The Leighton Chajnantor Telescope: Project update and mechanical structural analysis in preparations for new deployment in Chajnantor, Chile

J.T. Vial[1], D. Arroyo[1], C. Canales[1], J. Navarro[1], E. Dufeu[1], R. Reeves[1], D. Woody[2], S. Golwala[2], G. Parks[2], Z. Jinbiao[3], L. Jinpeng[3] and M. Yong[3]
[1]University of Concepción, [2]California Institute of Technology, [3]CAS Nanjing Astronomical Instruments Co., Ltd

INTRODUCTION

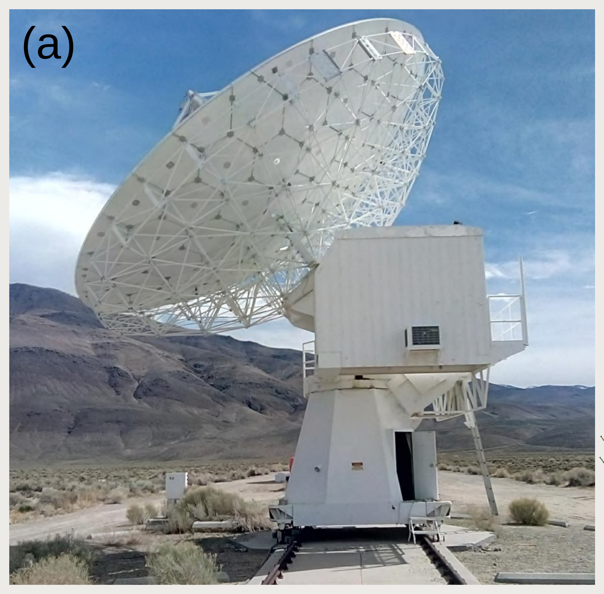
The Leighton Chajnantor Telescope (LCT) project is a collaboration between Caltech, Shanghai Normal University and the University of Concepción, that aims to relocate the Caltech Submillimeter Observatory (CSO) telescope from its current location in Maunakea to the Chajnantor Plateau in northern Chile. By refurbishing and relocating the telescope, the LCT project looks for boosting its performance and observation capabilities in a location with a sky opacity such as the Chajnantor Plateau. Nevertheless, the relocation sets challenges not only due to the site differences, but mainly due to the change in the enclosure type. This work presents some of the ongoing mechanical analyses needed to successfully overcome these challenges.

Figure 1. 10,600 kilometers journey of the telescope from Maunakea to the Chajnantor Plateau.

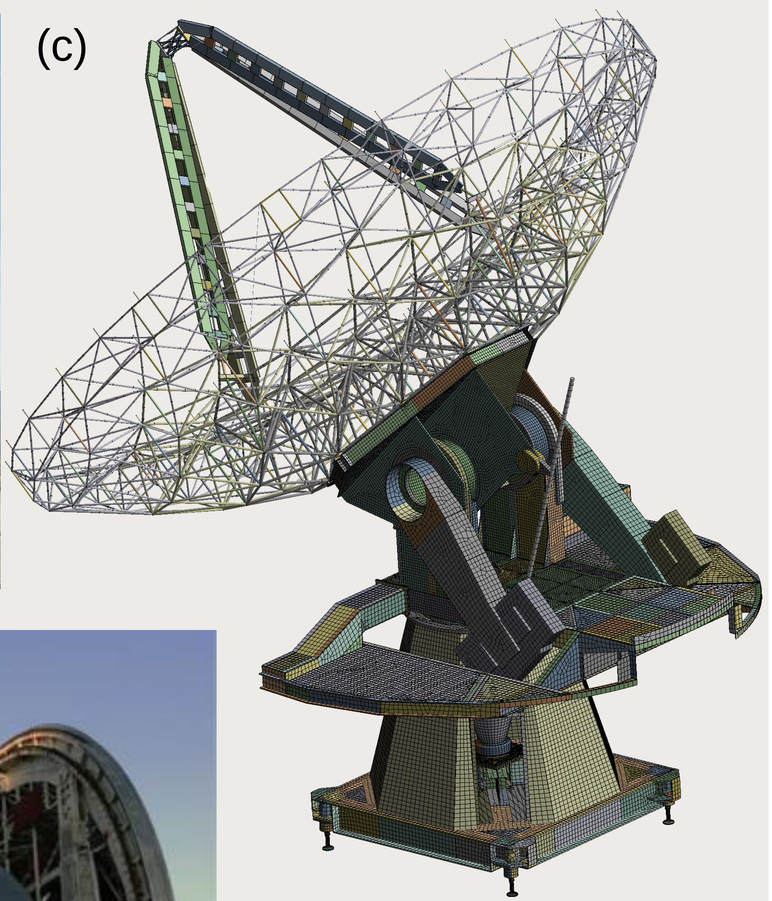
FE MODEL DEVELOPMENT

To perform the mechanical analyses, a detailed finite element model of the CSO antenna was developed using ANSYS software. This model was based on blueprints, photos and a CAD model of the Owens Valley Radio Obersvatory (OVRO) antennas, which are structuraly very similar to the CSO. The model and photos of the telescopes are shown in Figure 2.

(a)



(c)



(b)

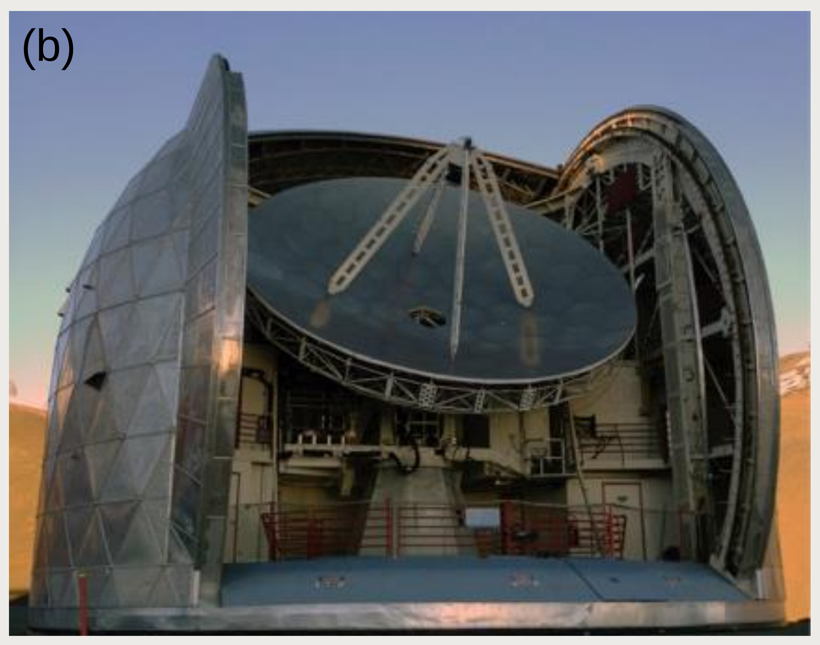


Figure 2. (a) Antenna in OVRO, (b) CSO antenna with its enclosure and (c) FE model of the CSO antenna.

MODEL VALIDATION

The dynamic response of the telescope was analyzed performing modal analysis with the FE model and then comparing with measurements on the CSO. Results of these analyses for the telescope pointing to zenith are listed in Table 1, while mode shapes of two of these eigenmodes are shown on Figure 3.

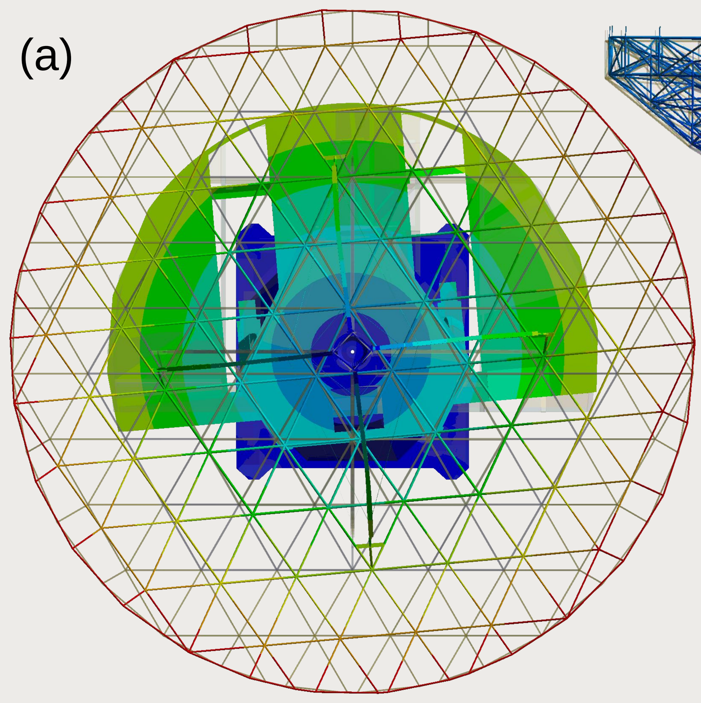
Table 1. FE modal analysis and measurement results at 90° elevation.

Location	Measured frequency [Hz]	FEA model frequency [Hz]
Az. drive	3.91	3.66
Elevation screw	3.20	4.11
	4.0	4.44
Counterweight arms	5.37/6.75*	8.95/8.76*
Feedlegs	8.85	8.34
	10.05	10.78

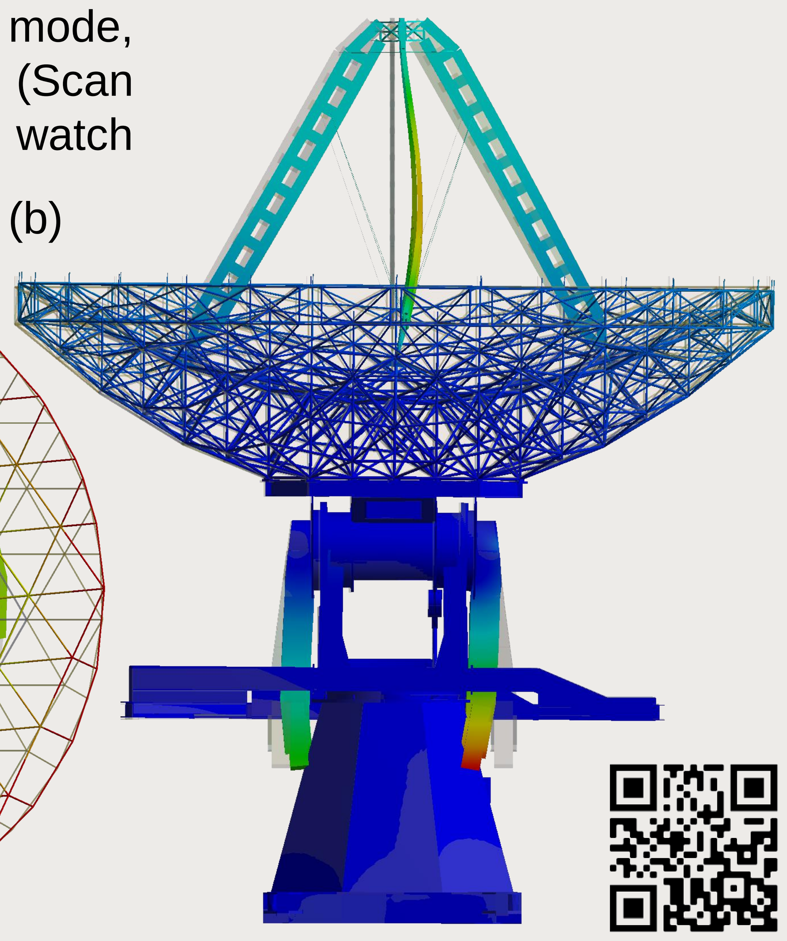
(*) left/right seeing the telescope from the front.

Figure 3. (a) Azimuth drive mode, (b) Counterwight arm mode. (Scan or click QR code to watch animations).

(a)



(b)



Results from the validation show a good representation of the dynamic response of the telescope with the FE model.

TELESCOPE IN CHAJNANTOR

In Hawaii, the telescope has a co-rotating dome, while in Chile it will instead have a retractile kind of enclosure. This new configuration, fully exposing the telescope during observation, demands a deep analysis of how will the telescope work, considering the harsh weather conditions at the Chajnantor Plateau.

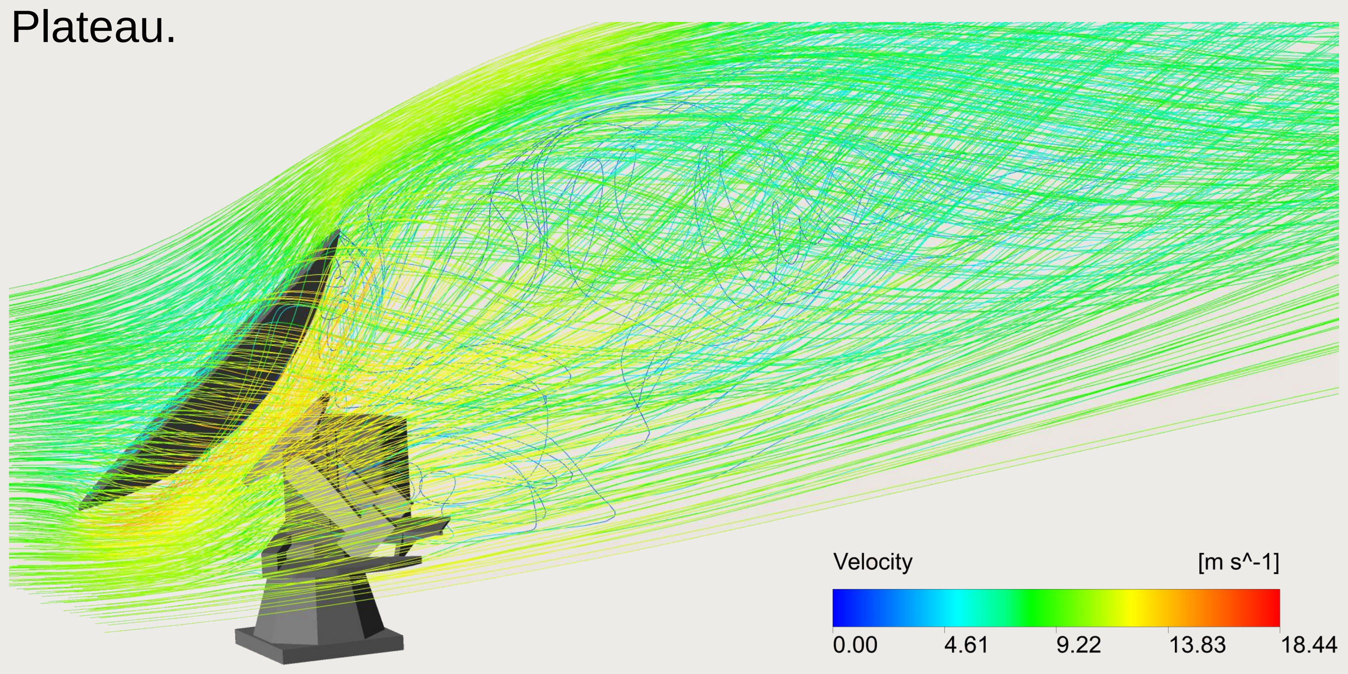
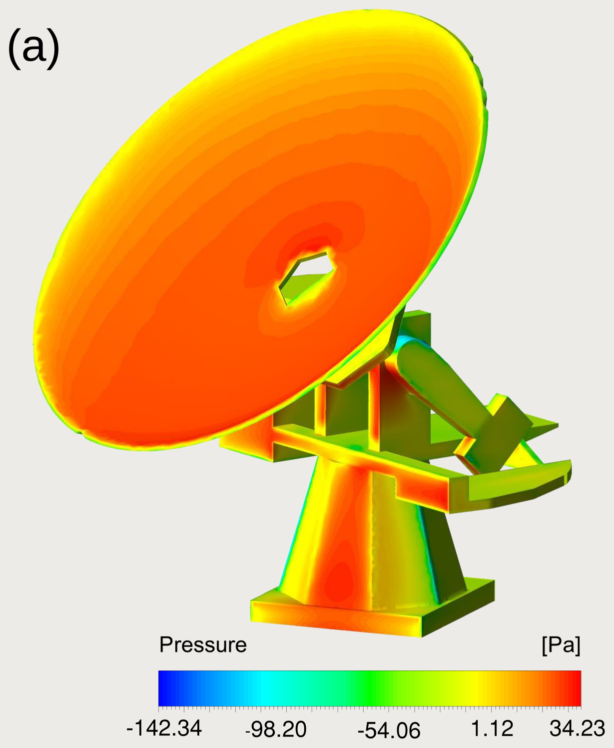


Figure 4. CFD Analysis of the telescope, 10 [m/s] wind speed with telescope oriented at 30° Az and 45° El, ρ_{air} = 0.715 [kg/m^3].

The FE model, alongside Computational Fluid Dynamics (CFD) tools, allow to simulate the conditions that the telescope will face in its new location. Figures 4 to 6 show as an example some of these analyses for the case where the telescope is oriented at azimuth 30° and elevation 45° with a 10 [m/s] windspeed.

(a)



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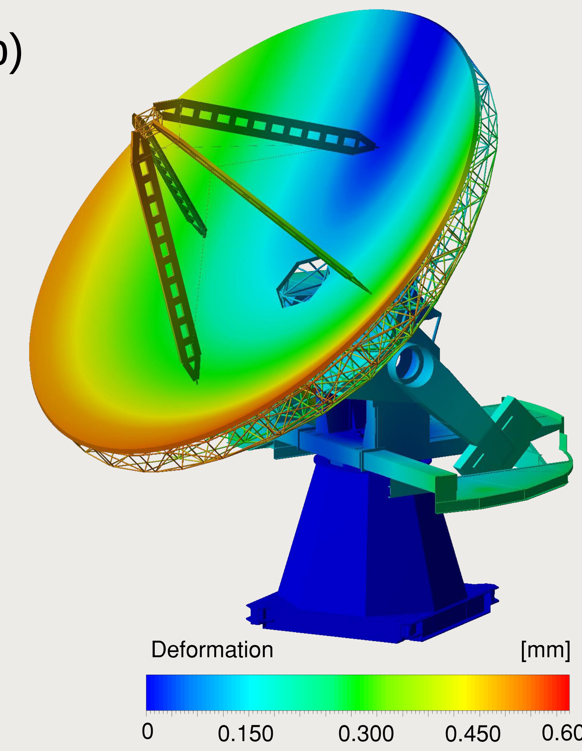
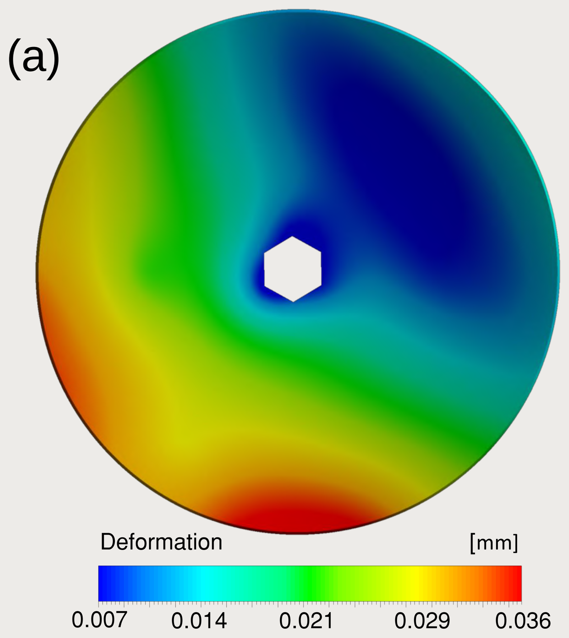


Figure 5. (a) Pressure distribution and (b) resulting deformation due to pressure.

(a)



(b)

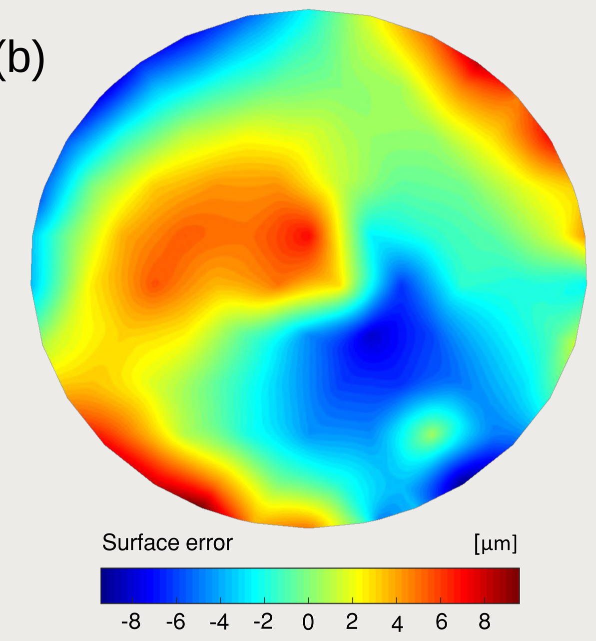


Figure 6. (a) Raw deformation map of the primary mirror and (b) best fit paraboloid surface error map.

The deformation of the primary mirror and the induced surface error for the shown case are inside expected and reasonable values. The moments generated on the azimuth and elevation axis are 2267 and 1958 [Nm] respectively, which are resisted by the drives and control system, avoiding the deformations (mainly an azimuth rotation) seen on Figure 5(b) (static analysis).

CONCLUSIONS & FUTURE WORK

A detailed FE model of the telescope was developed and successfully validated. Coupling this model with CFD simulations gives the opportunity to virtually test the telescope in the Chajnantor Plateau. The preliminary results showed a good performance of the telescope in its new location.

Besides the analysis showed, there are other challenges where this model will be very helpful:

- Telescope drives and control loops upgrade.
- Design of the foundation for the telescope considering the Chilean seismic activity.
- Design of the infrastructure for the transportation of the telescope and analysis of it during the transportation process.

Transportation of the telescope is expected to begin during 2021 while first light is expected to be during 2022.

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Author contact: jovial@udec.cl