SENER

e.deorbit Phase B1

Development of the clamping mechanism

for Active Debris Removal missions

Aeroespacial

www.sener.pl

Agenda

- **Introduction**

- **Clamping scenarios**
  - *Hold-downs*
  - *Launch Adapter Ring*
  - *Trade-off*

- **Overview of the clamping mechanism**
  - *Baseline design*
  - *Alternative design solution*

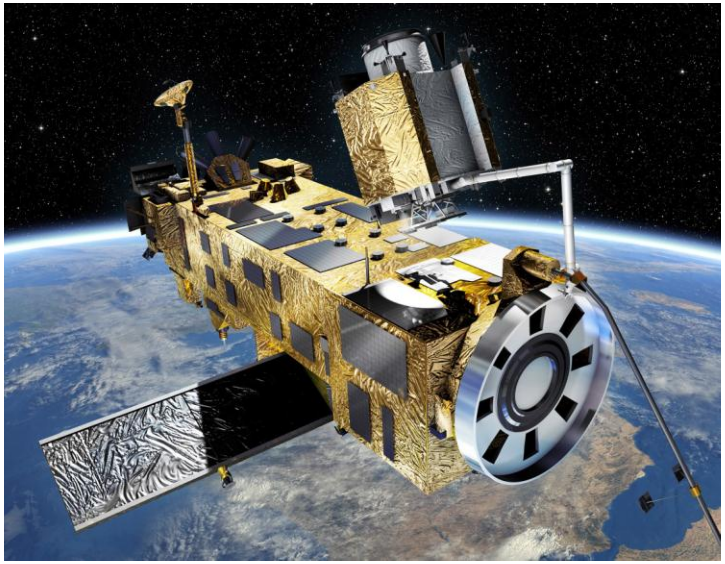
- **Important aspects to consider**

- **Future activities**

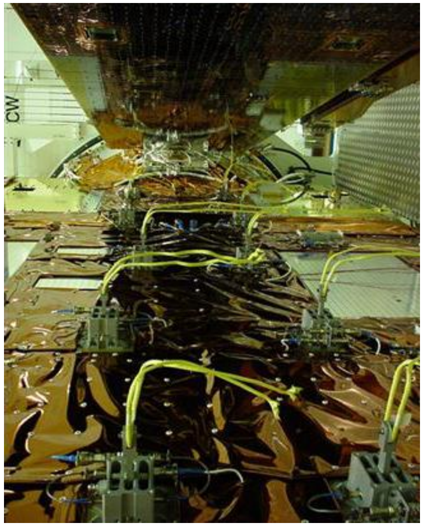
Introduction

e.Deorbit Phase B1

- Study led by Airbus
- SENER is responsible for the concept of clamping mechanism
- Study included trade-off between alternative clamping interfaces (hold-downs indicated as a baseline in Phase A and launch adapter ring)



Clamping scenarios



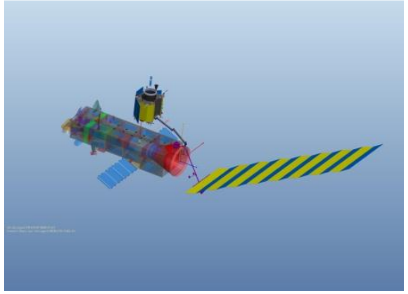
The following scenarios were considered in the beggining of e.Deorbit Phase B1:

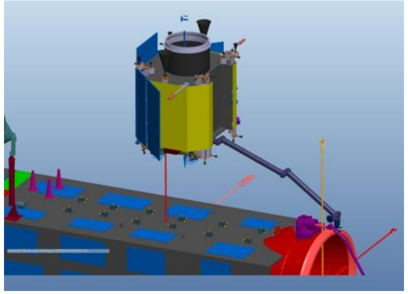
- Clamping on the Envisat's solar array hold-down points

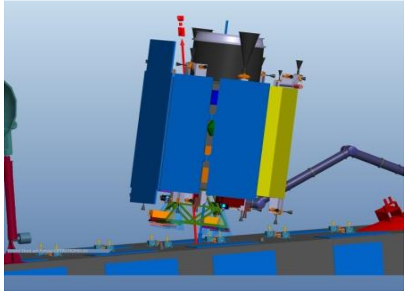
- Clamping on the launch adapter ring

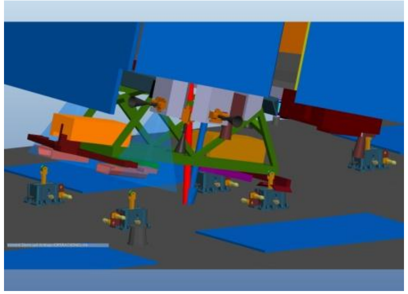
Clamping scenarios

Hold-downs

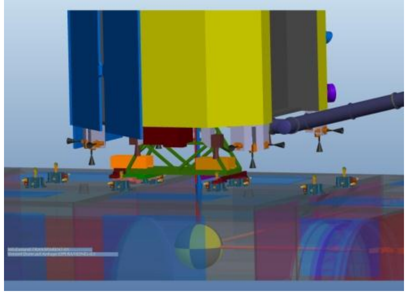

Capture (robotic arm)

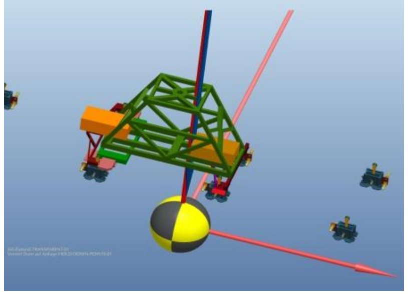

Detumbling (robotic arm)

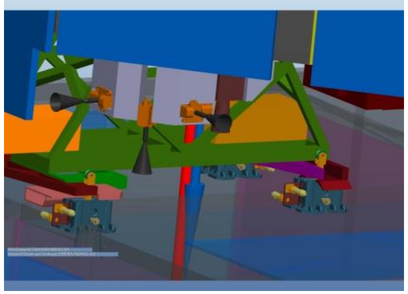

Positioning over the 3rd hold-down's row (rob. arm + cameras)


Positioning – the first contact (robotic arm + cameras)


Positioning – the first contact (robotic arm + active cameras)


Lowering to the 4th row while keeping contact with the 3rd row (robotic arm + cameras + guiding elements)

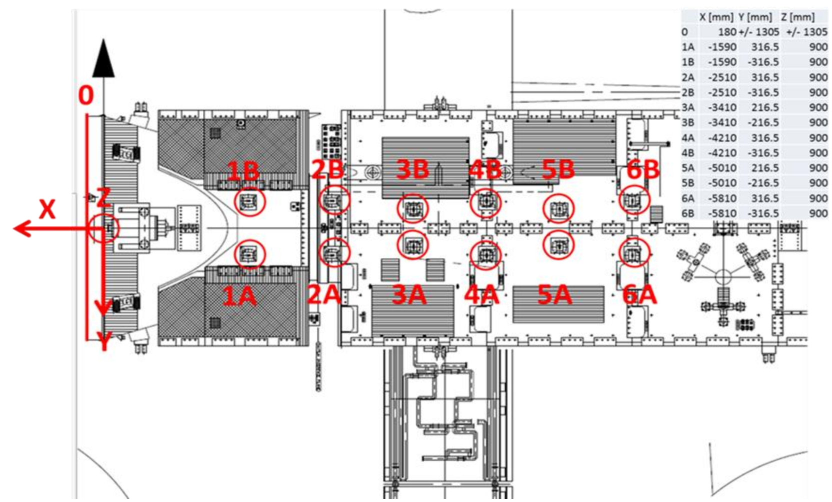

Locking of the linear actuators (clamping mechanism + supervising cameras)


Rigidisation of the clamping mechanism

Clamping scenarios

Hold-downs

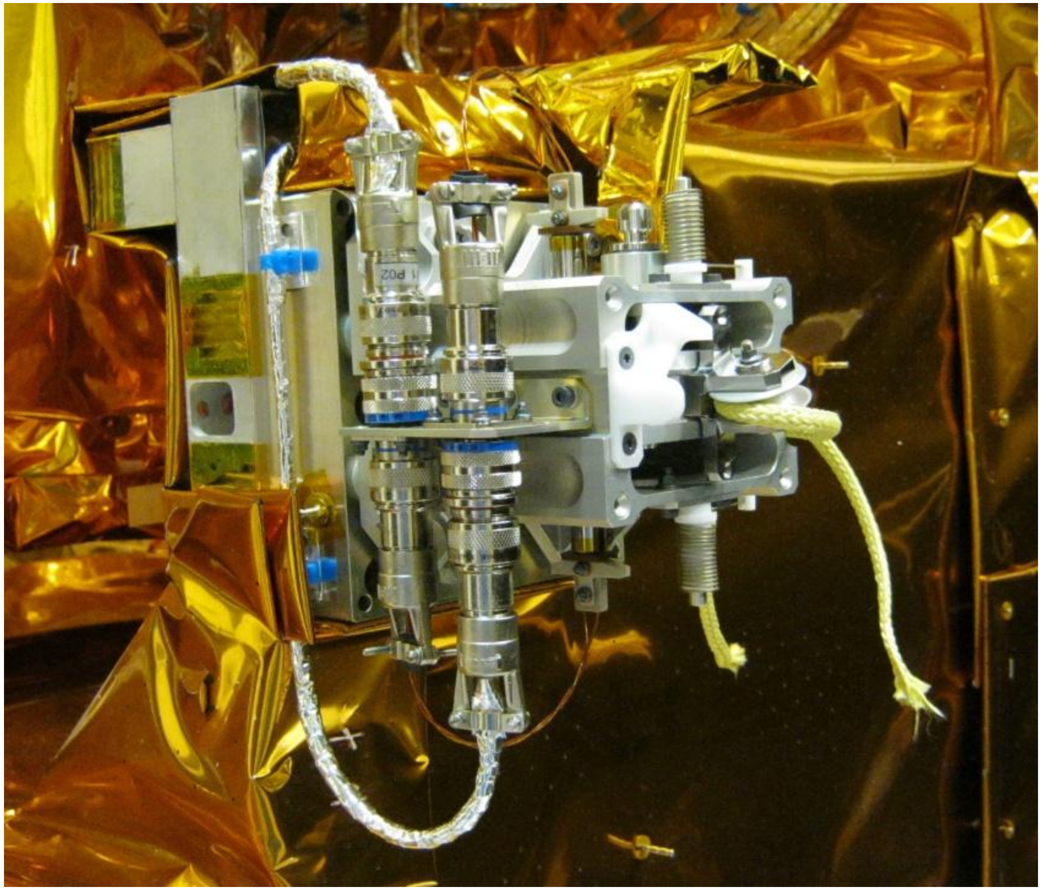
- Mechanism has to clamp on the ENVISAT's hold-down brackets in rows 3 and 4
- Hold-down brackets seem to be suitable points for clamping (but not perfect)
- Hold-downs are in unknown condition (free-flying cables, torn MLI sheets etc.)



	X [mm]	Y [mm]	Z [mm]
0	180	+/- 1305	+/- 1305
1A	-1590	316.5	900
1B	-1590	-316.5	900
2A	-2510	316.5	900
2B	-2510	-316.5	900
3A	-3410	216.5	900
3B	-3410	-216.5	900
4A	-4210	316.5	900
4B	-4210	-316.5	900
5A	-5010	216.5	900
5B	-5010	-216.5	900
6A	-5810	316.5	900
6B	-5810	-316.5	900

Clamping scenarios

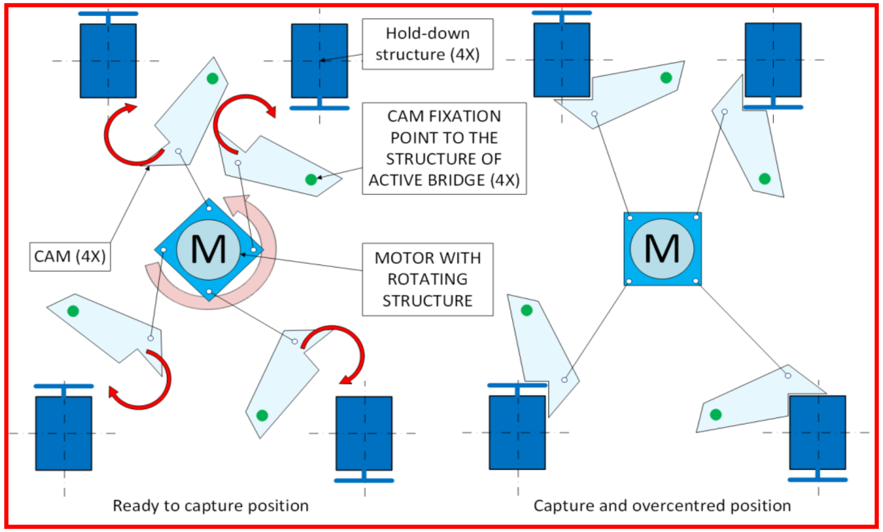
Hold-downs

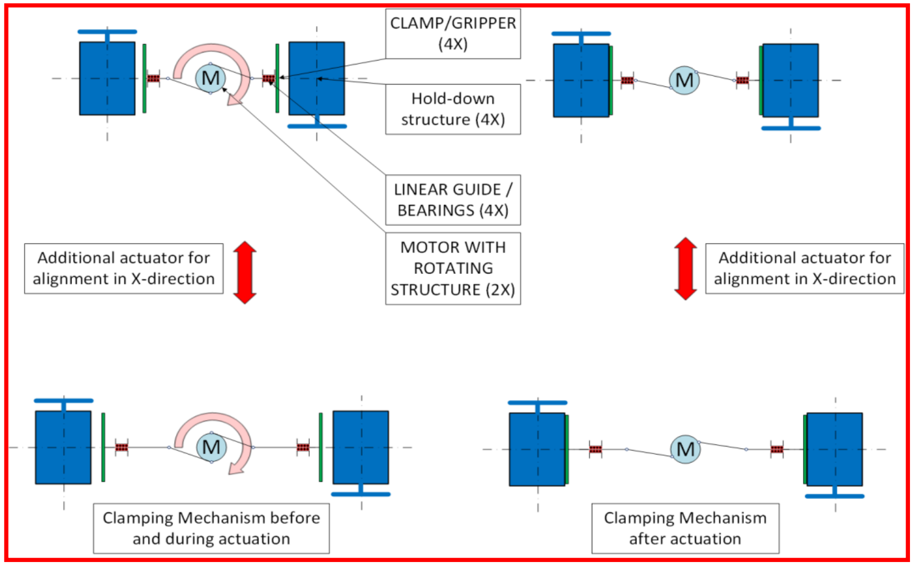


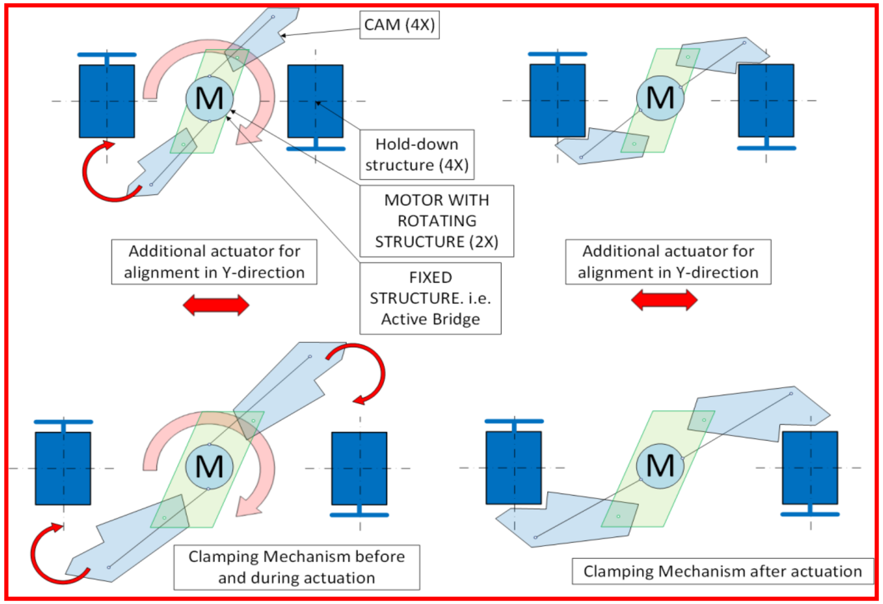
Clamping scenarios

Hold-downs

Concepts of mechanisms were proposed.



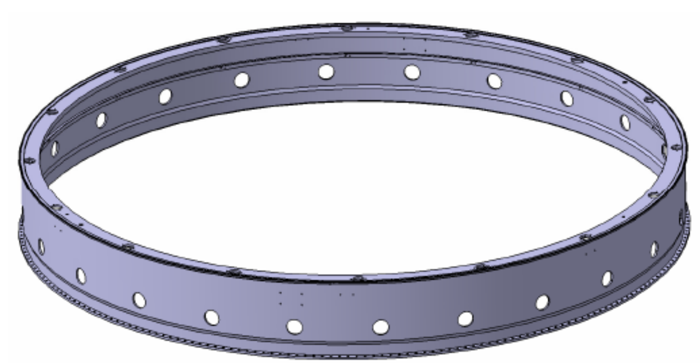


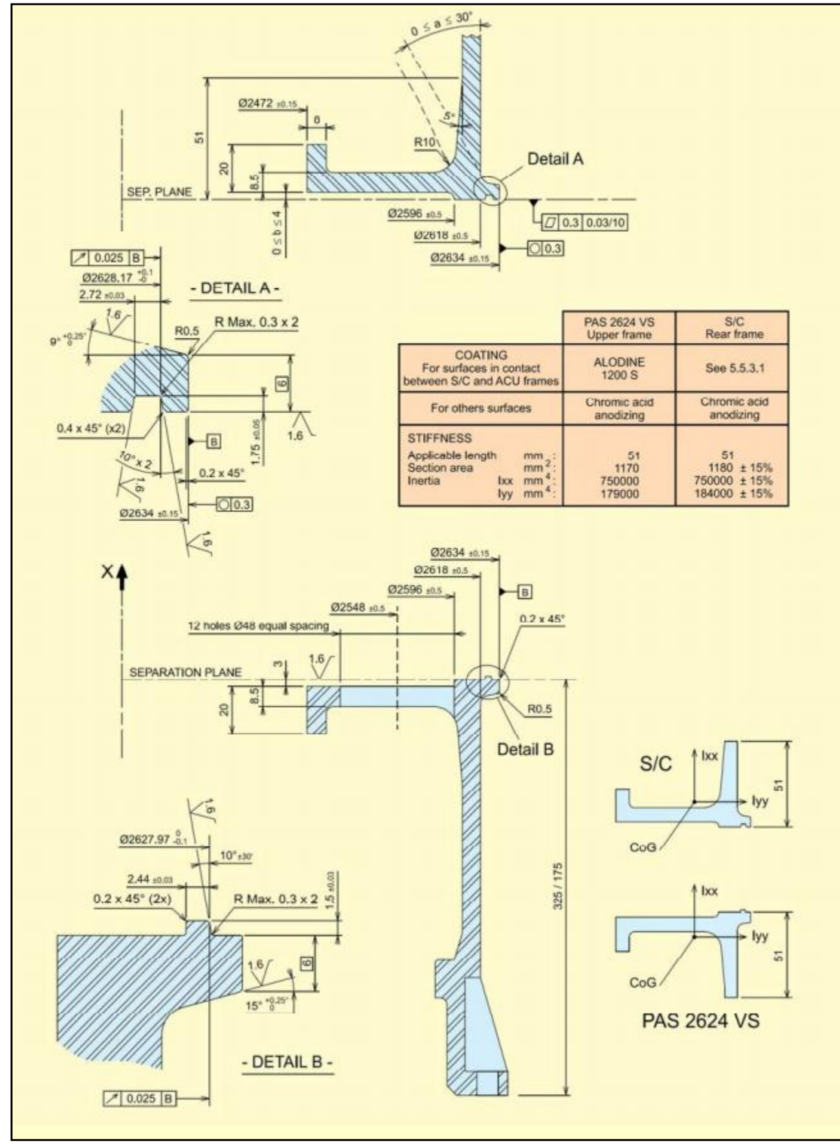


Clamping scenarios

Launch Adapter Ring (*PAS 2624VS*)

- Well known and defined interface (easier to capture)
- No major obstacles, in general it can be considered as a clean interface (micro-meteoroid damage)
- Stiff structure of the LAR



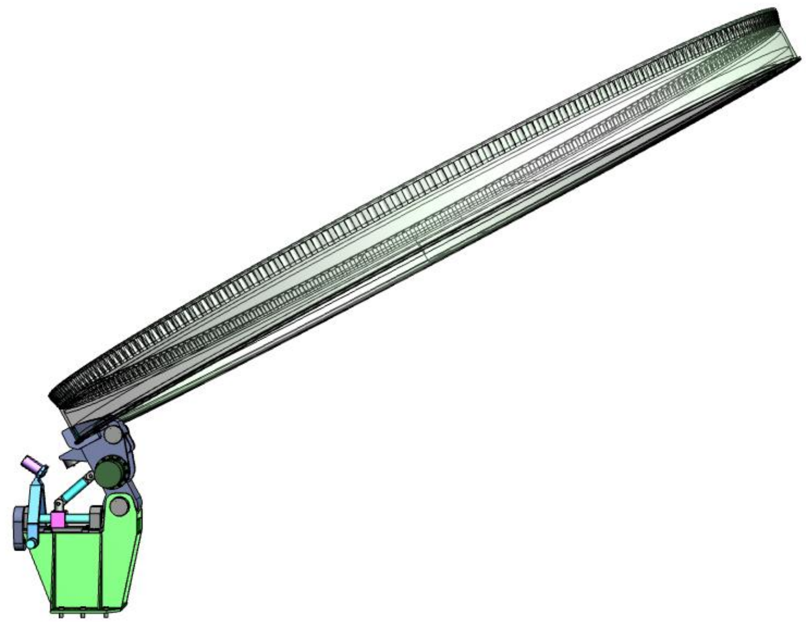


Clamping scenarios

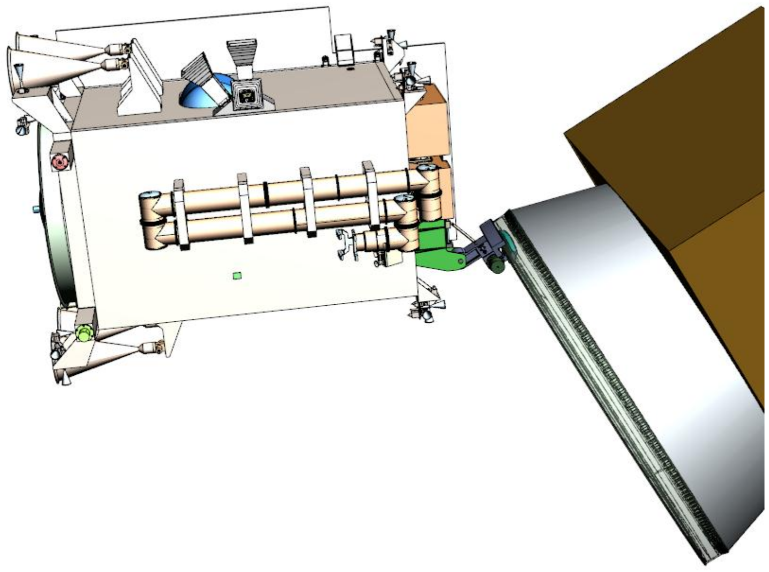
Trade-off

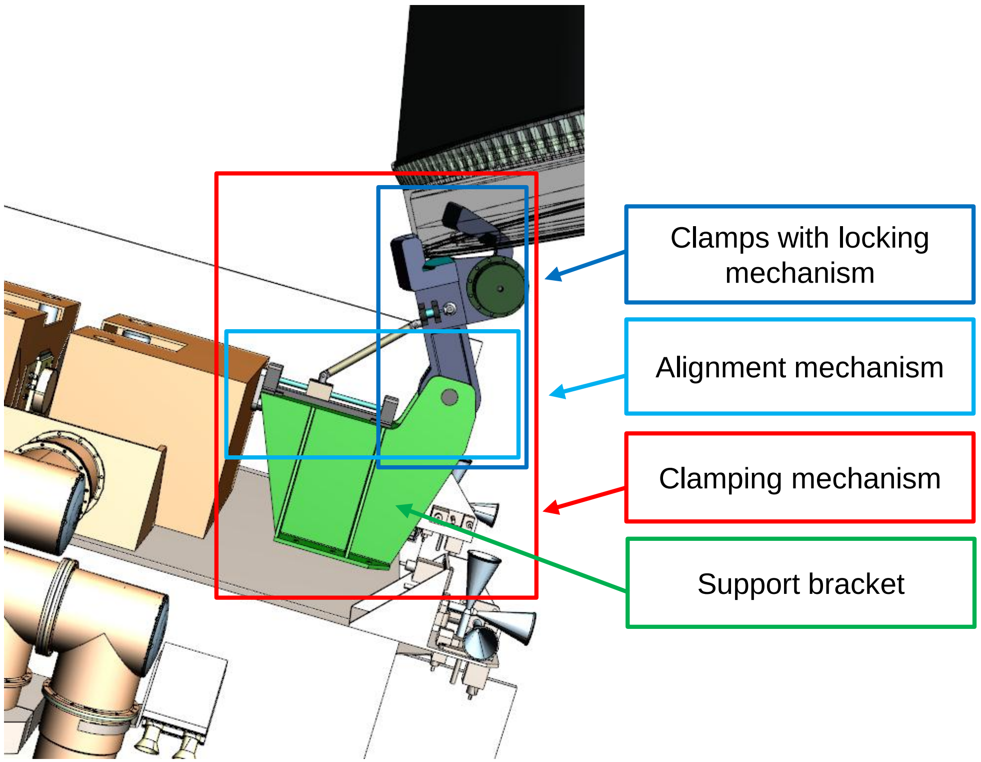
Final decision considered clamping on the LAR as the most suitable choice. The most important advantages of that solution include:

- Clean and known interface
- Ability to adapt to the encountered obstacles (clamping in a different position)
- Stiff structure of the LAR

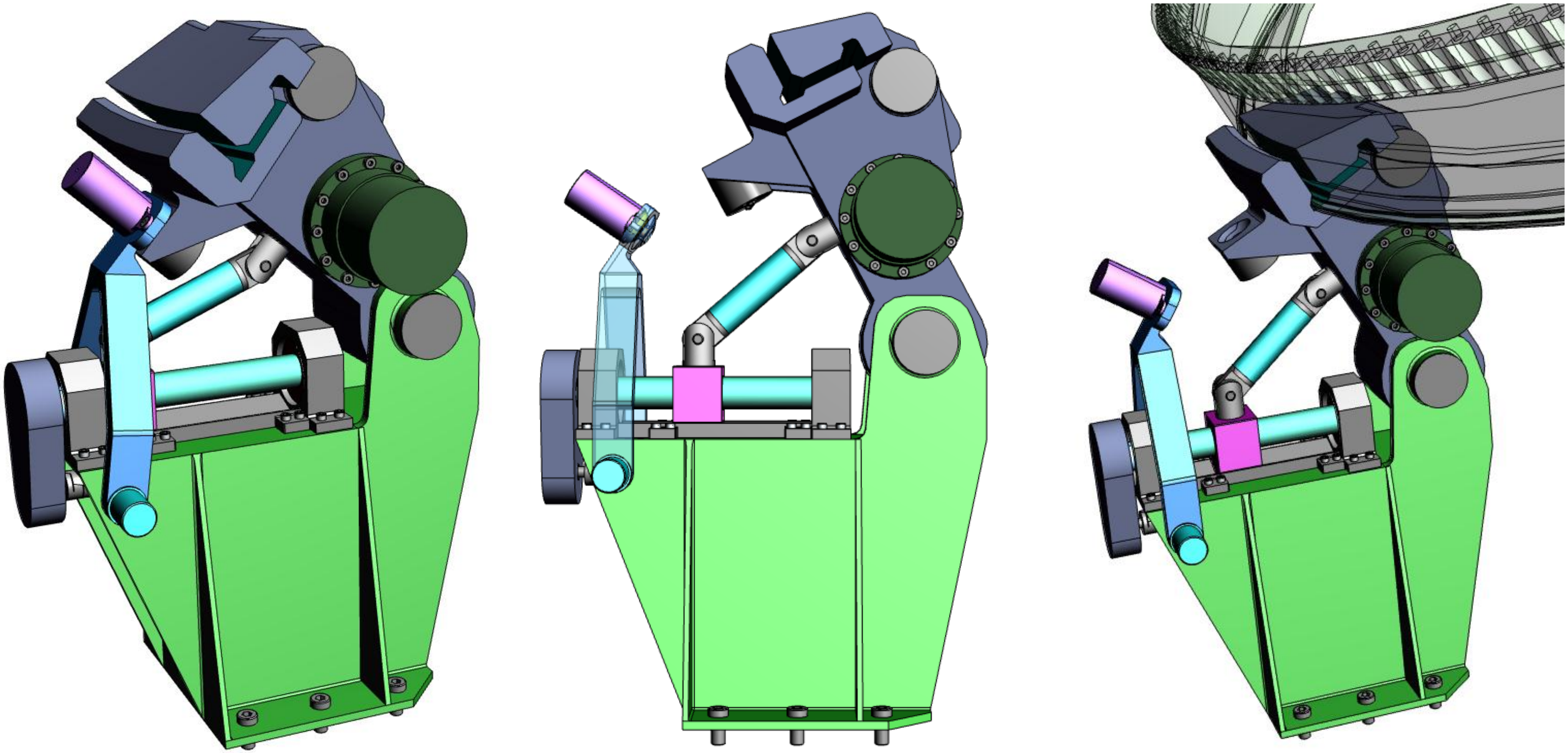


Overview of the clamping mechanism



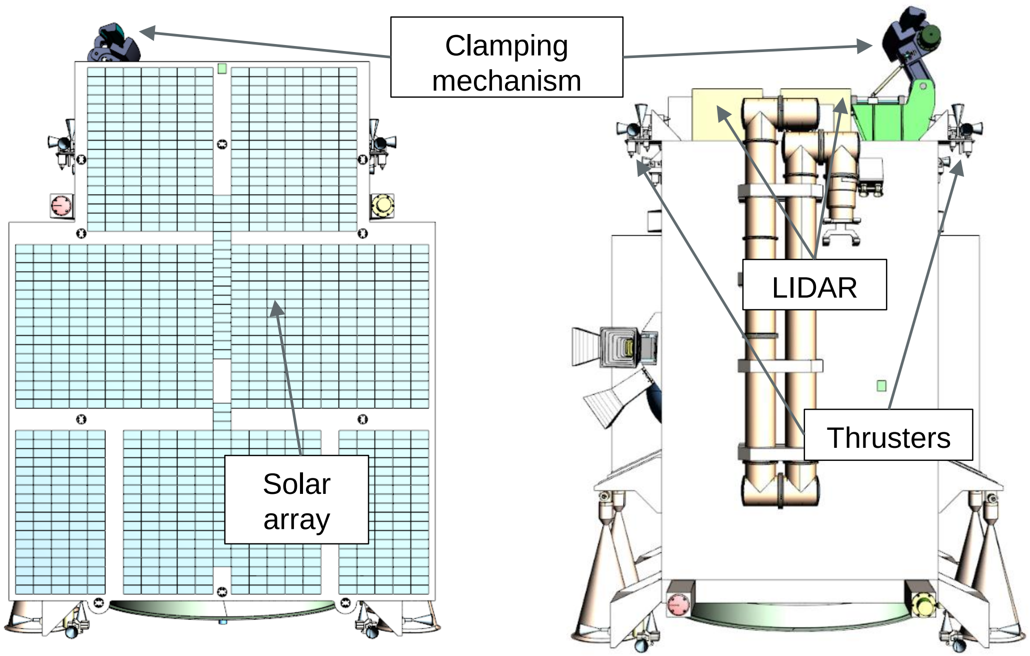


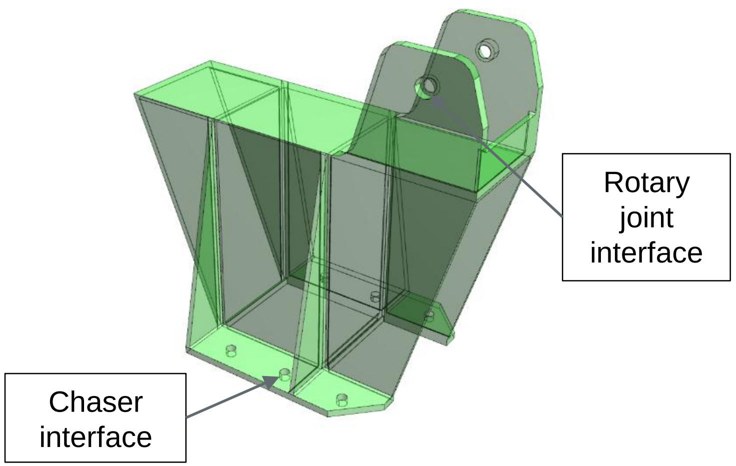
Overview of the clamping mechanism



Overview of the clamping mechanism

Support bracket

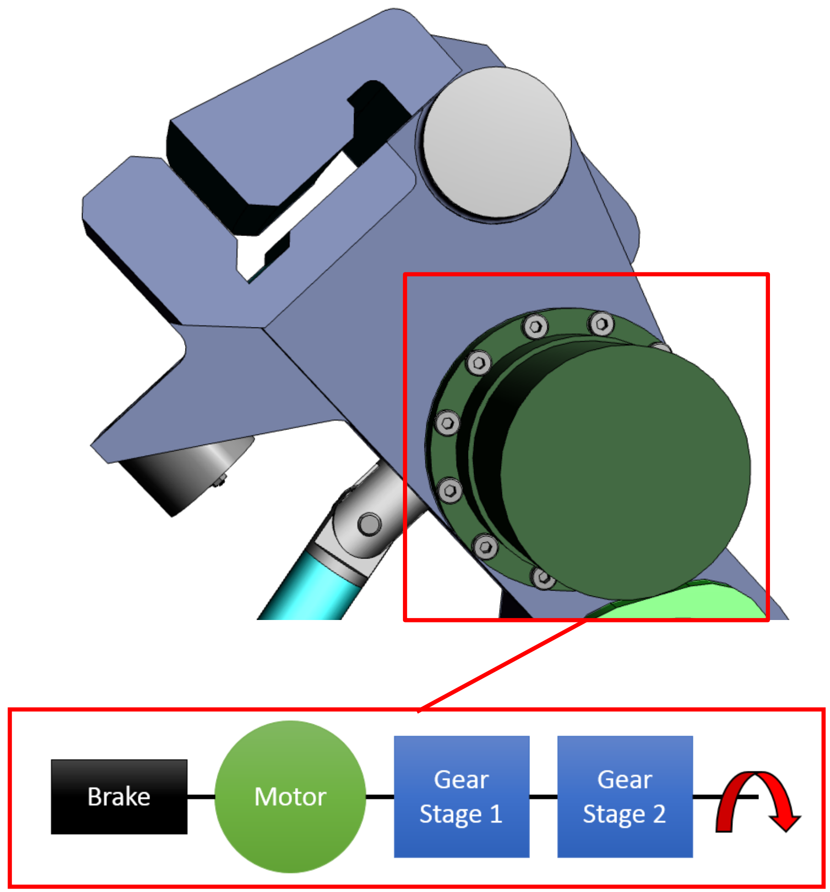




Overview of the clamping mechanism

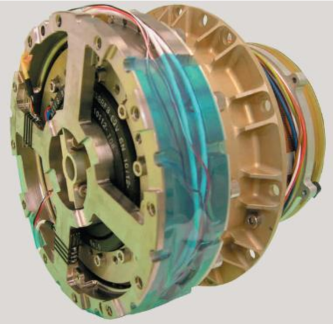
Rotary clamp with locking mechanism

- Clamps shape adjusted for Envisat's launch adapter ring
- Contact surfaces covered by elastic material (e.g. PTFE)
- Rotary actuator driving clamps and locking mechanism
- Locking in the overcentred position (power-off)
- Reversible operation (multiple clamping approaches possible)
- Provisions for HDRM mounting (optional)



Overview of the clamping mechanism

Rotary clamp with locking mechanism – SENER's heritage



REFERENCE	SEN-RA-004-01
DEVELOPMENT LEVEL	ENGINEERING MODEL
APPLICATION	ROBOT MOTORIZED HINGLES
MISSIONS	-
OUTPUT MOVEMENT	ANGULAR
MOTION TRANSPORTATION	HARMONIC DRIVE
ACTUATOR MASS	3.25 KG
TEMPERATURE RANGE	- 30º/ +70º

OUTPUT DATA		ADDITIONAL DELIVERABLE EQUIPMENT	
ROTATION RANGE	+/-175º	POWER AND CONTROL ELECTRONIC	YES
RESOLUTION	-	CONTROL SW	YES
ACCURACY	0.01º	POWER SUPPLY	YES
REPEATABILITY	0.001º	TYPE OF POSITION SENSOR	RESOLVER (OUTPUT), ELECTRIC-CAPACITIVE ENCODER (MOTOR CONTROL)
CONTINOUS TORQUE	100 NM		
PEAK TORQUE	152 NM		
ANGULAR SPEED	30º/SEG (WITHOUT LOAD)		
MAXIMUM POWER	20W (100 NM)		

OTHER PERFORMANCES	BRAKE, TORQUE SENSOR, INPUT & OUTPUT POSITION SENSORS

REFERENCE	SEN-RA-004-02
DEVELOPMENT LEVEL	ENGINEERING MODEL
APPLICATION	ROBOT MOTORIZED HINGLES
MISSIONS	-
OUTPUT MOVEMENT	ANGULAR
MOTION TRANSPORTATION	HARMONIC DRIVE
ACTUATOR MASS	3.25 KG
TEMPERATURE RANGE	- 30º/ +70º

OUTPUT DATA		ADDITIONAL DELIVERABLE EQUIPMENT	
ROTATION RANGE	+/-175º	POWER AND CONTROL ELECTRONIC	YES
RESOLUTION	-	CONTROL SW	YES
ACCURACY	0.01º	POWER SUPPLY	YES
REPEATABILITY	0.001º	TYPE OF POSITION SENSOR	RESOLVER (OUTPUT), ELECTRIC-CAPACITIVE ENCODER (MOTOR CONTROL)
CONTINOUS TORQUE	200 NM		
PEAK TORQUE	359 NM		
ANGULAR SPEED	30º/SEG (WITHOUT LOAD)		
MAXIMUM POWER	18W (200 NM)		

OTHER PERFORMANCES	BRAKE, TORQUE SENSOR, INPUT & OUTPUT SENSORS

Overview of the clamping mechanism

Rotary clamp with locking mechanism – SENER’s heritage

REFERENCE	DTA 100 & V200 SERIES
DEVELOPMENT LEVEL	DTA 100 SERIES ON QUALIFICATION. DTA 200 SERIES UNDER DEVELOPMENT
APPLICATION	• DEPLOYABLE RADIATOR ELECTRICAL PROPULSION MODULE • GENERIC ANTENNA MECHANISMS • ANTENNA REFLECTOR BOOM WITHOUT TRACKING SYSTEM • ANTENNA REFLECTOR BOOM WITH TRACKING SYSTEM (S/N 130) • LARGE DEPLOYABLE STRUCTURES
MISSIONS	-
OUTPUT MOVEMENT	ANGULAR
MOTION TRANSPORTATION	HARMONIC DRIVE
ACTUATOR MASS	2.2 KG
TEMPERATURE RANGE	- 40°/ +100°

OUTPUT DATA		ADDITIONAL DELIVERABLE EQUIPMENT	
ROTATION RANGE	360°	POWER AND CONTROL ELECTRONIC	NO
RESOLUTION	0.00625° (DTA 100 SERIES) 0.002° (DTA 200 SERIES)	CONTROL SW	NO
ACCURACY	0.01°	POWER SUPPLY	NO
REPEATABILITY	0.0075°	TYPE OF POSITION SENSOR	CONTACTLESS (HALL EFFECT) AND POTENTIOMETERS
CONTINOUS TORQUE	> 74 NM (RUNNING)		
PEAK TORQUE	DETENT TORQUE > 25 NM		
ANGULAR SPEED	2°/S (WITHOUT LOAD) 0.1°/S (NOMINAL)		
MAXIMUM POWER	<20 W (2-PHASE) <10 W (4-PHASE)		

OTHER PERFORMANCES	2 OR 4-PHASE CONFIGURATIONS, ADJUSTABLE END STOP

REFERENCE	SEN-RA-003-00
DEVELOPMENT LEVEL	SPACE QUALIFIED AND FLIGHT HERITAGE
APPLICATION	• GENERIC ANTENNA MECHANISMS (ADPM) • LARGE DEPLOYABLE STRUCTURES
MISSIONS	GAIA DSM AND SENTINEL 1
OUTPUT MOVEMENT	ANGULAR
MOTION TRANSPORTATION	HARMONIC DRIVE
ACTUATOR MASS	1.8 KG
TEMPERATURE RANGE	- 50°/ +85°

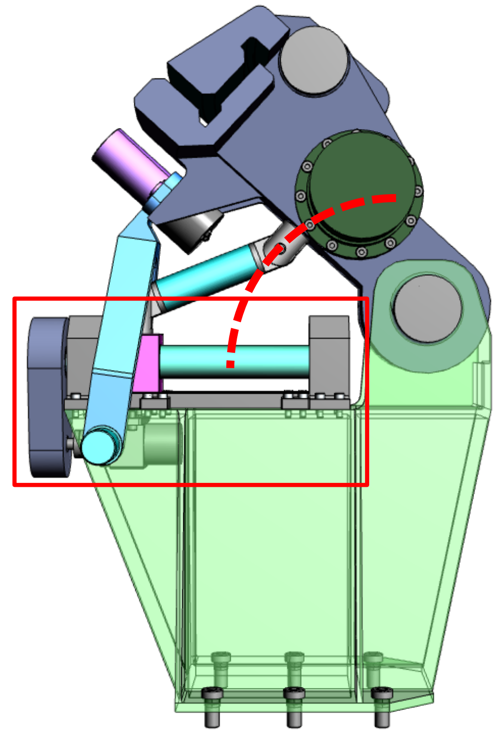
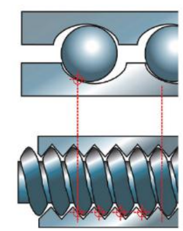
OUTPUT DATA		ADDITIONAL DELIVERABLE EQUIPMENT	
ROTATION RANGE	360°	POWER AND CONTROL ELECTRONIC	NO
RESOLUTION	0.00625°	CONTROL SW	NO
ACCURACY	0.01°	POWER SUPPLY	NO
REPEATABILITY	< 0.006°	TYPE OF POSITION SENSOR	POTENTIOMETERS
CONTINOUS TORQUE	47 NM (AT 0.1°/SEG) (RUNNING)		
PEAK TORQUE	DETENT TORQUE > 5.2 NM		
ANGULAR SPEED	2°/SEG (WITHOUT LOAD)		
MAXIMUM POWER	5 W		

OTHER PERFORMANCES	-

Overview of the clamping mechanism

Alignment mechanism

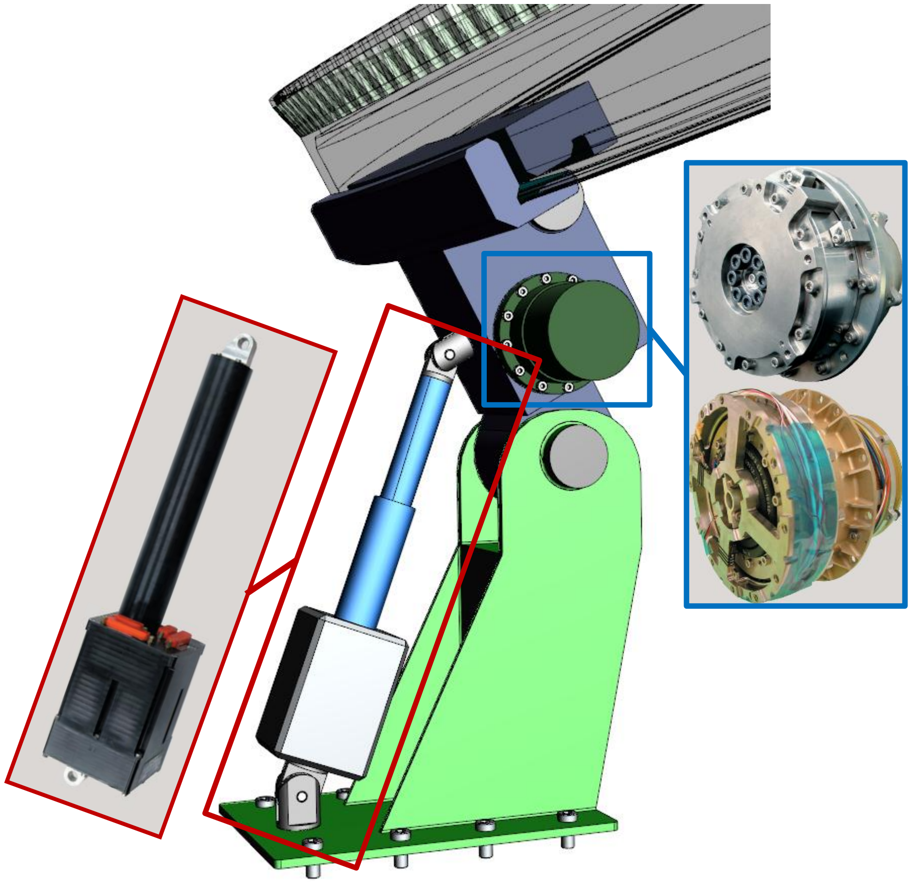
- Provides ability to align Envisat's and chaser's CoGs before de-orbit burns
- Linear actuator with linkage connecting actuator's carrier with clamps structure. Ball/roller screw design, braked while power-off
- Alignment angle estimated as 62deg (in case of the presented mechanism)
- Accuracy shall be at least 0,1deg in order to achieve acceptable alignment.
- In case of the presented design achieved accuracy depends on angular position of the clamps structure

Overview of the clamping mechanism

Alternative design solutions

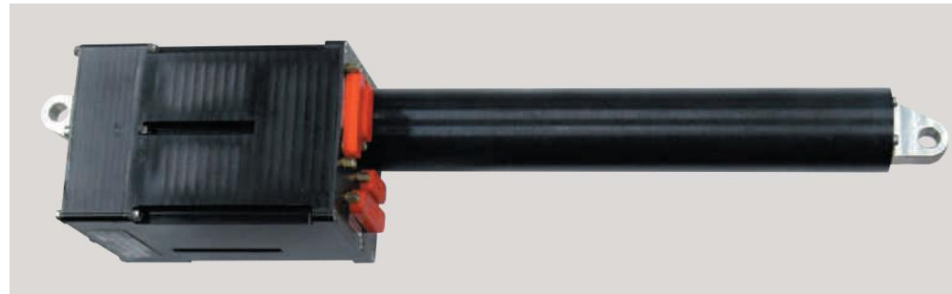
Applicable to the alignment mechanism’s design.



- Load transferred axially through the ball/roller screw (in case of the baseline design it is transferred both axially and radially)
- Lower volume of the suport bracket (possibly lower mass of the clamping mechanism)

Overview of the clamping mechanism

Alternative design solutions



IBDM actuator performances summary:

	Actual Value	Requirements
Speed	173 mm/s	Up to 125 mm/s
Stroke	> 293 mm	≥ 293 mm
Acceleration	ok	Up to 1,27 mm/s2
Backlash	Minor than 20 microns	≤ 75 microns
Thrust capability	Maximum force 730 N At 12 mm/s 710N At 75 mm/s 630 N	Nominal force > 400 N Peak force > 700N
Stiction	Max. 0,1 Nm	N/A
Back drive force	80 N	Backdriveable
Static torque margin	0,04 for peak load 0,825 for nominal load	Positive
Dynamic margin	OK	> 0 (4,5 kg 1270 mm/s2)
Absolute position feed-back	OK	Accuracy better than 0,25 mm
End position detection	Radial end stop OK Signal reed switches OK	
Stiffness	Retracted > 2E6 N/m Deployed >4E6 N/m	>5e5 N/m

Table 4: Performances summary

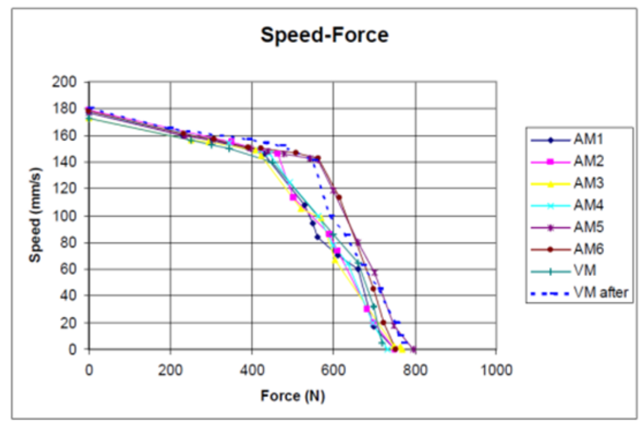
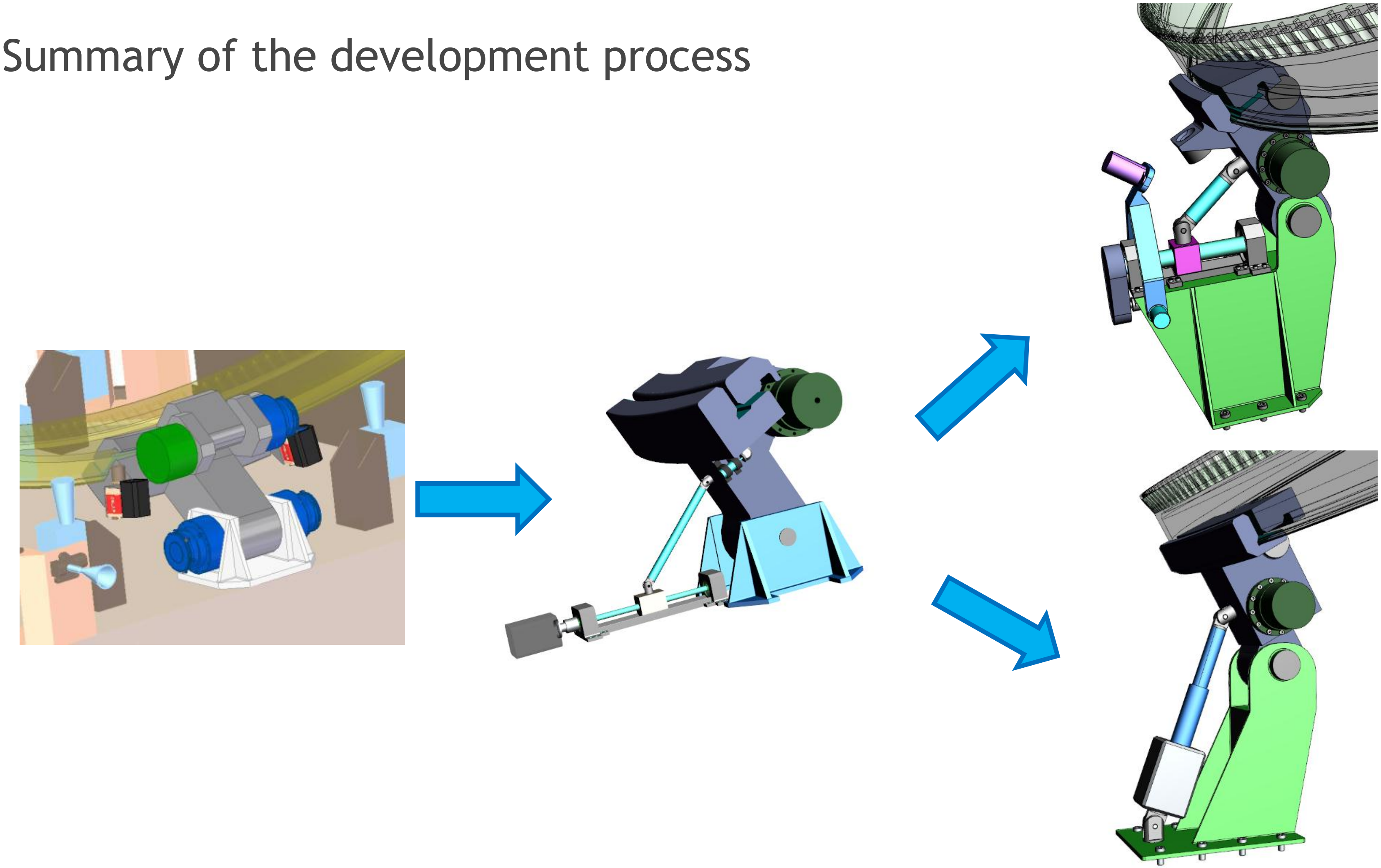


Figure 9: Actuators performance summary

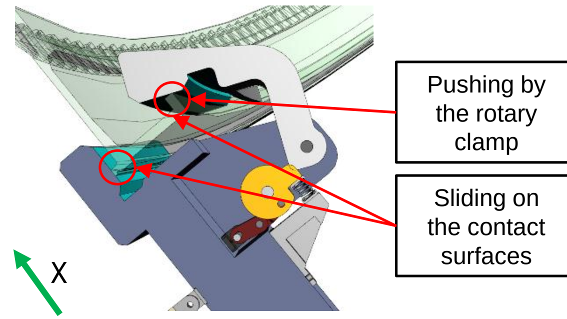
Overview of the clamping mechanism

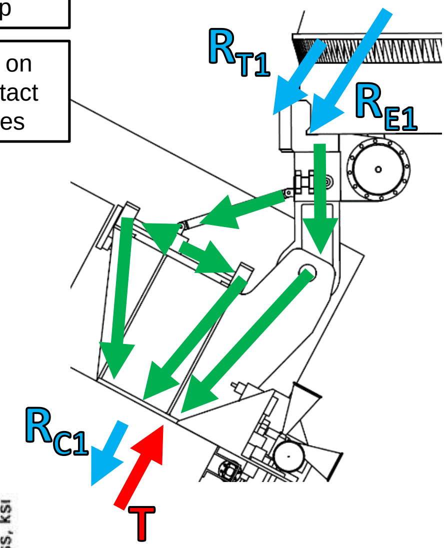
Summary of the development process



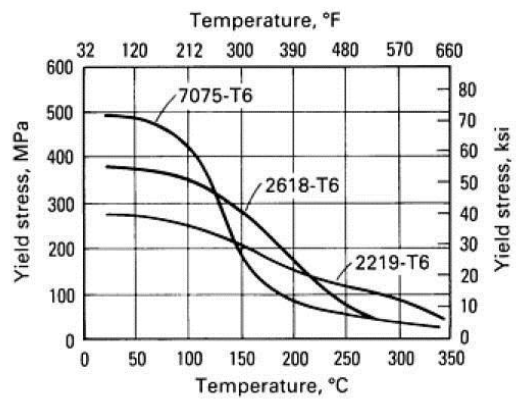
Important aspects to consider

- **Design and sizing** (torques, loads capability, stiffness of the mechanism, self-alignment capability, redundancy, thermal design, control system, mass)

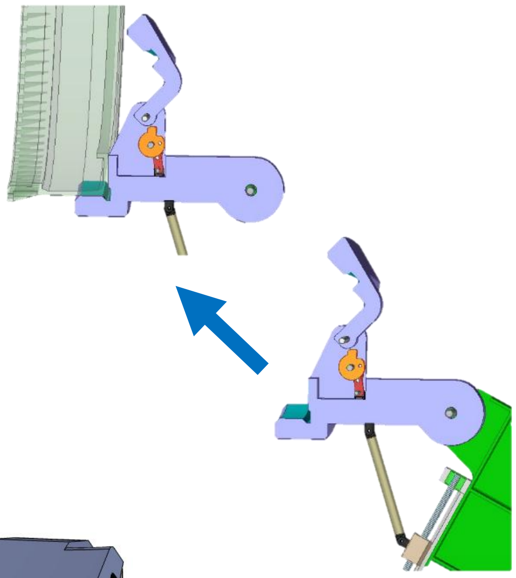




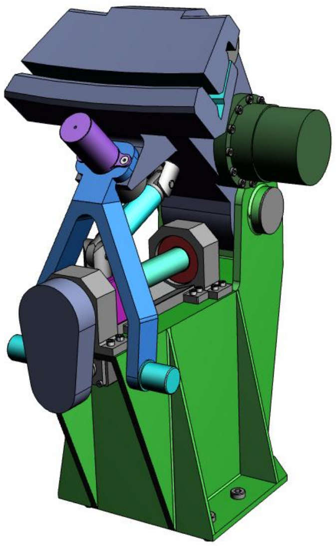
- **Condition of the LAR and the clamping mechanism** during clamping and de-orbit phase (obstacles, damages, temperature)



Important aspects to consider



- **Approach to the Envisat's LAR** (strategy, robotic arm accuracy, sensors considered)

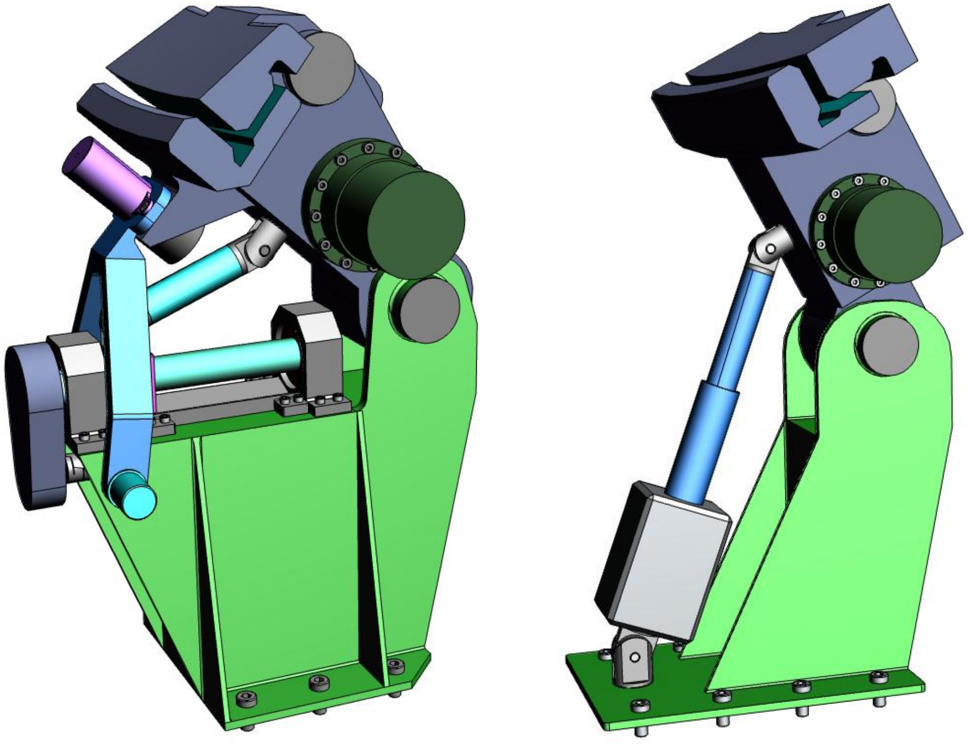


- **Hold-down and Release Mechanisms** (concept, release devices)

Future activities

- Finalisation of e.deorbit study (requirements, action items from KP2, remaining analyses, update of the documentation)

- Clamping mechanism TRP (?)



Sposób patrzenia w przyszłość

Dziękuję
Thank you