Science and Technology with SKA

From ALMA to SKA: a global technology approach

THE PROFILE

EIE GROUP

EIE GROUP is an International Leader in Management & Contracting, Engineering & Design, and Production & Services in Astronomy and Astrophysics.

EIE GROUP is structured in three Company Entities specialised in the realization of Observatories, Telescopes, Radio – Antennas, Instrumentations, etc.

EIE GROUP has been working for more than 20 years for applied Scientific Research and high International Scientific Organizations.

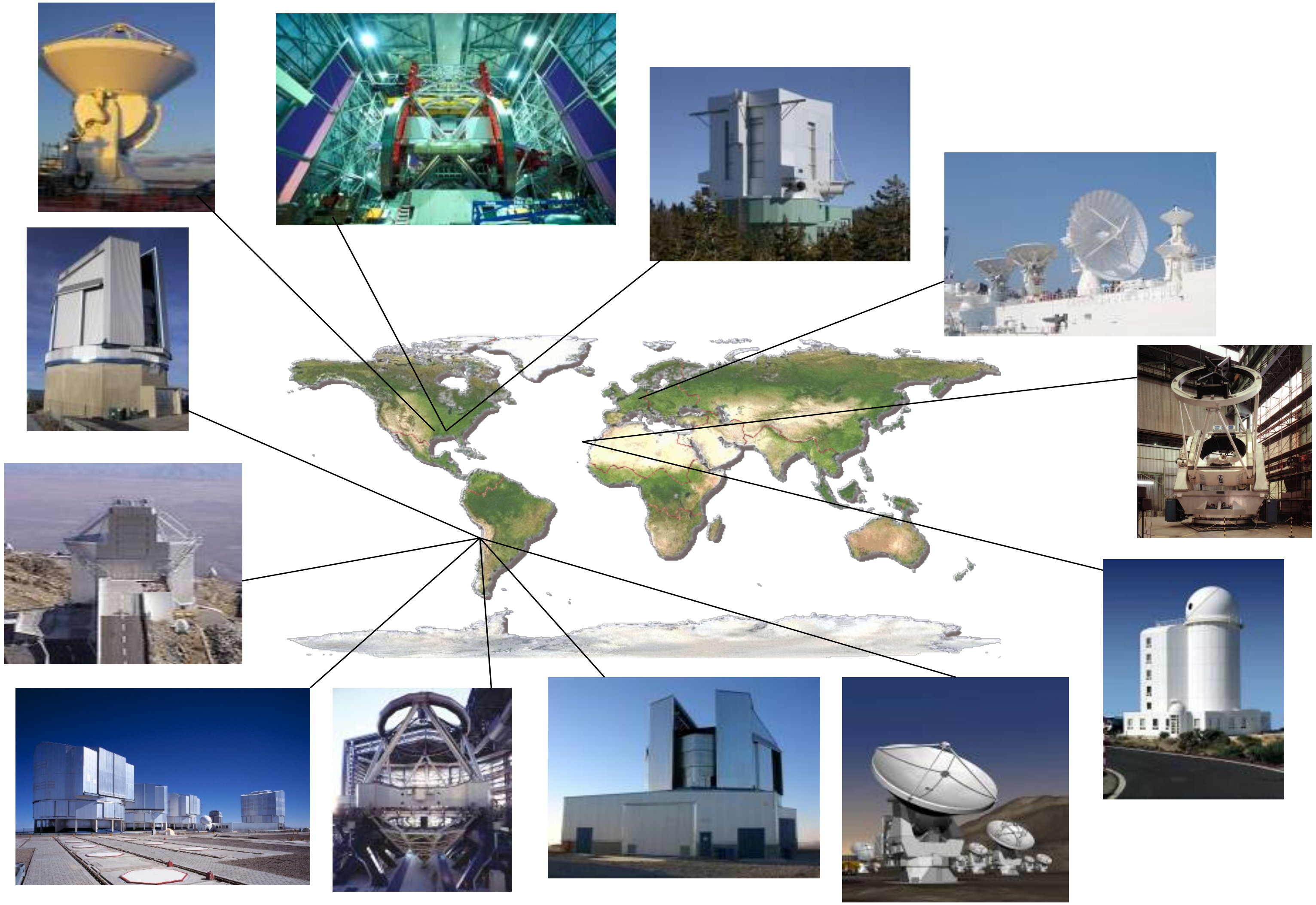
EIE MANAGEMENT & CONTRACTING

EIE ENGINEERING & DESIGN

EIE PRODUCTION & SERVICES

The Power of Creativity

SKA SQUARE KILOMETRE ARRAY



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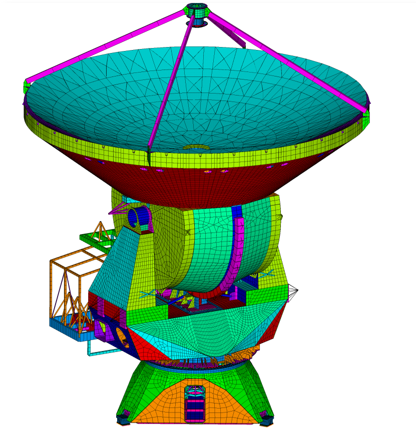
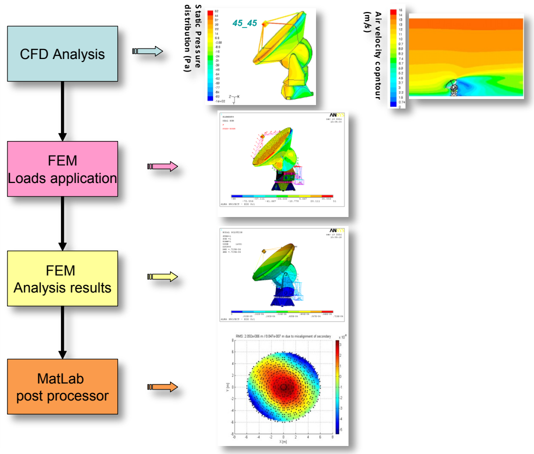
SQUARE KILOMETRE ARRAY





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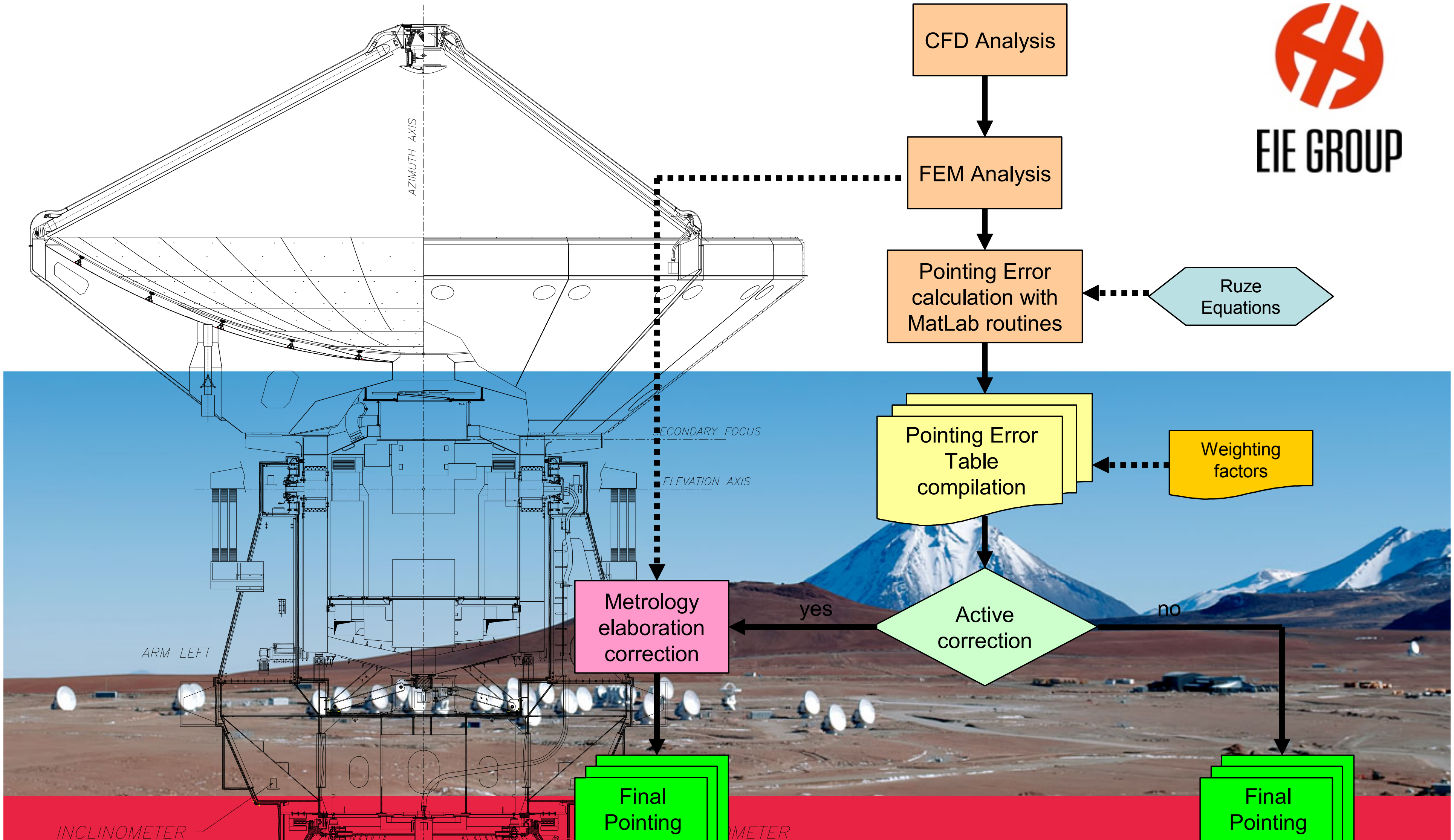
At the moment, ALMA is the most powerful array of the world, and the European Antennas represent the excellence in terms of Design, Technology, but above all in terms of Systemic approach.



ALMA is the result of more … 10 years of work, shared b… the scientific and industrial worlds. It is not possible to realize the best performing radio telescope without having planned a synergic work


Excellence
Innovation
Elegance
SCHEUERLE
Otto
SCHEUERLE

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- Northern Chile
- The Array: 66 Antennas (54 of 12 m and 12 of 7 m)
- Site: Chajnantor Plateau at 5000 m altitude.
- The antennas will operate up to 950 GHz.
- AEM Consortium

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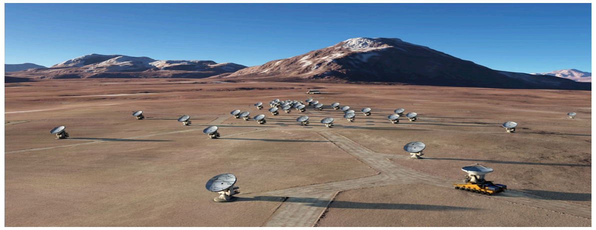
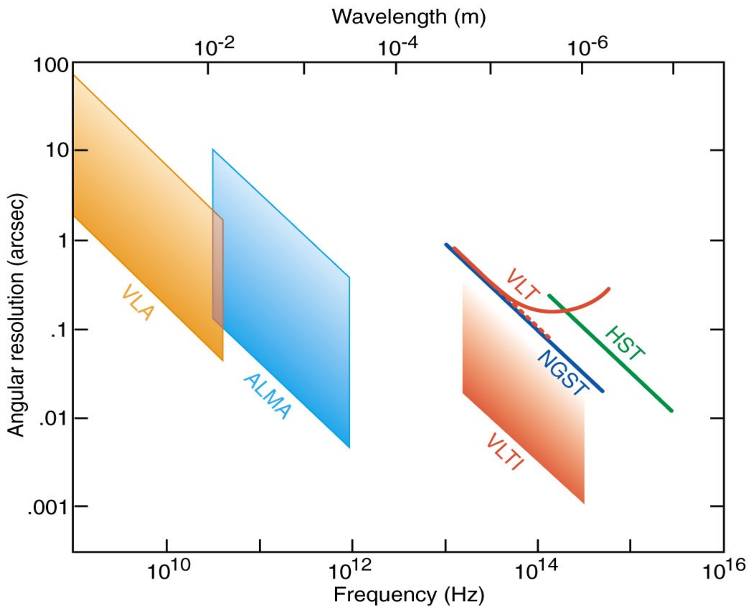


Alma Key Specifications:

- 12m diameter
- 25 µm rms surface accuracy (goal 20 µm);
- 2 arcsec rms absolute pointing; 0.6 arcsec rms offset
- 15 µm pathlenght stability over 3'
- Tracking accuracy better than 0.6 arcsec
- Fast switching required between target and calibrator (1.5° in 1.5s)



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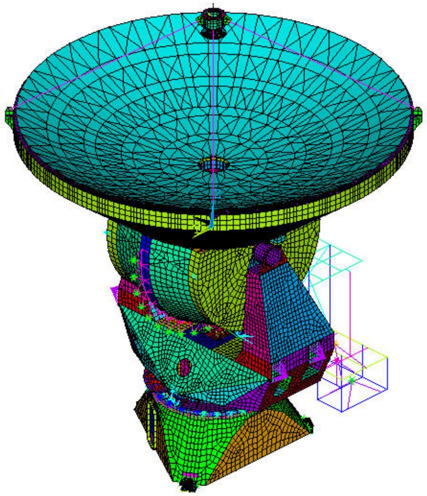
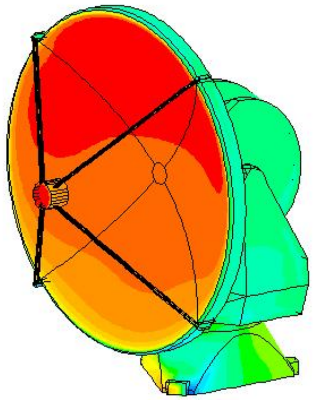
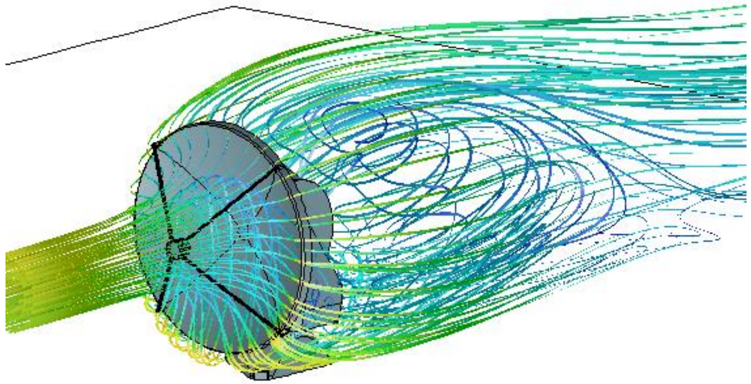
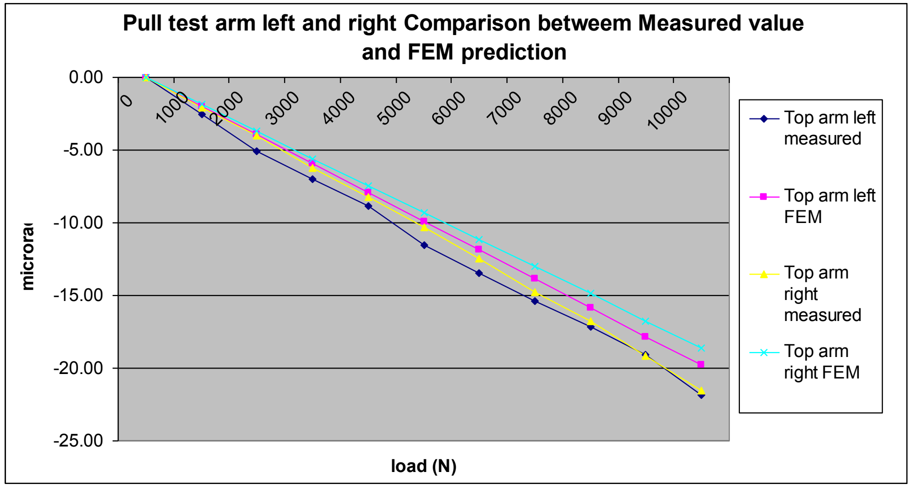




FEM MODEL VALIDATION

All FE model of the antenna and the predicted antenna performances are tested on site: the goal for each test was to have a deviation between the FEM prediction and real measurement lower than the 20%



Pull test alidade structure

This test has been performed in order to characterize the behaviour of the Steel structure and the correlation with the FE model. For the execution of these tests two additional inclinometers has been assembled at the level of the top arm.

Secondary mirror behaviour

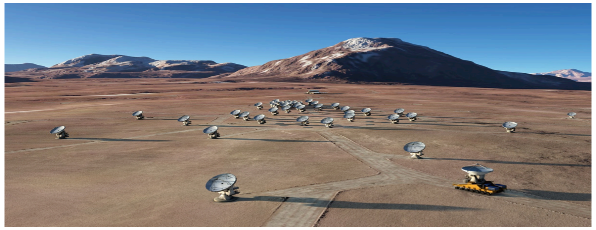
This test has been done in order to identify the Subreflector deviation during EL axis movement.

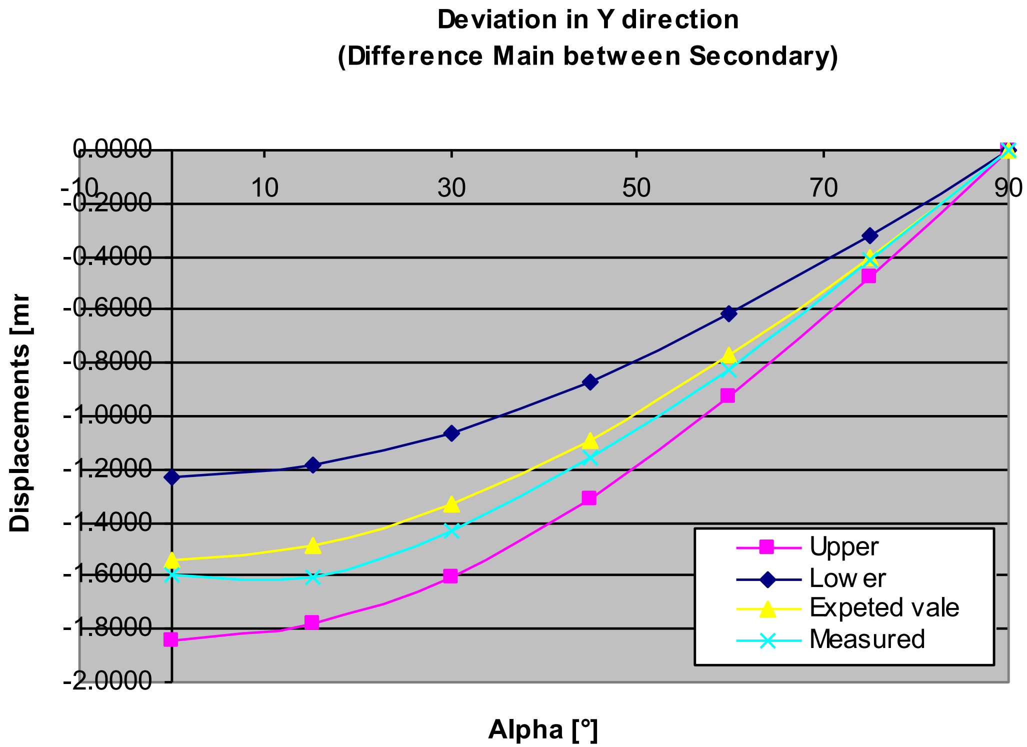
The antenna has been rotate from to 2° with steps of 15°.
The values of the Subreflector displacement are:

- TY=1.63mm
- ROTX=0.097deg

The same calculation performed vi FEM analysis give us the following prediction:

- UY=1.54mm
- ROTX=0.093deg



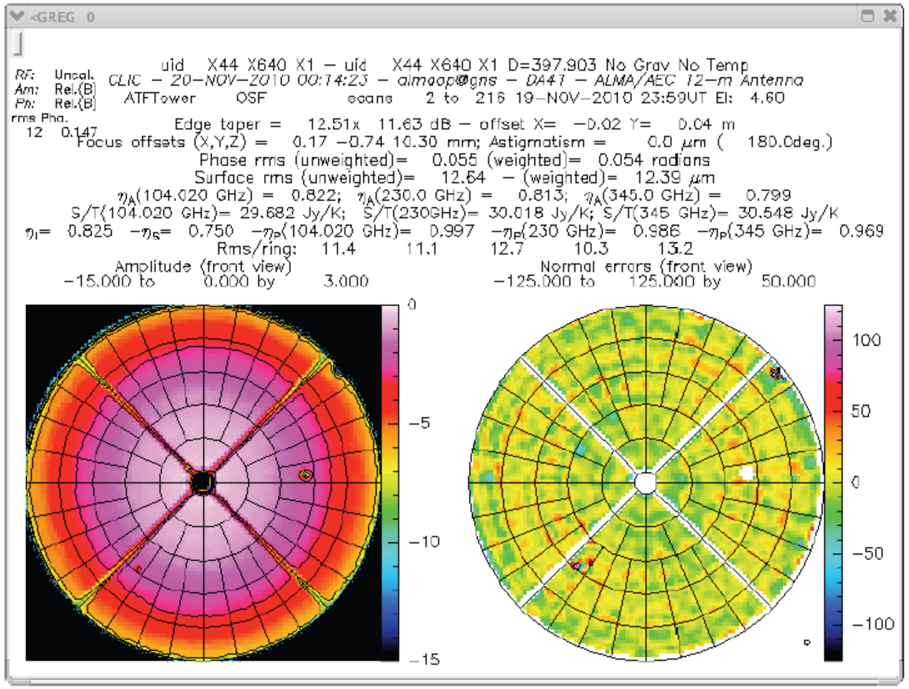


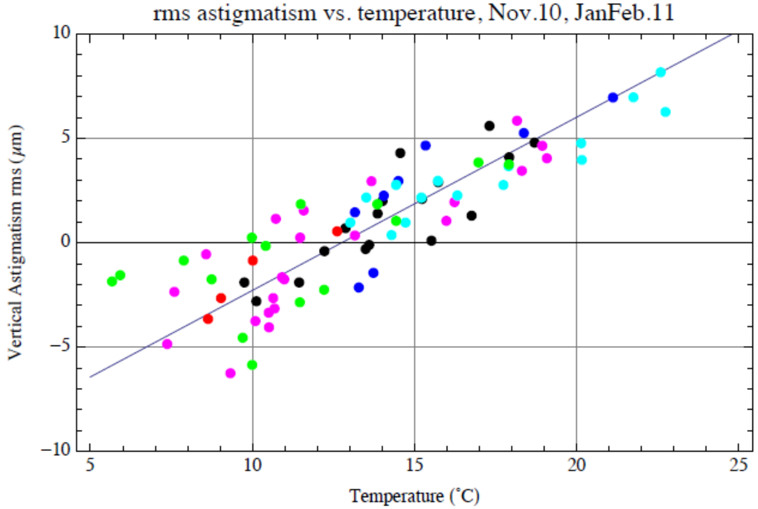
		STEADY DAY	STEADY NIGHT	GUST DAY	GUST NIGHT
PANELS[1]		**IN MICRONS**		**IN MICRONS**	
	MANUFACTURING	4,5	4,5	4,5	4,5
	AGING	2,0	2,0	2,0	2,0
	GRAVITY	2,9	2,9	2,9	2,9
	WIND	0,0	0,0	0,0	0,0
	ABSOLUTE TEMPERATURE	0,0	0,0	0,0	0,0
	TEMPERATURE GRADIENT	0,0	0,0	0,0	0,0
	TOTAL PANEL RSS	**5,7**	**5,7**	**5,7**	**5,7**
BACKUP STRUCTURE[2]					
	GRAVITY (IDEAL)	9,3	9,3	9,3	9,3
	GRAVITY (Departure from ideal)	2,0	2,0	2,0	2,0
	WIND	0,0	2,1	1,1	2,3
	ABSOLUTE TEMPERATURE	9,1	9,1	9,1	9,1
	TEMPERATURE GRADIENT	6,6	0,0	6,6	0,0
	AGING and MOISTURE	2,0	2,0	2,0	2,0
	TOTAL BACKUP RSS	**14,9**	**13,5**	**14,9**	**13,5**
PANEL MOUNTING[1]					
	ABSOLUTE TEMPERATURE	0,0	0,0	0,0	0,0
	TEMPERATURE GRADIENT	0,0	0,0	0,0	0,0
	PANEL LOCATION IN PLANE	0,0	0,0	0,0	0,0
	PANEL ADJUSTMENT PERP. TO PLANE[3]	2,0	2,0	2,0	2,0
	GRAVITY	0,0	0,0	0,0	0,0
	WIND	0,0	0,0	0,0	0,0
	TOTAL MOUNTING RSS	**2,0**	**2,0**	**2,0**	**2,0**
SECONDARY MIRROR					
	MANUFACTURING	4,5	4,5	4,5	4,5
	GRAVITY	0,1	0,1	0,1	0,1
	WIND	0,0	0,0	0,0	0,0
	ABSOLUTE TEMPERATURE	1,0	1,0	1,0	1,0
	TEMPERATURE GRADIENT	1,0	0,0	1,0	0,0
	AGING	2,0	2,0	2,0	2,0
	ALIGNMENT (coma error)	1,8	1,8	1,8	1,8
	TOTAL SECONDARY MIRROR RSS	**5,4**	**5,4**	**5,4**	**5,4**
TOTAL ERROR EXCLUDING SURFACE ALIGNMENT		**16,9**	**15,7**	**17,0**	**15,8**
SURFACE ALIGNMENT ERROR (HOLOGRAPHY)		**14,7**	**14,7**	**14,7**	**14,7**
UNANTICATED ERRORS		**2,0**	**2,0**	**2,0**	**2,0**
TOTAL SURFACE ACCURACY ERROR		**22,5**	**21,6**	**22,6**	**21,6**

SURFACE ACCURACY

The Antenna surface accuracy includes contributions from both primary reflector and subreflector.

The total surface accuracy during Primary Operating Condition must be < 25 micron RSS.





Surface accuracy behaviour with respect ambient temperature variation

SURFACE ACCURACY

The results derived during the holography tests have been extended for the whole ALMA environmental primary conditions.

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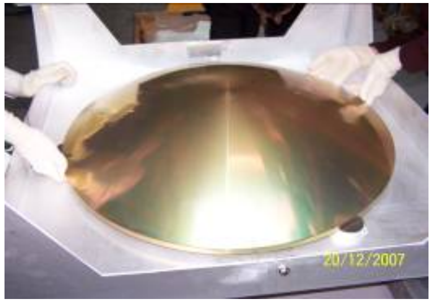




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POINTING ERROR

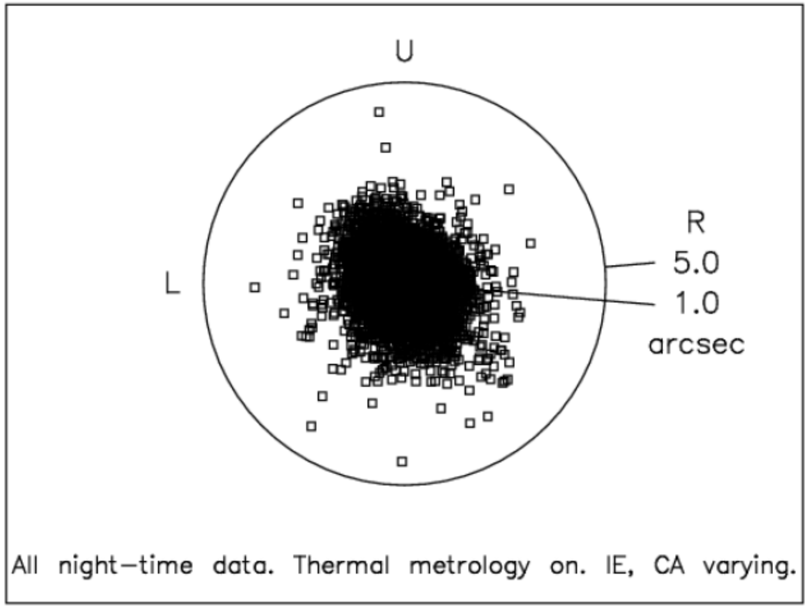
Absolute Pointing Errors: < of 2.0 arcesec RSS in the whole sky travel range.

Offset Pointing Errors: < of 0.6 arcsec RSS when the antenna is pointed within 2 degrees from any starting position, tracking over a 15 minute period.

Fast switching phase calibration: the antenna shall perform steps of 1.5 degrees and settle to within 3 arcsec peak pointing error, all in 1.5 seconds of time.

On-the-fly total power mapping: the antenna shall scan at 0.5 deg/s on the sky across a target source of one degree in size, then turn around at a distance of 1 arcmin, settle within 0.8 sec scan back across the source within 2 arcsec RMS.

On-the-fly interferometric mosaicking: the antenna will scan at a rate of up to 0.05 deg/s on the sky across a target source, then turn around and scan back across the source in the opposite direction within 1 arcsec RMS.



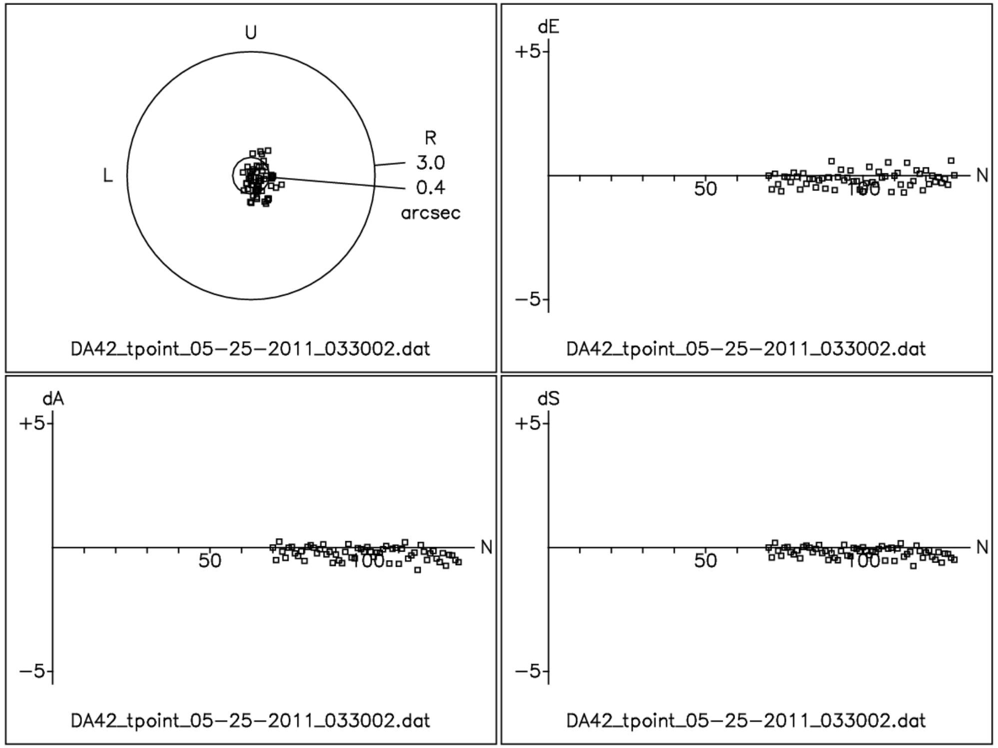
POINTING ERROR: ABSOLUTE

The pointing model has been derived from 49 individual tests (6274 measurements) whit a population SD of 1.00 arcsec.

The predicted all-sky pointing performance of the antenna at AOS, is 1.38 arcsec rms at night and 1.50 arcsec rms during the day, with the thermal corrections active.

The pointing model stability has been checked with excellent results.

The thermal metrology correction significantly improves the stability of the model.



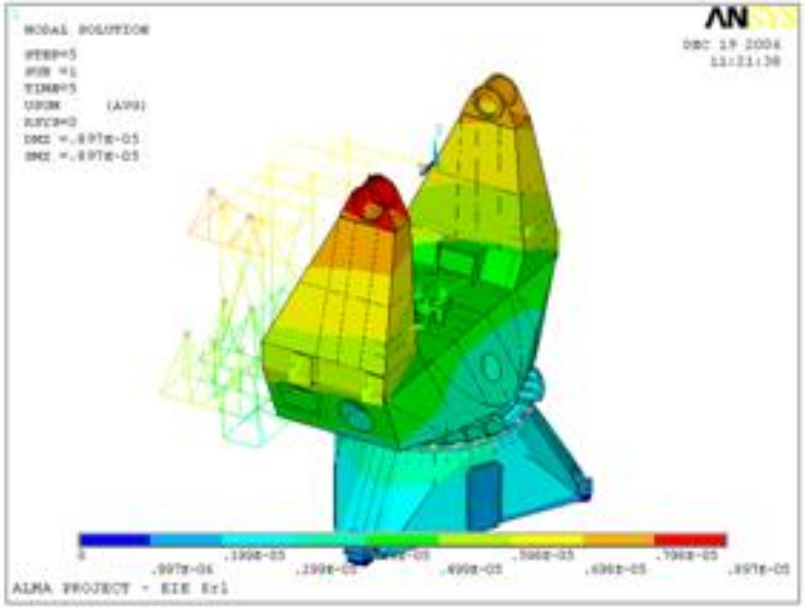
TPOINT plots of the residuals for the test on May 25, 2011, at 0330 (σ_{aosmw} = 0.24 arcsec.)

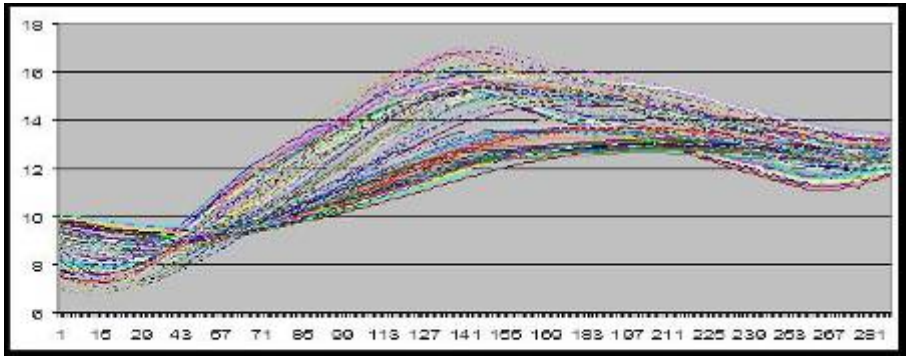
POINTING ERROR: OFFSET

The rms error at OSF, corrected for seeing, is 0.28 arcsec, with a worst case of 0.77 arcsec.

Thermal and dynamic metrology were setting on.

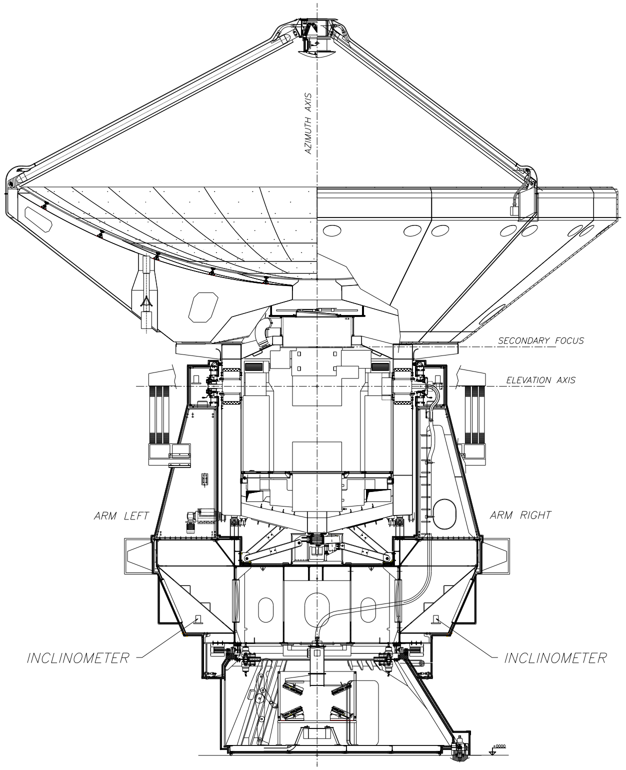
We note that a number of tests were performed at wind speeds in excess of 5ms−1.





METROLOGY SYSTEM

The **thermal metrology system** is composed by 86 Thermal sensors. 83 are located at the interior of the steel structure and 3 on the Apex Interface Cylinder.
The Thermal metrology system through a deformation matrix give an evaluation of the deformations of the elevation axis due to the temperature changes.
The position of the 83 thermal sensors has been studied in order to cover adequately the whole structure



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Parameter	Value	Motivation/ comments
Resolution	< 0.01arcsec	The entity of the correction to be applied is in the 0.1arcsecond level. The resolution of the instrument shall be at least 10 times better
Stability over 60min	< 0.2arcsec	From the error budget, such error from the tiltmeter can be accepted. 60min is the typical interval between calibrations
Thermal stability	< 0.2arcsec/°C	Derives from the previous specification and from the expected temperature stability at the tiltmeter place
Bandwidth	> 0.5Hz	From wind gust PSD
Recovery from saturation	< 500ms	According to the dynamic requirements, the axes shall settle (< 3 arcsec on sky) on a step command within 1.5s and meet the tracking requirements 0.5s after. This time is therefore free of saturation and available for recovery
Range	> ±150arcsec	Such range would allow avoiding levelling of the instrument after antenna transportation
Electrical interface	RS485	A digital interface is definitely advantageous in terms of noise immunity

The **Dynamic Metrology System** is based on two high accuracy tiltmeters placed on the yoke base, on steel plates thermally coupled with the yoke structure.

The elevation error and the cross-elevation is measured taking into account the reading of the tiltmeters placed on the yoke base and corrected through simple correlation formula via ACU at the level of the encoder systems

SKA SQUARE KILOMETRE ARRAY

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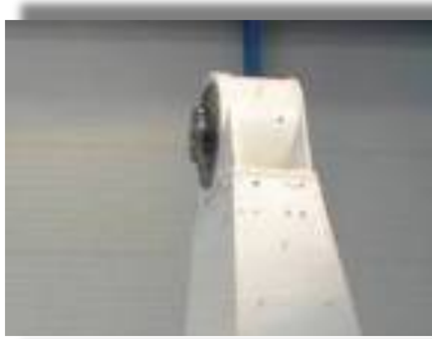

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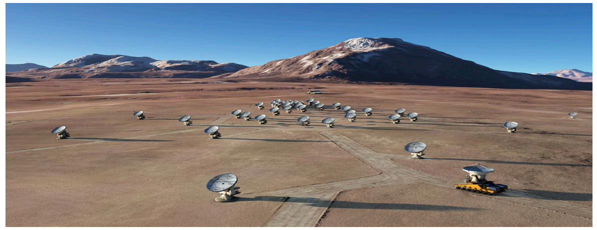

Optimization for serial production

- Use of forgings and castings to minimize welding and machining
- Set-up of dedicated assembly lines in dedicated assembly areas
- Utilisation of rotating jigs for welding of Base and Yoke Base structures in parallel and in optimal welding position
- Minimizing of transportation times (e. g. machining, assembly and integration in the same building complex; cutting and painting in same industrial area)

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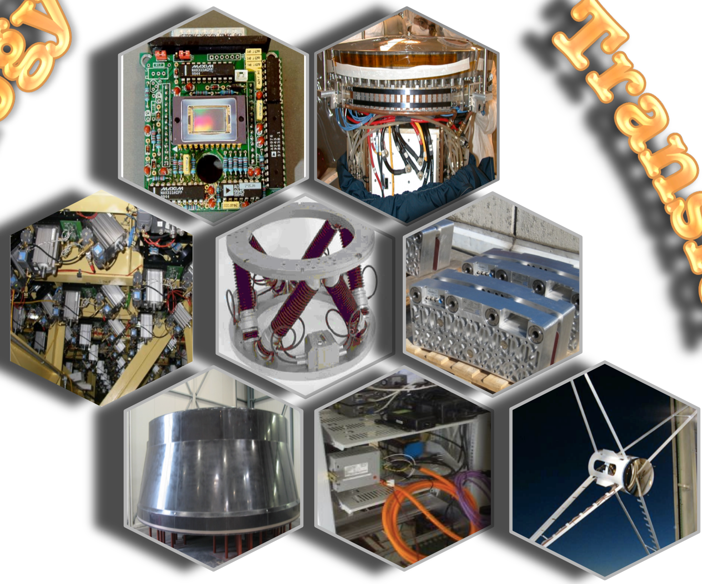
Italian Industry is ready for SKA?

Technology



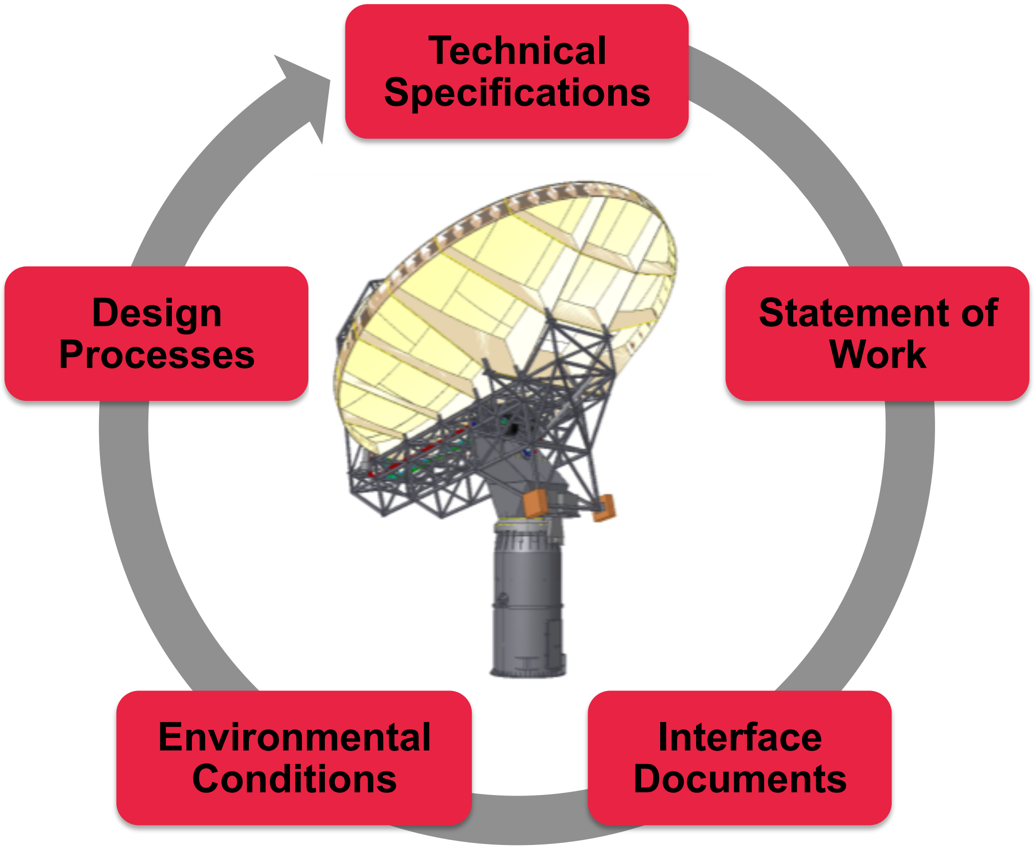
Transfer

Italian Industry is ready for SKA?

➔Activities ongoing:

- Combined Science & Industry Entities
  - ➔Combined interests
- Coherent International Actions
  - ➔ Combined interests
- Strong pressure for Government Support

A Global Design & System Engineering approach



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NRF – NATIONAL RESEARCH FOUNDATION
MeerKAT PROJECT
MeerKAT Antenna Positioners

SKA AFRICA
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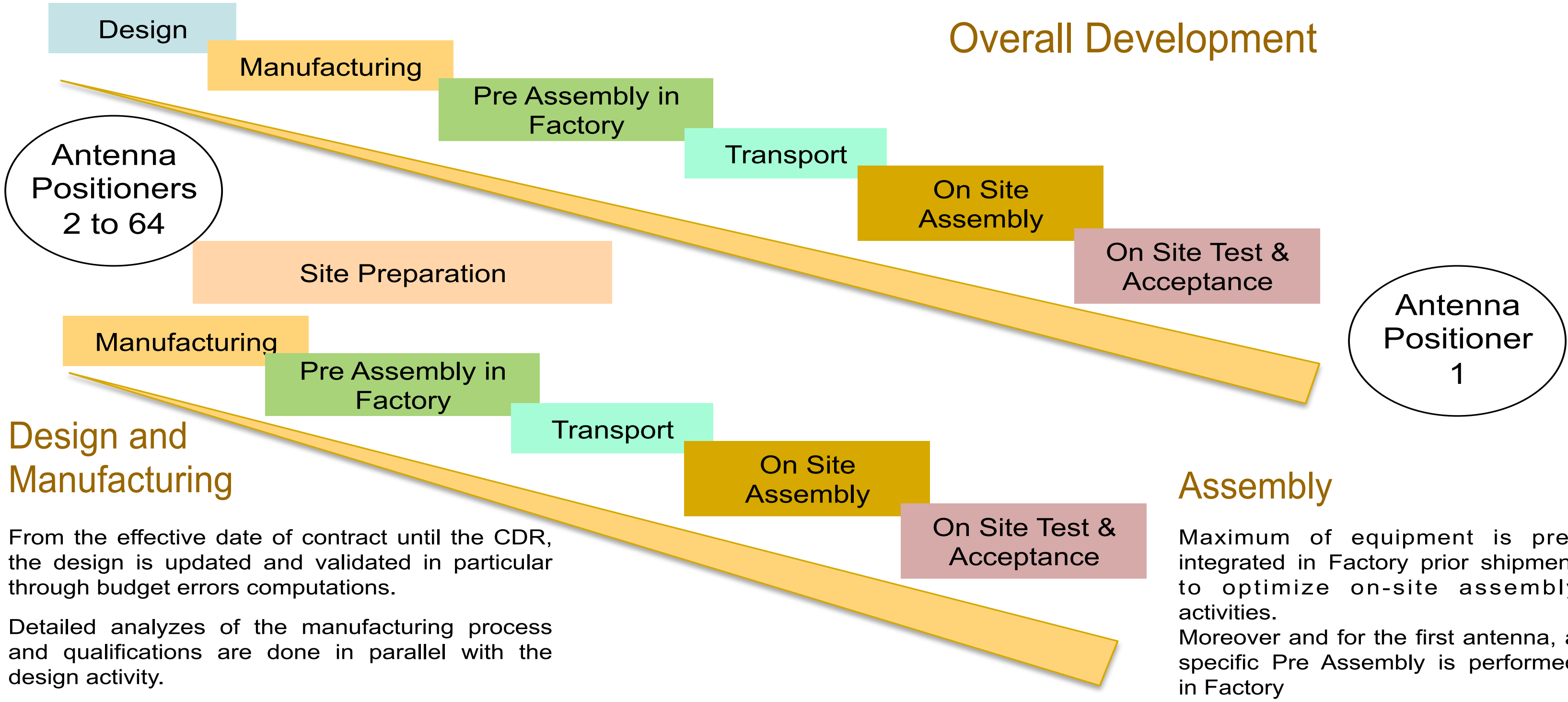
SKA
SQUARE KILOMETRE ARRAY

A RELIABLE INDUSTRIAL APPROACH GAINED FROM THE TEAM EXPERTISE

SKASA follows a robust System Engineering process as is required for a project of this integration complexity. EIE & RRS follow a similarly robust process to allow successful integration of all the components and subsystem into Antenna's system upon completion of development of the manufacturing process.

Overall Development



Design and Manufacturing

From the effective date of contract until the CDR, the design is updated and validated in particular through budget errors computations.

Detailed analyzes of the manufacturing process and qualifications are done in parallel with the design activity.

The manufacturing phase comes after the design phase and the CDR review.

Only material purchasing and specially the carbon fiber, or manufacturing of non critical parts are anticipated from PPDR acceptance.

Assembly

Maximum of equipment is pre-integrated in Factory prior shipment to optimize on-site assembly activities.
Moreover and for the first antenna, a specific Pre Assembly is performed in Factory
Final assembly is performed on-site in RAAA work area.

EIE GROUP

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Ready to support the SKA Project

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