Subaru External Evaluation Review, 2022, Final Report
Version 26 June 2022 (R3)

Submitted by the External Evaluation Committee (EEC)
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VERSION HISTORY

R1	7 June 2022	Release 1
R2	12 June 2022	Release 2 At request of Subaru Team, made three minor changes: 1. Question [1-1], Recommendation 2, changed “Computer and Data Management Division” to “NAOJ Astronomy Data Center” (clarification of responsible group); 2. Question [2-1], Finding 6, deleted “day crew” (redundant nomenclature); 3. Question [2-1], Observations, replaced “day crew” with “summit telescope technicians” (clarification of responsible group).
R3	24 June 2022	Release 3 At request of Subaru Team, the following revisions were made in the Appendix “Basis of Review”: 1. Added correct position title for Katarura (p. 19, table 2). 2. Added directions regarding inquiries about presentations (p. 20, paragraph 1). 3. For PS02, added author and affiliation (p. 20). 4. For PS03, expanded “Subaru” to “Subaru Telescope” (2 places) and IPMU to “Kavli IPMU” (p. 20). 5. For PS04, PS06 and PS07, added “Subaru Telescope, NAOJ” as author affiliations 6. Clarified delivery and revision history (p. 20, bottom)

PREAMBLE

This is the final report of the 2022 Subaru external evaluation review.

Subaru remains one of the world's most productive ground-based optical observatories. The high complementarity of its instruments, combined with the large 8.2-m aperture and the exceptional image quality of the Maunakea site, make Subaru ideally suited to advance our knowledge on a vast array of science topics, from the nature of our own solar system to the formation of structure in the early universe. It has an excellent record of accomplishment over the last seven years, comparable with other 8-m class observatories.

Looking forward into the early 2030s, Subaru remains **critical** for the continued success of Japanese astronomy and astrophysics research community (in collaboration with its international partners) and **important** for the continued success of the Japanese instrument and technology development community (also in collaboration with its international partners). More specifically, the Subaru-2 vision is exciting and impressive; however, many challenges remain to achieve that vision, especially regarding funding (and indeed funding structure), tension between Subaru Strategic Programs (SSP) and open-use programs, resolving demands for technical and operational support from different groups, and completing knowledge transfer from Mitsubishi Corporation (MC) to the Subaru team. Achieving and sustaining the Subaru-2 vision will require successful implementation of the recently developed enhanced maintenance and renovation plan.

Looking towards the Thirty-Meter Telescope (TMT), the combination of a wide-field 8-m class telescope and a 30-m narrow-field, adaptive optics driven telescope on the best developed observing site in the world will be the world-best scientific facility for decades into the future. However, Subaru will continue to stand on its own, and even in the unfortunate event that TMT does not reach fruition, Subaru can and should remain an essential, world-leading facility into the 2040s and perhaps beyond.

Acknowledgements

The External Evaluation Committee (EEC) thanks the entire Subaru team for helpful, clear, and comprehensive interviews, documentation, presentations, and answers to follow up questions. The *Report from Subaru Telescope for International Review FY2015 – 2021* (hereafter DDO4) was particularly strong. Combined with the presentations, it is a fundamental record of where Subaru is today and where it can go. As far as the EEC could assess, the team was transparent and internally self-consistent in all matters. Our one regret is that we could not meet in person in Hawai'i/USA or Japan.

Special thanks to Dr. Hori Kuniko and Dr. Masao Saito for their excellent organization and patient support.

The review charge and process are summarized in two appendices. For each question from the review charge, the EEC provides findings (statements of fact), observations (comments, thoughts, suggestions), and recommendations (suggested action items).

1 SCIENTIFIC ACHIEVEMENT, OPEN-USE, PAST 7 YEARS

[1-1] What is the international level of Subaru Telescope's science output (including in terms of impact and balance between disciplines) over the past seven years?

DD04 reference: Ch2: Scientific Achievement / Sec3.3: Open-use and Science Statistics

Findings

1. The observatory can support very diverse science investigations. The Subaru wide-field capabilities, combined with excellent image quality, are not duplicated at any other 8-m class observatory.

2. The oversubscription rate is consistent with international standards and reflects high demand for open-time by both domestic and international users.

3. The publication rate is healthy and competitive with that of other 8-m telescopes.

4. The publication rate from domestic PIs has remained constant for at least 15 years, while the publication rate of international PIs has increased dramatically over the same period, despite the few open-use nights allocated to international PIs.

5. Open-Use time is very effective, and currently leads to more papers than SSP allocated time.

Observations

Subaru remains one of the world's most productive ground-based optical observatories. The high complementarity of its instruments, combined with the large 8.2-m aperture and the exceptional image quality of the Maunakea site, make Subaru ideally suited to advance our knowledge on a vast array of science topics, from the nature of our own solar system to the formation of structure in the early universe.

In particular, HSC's capabilities remain unique worldwide and unparalleled for studies requiring wide field surveys. HSC continues to push our knowledge of the early universe to new heights: data from HSC's traced the largest 3D dark matter distribution at z~1 (Oguri et al. 2018); provided important constraints on cosmological parameters (Hike et al. 2019; Yasuda et al. 2019); greatly extended the low-luminosity end of the UV luminosity function at z~6 (Ono et al. 2018); and detected the most distant protocluster to date, at z~6.6 (Harikane et al. 2019). At the opposite end of the spectrum, HSC has advanced our understanding of Kuiper Belt Objects and pushed the outer frontier of our own Solar system.

While HSC might be the most productive of Subaru's current instruments, all instruments remain competitive and compelling. IRCS continues to push the envelope thanks to the high spatial resolution afforded by its AO capabilities, as demonstrated by the study of the rest-frame structural properties of quiescent galaxies at z~4 (Kubo et al. 2018). FMOS's multi-object capability has allowed us to constrain the rate at which structure grows at z~1.4, greatly extending previous results back in time. IRD and HiCIAO have improved our understanding of planetary systems around low mass stars and of protoplanetary disks.

In summary, the committee believe that Subaru's instrument suite is cutting edge, versatile, and capable of serving the diverse needs of its user community.

The fact that the publication rate from international PI has increased dramatically even as Japanese PI publication rate has remained constant is an indication that the observatory is extremely competitive on a world-wide stage and provides capabilities not available elsewhere. Expanding on the above, further increasing the fraction of open-use time dedicated to the international community (through mechanisms other than time-exchanges) will lead to an increase in scientific impact and productivity (evidenced by the high publication rate from international PIs), but also risk disengaging the Japanese community if the fraction of open-time available to them becomes too small.

The committee notes that several of Subaru's results have made use of data from other observatories, in particular Keck and Gemini. This is relevant, as collaboration amongst observatories, in particular on Maunakea, can only be scientifically beneficial. Time exchange programs, such as those currently in place with Keck and Gemini, have been effective and well utilized. Additionally, Subaru's success in following up optical counterparts of gravitational-wave events bodes well for Subaru's future role in the burgeoning field of multi-messenger astronomy.

The committee believes that the impact of SSP as well as open-use data would be greatly enhanced if 1) open-source data reduction packages were available for all Subaru instruments, and 2) fully reduced data were included in the Subaru data archive. Additionally, Subaru is encouraged to ask the SSP teams to deliver reduced data and advanced data products for wider community usage. For future SSPs, this should become a standard requirement.

Graduate student led or focused projects are discussed in Section 4 below.

Recommendations

1. Open-source data reduction packages and/or cookbooks based on open-source software packages should be made available for all Subaru facility instruments.

2. All current SSP teams should be encouraged to deliver science-ready, documented data products, including advanced data products (e.g., object catalogs) for wider community use; and all such products should be made available after a reasonable proprietary period. This will likely require support from the NAOJ Astronomy Data Center.

3. All future SSP teams should be required to meet the above recommendation.

4. Subaru should compile statistics that show the percentage of completion for individual proposals. If a significant number of proposals are not fully executed (i.e., only partial data are obtained), the observatory should explore ways to correct the issue.

2 TELESCOPE OPERATIONS, PAST 7 YEARS

[2-1] Have Subaru Telescope's past operations, open use, and utilization of observation data been effective in producing scientific results?

DD04 reference: Ch3: Operations

Findings

1. Subaru open-use operations provide an international standard range of observation modes, including Normal, Intensive (“large”), Service (“queue”), Filler (“poor weather”), Time Exchange, and Target of Opportunity (“time-domain”, “multi-messenger”)
2. Several Subaru Strategic Programs (SSP) are running and/or have been completed with the goal of establishing and/or sustaining scientific leadership in key areas. As a byproduct SSPs can produce science-ready data products suitable for reuse.
3. Subscription rates have been discussed in Section 1 of this report.
4. Several incidents of extended downtime have been experienced in the last 7 years, some due to external events beyond Subaru’s control (e.g., COVID-19 pandemic).
5. Lack of strict FITS header rules has created problems with data management and reuse.
6. There appear to be several critical operations risks related to the summit mechanical / telescope technicians, mostly related to recruitment, retention, and number.
7. There are many PI-instruments, often motivated by a desire to implement new, innovative technological approaches.

Observations

Subaru Telescope's past operations, open use, and utilization of observation data have been effective in producing scientific results. The following comments are designed to highlight possible ways to further increase productivity.

Moving towards remote, unstaffed, nighttime summit operations is viewed as positive. It is imperative that Subaru capitalizes on expertise and lessons learned by other observatories, in particular Gemini and CFHT, to ensure that the transition to remote observations at the summit is smooth and does not result in loss of observing time.

Having a skilled and well-trained summit telescope technicians team is critical. Personnel shortage in this area is an issue that requires immediate attention. This is not just a matter of operation efficiency. Less experienced personnel increases likelihood (risk) of accidents that could damage equipment or lead to personnel injury.

Subaru has been well managing the software, computers and archiving for the past 7 years, including the large dataset by HSC. Outsourcing the data archive does not present a problem, but more important is to ensure that the users are delivered fully processed data (as much as possible). While science-ready data products are produced for HSC and PFS SSP, a robust data pipeline should be available for PIs and other instruments to maximize the scientific outputs.

Subaru receives some indirect support from external groups who built non-facility instruments. However, the cost of supporting too many such instruments is not counted in just dollars but also by using Subaru staff personnel effort to support instruments when such personnel could be maintaining and renovating the core facility. This challenge likely causes stress on the day crews, and potentially negatively impacts the ability of the observatory to retain and train personnel, as well as carry out preventive maintenance.

Many other observatories have “carry forward” policies, i.e., high priority and/or nearly completed programs are automatically allocated time in future schedules. This can be important for projects where partial datasets are not complete enough to produce useful scientific results. Subaru seems to have an analogous policy for Intensive programs, but not for other types of open-time programs.

Subaru maintains an active program to upgrade existing facility instruments (e.g., new grisms for MOIRCS, new narrow-band filters for HSC), often in partnership with the Subaru users and institutional partners. There also appears to be an active flow of PI-class instruments to Subaru. While a strong community-based instrumentation program is generally positive, supporting many non-facility instruments is not cost-free, especially in terms of distracting the Subaru team from their core mission of operations, maintenance, modernization, and preparation for Subaru-2. This is particularly true when PI-instruments are using new, innovative technology. Finding the right balance between the needs of the core facility and the aspirations of the instrument building community will be critical in the years ahead, especially if the Subaru operations budget remains constrained.

Recommendations

1. Subaru should continue to work towards implementing fully remote summit operations as far as possible. This should not take precedence over other more important activities, in particular preventive maintenance.

2. Non-flagship instruments should be decommissioned, and resources should be reallocated to ensure the success of Subaru-2. This is critical not only from a budgetary perspective, but also to avoid staff burnout and ensure safety.

3. The observatory should explore recovering specific, high-profile science cases that cannot be addressed by flagship instruments (if any) through time exchanges with other observatories that do offer the relevant instrumentation.

4. In the case of visitor (PI) instruments, the instrument teams should be required to deliver fully functional data reduction pipelines to the community. Once tested, the ownership of such pipelines should be transferred to Subaru.

5. Subaru should perform regular user surveys (perhaps send questionnaires to proposers, if not done already), to solicit feedback and suggestions, and anticipate possible issues.

6. Subaru should investigate whether transitioning all instruments to queue mode could increase the observing efficiency.

5. To prevent frustration by the PIs, and ensure high program completion, the observatory should explore the possibility of carrying forward partially completed highly ranked programs by one or two semesters.

[2-2] Has a stable and safe telescope maintenance and repair plan been developed?

DD04 reference: Ch4 Telescope / Ch6 Safety

Findings

1. An independent safety office with a full-time safety officer was established in 2020.
2. A fault-analysis driven maintenance and renovation plan has been developed.
3. A risk register has been created.
4. Knowledge and technology transfer from Mitsubishi Corporation (MC) to NAOJ / Subaru has been a key organizing principle in recent years.

Observations

The committee observes that Subaru's safety record has been less than perfect in the past. However, it appears that the right corrective measures have been implemented. Hiring a full-time safety officer with responsibility and authority over all activities on behalf of the Director is long overdue and an important step forward.

The recently created fault-analysis driven maintenance and renovation plan is well-thought out and seems to be addressing the right problems. The committee observed no fundamental problems with the plan. However, progress has been slowed by cumbersome funding restrictions that prevent using current year funding over multiple years. Such restrictions are programmatically and financially inefficient, especially for large mechanical systems located at high attitude (4200-m).

The parallel creation of a risk register is a welcome development. To be a useful tool, regular review and revision is required. Subsystems where failure would result in loss of nights, damage to equipment, or harm to personnel should be added.

The committee applauds the high priority given to technology and knowledge transfer from Mitsubishi Corporation (MC) to NAOJ / Subaru, as well as efforts to reimplement critical control systems using modern technology. However, the new in-house expertise must be captured and held by long-service personnel, or these transfer efforts could come to naught (cf. Question 3-1 below)

Recommendations

1. The risk register should be reviewed and revised at least quarterly, with an emphasis on identifying and adding subsystems where failure could create significant safety impacts (e.g., damage to equipment, injury to people) and/or loss of observing time.

2. The observatory should ensure that knowledge transfer from MC is captured by trained employees who are likely to remain at NAOJ / Subaru for many years into the future.

3 MANAGEMENT, PAST 7 YEARS

[3-1] Were the observatory's staffing and funding plans sufficient to achieve the science goals?

DD04 reference: Ch5: Management

Findings

1. The Subaru funding structure changed significantly in 2018. Apart from Fiscal Year 2019, the amount of allocated funding is the same or greater than before but is now divided into task-specific fractions.
2. Large variations in the JPY/USD exchange rate have created cash flow stress for the Hawai'i group.
3. Observatory staffing has remained approximately constant over last seven years. The number of staff is analogous to other similar facilities, i.e., other 8-m to 10-m class telescopes such as the Keck Observatories, the ESO Very Large Telescope, and the Gemini Observatories.
4. While total staffing levels have been stable, FTE distribution has changed, e.g., more Hawai'i based personnel are working on development and future preparation work than before.
5. Staff retention is a growing challenge, within specific groups, such as the Day Crew.

Observations

Judging from the high impact science results (Section 1), the general answer to this question is "yes".

Subaru has been operating well for the past 7 years despite dramatic funding structure changes in and after 2018. After two years for overall reduction, total funding was restored and/or increased. However, funding is now divided into on-going operations / maintenance activity and project-specific activity. The latter is constrained to be spent in the same year it has been allocated. This leads to programmatic and fiscal inefficiencies as some high priority renovation tasks are not easily split into one-year sub-projects. Moreover, recruiting personnel for highly technical but short-duration projects is very difficult in Hawai'i in general and the Big Island in particular. The situation is unlikely to be sustainable; in particular, hiring and retaining highly qualified personnel will require more flexibility in the funding scheme. An additional risk is that knowledge from MC is transferred to short-duration staff, so that no one has long-term knowledge or experience with mission-critical sub-systems.

Driven by the change in funding structure, as well as anticipating Subaru-2, the Subaru team has been structured in a variety of ways to meet current challenges (e.g., creation of independent safety office with full-time safety officer in 2020, preparation for PFS/GLAO). In the past, it seems that there was tension and poor communication between the science and technical operations divisions. The situation is much improved thanks to the new management structure. That conclusion should be validated through a survey process to gauge workplace climate.

Subaru has recently appointed a Head of Science, a very positive development for the observatory. Even if the plans for Subaru-2 are already well defined, such a position is important to ensure that the observatory optimizes operations for high science impact in the era of Rubin, Euclid, Roman and TMT.

While the Subaru team seems to have adapted to these changes well (a sign of a strong team), the committee is concerned that regular maintenance and operations tasks have or will not get the attention they need, accelerating growth in technical failures by an aging facility. The committee welcomes Subaru's plan to increase the number of staff personnel to better address concurrently maintenance, modernization, engineering, and GLAO projects. However, as mentioned above, achieving that staff growth may be hobbled by the current funding structure.

The turnover rate during the pandemic has been similar to other observatories (e.g., Gemini, Keck). However, the pre-pandemic Subaru is much higher in comparison (11 – 15%). This is driven, at least in part, by the fact that NAOJ employees are reassigned (by NAOJ) to other projects. High turnover in some divisions is unavoidable (e.g., night observers do not generally stay around for long) — in these cases, over-hiring can be justified to minimize the risk of a staff shortfall.

Recommendations

1. NAOJ should continue its efforts to work with Japanese funding agencies for more flexible usage of the supplementary funding, to allow for the creation of multi-year renovation projects.

2. NAOJ should ensure that personnel are assigned to the observatory for as long as they are needed, and certainly long enough for them to work at 100% efficiency after the initial training period.

3. The observatory should review retention actions to entice employees (both NAOJ and RCUH) to stay (e.g., pay increases/bonuses/promotions/reallocation to different activities).

4. The observatory should explore possible sharing of personnel with other observatories, especially for activities that might not require full time employees.

5. The observatory should conduct an internal “climate survey” to understand what does/does not work at the observatory and, hopefully, reveal the reasons for the high turnover rate.

4 PIO, EDUCATION

[4-1] How do you evaluate the achievements in human resources education and development?

DD04 reference: Ch7: Education

Findings

1. The number of graduate students who received Ph.D. supervised by Hawai'i-based Subaru staff is not large compared to the number of staff members.

2. The fractions of proposed and approved observing programs per semester led by student PIs has been approximately constant during this period.

3. The number of doctoral projects based on Subaru data completed per year during this period has been approximately constant, while the analogous number of masters projects has been increasing.

Observations

Recent achievements seem consistent with available albeit constrained funding.

Encouraging students to plan and execute new observing programs is important to foster the next generation of researchers. Nevertheless, there is a growing archive of science-ready data products that provides exciting opportunities for research projects based on archival data.

The constant level of doctorate production vs. the increasing master's degree projects seems in large part due to different job prospects. This may be another reason to encourage use of advanced data products (e.g., object catalogs) as they lend themselves to training in data science and analytics techniques that are attractive to a wide variety of employers in the modern information economy.

Research training programs open to Japanese students and researchers appear to be welcomed and well-used. Such programs are important for sustaining scientific interest in Subaru and preparing the next generation. However, recent budget restrictions have led to reductions in such programs. It seems inevitable that re-prioritization mixed with terminating some training activities may be necessary.

Recommendations

1. Subaru should engage in collaborative discussions with universities offering graduate programs to determine ways to maintain and increase the number of student-led research projects, based on new observing projects and/or use of archival data (esp. science-ready data products).

2. All Subaru-based research scientist and student training activities should be reviewed and prioritized by impact, so that low-impact programs can be deferred to strengthen high-impact activities.

[4-2] Are the achievements and current status of public relations and dissemination activities sufficient?

DD04 reference: Ch7: PIO

Findings

1. The Subaru PIO effort has been recently refocused on local engagement in Hawai'i.
2. The Subaru PIO personnel regularly conducts activities that are attended by hundreds to thousands of people per event.
3. The Subaru PIO personnel regularly post on all standard social media platforms.
4. The number of PIO personnel has declined in recent years.

Observations

Recent achievements seem consistent with available albeit constrained funding, and perhaps exceed expectations given those limitations.

Subaru has been conducting various public relations/outreach activities to showcase the activities of the observatory to the local community. The activities include the in-person events and social media. The committee reviewed data that demonstrated these activities were high-impact and well-attended. Anecdotal evidence suggests these events are well-appreciated by the local community, sustaining support for Subaru and other Maunakea observatories. Participant surveys at the events and/or by email after the event would be very insightful.

Recommendations

1. Subaru should continue to capitalize on its unique heritage to connect to the local community — the Tanabata Star Festival is an excellent example.

2. Subaru should continue to partner with the Maunakea Observatories in the various outreach activities, both to foster collaborations amongst the observatories, and to maximize the impact of Subaru's PIO resources

3. Development of activities that connect to local traditions (e.g., long-distance ocean navigation) should be encouraged.

4. Subaru should conduct participate surveys to gather data on community impact of PIO events.

5 SUBARU-2: SCIENCE GOALS AND CONCEPT

[5-1] Are the science goals of "Subaru-2" appropriate for the next 10 years?

DD04 reference: Chapter 9

Findings

1. The wide-field instruments HSC, PSF and ULTIMATE are unique in this class of the telescope.
2. PFS construction and deployment is proceeding, albeit somewhat behind schedule.
3. ULTIMATE-GLAO funding has been approved, at least the initial commitment.
4. ULTIMATE-WFI funding has not been awarded yet.
5. Exoplanet science and instrumentation will also be important in the Subaru-2 era.

Observations

The committee observes, that, even in isolation, the Subaru-2 science vision is excellent and very compelling. The science goals and concept of "Subaru-2" are competitive for cosmology, galaxy formation, multi-messenger astronomy and exoplanet characterization. Therefore, Subaru-2 addresses questions that will certainly dominate the astronomical landscape in the decade to come, and Subaru and its community should be commended for their vision and ambition. Most of planned science seems to rely on wide-field instruments. It is okay to optimize the Subaru telescope for the large surveys. On the long run, Subaru-2 and TMT would be highly synergistic.

Subaru-2 includes major upgrades of Subaru's science capabilities, by developing a suite of new instruments (PFS, ULTIMATE), focussing on the unique wide-field capabilities. Its key science goals are (1) understanding the nature of dark matter and dark energy and determination of the mass of neutrino; (2) understanding the physics of galaxy formation and evolution in the context of the structure formation of the universe; (3) revealing the origin of heavy elements as well as high-energy cosmic rays by playing major roles in multi-messenger astronomy; (4) search for earth-like exoplanets. For this purpose, an adaptive secondary mirror (ASM) will be installed to realize the wide-field ground-layer adaptive optics (GLAO) correction for the ULTIMATE-WFI instrument at the Cassegrain focus.

The committee regards the instruments HSC, PSF and ULTIMATE unique in their wide field-of-view capability in the 8m-class of telescope. The ULTIMATE-WFI funding, however, has not be awarded yet. In addition to the strong cosmology focus, exoplanet science and instrumentation will be important as well, and will be partially supported through PI-led instruments.

Hyper-Suprime-Cam (HSC) has already produced many excellent results and PFS is highly demanded. The combination of HSC and PFS by themselves, in particular the Subaru Strategic Programs (SSP), will have very high impact, but synergy observations are also highly demanded by other cosmology space mission like Euclid and Roman. Therefore, the delay of PFS raises quite some concerns.

ULTIMATE is an excellent choice for an optimum use of bright nights because the dark nights are in heavy demand for cosmology and extragalactic work. In this context, the balance between bright night use of ULTIMATE and PFS should be further evaluated (see below).

The wide and deep capability of Subaru-2 is powerful to study multi-messenger targets that have large positional uncertainties. The Laser-Tomographic adaptive optics (LTAO) instrument ULTIMATE-NINJA is very useful for follow-up observations of multi-messenger targets, although it cannot be used when HSC or PFS are mounted on the telescope. If multi-messenger science is critical to the observatory, Subaru needs to be prepared to handle it. The operational challenges of an optimum multi-messenger observing strategy are addressed in the recommendations.

While the future of Subaru may be dominated by large projects with significant allocations of observing time and other observatory resources, small-size projects should not be abandoned. How to keep the Japanese community excited and how to include future international partners within the Subaru collaboration need to be carefully considered. One big question is whether three facility instruments + PI instruments are enough for the Subaru-2 science topics. How to encourage new PI instruments would be important. For example, the FOCAS spectrograph is still very much in use, almost the same amount of time as HSC. Whether PFS can completely take over this role (e.g., low resolution and/or deep spectroscopy) needs to be carefully investigated. Well-made pipelines (and computer resources) for the survey instruments are essential to maximize the return from the survey and encourage a wide user base. It is not clear whether PFS has enough resources to prepare for broad community use.

Recommendations

1. Continue plans for advanced exoplanet characterization instrumentation and operations in the era of JWST and future extremely large ground-based telescopes (ELTs).

2. The observatory should look at re-balancing the possible bright-time use of PFS to reduce the number of needed top-end swaps.

6 SUBARU-2: OPERATIONS AND MANAGEMENT

[6-1] Is the operation plan of the observatory reasonable to achieve the science goals?

DD04 reference: Chapter 3

Findings

1. New processes and operations modes for the Subaru-2 era are under development. Fully remote night-time operation from the base facility is one of the near-term plans.
2. Day Crew teams are being re-organized for stable and safe operation.
3. Instruments will be reduced to five facility instruments (HSC, PFS, ULTIMATE-WFI, MOIRCS, GLAO) and some PI-Instruments in five-year timescale.
4. More comprehensive data analysis and archive systems are under development.
5. Subaru plans multiple top-end changes per lunation.
6. Efforts to develop and sustain international partners for Subaru operations have so far met limited success.

Observations

The ambitious Subaru-2 science vision will trigger new operational challenges and opportunities. Not only will the facility instruments be significantly more complex than at present, demand from the user community for highly capable data reduction software and/or science ready products far exceeds the current requirements. The current operations vision seems sufficient to maintain the core facility but may fall short of meeting the scientific support expectations of the Subaru user community.

The focus on wide-field observations capitalizes on Subaru's strengths. HSC is already very productive, and PFS will become the most powerful multi-fiber spectrograph during the Subaru 2 era. ULTIMATE-Subaru can also be a world competitive instrument at near-infrared (NIR) wavelengths and can make excellent use of bright time. PI type instruments targeting exoplanets will also increase the capabilities of the Subaru telescope. Subaru can also play a critical role in the era of multi-messenger astronomy thanks to its wide-field instruments.

On the other hand, the many planned top-end changes in the Subaru-2 era are a serious concern, since equipment and personnel risk is directly proportional to the number of changes per year. While any accident is bad, the complexity of the top-end systems under development means recovering from a future accident will be dramatically more costly in time and expense than at present. Risk could be reduced by keeping wide-field instruments mounted through entire lunations, at least part of the time, as is done at other facilities (e.g., NOIRLab Blanco/DECam, NOIRLab Mayall/DESI).

Reducing the number of instruments is planned but deciding which instruments to decommission and when requires very careful consideration. Telescope time exchange is one way to maintain community access to various capabilities, but the total number of usage of instruments should be carefully compared with the total number of exchange nights. Careful consultation with the Subaru domestic and international user communities must be part of the decision process.

Although Subaru has successfully met the ToO / multi-messenger challenge so far, the observatory should explore whether the current operation mode is flexible enough to accommodate the potentially large number of (interesting) follow-up from LIGO/Virgo, LSST and other multi-messenger channels. In particular, the observatory should explore the impact of a potentially large number of disruptive ToOs on queue operations and on the SSPs.

Other 8-m class observatories are run as multi-national partnerships, including the ESO Paranal Observatory, the Gemini International Observatory, the Gran Telescopio Canaries Observatory, and Large Binocular Telescope Observatory. The W.M. Keck Observatory is the exception but even it is run as a multi-partner organization. Beyond the obvious potential access to more funding, such a Subaru partnership would provide a broader diversity of expertise (scientific, technical, operational, cultural) and access for the Japanese community to other facilities and collaborations. The goal should be not to just "sell time" but to strive for an integrated partnership with a new governance model where all partners have a say in the future of the observatory and are, therefore, fully invested in its success. One obvious framework for such partnership building is the TMT partnership and an integrated vision for TMT/Subaru science and technical operations.

On a more utopian level, such international scientific endeavors also help build international communication, understanding, and stabilization. In this fraught moment of global stress due to the Covid-19 pandemic and political disagreements around the Pacific Rim, encouraging such collaborative activities seems particularly important.

Recommendations

1. Review top-end change planning with the goal of reducing number of top-end changes per unit time to reduce risk to personnel and equipment.

2. In consultation with the broader community, review, and revise planning for non-facility instruments in the Subaru-2 era.

3. A deeper analysis of user scientific support requirements around data processing software and science ready products should be completed, so that the user community and observatory expectations are well-matched and/or Subaru can work with the PFS and ULTIMATE teams on delivery what the community needs and/or wants.

4. As the pandemic wanes, reengage with the potential partners to explore a true international partnership and governance structure for the Subaru-2 era and beyond.

[6-2] Is a stable and safe telescope maintenance and repair plan developed?

DD04 reference: Chapters 3, 4

Findings

1. A fault-analysis driven maintenance and renovation plan has been developed

Observations

The envisioned telescope maintenance and repair plan has already been discussed in response to Question 2-2. The remarks below are supplementary to that discussion.

Although no serious concerns were found for safety, accidents have occurred in the past. Efforts to reduce accidents should continue. While the establishment of a new safety team is welcomed, more attention and resources will be needed when in-house maintenance is increased in the near future.

Telescope maintenance and repair plans have improved significantly since the last review. Although the group size is not large, establishing a Renovation Division is a positive step forward. Increasing in-house maintenance has reduced the cost for repair and maintenance. It should also contribute to fixing the problems quickly. The target goal to reduce downtime to levels comparable to the Gemini telescope is ambitious, given Subaru's complexity, but should be attainable.

Recommendations

1. See recommendations under Question 2-2.

2. The observatory is encouraged to meet regularly with other Maunakea observatories to discuss operational experiences, especially topics related to safety.

[6-3] Are the observatory's staffing and funding plans sufficient to achieve the science goals?

DD04 reference: Chapters 4, 5

Findings

1. The staffing plan seems appropriate if the staff turnover rate can be reduced.
2. The Software and Computer & Data Management Divisions have enough staff for baseline operations but not for developing and/or delivering high quality science data products
3. The key Subaru-2 instruments will be much more complex, and therefore potentially more resource intensive to maintain, than current generation instruments
4. The ULTIMATE project has not yet been completely funded; in particular, funding for the wide-field IR camera has not yet been received.

Observations

The committee is concerned that targeted staffing levels may not be sufficient for the Subaru-2 era.

Staffing issues will become critical in the Subaru-2 era: more human resources and operation budget will be needed in the next few years for large survey type instrument, HSC, PFS and ULTIMATE.
For example, PFS is a very complicated instrument, built by many different institutes. The observatory should not miss hiring key personnel for hardware maintenance. Efficient use of optical fibers for mixed programs can be complicated and reducing data may not be simple for PIs not connected to the instrument team. To make the best use of PFS, software development is very important. Some software development can be done by the PFS international team, but it is the responsibility of the Subaru observatory to make sure that the open-time users can produce high-impact science results in a timely manner.

Given the increased technical complexity of the Subaru-2 system as well as on-going pressure to complete preventive maintenance and modernization efforts in a timely manner, monitoring day crew available FTE vs. requested workload will be critical. The recently hired summit work coordinator is a welcome addition and should be responsible for such monitoring. However, Subaru upper manager should regularly check-in, review what is happening in this mission-critical area and adjust in available FTE or demanded workload.

Fully remote nighttime operations are important to constrain staff growth as well as for safety purposes. When fully implemented, the total number of people to monitor and/or operate various components at the summit will be reduced. Considering that the observatory and its instruments are aging, the role of Day Crews will become increasingly important. Adding cameras and sensors to monitor the status by the GERS remote observing system and Gen2 is important, and careful design and follow-up activities should be done.

The Software Division as well as Computer & Data Management Division seem to be understaffed, and new resources may be necessary to meet user community expectations. More so than other areas, it is important to consider that a small number of talented but perhaps more expensive people may have higher impact than total number of people. Inviting skilled workers from other NAOJ projects or divisions or from outside of NAOJ for middle term may work well.

The Subaru observatory and the Japanese community need to raise more funds for ULTIMATE-Subaru. It is not clear whether the Subaru team has enough skilled people. Involving younger astronomers is also important to keep instrument activities at NAOJ and within the Japanese community.

For multi-messenger astronomy, quick data analysis is crucial. The availability and ease of use of reduction software are critical to the rapid pace of transient science, where results are needed in hours (or minutes), not days or weeks. Processing speed is often limited by data transfer, and increasing the network speed and adopting SSDs, for example, may be a way to speed things up.

Like current operations, Subaru-2 era operations may be hindered by a complex, partitioned funding structure. Thus, all observations and recommendations related to funding structure (as well as international partnerships) in Section 3 are applicable here.

Recommendations

1. As stated early, it is critical that Subaru continue efforts to lessen dependency on Mitsubishi Corporation (especially regarding control systems, both hardware and software) and bring expertise in house. This is important not only to reduce cost, but also to ensure that issues are addressed and resolved in a timely fashion.

2. In collaboration with all Subaru-2 instrument teams, Subaru should carefully review science user support software plans to determine what data analysis software and science-ready data products can be developed and delivered within available funding (internal and external), and when it will be delivered. The user community should then be informed so that their expectations are consistent with what can be delivered.

APPENDIX: REVIEW CHARGE

The external evaluation committee (EEC) was asked to respond to the questions in the table below.

Review Items	**Review Perspectives and Criteria**	**Corresponding Chapters**
RI1: Scientific achievement during these 7 years through Open-use of Subaru Telescope	1-1: What is the international level of Subaru Telescope's science output (including in terms of impact and balance between disciplines) over the past seven years? - Results for primary science. - Results from Open Use.	Ch2: Scientific Achievement Sec3.3: Open-use and Science Statistics
RI2: Subaru Telescope operations including Safety during these 7 years	2-1: Have Subaru Telescope's past operations, open use, and utilization of observation data been effective in producing scientific results? 2-2: Has a stable and safe telescope maintenance and repair plan been developed?	Ch3: Operation Ch4: Telescope Ch6: Safety
RI3: Subaru Telescope management including HR and funding during these 7 years	3-1: Were the observatory's staffing and funding plans sufficient to achieve the science goals?	Ch5: Management
RI4: PIO (Public Information and Outreach) and education	4-1: How do you evaluate the achievements in human resources education and development? 4-2: Are the achievements and current status of public relations and dissemination activities sufficient?	Ch7: Education Ch8: PIO
I5: Science goals and concept of "Subaru-2"	5-1: Are the science goals of "Subaru-2" appropriate for the next 10 years?	Ch9: Subaru-2
RI6: Subaru Telescope operations and management plans in the Subaru-2 era.	6-1: Is the operation plan of the observatory reasonable to achieve the science goals? 6-2: Is a stable and safe telescope maintenance and repair plan developed? 6-3: Are the observatory's staffing and funding plans sufficient to achieve the science goals?	Sec3.4.3: Data Management Sec3.5.7: Operation Sec3.6.2: Day Crews Sec3.7.3: Instruments Sec3.8.3: Software Sec3.9.3: Computing Sec4.4.3: Maintenance Sec4.5.6: Renovation Sec5.2.2: Headcount Sec5.3: Budget

APPENDIX: BASIS OF REVIEW

The external evaluation committee (EEC) listed below was assembled by the NAOJ in late 2021. The committee elected its own chairperson, Dr. David Silva.

Doi, Mamoru	Professor, Institute of Astronomy, School of Science, University of Tokyo
Ferrarese, Laura	Principal Research Officer, National Research Council of Canada
Hasinger, Günther	Professor and Director of Science, ESA Director of European Space Astronomy Centre (ESAC)
Kawabata, Koji	Professor, Hiroshima Astrophysical Science Center, Hiroshima University Member, Project Review Committee, NAOJ
Nagata, Tetsuya	Professor, Department of Astronomy, Kyoto University
Silva, David R. (EEC chair)	Distinguished Professor, Physics & Astronomy, The University of Texas at San Antonio Dean, UTSA College of Sciences
Sumi, Takahiro	Professor, Department of Earth and Space Science, Graduate School of Science, Osaka University

A kick-off meeting was held in Jan 2022. Afterwards, the EEC created and submitted a workplan to the NAOJ late January 2022. Following that plan, four EEC meetings were held during February and March 2022.

During March 2022, the EEC as a group (except Hasinger, who was unavailable) met for 60 minutes with the key individual listed below. For each interview, the EEC asked the individual(s) to present their view of key challenges and opportunities in their areas. Each EEC member then asked follow up questions. We thank everyone for clear and helpful interviews. In a separate meeting, the EEC chair (Silva) interviewed the NAOJ Director General (Tsuneta) for 90 minutes.

Project Controller / HR Manager	Katakura / Nakajima
Director	Yoshida
Head, Science & Telescope Operations	Kambe
Vice Director	Takami

The table below lists the review document provided to the committee. In particularly, Document DD04 (*Report from Subaru Telescope for International Review FY2015 – 2021*) was excellent and much appreciated by the committee.

AD00	Review Items, Perspectives, and Criteria - Subaru Telescope
AD01	Scientific Goals and Missions – Subaru Project
AD02	FY2021 NAOJ Project Review Members List of the External Evaluation Committee for Subaru Telescope (December 22, 2021)
DD01	Subaru Telescope Organization (2021.12)
DD02	List of NAOJ Executive and SAC/TAC Members of Subaru Telescope
DD03	Likely impact of revised Maunakea master lease and sublease, specifically expected new programmatic and financial requirements on Subaru.
DD04	Report from Subaru Telescope for International Review FY2015-2021

Two 4-hour review meetings were organized:

- Meeting 1 (25 March in Japan, 24 March outside of Japan) focused on the Subaru science accomplishments, Subaru-2 science vision, education, and public information & outreach
- Meeting 2 (31 March in Japan, 30 March outside of Japan) focused on Subaru management, operations, and maintenance

All presentations (listed below) were made available to the committee immediately following the meetings. The committee asked for additional information or clarifications, which were provide by the Subaru team quickly and thoroughly. All presentations were clear and thorough, the EEC congratulates the team. For inquiries regarding presentations, please contact the Office of the Project Review Committee at NAOJ.

PS01	Science Achievement and Statistics, Masato Onodera (Subaru Telescope, NAOJ)
PS02	Public Information and Outreach & Education, Masayo Nakajima (Subaru Telescope, NAOJ)
PS03	Science Goals/Concepts of “Subaru-2”, Yusei Koyama (Subaru Telescope, Sec.9 Editor), Yuki Moritani (Subaru Telescope /PFS), Yosuke Minowa (Subaru Telescope /GLAO), Masahiro Takada (Univ. of Tokyo/Kavli IPMU), Masaomi Tanaka (Tohoku Univ.), Motohide Tamura (Univ. of Tokyo/ABC/NAOJ), Takayuki Kotani (NAOJ/ABC)
PS04	Overview of Subaru Telescope, Michitoshi Yoshida (Subaru Telescope, NAOJ)
PS05	Operations, Eiji Kambe (Subaru Telescope, NAOJ)
PS06	Maintenance and renovation of telescope and enclosure, Yoshinori Kumura (Subaru Telescope, NAOJ)
PS07	Management, Junichi Katakura (Subaru Telescope, NAOJ)

Responses 1	RIQ1-RIQ14, (A collection of answers to questions from EEC after Day1)
Responses 2	Subaru Telescope's Response to Questions on April 3, 2022

The EEC meet for two hours on 5 April (4 April outside of Japan) to finalize preliminary findings and create a presentation. On 8 April (7 April outside of Japan) the EEC met with the NAOJ / Japan to present preliminary findings and answer initial questions.

Creation of this final report took more weeks than initially expected due to busy schedules of various EEC members, especially the EEC chair. On 26 April (25 April outside of Japan), the EEC meet to agree on the final report structure and writing assignments. EEC members submitted all preliminary input to the EEC chair by 13 May 2022. The EEC chair then merged and edited all input to create a complete preliminary report, which was distributed to the committee on 24 May 2022.

Based on feedback, a revised preliminary report was created and then discussed by the committee. Once final changes were approved, the initial release was provide to NAOJ on 7 June 2022.

Several corrections were requested over the next few weeks. Details are provided in the Version History on page 1.