Introduction

This is the seventh monthly progress report on the HMI program at LMSAL. We/LMSAL are collaborators with Stanford University on the HMI/SDO solar physics investigation, being led by Prof. P. Scherrer of Stanford University. Phase A, which includes the periods described as Phase A and the Bridge Phase in the AO, began on 1 October 2002 and will last 12 months.

Summary of Status

Key activities this month included preparing for and participating in the Observatory SRR/SCR, making progress on the Michelson specification and on sole sourcing the procurement to Light Machinery, getting (via NRL) E2V under contract to begin designing the CCD that will be used by both HMI and AIA, receiving the updated MAR, defining a desired set of reliability enhancements, and interacting with the Project on a variety of interface topics. In addition, our team continued to grow and we continued to have weekly SDO Project telecons, weekly HMI-specific telecons, and HMI weekly status meetings.

Schedule and Milestones

The HMI proposal contained a top-level schedule that was based on the dates given in the AO. Now that the program is in full swing, a more detailed schedule has been developed and discussed with the Project. As personnel are added to the HMI team, the schedule in their areas of responsibilities are being refined and expanded. Shown below are some key milestones, with an emphasis on those that will occur in the near term, or have occurred recently (for completeness).

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Location/Remarks</th>
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<tbody>
<tr>
<td>Observatory SRR/SCR</td>
<td>Apr 8-11</td>
<td>At GSFC &amp; by the Project &amp; us</td>
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<tr>
<td>Initiate CCD Study Contract</td>
<td>April</td>
<td>NRL subcontract to E2V</td>
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<tr>
<td>HMI Team (Co-I) Meeting</td>
<td>May 1-2</td>
<td>At Stanford</td>
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<tr>
<td>Initiate Michelson Study Contract</td>
<td>May</td>
<td>Vendor is Light Machinery</td>
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<tr>
<td>Visit E2V and RAL</td>
<td>May 15-16</td>
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<tr>
<td>Submit Concept Study Report</td>
<td>June</td>
<td>Includes a formal cost proposal</td>
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<tr>
<td>Begin Phase B-E</td>
<td>October</td>
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<tr>
<td>PDR</td>
<td>October</td>
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<tr>
<td>CDR</td>
<td>July ’04</td>
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Deliver HMI to S/C    July ’06
Launch                    Aug ’07
Five year baseline mission

Major Activities During this Reporting Period

The primary thrust for the first two weeks of the month was preparing for, and then participating in, the Observatory SRR/SCR that took place near GSFC on 8-11 April. Three persons from LMSAL and two from Stanford attended the review. Although the HMI presentation was only an hour long, considerable effort went into fine tuning it with the Project, who themselves presented nearly a thousand charts. We believe the review was quite successful and should make moving forward on all fronts relatively straightforward. When we receive the official action items we’ll prepare our responses. In addition to the large SRR/SCR meeting there was a half day programatics session and several splinter discussions. Our concepts for incorporating reliability enhancements into the HMI electronics received attention during these discussions as did a variety of other topics.

In the optical-mechanical area we continued to iterate the optics package (OP) configuration towards one that can be frozen and to interact with the Project on how it will be placed onto the observatory. Freezing most of the OP internal configuration has enabled us to establish the mechanical properties of the two mechanisms upon which we will perform extensive life tests; the hollow-core tuning motors and the camera shutters. This information combined with considerations imposed by the relatively harsh radiation environment and refined performance requirements will enable us to complete the mechanism designs and order life-test units. Since these mechanisms will move every few seconds for 5 years even an accelerated life test will take a very long time and needs to begin as soon as possible. Several discussions took place this month aimed at determining how many units of each mechanisms will undergo the life test and what differences in their construction will be tested; such as lubricant type, bearing preload, etc.

In the last report we described our visit to potential vendors for the Michelson Interferometers. We have determined that the best vendor is Light Machinery in Ottawa, primarily because the team that produced the MDI Michelsons is now located there. Interactions with them on the specifics for these units took place along with working on the paperwork to get them under contract and on the paperwork that is required by ITAR since they are not located in the US – the dreaded TAA (Technical Assistance Agreement). Another major optical/filter item that received some attention this month was the Lyot filter in that we received some potentially high-quality calcite (from Brazil) and are setting up to determine in detail how good it is and how many Lyot elements might be fabricated from it.

On the electrical and software fronts, the C&DH design continued to mature. Besides normal progress, substantial effort was expended to evaluate how one might make this aspect of HMI more robust by items such as cross-strapping of the already added redundant high rate data interface, adding a redundant power system, and adding a redundant central processing unit. Our recommendations were then given to the Project. We hope that an agreement in this area can be reached shortly so that a single overall system design can be pursued in detail. The draft Software Management Plan continued to mature as did the draft Software Requirements
Documents. Based on a modest trade study, we have decided to do the SUROM software in house and to base it on the code implemented on the HIRDLS program. We have not yet received feedback from the Project on the preliminary EEE parts list we provided in February and hope that discussion of that list and of potential common buy EEE parts will take place shortly.

Along with the SHARPP team, we iterated a draft specification of a CCD that can be used in both instruments. This was then further iterated with the vendor of choice, E2V, and the potential camera electronics providers at RAL and LMSAL. The latter involved a structured telecon with all of the mentioned parties participating. With NRL/Praxis as the conduit, E2V was issued a study contract to design such a CCD and produce a run of non-flight devices. NRL has selected RAL to build the SHARPP camera electronics; and the HMI baseline is to do likewise. The specification of these electronics underwent several iterations and a proposal for a study phase effort by RAL has now been received. The plan is to fund it through NRL/Praxis as is being done for the CCD. Separate programs to build developmental, qualification, and then flight cameras for HMI and SHARPP would then be established with RAL by NRL and LMSAL. A prime motivation in this approach is to decouple the two programs downstream if/when tradeoffs of technical capability, schedule, and cost are needed.

Several exchanges of ICD-like information took place this month. We asked if the glint-free FOV could be increased from +/- 10 degrees to +/- 12 degrees and were told that this should not be a problem. We documented our detailed understanding of the 1553 (mainly software) interface, gave it to the Project, and received a response that addressed our areas of uncertainty. Further clarification will take place in the weekly SDO-wide telecon on 14 May. A set of questions were received from the Project concerning the configuration of the HMI Electronics Box (HEB) and we responded with a 14 item memo on this subject, pointing out that the yet-to-be-approved redundancy features were being baselined so the box size was maximum. An updated model of the optics package was provided along with some explanatory caveats.

Other Activities During April

1. A new version of the MAR was received. Although asked to comment upon it, we declined, since it seems that having commented extensively before it will be more worthwhile to now write the HMI PAIP and begin the iterations that will result in it being the controlling document for the program.

2. The details of what fixed assets need to be ordered by LM to support the HMI development program matured; the ordering of some items is about to commence.

3. A brief Photographic Documentation Plan was drafted and provided to the Project in response to their inquiry as to our plans for taking photographs as HMI comes together.

4. A prototype shutter blade was manufactured and put on an existing SXI/FPP shutter motor, that being the baseline for HMI. Initial measurements show that the performance of such a system meets the required specifications.
5. Iteration of the preliminary fault tree analysis and reliability block diagram continued as an aid to making our recommendations as to how to make HMI more robust.

6. In response to a request from the Project, we prioritized our needs in terms of interface information.

7. We continued to enlarge the HMI team, with three electrical engineers beginning now working on specific aspects of the electronics design (mechanism control FPGAs, power system, and the ISS) as they phase out of their efforts on Solar-B FPP.

**Planned Activities During MAY**

1. Visit both E2V and RAL as part of moving forward on the CCD camera systems.

2. Receive RFAs from the Mission SSR/SCR and prepare responses to them.

3. Continue to increase the size of the LMSAL HMI team.

4. Freeze the optical design and begin drafting procurement specifications for the longer lead time optical elements.

5. Draft the HMI PAIP and submit it to the Project for discussion.

6. Establish, through NRL, a study contract with RAL for the camera electronics design.

7. Submit Technical Assistance Agreement requests for Light Machinery and E2V plus RAL.

8. Finalize the specifications on the tuning motors and camera shutters and initiate their detailed designs. Order shutter motors and bearings for the upcoming life test.

9. Establish a study contract with Light Machinery.

10. Participate in the first HMI Co-Investigators Science Meeting at Stanford on 1-2 May.


13. Continue to participate in weekly Project telecons and HMI-specific telecons, and conduct weekly HMI team meetings.

**Design Updates**

There were basically no design updates this month. However, reliability enhancements that will result in design changes were defined and recommended to the Project.

**Resource Requirements**
Attached are preliminary power and mass status updates. These are being provided in a format similar to that used last month until we learn of a format that is desired by the Project. Explanatory notes indicate the items that are included (like for redundancy) although not yet agreed to by the Project.

**Issues/Concerns**

- The numbers of reviews and additional documentation required by NASA on flight programs ever since the Mars failures make it difficult to put adequate effort into doing “real work.”

- The lack of a UK-provided camera systems puts an additional burden on us and will be a cost impact to NASA.

- Based on past experiences we expect obtaining TAAs will be a lengthy process and may impact our ability to interact efficiently with E2V, RAL, and Light Machinery.