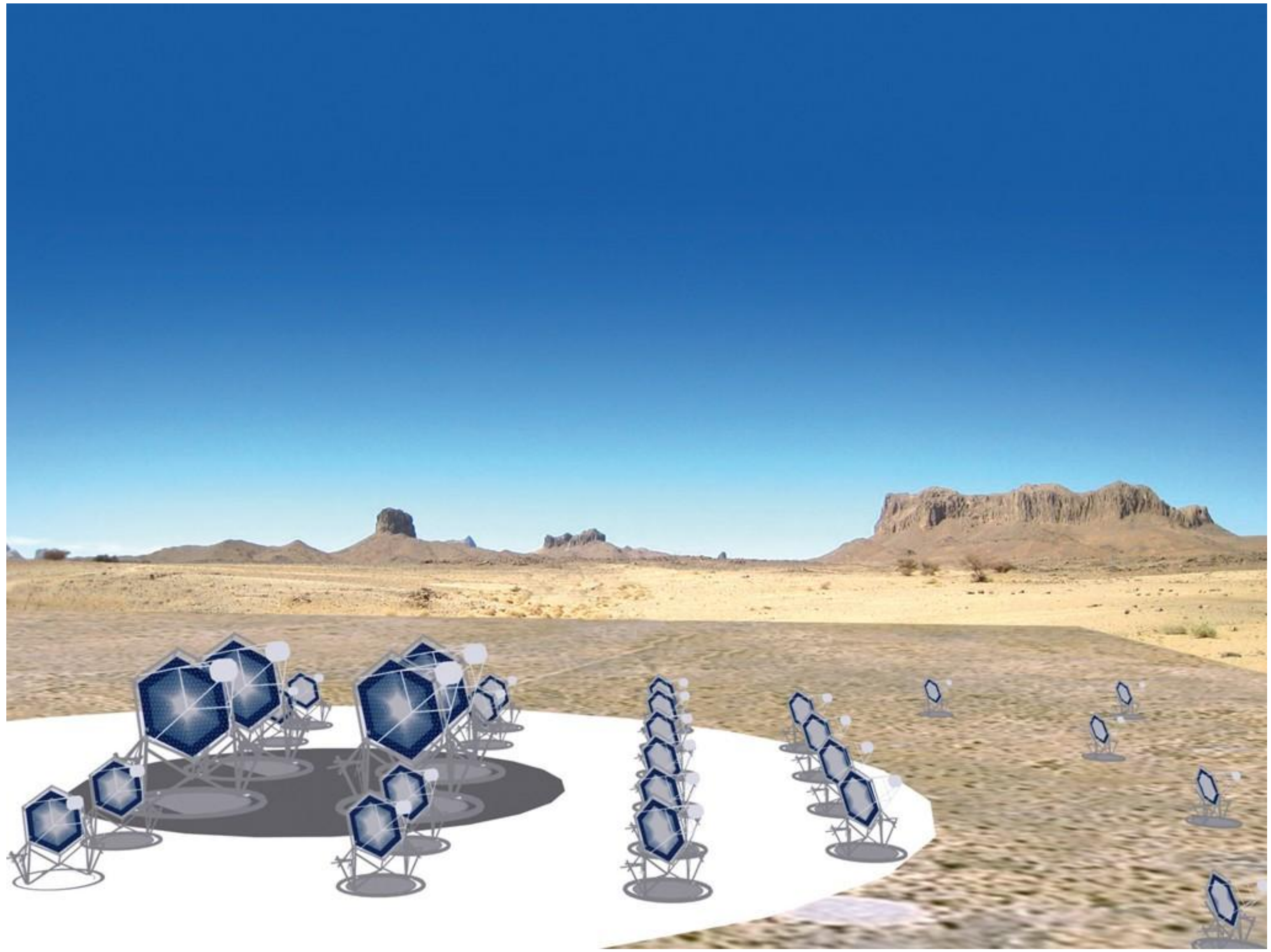
Progress with two-mirror design for high energy section of CTA

- Introduction.
- Mechanical design.
- Costing.
- Summary.

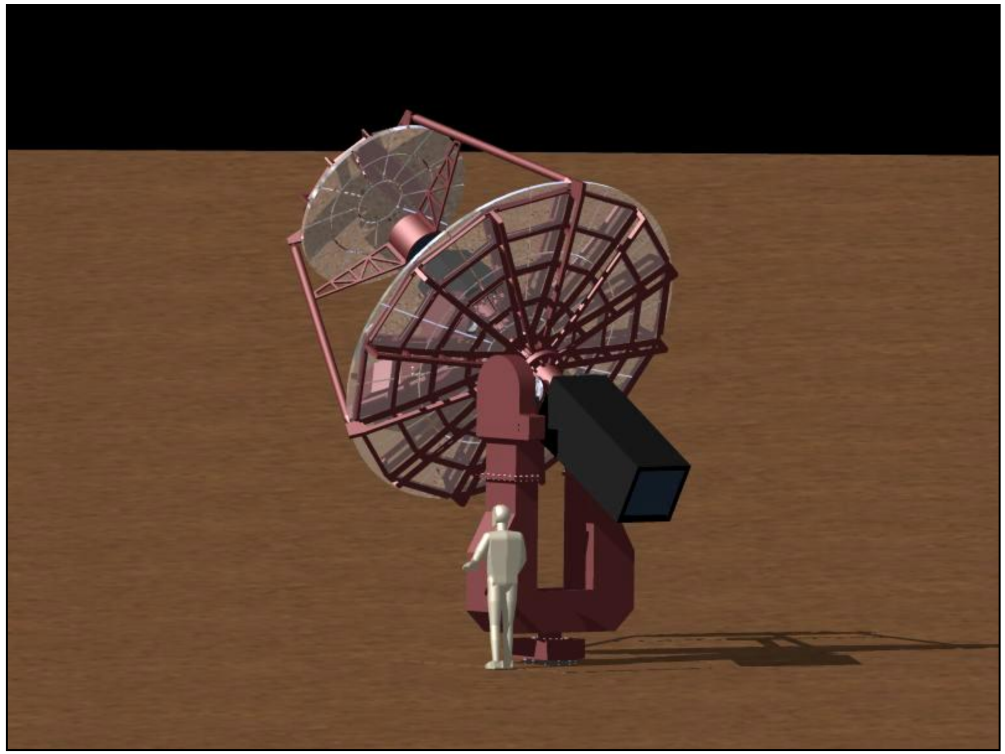


Tim Greenshaw, for Simon Blake, Centre for Advanced Instrumentation, Durham University

Mechanical design

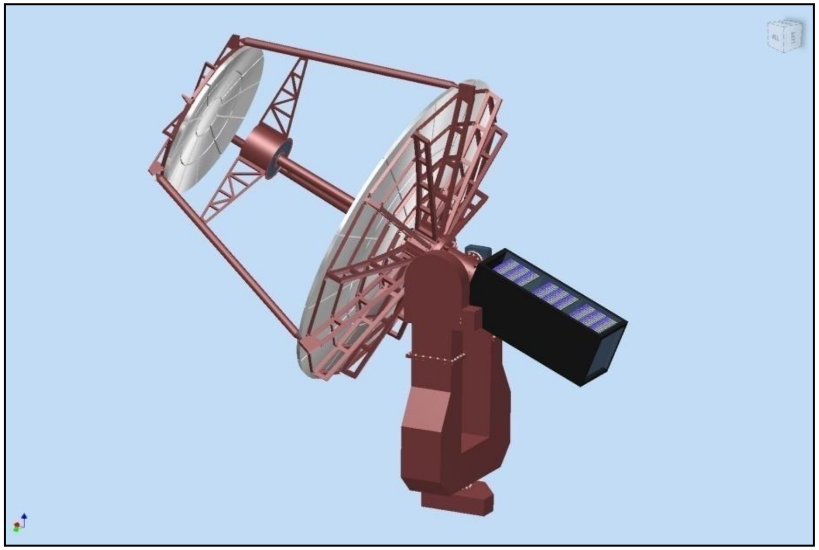
- Design mechanical structure that can satisfy optical tolerances as well as CTA specifications, including:
- Normal operation, wind speed up to 50 km/h.
- Tracking prec. 6' and pointing 10".
- Max. elev. vel. 90/min.
- Max. elev. acc. 0.5/sec^2.
- Max. azim. vel. 180/min.
- Max. azim. acc. 1/sec^2.
- Wind 50...65 km/h, drive to safe position with 70% acc. and vel.
- Wind 65...100 km/h, drive to safe position with 10% acc. and vel.
- Max. survivable wind 180 km/h.

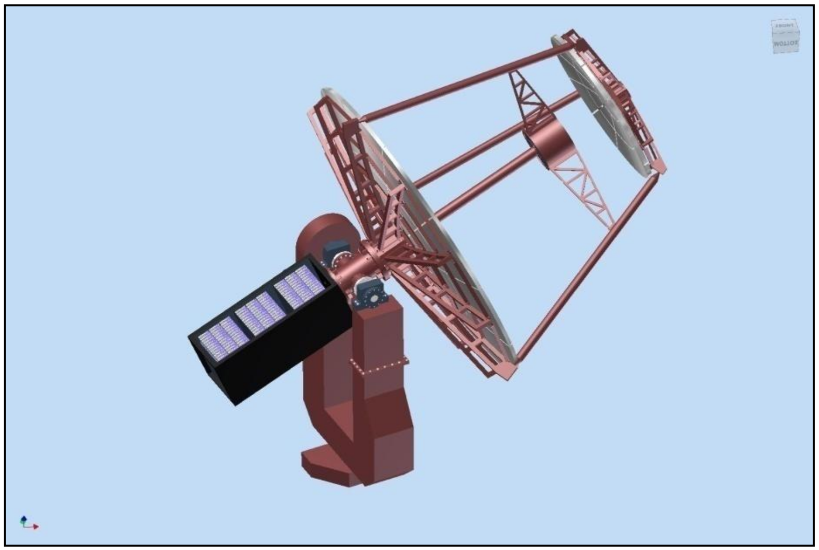
- CTA two-mirror 4 m diameter telescope:



Mechanical design

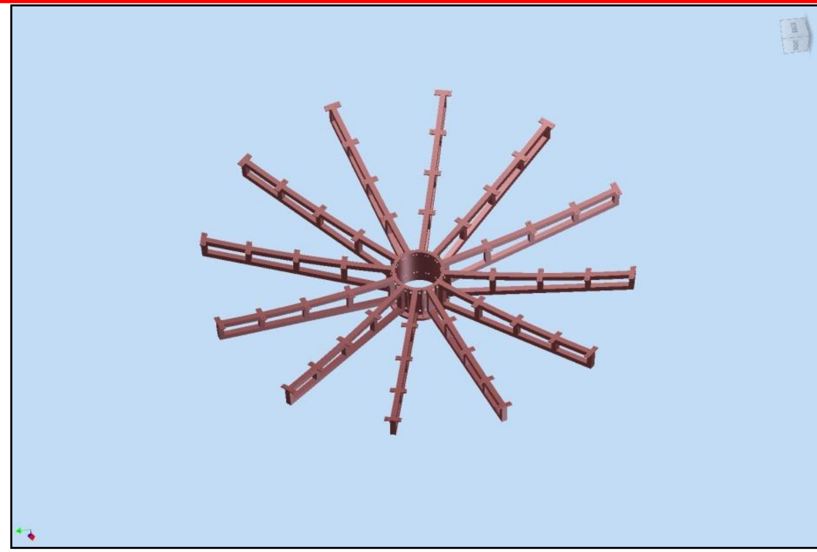
- Principles:
- Simple structures and manufacture, e.g. on-site bolt together “flat-packed” optical tube assembly.
- Modest camera/secondary weight allows counterbalancing with electronics etc. fork mount feasible.
- Use AC servo motor driven worm gears for axis drive as inherently fail-safe; no brakes needed (alternative, torque motors).

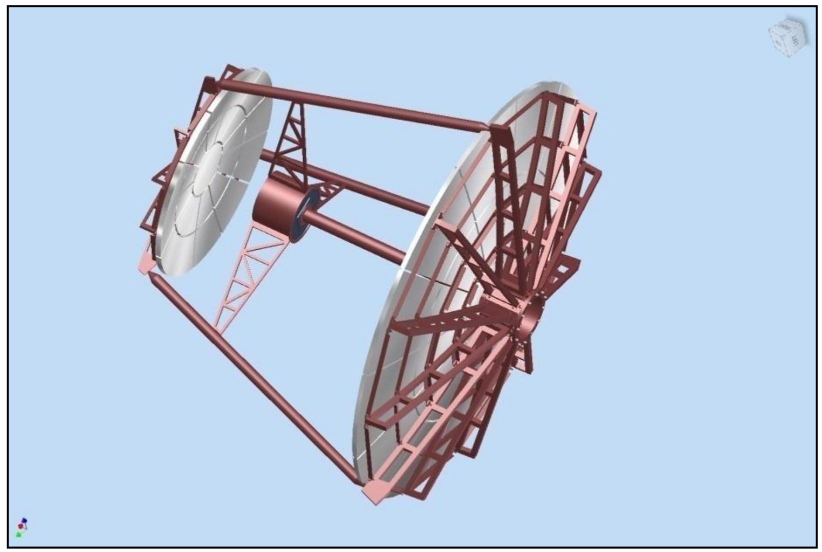




Optical tube assembly

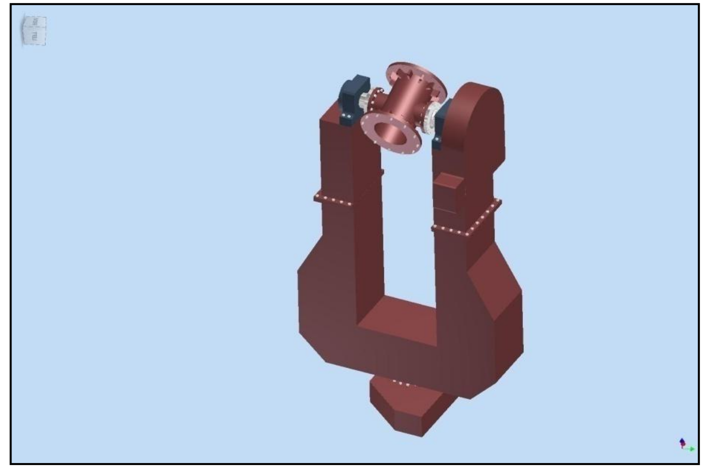
- Optical tube assembly composed of primary and secondary mirror cells, truss tubes and camera support structure.
- Mirror cells fabricated from TIG welded aluminium box sections.
- Bolt to central stiff (rolled and welded) core.
- Support camera using spider arms attached to truss tubes and central perforated tube which carries services for sensors.

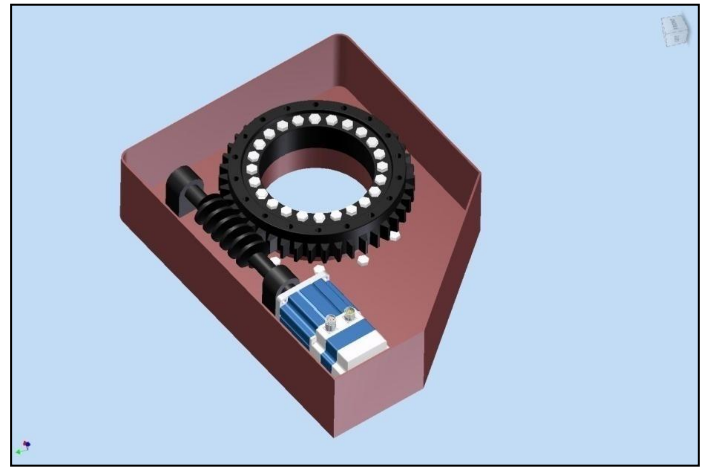


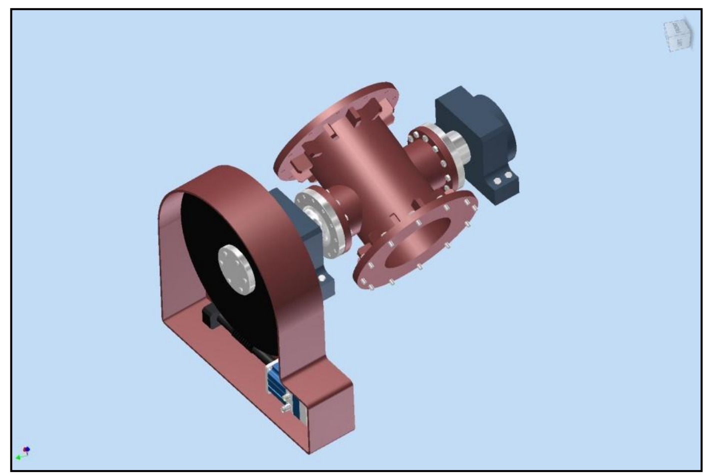


Fork mount

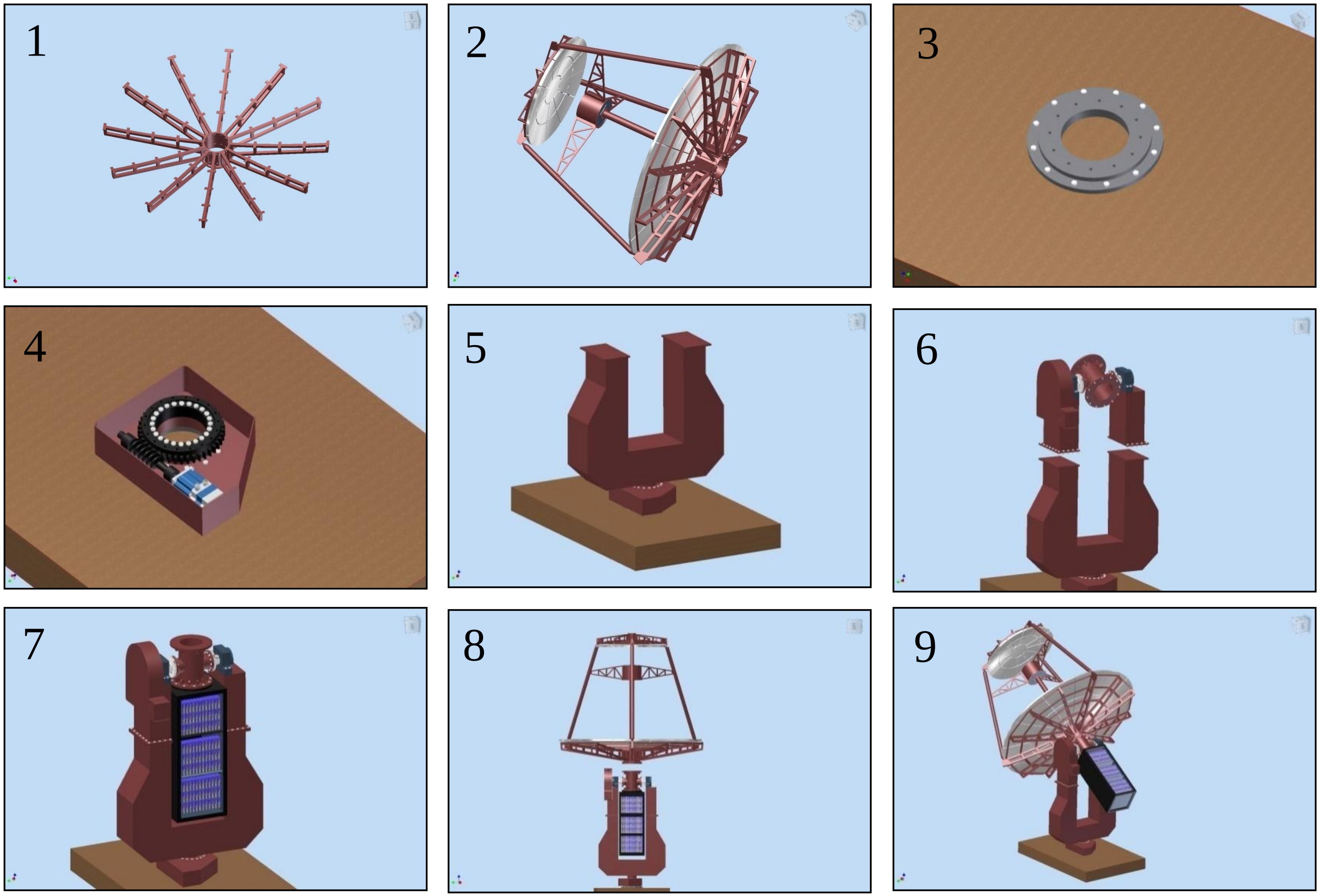
- Modular design, critical assemblies manufactured and tested in workshop.
- Fork arms welded 8 mm steel plate.
- Azimuth: 8 point contact double roller slew bearing with external gear and preloaded worm driven by AC servo motor with absolute encoder.
- Elevation: shafts on 8 point contact double roller bearings, driven by worm-gear and AC motor as above.
- Simple flange joint interfaces to elevation axis ‘core’ for the optical tube assembly and detector electronics (counterweight).
- Worm drives require lower torque and hence power (0.4 kW per axis) than direct drives (up to 6 kW per axis).







Installation



Assembly Sequence.

1. Bolt together mirror cells.
2. Bolt together optical tube assembly.
3. Install azimuth assembly support ring onto foundation slab.
4. Install azimuth drive assembly.
5. Install fork arms onto azimuth drive assembly.
6. Install elevation drive assembly onto fork arms.
7. Rotate elevation drive to zenith and install detector electronics enclosure.
8. Install optical tube assembly.
9. Installation complete!

Further considerations

- Locking pins on axes can be remote operated for (survival stowing) or manually (maintenance).
- Telescope control to prevent out of balance conditions, e.g. switches prevent removal of detector unless altitude locks engaged.
- Minimum elevation –8° to ensure detectors accessible.
- Telescope painted to minimise visibility to detectors.
- Telescope locked in minimum elevation if wind above max.
- Clamshell fabric cover suggested to protect the telescope when not in use.
- Telescope presently shown installed on foundation at ground level.
- Site may require pedestal to prevent abrasion of optics by ground layer wind blown sand.
- Foundation costs dependent upon local geology.
- If telescope is pedestal mounted, could have azimuth platform or use mobile truck mounted platform.

Cost and milestones

- Costs studied in some detail.
- Quotes obtained for major components (e.g. bearings, motors, worm gears...).
- Fabrication costs estimated using material costs, person-power at £40/hr plus 30% margin, in line with recent similar projects.
- Estimate of cost reductions due to mass production from power law in "The Design And Construction Of large Optical telescopes" (Bely).
- Spreadsheet available for detailed discussions.
- Bottom line:
- One telescope, cost T = £79k.
- N telescopes, cost = TN^{α}, where $\alpha = 1 - \log_2\left(\frac{1}{s}\right)$ and $s = 0.9$ here.
- Unit cost for 70 telescopes, £41k.
- Now demonstrate concept for camera and feasibility of mirror construction!

Summary

- Feasibility of optical design of two-mirror telescope demonstrated.
- Tolerances reasonable.
- Mechanical design produced, some FEA still required.
- Costs reasonable.
- Work needed on camera and electronics.
- Study required of construction of necessary aspherical mirrors.