

The National Solar Observatory (NSO) Users Committee Report

November 2016

To: Dr. Valentin M. Pillet, Director
National Solar Observatory

Introductory Remarks

The NSO Users Committee (UC) met on 11 May 2016 at NSO/Boulder. The UC thanks Director Pillet, Dr. Frank Hill, Dr. Matthew Penn (by telecon), Dr. Thomas Rimmele, Dr. Han Uitenbroek, and Dr. Mark Rast (CU Boulder) for their comprehensive presentations, and we recognize the dedicated work of dozens of staff members that undergirds the accomplishments described. We appreciated the remote participation by NSO Program Officer Dr. David Boboltz and NSO staff member Dr. Jack Harvey.

We are grateful to Priscilla Piano for her always-seamless coordination of the meeting logistics, carried out among many other responsibilities.

For this meeting, the UC experimented with a one-day format. We expect to discuss the viability of this model during planning for the 2017 meeting.

To better match NSO's renewal, our report will continue to focus on key user-related capabilities and issues rather than the traditional sites.

On a personal note, the chair expresses his gratitude to NSO and the committee for according him the privilege of helping to represent the NSO user community during exciting years of change and challenge; a roseate glow on the eastern horizon signals the approaching dawn of the DKIST-NIST era. It will be my pleasure to serve for a further year as a UC member under the new leadership of Dr. R. T. James McAteer.

Committee members participating: Braun, Casini, Choudhary, DeForest, Henney, Lin, McAteer, Rabin (chair), Reinard, Boboltz (ex officio)

Plaudits

The UC was buoyed by NSO's accomplishments and progress on many fronts, including

- The final approval of a new 10-year cooperative agreement made possible by untold hours of work by NSO and NSF staff
- Continuing progress in the construction of the Daniel K. Inouye Solar Telescope (DKIST), on schedule and within budget as confirmed by the Project Execution Review
- NSO's well-considered approach to the challenge of keeping the Dunn Solar Telescope (DST) available as a productive telescope and key transition resource
- NSO's high-profile community engagement as host of "The Sun's Chromosphere in the Era of ALMA, IRIS, and DKIST" in March 2016 and the American Astronomical Society Solar Physics Division (SPD) meeting in June 2016
- Confirmation that NSF will make available \$2.5M for the refurbishment of the Global Oscillations Network Group (GONG), due in large part to NSO's effective engagement with NSF and OMB on GONG's role in a national space weather strategy

- The impending five-year agreement between NSO and NOAA that will provide \$0.8M/year to NSO in return for real-time space weather data delivered to the NOAA National Centers for Environmental prediction (NCEP)
- The advent of high-quality SOLIS vector magnetograms in the Ca II 854.2-nm chromospheric line, a valuable new data product that should be widely used
- Installation of a new network attached storage system for the NISP Data Center that should enhance community access to data with lower maintenance costs
- NSO's perseverance and flexibility in pursuing a consortium led by New Mexico State University (NMSU) to operate the Sacramento Peak site
- NSO's commitment of 50% (during at least the life of the cooperative agreement) for a joint tenure-track faculty position at NSO and the University of Colorado Boulder (CU).

The UC joins NSO in mourning the unexpected passing of Sac Peak observer Mike Bradford. The UC also thanks Dr. Richard Radick for continuing in Emeritus status to assist the DST Time Allocation Committee.

Review of Previous Findings

We summarize NSO's responses to findings of the previous UC meeting.

- "Because the unique scientific investigations and infrared technology development being carried out at the McMP merit operation for a year beyond June 2016, NSO and NSF should strive to forestall new site charges on Kitt Peak and seriously consider directing potential savings in Tucson operations to McMP operations for that period."

NSF has approved \$24K in carry-forward funding to help cover the nominal \$99K facilities use fee. NSO also dropped out of the motor pool to achieve a 50% reduction in the fee. NSO intends to support joint McMath-Pierce Solar Telescope (McMP) observing with the Atacama Large Millimeter/submillimeter Array (ALMA) during a 2017 campaign led by the Solar Simulations for the Atacama Large Millimeter Observatory Network (SSALMON).

- "The UC concurs with NSO's ramp-down plan for the DST and realizes that difficult decisions may be necessary to avoid impacting the DKIST schedule if a major DST system fails. However, the UC concurs with the 2014 recommendation of the Cooperative Agreement Review Panel that NSF should give high priority to limiting to no more than two years a gap in new high-resolution observations available to the NSO user community before the start of DKIST operations. Maintaining some level of availability of the DST in 2018 is the best option for ensuring this."

NMSU submitted a White Paper, "The Dunn Solar Telescope: A Transition to Operations by Sunspot Solar Observing Consortium," describing the scientific case for maintaining DST observations. NMSU continues to work to augment the consortium to support this goal. There is some reason for optimism that a gap will not occur.

- "Although the scientific purview of joint NSO-CU faculty positions should not be unduly narrow, there should be a clear emphasis on science with core relevance to DKIST capabilities."

DKIST was emphasized in the December 2015 announcement, which also mentioned NIST and science connected with it. There was an excellent response. (After the UC meeting, an offer was made and accepted.)

- "NSO should seriously consider replacing the aging and inadequately spared VSM camera system

with a system that will make VSM data reliably available to users, provide effective support of DKIST, and constitute a viable model for inclusion in a future SPRING network.”

There has been no significant movement in this direction because of funds and resources needed to support the relocation of SOLIS and the operation of current SOLIS instruments.

- “With the DKIST Data Center staffed and progressing toward Final Design Review, the DC should find avenues to socialize the anticipated user interface with the user community. Correspondingly, the UC should participate by identifying and communicating to the UC the types of information that would be most helpful.”

The Final Design is still more than a year away as of the UC meeting. There will be an opportunity for interaction on the occasion of the Conceptual Design Review (CoDR) in the fall of 2016.

NSO Status

Dr. Pillet highlighted a recent scientific result featured on the cover of *Nature Physics* (Jess et al., 2016, doi:10.1038/nphys3544) that showed how MHD wave modes can be used to infer coronal magnetic fields. DST images from ROSA and HARDcam instruments were used in the paper.

The ALMA-IRIS-DKIST meeting attracted 90 participants (more than expected), including the ALMA Director. ALMA and DKIST have comparable angular resolution and provide complementary data. NSO will be represented in proposals to both ALMA Cycle 4 (submitted) and Cycle 5 (upcoming).

Dr. Pillet called attention to the FY 2015 Annual Progress Report and FY 2016 Annual Program Plan, which gives a comprehensive overview of NSO science, operations, construction, community support, transition plans, spending, and education and public outreach.

The FY 2017 President’s Budget Request includes \$20.0M (an 8.1% increase over the FY 2016 estimated budget) for the NSO base and \$20.0M for DKIST construction. The request includes a special allocation of \$2.5M for partial funding of a DKIST Remote Operations Building (ROB) in Maui, which would relieve AURA of the need to secure a loan for ROB construction. If the enacted FY 2017 budget closely follows the request, NSO will be in a strong position (including also the \$2.5M GONG refurbishment allocation) to execute its planned program.

The laudatory DKIST Project Execution Review was cited above. The review panel recommended that the project develop with NSF a plan to mitigate potential construction delays related to permitting and to work with its German partners to develop a plan to improve the likelihood that the Visible Tunable Filter (VTF) will be available to help execute the Critical Science Plan at the start of DKIST operations.

NSO participated actively in the development of the National Space Weather Action Plan that was issued in October 2015 by the National Science and Technology Council. The plan is relevant to NSO strategic planning in several areas, including GONG refurbishment, SPRING (Solar Physics Research Integrated Network Group), detectors for spectropolarimetry, and future space missions at L1 and L5.

Dr. Pillet placed DKIST in the broad international context of solar observatories, including five space observatories at 1 AU, four 1-m class ground-based telescopes, and two future encounter missions (Solar Orbiter and Solar Probe Plus) inside 0.5 AU. Coordination with Solar Probe Plus was the subject of a separate discussion described below.

Dr. Pillet highlighted NSO participation in education and public outreach (EPO) connected with the eclipse of March 8, 2016. EPO efforts in the near future will focus strongly on the eclipse of August 21, 2017, which has a path of totality that crosses the continental U.S. Two EPO positions were advertised,

in Boulder and in Maui. About 30 applications were received for each position. An offer for the Boulder position has been accepted; the Maui position is still in process.

Daniel K. Inouye Solar Telescope

Dr. Rimmele reported on the status of DKIST and its operational plan. As described above, construction is proceeding on schedule and within budget. The targeted start of operations is January 31, 2020. Stimulus (American Recovery and Reinvestment Act) funds are fully spent. Funding now derives entirely from the NSF Major Research Equipment and Facilities Construction (MREFC) program and has 30% contingency.

A milestone has been reached: the polishing of the primary (M1) mirror is complete! The M1 mirror meets or exceeds all its performance requirements and is now in storage.

The project is working actively to mitigate schedule risk associated with the complex integration, test and commissioning (IT&C) process.

Dr. Rimmele displayed the four major components (with many sub-components) of the Critical Science Plan (CSP). The first major CSP Workshop will be held on June 4 in conjunction with the SPD meeting hosted by NSO. Dr. Mark Rast, Chair of the DKIST Science Working Group (SWG), will chair the meeting with support from the DKIST science staff. 50-60 participants are expected from the U.S. and abroad. Future CSP Workshops are planned.

The Visible Tunable Filter (VTF) poses the most significant risk to the operational readiness of a full complement of first-generation instruments. The VLT as originally proposed, which incorporates two Fabry-Perot etalons, is \$3M over budget and behind schedule. The Kiepenhauer-Institut für Sonnenphysik (KIS, the instrument PI institution), NSO, and the SWG are considering the science and cost tradeoffs associated with descoping to a single etalon system. A descoped system seems to be the only option that could be ready for initial operations, but programmatic risk remains even if that choice is made. A future upgrade to a dual etalon system (~\$1M) would have to be funded by some combination of delaying the development of a second-generation DKIST instrument and seeking a partnership.

The design of the ROB is 100% complete; the land is purchased. The public comment period for the Environmental Assessment is closed (no comments received), and it is hoped the EA will conclude with a finding of No Significant Impact. Construction is projected to begin during 2016 with occupancy late in 2017.

DKIST Data Center

Dr. Rimmele summarized the status of the Data Center (DC). The DC budget is separate from the construction budget and has no contingency. Although budget and schedule development for the initial phase has made good progress, significant uncertainty and programmatic risk remains for the implementation phase, particularly with respect to calibration of the first-light instruments. Whether descopes to DC implementation need to be considered should be known after CoDR, scheduled for November 2016 (before the next UC meeting).

Dr. Rimmele put the DC challenge in perspective by showing the projected data volume from DKIST: about 2.8 PB per year—about one order of magnitude greater than the Solar Dynamics Observatory, the most data-intensive solar facility to date (with much higher funding for data processing and distribution).

NSO Integrated Synoptic Program (NISP)

Dr. Hill reported on the status of NISP. In view of previous UC findings on the criticality of a robust synoptic program to a balanced NSO portfolio that serves a broad user community, complements DKIST, and contributes to a national space weather program, it was heartening to see an expected FY 2016 budget of \$5.9M that includes \$2.5M for GONG refurbishment and \$0.8M from NOAA. The expected FY 2017 budget of \$3.4M reminds us that the challenge of maintaining a vigorous synoptic program remains.

NISP has been impacted by several personnel departures, including the program manager. There will be one additional temporary hire for GONG refurbishment. Personnel relocation to Boulder is in full swing.

A new network-attached storage system (EMC ISILON) has been installed, configured, and populated with an initial data transfer. The system is scheduled to be installed in the CU data center in September. The substantial initial cost of this system is justified by lower maintenance costs and the expectation of better data service to the user community.

GONG is an aging but functional network. Entrance windows have been replaced at all sites and the data acquisition system installed at all but one site. GONG H α data is being widely used in published papers. Consistency of the magnetic zero point and image orientation across the network continues to be issues. Dr. Hill described efforts underway to improve the quality of real-time GONG magnetograms with particular emphasis on the requirements of space weather modeling. Helioseismology data processing is recovering from a 9-month hiatus caused by technical and staff health issues.

Dr. Hill outlined NSO's two-year plan for refurbishing GONG. A candidate for replacing the current cameras will soon arrive for testing. Liquid crystal retarders have been replaced and relocated in the optical train to improve the accuracy of the magnetic zero point. The H α filters have been replaced with pressure-tuned units that provide Doppler velocities. Data center storage has been augmented to accommodate H α data. Dr. Hill queried the UC on relative priorities for other potential improvements such as additional filter wavelengths or higher spatial resolution. Dr. Henney noted that the USAF has a continuing need for white-light images.

Dr. Hill described a five-year agreement between NSO and NOAA that will provide \$0.8M/year to NISP in return for real-time space weather data delivered to the NOAA National Centers for Environmental prediction (NCEP). A formal NOAA-NSF Memorandum of Understanding is expected to be signed soon; UC member Dr. Reinard is NOAA program manager for this effort. Installation of NISP space weather data processing pipelines at NCEP is underway and proceeding well.

SOLIS instruments are working well in Tucson. With repair of its water damage completed, the FDP will replace the VSM for the purpose of acquiring He I 1083-nm observations. SOLIS is also acquiring high-quality vector magnetograms in the Ca II 854.2 chromospheric line.

Perhaps the most important near-term choice facing NISP is site selection for the relocation of SOLIS. The improved observational coverage will allow SOLIS to provide improved synoptic products (e.g., global magnetic maps). The Committee recognizes the uniqueness of the SOLIS/VSM data: they provide the user community with daily, high-quality, full-disk Stokes profiles, mapping the magnetism of the solar photosphere and chromosphere to a level of polarimetric accuracy unmatched by any other existing synoptic program. Dr. Hill reported that two potential sites are being considered: Sacramento Peak in New Mexico and Big Bear in California. Installation costs (\$311K versus \$143K) and operational costs (\$150K/year versus \$50K/year) would be higher for the Big Bear site. The two sites are similar in geographic longitude, providing approximately 3 hours of full-disk context for DKIST

daily scheduling. From previous DKIST site surveys, Big Bear would provide consistently better seeing conditions and 40% more clear days than Sac Peak. Therefore, SOLIS/VSM vector magnetograms from Big Bear should be of greater scientific value to the solar community. The most important part of this transition is to minimize delays in site selection. Pending environmental impact studies and confirmation of costs, the committee supports the relocation of SOLIS from its current temporary location in Tucson, with a preference towards the Big Bear site based on the expected improvements in both seeing and observational coverage.

Dr. Hill updated the Committee on plans for the Solar Physics Research Integrated Network Group (SPRING), envisioned as the successor to SOLIS and GONG. NSO will hold a meeting soon after the UC meeting to draft a proposal to NSF for SPRING concept development that will emphasize ties to the US national space weather strategy and coordination with the European SOLARNET concept.

Transitional Facilities

Dr. Penn presented a science highlight recently published in *Astrophysical Journal Letters* (Penn et al., 2016, doi:10.3847/2041-8205/819/2/L30). The paper reports the first broad-band observations of the spectral energy distribution of a solar white-light flare in two wave bands at 5.2 μm and 8.2 μm , obtained with a Quantum Well Infrared Photodetector (QWIP) camera not previously used for solar observations. Observations in infrared and submillimeter bands are important for understanding the flow of energy in solar flares and provide an important bridge to ALMA in wavelength and height. Thus, even as it approaches the end of its operational life, the McMP is fulfilling two key aspects of its transitional role: the exploration of new infrared diagnostics and the application of state-of-the-art technology.

NSO's response to a previous UC finding on the ramp-down of the McMP has been given above. The UC strongly supports NSO's intention to support a joint McMP-ALMA observing campaign during 2017 and reiterates the desirability of maintaining at least the technical feasibility of McMP observing for as long as possible leading up to DKIST commissioning.

Dr. Uitenbroek reported on the status of the DST. The goals of the DST program are to continue to make observing time available to the user community through the end of CY 2017, to transition key personnel to DKIST while supporting DST, and to maintain the facilities at a level that keeps them viable for a potential operating consortium. Dr. Uitenbroek noted the departure of several members of the non-observing technical staff; Dr. Valentin-Pillet said that retention bonuses can be and have been used to mitigate losses. DKIST has hired three new observers with partial funding from DST. These observers will train in Sunspot and help to operate DST through 2017; they will also visit Maui to begin learning how to operate DKIST. Scheduling strategies described in the last UC report continue, with the exception that it has been decided to retain quarterly rather than semi-annual time allocation. Physical maintenance and software improvements also continue.

Dr. Uitenbroek described two science highlights: the successful flight of the CLASP sounding rocket, supported by DST observations, and measurements of absorption by Mercury's exosphere during a solar transit.

On April 14, NMSU submitted a white paper to NSF requesting bridge funding to allow NMSU more time to establish a consortium to operate DST and the Sunspot site after NSO vacates. Dr. Boboltz commented that such a funding request will presumably be reviewed as an unsolicited proposal. NMSU's long-term vision is 50-50 cost sharing between the consortium and NSF (about \$1.2M/year total). NMSU has resubmitted a proposal to the State of New Mexico to support NMSU's consortium share for five years; the probability of success will be influenced by state revenues, which are sensitive to uncontrollable factors such as oil prices. Dr. McAteer estimated that the consortium is perhaps 75%

of the way to assembling commitments to support the consortium cost share for the initial five years.

Building the NSO User Base

The committee and NSO held a brief discussion, led by Dr. Choudhary, on building the NSO user base for the DKIST/NISP era. Should we try to initiate an affiliation of researchers, with associated workshops, modeled after SHINE (Solar Heliospheric and Interplanetary Environment)? Dr. Boboltz commented that carving a new SHINE-like program out of the NSF/AST budget is unlikely because the grants program is treated as a single unit. Dr. Casini called attention to the DKIST Critical Science Plan workshops as a potential vehicle for attracting new users. The UC expects that continuing discussion of building the NSO user base will lead to more concrete plans.

NSO Coordination with Solar Probe Plus (SPP)

Dr. DeForest led a discussion of how ground-based facilities, including NSO, could increase the scientific return from the SPP mission. SPP has formed a Ground-Based Working Group with 9 core members (total membership about 20). SPP will seek augmented funding from NASA to help establish ground-based supporting facilities as a “fifth Science Operations Center.” The sense of the discussion was that coordination with SPP and Solar Orbiter should be an essential component of NSO’s future program.

Community Engagement and Education and Public Outreach (EPO)

Some aspects of the NSO EPO program are described above under NSO Status. Dr. Steven Cranmer (CU) presented an update on the Hale Collaborative Graduate Education (COLLAGE) program. COLLAGE aims to

- Create advanced solar courses that often would attract small numbers of students at any one institution but are needed for capacity building.
- Teach these courses using web-enabled technologies to multiple institutions.
- Employ the highest-quality interactive learning methods

Over 2013-2016, four courses were given, the latest delivered via WebEx in spring 2016: “Topics in Solar Observation Techniques” with 16 students at three universities. Negotiations with instructors for spring 2017 is underway.

During Committee discussion, Dr. Reinard stressed the importance of reaching potential students early in their undergraduate careers. Dr. McAteer recommended increased NSO/CU presence at the AAS winter meeting (larger audience). Dr. Choudhary noted that CSP meetings are another opportunity to expose students to solar science.

Findings

- The UC recommends that, owing to better seeing and higher duty cycle, Big Bear be selected as the permanent site for SOLIS. Higher initial and operating costs (as compared with the Sacramento Peak site) appear to be justified by the scientific benefits to the user. The UC believes that finalizing the relocation decision should be a high priority for NSO.
- The UC supports a descoped VTF as offering the best chance for this instrument to be available to users at or shortly after the start of DKIST operations. The Committee would appreciate being consulted with respect to future VTF upgrades so that it can assess the benefits to the user community in comparison with the potential for delaying one or more second-generation DKIST

instruments.

- The UC strongly supports NSO's intention to support a joint McMP-ALMA observing campaign during 2017 and reiterates the desirability of maintaining at least the technical feasibility of McMP observing for as long as possible leading up to DKIST commissioning.
- The UC recommends that NSO continue to take the DKIST Science Working Group to university locations around the U.S.
- Coordination with SPP and Solar Orbiter should be an essential component of NSO's future program.

Respectfully submitted,

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