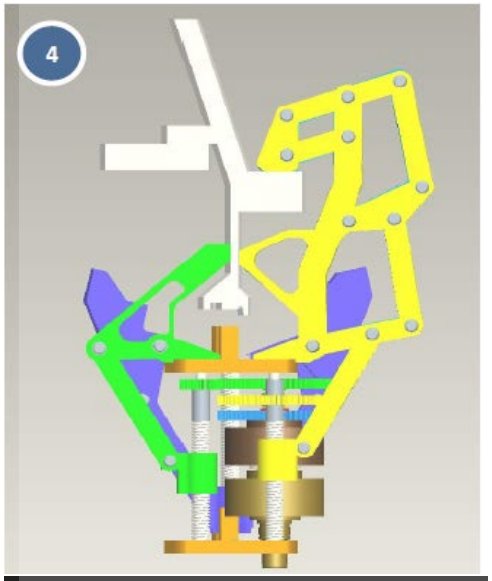
FAST GRIPPER – SOFT CAPTURE PHASE



PREVIOUS PHASE



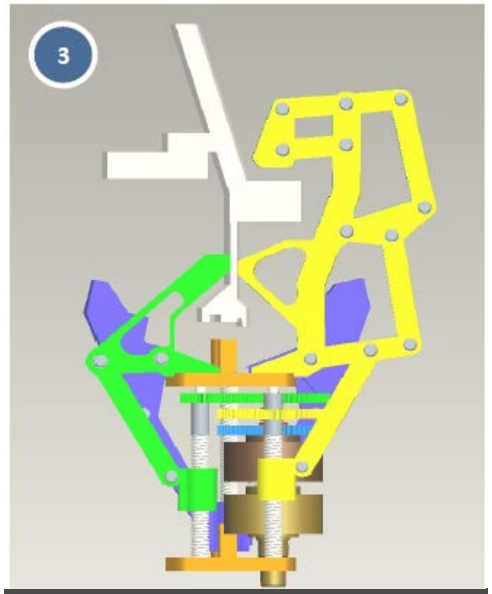
3. SECONDLY CONTACT BEGINNING UPPER PHALANGES OF FINGERS STARTS ENCLOSING (RED).



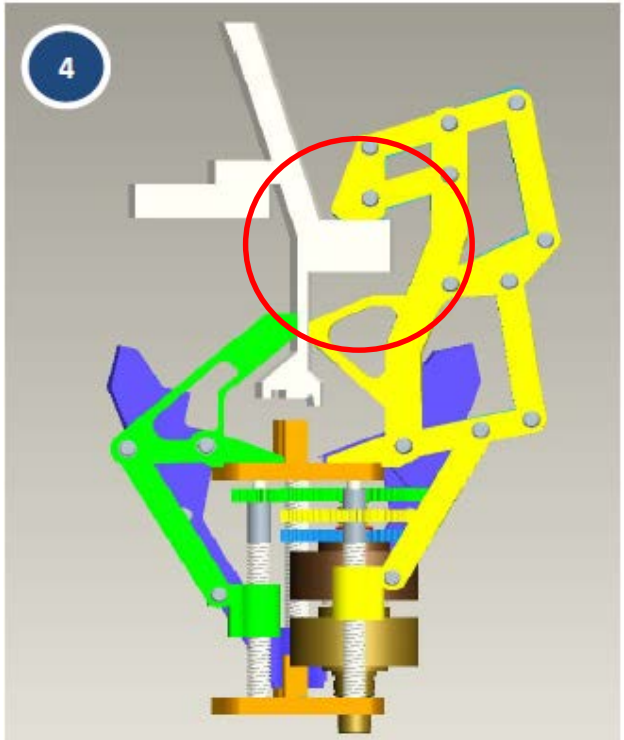
NEXT PHASE

7. CAPTURING PHASES

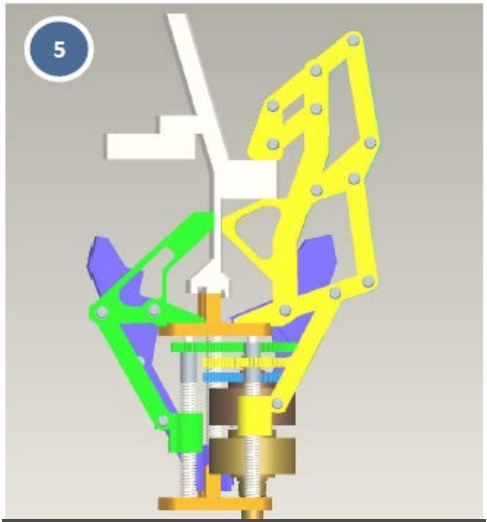
FAST GRIPPER – SOFT CAPTURE PHASE



PREVIOUS PHASE



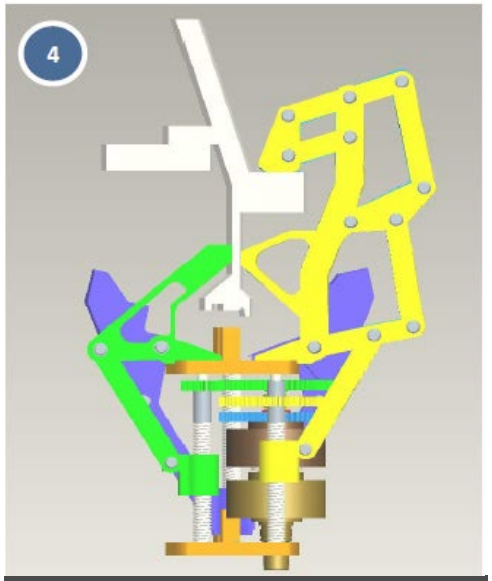
4 SECONDLY CONTACT
UPPER PHALANGES TOUCH HORIZONTAL SURFACE OF THE FLANGE AND STARTS SHIFTING LAR DOWN (RED).



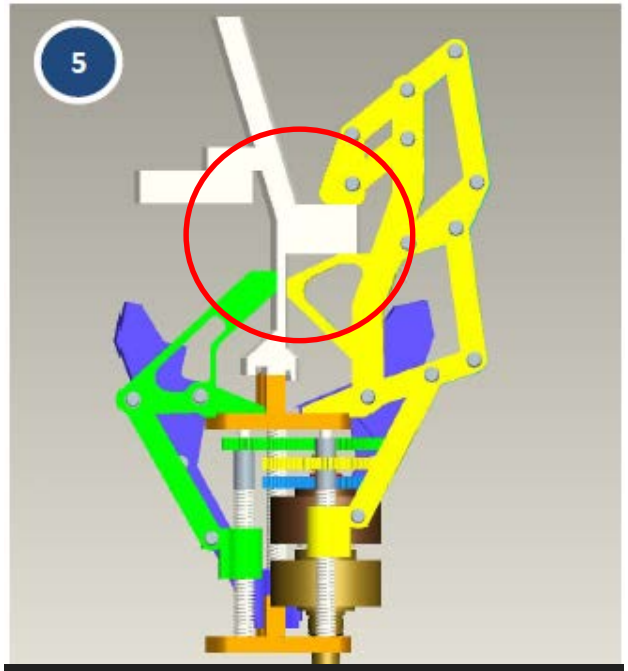
NEXT PHASE

7. CAPTURING PHASES

FAST GRIPPER – SOFT CAPTURE PHASE



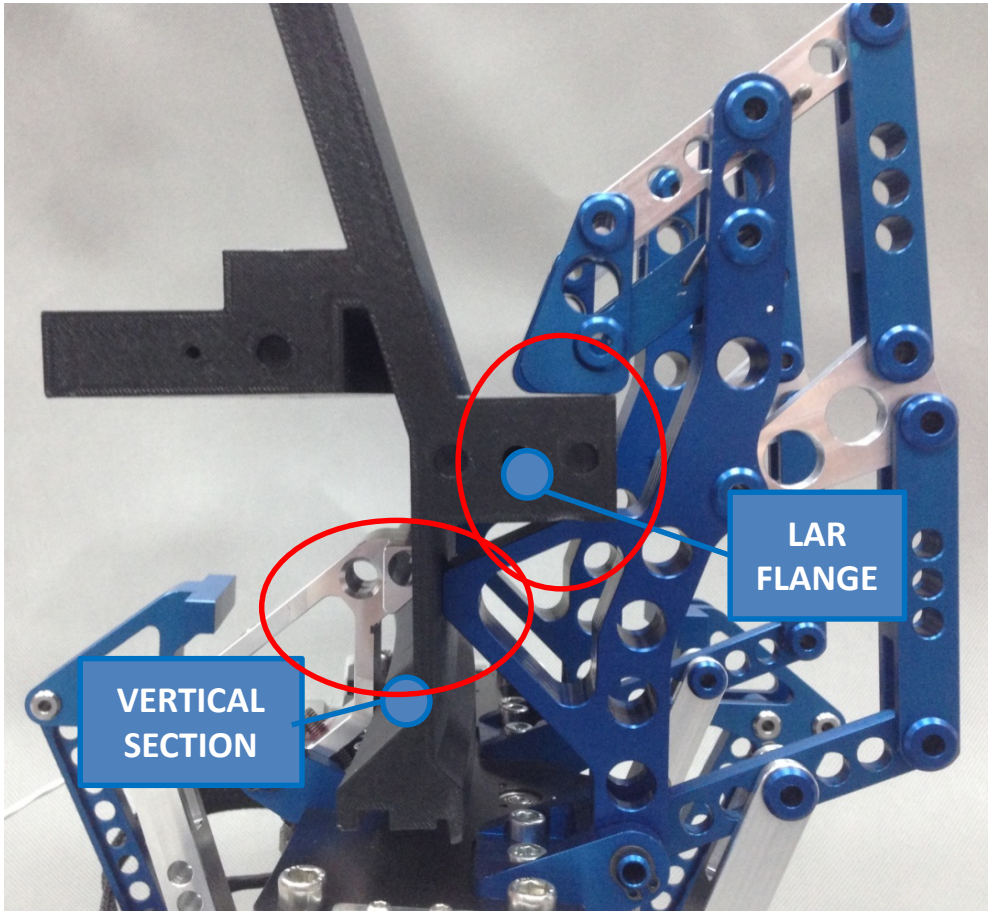
PREVIOUS PHASE



4. END OF SOFT CAPTURE
FAST GRIPPER HOLDS LAR ON YHE NOMINAL POSITION (RED).

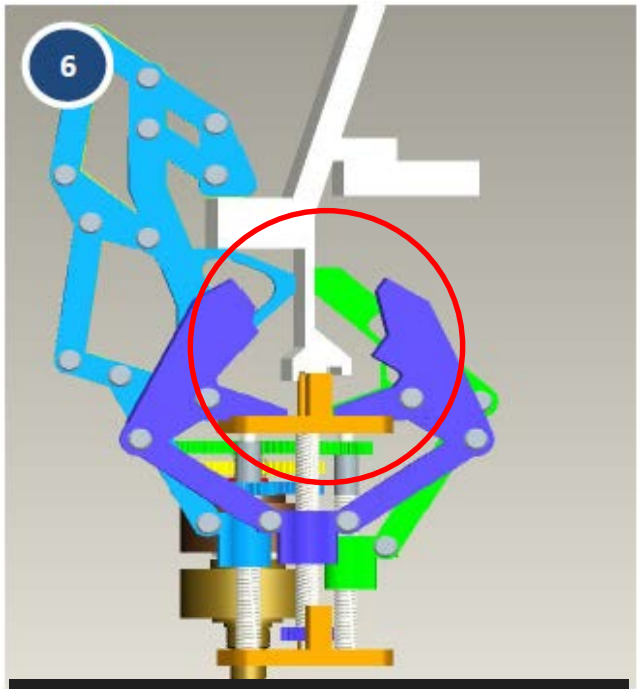
7. CAPTURING PHASES

FAST GRIPPER – SOFT CAPTURE PHASE

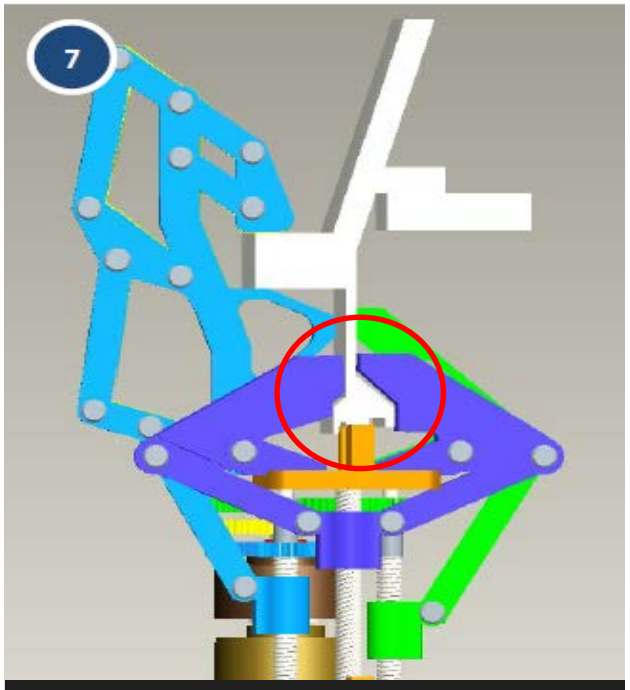


7. CAPTURING PHASES

STRONG GRIPPER – RIGID CAPTURE PHASE



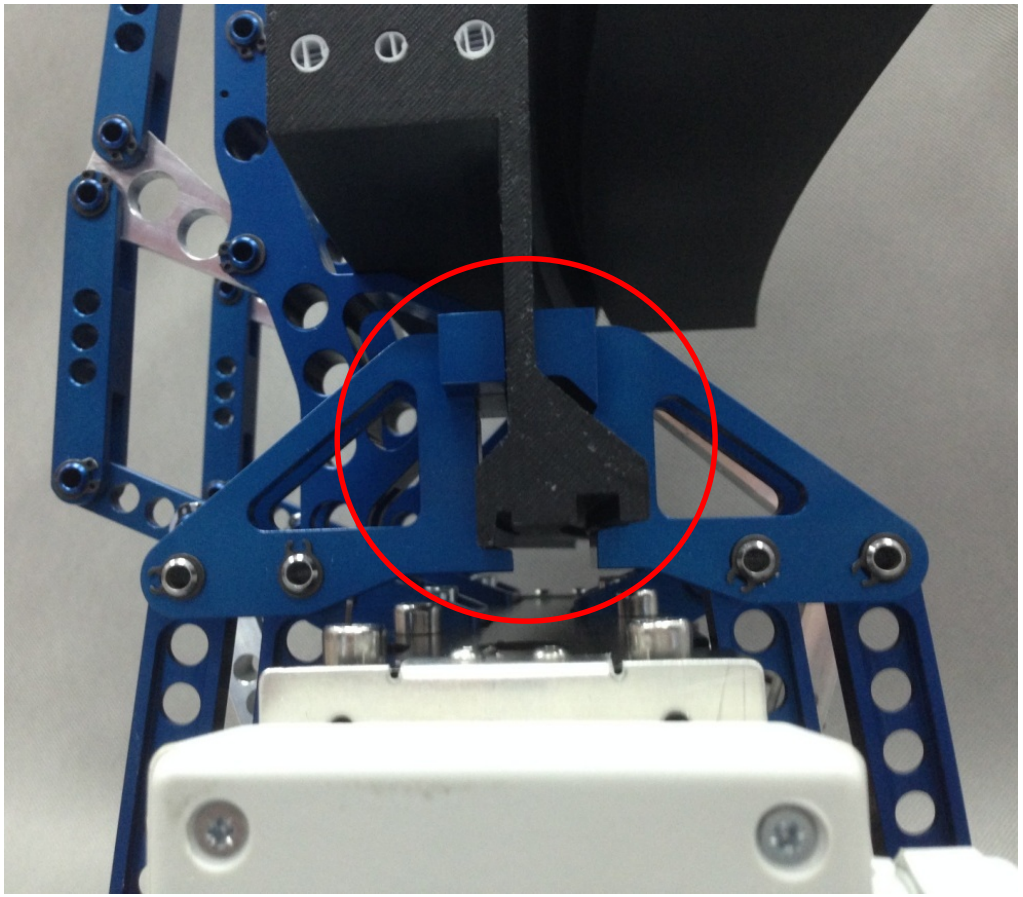
6. STARTING POSITION:
STRONG GRIPPER IS WIDELY OPEN,
LAR IS LOCATED IN NOMINAL POSITION (RED).



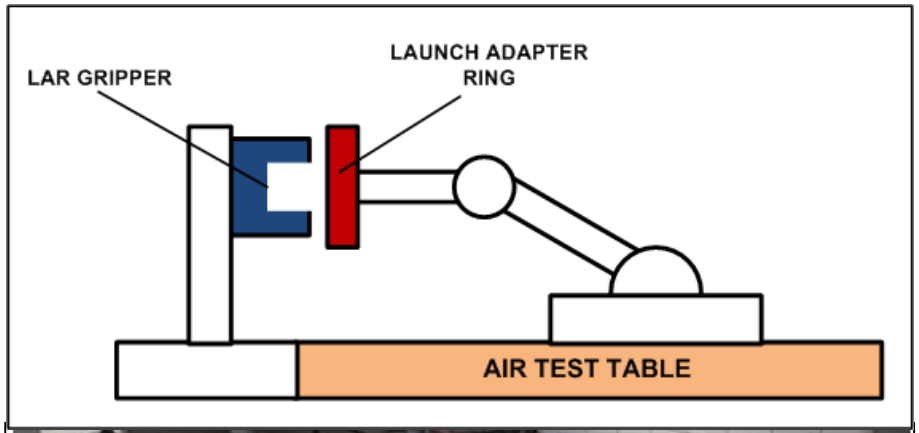
5. END OF SOFT CAPTURE
STRONG GRIPPER HOLDS LAR GEOMETRICALLY AROUND CLAMP BAND SECTION (RED).

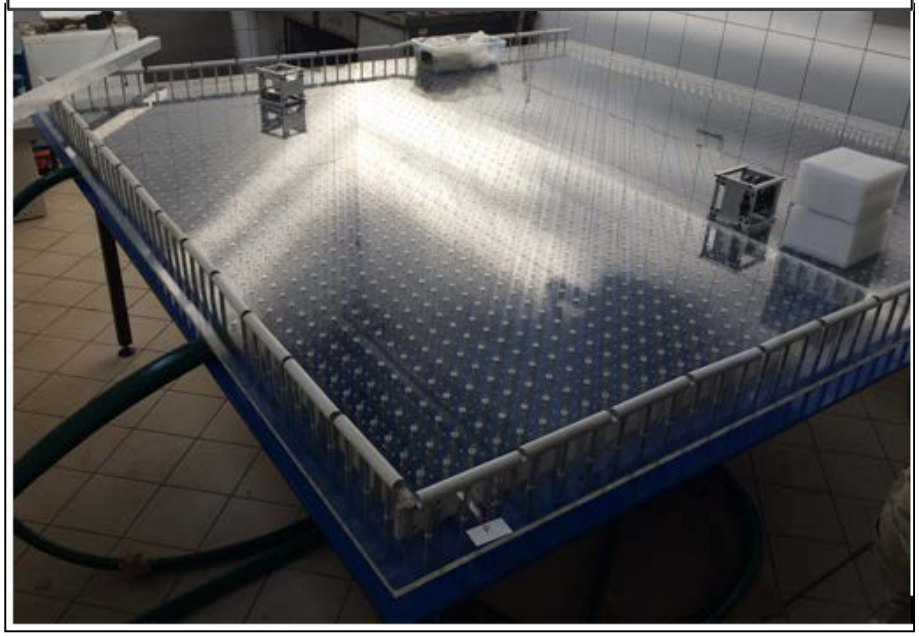
7. CAPTURING PHASES

STRONG GRIPPER – RIGID CAPTURE PHASE



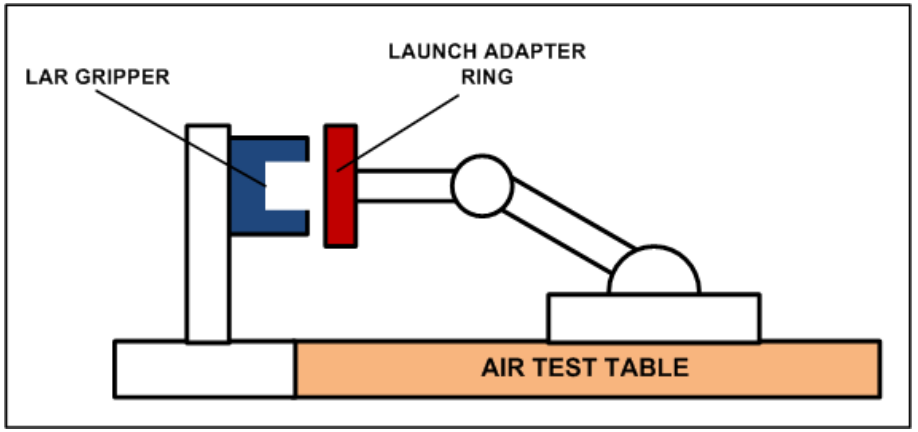
8. FUNCTIONAL TESTS (1)





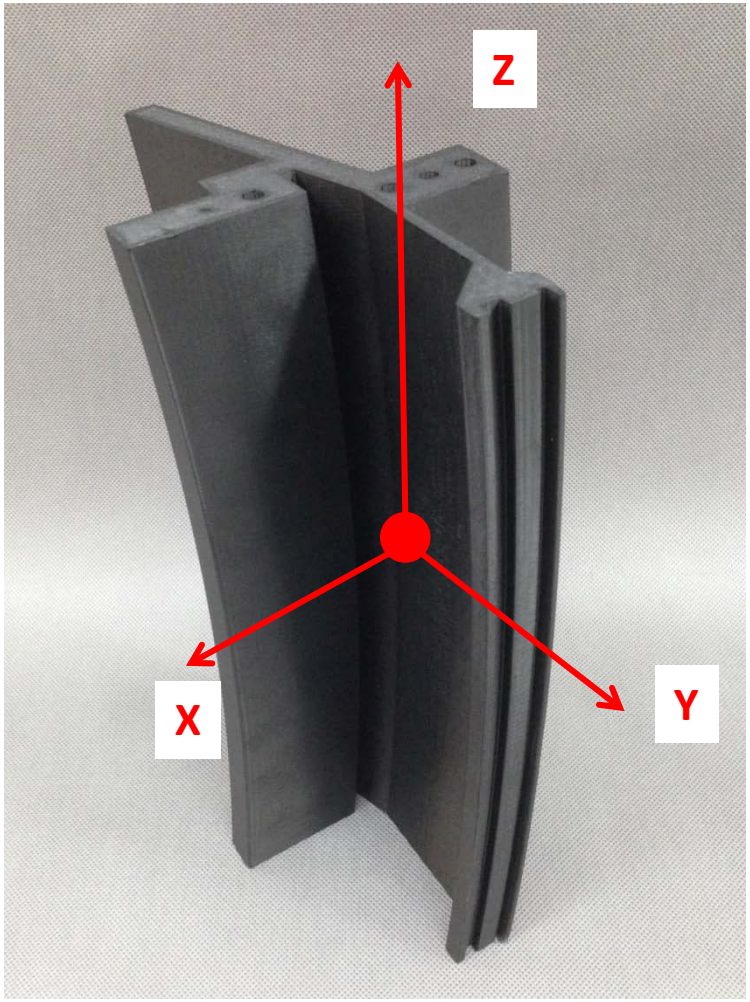
8. FUNCTIONAL TESTS (1)

- AIR TABLE TEST BENCH, CONTINOUS WORK
- LAR INSTALLED ON THE PLATFORM LOCATED ON THE AIR TABLE
- ADDITIONAL ROBOTIC ARM INSTALLED ON THE PLATFORM
- **GOAL: IDENTIFICATION OF CAPTURE ENVELOPE**
- GRIPPER TELEOPERATED
- NO SCALING
- 200 TESTS
- ADDITIONAL WEIGHTS TO INCREASE PLATFORM MOMENT OF INERTIAS

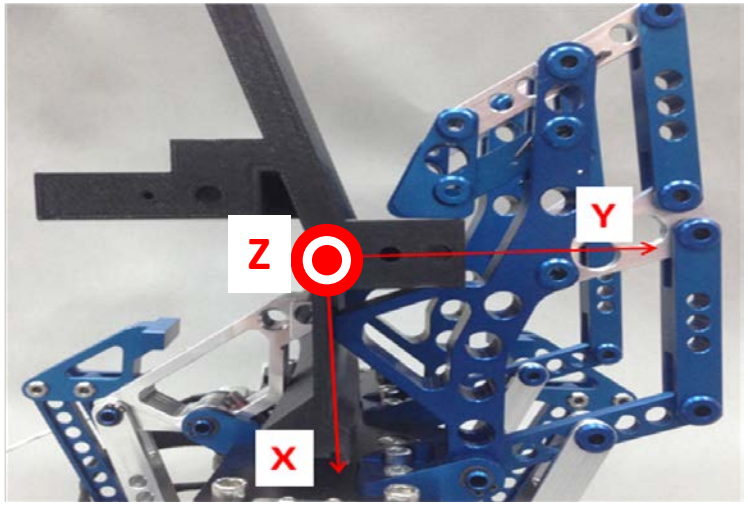


8. FUNCTIONAL TESTS (1)

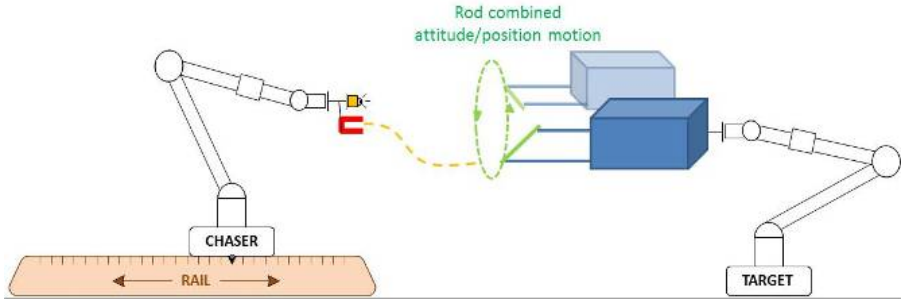
8. RESULTS – CAPTURE ENVELOPE

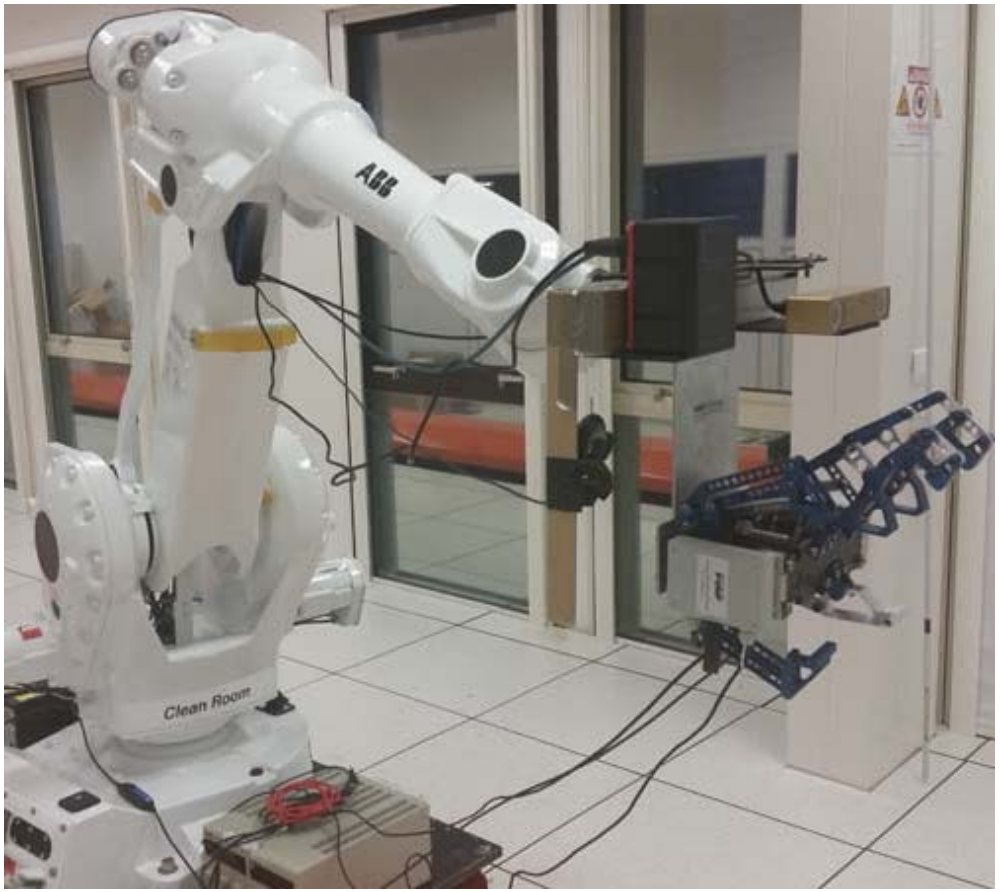


DEVIATIONS OF THE GRASPED OBJECT		
X [mm]	+10,0	-45,0
Y [mm]	+25,0	-25,0
Z [mm]	+60,0	-50,0
α [deg]	+9,0	-12,0
β [deg]	+5,0	-2,0
γ [deg]	+10,0	-10,0



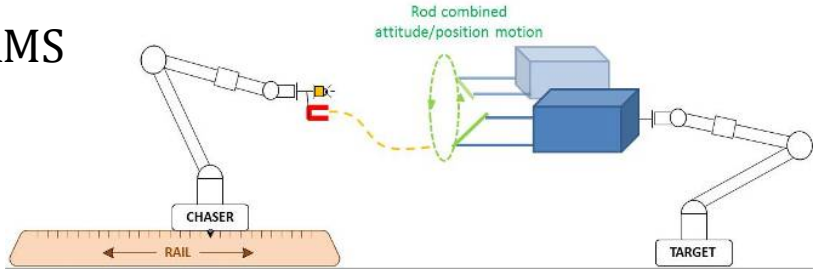
9. FUNCTIONAL TESTS (2)





9. FUNCTIONAL TESTS (2)

- RENDEVOUS TEST BENCH: TWO ROBOTICS ARMS
- PROCEED BY TAS-F
- GRIPPER IS OPERATED AUTONOMOUSLY



- **GOAL: VERIFICATION OF THE CONTROL ALGORITHM**
- TESTS IN CLOSED LOOP:
  - THE CAMERA MEASUREMENT AND NAVIGATION ALGORITHMS ARE USED TO ESTIMATE THE POSE OF THE LAR
  - THE CONTROL ALGORITHM COMPUTES THE TORQUE AND THE FORCE TO BE APPLIED ON THE CHASER IN ORDER TO MAKE THE ESTIMATED POSE FOLLOW THE DESIRED POSE PROVIDED BY THE GUIDANCE.
  - GRIPPER APPROACHES UP TO 20CM DISTANCE, RELATIVE POSITION/ATTITUDE MAINTAIN, THEN APPROACH UNTIL LAR CAPTURE.

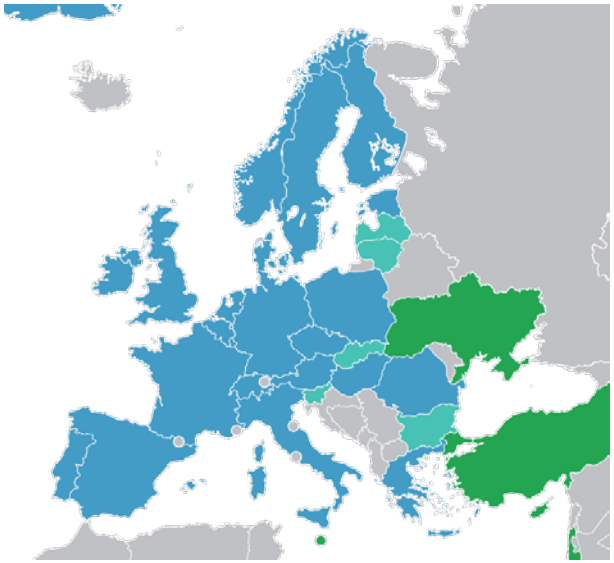
9. FUNCTIONAL TESTS (2)

9. CONTINUATION

LAR GRIPPER DEVELOPMENT:

- TESTS IN ESA ROBOTICS FACILITY ON THE AIR TABLE
- ADAPTATION OF THE FINGERS TO DIFFERENT MODELS OF LAR (ENVISAT)
- INCREASEMENT GRIPPER PERFORMANCE (CAPTURE ENVELOPE)
- EXPANDING GRIPPER CAPABILITIES (E.G. ADDING TACTILE SENSORS, TORQUE SENSORS)
- INTERFACE ADAPTATION TO BE COMPATIBLE WITH SPACE ARMS END-EFFECTORS
- DESIGN ADAPTATION FOR WORKING IN VACUUM-THERMAL

10. OVERVIEW – „ADREXP”



„ACTIVE DEBRIS REMOVAL DEMONSTRATION IN LABORATORY CONDITION EXPERIMENT ADREXP”

GOAL: DEVELOPMENT A GRIPPER FOR SATELLITE’S LAUNCH ADAPTER RING CAPTURE AND VERIFICATION CRITICAL FUNCTIONALITY IN LABORATORY CONDITIONS.

BUDGET: 220K EURO (2ND CALL FOR OUTLINE PROPOSALS UNDER THE POLISH INDUSTRY INCENTIVE SCHEME)

ENDING TRL: 3 / 4

PATENT APPLICATION NUMBER: EP16170851.6

MAIN ITEMS:

- GRIPPER DESIGN, MANUFACTURING & ASSEMBLY
- ALGORITHM DESIGN
- FUNCTIONAL & PERFORMANCE TESTS

11. ABOUT US

INDUSTRIAL RESEARCH INSTITUTE FOR AUTOMATION AND MEASUREMENTS PIAP

- ONE OF LEADING EUROPEAN MOBILE ROBOTS INTEGRATOR,
- MORE THAN 150 MOBILE ROBOTS ON 20 WORLD MARKETS.

- SHAREHOLDERS: **POLISH MINISTRY OF DEVELOPMENT (100%)**
- EXPERIENCE: **50 YEARS OF MARKET ACTIVITIES**
- STAFF: **320 (60% SCIENTISTS & ENGINEERS)**
- TURNOVER: **15 MLN EURO (40% COMMERCIAL, 60% R&D)**
- PRODUCTS: **9 MOBILE ROBOTS, 8 SPECIAL ACCESSORIES**
- KEY TECHNOLOGIES: **AUTONOMY, IMAGE PROCESSING, MANIPULATION & GRIPPING, HMI & MMI, ATX, SAMPLERS, SHOCK-PROOF ELECTRONICS**
- SPACE SECTOR: **3 PROJECTS**

11. ABOUT US

THANK YOU
Q & A

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More:

www.piap.space.pl