



## Opto-Mechanical Overview

Quartus Engineering Incorporated was founded in 1997 to provide quality advanced engineering services. Quartus specializes in the design and analysis of aerospace and mechanical systems using computer-aided technologies. Pairing skilled teams and high powered CAD/CAE tools, Quartus' Opto-Mechanical Design and Analysis group has proven to meet design objectives with efficiency and flexibility in a fast paced environment. We are committed to serving the needs of the engineering community in a timely and cost effective manner.

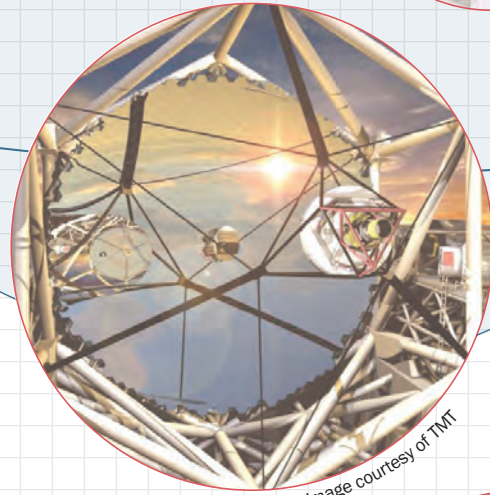
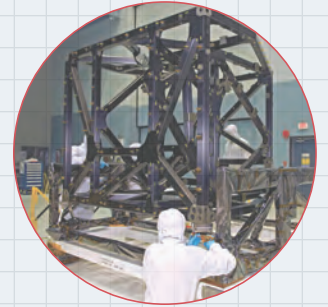
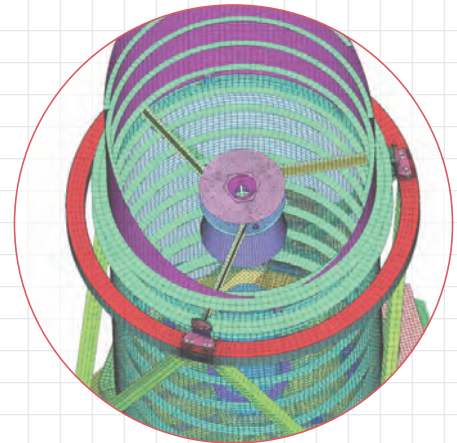
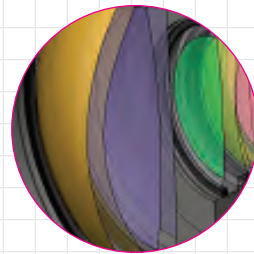
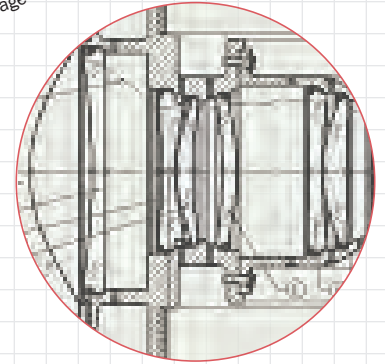


Image courtesy of TMT



**INNOVATIVE**

**ACCURATE**

**EFFICIENT**

## Quartus Engineering Opto-Mechanical Group

Quartus' staff has proven expertise in the design, analysis, fabrication, assembly, integration and testing of opto-mechanical systems. From large scale astronomical telescopes to fiber optic applications, Quartus' Opto-Mechanical Design and Analysis team will advance your design requirements to a complete and tested prototype. Our approaches include:

- Kinematic mounting principles
- Decoupled DOF adjustments
- Precision positioning mechanisms
- Motion controlled flexure mounting
- Material trade studies
- Static and Quasi-static analyses
- Structural dynamics analysis
- Thermal and vibration stabilization
- Beam pointing stability analyses (drift & jitter)
- Static/Vibration testing

Quartus designs opto-mechanical assemblies to meet our customers' tight optical spacing, tip/tilt, and centration requirements. Performing structural and thermal analyses, Quartus can verify mechanical integrity and system performance under aggressive environmental conditions; including high g-loading, sine on random vibration, and extreme temperature variations. Quartus can control fabrication, assembly, and prototype builds, and then perform design verification testing to validate the design hardware, including modal surveys, shock and vibration testing, thermal-vacuum testing, etc. Quartus' proven experience can fill your opto-mechanical design and analysis needs.



### UH, IfA, Pan-STARRS Support

#### CASE 1

Quartus supports the University of Hawaii, Institute for Astronomy, Pan-STARRS PS1 telescope effort through completion of design, analysis, and build of critical telescope & camera optical, mechanical, and electro-mechanical systems, including on-summit assembly and installation at the Haleakala observatory.

Efforts completed by Quartus include:

- Analysis, redesign, and installation of a flexure based, whiffle tree secondary mirror support structure to improve surface figure error
- Modal survey and on-sky vibration measurements of the telescope to characterize contribution to image blurring or "fuzz balls"
- Design of the Lower Cassegrain Core (LCC) cable wrap and cable drape to minimize additional torque on the gimbal rotator servo motors and mitigate any variations in the torque as the camera system orientation changes with telescope elevation angle
- Installation of the science grade 0.9m secondary mirror on its hexapod structure and then onto the PS1 secondary support truss.
- Design of the tip/tilt & piston adjustment mounts and thermal management system for the 60 cryo-cooled orthogonal transfer array (OTA) CCD components
- Design of camera radiation shields, charcoal getters, and cryocooler mounts
- Day-to-day on-summit support

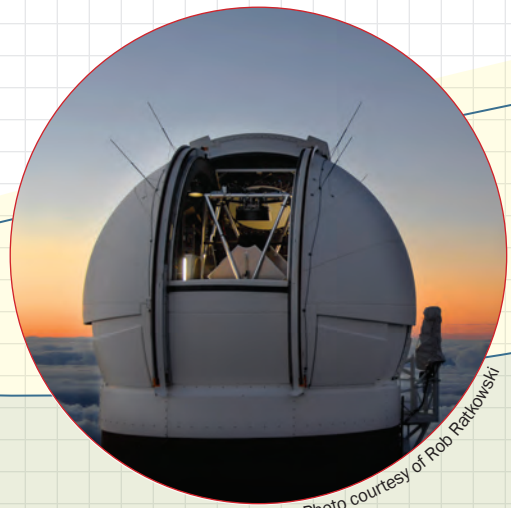


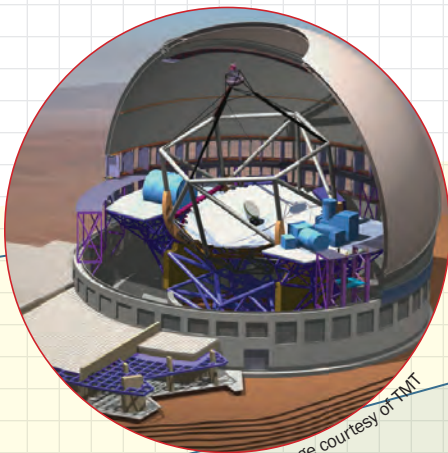
Photo courtesy of Rob Rakowski

## TMT Observatory Corp. M2CA

### CASE 2

The Thirty Meter Telescope Observatory Corporation (TMT) contracted Quartus to execute the Planning Study for the TMT Secondary Mirror Cell Assembly (M2CA). Quartus generated the system baseline design, program plan, budget, and schedule from PDR through installation on summit and first light. Quartus assembled a multi-disciplinary team including Adaptive Optics Associates Inc., L-3 Brashear, and the University of Arizona College of Optical Sciences in order to develop the full M2CA baseline design and program plan. Quartus led this dynamic team of experienced partners in the development of a pneumatic actuator based, active correction optical system, addressing opto-mechanical design, electro-mechanical design, identification of mirror fabrication & metrology processes, and controls architecture definition.

Quartus engaged in an analysis-driven effort to optimize mirror surface figure under the various thermal and gravitational loading conditions. This included development of internal code for fitting Zernike polynomials to the deformed shapes predicted by finite element analysis (FEA) and using a least squares approach to determine required actuator forces. TMT continues to use the M2CA Planning Study submitted by the Quartus led team as the basis for project planning through telescope installation and first light. Quartus looks forward to contributing to the upcoming Preliminary Design phase of the TMT's M2CA.



## Composite Optics ABL Beam Expander

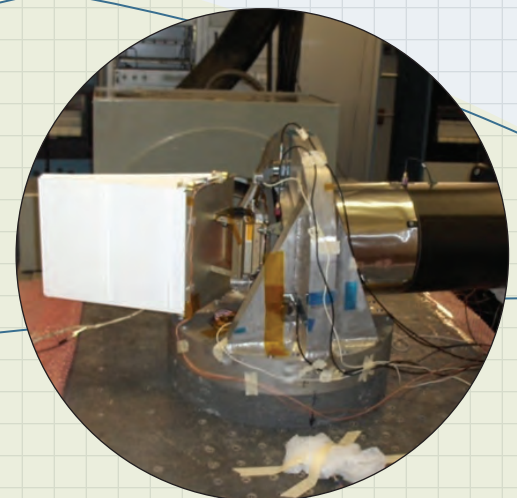
### CASE 3

Under contract from Composite Optics, Inc. (now a division of Alliant Techsystems, Inc.), Quartus completed a structural optimization effort on the Airborne Laser beam expander design. Graphite epoxy composites were selected for high stiffness to weight ratios and thermal stability characteristics. Initially Quartus performed stress/strain analyses over defined load cases, then iterated on mechanical design, material selection, and ply lay-up. The Quartus engineering team was able to reduce structural weight by 12% while improving upon boresight jitter and drift performance. Compatibility between all design modifications and Composite Optics manufacturing processes were verified through the design process.

## Malin Space Sciences Systems LROC

### CASE 4

Quartus was contracted by Malin Space Science Systems (MSSS) to perform analysis, testing, and design for NASA's Lunar Reconnaissance Orbiter Cameras (LROC). Quartus built high fidelity finite element models (FEM) to predict the quasi-static structural, dynamic (random vibration and acoustic), and thermal response of the Narrow Angle Camera, Wide Angle Camera, and Sequence Compressor System in operational environments and during launch. Quartus then conducted force limited vibration and thermal-vacuum testing for the LROC. Test results were correlated with the FEM and Quartus redesigned key performance features to improve reliability. Nasa's LRO launched successfully in January 2009, and continues to take images and measurements of the moon's surface.



## ENGINEERING TOOLS

Quartus supports a wide variety of the leading CAD and CAE programs:

### DESIGN

I-DEAS  
Unigraphics  
Pro/ENGINEER  
CATIA V4 and V5  
SolidWorks  
Inventor  
AutoCAD  
Teamcenter (PDM)

### ANALYSIS

**Solvers**  
MSC.NASTRAN  
NX NASTRAN  
ABAQUS  
LS-Dyna  
Zona ZAERO  
Optistruct

**Pre and Post**  
I-DEAS  
FEMAP  
HyperMesh  
Patran

### SPECIALTY

Matlab  
MathCAD  
NASGRO  
CompositePRO  
Zemax (Optical Design  
and Analysis)  
I-deas ESC & TMG  
LabView  
Quartus CLAS

## FACILITIES

Quartus has engineering facilities in San Diego CA, Los Angeles CA, and Washington DC. The San Diego office includes multiple secure rooms for sensitive projects plus a laboratory for systems integration. Quartus also has a prototype development and testing laboratory located near the San Diego office. This facility includes equipment for prototype construction and provides space for structural testing of large hardware.

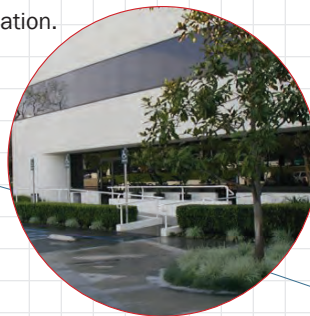
Please contact us or visit our website for additional information.



Washington DC  
45240 Business Court  
Suite 140  
Dulles, Virginia 20166



Los Angeles  
300 Continental Blvd  
Suite 610  
El Segundo, California 90245



San Diego  
10251 Vista Sorrento Parkway  
Suite 250  
San Diego, CA 92121-3776

## CONTACT

### San Diego Headquarters

**Jeff Frantz**  
**Vice President, Sales & Marketing**  
E: jeff.frantz@quartus.com  
PH: 858-875-6042

**Brad Steele**  
**Director of Engineering**  
E: brad.steele@quartus.com  
PH: 858-875-6057