

## CCAT Facilities Concept Feasibility/Concept Study Review

M3 Engineering & Technology Corporation

### Presentation Summary



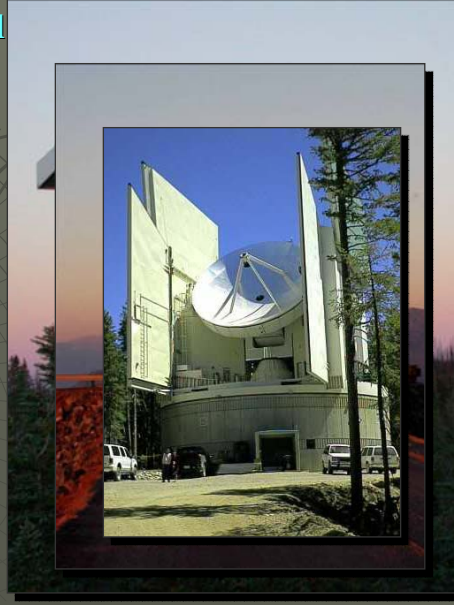
- ◆ M3 Engineering & Technology Corp.
- ◆ Scope of Work
- ◆ Site Access Road
- ◆ Mountain and Support Facility Requirements and Concept Design
- ◆ Support Facility Requirements and Concept Design
- ◆ Critical Risk Assessment

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## M3 Engineering & Technology Corp.



- ◆ Full Discipline Architectural and Engineering Firm
- ◆ Offices in Arizona, Mexico
- ◆ Specialize in Telescope Enclosures and Support Facilities
- ◆ Over 17 Years Experience in Telescope Observatory Design and Construction
- ◆ Projects in Arizona, California, Hawaii, New Mexico, Texas and Chile
- ◆ Design Experience of All Observatory Sizes and Dome Configurations



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## M3 Current Telescope Enclosure Projects



- ◆ ALMA AOS Site Infrastructure and Technical Support Facility, Chajnantor, Chile
- ◆ Discovery Channel Telescope Observatory, Happy Jack, Arizona
- ◆ SST Enclosure, White Sands Missile Range, New Mexico
- ◆ Mew Mexico Tech Interferometer Array, Magdalena Ridge, N.M.
- ◆ GMT Enclosure Concept Design and Cost Study
- ◆ TMT Facilities Concept Design and Cost Study
- ◆ LSST Concept Design and Cost Study

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## Scope of Work



- ◆ **Concept Design Study and Budget Estimate**
  - **Site Access Road**
  - **Mountain Facility: Cerro Chajnantor**
    - ◆ Telescope Foundation
    - ◆ Telescope Base Enclosure and Control Facility (Excluding Dome)
    - ◆ Site Infrastructure and Improvements
  - **Support Facility, San Pedro de Atacama**
    - ◆ Administration and Dormitory Facilities
    - ◆ Site Infrastructure and Improvements

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## Site & Access Road



- ◆ **Three Potential Sites in the Atacama Region**
  - ◆ Sairecabur (Existing Road Used by Smithsonian Telescope)
  - ◆ Cerro Chascon
  - ◆ Cerro Chajnantor (For the purpose of the conceptual design, CCAT selected Cerro Chajnantor as the preferred site.)
- ◆ **Road Design Criteria:**
  - ◆ 4 meter Wide, Single Lane, Dirt Access Road with Guardrails and Safety Pullouts
  - ◆ Minimum Width Required to Transport Large Instruments and Telescope Parts
  - ◆ Minimize Switchbacks
  - ◆ Maximum 10% Grade
  - ◆ Cut and Fill Slopes at 2:1
  - ◆ Culverts for Proper Drainage, Minimize Erosion
  - ◆ Locate the access road on the mountain side exposed to the sun thereby minimizing snow and ice build-up

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## Site Access Road: Cerro Chascon



- ◆ Located Within the CONICYT Science Preserve
- ◆ Site Elevation: 5675m
- ◆ Total Length: 13 Kilometers
- ◆ 3.0 Kilometers of Road at 10% Grade.
- ◆ 5 Switchbacks
- ◆ Most of the Road Located on the Southeast Side of the Mountain

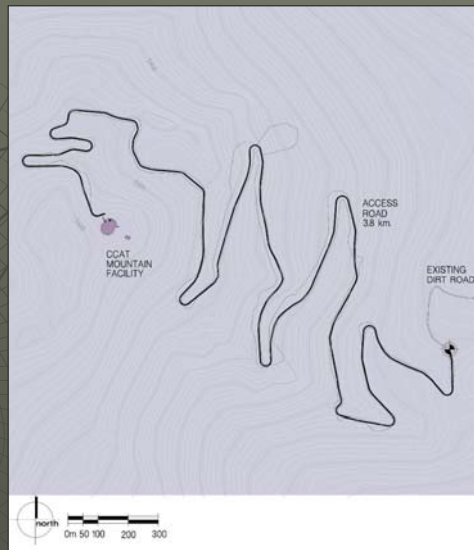


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## Site Access Road: Cerro Chajnantor



- ◆ Within the CONICYT Expanded Science Reserve
- ◆ Site Elevation: 5600m
- ◆ Total Length: 6.26 Kilometers
- ◆ 15 Switchbacks
- ◆ Most of the Road on the East and North Side of the Mountain.
- ◆ Plateau Just Northeast of the Peak is the Preferred Mountain Facility Location



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## Mountain Facility Requirements



- ◆ **Telescope Foundation**
- ◆ **Dome Foundation**
- ◆ **Control Building**
  - Local Control Room and Open Office Space
  - Conference Room, Kitchenette, Toilet/Shower
  - Computer and Backend Room
  - Instrument Preparation Lab and Workshop
  - Mechanical / Electrical Support Space
- ◆ **Utility Building and Lay Down Yard**
  - Electric Power Generators and Transformers
  - Chillers and Pumps
  - Domestic and Fire Water Holding Tank and Pumps

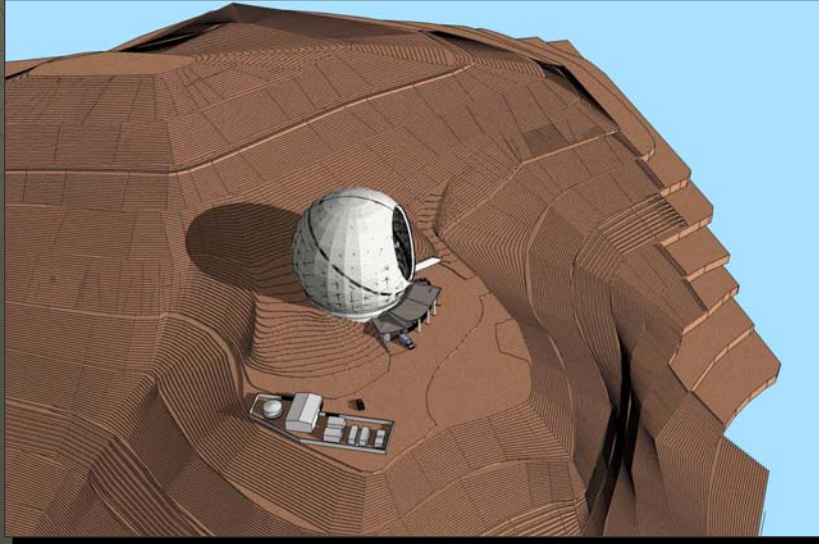
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## Mountain Facility: Site Plan



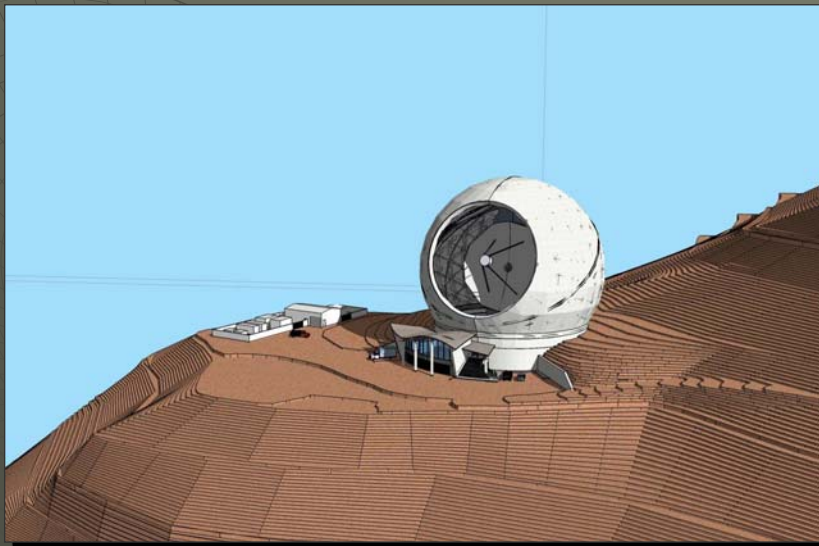
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## Mountain Facility: Aerial View



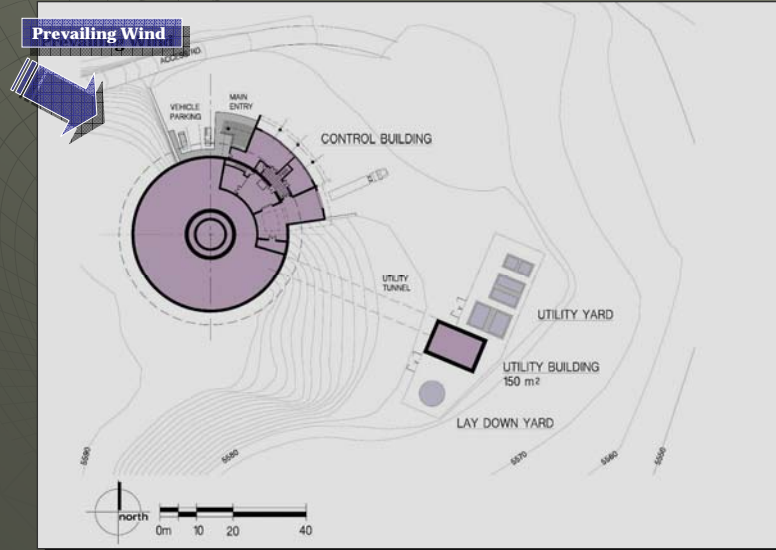
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## Mountain Facility: Aerial View



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## Mountain Facility: Site Plan



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## Mountain Facility: Grade Level Plan



- ◆ Receiving
- ◆ Computer Backend
- ◆ Instrument Lab
- ◆ Mechanical, HVAC, Hydrostatic Oil
- ◆ Electrical
- ◆ Circulation to Second Level



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## Mountain Facility: Observing Level Plan

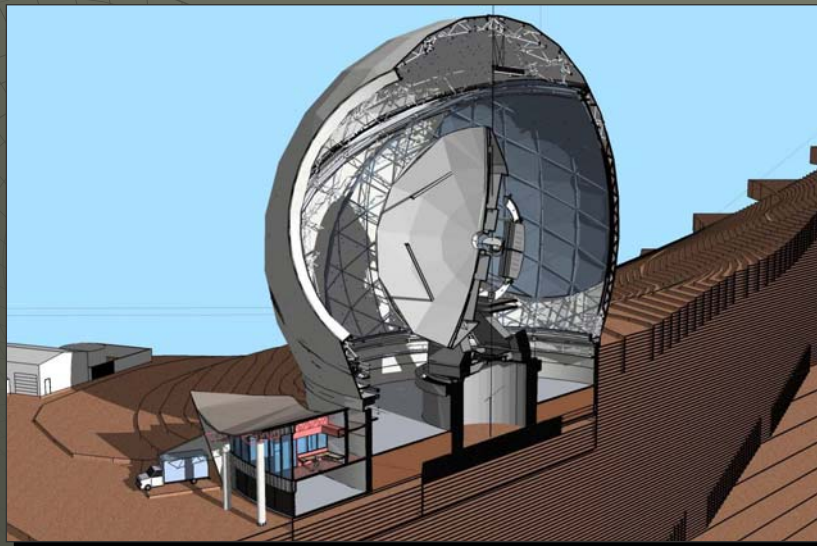


- ◆ Main Entrance
- ◆ Control Room / Open Office
- ◆ Conference Room
- ◆ Kitchenette, Toilet & Shower
- ◆ Telescope Chamber
- ◆ Capture Mountain Views



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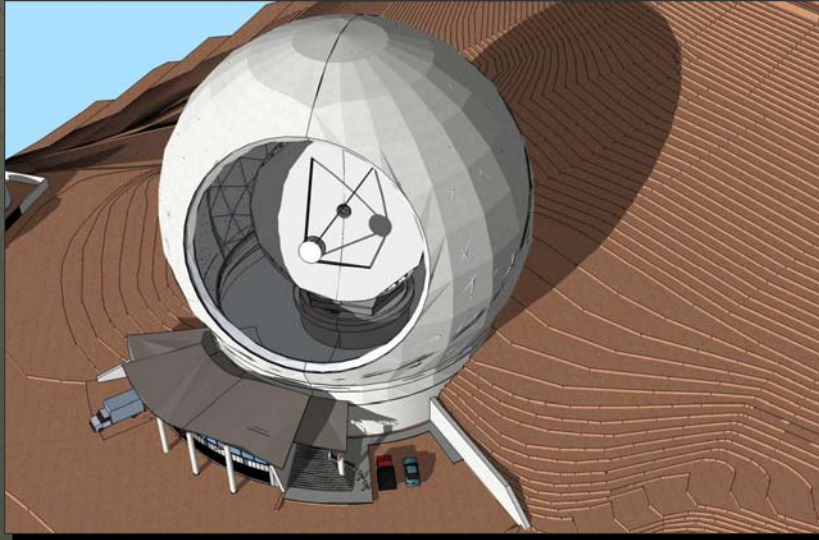
## Mountain Facility: Building Section



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## Mountain Facility: Exterior



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## Mountain Facility: Exterior



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## Mountain Facility: Exterior



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## Support Facility Requirements



- ◆ **Site Improvements and Infrastructure**
  - Electric Power Generators and Transformer
  - Domestic Water and Sewage System
  - Parking
- ◆ **Support Facility**
  - Remote Control Room
  - Offices
  - Instrument Labs
  - Workshops
  - Warehouse
  - Dormitories
  - Cafeteria and Kitchen
  - Mechanical and Electrical Support Space

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## San Pedro Architecture

- ◆ Massive Adobe Wall Construction
- ◆ Straw Roof
- ◆ Wood Shade Structures
- ◆ Courtyard Spaces Within the Compound



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## Support Facility: Site Plan



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## Critical Risk Assessment



- ◆ **Minimizing Risks:**
  - Keep it Simple.
  - Follow Traditional Construction Methods and Systems.
  - Use Materials that are Used Commonly by Local Contractors.
- ◆ **Support Facility:**
  - The Use of Materials such as Concrete Block, Adobe, Wood and Steel are Traditional Materials. This Facility does not have Significant Risks in the Design or Construction.
- ◆ **Mountain Facility:**
  - The Construction Materials are Poured-in-Place and Pre-cast Concrete, Steel, Metal Panels, etc. These Materials are very Easy to Fabricate and Erect at a Typical, Low Altitude Site but can be Very Challenging at a Remote, High Altitude Site such as Cerro Chajnantor (5500m) with a Low Oxygen Level.

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## Critical Risk Assessment



- ◆ **Mountain Facility Challenges:**
  - **Contractor's Availability:**
    - ◆ Santiago Construction Industry is Booming. Many Contractors Prefer to Work in the City and not at High Altitude, Remote Sites.
    - ◆ Copper Prices are Above \$2.00US/lb. Contractor's are Overwhelmed with Mining Work Especially in the Northern Region of Chile.
  - **Remote Site Complication:**
    - ◆ Provide Contractor's Camp, Room and Board for their Workers at a Lower Altitude Site.
    - ◆ Transport Workers to the Construction Site Every Day.
    - ◆ Availability of Materials and Labor Needs to be Well Coordinated and Scheduled in Advance.
    - ◆ Why Work at a Difficult Site when there is Plenty of Work at Lower Elevation Sites?
  - **Weather and Construction Seasons:**
    - ◆ Severe Weather and Limited Construction Seasons.
    - ◆ Productivity Diminishes Significantly with Unfavorable Weather Conditions.
    - ◆ Mobilize Onsite Several Times and the Project Needs to be Phased.

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## Critical Risk Assessment



- ◆ **Mountain Facility Challenges:**
  - **Lack of Oxygen:**
    - ◆ Use of Portable Oxygen Tanks and Masks.
    - ◆ Difficult to Build within Typical Construction Tolerances Requiring Modifications or Rebuilding.
  - **Equipment Operation and Warranty:**
    - ◆ Typical Mechanical and Electrical Equipment is Rated for Sites Under 3000m
    - ◆ Built to Withstand Normal Environmental Conditions.
    - ◆ Equipment Performance Guarantee is Usually not Available for Equipment at 5500m Altitude or Higher.
    - ◆ Off the Shelf Equipment Needs to be Modified to Withstand the Severe Environmental Conditions and Require Additional Anchorage.
- ◆ **All of these Factors have a Direct Impact and Risk on the Project's Schedule and Costs. Construction Delays, due to Weather, Labor Availability, etc. are Additional Costs to the Contractor and Owner Extending the Overall Construction Schedule, Possibly into the Next Construction Season.**

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