



Magdalena Ridge Observatory - New Mexico Tech - 101 East Road – Socorro - NM 87801 - USA

# **MRO-Interferometry**

## **Unit Telescope Fast Tip-Tilt System**

### **Design Review**

INT-403-CON-0130 rev. 1.0

**August 9, 2010**

## Revisions

| REV | DATE          | AUTHOR | COMMENTS  |
|-----|---------------|--------|---|
| 0.1 | July 21, 2010 | EJB    | Document created  |
| 0.4 | July 27, 2010 | EJB    | Numerous small updates  |
| 0.5 | Aug 3, 2010   | EJB    | Merged document INT-403-CON-131 into this document.<br>Incorporated input from various sources. |
| 0.6 | Aug 8, 2010   | EJB    | Incorporated input from JY, and updated date for SOW reference document.                        |
| 1.0 | Aug. 9, 2010  | EJB    | Updated reference document version, and prepared for release.                                   |

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## **Executive Summary**

The New Mexico Tech (NMT) administration is seeking an independent and expert assessment on the Magdalena Ridge Observatory (MRO) Interferometer Unit Telescope Fast Tip-Tilt System (FTT) Design.

The top-level questions that a review team should consider are:

1. Is the proposed design compliant with the requirements?
2. What are the major performance risk factors for the proposed design and are the strategies for mitigating them adequately defined?
3. Are the risks associated with the schedule reasonable?

## 1. Introduction

The only major telescope subsystem that is still in the early design phase is the fast tip-tilt system. This latest contract has been awarded to the MRO consortium partner, the University of Cambridge (UK). The contract for phase 1a was signed on July 27, 2010. The contractual schedule for delivery is listed in Table 1, and the full requirements are available in the associated reference document.

| Identifier | Milestone                                   | Due date           |                        | Actual or planned |
|------------|---|--------------------|------------------------|-------------------|
|            | <b>SOW page 15</b>                          | <b>SOW page 11</b> | <b>Email 7/14/2010</b> |                   |
|            |   |                    |                        |                   |
|            | <b>Phase 1a: Design FTT/NAS &amp; FLC</b>   |                    |                        |                   |
|            | Kick-off phase 1a                           | 15-Apr-10          |                        |                   |
| 00         | <b>Conceptual Design</b>                    |                    |                        |                   |
| 00.1       | Derived Requirements                        |                    |                        |                   |
| 00.2       | Camera Evaluation                           |                    |                        |                   |
| 00.3       | Conceptual Design                           |                    |                        |                   |
| 00.4       | Conceptual Design Report & Review           | 19-Aug-10          |                        | 9-Sep-10          |
| 01         | <b>Preliminary Design FTT/NAS &amp; FLC</b> |                    |                        |                   |
| 01.1       | Optical Design                              |                    |                        |                   |
| 01.2       | Mechanical Design & Production              |                    |                        |                   |
| 01.3       | Electronic Design & Production              |                    |                        |                   |
| 01.4       | Test Design and Development                 |                    |                        |                   |
| 01.5       | Software Design and Development             |                    |                        |                   |
| 01.6       | Preliminary Testing                         |                    |                        |                   |
| 01.7       | Systems Engineering                         |                    |                        |                   |
| 01.8       | Interim Preliminary Design Report           | 29-Mar-11          |                        |                   |
|            | End of Phase 1a contract                    | 31-Mar-11          |                        |                   |
|            | <b>Phase 1b: Design, Assembly, and AIV</b>  |                    |                        |                   |
|            | Kick-off phase 1b                           | 1-Apr-11           |                        |                   |
| 02         | Test and Review                             |                    |                        |                   |
| 02.1       | Integrated Testing                          |                    |                        |                   |
| 02.2       | PDR Test Report & Review                    | 30-May-11          |                        |                   |
| 03         | First Light Camera Delivery                 |                    |                        |                   |
| 03.1       | First Light Camera Testing                  |                    |                        |                   |
| 03.2       | First Light Camera Install and Test         | 30-Jun-11          |                        |                   |
|            | End of phase 1 bcontract                    | 30-Jun-11          | 30-Sep-11              |                   |
|            | <b>Phase 2: upgrade of FLC to FTT</b>       |                    |                        |                   |
|            | Kick-off phase 2                            |                    | 7-Jun-11               |                   |
|            | FTT/NAS #1 FATs complete                    |                    | 13-Dec-11              |                   |
|            | FTT/NAS #1 SATs complete                    |                    | 24-Jan-12              |                   |
|            | Handover of FTT/NAS #1                      |                    | 30-Jan-12              |                   |
|            | End of Phase 2 contract                     |                    | 27-Mar-12              |                   |

Table 1: Delivery schedule for the first light camera and the fast tip-tilt system for the telescope #1.

As part of the design review process, the NMT administration is seeking an expert recommendation on the material provided for the reviews.

## 2. Reference Documents

- [1] INT-403-CON-0128  
Statement of Work: Fast Tip Tilt/NA System Development - Phase 1a and Option for Phase 1b  
June 16<sup>th</sup> 2010
- [2] INT-403-ENG-0003  
Technical Requirements: Fast Tip-Tilt/Narrow-field Acquisition System - rev 2.2  
May 20<sup>th</sup> 2010
- [3] INT-403-TSP-0107  
Technical Requirements: First Light Camera - rev 1.0  
May 20<sup>th</sup> 2010
- [4] INT-403-ENG-0115  
FTT/NAS vs FLC: Comparison of Technical Requirements - rev 1.1  
May 20<sup>th</sup> 2010

## 3. MRO Interferometry Project

The Magdalena Ridge Observatory (MRO) is a new astronomical facility being built at 10,400 ft in the mountains west of Socorro, overlooking the Very Large Array (VLA). The Observatory will consist of two instruments: a 2.4-meter fast-tracking telescope and a 10-element state-of-the-art optical/infrared imaging interferometer (MROI).

The MROI is planned to be initially deployed with a complement of six relocatable 1.4 meter telescopes that will be combined together interferometrically to produce images in the near infrared J, H, and K bands. Following phases will add additional telescopes up to a total of ten for the full array, and will extend the interferometric capability to the visible R and I bands. The interferometer baselines of up to 340 meter will result in images with spatial resolutions about 200 times those produced by the Hubble Space Telescope. The science mission of MROI centers round three key areas:

1. Characterization of star forming regions and the earliest phases of planetary formation;
2. Detailed studies of stellar astrophysics in complex environments such as those seen in pulsating stars, interacting binary stars, and stars undergoing convection and mass-loss;
3. Imaging of the environments of black holes in the hearts of Active Galactic Nuclei.

The MROI will be a unique astronomical facility and will present many opportunities for students and researchers in the US and from all over the world. The current development status (August 2010) of the “unit telescope system” is shown in Table 2.

MROI development status  
 Aug/3/2010  
 MROI\_development\_status\_i05.xlsx

|  | Design | Unit telescopes |    |    |    |    |    | Phase A |
|--|--------|-----------------|----|----|----|----|----|---------|
|  |        | #1              | #2 | #3 | #4 | #5 | #6 |         |
| 1 Telescope foundation                       | ✓      | →               |    |    |    |    |    |         |
| 2 Telescope enclosure                        | ✓      |                 | *  |    | *  | *  | *  |         |
| 3 Telescope optics                           | ✓      | →               | →  | →  | *  | *  | *  |         |
| 4 Telescope mount                            | ✓      | →               |    | →  | *  | *  | *  |         |
| 5 Telescope fast tip-tilt system             | →      | →               | *  | *  | *  | *  | *  |         |
| 6 Wide field acquisition system              | ✓      | →               | *  | *  | *  | *  | *  |         |
| 7 Interferometric supervisory system         |        | →               |    |    |    |    |    |         |
| 8 Environmental and safety monitoring system |        | →               |    |    |    |    |    |         |
| Delay lines                                  | ✓      | →               | *  | *  | *  | *  | *  |         |
| Fringe tracker                               | →      | →               |    |    |    |    |    |         |
| Science beam combiner                        | →      | *               |    |    |    |    |    |         |

✓ : completed  
 → : in progress  
 \* : not yet started

Table 2: Overview of the current status of procurements (design and development) of the unit telescope systems.

The MROI interferometry project is going through an exciting phase. It is transitioning from the design to the assembling and commissioning phase. First light for the first three telescopes are planned for:

- first light telescope #1     December 2011
- first light telescope #2     June 2012
- first light telescope #3     December 2012

The fast tip-tilt system is the last remaining critical subsystem of the telescope that has not completed the design phase. This document addresses the review process of that subsystem. This current version of this document is limited to the Conceptual Design Review. Future versions of this document will include a scope description for the preliminary and final design reviews.

## 4. Conceptual Design Review

### 4.1. Key Questions

The three key questions that we ask the review team to address are:

1. Is the proposed design compliant with the requirements?
2. What are the major performance risk factors for the proposed design and are the strategies for mitigating them adequately defined?
3. Are the risks associated with the schedule reasonable?

### 4.2. MRO-Identified Key Requirements

MRO has identified the following key areas that should be addressed in the review:

| Description   | Req. |
|---|------|
| Maintaining the opto-mechanical stability of the overall FTT/NA System at the level required  | #66  |
| Handling the time varying offsets without interrupting the FTT loop   | #21  |
| Adequately communicating with the MROI-provided systems including sending telemetry and receiving updates to the pointing model while keeping the FTT loop closed | #35  |
| Meeting the limiting sensitivity requirement  | #64  |
| Meeting the residual tip-tilt error requirement   | #65  |
| Managing bright source targets  |      |
| Supporting user-selectable closed-loop 3dB bandwidths   | #47  |
| Supporting the dither function  | #48  |
| Meeting the schedule linked to the delivery of UT#1   |      |

Table 3: Key requirements on the FTT system.

### 4.3. CoDR Deliverables

| Title Document                           | Document Identifier   |
|--|-----------------------|
| CoDR Data Package List                   | MRO-LIS-CAM-0000-0100 |
| Derived Requirements Document            | MRO-TRE-CAM-0000-0101 |
| FTT/NAS Conceptual Design Document       | MRO-TRE-CAM-0000-0102 |
| FLC Conceptual Design Document           | MRO-TRE-CAM-0000-0103 |
| FTT/NAS Requirements Verification Matrix | MRO-TRE-CAM-0000-0104 |
| FLC Requirements Verification Matrix     | MRO-TRE-CAM-0000-0105 |
| FTT/NAS & FLC Development Plan           | MRO-PLA-CAM-0000-0106 |
| ICD List and Expected Content            | MRO-LIS-CAM-0000-0107 |

Table 4: Expected documents to be provided at CoDR to the review teams.

The conceptual design document will address the following issues at the minimum:

1. Presentation of top-level design of deliverables;
2. Summary of key requirements and operating scenarios;
3. General system approach and description (including alternatives);
4. Block breakdown of hardware and software elements and functions, etc.;
5. Back of envelope calculations to get basic predictions of performance for each subsystem;
6. Back of envelope calculations to see if the key requirements are met.

#### 4.4. Document Delivery & Questions

| Days before CoDR | Tasks completed  |
|------------------|--|
| 14               | CoDR documents should be delivered two weeks prior to the review |
| 3                | Reviewers to send questions on CoDR documentation to Cambridge   |
| 0                | Cambridge to answer to these questions                           |

Table 5: Schedule towards CoDR.



## 4.5. Agenda of Review

The date has been set to Thursday, September 9, 2010, by teleconference.

| Time        | Topic   | Moderator Speaker |
|-------------|---|-------------------|
| 8:30am MST  | Introduction, who is who  | EB                |
| 8:45am MST  | FTT/NAS conceptual design - overview of each principal section of the design report, followed by questions on that section  | MF/JY             |
| 10:20am MST | FLC conceptual design - overview of each principal section of the design report, followed by questions on that section. NB only sections where there are significant differences to the FTT/NAS design will be presented. | MF/JY             |
| 10:45am MST | Closing discussion  | EB                |

Table 6: Tentative agenda for the FTT CoDR.

The principal sections mentioned in the agenda (Table 6) for the FTT and FLC CoDR are listed in Table 7.

| Principal section                 | FTT | FLC            |
|-----------------------------------|-----|----------------|
| Derived Requirements              | yes | yes            |
| System Design                     | yes | <del>yes</del> |
| Optical Layouts                   | yes | yes            |
| Camera Selection                  | yes | <del>yes</del> |
| Conceptual Opto-Mechanical Design | yes | yes            |
| Conceptual Thermal Design         | Yes | <del>yes</del> |
| Conceptual Electronics Design     | Yes | <del>yes</del> |
| Conceptual Software Design        | yes | yes            |
| Interfaces                        | yes | yes            |
| Summary and path forward          | yes | yes            |

Table 7: Principal sections to be presented for the FTT and FLC CoDR.

## 5. Review Teams

### 5.1. Review Team Activities

The activities of the review teams are:

1. Read the review material in advance;
2. Send a list of questions to be addressed in advance of the review;
3. Attend the review (in person or by teleconference), analyze the answers to the questions provided, ask any additional questions that have arisen, participate in any discussion;
4. Participate in a closed-session for reviewers to share their opinions and ideally reach a consensus on the performance review;
5. Prepare a short written report that answers the top-level questions. If reviewers wish to provide additional feedback outside the scope of these top-level questions, it is welcome but we ask that it be included in a separate section of the report.

### 5.2. External Review Team

Members of the external review team are listed in Table 8.

| Name                | Organization |
|---------------------|--------------|
| Contact information | Position     |
| TBD #1              |              |
| TBD #2              |              |
| TBD #3              |              |

Table 8: External review team members.

The review team will identify a chair amongst themselves. The role of the chair is

- To chair the external review;
- To compile the final report;
- To be the spokesperson of the external review team.

### 5.3. Internal Review Team

To manage and oversee the MRO Fast Tip Tilt System procurement an MRO internal team has been established (Table 9).

| Name   | Position                                   |
|--|--|
| Contact information<br>Andres Olivares<br><a href="mailto:aolivares@mro.nmt.edu">aolivares@mro.nmt.edu</a><br>(575) 835 – 6758 | Mechanical Engineer                        |
| Colby Jorgenson<br><a href="mailto:cjurgenson@mro.nmt.edu">cjurgenson@mro.nmt.edu</a><br>(575) 835 - 6800                      | Instrument Scientist                       |
| Allen Farris<br><a href="mailto:afarris@nmt.edu">afarris@nmt.edu</a><br>(575) 835 - 6645                                       | Lead Software Engineer                     |
| Eric Bakker<br><a href="mailto:ebakker@mro.nmt.edu">ebakker@mro.nmt.edu</a><br>(575) 518- 8854                                 | Manager Telescope System and Commissioning |

Table 9: MRO interferometry FTT team.

- end of document -