Large Synoptic Survey Telescope

LSST Summit Testing and Facility Design

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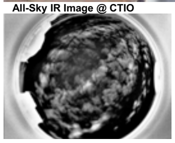
The LSST facility design layout atop the El Peñón summit in Northern Chile makes use of the natural terrain to provide efficient use of space and natural ventilation. Initial numerical fluid models of the site and the 30-m cylindrical dome indicate good flow across the terrain and more than 50 dome air changes per hour in median wind conditions. The recent geotechnical survey data shows exceptional bedrock quality that contributes to an 8.3 hz first natural frequency of the telescope analyzed on the pier and foundation. The ongoing survey of weather and astronomical conditions is providing data for engineering and is adding to the database that guides operational planning and performance predictions.

An infra-red all-sky camera was recently installed on Cerro Pachon. It is located near the SOAR telescope on the same post used by the visible SOAR All-Sky Camera (SASCA).

All-Sky InfraRed Camera

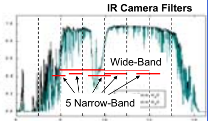
All-Sky IR Image @ CTIO



The IR camera is sensitive in the 8-12 micron atmospheric window. It includes six filters, one wide-band filter and five narrow-band filters. The system uses an IR fish-eye lens to get a 180deg field of view. A black body located in the protective lens hatch cover is used periodically during the night to get a reference image.

During regular night operation, the LSST scheduler will be used to select fields.

IR Camera Filters

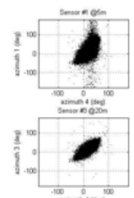


Real-time adjustments to the schedule will be assessed using input parameters like cloud cover. The current focus is on the detection of high cirrus clouds. These clouds are usually thin and difficult to detect. Our plan is to compare the images from SASCA and the IR Camera in different cloud cover conditions in order to correlate temporal and spatial variations.

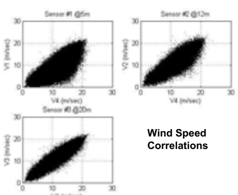
Anemometer Tower

A 30m wind tower was installed on the El Peñón Peak where the telescope will be located. This tower is equipped with 4 wind anemometers that record wind speed, direction and temperature. The sensors are located at 5m, 12m, 20m and 29m height from the ground. The measurements will be collected for approximately 1 year.

Examples of wind speed and azimuth correlations between the anemometers at different heights (5m, 12m, 20m and 29m). The highest sensor is used as reference on the x-axis.



Azimuth Correlations

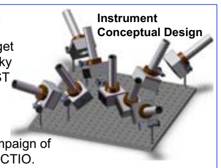


Wind Speed Correlations

Site Characterization

Beyond the site testing already completed, a primary objective of the ongoing site characterization is to measure the height of the boundary layer to determine the height of the telescope. In addition, the plan is to monitor the sky brightness in the z and Y science filter bands to create an accurate model as input to the LSST operational simulator. The characterization campaign also includes the detection of high cirrus clouds using infrared and optical all-sky cameras for scheduling and calibration purpose. To that end, LSST is using three instruments described here in more details.

Sky Brightness Monitor



A new instrument is being developed to get an accurate measurement of the mean sky brightness over Cerro Pachon in the LSST z and Y science filter bands. This instrument will be able to monitor spatial and temporal variations.

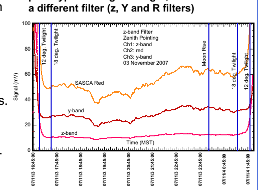
A prototype has been built and a first campaign of measurements was recorded recently at CTIO.

The prototype consists of 3 single channel units that can be pointed in any (Az, El) direction. Each unit has a field of view of 7deg. It is built around a calibrated photodiode with a peak sensitivity around 960nm. A wide-band filter is located in front of the photodiode to select the wavelength.

The data recorded with this instrument will be used to create an accurate model of the sky brightness as input to the LSST operational simulator. This model will include the twilight periods during which the LSST will be observing in the z and Y filter bands.

The final version of the instrument will be populated with nine of these single channel units to cover all directions simultaneously.

Example of measurements recorded on the prototype. During that night, each unit had a different filter (z, Y and R filters)

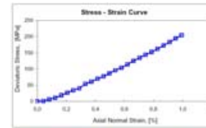


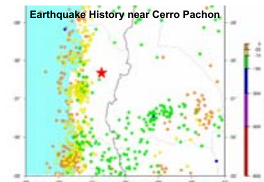
Geotechnical Work

An initial geotechnical investigation was undertaken to validate preliminary foundation assumptions & to provide data for planning of major excavation. 3 test borings were performed by IDIEM – a department of the University of Chile. On site inspection to locate dikes (major natural rock discontinuities) showed that none were found at the proposed telescope site. General rock quality was assessed according to established geotechnical standards and it was rated as "good to very good" at the depth of telescope pier foundation.

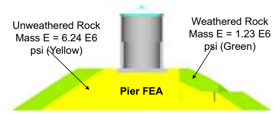
Subsequent lab testing determined the following characteristics of the unweathered rock on which the telescope pier will bear:

- -Bearing Capacity = 230 Mpa
- -Average Young's Modulus (E) of rock mass = 36,000 MPa (6,244,000 psi)
- -Poisson's Ratio – 0.29
- -Estimated Settlement under pier ~0.3mm





Lab Stress Measurements from Boring Samples



For structural design IDIEM recommends using a maximum seismic acceleration of 0.40g which is the same value LSST independently determined by review of seismic history and assumptions made for Gemini Design.

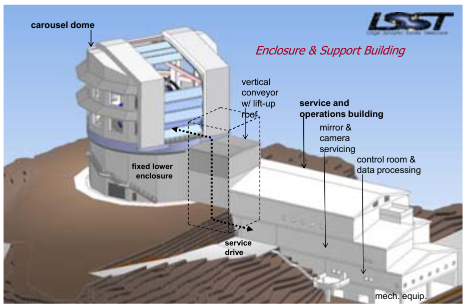
Greater depth of the plate interaction at more inland locations, such as under the Cerro Pachón area, results in typically deeper and less frequent seismic events. From wedge and planar sliding kinematic stability analysis it was determined that slopes will present a stable behavior

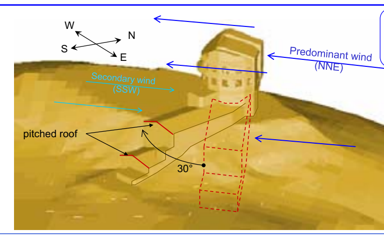
This geotechnical data has now been incorporated into FEA of the telescope–pier–site structure. The resulting LRF of 8.3 Hz meets the derived stiffness requirements of the overall system. The geotechnical report provides sufficient data to proceed with specifications and plans for leveling the platforms for the telescope and buildings

The next step is to submit an Environmental Impact Declaration (along with the Baseline Biological Studies already completed) before site leveling and more in-depth geotechnical work can be started. No major cultural or environmental issues are anticipated from that study.

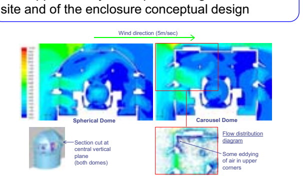
Facility Design

Proposed Plan for LSST Facilities on the summit



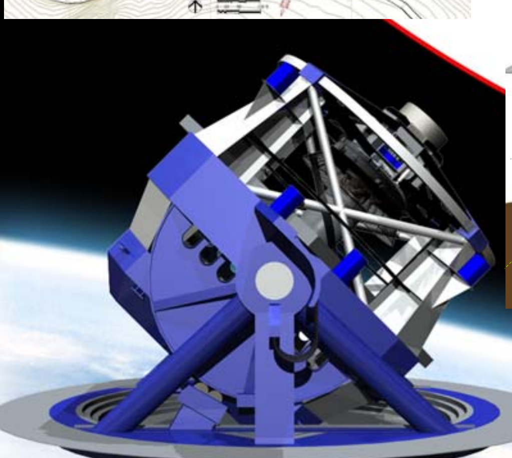


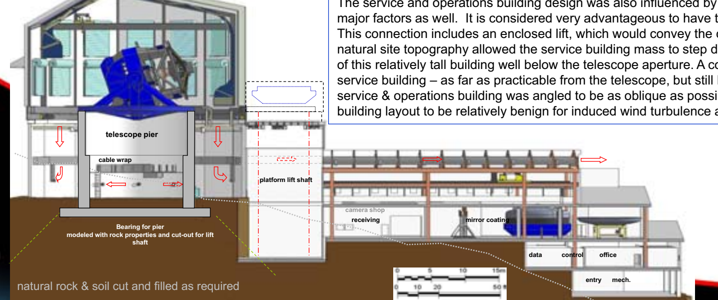
Computational Fluid Dynamic (CFD) analysis of the support facility conceptual design on the summit site and of the enclosure conceptual design

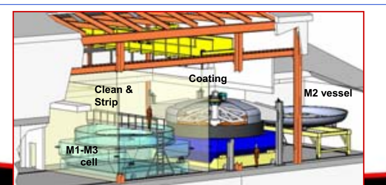


The enclosure and support facility conceptual designs were developed through evaluation of alternative concepts, including CFD analysis of wind flushing performance, as well as consideration of functionality and feasibility criteria. For interior flushing around the telescope the 30m cylindrical (carousel) dome outperformed a similarly sized spherical dome – largely because the carousel has more surface area for ventilation openings, and the openings were naturally more perpendicular to the wind flow. The proposed dome size, shape and configuration are very similar to the existing VLT domes. Preliminary structural and cost analysis indicates that the carousel has somewhat simpler mechanisms and can be more readily structured than the spherical concept that was used for comparison.

The service and operations building design was also influenced by site wind flow analysis, although practicality and topography were major factors as well. It is considered very advantageous to have the service building directly connected to the telescope enclosure. This connection includes an enclosed lift, which would convey the camera and mirrors up and down for periodic maintenance. The natural site topography allowed the service building mass to step down from the main peak to a saddle area below. This places the roof of this relatively tall building well below the telescope aperture. A conditioned operations and mechanical building is located below the service building – as far as practicable from the telescope, but still having a direct, enclosed pathway to the telescope. The entire service & operations building was angled to be as oblique as possible to the prevailing wind direction. Site CFD analysis shows this building layout to be relatively benign for induced wind turbulence and within the tolerance for site-seeing contribution.







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