M1 Control System
Actuators, Sensors, and Electronics

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TMT.CTR.PRE.09.138.REL01
M1CS Summary

Sensors

Primary Segment Assembly

Primary Mirror

Actuators

Segments
M1CS Components

- **Actuators**
  - 1476 for 492 segments
  - 100 spares
  - 1576 total

- **Sensors**
  - 2772 for 492 segments
  - 462 for 82 spare segments
  - 200 spares
  - ~3500 total

- **Distributed Control Electronics**
  - 82 Node Boxes
    - Insulated and liquid cooled
  - 574 segment cable harnesses (492 + 82 segments)
  - ~4400 PCB assemblies (printed circuit board assemblies)
TMT M1CS Components

Segment 1.4 m
Segment Support Assembly
Actuators
3 per segment
Sensor Preamp
Sensor Control Bd.
Drive half
Sense half
Keck Analogies to TMT

Node Boxes

Segment and mirror cell cabling
# Summary of Actuator and Sensor Requirements

<table>
<thead>
<tr>
<th><strong>Actuators</strong></th>
<th><strong>Requirements</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>≤ 10Kg</td>
</tr>
<tr>
<td>Load (Performance)</td>
<td>0 to 850 N</td>
</tr>
<tr>
<td>Range</td>
<td>≥ 5 mm</td>
</tr>
<tr>
<td>Noise</td>
<td>≤ 4.4 nm RMS</td>
</tr>
<tr>
<td>Peak error</td>
<td>≤ 50 nm</td>
</tr>
<tr>
<td>DC Stiffness</td>
<td>≥ 20 N/μm</td>
</tr>
<tr>
<td>Stiffness at 1 Hz</td>
<td>≥ 10 N/μm</td>
</tr>
<tr>
<td>Power</td>
<td>≤ 1 Watt</td>
</tr>
<tr>
<td>Survive -2000 N to +3000 N</td>
<td>3g earthquake survival</td>
</tr>
<tr>
<td>Design for 50 year life time with preventative maintenance</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Sensors</strong></th>
<th><strong>Requirements</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge Sensor Noise (Height)</td>
<td>≤ 2.8 nm/Hz RMS</td>
</tr>
<tr>
<td>Edge Sensor Noise (Gap)</td>
<td>≤ 1 μm RMS</td>
</tr>
<tr>
<td>Edge Sensor Noise (dihedral angle)</td>
<td>≤ 330 nRad RMS</td>
</tr>
<tr>
<td>Quasi Static Mean Sensor Error</td>
<td>&lt; ~ 2nm</td>
</tr>
<tr>
<td>Non Interlocking</td>
<td></td>
</tr>
<tr>
<td>In-plane sensitivities</td>
<td>Various</td>
</tr>
<tr>
<td>Mass (to be confirmed)</td>
<td>≤ 115 grams</td>
</tr>
<tr>
<td>Dimensions (to be confirmed)</td>
<td>55 mm x 60 mm x 20 mm</td>
</tr>
<tr>
<td>Design for 50 year life time with preventative maintenance</td>
<td></td>
</tr>
</tbody>
</table>
Actuator 1

- TOP LEVER
- DRIVE LINK
- OFFLOADER MOTOR
- OFFLOADER GEAR BOX
- OFFLOADER PIVOT
- OFFLOADER LEAD SCREW
- VOICE COIL
- OFFLOADER FLEXURE
- SENSOR MOUNT
- OUTPUT SHAFT
- TOP SHAFT PIVOT
- MAIN PIVOT 1
- OFFLOADER TOP SPRING
- OFFLOADER LEVER PIVOT
- OFFLOADER LEVER
- OFFLOADER SPRING PIVOT
- OFFLOADER BOTTOM SPRING
- BOTTOM SHAFT PIVOT
- BOTTOM MAIN PIVOT
Actuator

Summary Statement of Work

- Third generation prototype
  - Procurement, fabrication, assembly, and test
  - 10 to 20 actuators
  - Design for manufacturability
  - To be used for reliability tests
  - To be used for final evaluation
  - To be used to evaluate test and quality control equipment and procedures
  - Ideally fabricated, assembled, and tested at supplier for production units

- Production build
  - Pre-production procurement, fabricate, assembly, test, and evaluate
  - Production procurement, fabrication, and assembly
  - Acceptance testing
  - Repair and test of rejected units
  - Quality control
  - Pack and ship
Capacitive Sensor

Drive Block   Sense Block
Sense Block

TMT.SEN.SENSORS
BY J. MOORE
REV X 5-14-09

NOTE: UNLESS OTHERWISE SPECIFIED:
1. REMOVE BURRS AND BREAK SHARP EDGES
2. ALL INSIDE CORNER RADIUS 0.0625 Minimum except small
   HOLES AND POCKETS
3. TOLERANCES: DIM. XX ± 0.05
   .05 ± 0.05
   ANGLES ± 0.2º
4. THIS IS A LIMITED DIMENSION DRAWING. SEE MODEL FOR
   DIMENSIONS NOT SHOWN. ALL SURFACES PROFILED TO WITHIN
   Tolerances ±

0.01 GROUND 0.004

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Sense Block Coating

COATING NOTES
1. COATINGS ARE 5 UM GOLD OVER 05 UM CHROMIUM
2. SPUTTERING APPLICATION PREFERRED TO INSUL COATING
3. SUBSTRATE TEMPERATURE MAY NOT EXCEED 150 DEG C
   DURING COATING OR PROCESSING
4. FRONT AND BACK (50 X 45 mm) COATING THICKNESS FACES ± 10%
5. SIZE MAY BE ±100%/50/-%
6. ETCHED UNCOATED PATTERNS ARE 1 mm WIDE, ETCHED PATTERN SIZE
   TOLERANCE ± 0.1 mm
7. ETCHED PATTERN IS LOCATED ±0.1 mm FROM SIDES OF BLOCK

SENSE PADDLE COATING DIMS

TMT SENSORS
BY J. MOSE
REV X 4.2.09
Drive Block

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Drive Block Coating

COATING NOTES
1. COATINGS ARE 3.5 UM GOLD OVER .02 UM CHROMIUM
2. SPUTTERING APPLICATION PREFERRED TO INSUR COATING INSIDE COUNTERBORE
3. SUBSTRATE TEMPERATURE MAY NOT EXCEED 150 DEGS C.
   DURING COATING OR PROCESSING
4. FRONT AND BACK (50 X 45 MM) COATING THICKNESS FACES ± 10%
5. SIDES MAY BE ±100MV-50-50%
6. ETCHED UNCOATED PATTERNS ARE 1 MM WIDE. ETCHED PATTERN SIZE
   TOLERANCE ±.01 mm
7. ETCHED PATTERN IS LOCATED ±.1 MM

COATING DIMENSIONS - DRIVE PADDLE

TMT SENSORS
BY J. MOORE
REV X 5/20/09

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Sensor

Summary Statement of Work

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  – Procurement, fabrication, assembly, and test
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🔹 Production build
  – Pre-production procurement, fabricate, assembly, test, and evaluate
  – Production procurement, fabrication, and assembly
  – Acceptance testing
  – Repair and test of rejected units
  – Quality control
  – Pack and ship
Electronics
Summary Statement of Work

- Parts procurement
- Printed Circuit Board (PCB) fabrication (bare board)
- PCB assembly
- PCB assembly testing
- Cable harness fabrication and test
- Node Box assembly and test
- Quality control
- Pack and ship