

# Mechanism Products Germany



MWS  
MetOp 2<sup>nd</sup> Gen.



MWI – Export



ICI  
MetOp 2<sup>nd</sup> Gen.



MWHS – Export

## EARTH OBSERVATION

More than 25 Scanning Mechanisms have been delivered to various customers, the department successfully contributes to RF and Optical Instruments.

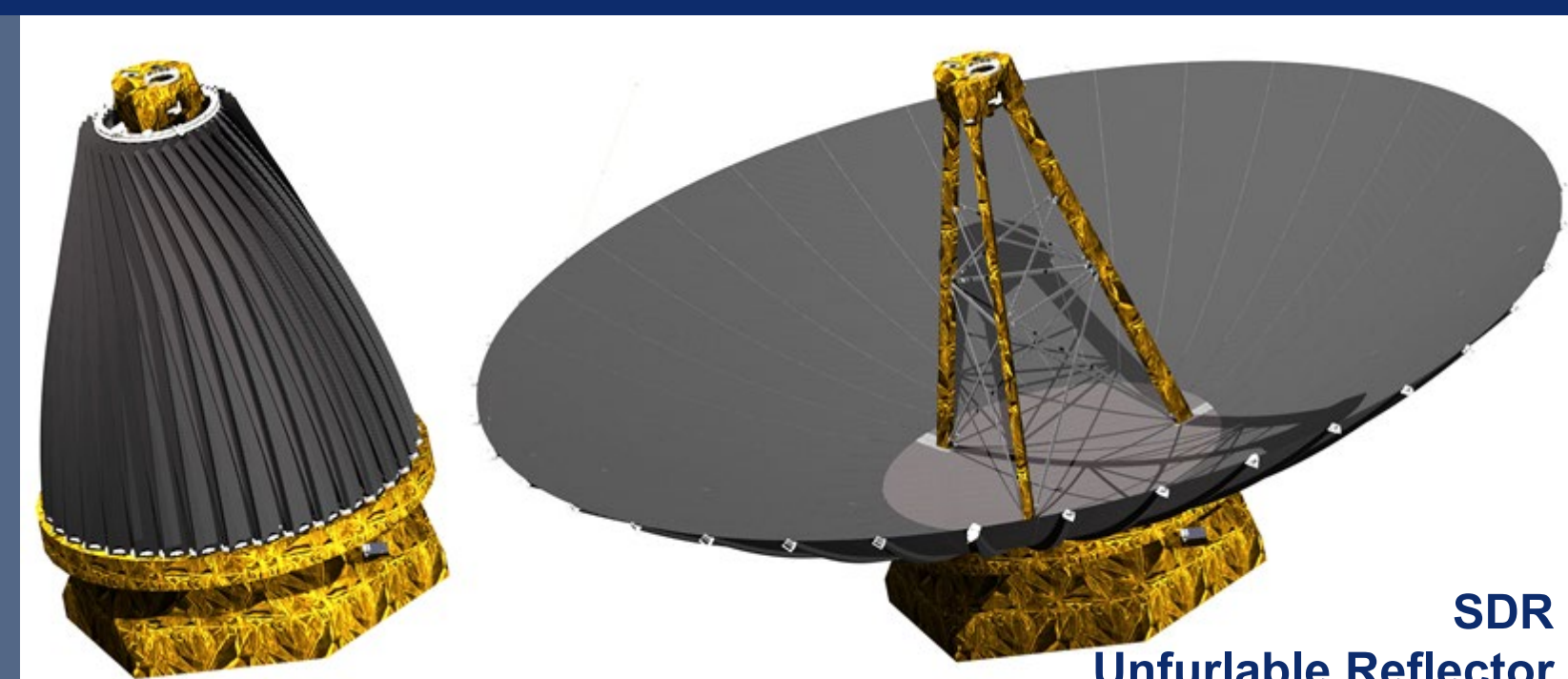
ENS support to ESA missions such as MetOp 2<sup>nd</sup> Generation Scanners for MWI, ICI, MWS and Instrument METImage has built a cutting-edge expertise within the Centre of Excellence.

Export projects have enabled the creation of a product line, benefiting from batch orders and standardization, in order to offer high performance at reduced costs.

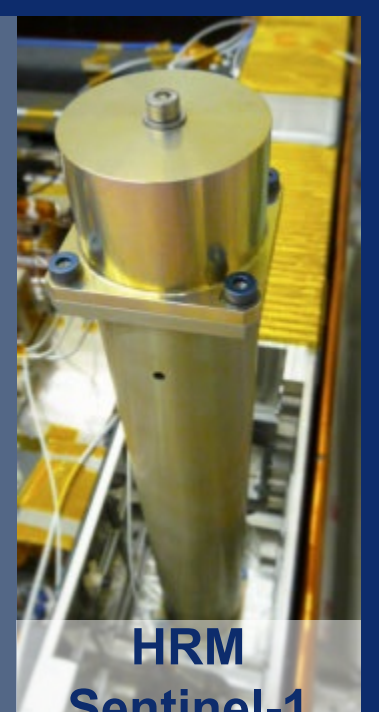
## DEPLOYMENT

With options for 3 and 5 meter diameter, the Unfurlable Reflector deploys itself in orbit. Its lightweight CFRP structure is composed by individual panels, easily exchangeable and maintainable prior launch.

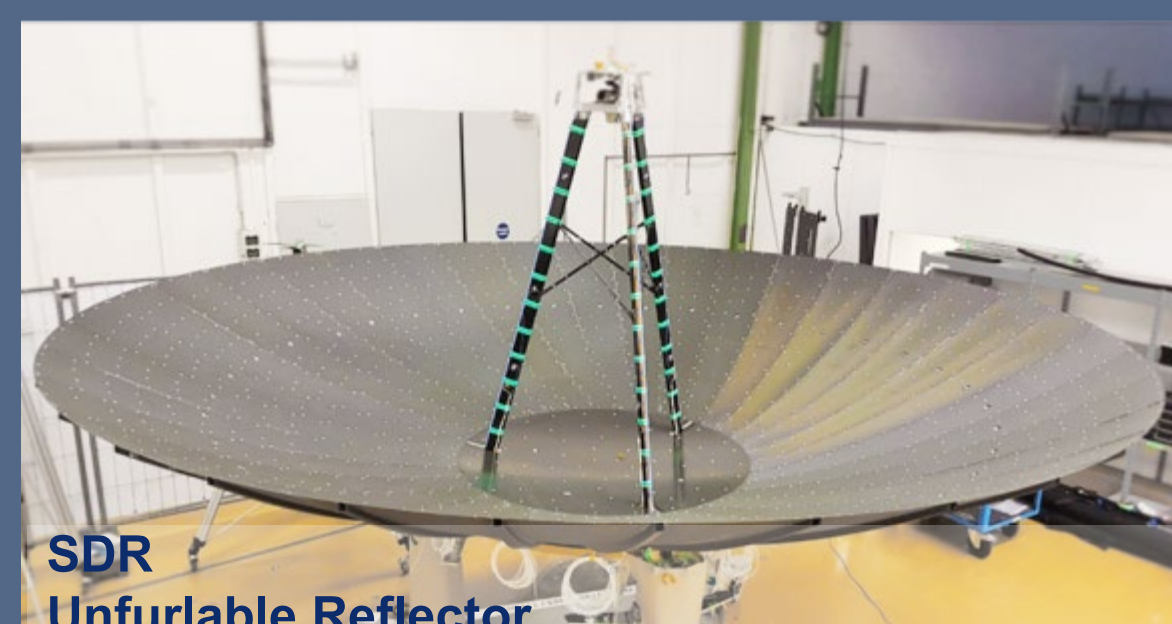
The department has delivered more than 20 deployment and trimming mechanisms, which range from non-ITAR Hold-Down and Release Mechanisms to Opening-closing mechanisms using Shape Memory Alloys.



SDR  
Unfurlable Reflector



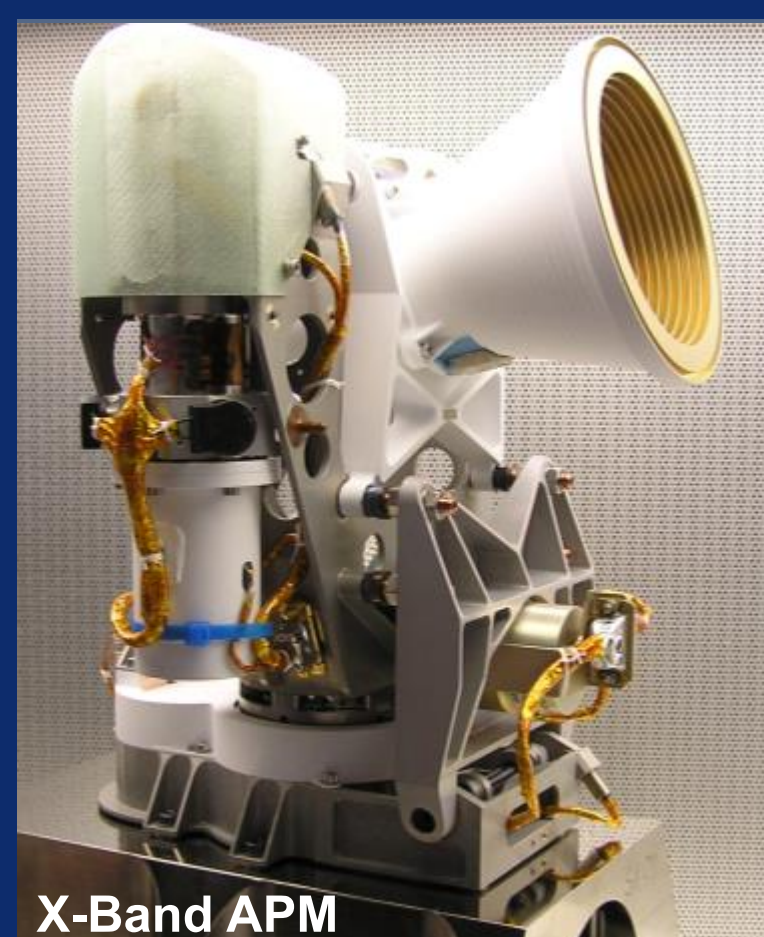
HRM  
Sentinel-1



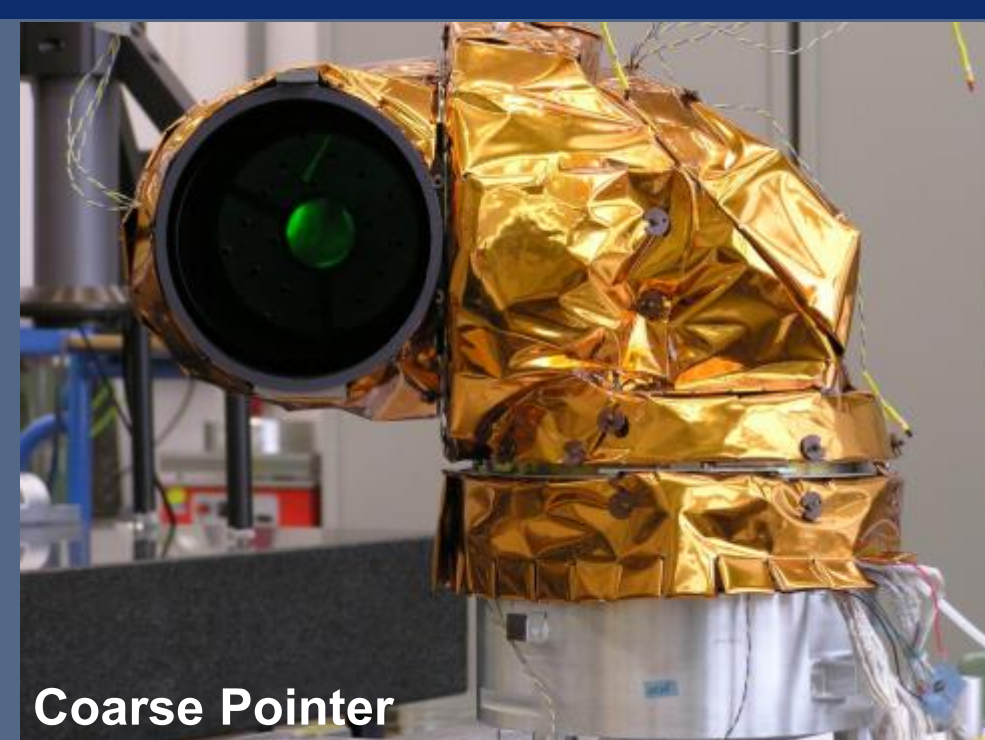
SDR  
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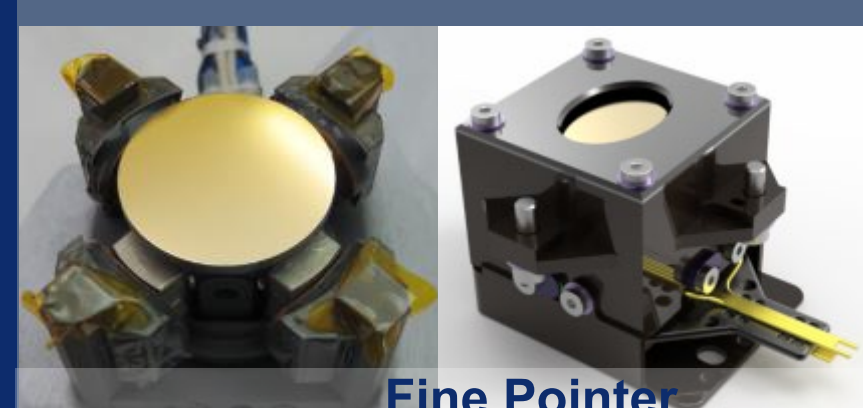
2CIR  
Calibration Mechanism



X-Band APM



Coarse Pointer



Fine Pointer



CPA70

## COMMUNICATIONS

More than 30 Antenna Pointing Mechanism units have been flown, providing 2-axis movement in LEO, MEO & GEO, supporting both X and Ka bands.

The Fine Steering Mechanisms have been developed for laser communication terminals, and the coarse pointers enable inter-satellite links.





# RF EARTH OBSERVATION

On the MetOp 2<sup>nd</sup> Generation Satellites, Copernicus CIMR Mission and on export missions, our mechanisms are a performance enabler in the RF Scanning Instruments onboard.

### Continuous Scanning

- Rotation of large RF Instruments up to 160kg
- Bearing off-load device for launch guarantees long in-orbit lifetime
- Power and data transfer via Roll Ring
- Actuation via redundant BLDC Motor
- Position feedback via Optical Encoder
- Designed for long-term storage applications (>20 years)
- Qualified for up to 230 million revolutions

### Discontinuous Scanning

- Rotation of large reflectors up to D35x50cm
- Highly agile drive profile
- Actuation via redundant BLDC Motor
- Position feedback via Optical Encoder
- CFRP Reflector with qualified coating
- Designed for long-term storage applications (>20 years)



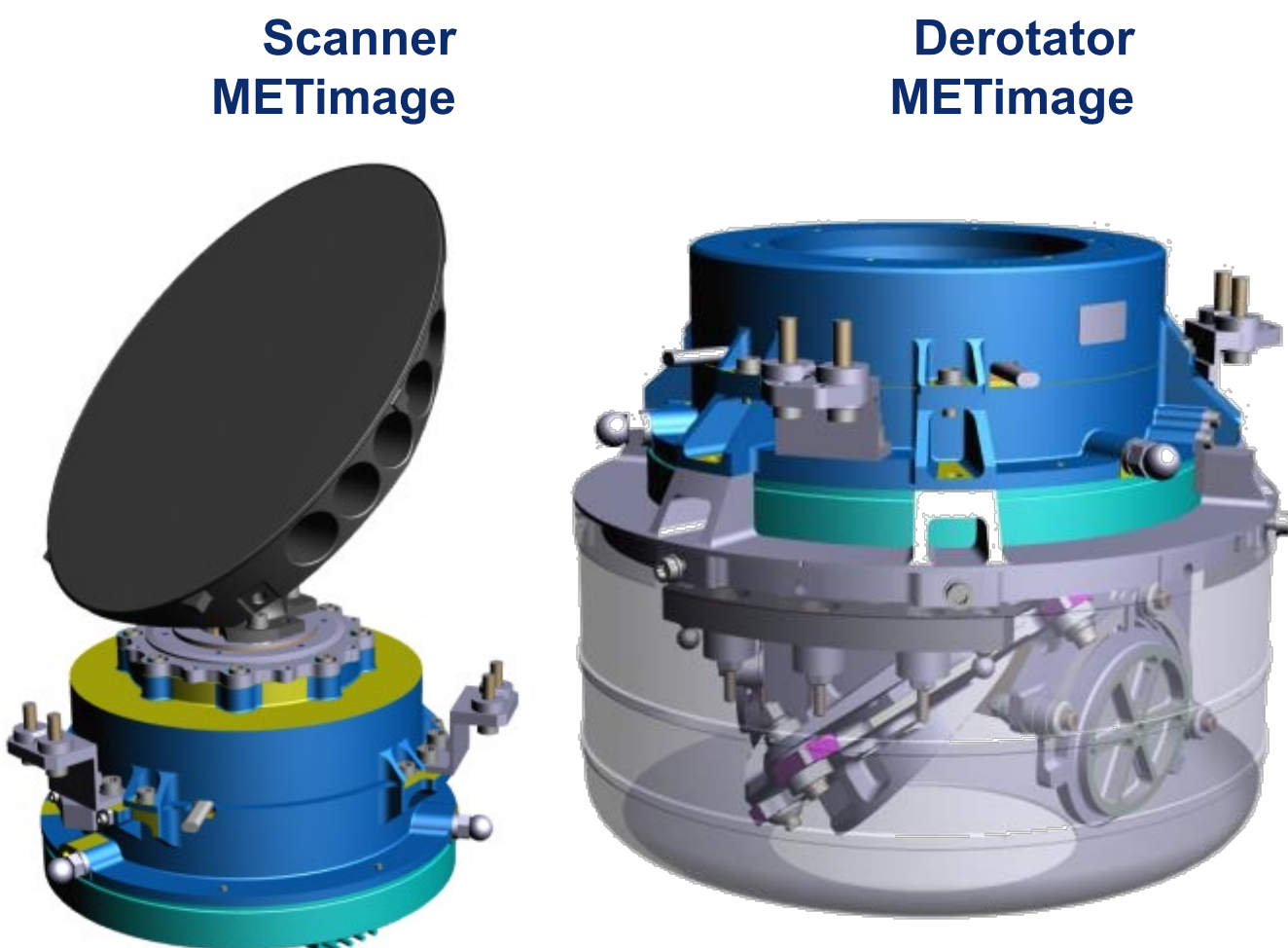
System	Heritage	Envelope [cm]	Scanning Accuracy [μrad]	Velocity [deg/s]	Frequency [GHz]	Power [W]	Mass [kg]
Continuos	MetOp SG MWI, MetOp SG ICI , Copernicus CIMR, several export missions	D30 x 50	10	180 – 270		25 – 40	20 – 30
Discontinuos	MetOp SG MWS, multiple export missions	D35 x 50	–	75 – 150	23 – 230	25 – 35	16 – 20

# OPTICAL EARTH OBSERVATION

In the frame of MetOp 2<sup>nd</sup> Generation, the department is developing two mechanisms for the METImage Instrument, with the following characteristics:

- High accuracy across-track scanning and de-rotation for image stabilization
- Highly dynamic operational profile (optimized for Earth view scanning duration)
- Also available with hollow shaft, optimized w.r.t. stray light
- Actuation via redundant BLDC Motor
- Position feedback via Optical Encoder
- Developed from heritage scanner missions
- Electronically synchronized mechanisms

System	Heritage	Envelope [cm]	Accuracy [μrad]	Velocity [deg/s]	Wavelength [nm]	Mass [kg]
Scanner / Derotator	Several Export missions, Bepi Colombo ADM	D21 x 34 D30 x 20	< 50	160	443 – 13,345	8







Centre of Excellence  
MECHANISMS

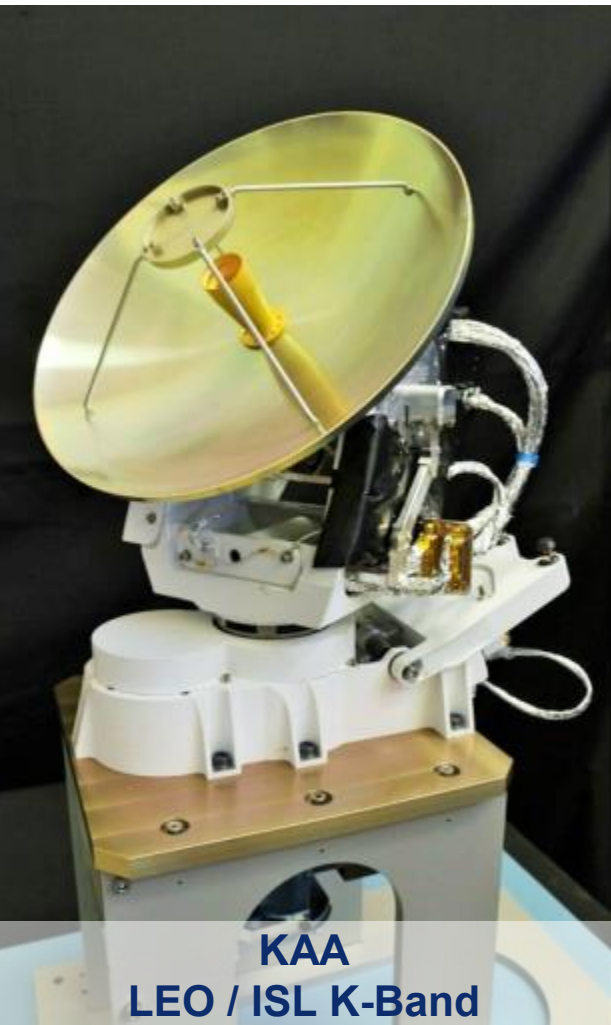
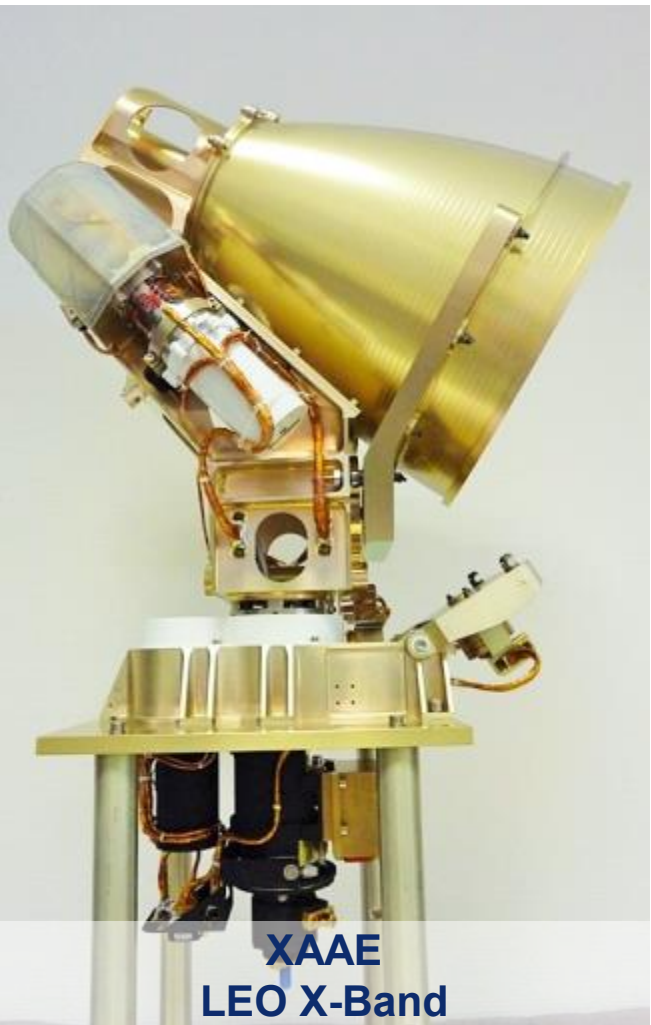
Communications  
Mechanisms

# RF COMMUNICATIONS

The department counts with ample experience in Antenna Pointing Mechanisms for different orbit applications. Some design characteristics include:

- Independent 2-axis movement (full Azimuth rotation, variable Elevation)
- Geared stepper motor drive
- Contactless Rotary Joints for RF signal transfer
- Slip Ring for electrical signal transfer
- Qualified control electronics (developed also at Airbus Friedrichshafen)
- Built-in Launch Lock

The New Generation Mechanism for RF Communications is now under development, using a standard drive with adaptable RF Path and Antenna.



System	Heritage	Envelope [cm]	Accuracy [deg]	Velocity [deg/s]	Accel. [deg/s2]	Rotation Range	Frequency [GHz]	Power [W]	Mass [kg]
LEO X-Band	XAA (4 units in-orbit), XAAE (4 units in-orbit)	D68 x 65	< 0.5	< 10	< 10	Full Hemispheric	8 – 8.4	7.5	< 12.5
LEO Ka-Band	KAA (FM qualified & delivered)	D55 x 52	< 0.5	< 10	< 10	Hemispheric	25.5 – 27	60	< 9
MEO K-Band	GISL (EM built & qualified for G2G)	D35 x 50	< 0.25	< 60	< 120	Hemispheric	22.5 – 23.5	15	< 11.5
GEO (gimbal)	Skynet, SatcomBW, DFH-3 (total >19y acc. flight heritage)	40 x 40 x 15	< 0.05	< 5	-	+/- 13 deg	< 22kg dishes	16	< 5.5

# OPTICAL COMMUNICATIONS

## Coarse Pointer

- Independent 2-axis movement
- Application for Laser Terminals and Inter-Satellite Links
- Direct drive with BLDC motor and Optical Encoder
- Built-in Launch Lock

## Fine Pointer

- Cardan 2-axis Gimbal pointed mirror
- Suspended by flexural pivots
- Actuation via four Spherical Linear motors
- Position feedback by Eddy Current sensors

System	Heritage	Envelope [cm]	Accuracy [μrad]	Velocity [rad/s]	Accel. [rad/s2]	Rotation Range	Mass [kg]
Coarse Pointer	TerraSar, NFire (18y acc. flight heritage)	35 x 35	125	-	-	Unlimited	15.5
Fine Pointer	TerraSar, Nfire, Alphasat (21y acc. flight)	8 x 5.7 x 4.7	< 100	5	10,000	+/- 3 deg	0.25



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MECHANISMS

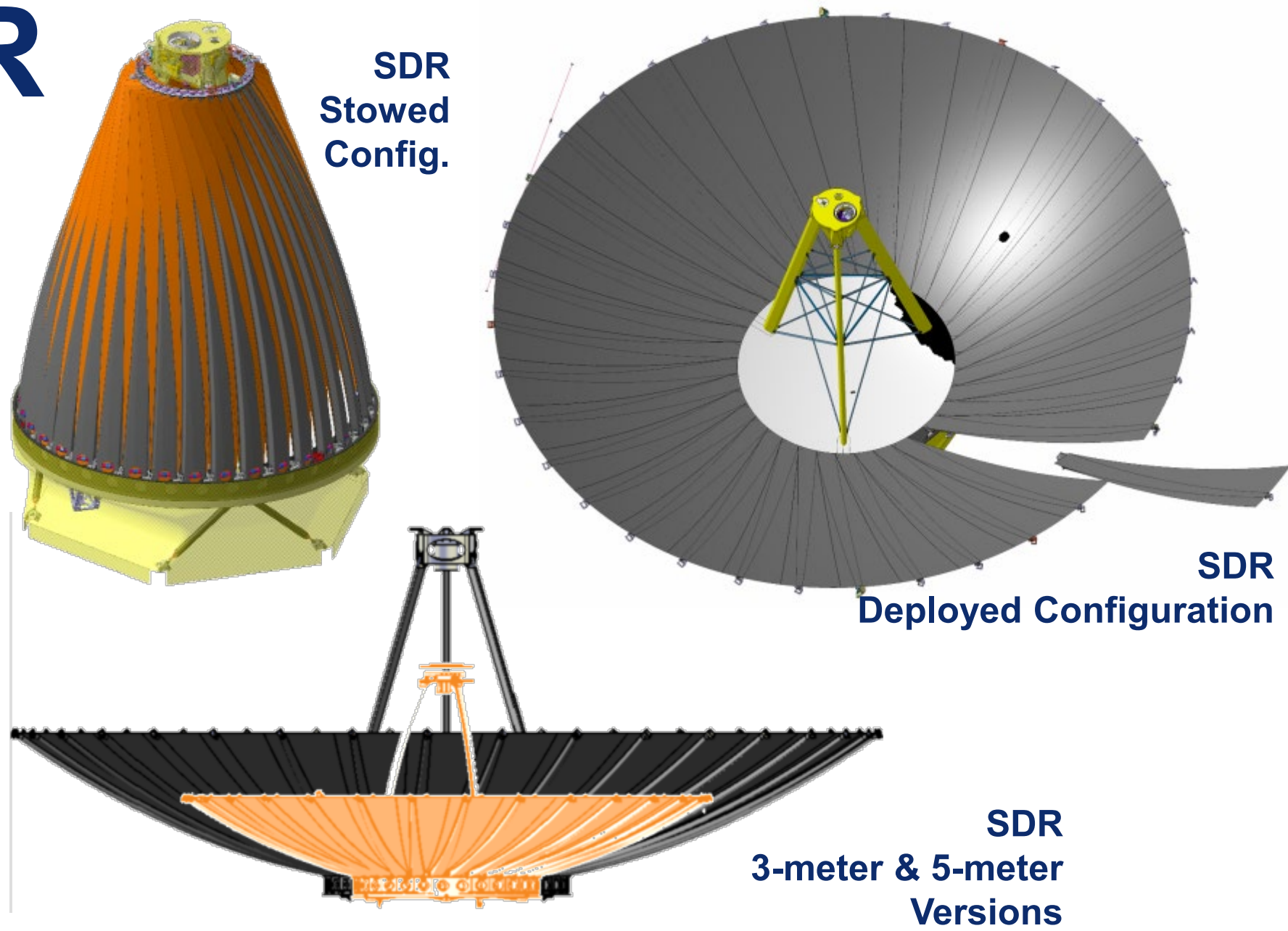
# Deployable Mechanisms

## UNFURLABLE REFLECTOR

The Unfurlable Reflector product allows the launch of a scalable CFRP reflector with a deployed diameter range from 3 till 5 meter and a stowed volume between 1.1 and 1.6 meter with the following characteristics:

- Very compact design with high contour accuracy
- Scalable design with 3-meter, 3.5-meter and 5-meter diameter
- Individual CFRP panels avoiding mechanical and thermal cross-couplings
- Fully cold redundant release and damping system
- Easy repair and maintenance of damaged panels (in 2 working days)
- Spring-driven deployment (no electric motorization)
- Different Reflector configurations (Apex-fed, Cassegrain, Gregorian...)
- Surface reflectivity >97% of Aluminium
- Photogrametry Inspection for end-to-end reflector alignment

The current use of the Unfurlable Reflector is Earth Observation, in SAR instruments, and Communications, for MEO data downlink.



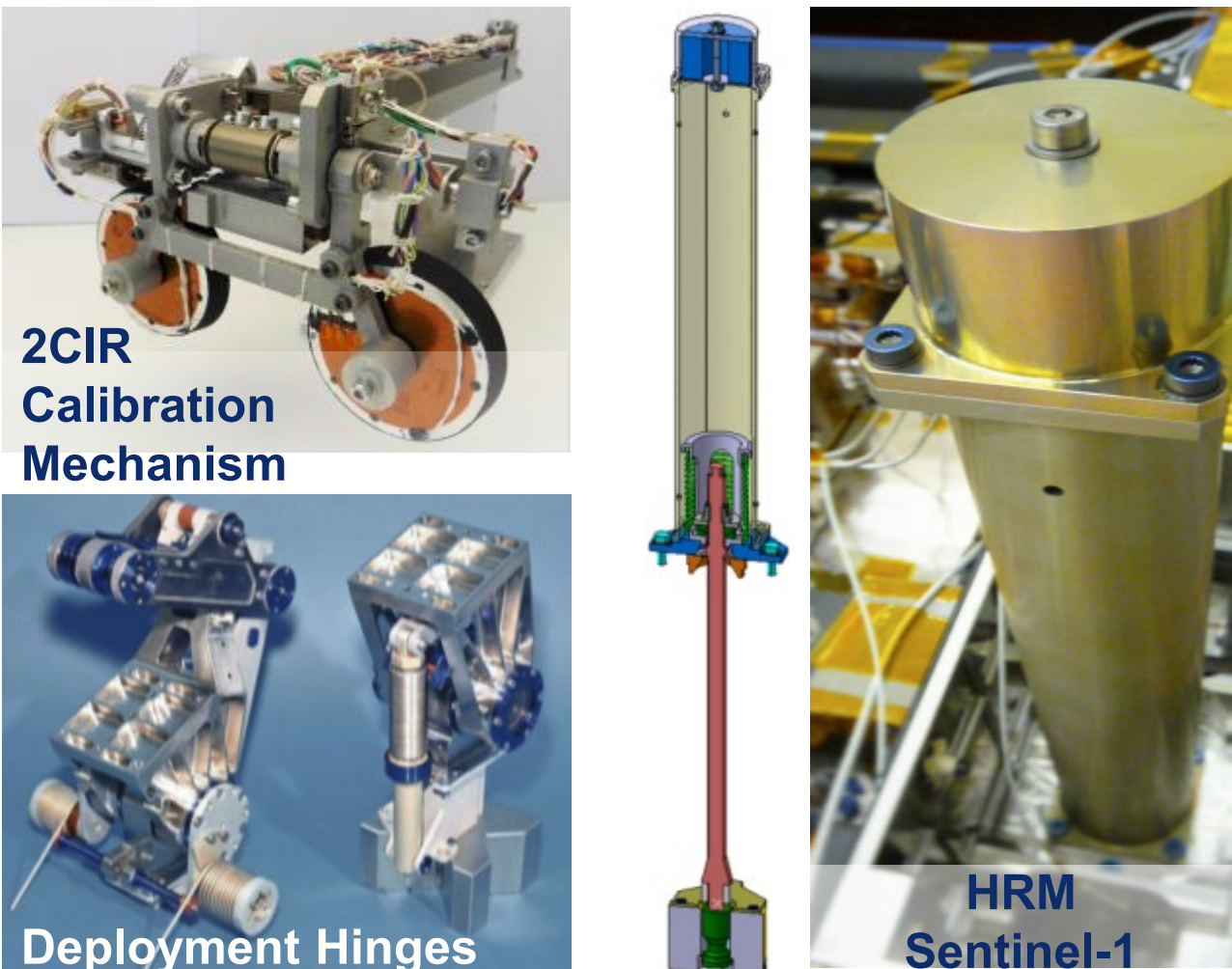
System	Heritage	Deployed [m]	Stowed [m]	Contour Acc. RMS [mm]	1 <sup>st</sup> Eigenfrequency Stowed/Deployed [Hz]	Deployment Time [s]	Frequency [GHz]	Contour Symm. Parab. [mm]	Main Refl. Mass [kg]
3-meter	Development model produced in 2003	D3 x 1.4	D1.1 x 1.4	< 0.5	28 / > 12	5 – 10	8 – 12	F = 1100	< 20
5-meter	Qualification successful finalized; flight model in delivery	D5 x 2.1	D1.6 x 2.1	< 0.5	26 / > 4	50	8 – 12	F = 1800	< 43
3.5-meter	Development Study finalized; for constellation purposes	D3.5 x 1.7	D1.2 x 1.7	< 0.4	40 / >10	35	8 – 12	F= 1000	< 19

## HRM & DEPLOYMENT

Apart from unfurlable reflectors, the department offers a wide range of mechanisms to deploy antenna booms, solar arrays, instrument baffles and calibration mechanisms. The 2CIR Calibration Mechanism opens and closes 2 covers with Shape Memory Alloy technology. The covers act as calibration targets for the optical instrument.

Furthermore, Antenna Deployment Hinges based on springs have been successfully flown. With a self-locking capability, they act as a Hold-Down mechanism too.

In addition, a Hold-Down and Release Mechanism with non-ITAR technology was developed for Sentinel 1. Using NEA as release device, it has a load capacity of 30kN. The shock is absorbed by a honeycomb damper. Already 24 units are in orbit, with 24 more to be flown in the next batch.



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# Standard Mechanism Drive Electronic (sMDE)

## sMDE

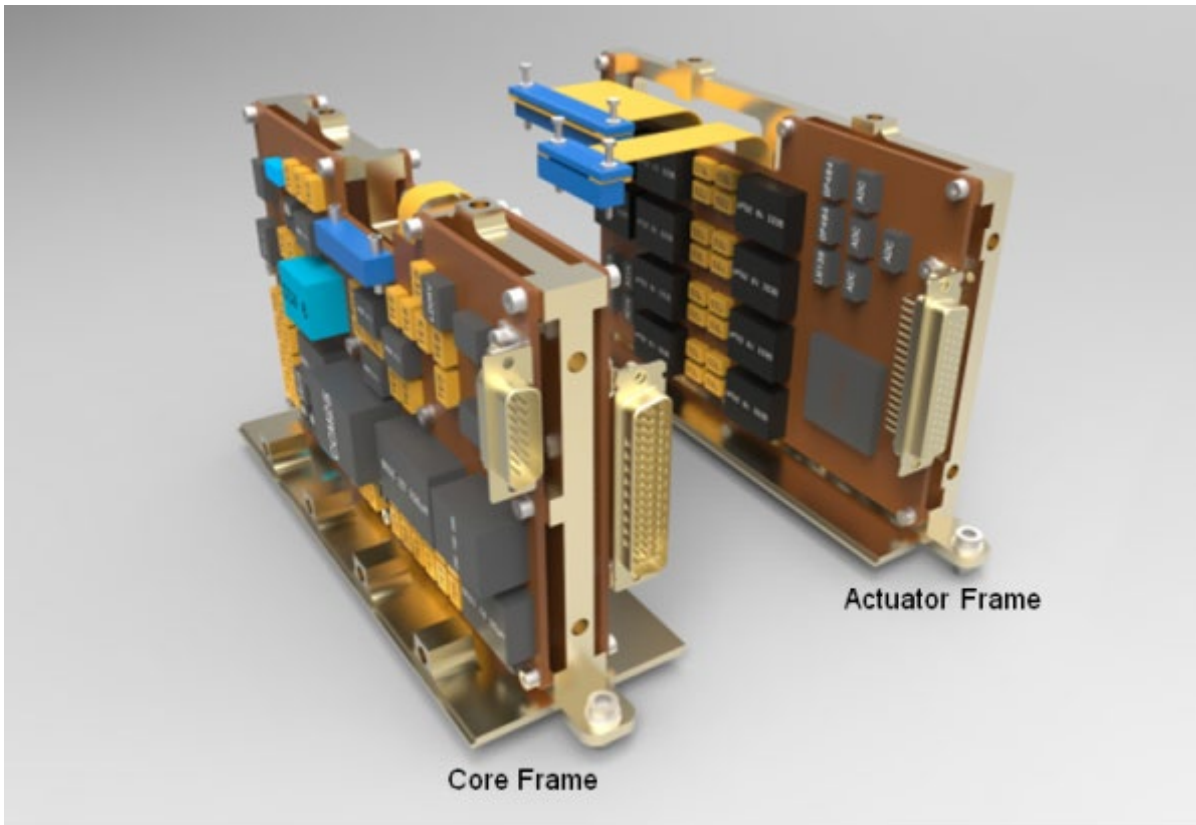
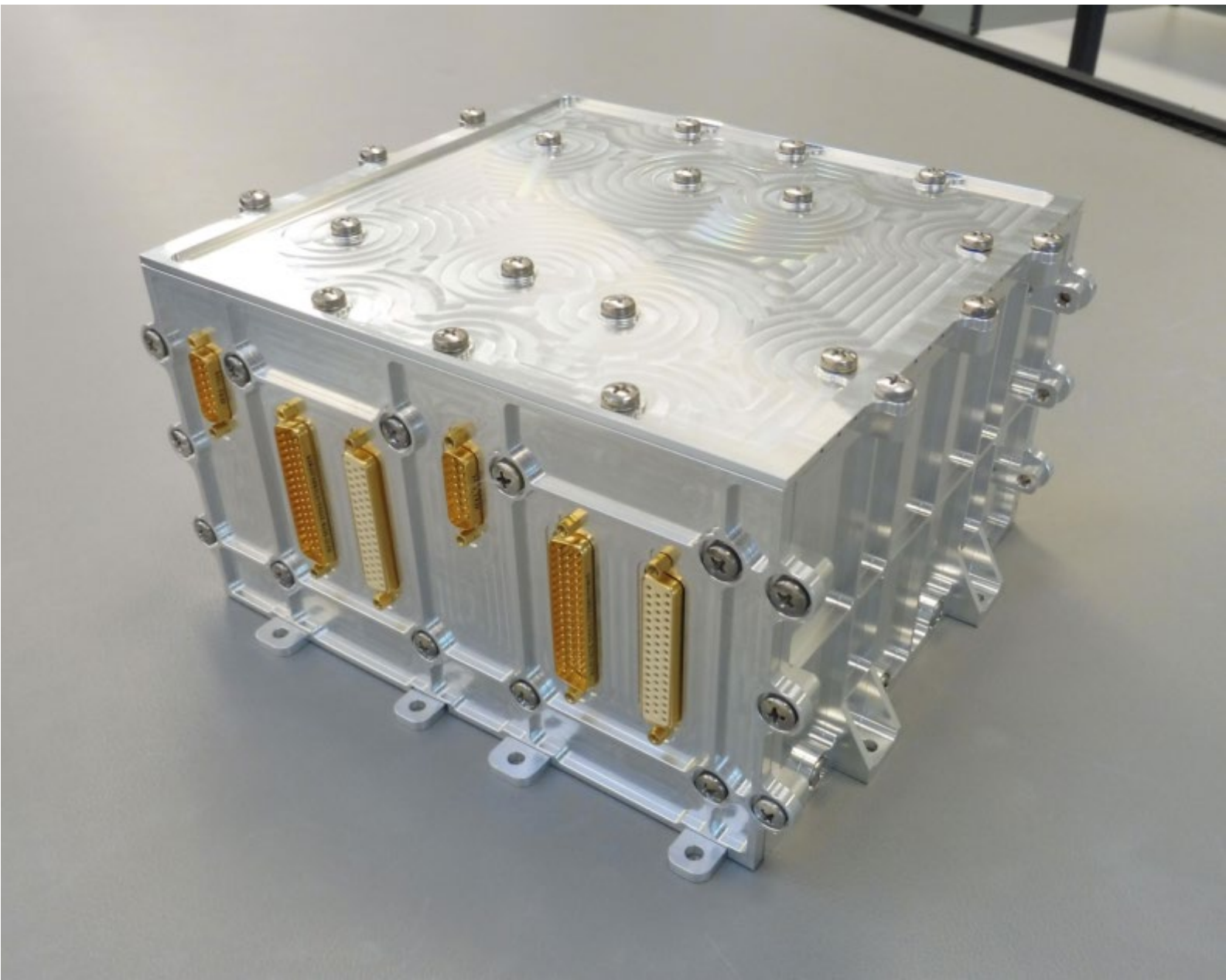
### Standardized Electronics for wide range of Mechanisms

The sMDE (standard Mechanism Drive Electronic) is the common design/product electronic equipment to serve as motion and actuator controller the wider range of mechanisms:

- Earth Observation Scan Mechanisms
- Antenna Pointing Mechanisms
- Deployment Mechanisms
- Solar Array Drive Mechanisms

### Functionalities

- Control and drive up to 2 actuators (electrical motors)
- Parametric and programmable Control-Loop strategy and response
- Receive commands and transmit telemetry data to the spacecraft Control Unit
- Acquire and transmit to the CU signals from Mechanism dedicated sensors (thermistors, switches, etc.)



### sMDE Mechanism-Target Technical Characteristics

- Control of BLDC (3-phases) as well as Stepper (2 coils) motors
- Support several data interface protocols to CU (RS422, MIL-BUS, Spacewire)
- Use of digital or Analog Encoder as principal position sensor
- Wide primary input voltage range (22-55V)
- >15W steady state power available for each actuator
- Control Loop modules for different position, speed and profile control modes
- Single to double actuator and full cold redundancy scalability with minimum NREC impacts

### sMDE Schedule

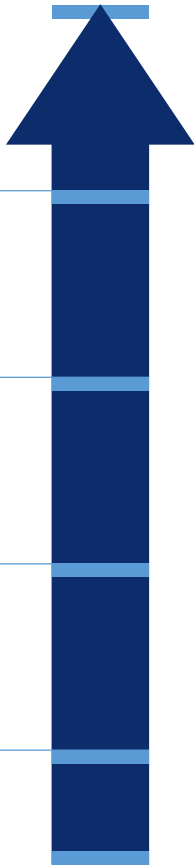
FMs  
06.2023

QM  
12.2022

CDR  
06.2022

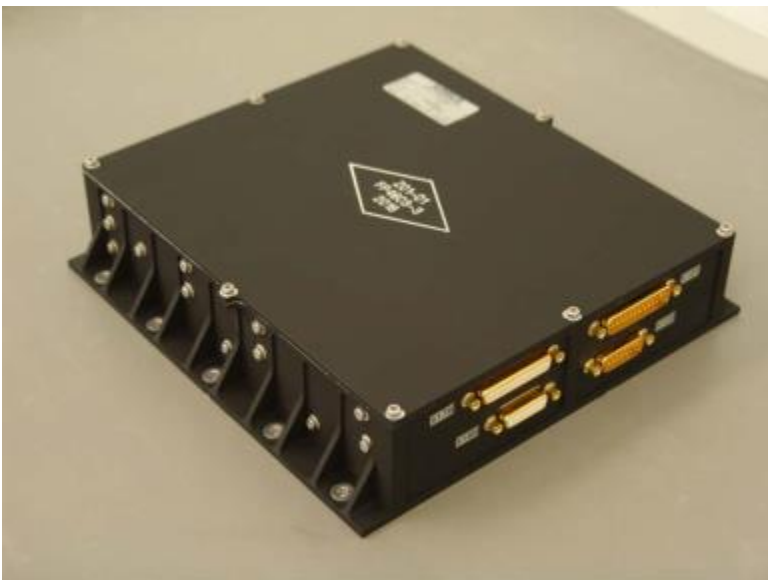
PDR  
09.2021

KO  
03.2021



### Heritage Electronics Units for Re-Build available

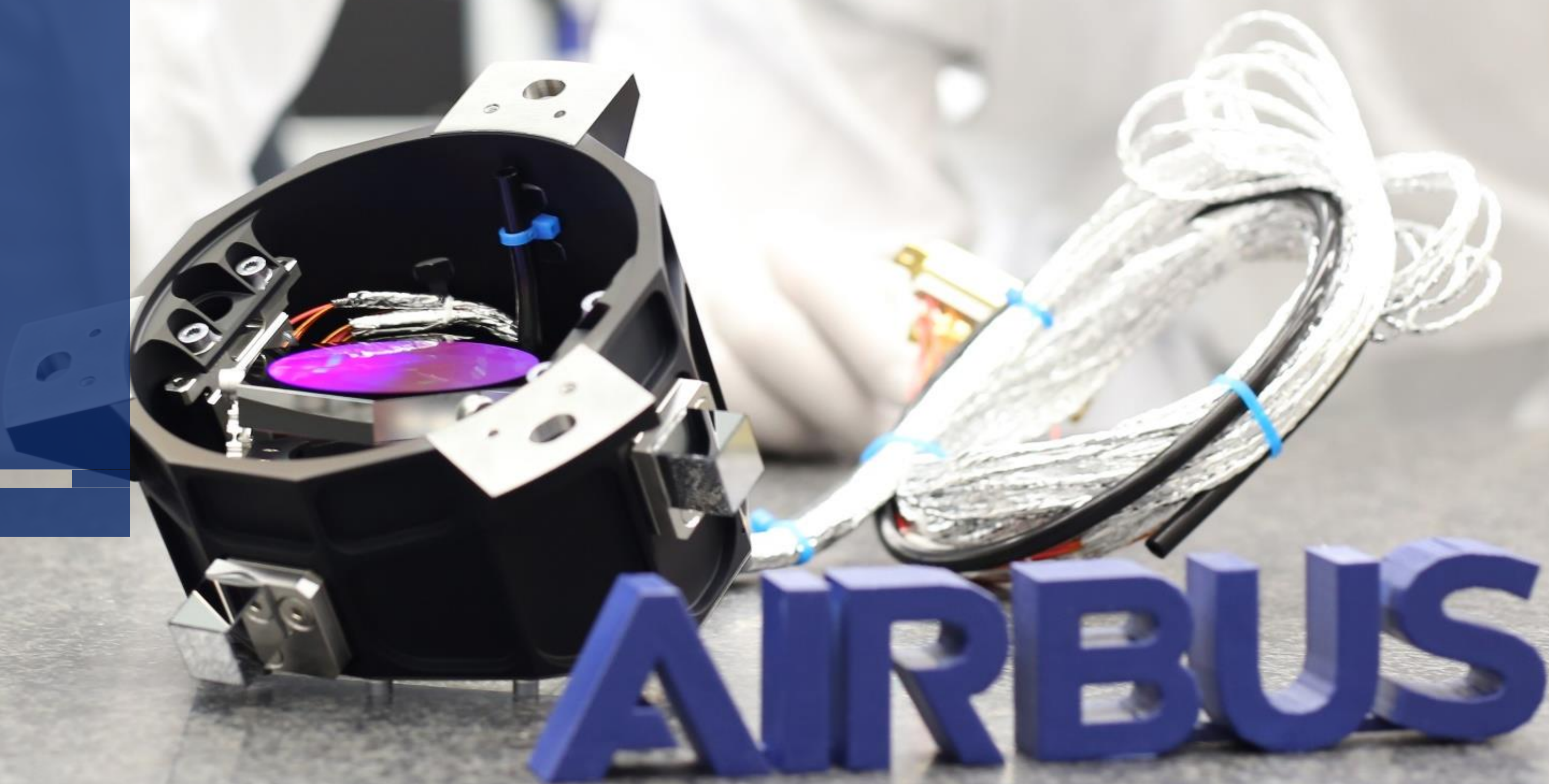
- Re-Build of most Airbus heritage electronics units available:
  - Antenna Pointing Electronics for GEO-/LEO-Orbit
  - Scan Control for Instrument Scan
  - Solar Array Drive Electronics
  - Electronics for Mass Trim Assembly





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Verification  
Services



VERIFICATION SERVICES

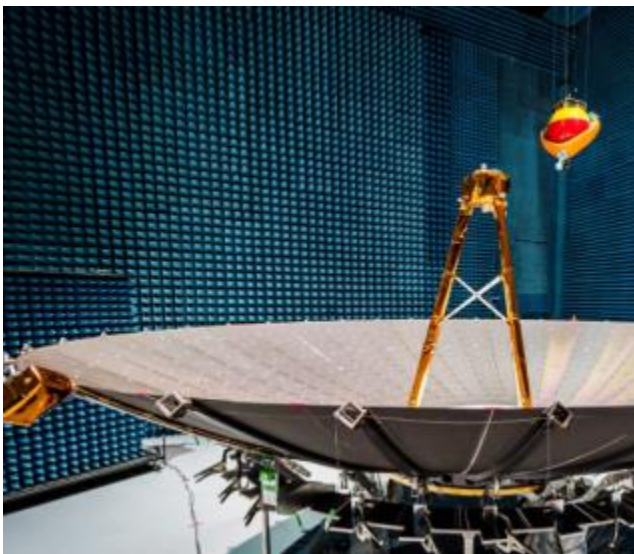
End-to-end System Verification & Qualification

Airbus Defence and Space provides end-to-end functional and environmental verification services for mechatronic systems as well as for mechatronic components:

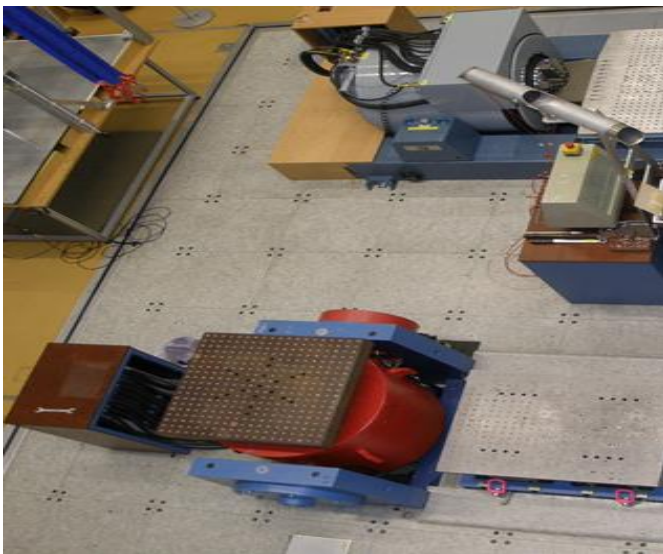
- On-site Vibration, Shock, Thermal Vacuum, RF, EMC testing, electrical and mechanical I/F verification
- Mechanisms Life testing with HIL in thermal vacuum environment
- Functional tests with HIL, bearing and drive characterization, emitted micro-vibrations measurements and more
- State-of-the-art Cleanroom Facilities (ISO-8 and ISO-5) in our new Integrated Technology Center for hardware integration and testing
- Heritage of several qualification and FM acceptance test campaigns (e.g. MetOp Scan Mechanisms, SDR Deployable reflector)



Functional Verification



RF PAMS



Vibration and Shock

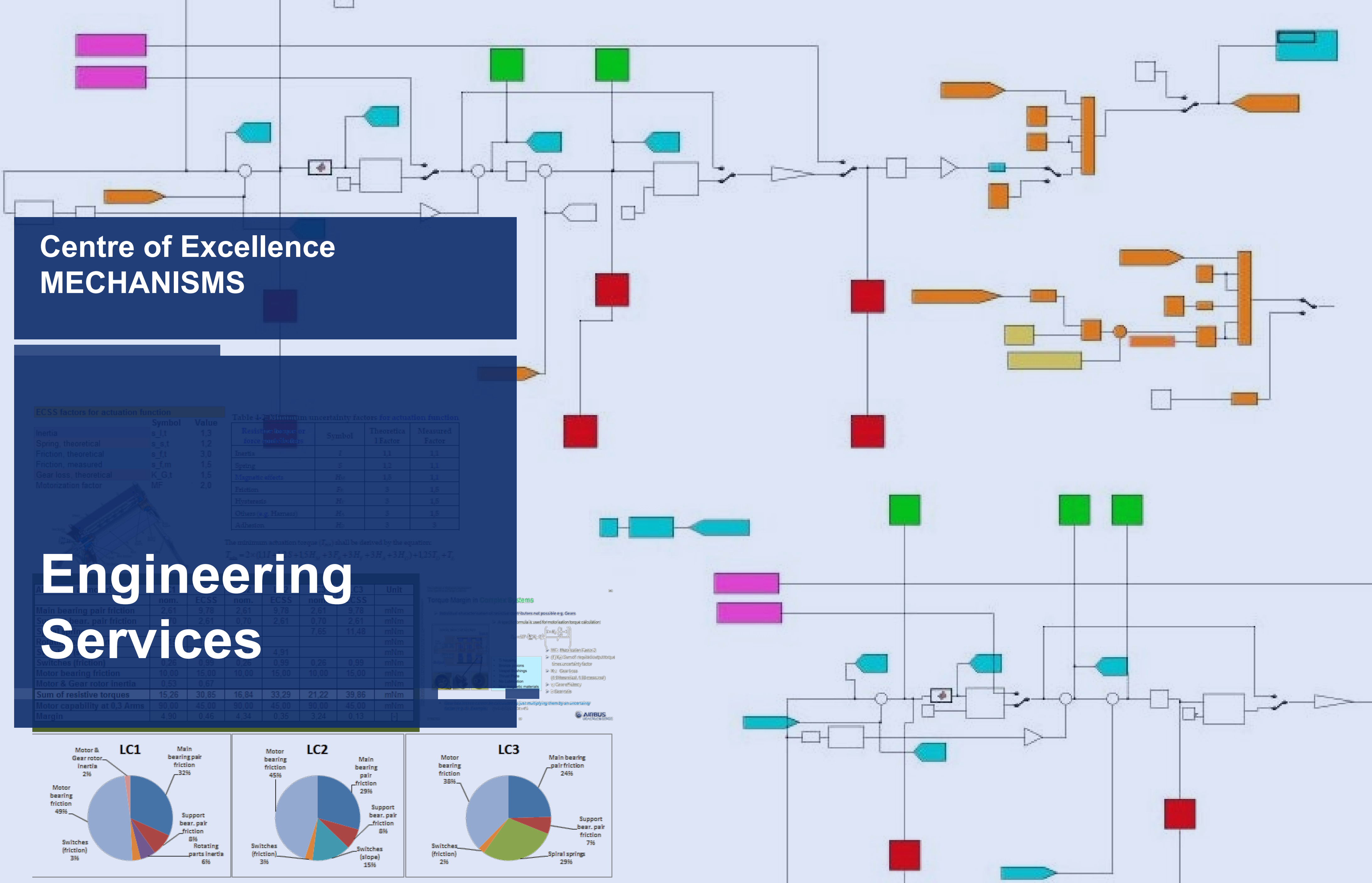


Integrated Technology Center



Test		Detail	Capability
Environmental Verification	Vibration and Shock	Shakers: 5kN – 111kN, sine, 3-3000Hz, 100 – 220g, 500 – 862kg, 3 axes Shock: up to 3000g SRS (2-10kHz) for 15kg, 10000g SRS (6-8kHz) for 2kg	Head expander 1.12 x 1.12 m Slip Table 1.2x1.2 m
	Thermal Vacuum	TBS 1400: <1E-5 hPa, -70°C to +130°C, feed-throughs Other chambers available upon request	Test volume 0.9 x 1.38 x 0.98 m
	EMC	MIL-STD-461/462, static magnetic field measurements, EMI, symmetric & asymmetric signal transmission parameters	Shielded measuring room: 6.5 x 4.8 x 2.3m Anechoic Chamber: 5.2 x 5.2 x 2.3 m
	RF	Direct RF measurement of large antennas/reflectors, sampling of radiation pattern on irregular surface using a standard crane as near-filed scanner	L-, X-, and Ka- Band antennas
Functional Verification	Balancing	Static and dynamic unbalances through torque and force measurements	Unbalances < 0.1 N / < 0.1Nm ; Low velocity balancing
	Bearing Run-out Characterization	Synchronous & asynchronous run-out (wobble)	Noise floor 1-2 micro-rad
	Electrical Checks	Insulation, bonding isolation, resistance / continuity, inductance and capacitance	Adjustable measurements frequency, bonding in mOhm, insulation in MOhm
	Micro-vibration	Exported Forces and Torques, FFT (PSD, ASD) of time-domain data	Noise floor 1mNm
	Motor Characterization	Torque constant, power measurements, back-EMF constant	
	Photogrammetry	10k measurement points	Object size: 16mm – 10m Accuracy: 0.03mm + 0.01mm/m
	Strain Gauges	Installation and operation, 24bit - 50000µm/m or 10000µm/m	Full / Half / Single Bridge Setups up to 8 Ch
	Resistance Measurements	High-frequent (to 25kHz) dynamic resistance measurements of Power /Data Transfer Devices	Up to 30 channels, accuracy 0.5 -10mOhm
	Torque Measurements	Bearing characterization, resistive torques over temperature Velocity & position depending torques evaluation (FFT)	Noise floor 1-10mNm
	Life Testing	Proof of mechanisms functionality & EOL performance in thermal vacuum conditions. Regular functional checks and status monitoring	Accelerated or nominal speed typically 1-3 years





# DESIGN AND DEVELOPMENT

Airbus Defence and Space provides the complete portfolio for the design and development of mechanisms for space applications and ground applications in demanding environments, such as vacuum or high radiation. Our portfolio includes:

- 3D design and drawing preparation, from initial draft to manufacturing/interface/measurement drawings
- Design trade-offs, involving all relevant engineering disciplines and making use of our extensive product and engineering heritage
- Selection of mechanism components, such as bearings, motors or sensors
- Design of features and complex structures, such as mirror mounts, isostatic mounts, thin structures, large deployable structures or redundancy concepts for demanding applications
- Coverage of all mechanisms-related disciplines, including structural/thermal aspects, kinematics, mechatronics, tribology

# SYSTEMS ENGINEERING

Airbus Defence and Space is able to provide systems engineering for the entire life cycle of mechanism products. Activities typically performed by our systems engineers are:

- Generation of project-specific end-to-end development and verification processes
- Requirements breakdown and consolidation
- Generation of technical specifications on all levels
- Design and process optimization for risk mitigation, cost saving, schedule optimization
- Supplier management
- Failure investigation and root-cause analysis

# ANALYSIS AND SIMULATION

Airbus Defence and Space is able to provide engineering services for all disciplines involved in mechanisms design and development. Airbus engineers from the different disciplines work closely together in our internal projects as well as in engineering service work packages provided to external customers.

## Mechanism simulation and analysis

- Performance prediction with guaranteed confidence
- Closed-loop control system design and simulation with hardware in-the-loop
- Robust performance and stability analysis of closed-loop control systems
- Exported torque spectrum (micro-vibration) prediction
- Multi-body and -actuator modelling, simulation and design model derivation
- Dynamic simulation, using state-space models

## Bearings and tribology

- Conceptual design, bearing & lubricant selection
- Bearing calculation according to ISO 76 and ISO 281, incl. consideration of thermo-elastic effects
- Bearing lifetime prediction

## Torque and power budget assessments

Assessment of torque and power budgets for all types of mechanisms and mechatronic sub-systems, such as single-axis or multi-axis BLDC-driven mechanisms, stepper motor mechanisms or spring actuators

## Pointing analysis and budgets

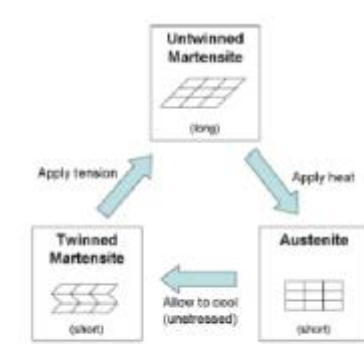
- High accuracy statistical analysis of performance and knowledge errors
- Pointing analysis in line with ESA's Pointing Error Engineering Handbook
- Line-of-Sight and ground path uncertainty cone analysis

## Dynamic and kinematic deployment analyses

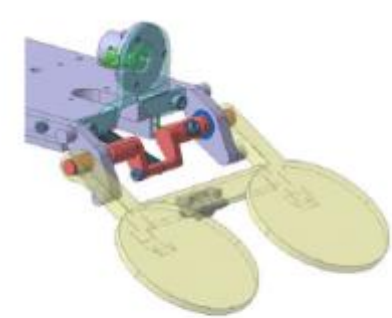
- Simulation of rigid and flexible body kinematics
- Modelling of non-linear problems (e.g. contact or friction) based on empirical test data.
- Robustness & sensitivity analysis

## Fuel Sloshing Analysis

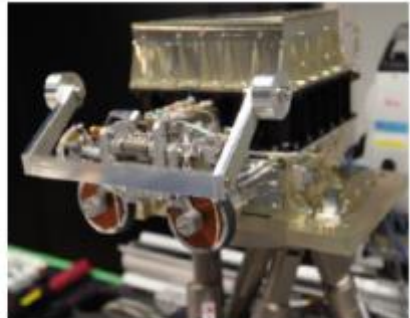
- Tightly coupled dynamics analysis with CFD-in-the-loop
- Derivation of simplified fuel sloshing models for performance campaigns and controller design



Feasibility on BB Level

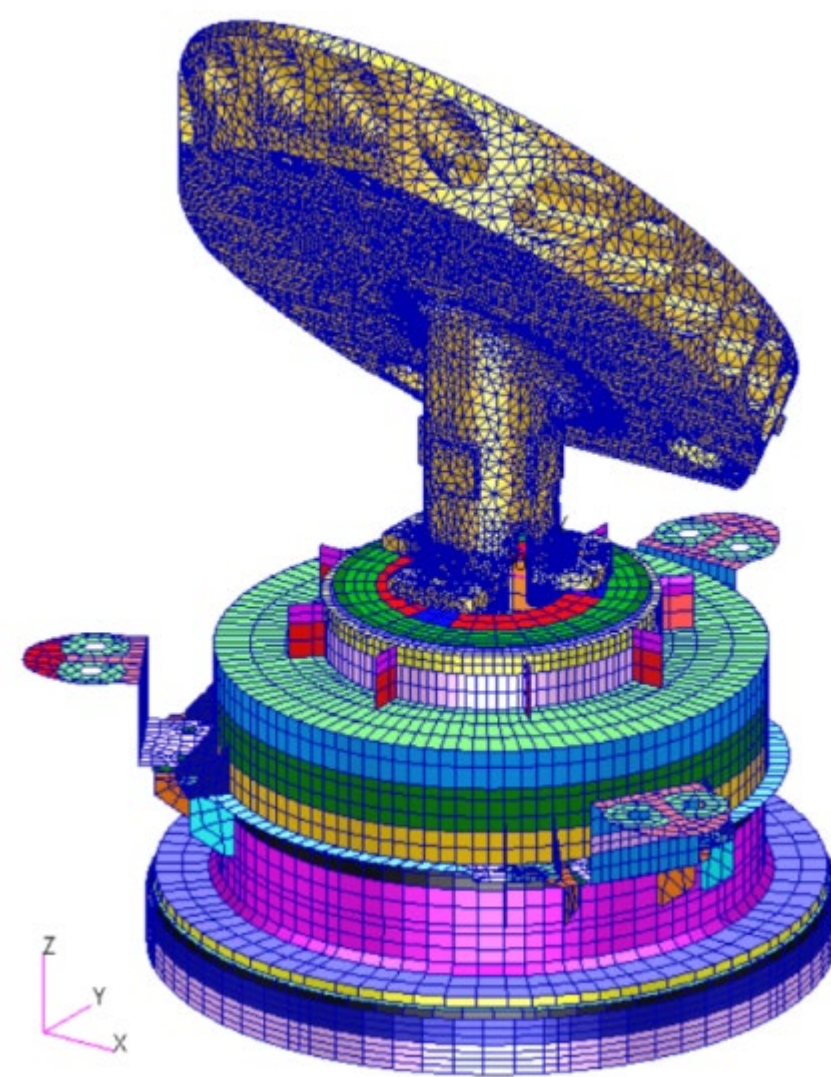


Design of Calibration Unit

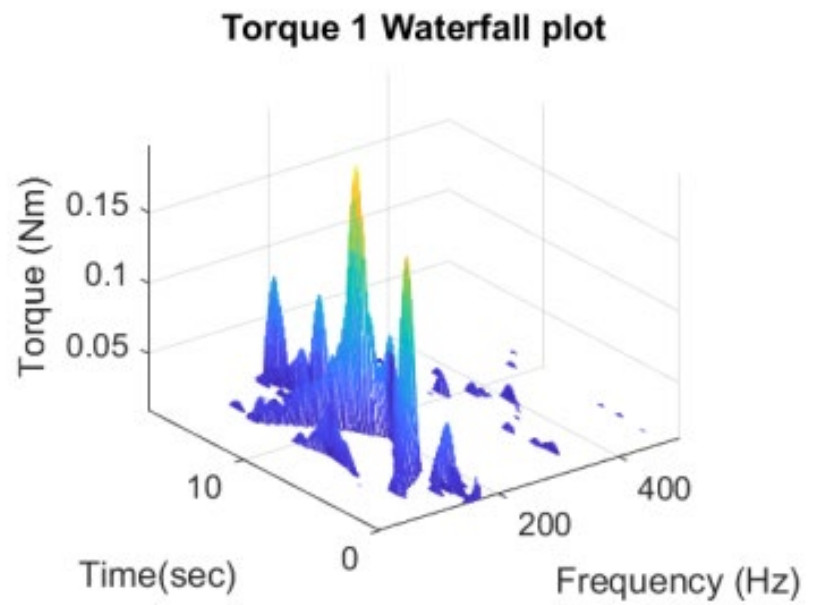
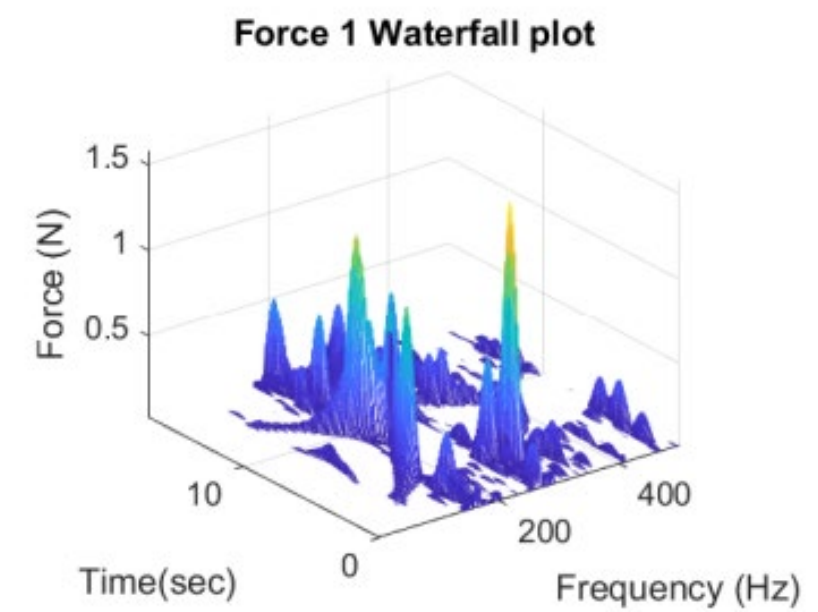


Production and Test

From Design Concept to Flight Hardware

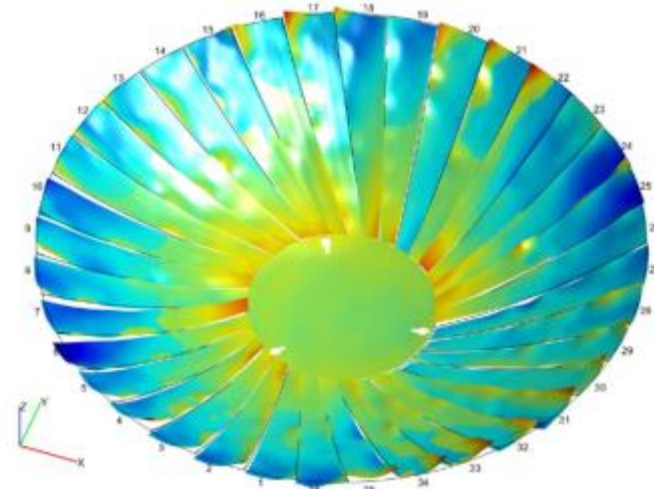
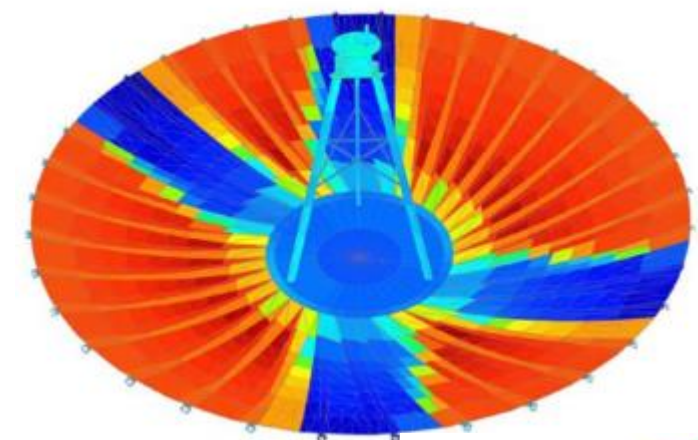


FEM Modelling



Exported Forces

## Thermal Analysis & TED



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