SKA Dish Array CoDR
Reflector Design, Stress and Deflection

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Why Composites?

- High Uniformity between (molded) parts
- High surface accuracy with little additional cost
- High stiffness to weight ratio: less deflection under gravity
- Higher thermal stability (Low CTE)
- Cheaper in production: can mold large complex objects
- Lower maintenance: no corrosion.
- Fewer parts: Lower assembly costs

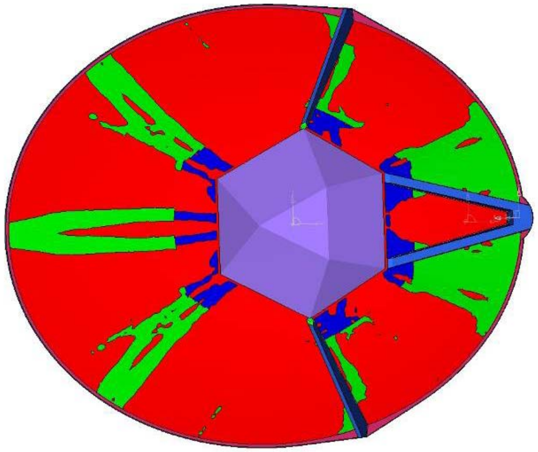
Typical Objections to Composites:

- Creep
  - Answer: Not an issue, stresses too low. On-going monitoring of 10m MkII underway. Contract investigation conducted 2010.
- Weathering degradation
  - Answer: Not an issue, paint with epoxy paint, lifespan 20 years. Contract investigation conducted 2010. Real time investigation underway with Mk1 and MkII
- Fatigue
  - Answer: Not an issue, stresses too low.
- Reflective Layer
  - Answer: Solved through internal research, reflectivity nearly as high as solid aluminum sheet.
- Cost
  - Answer: Material is cost effective if used properly. See SKA memo 116.
- Risk
  - Answer: Development risk low; we have demonstrated two dishes already with the third prototype slated for 2012. Materials research is also ongoing

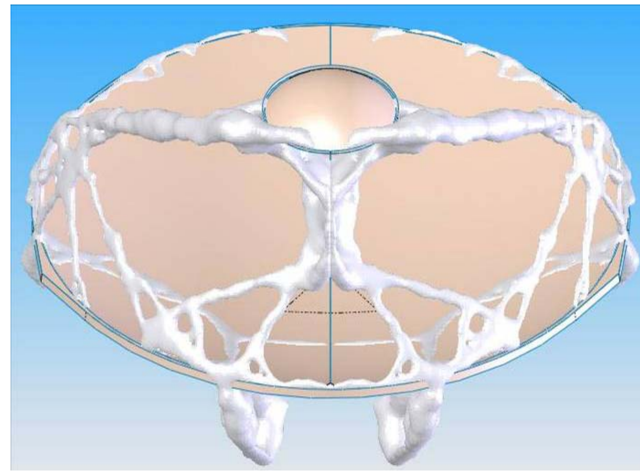
Reflector Design: Stress and Deflection Analysis

- Extensive FEA stress and deflection analysis were performed on the selected design, the results of which were used to optimize the design
- Several structural optimization studies were also contracted out
- The current design is the resultant of this combined optimization work

Optimization Work Highlights



Topological Optimization of back structure

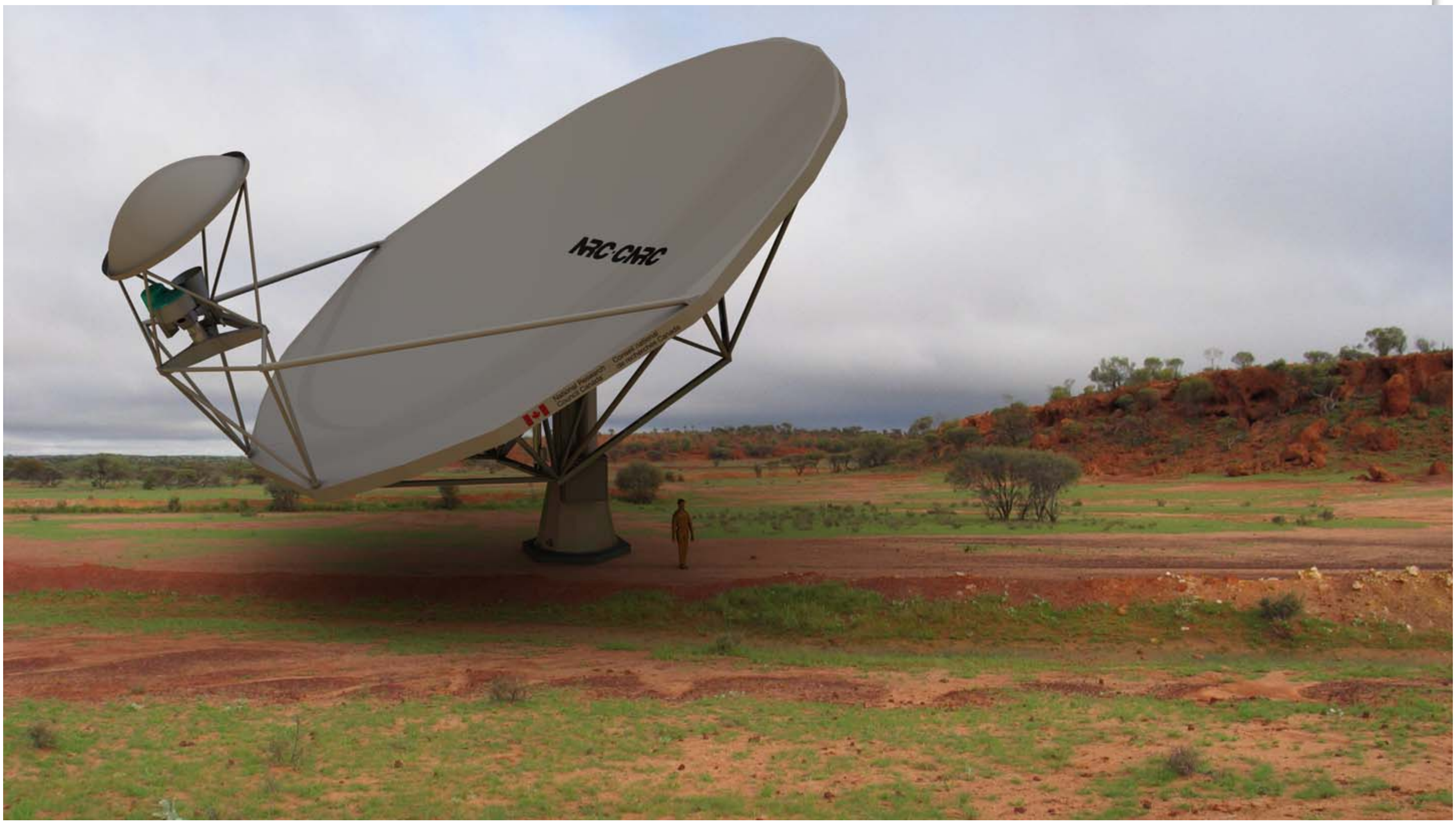


Topological Optimization of feedlegs

Runs	Objective	Disp Ctr (m)	Final Mass (Kg)	Is design feasible?
BASELINE	N / A	0.0087	5586	INITIAL DESIGN
Run 8	Minimize Mass	0.0040	5998	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).
Run 9	Minimize Mass	0.0042	5897	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).
Run 10	Minimize Mass	0.0035	8133	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).
Run 11	Minimize Mass	0.0030	9375	INFEASIBLE DESIGN (AT LEAST ONE CONSTRAINT VIOLATED).
Run 12	Minimize Mass	0.0030	10450	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).
Run 12a	Minimize Mass	0.0040	6021	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).
Run 13	Minimize Mass	0.0030	12375	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).
Run 14	Minimize Mass	0.0040	5686	FEASIBLE DESIGN (ALL CONSTRAINTS SATISFIED).

Shape and Size optimization of selected design

Selected Design, Top View



Selected Design, Bottom View

Gravity and Wind at 25kph

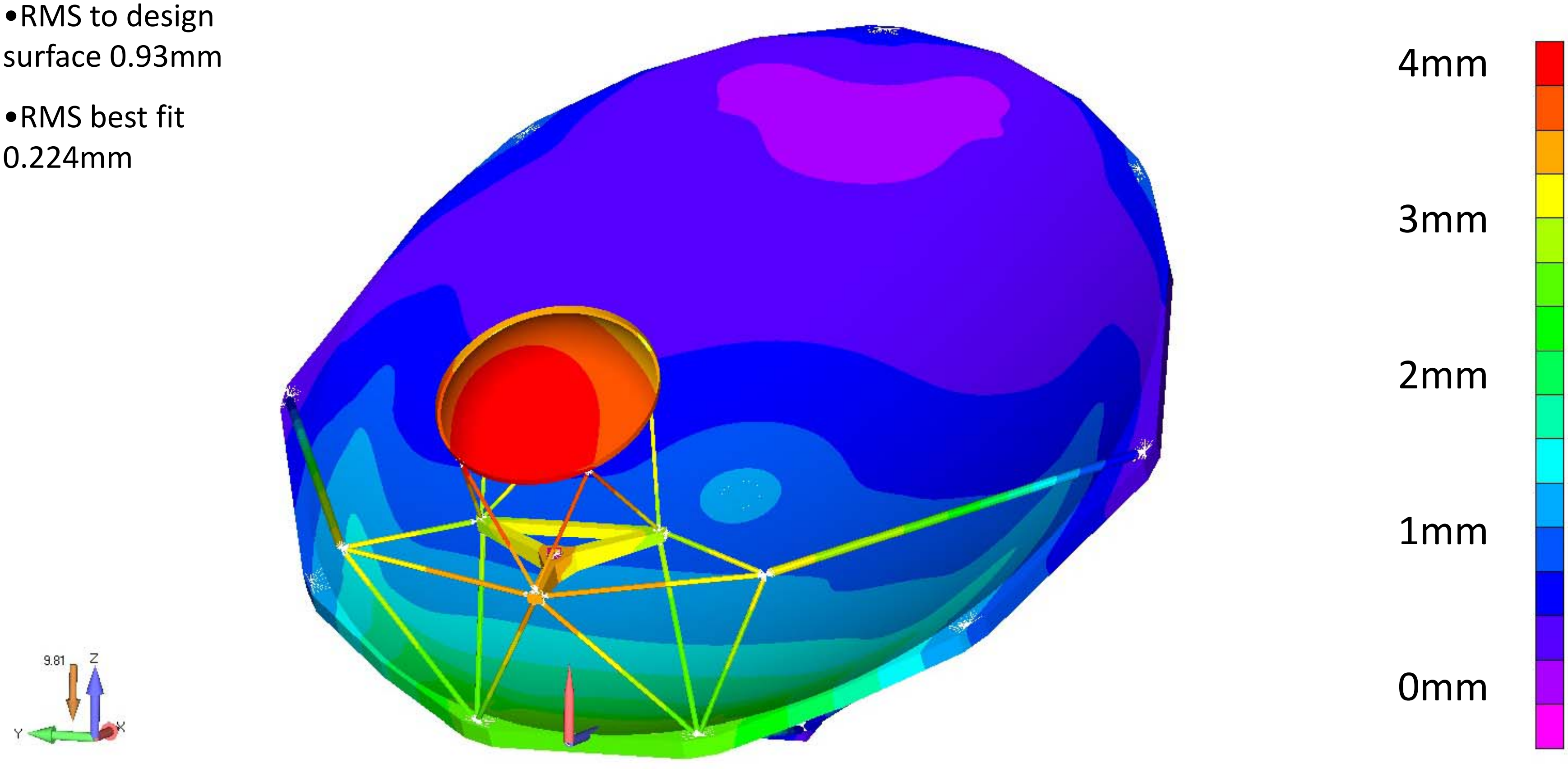
- Wind contours were taken from a wind tunnel test program undertaken for us at the Institute for Aerospace Research (Part of the NRC).
- Wind data included both front and rear pressure data and includes turbulent flow tests
- Frontal wind data at 15 degrees, 55 degrees, and 90 degrees elevation was used for this work

Gravity and Wind at 25kph

- RMS half pathlength errors to the design surface are shown
- Best fit RMS data are restricted to rotations about Y and translations in X-Z plane
- Under gravity alone the structure is very stiff
- Under wind loads the dish surface shows very little additional deflection

Total Deflection
Gravity at 90 degrees

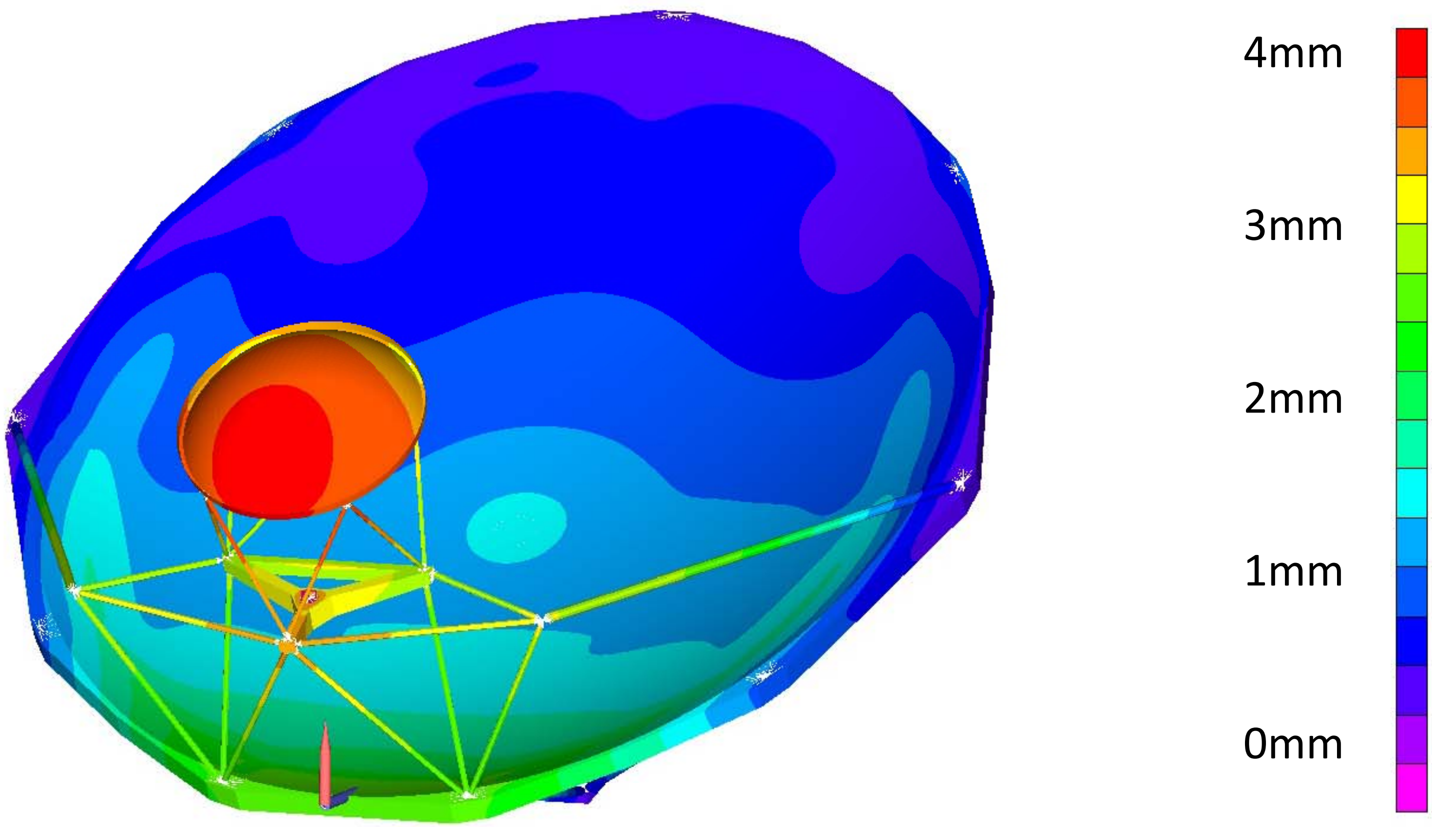
- RMS to design surface 0.93mm
- RMS best fit 0.224mm

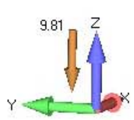


Output Set: Gravity at 90
Deformed(0.00403): TOTAL TRANSLATION
Contour: TOTAL TRANSLATION

Total Deflection
Gravity + 25kph wind at 90 degrees

- RMS to design surface 1.06mm
- RMS best fit 0.286mm

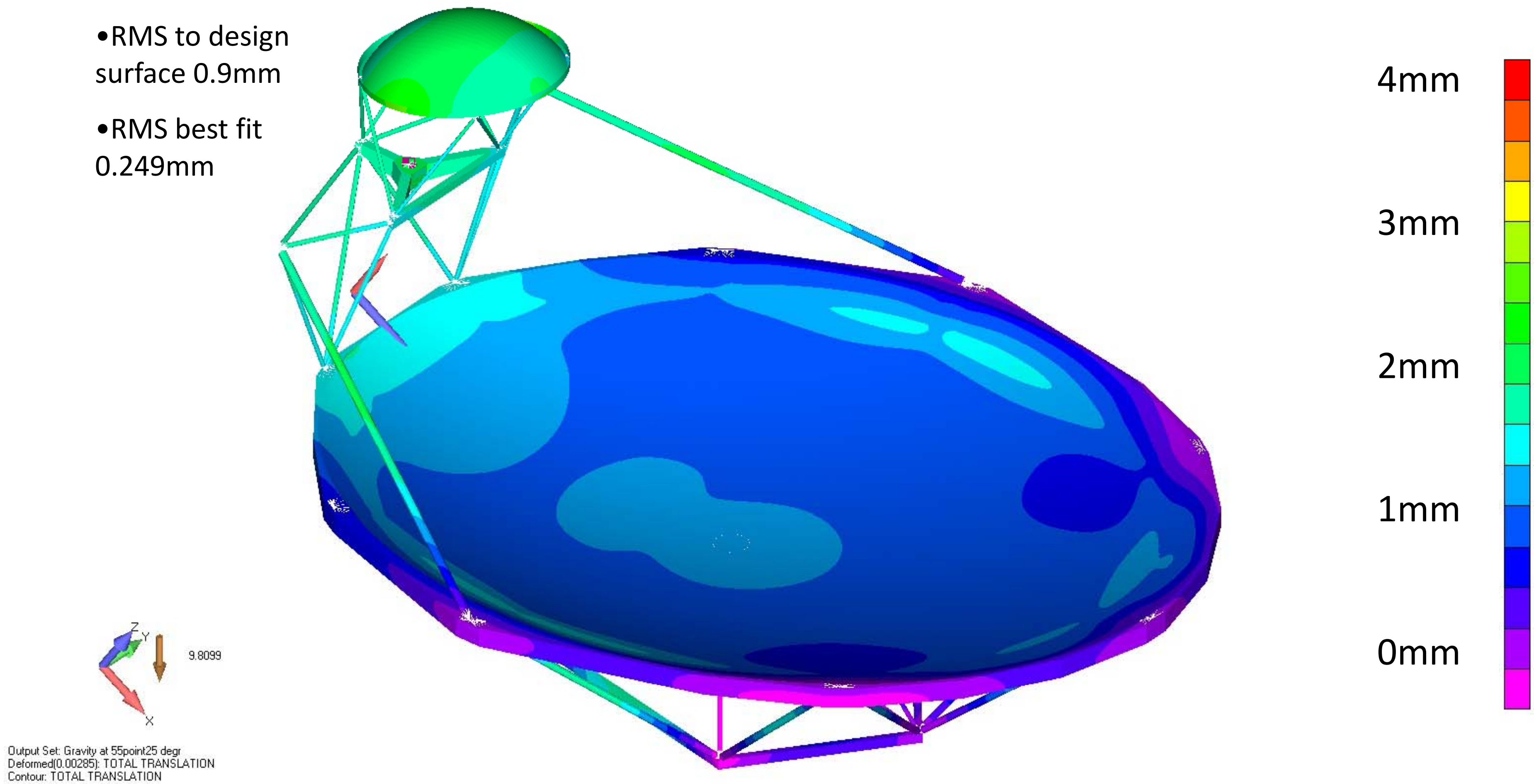




Output Set: Gravity at 90 with 25kph
Deformed(0.00397): TOTAL TRANSLATION
Contour: TOTAL TRANSLATION

Total Deflection
Gravity at 55 degrees

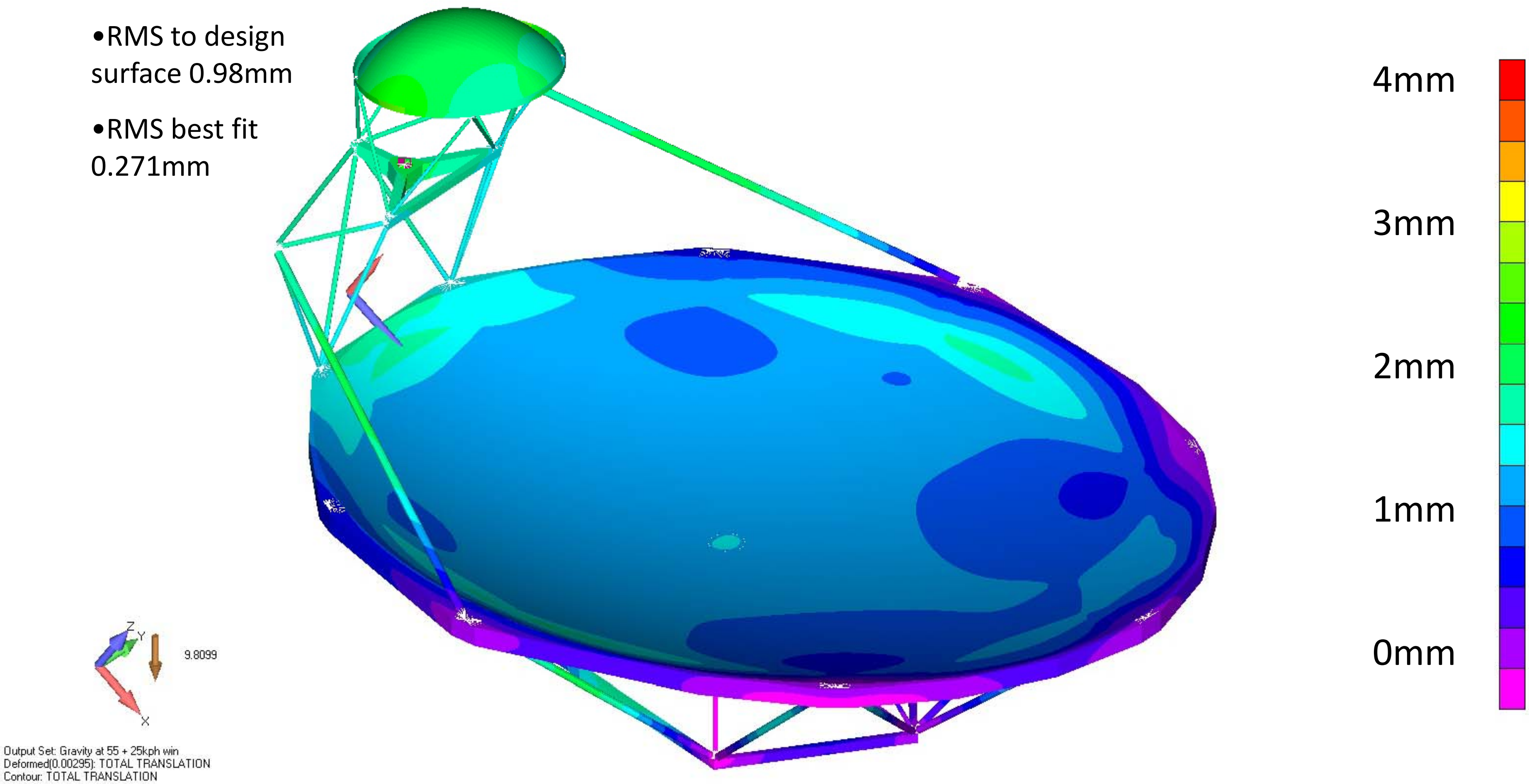
- RMS to design surface 0.9mm
- RMS best fit 0.249mm



Total Deflection
Gravity + 25kph wind at 55 degrees

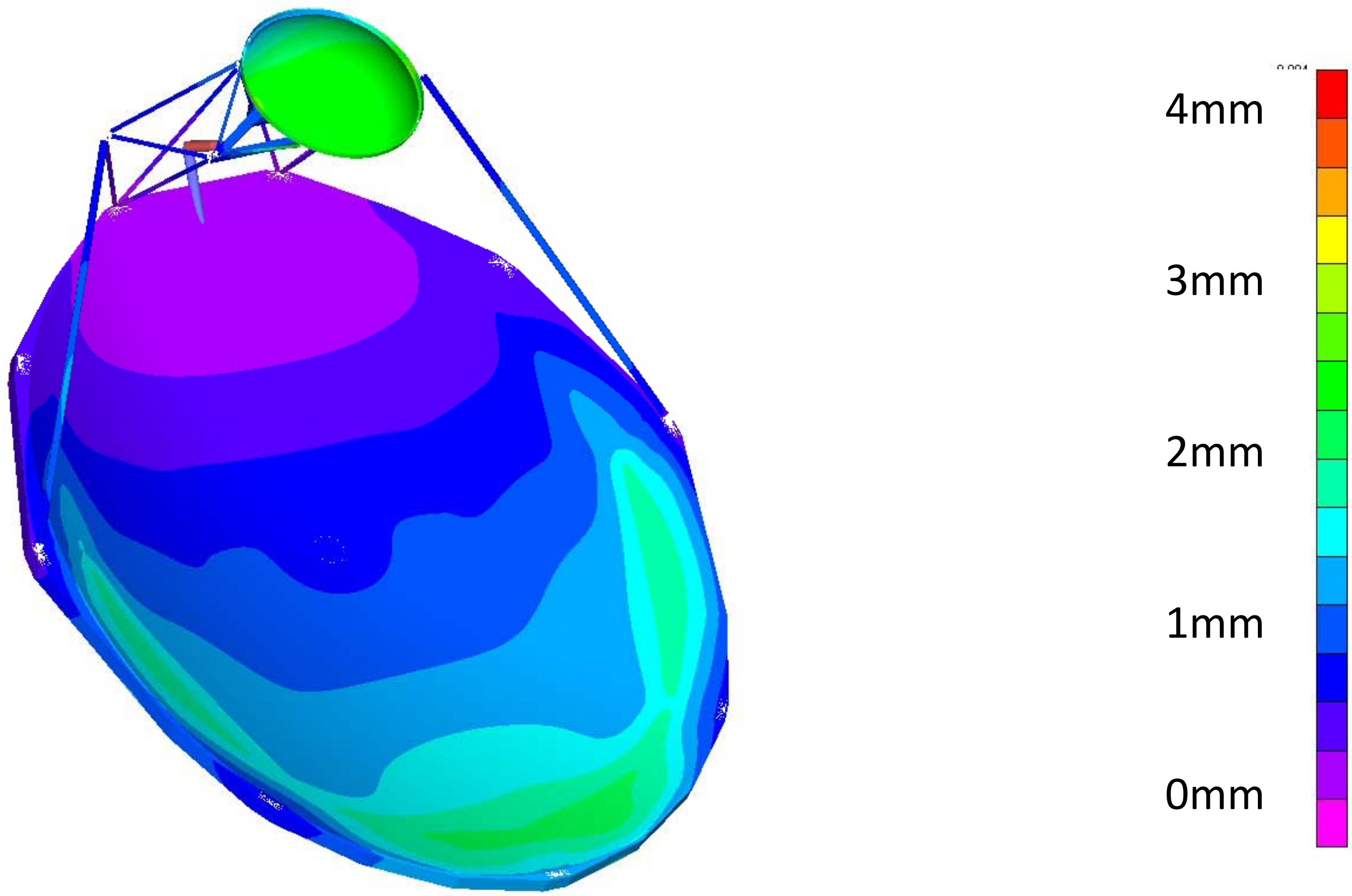
•RMS to design surface 0.98mm

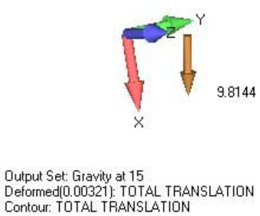
•RMS best fit 0.271mm



Total Deflection
Gravity 15 degrees

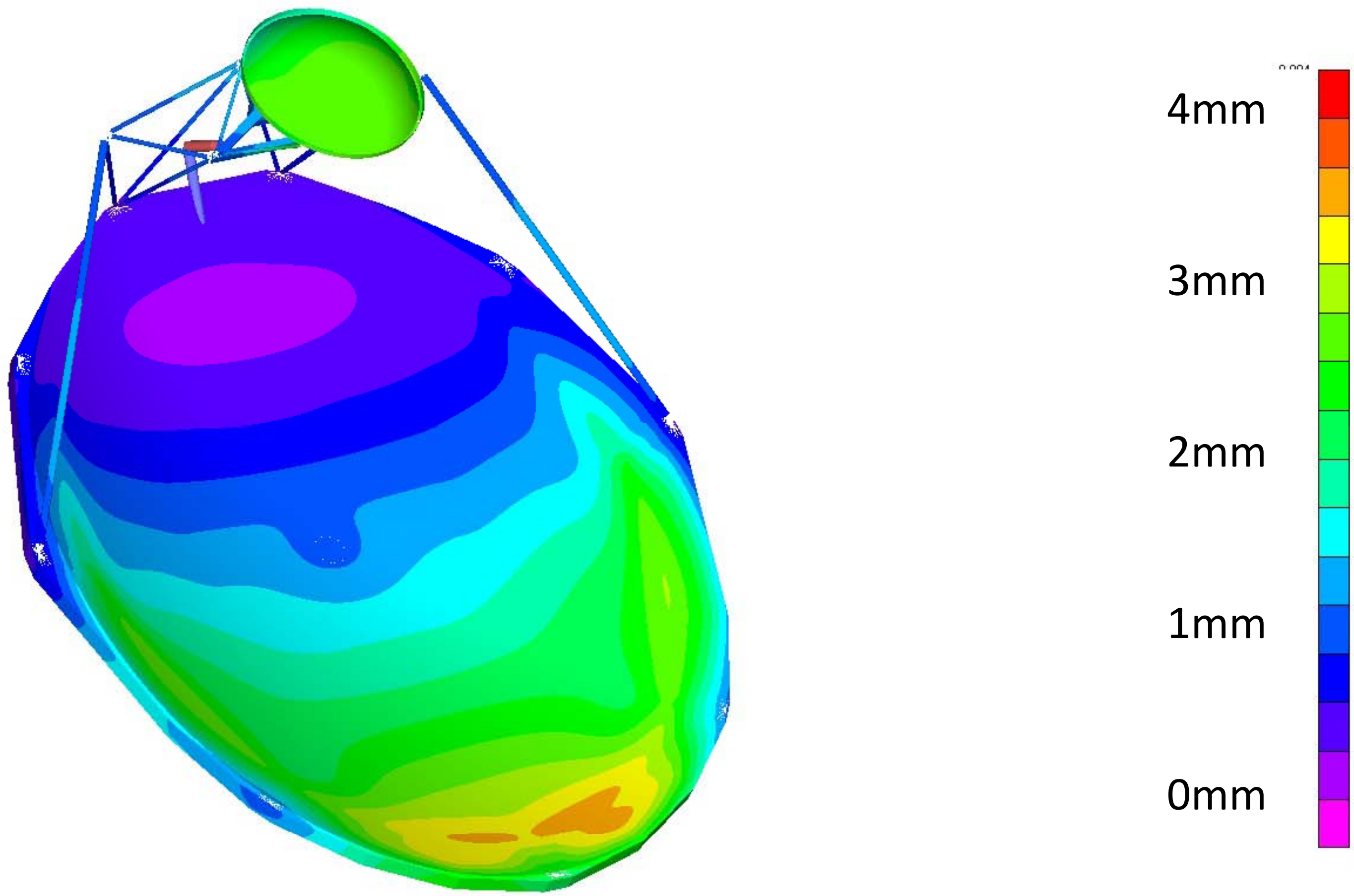
- RMS to design surface 0.8mm
- RMS best fit 0.235mm

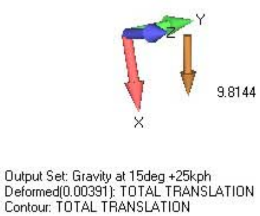




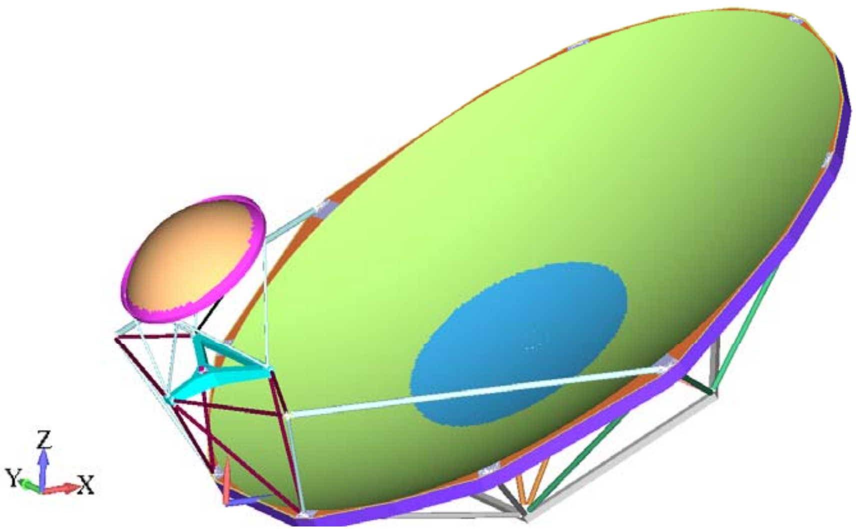
Total Deflection
Gravity + 25kph wind at 15 degrees

- RMS to design surface 1.19mm
- RMS best fit 0.337mm





RMS Errors and a Best Fit Analysis

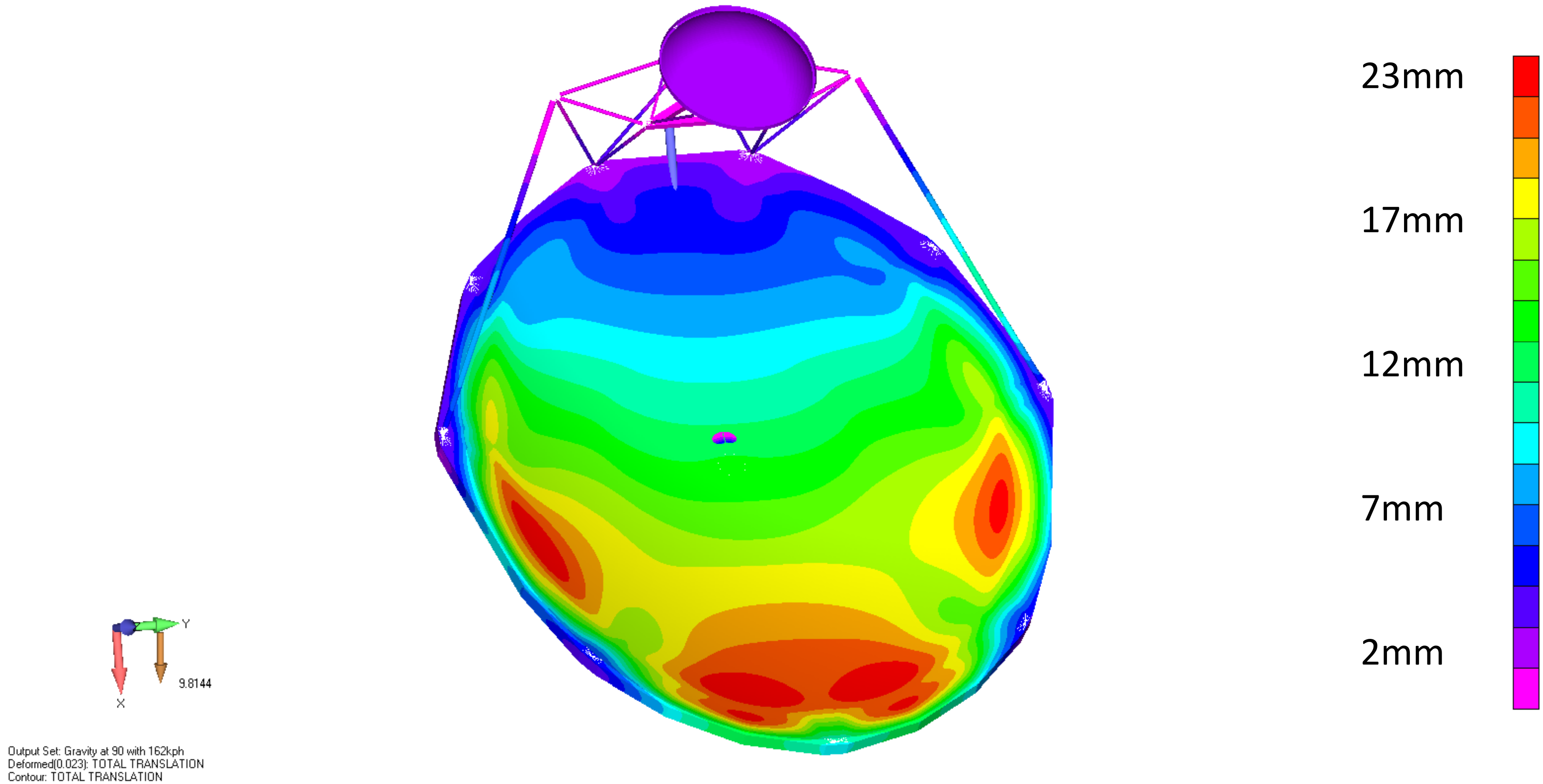


Wind Speed/kph	Elevation Angle in degrees	RMS/mm	X offset/mm	Z offset/mm	Focal-Length offset/mm	Rotation about Y/arcsec
0	15	**0.235**	2.42	0.49	1.93	**21.43**
0	55.25	**0.249**	0.47	-1.26	-0.35	**-1.40**
0	90	**0.224**	-1.43	-2.31	-2.22	**-20.97**
25	15	**0.337**	2.64	0.97	1.70	**3.33**
25	55.25	**0.271**	1.30	-1.25	0.02	**10.47**
25	90	**0.286**	-0.44	-2.20	-1.94	**-14.33**

Gravity and 162kph wind at 15 degree elevation

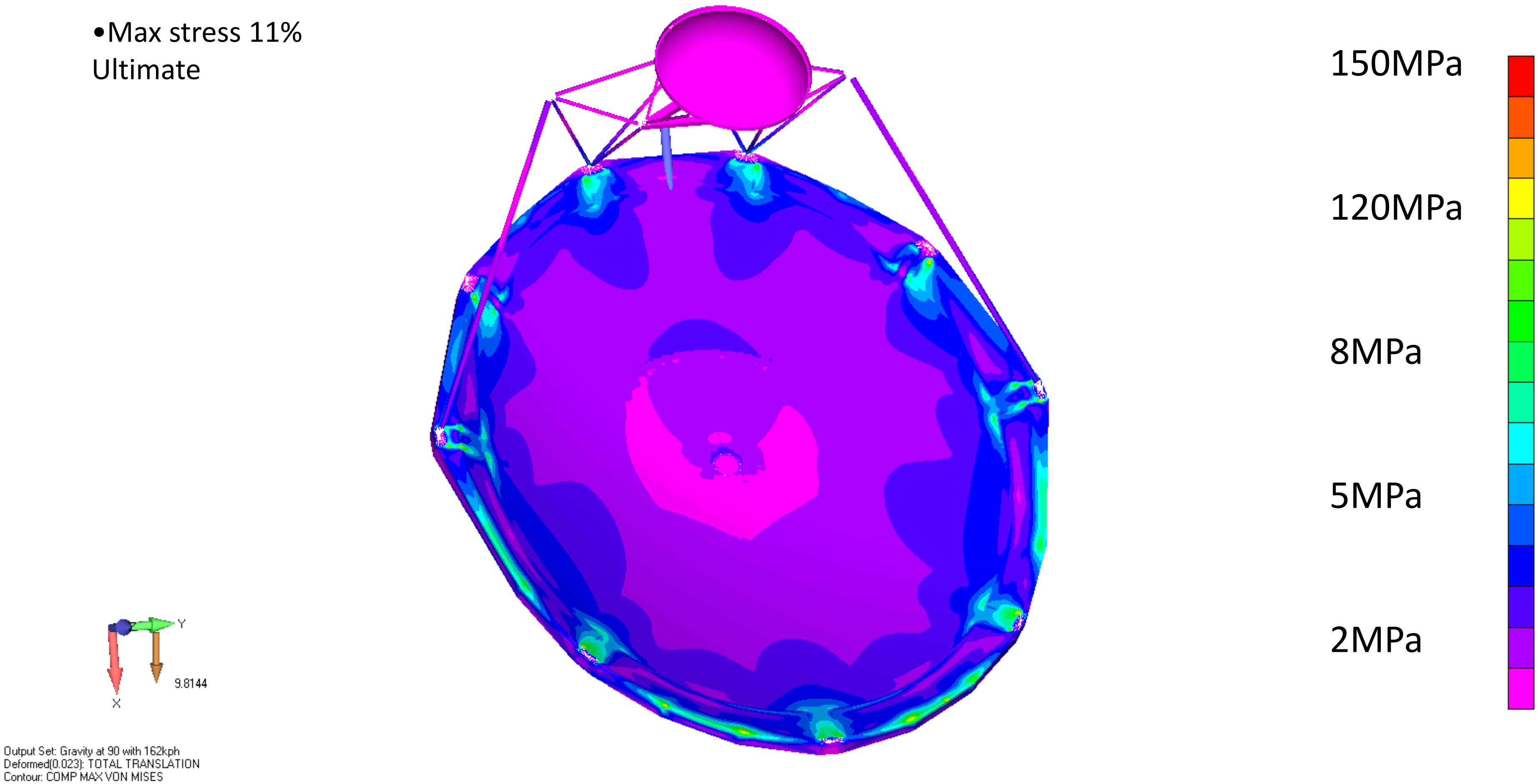
- We are interested only in survival at 162kph
- Stresses in composite surface are still very low
- Stresses in steel back structure survivable but currently at 50% yield in some areas which is high for repeated loads

Total Deflection at 162kph and 15 degrees Elevation



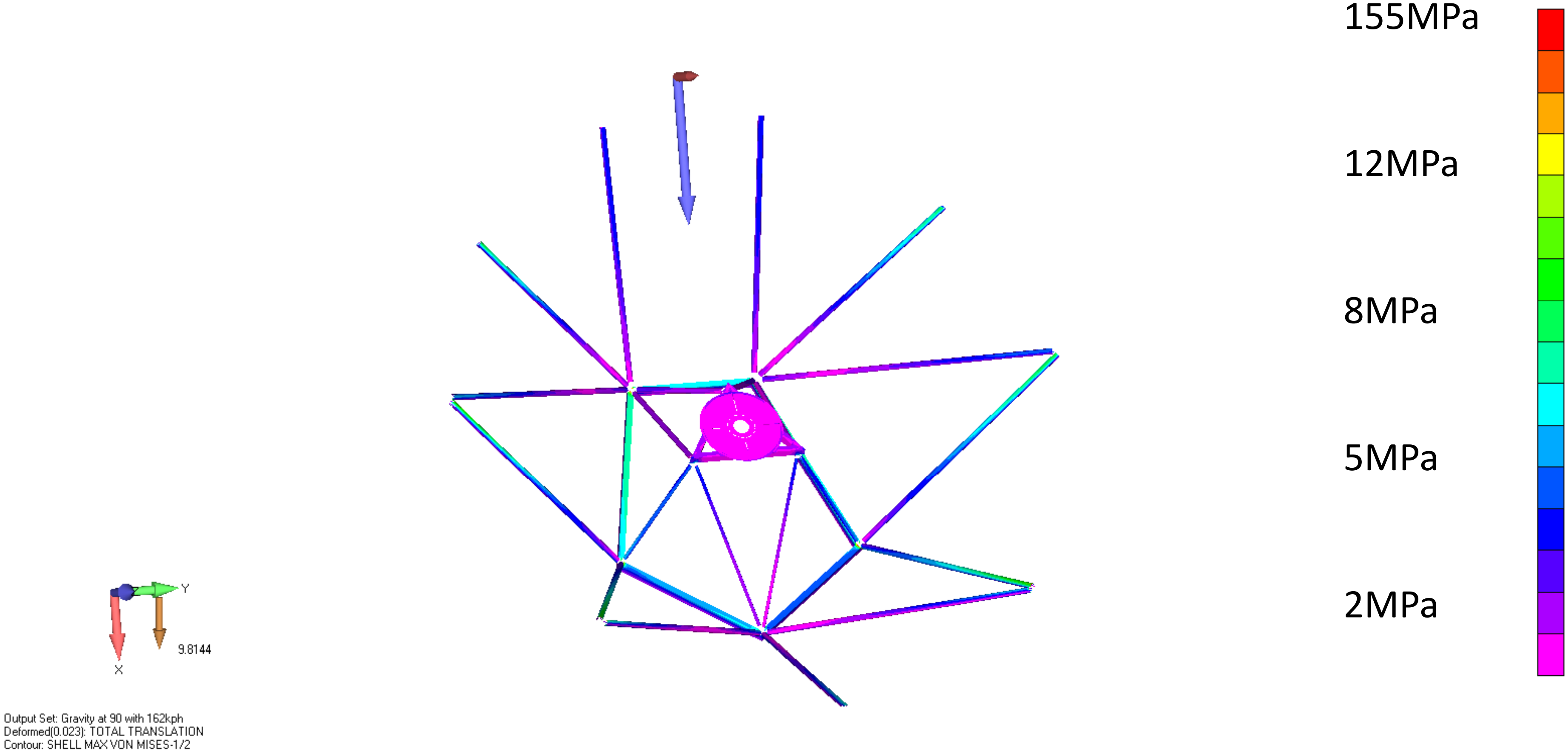
Total Von Mises Stresses in Composite Surface at 162kph and 15 degrees Elevation

- Max stress 11% Ultimate



Maximum Von Mises Stresses in Steel Backing Structure at 162kph and 15 degrees Elevation

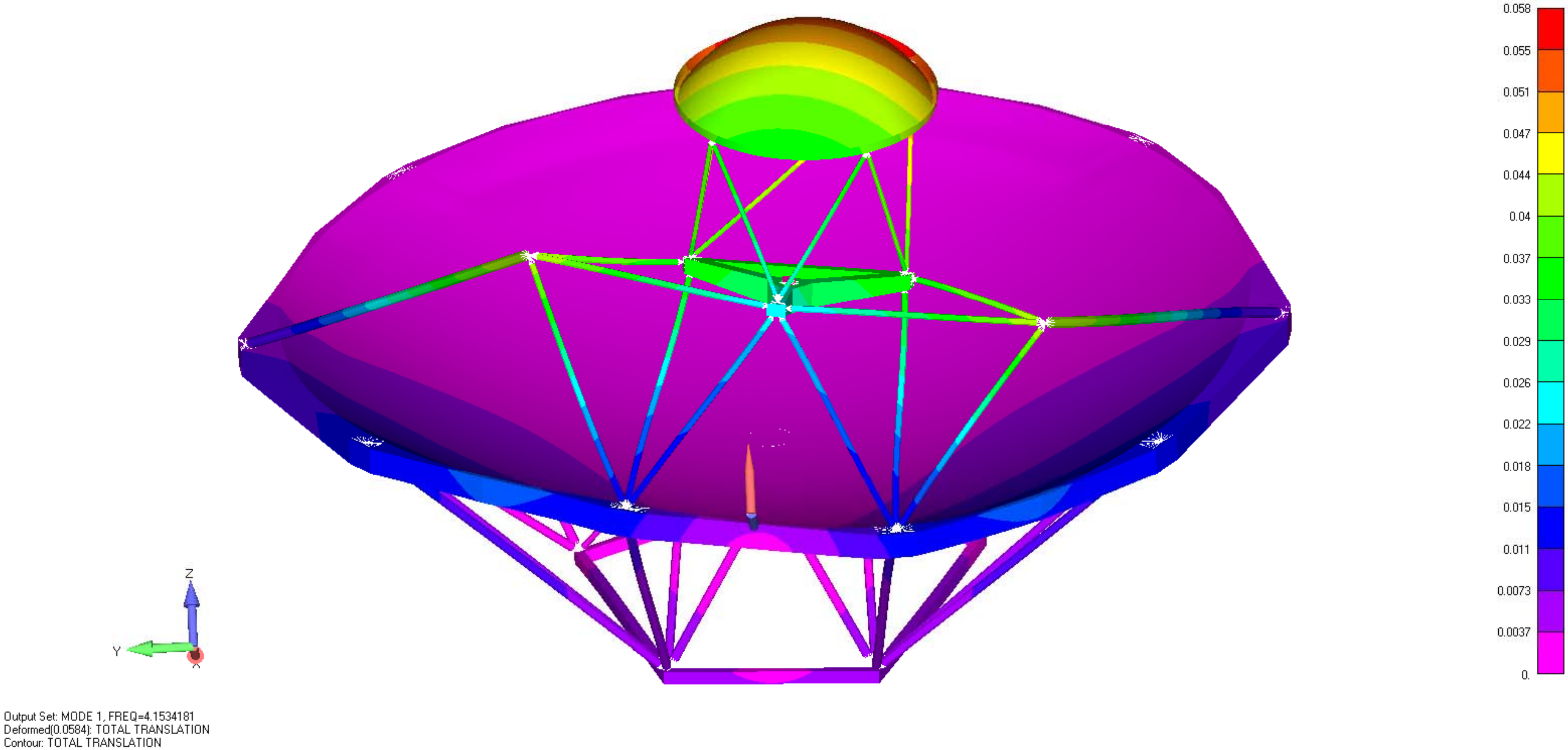
- Max stress 50% Yield



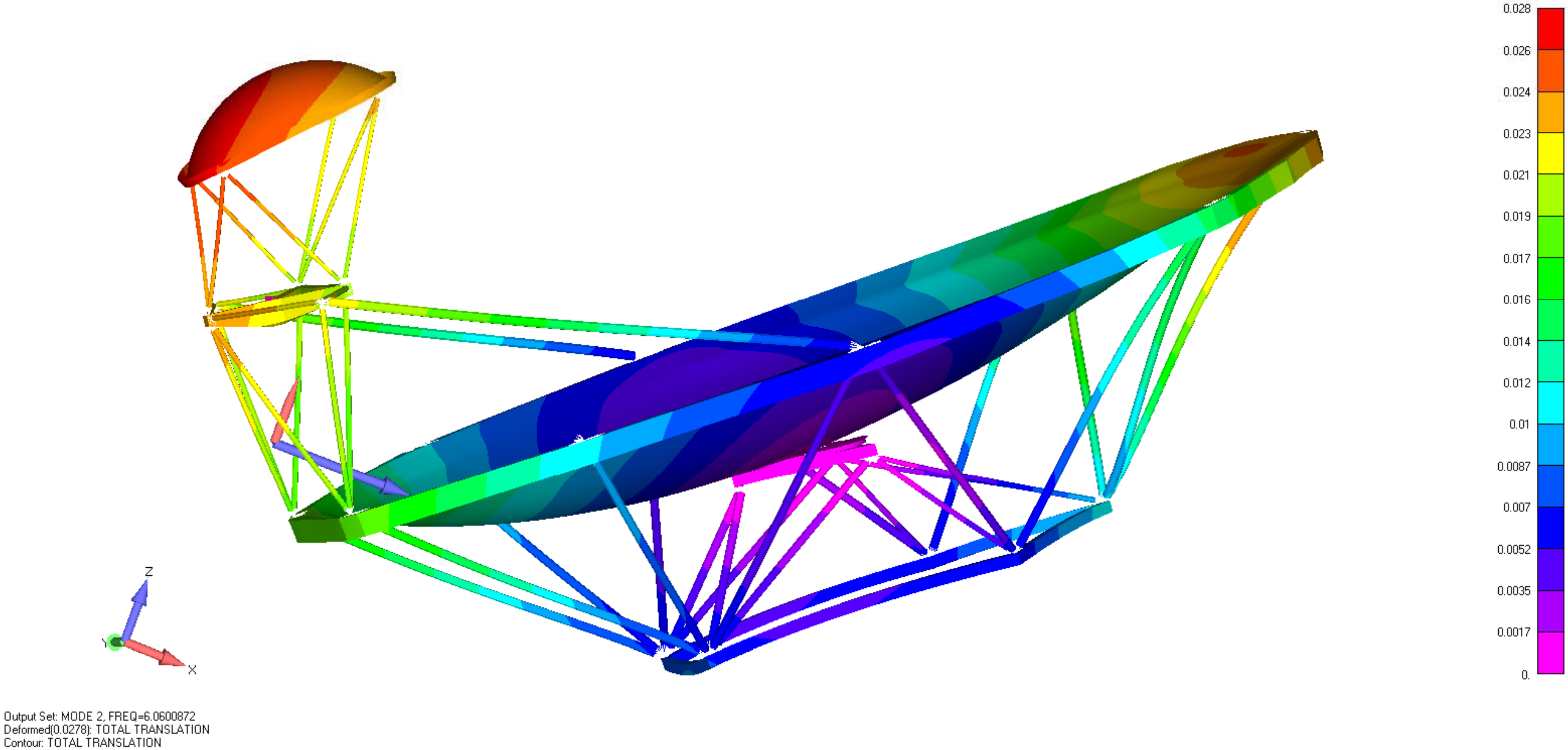
Normal Modes:

Or how does the structure vibrate?

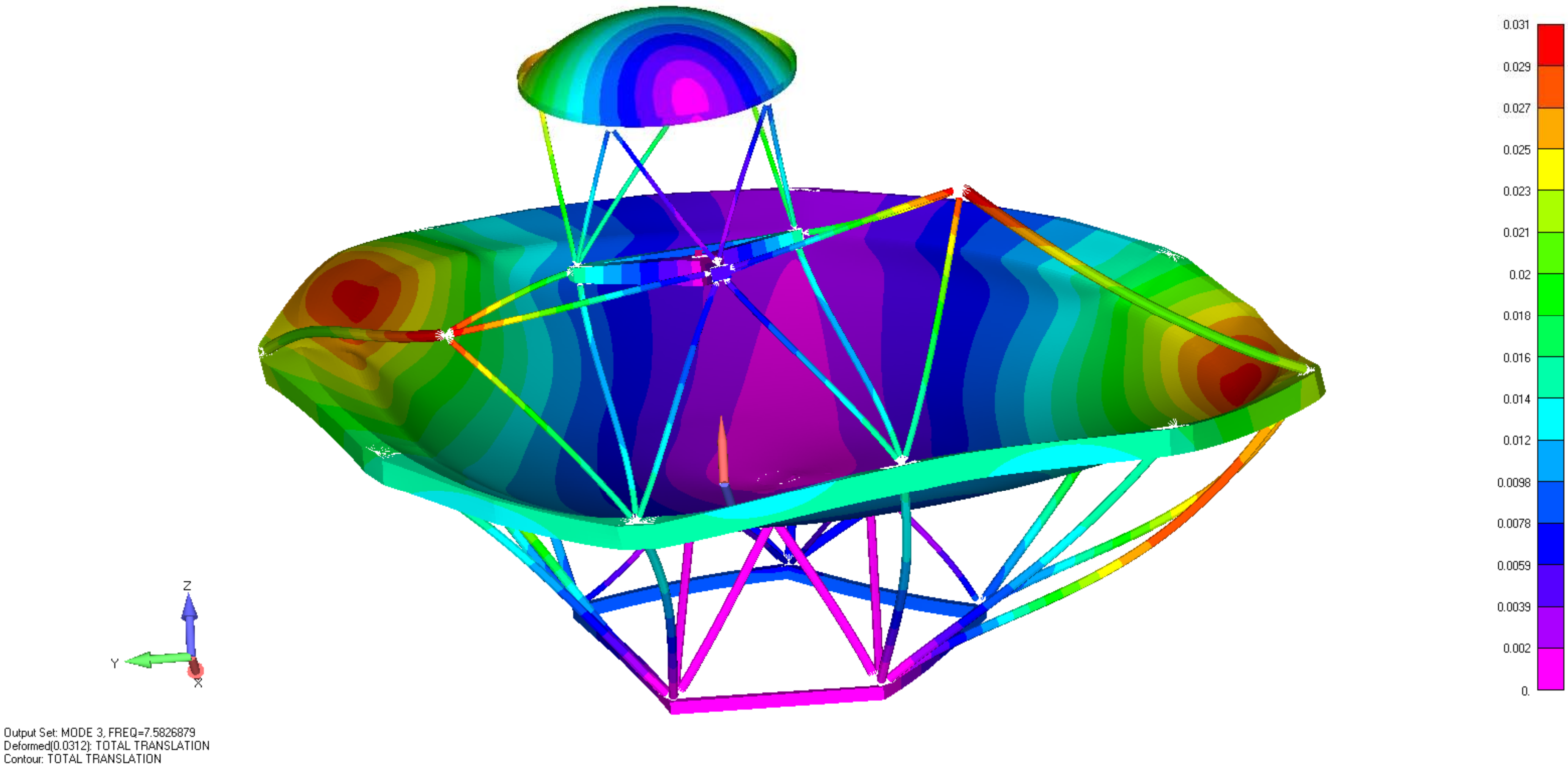
Normal Modes
Fundamental, 4.15Hz



Normal Modes
1'st Harmonic 6.06Hz



Normal Modes
Second Harmonic 7.58Hz



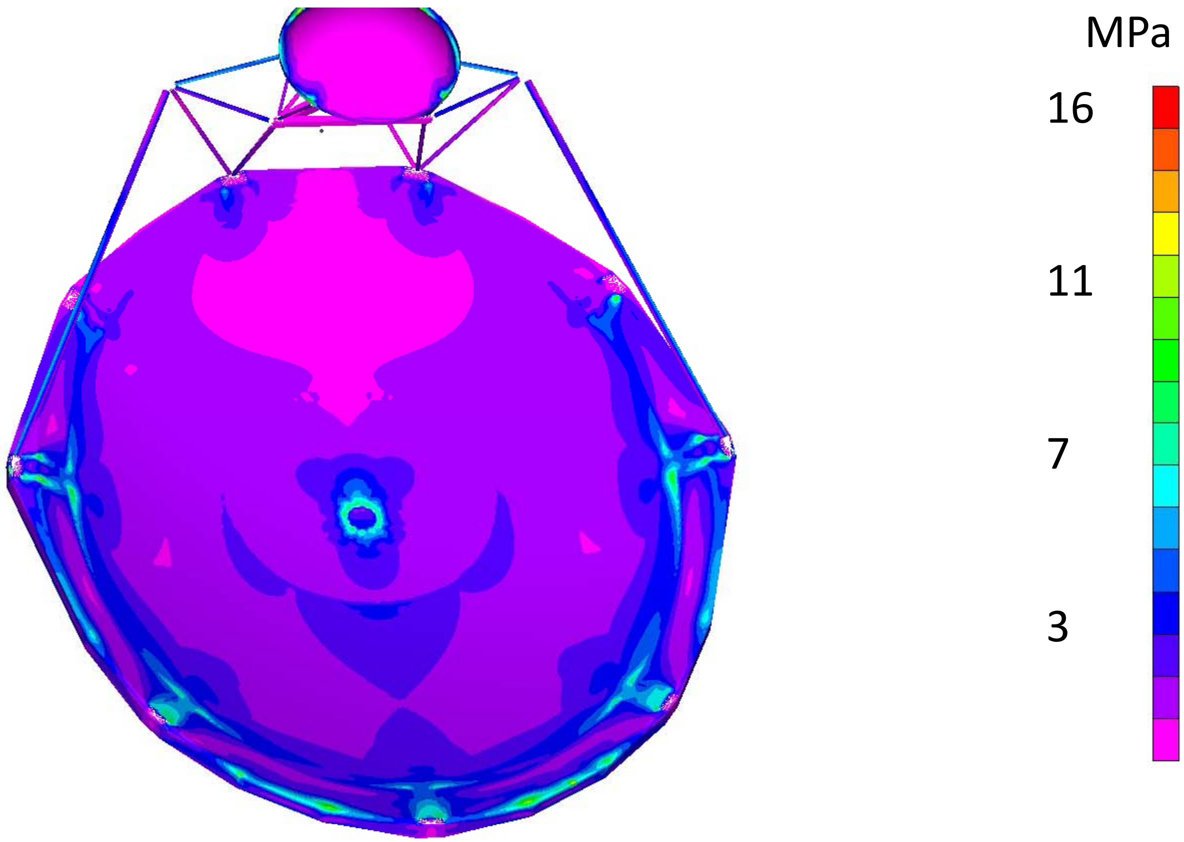
New Results

- Spring-back Analysis:
  - A contract investigation into the effect of “Process Induced Deformation” has been completed. The results show that this effect is small and can be easily controlled for structures of this type.
- 4.2m test part:
  - A 4.2m offset test part was built earlier this year. It’s surface accuracy is very high, similar to the MkII. Thermal measurements with this part are not yet complete, and will be used to model thermal effects on the 15m offset.
- 10m MkII surface stability results:
  - Results from surface measurements of the 10m MkII over a 3 year period will be published at URSI GAS 2011. The structure shows good stability.

End

Von Mises Stresses in Composite Structures at 25kph wind and 15 degree Elevation

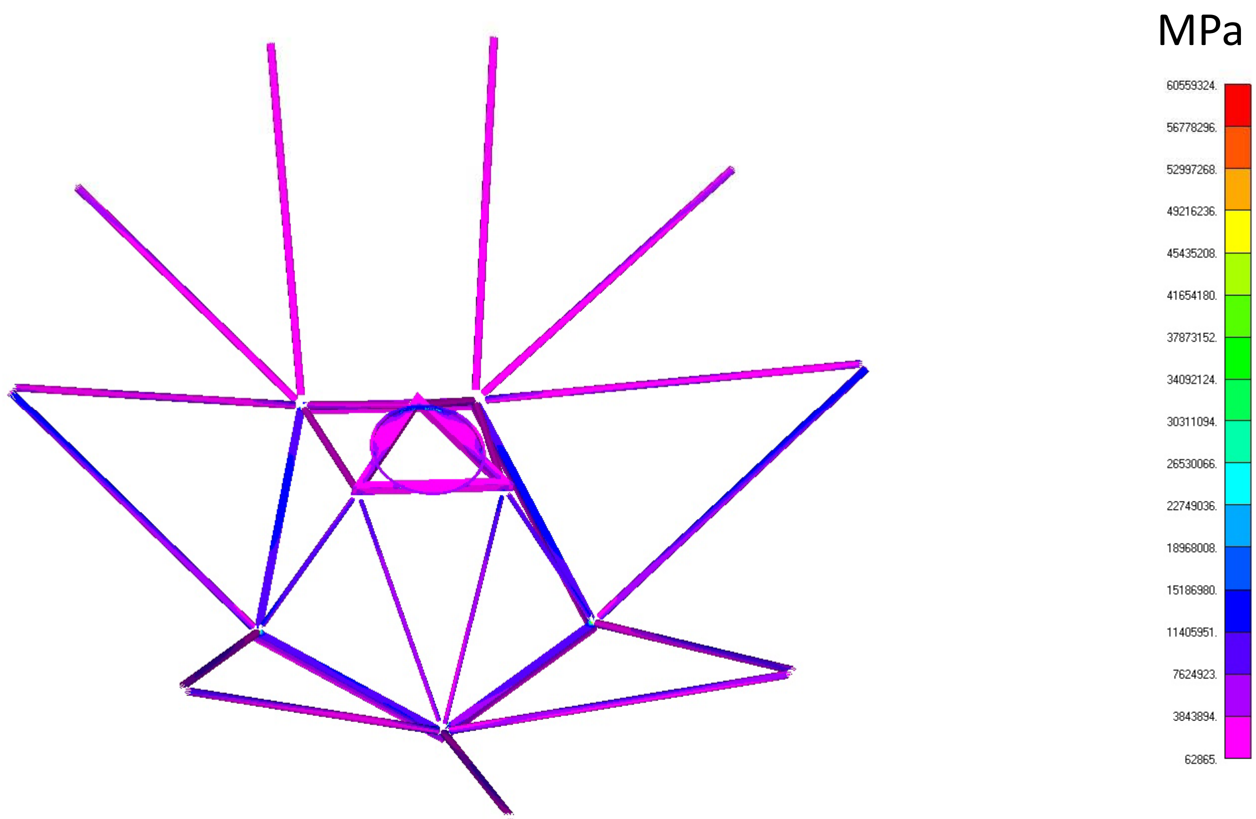
Max stress < 5% ultimate



Output Set: Gravity at 15degrees with
Deformed(0.00391): TOTAL TRANSLATION
Contour: COMP MAX VON MISES

Von Mises Stresses in Metal Structures at 25kph wind and 15 degree Elevation

Max stress < 6% yield strength



Output Set: Gravity at 15degrees with
Deformed(0.00391): TOTAL TRANSLATION
Contour: SHELL MAX VON MISES-1/2

Global Buckling at 162kph and 55 degree Elevation

- Diaphragm buckles at an eigenvalue of 1.58