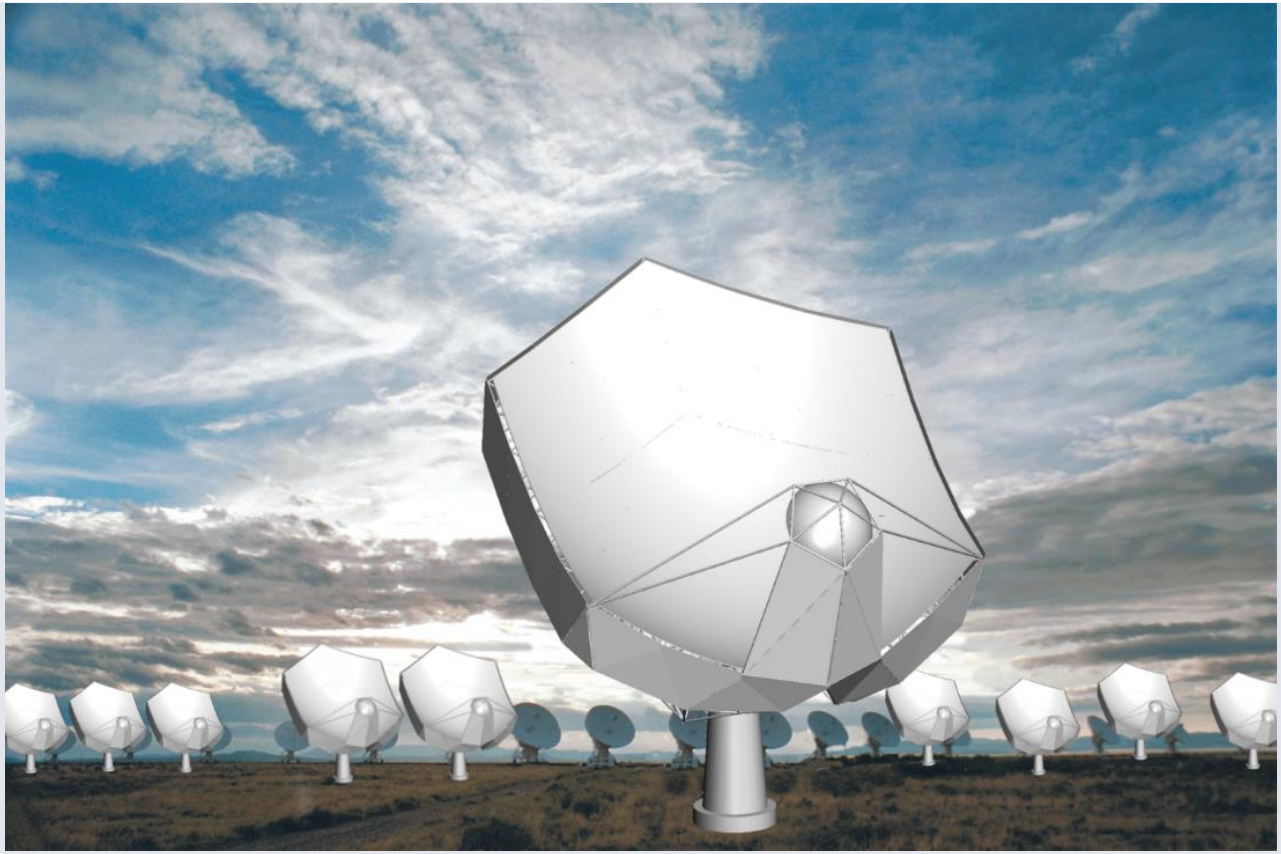
MT MECHATRONICS
An OHB Company



MTM's Approach for the NGVLA

MT MECHATRONICS
An OHB Company

MTM - Selected Highlights 1962 - present


64m Radio Telescope
Parkes, Australia


ARIANE Launching Facility
Kourou, French Guyana


32m SatCom Antenna
Raisting, Germany


32m Radio Telescope
Cambridge, UK


M2 Subreflector
Effelsberg, Germany


40m Radio Telescope IGN
Yebes, Spain


6.4m X-Band
Gelsdorf, Germany


50m LMT Radio Telescope
Pico La Negra, Mexico


XXL CT
Fürth, Germany


VLBI 2010
various

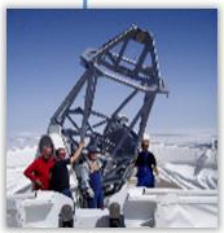
1960s | 1970s | 1980s | 1990s | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014


100m Radio Telescope
Effelsberg, Germany


6m Transportable
Observatory,
Concepcion, Chile


30m Millimeter Radio Telescope
Pico Veleta, Spain


SOFIA
DLR / NSA


1.5m Solar Telescope Gregor
Tenerife, Canary Islands


Heavy Ion Gantry
Heidelberg, Germany


64m Radio Telescope
Sardinia, Italy


25m ALMA Antennas
Atacama Array, Chile


DKIST
Rockford, USA

Inspiration

Inspiration

Influence of IKEA® philosophy on our SKA design

Key Points of IKEA® Products (taken from IKEA®'s website):

Form follows Function (focusing on what is important):

"Then they use their creativity and knowledge and use low-cost raw materials and manufacturing processes to create functional products. Then large volumes are purchased to push prices down even further."

→ our SKA Concept Design (Low Cost Manufacturing with Excellent Performance)

Transportation:

"Most IKEA products are also designed to be transported in flat packs and assembled at the customer's home. This also lowers the price by minimizing transportation and storage costs. By doing all this, the IKEA concept uses design to make sure that IKEA products can be bought and enjoyed by as many people as possible."

→ our SKA Concept Design (only 5 standard containers per antenna)

On-site Assembly:

"IKEA products can be assembled very easily."
Everything arrives "prepared" + Ultra-easily understandable Assembly Procedure!

→ our SKA Concept Design (Easy Assembly Procedure; no special knowledge required)

Inspiration continuous

Volkswagen's BlueMotion Technologies include all products, basic technologies and innovations that significantly improve fuel economy and reduce emissions. These basic technologies represent the foundations of BlueMotion.

Influence of Blue Motion® philosophy on our SKA design

BlueMotion philosophy on our SKA Design:

- Low Energy Consumption through Optimized Design
  - elevation bearings close to upper chord of the BUS
  - optimized balancing of masses
  - low friction Az & El drive system
  - light weight structure (advanced materials CFRP)

→ Lower Costs for the operation of 3,000 Antennas

Example (rough calculation):
ALMA needs 1.3 MW for 66 Antennas

Considering this:
SKA needs for the Antenna Array app**. 60 MW** per year!
This means **90 M USD** per year just for fuel!

Our SKA design goal is to manufacture an antenna that uses 15% less energy
→ This saves Operation Costs of **13.5 M USD** per year!

SKA Multi-Panel Design Concept

Design Features:

As part of the work on the design of the 15m offset antenna for the SKA project the following criteria were considered:

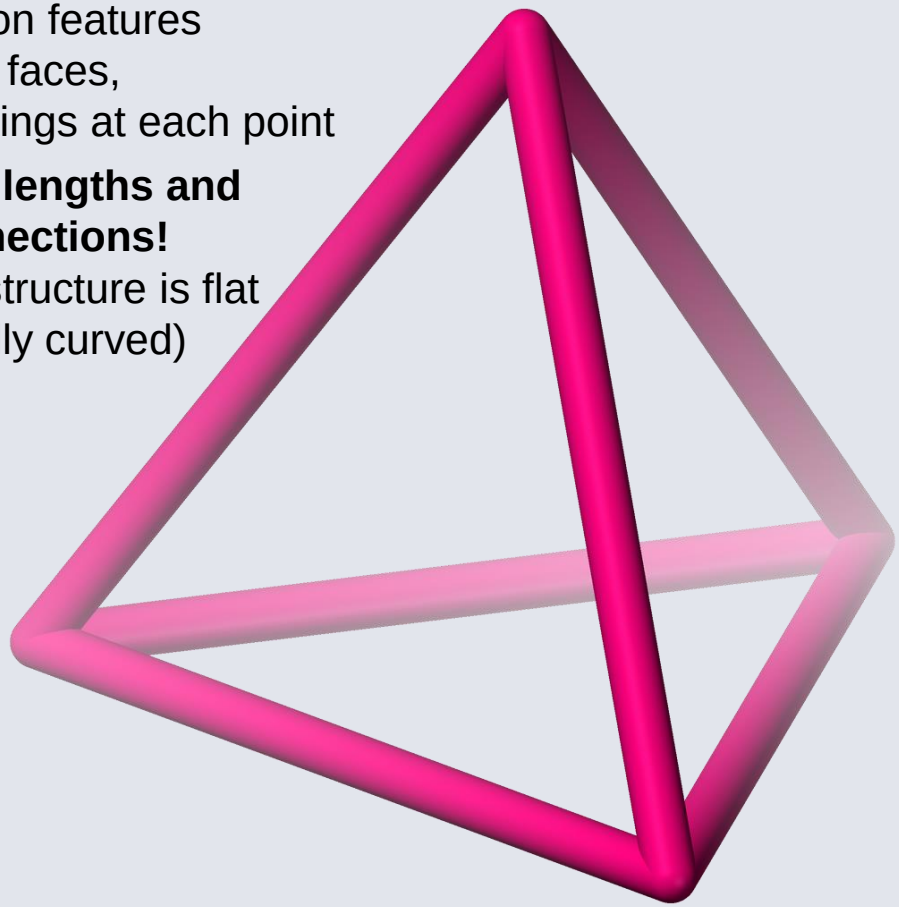
1. Fulfillment of all SKA specifications
2. Modular Design of the antenna structure for highly automated low-cost production of structural components
3. Low Mass of inertia about the Az and El axis
4. Well-balanced Mass Distribution around the El axis
5. Energy Saving, Low-Friction Drive Systems
6. High Temperature Stability for the Main Reflector Panels, Feed Arm and Subreflector based on the use of CFRP material
7. Adjustable Main Reflector Panels to improve the accuracy and long-term stability
8. Pre-Assembled Antenna Subsystems
9. Optimized Transport Volume for all antenna subsystems and components
10. Easy Installation and Commissioning on site

Reflector Design

Space Framework: Tetrahedron

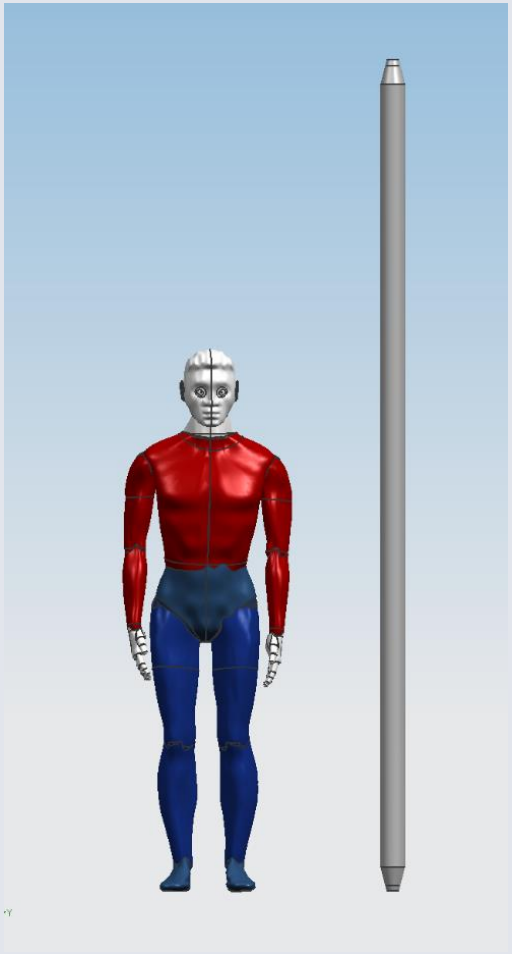
Tetrahedron (Definition)

- a tetrahedron features
  4 triangular faces,
  with 3 meetings at each point
- **equal side lengths and angle connections!**
  (when the structure is flat or spherically curved)



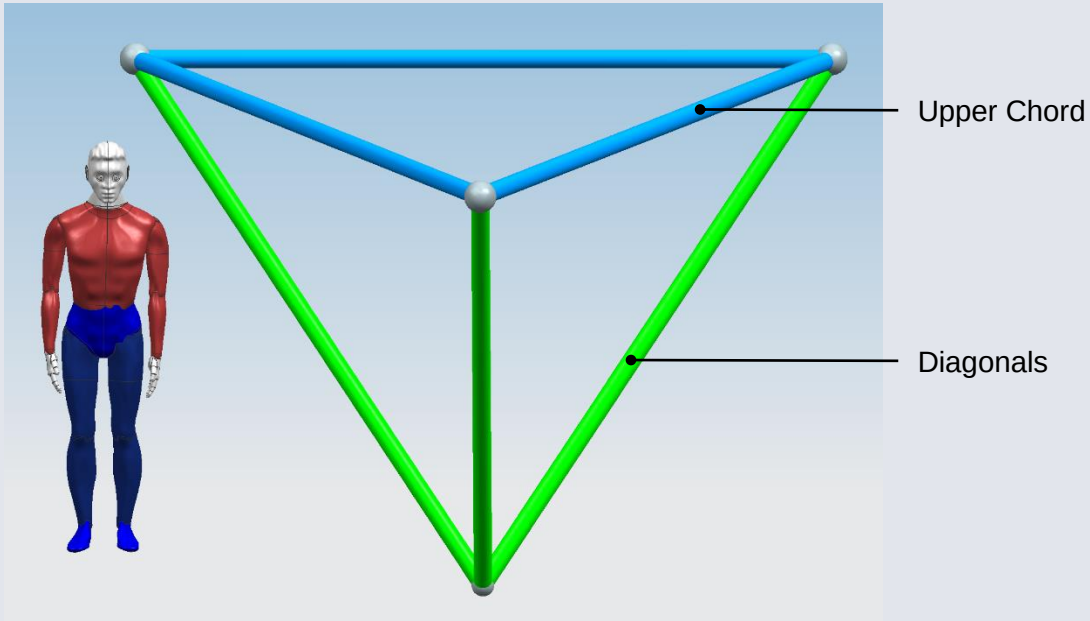
Elements of a Tetrahedron Space Frame

Steel Tubes with an equal length



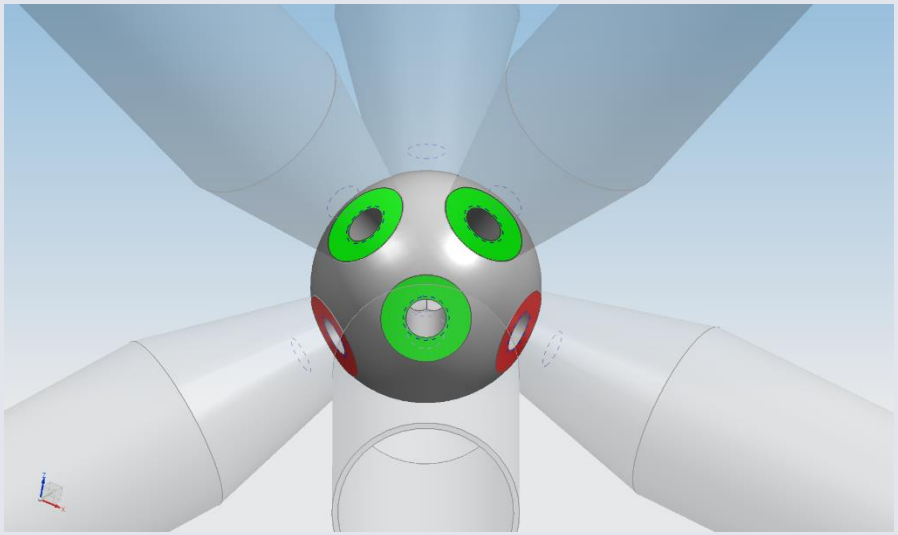
Elements of a Tetrahedron Space Frame

can be easily connected with steel knots to a high stiff Tetrahedron Space Frame Structure!

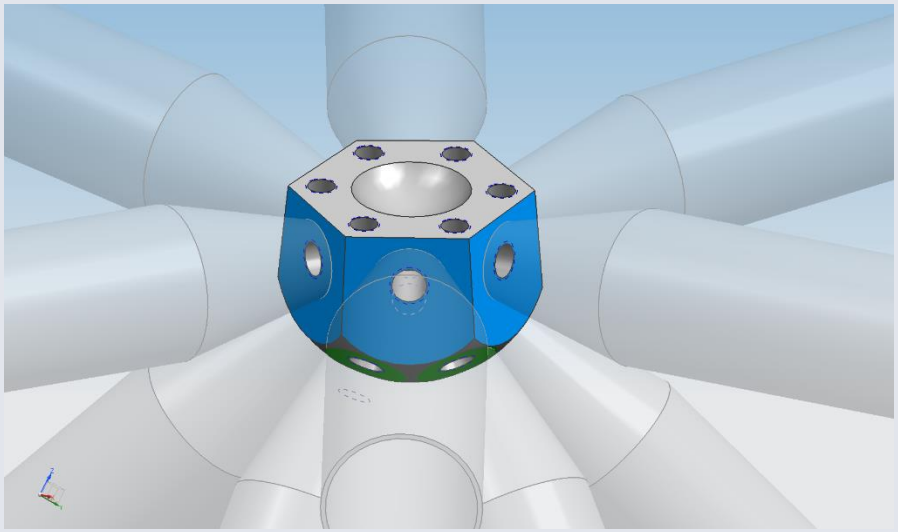


Elements of a Tetrahedron Space Frame

only two different knots made out of steel for the Antenna BUS:



Knot for lower chord



Knot for upper chord

Diameter:	100 mm	140 mm
Weight:	2.5 kg	5.1 kg
Manufacturing Tolerance:	± 10 µm	± 10 µm

Elements of the 15 m SKA Reflector

Steel Tubes with equal diameter (80 mm) & equal wall thickness (2.5 mm) and nearly similar length (2.88 m)**:**

- 109 Tubes for the Upper Chord
- 186 Tubes Diagonals
- 76 Tubes for the Lower Chord
- 371 Steel Tubes total per Antenna

→ 1,113,000 Tubes for 3,000 Antennas (planned Qty. of SKA antennas)

Steel Knots:

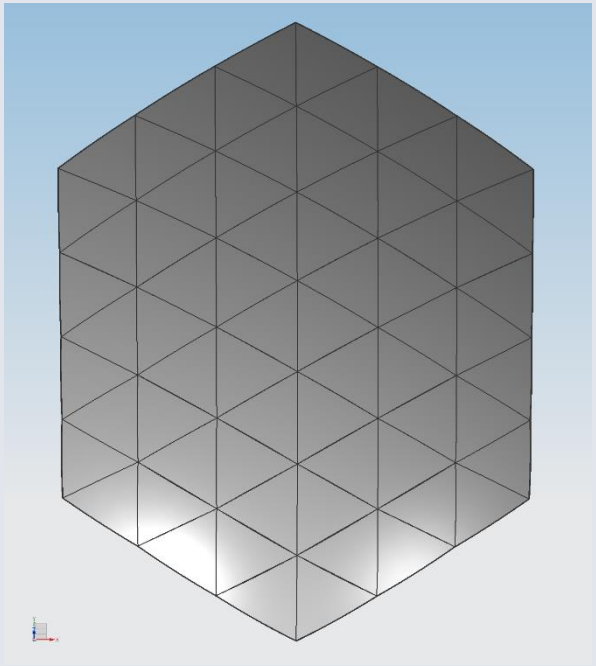
- 44 Knots Upper Chord
- 62 Knots Lower Chord
- 106 Knots total per Antenna

→ 318,000 Knots for 3,000 Antennas (planned Qty. of SKA antennas)

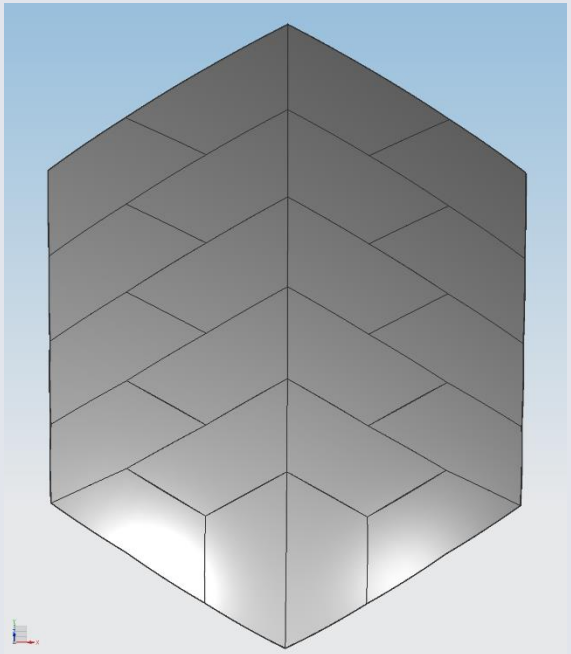
Tubes and Knots can be manufactured cost-effectively in large quantities (fully automated CNC machining)

Panel Design (Size and Material)

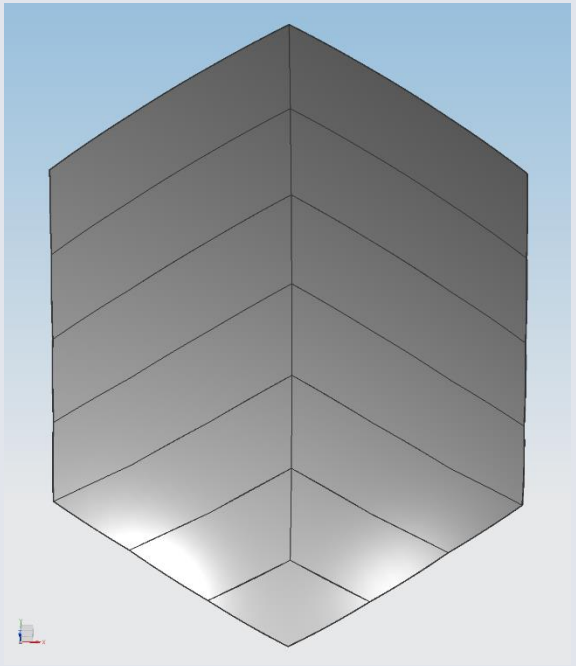
Version 1
66 Panels



Version 2
22 Panels

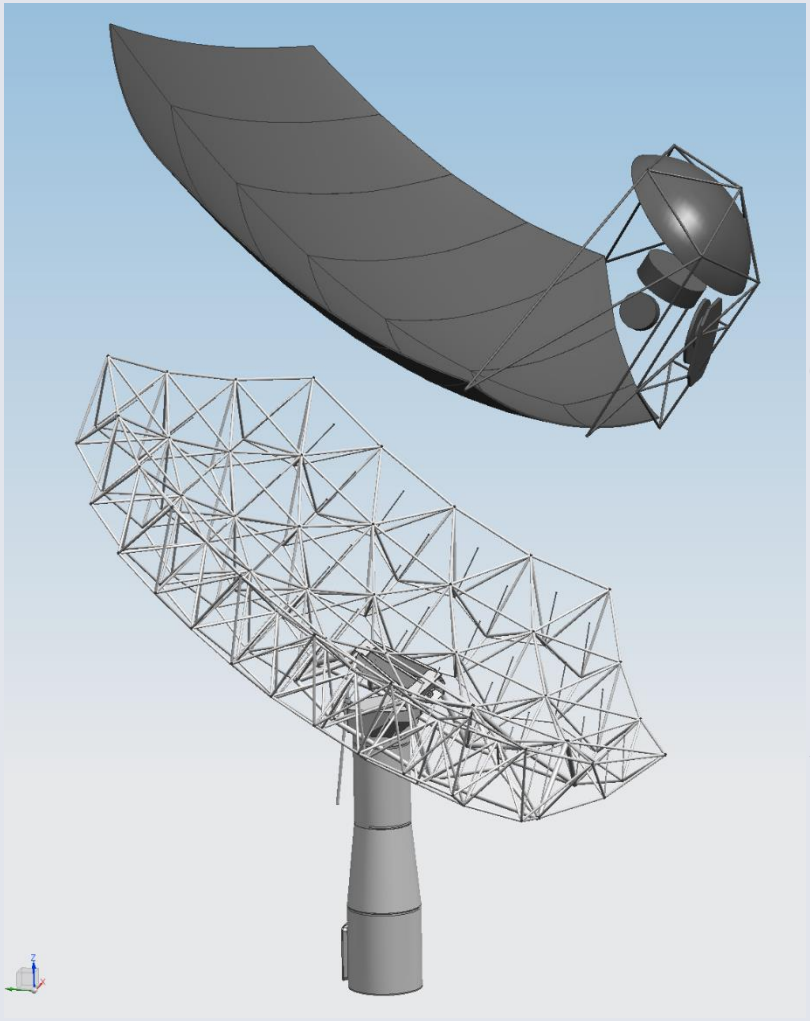


Version 3
13 Panels



Panel Material : CFRP or Al

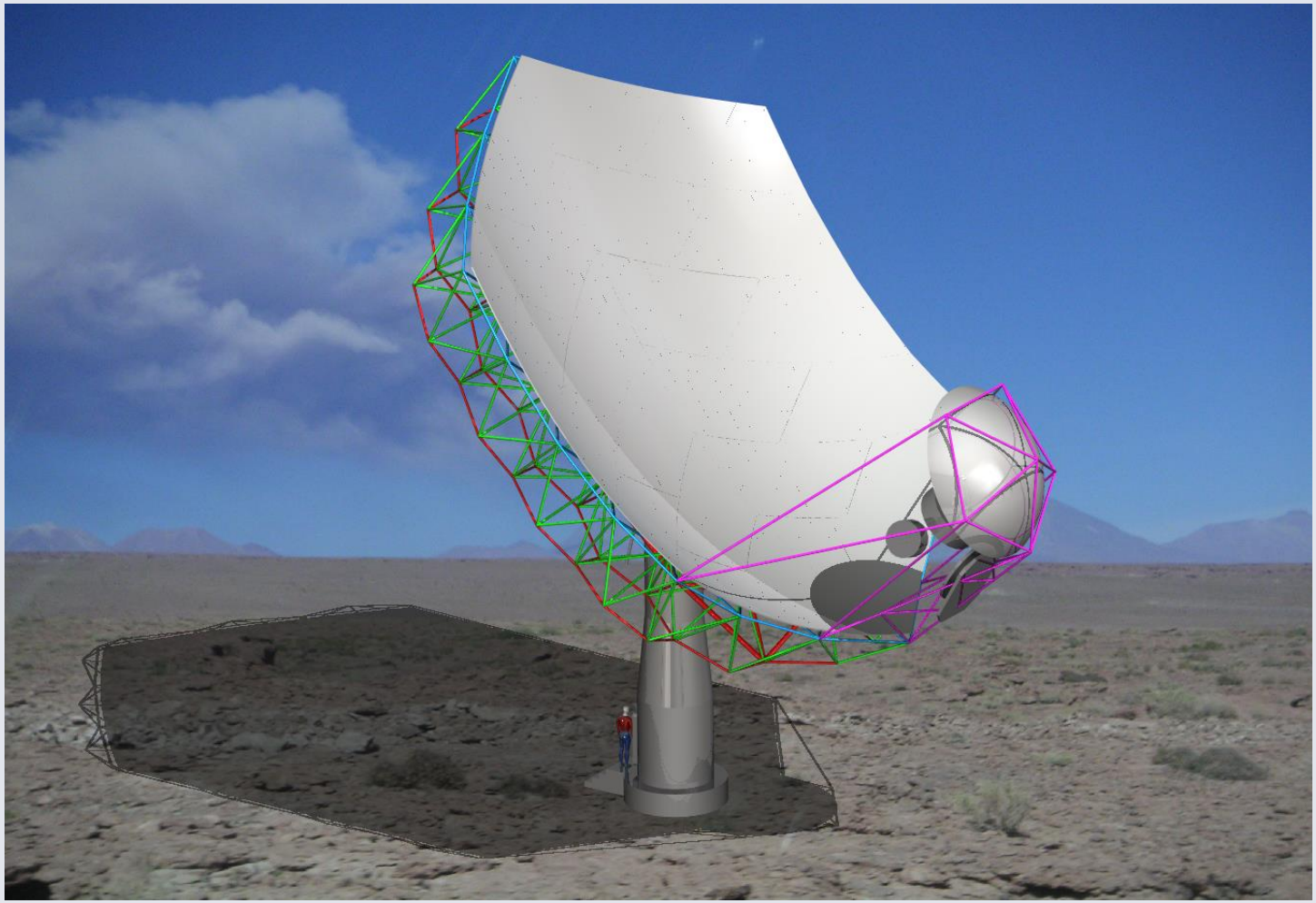
CFRP and Steel Elements



CFRP

Steel

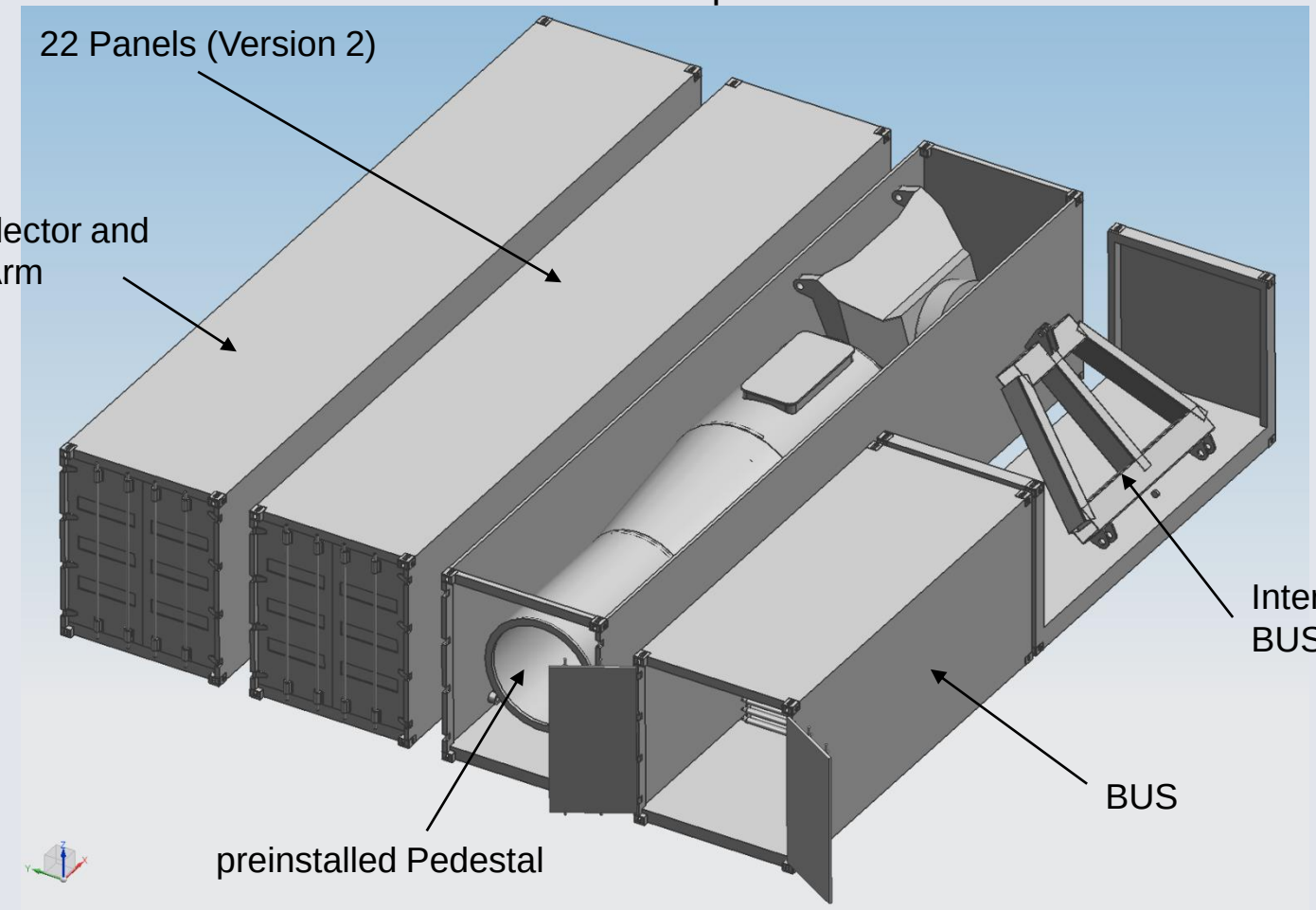
SKA Feed Down Design



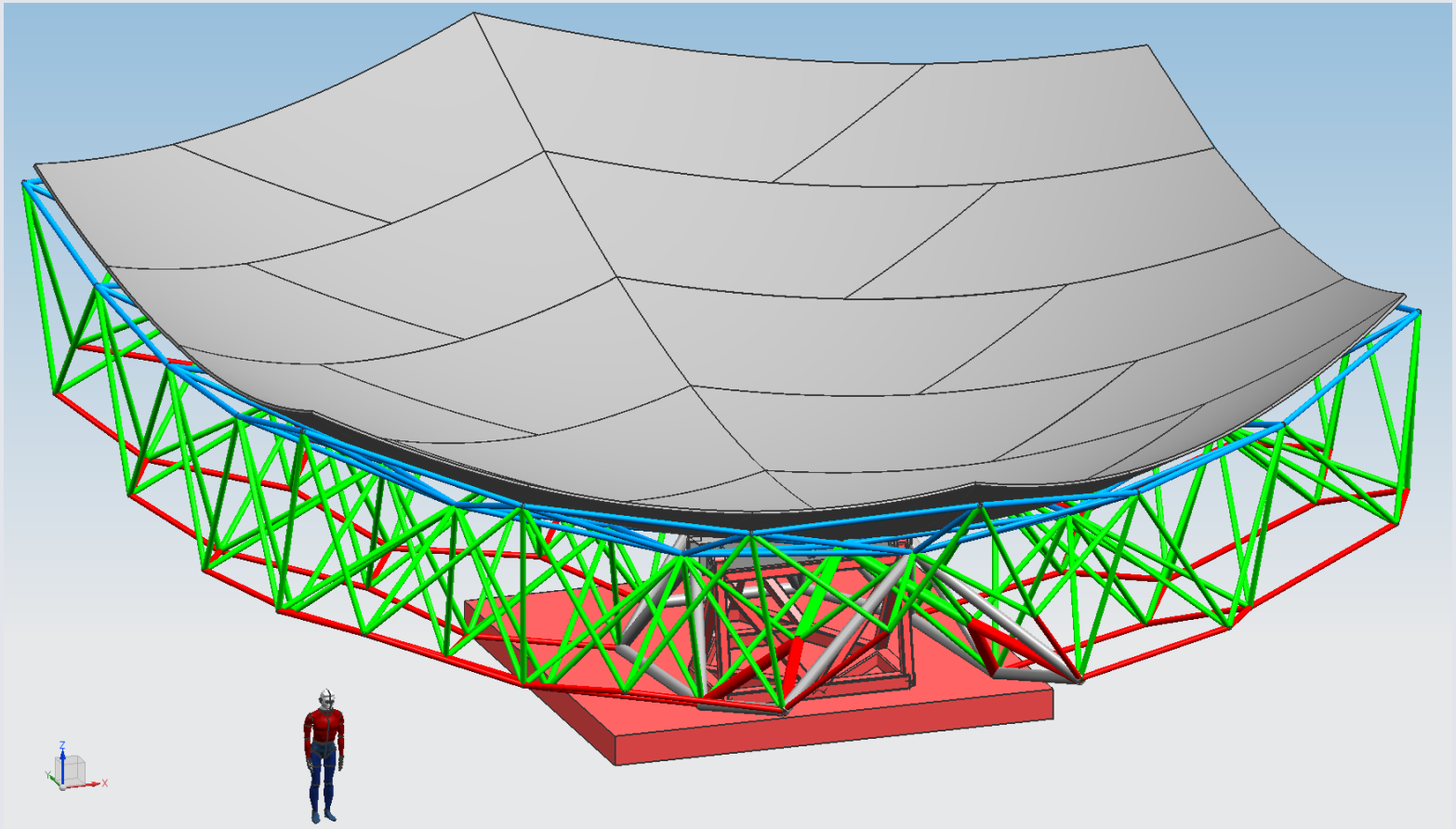
Transport Configuration and Reflector Assembly

Shipment Configuration Feed Down Design

5 Containers per Antenna



Panel Installation and Panel Adjusting



Performance Comparison

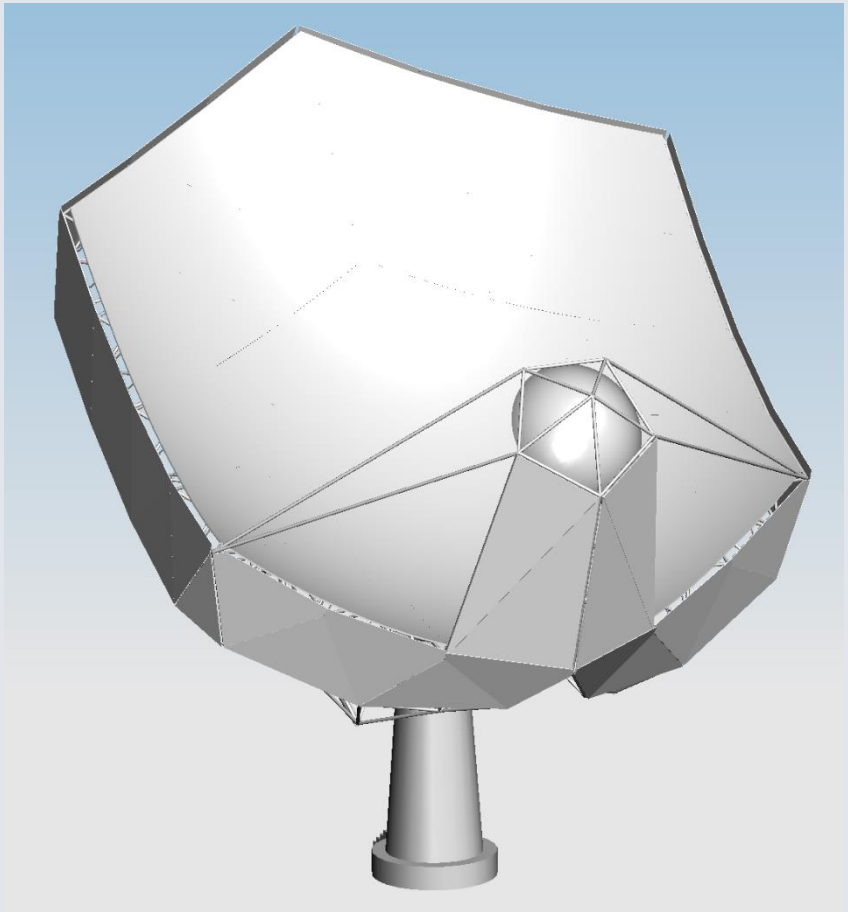
Performance Comparison
MTM 15m Design vs. 13.5m MeerKat

Performance Criteria	15m SKA Feed Down Design	15m SKA Feed Up Design	13.5m MeerKat [1)]
Surface Error total RSS [µm]	293	350	556
Locked Rotor Frequency at 15° El [Hz]	4.2	3.7	2.7
Pointing Error Wind 7 m/s, at night [arcsec]	8.5	4.7	7.8
Total Dead Weight [kg]	29,980	27,140	47,100

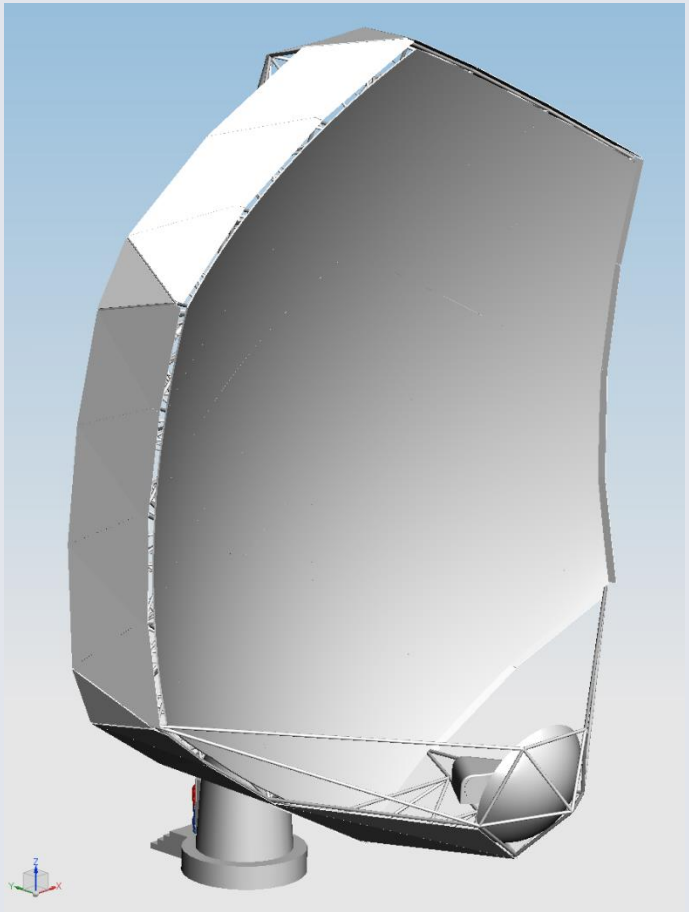
[1)] values taken from SKA-TEL-DSH-0000019

NGVLA Vision

18m NGVLA



Elevation 80°



Elevation 30°

18m NGVLA
Error Budget Primary and Subreflector (Preliminary Results)

Primary and Subreflector	CFRP Panel, CFRP Subreflector, Steel BUS	[µm]
Gravity (Panel + BUS)	adjusted, 47° Elevation Angle	120
Wind (Panel + BUS)	7 m/sec	40
Temperature	BUS Ambient Change dT = 25 K	20
Temperature	BUS Gradient dT = 5 K	60
Temperature	Panel Ambient Change dT = 25 K	3
Temperature	Panel Gradient dT = 2 K	2
Manufacturing	Panel	90
Error Budget	Subreflector	60
Total	**RSS**	**177**

Performance Comparison
15m SKA / 18m NGVLA

Performance Criteria	15m SKA MTM Design	18m NGVLA MTM Design
Surface Error total RSS [µm]	293 < 600 [1)]	177 < 185 [1)]
Locked Rotor Frequency at 15° El [Hz]	4.2	3.1
Total Dead Weight [kg]	29.980	42.500

[1)] Specification value


Thank you very much.