The Dish Verification Antenna

A low-cost, high-performance antenna for the SKA

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Introduction

- DVA-1 is a prototype antenna developed for PrepSKA
- A partnership between NRC, SPDO and TDP

- Aims to meet specifications of an SKA antenna.
  - cost/performance and mass manufacturing
- Design for low, whole-of-life cost
- Uses technology for mass production and low maintenance
  - Mold-based, composite manufacture
  - Low cost fabrication technique

- Build one to perform real world tests

SKA requirements

- The dish shall be of sufficient quality that it is compatible with the attainment of the system imaging dynamic range requirement of 73 dB at 1.4 GHz. *E.g.* Pointing stability of the SKA dishes is required to be no worse than 1/100th of a beamwidth at 1.4 GHz in all operating conditions.
    - designed to maximise A/T
    - Composite: low thermal expansion
    - Composite: Very stiff structure

- The dish design to maximise the sensitivity per unit cost of the system over the frequency range 0.45 to 10 GHz
    - The reflector surface rms determined by mold quality

- The dish must be energy efficient
    - lightweight

- As feeds are still an item under investigation, there must be sufficient flexibility to accommodate multiple feeds.
    - Large focal region provides flexibility

- The solution must be amenable to mass manufacture techniques.
    - Mold based, low cost manufacturing technique ideal for mass manufacture

Approach

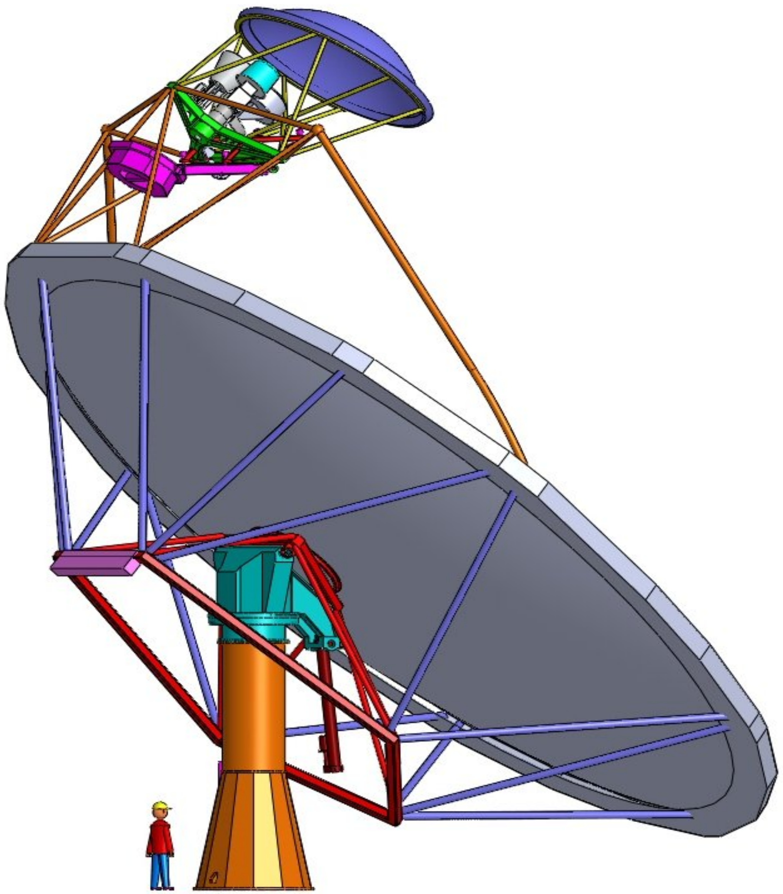
- Rim-supported centre-retained reflector
- Molded composite one-piece manufacture
  - on-site assembly
  - Low CTE
- Light-weight modular mount
  - off-site assembly
- 15m “Mild” shaped offset-Gregorian
  - No blockage
  - No scattering
- Feed-high optics
- Large focal region capacity/flexibility

Focus:
- manufacturability/maintainability
- performance/cost

NRC-HIA:
- Reflector/feed mount design
- DVA construction

TDP:
- Optical Design
- Mount Design

SPDO:
- Mount components.

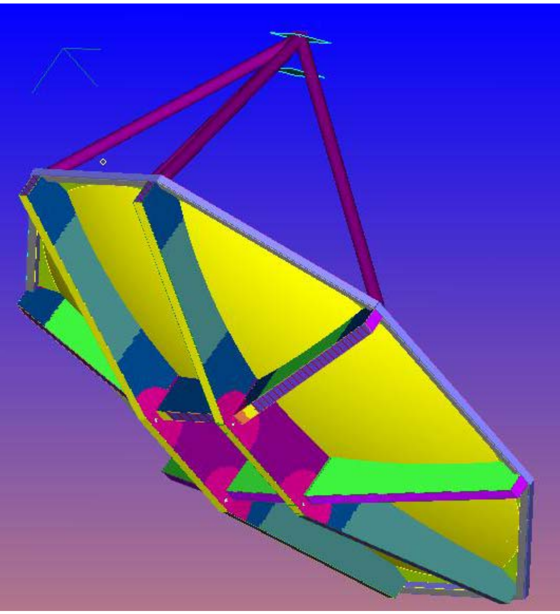


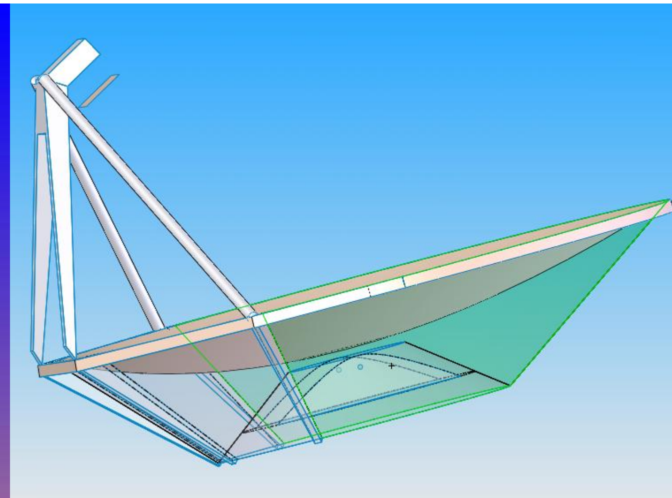
Leveraging the CART experience

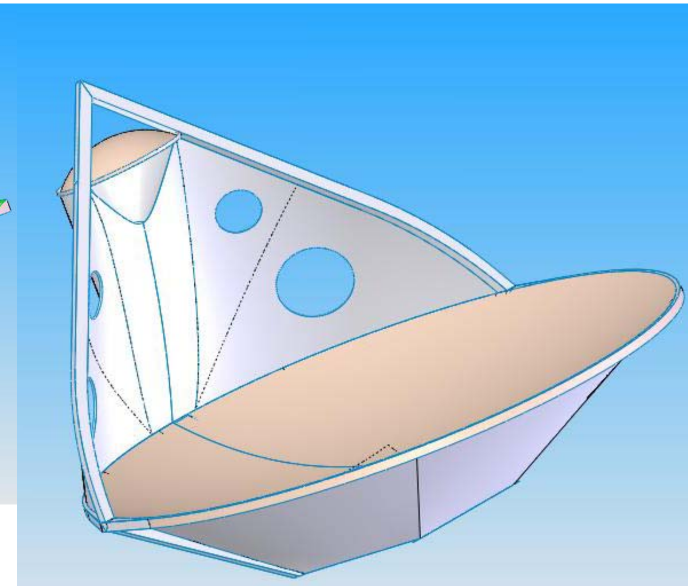
Mk1 Dish 2007

MkII 2008

Initial Work







Work on composite offsets was ongoing throughout 2009.

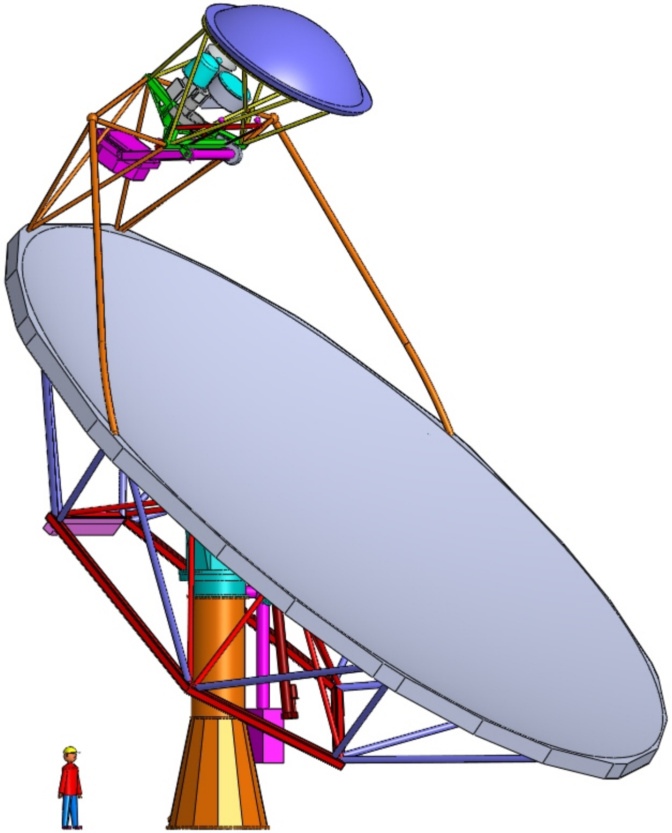
With only preliminary optics, a best guess was made on configuration.

Many structural arrangements were explored.

An all-molded concept looked promising

Concept Reflectors

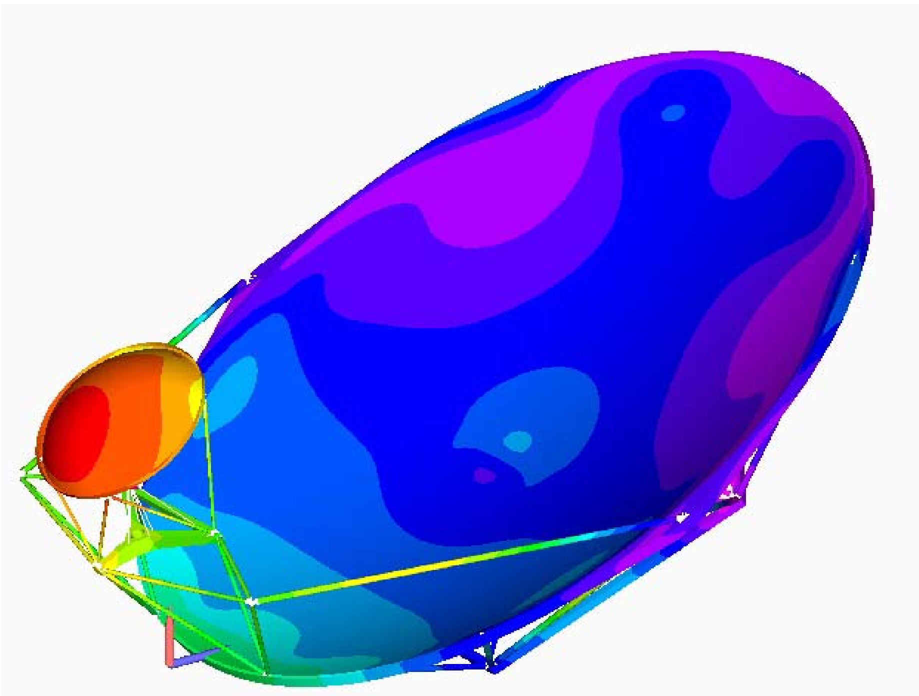
An early dish concept



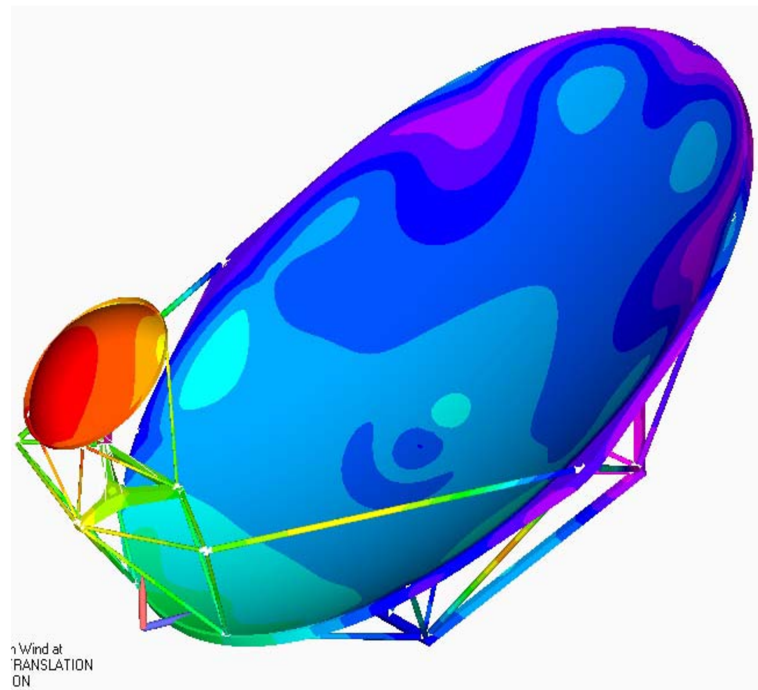
15m design carried to CoDR

Gravity and 25kph wind at 90 Degrees Elevation

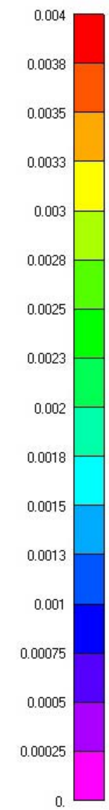
Red = 4mm total deflection, Purple < 0.25mm total deflection



Gravity at 90 Degrees

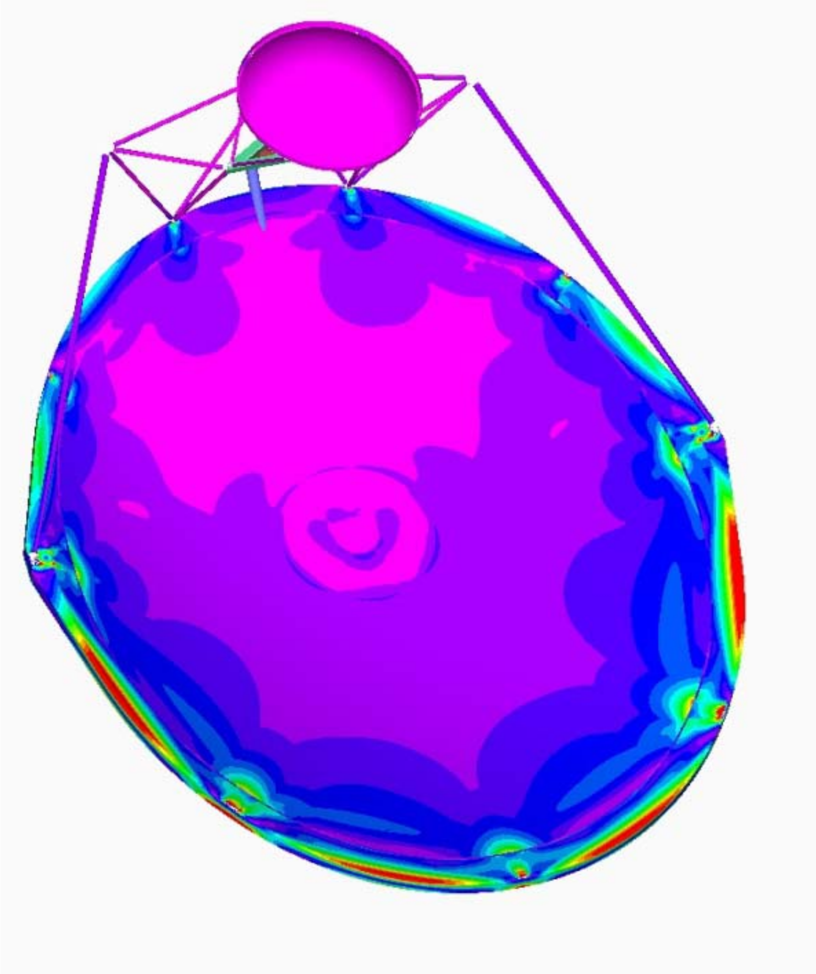


Gravity and 25kph wind at 90 Degrees



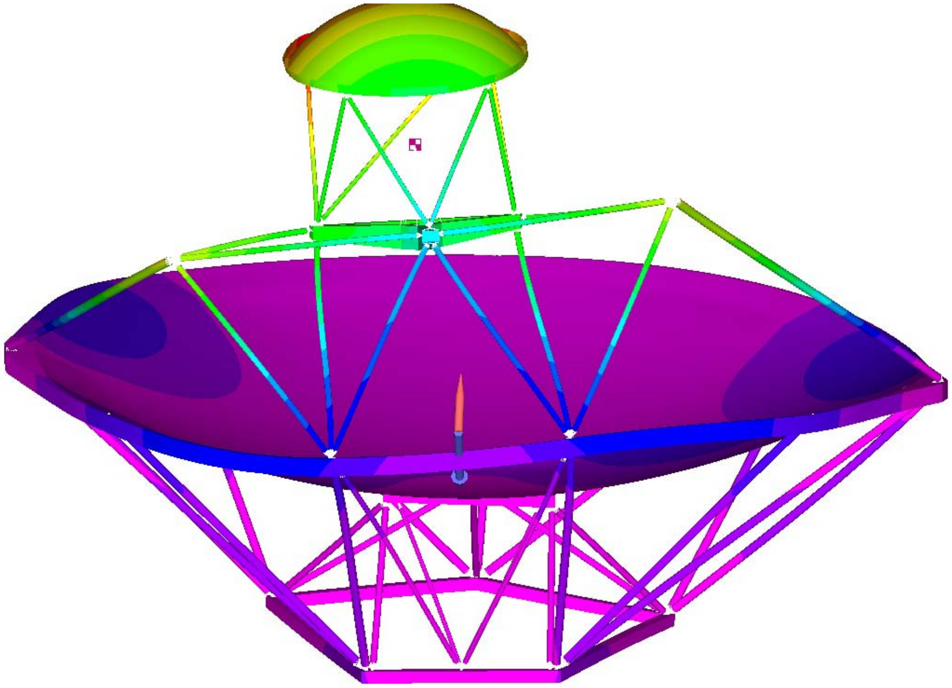
Stresses in Composite Surface at 162kph Frontal Wind.

Red indicates a stress of about 20% of the ultimate strength of the composite material.

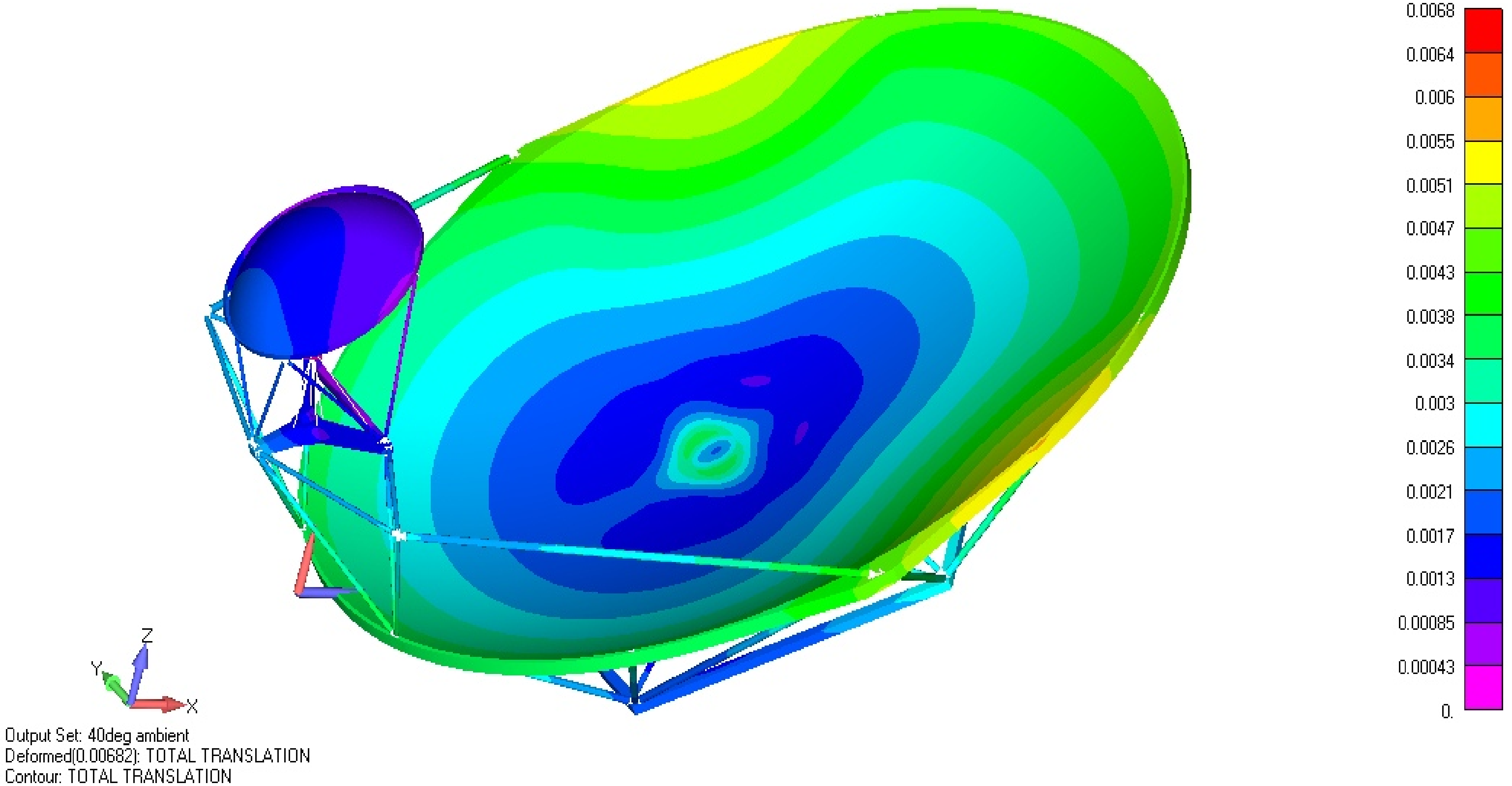


Fundamental Frequency

- The fundamental (lowest) frequency of the structure is >5 Hz
  - a side to side wobble of the secondary relative to the primary
- A further increase (if desired) can be readily achieved.

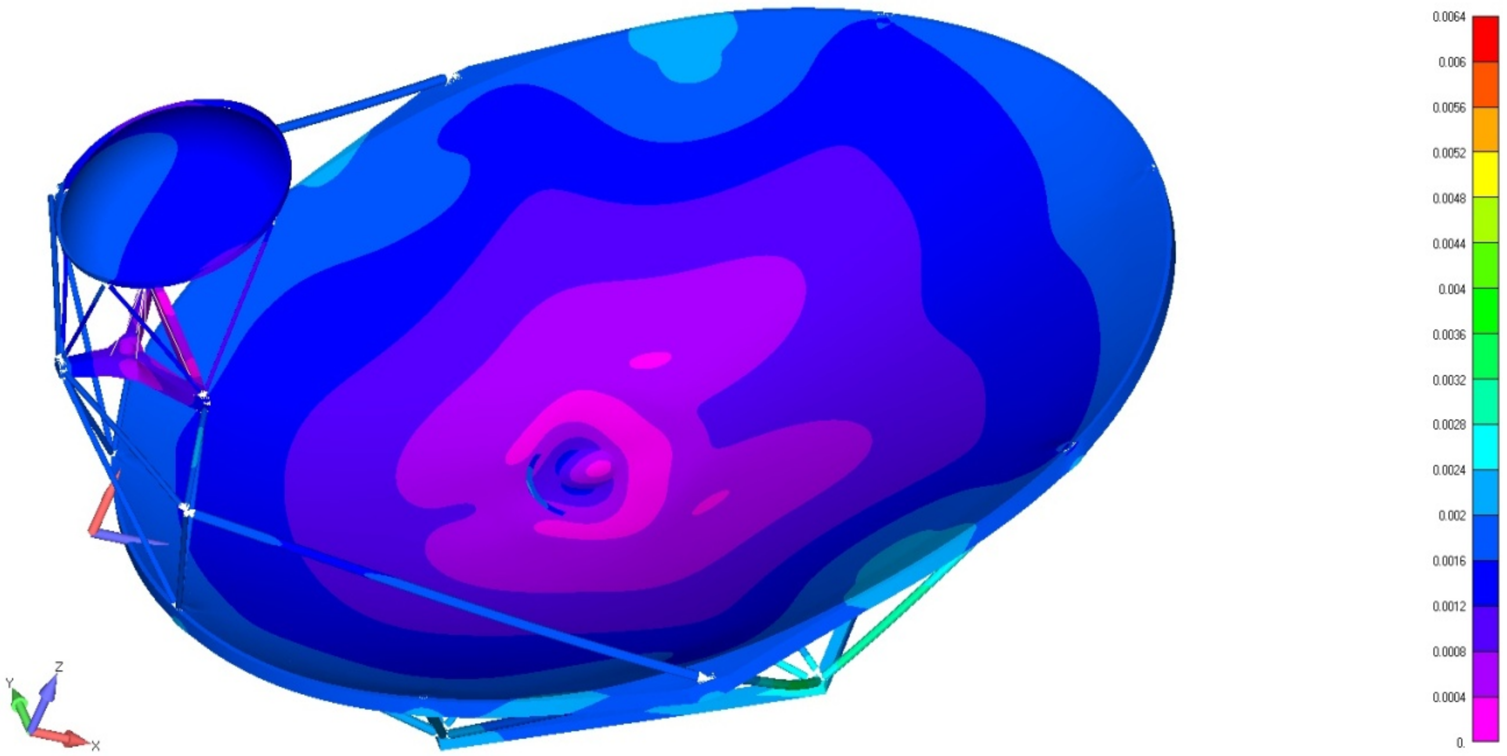


Preliminary Thermal Results



Total structural movement under a +20C temperature change. Of interest is the very smooth nature of the expansion, no ripples or other features caused by backing structure.

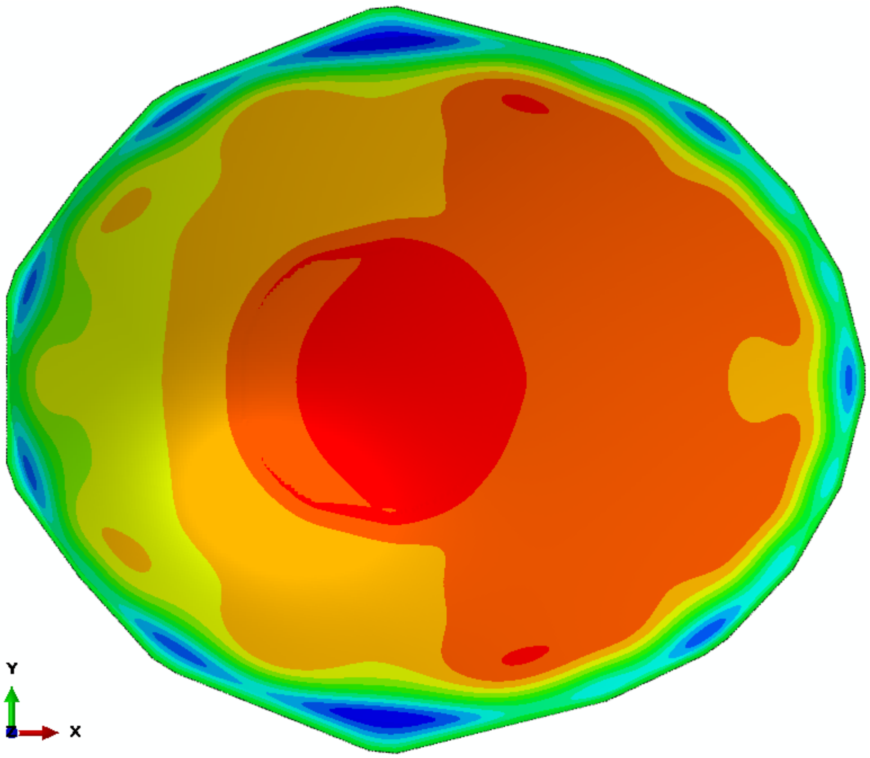
Preliminary Thermal Results



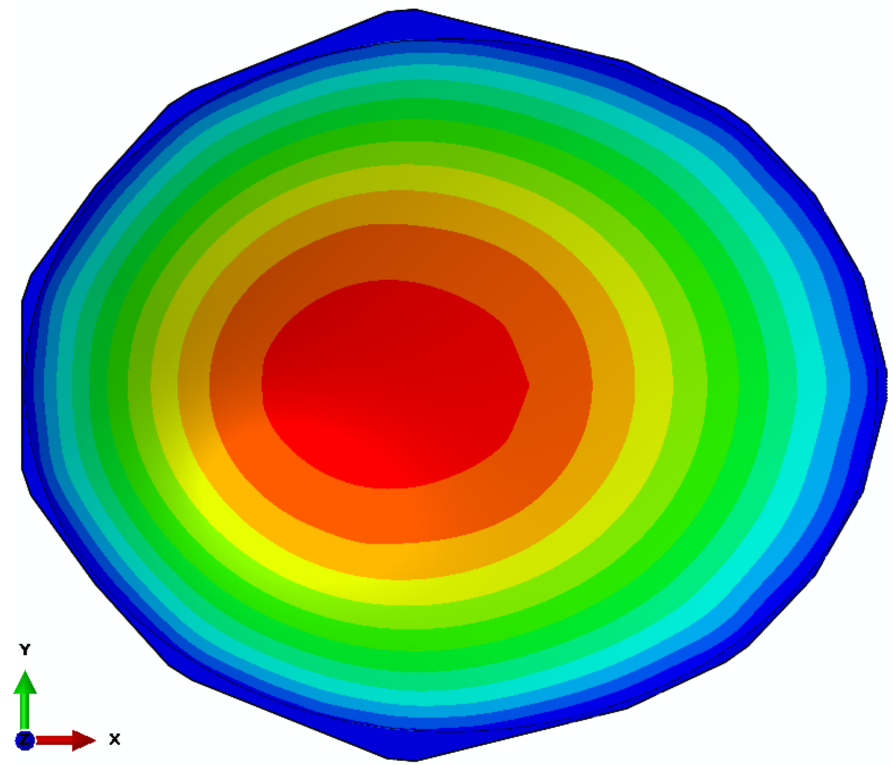
Output Set: 40deg ambient
Deformed(0.00636): TOTAL TRANSLATION
Contour: TOTAL TRANSLATION

Same as before except with material changes in both the backside structure and the reflector surface..

Processed-Induced Deformation



Case A: Max deformation = 5mm



Case B: Max deformation = 1mm

Merits of Current Design

• Gregorian offset optics offer a clear aperture and a large area to mount feeds

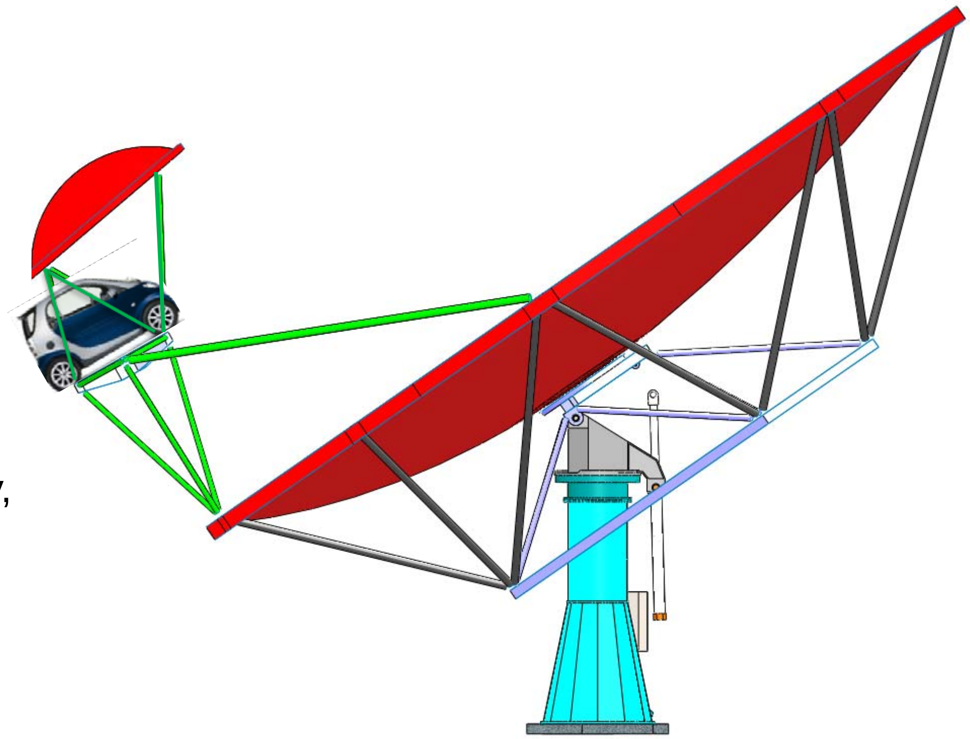
• One-piece vacuum-infused carbon composite construction for the reflectors

- thermally stable
- repeatable
- lightweight
- high precision
- low-cost manufacture

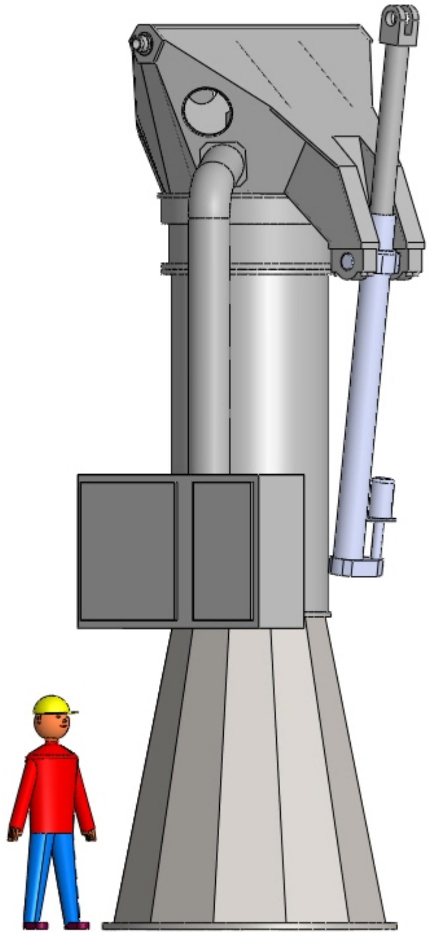
• Rim supported structure is stable under gravity, wind, and thermal loads

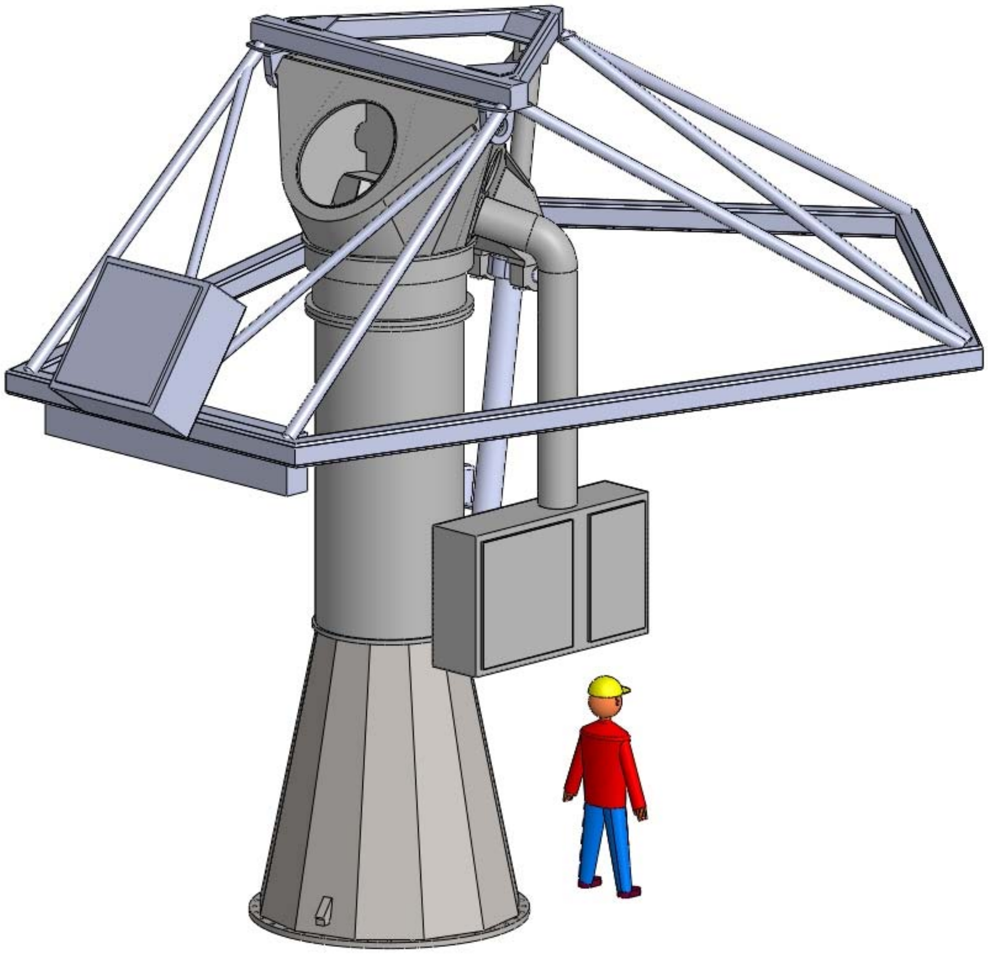
• Optimized feed-leg structure represents a very stiff, yet light, and low cost, solution for feed and secondary mirror support.

• Backup structure for primary dish is simple, and very stiff.

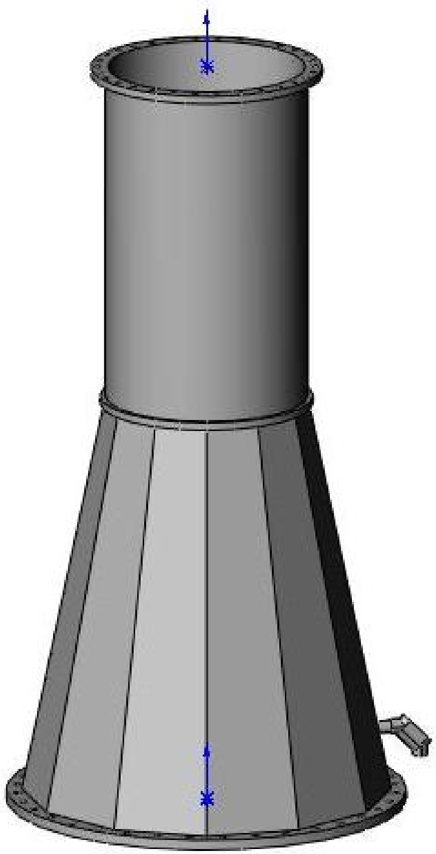
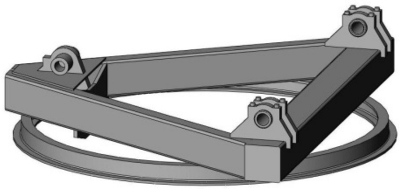
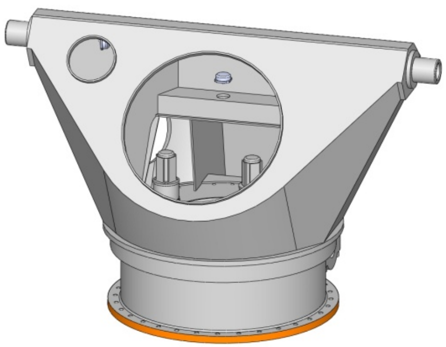
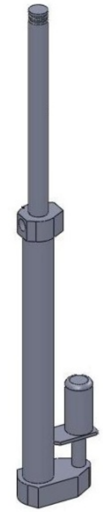
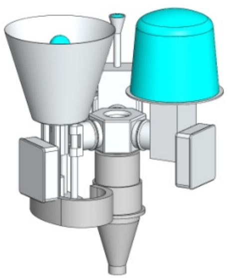
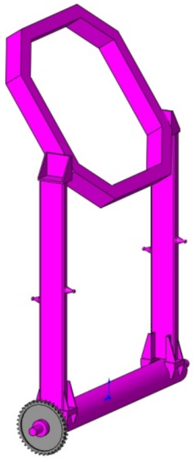
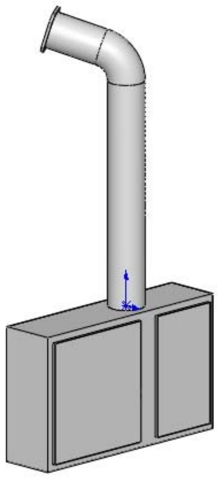
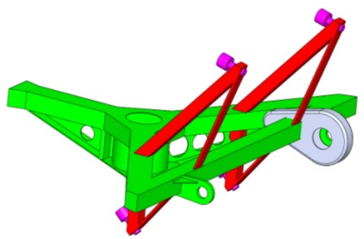


Mount Assembly

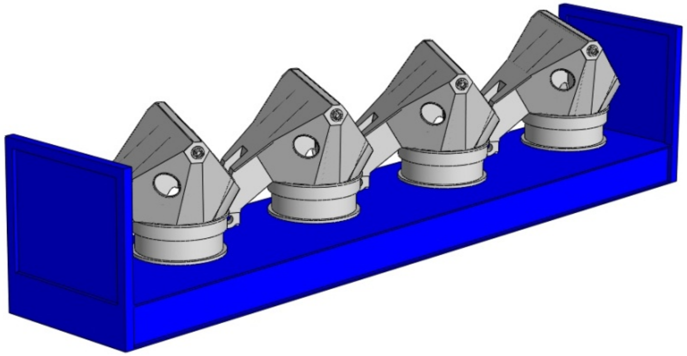


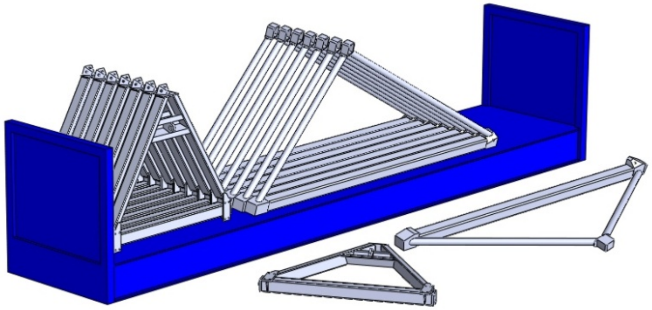


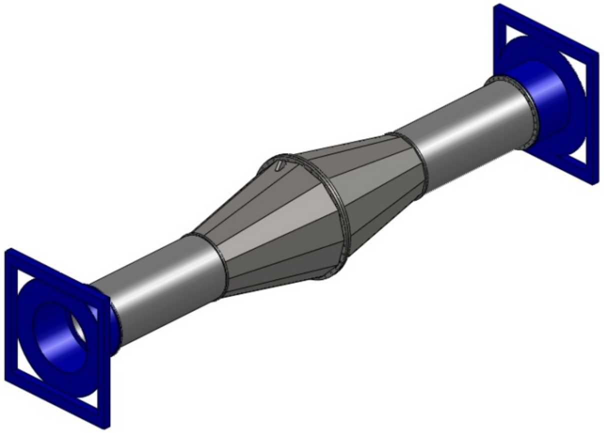
Deliverables

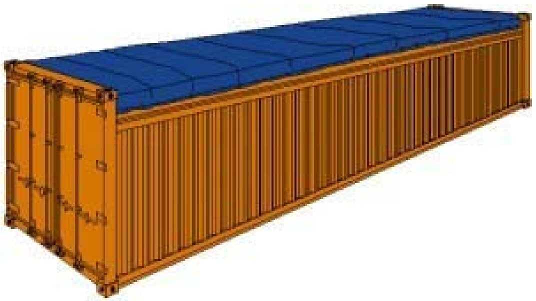









Shipments









Project Status

- Conceptual design review
  - complete – Feb 2011
- Preliminary Design Review
  - complete – Oct 2011
- Optical design complete
- Structural design complete
- Critical Design Review
  - Q2 2012.
- Project fully-funded ($2.5M)
  - Mold & mount procurement underway (9 mon)
  - Feed-leg contracts underway
  - Material selection being evaluated
- To be built at HIA-DRAO, Canada
  - Fabrication is 3 months.

Questions?

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