External Review of the National Astronomical Observatory of Japan
Report by the International Review Committee

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External Review Committee:

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Executive Summary, Part I – Accomplishments –

NAOJ has evolved from a small national research group into a world leading organization of modern astronomy. It plays a central role as an inter-university research institute in Japan to provide access to first rate and internationally highly competitive astronomical facilities and to stimulate new astronomical science. In the world NAOJ is well accepted as a most competent scientific partner with an enormous know-how and experience. It is also seen as a very strong scientific competitor.

During the review period of the last four years NAOJ has made outstanding accomplishments, which have put Japan at the forefront of world astronomy. The 8.2-m Subaru Telescope on the summit of Mauna Kea delivers the best image quality of the existing 8m class telescopes in the world and has developed into a world-leading facility in ground-based astronomy. Used by a vibrant national and international community of scientists it has made fundamental contributions to the advancement of modern astrophysical science covering a wide range from the solar system, star and planet formation, stellar physics to extragalactic astronomy and cosmology. The Hinode space mission is extremely successful and an outstanding example of world science leadership in solar astronomy engaging a large fraction of the international solar research community. Still less than two years since launch, Hinode promises to continue to revolutionize our understanding of the sun. Japan was already a world leader in radio astronomy and has taken another step forward through its participation in the construction and operation of ALMA, which is an extremely ambitious and complex project of enormous scientific potential and visibility. Advanced and innovative technology

developed independently and contributed by NAOJ has enhanced the scientific scope of the project significantly. Building on the success of VSOP-1 the next generation follow-up space mission VSOP-2 has been prepared and proposed and recently been approved as a new milestone of space radio astronomy. The GRAPE project to develop special purpose computer hardware for astrophysical simulations has a major international impact in theoretical astrophysics. The new GRAPE-DR chip is the fastest special-purpose programmable processor in the world for high performance computation applications, and will make NAOJ the most powerful computational astrophysics center in the world.

The committee acknowledges the important and successful role of NAOJ in the education of graduate students. The level of commitment is seen as appropriate and close collaboration with universities should be maintained as a key component of the organization.

Much of NAOJ's success has been accomplished, because the staff is extremely dedicated and committed and is used to deliver results even in situations where manpower is spread extremely thin. In the long run under such circumstances, there is a risk of burn-out. The committee detected signs of stress in the form of chronic overwork by scientists who have had to take on project management, engineering and operational activities. We recommend that NAOJ consider employing professionally trained project managers and engineers to be assigned to projects so that scientists can concentrate on extracting the maximum scientific yield while attracting and training the next generation of astronomers.

Executive Summary, Part II – Future Plan –

The future plans of NAOJ are ambitious and bold. They keep the momentum obtained from the present success and envisage an exciting scientific future. The committee has reviewed and discussed the NAOJ future plans intensively and provides the following evaluation and recommendations:

- The committee strongly endorses the plan to join the Thirty Meter Telescope project (TMT) should that telescope be sited on Mauna Kea. In this way, Japanese astronomers will gain access to the first ELT to be built, while being able to use the already existing infrastructure and Subaru as a unique wide field 8m-class telescope. The committee urges NAOJ to use the full weight of its considerable influence to ensure that the TMT ***is*** built on Mauna Kea. This is now a matter of the highest priority and greatest urgency.

- As a back-up strategy for the case that the TMT project will decide not to select Mauna Kea as its site the committee recommends that NAOJ keeps all options open and carefully investigates possible partnerships with ESO

and the GMT alternatively to the TMT. Another option is a somewhat descoped version of an ELT, for instance a 20m telescope, with new partners on Mauna Kea.

- The committee endorses the Subaru plan for future instrumentation, both short and long term. FMOS, Hyper Suprime-Cam, and HiCIAO will be unique instruments opening the perspectives for a scientifically exciting future and PIAA has the potential to revolutionize high resolution optical/infrared astronomy in space and on the ground. While scientifically tremendously attractive, in particular in regard of future synergy with the TMT on Mauna Kea, a decision on WFMOS requires a more careful consideration of the tradeoffs for Japanese astronomical community.

- The new paradigm of swapping observing time with other large telescopes on Mauna Kea rather than continuing to provide a comprehensive set of first class, very expensive instruments together with frequent instrument changes for observations is very attractive in the long term. The committee encourages a detailed investigation of such an operational model.

- The committee endorses the future operational and science use plan, which was presented for ALMA. However, the committee is concerned that the Japanese ALMA participation may be under-resourced in terms of astronomical manpower and operational support and recommends that NAOJ seeks support for shared operation in the Asian-Pacific region.

- The NRO 45m telescope will continue to play an important and complementary role in millimeter astronomy. This is an essential activity that must continue for Japan to obtain the scientific return on its substantial investment in ALMA. To guarantee efficient future operation, however, major investments must be made: foremost here is refurbishment of the telescope.

- Of concern to the committee was the evident lack of a long-term plan in the NAOJ radio astronomy division. The committee notes that this planning gap could be very well filled if Japan became involved in the international collaboration to develop the Square Kilometer Array (SKA). Japanese astronomers and industry are already involved in many key SKA technologies and could become involved in both planning and technology developments without the need to make long term financial commitment at this stage.

- Based on the continual success and evolution towards more ambitious missions, the committee strongly endorses NAOJ's development of Solar C as highly appropriate to enhance and maintain Japan's leading position in

space solar physics.

The committee also reviewed the situation of the ground-based facilities of the Division of Space and Plasma Astrophysics and makes specific recommendations about their future.

- The unique role of NAOJ's Department of Theoretical Astrophysics and the Center for Computational Astrophysics for Japanese astronomy is recognized. Several measures are recommended to strengthen the division, a visitor program (both medium- and long-term), additional funding of carefully selected R&D programs, and three permanent positions, the first for the GRAPE initiative, the second for the 4D2U project, and the third for a liaison between theory and observation.

The committee has also identified a few areas of a concern, which are summarized in the following.

- The committee is concerned with the fact that there seems to be no clear mechanism to prioritize future projects in terms of science. This is not only the case within NAOJ but also the nation wide. In particular, big projects may well conflict with each other at the level of funding agencies. Some mechanism should be worked out to evaluate and prioritize them from scientific point of view.

- In the international radio astronomy community it is quite noticeable that while Japan has developed an impressive range of innovative technologies, little of this technology has diffused into the broader international community. A possible way to improve this situation might be for NAOJ to provide more organizational structure to support the existing fruitful cooperation between academic and industrial sectors.

1. Introduction

The external review of the National Astronomical Observatory of Japan (NAOJ) was initiated in October 2007 by Director General Shoken Miyama. In a first step, eight international committees evaluated NAOJ's four divisions, three centers and two projects in February 2008 and provided detailed reports of their evaluation. In addition the ALMA project was subject to an external review in October 2007 which was also summarized in a detailed review. All reports were then made available to the External Review Committee for a final comprehensive review of NAOJ to assess the accomplishments, activities and future plans of the whole organization. The report presented here is the result of this final review.

The review committee met on the two subsequent days, May 9 and 10, in Tokyo.

On the first day, after opening remarks by the Director General and a discussion of the purpose of the review an overview was presented of the NAOJ activities over the past four years by Deputy Director General Takashi Sakurai followed by an extended question and answer session. The meeting continued with a detailed discussion of the eight individual assessment reports of the NAOJ divisions, centers and projects. The afternoon of the first day focused on the future of NAOJ. Presentations of the basic overall concept of the plan were given together with more detailed descriptions regarding ALMA, Subaru and the ELT. The plans were then discussed extensively with the committee. The second day was spent in closed discussion in preparation for this report.

2. NAOJ – a world leader in astronomy

Over the last decades NAOJ has grown from a small national research group to a powerful institution with more than 550 staff, including 250 permanent, 250 non-permanent, and some 60 post docs. Simultaneously, it has evolved into a world leading organization of modern astronomy. In Japan it plays a central role as an inter-university research institute to provide access for the country's professional astronomers to first rate and highly competitive astronomical facilities and to stimulate new astronomical science. In the world NAOJ is seen as a fierce competitor on the highest level but simultaneously also as a most competent scientific partner with an enormous know-how and experience to bring into a collaboration. The committee is impressed by this remarkable development.

During the review period of the last four years NAOJ has made outstanding accomplishments, which have put Japan at the forefront of world astronomy. The 8.2-m Subaru Telescope on the summit of Mauna Kea delivers the best image quality of the existing 8m class telescopes in the world and has developed into a world-leading facility in ground-based astronomy. Supported by a dedicated team of observatory staff and used by a vibrant national and international community of scientists it has made important and in many cases fundamental contributions to the advancement of modern astrophysical science. The scientific accomplishments cover a wide range of astronomical science from the solar system, star and planet formation, stellar physics to extragalactic astronomy and cosmology. A large number of refereed scientific papers based on Subaru observations is published every year. The generally high citation rate of these papers indicates world-wide recognition of the Subaru scientific accomplishments.

Building on the success of Subaru and the experience and momentum gained, NAOJ has become engaged in the development of the next generation Extremely Large Telescope (ELT). Remarkable developments towards a 30m diffraction limited ground-based optical/infrared segmented mirror telescope have

been made, which have now led to a close collaboration with the California/ Canada Thirty Meter Telescope project and the scientifically extremely exciting perspective of Japanese astronomers gaining access to the most advanced telescope in the world.

NAOJ has joined the Europe/US collaboration to construct and operate the Atacama Large Millimeter Array (ALMA), which is an extremely ambitious and complex project of enormous scientific potential and visibility. Advanced and innovative technology developed independently and contributed by NAOJ has enhanced the scientific scope of the project significantly. ALMA is truly impressive in scope as well as in the capabilities it will bring to sub-millimeter astronomy. The payoff to its respective scientific community and the collective efforts in achieving this vision is something for all involved to take pride in. This step will maintain Japan's world leadership in mm radio astronomy.

In February 1997 VSOP-1 (Halca) was launched and demonstrated to the world the feasibility of space VLBI and, most importantly, involved Japanese radio astronomers in a complex network of international collaborations. These collaborations included space agencies, ground based astronomy facilities in many countries, and correlator centers. Strong international scientific collaborations also emerged and the whole science program was coordinated by an international committee of astronomers. The collaborative programs originally set up for VSOP are regarded as highly successful by the international community. Building on this success the next generation follow-up mission VSOP-2 has been prepared and proposed and recently been approved as a new milestone of space radio astronomy.

NOAJ's highly successful Hinode space mission done together with JAXA is an outstanding example of world science leadership in solar astronomy. Hinode follows the very productive Hinotori and Yohkoh missions in the continuing evolution of Japanese space solar physics from small to major missions. During the first months of 2008, Hinode science papers are appearing about one per day and at a general solar physics meeting in May 2008 Hinode results were featured in 53 of the 209 papers. Besides engaging a large fraction of the international solar research community, we note with pleasure that student these are now appearing based on Hinode results. Still less than two years since launch, Hinode promises to continue to revolutionize our understanding of the sun, particularly as the new solar cycle starts.

The GRAPE project to develop special purpose computer hardware for astrophysical simulations has a major impact in theoretical astrophysics and the technology is now used in dozens of places around the world. The new GRAPE-DR chip is the fastest special-purpose programmable processor in the world for high performance computation applications and will make NAOJ the most

powerful computational astrophysics center in the world, by the end of 2008.

These examples highlight the international success of NAOJ and the competitiveness of the organization. There are many additional high level science accomplishments and projects, which are discussed in detail in the evaluation reports of the divisions, centers and projects and which underline the scientific width and simultaneous depth of NAOJ as a world leading astronomical institution. The mere statistics of the continuously increasing number of publications in refereed journals (440 in 2006) also indicates that the scientific development of the organization is extremely successful.

3. The Future

Astrophysics is an extremely dynamic and successful part of modern science. The scientific funding agencies in countries all over the world have realized and acknowledged the enormous potential of astronomy for fundamental science detections and technological breakthroughs. As a result, astronomy is internationally extremely competitive. For NAOJ as an organization, which has succeeded to become a world leader, it is most important to carefully plan the future in order to stay on top and to keep up the momentum. The committee has reviewed and discussed the NAOJ future plans intensively and provides an evaluation together with comments and recommendations in the following (not in priority order).

The Subaru Telescope and its instrumentation have been scientifically very successful over the last eight years of operation. It is very important to keep these high standards and to remain at the forefront internationally. The competing large telescope projects in the world, Keck, Gemini and the ESO VLT, and their science communities have developed very ambitious plans for the 2nd generation instruments. The Subaru instrumentation plan (both short term and long term) is equally ambitious and very competitive.

The near-infrared multi-object wide-field spectrograph FMOS, the wide-field imager Hyper Suprime-Cam, and the extreme adaptive optics imager HiCIAO will be unique instruments opening the perspective for a scientifically extremely exciting future. In addition, the PIAA (Phase Induced Amplified Apodization) extreme adaptive optics system developed by Subaru using the innovative concept of an apodized pupil without losing light and avoiding very strong off-axis aberrations has the clear potential to revolutionize astronomy in space and on the ground. It will allow making high dynamic range and high contrast coronographic observations possible on hitherto unprecedented spatial scales and might be the breakthrough towards the detailed astronomical studies of the physics of extra-solar planets and planetary systems. The committee strongly supports the continued development of these instruments.

WFMOS is an instrument proposed to use the same field of view as supported by Hyper Suprime-Cam but for high and medium resolution multi-object spectroscopy and with the revolutionary multiplex capability of 4000. The committee understands that WFMOS is an extremely expensive instrumentation project that will rely on solid financial and technical support from the Gemini community, which is yet to be committed. Moreover, observing time needs to be exchanged with Gemini and a Japanese participation in a large scale structure survey with WFMOS would require a large fraction of the observing time otherwise available to the Japanese community. Nevertheless, a future constellation on Mauna Kea with the Thirty Meter Telescope (TMT), Subaru with Hyper Surprime-Cam and WFMOS and the University of Hawaii Pan-STARRS telescope is a vision of breathtaking scientific power. The committee agrees with the NAOJ's strategy to first enter into a detailed dialogue with the Japanese and the Gemini astronomy community about WFMOS, before further decisions are made.

The Subaru Telescope is the only 8-m class optical and infrared telescope available to the Japanese astronomical community. In order to satisfy all the needs of the community, the suite of instruments is unusually large for one telescope. While this is definitely a challenge for instrument operation and maintenance, it has also opened a large variety of science opportunities, which would not have been available otherwise. However, an alternative model for the future is to take advantage of the fact that with Keck 1 and 2 and Gemini there are other very large telescopes of the same class accessible on Mauna Kea in Hawaii. Thus, rather than trying to cover all science needs with comprehensive instrumentation for each individual telescope, they could be equipped complementary so that the sum of all telescopes is capable of investigating all the important science questions. The different science communities using the Mauna Kea telescopes could then carry out their science by just simply swapping observing time. In this way, a system of telescopes would be available to the Japanese community with Subaru still being the most important core facility. The advantage of this model is obvious. It reduces costs for instrument development, exchange and maintenance while keeping all the important science options open. Of course, this requires a lot of careful administrative work and the openness of all involved communities to collaborate and to share the facilities. The committee encourages Subaru and NAOJ to carefully investigate this model further and to discuss it with the Japanese community.

The planning, design, construction and operation of Subaru are remarkable successes, which has created an enormous scientific momentum. Now at the forefront of ground-based optical and infrared astronomy, it is important for NAOJ to keep this position. This includes the participation in projects for the next generation of even more powerful telescopes.

There have been impressive developments by NAOJ over the last years towards a 30m Japanese Extremely Large Telescope (JELT). However, the scale and cost of constructing such a telescope led to the project's decision in early 2007 to seek to join the California led Thirty Meter Telescope project (TMT) should that telescope be sited on Mauna Kea. A major advantage of this approach is that *Japanese astronomers will gain access to the first ELT to be built, while being able to use the already existing infrastructure and Subaru as a unique wide field 8m-class telescope*. The committee views this decision very positively and urges the Japanese community to use the full weight of its considerable influence to ensure that the TMT ***is*** built on Mauna Kea. This is now a matter of the highest priority and greatest urgency.

NAOJ also needs a back-up strategy for the (rather unlikely) case that the TMT project will decide not to select Mauna Kea as its site. The committee recommends that for this case NAOJ keeps all options open and carefully investigates possible partnerships with ESO and the GMT alternatively to the TMT. Japanese ground-based infrared/optical astronomy has become very strong and will certainly be welcomed as a partner in any of these large projects. Another option is a somewhat de-scoped version of an ELT, for instance a 20m telescope such as the GMT, with new partners on Mauna Kea. There is a serious discussion going on about the future of the Canada-France-Hawaii-Telescope and the partner institutions are looking for possible new partners.

It is important that in the immediate future NAOJ engages the wider Japanese community to endorse participation in TMT as the highest priority following the completion of ALMA. The aspiration for Japanese astronomers to build two instruments for TMT will be an effective tool in this engagement. This will require a substantial expansion of staff effort in the ELT project office.

Technology developed for ALMA-J is impressive and is having impact on the entire ALMA project with high and positive visibility for Japan. The construction and on-time delivery of the first three ALMA-J dishes to the ALMA site is a very impressive milestone and sets a benchmark for the entire International project. However the continuing ALMA operational commitment will have a huge impact on NAOJ and the committee is concerned that the Japanese ALMA participation may be under-resourced in terms of astronomical manpower and operational support. We recommend that NAOJ continues to seek support from the Asian-Pacific region for shared operation.

VSOP-2 has now been approved (ASTRO-G) by the Japanese Space Agency. It will combine the increased resolution possible in space with attributes that surpass those available to its very successful predecessor VSOP-1(Halca). Its bandwidth, polarization and phase referencing capability will make VSOP-2 an extremely powerful instrument.

One issue of concern is the organizational change of the space agencies in Japan. ISAS has become a part of JAXA which is a large and relatively bureaucratic organization. NAOJ needs to watch carefully to ensure that the same flexibility in operation as achieved in VSOP/Halca can be realized with VSOP-2.

The committee noted that there is now a gap in the long-term plan for radio astronomy which could be very well filled if Japan became involved in the international collaboration to develop the Square Kilometer Array (SKA). Given the potential overload in NAOJ due to the breadth of projects undertaken this may seem surprising advice but the long lead times for major projects necessitates some early engagement even with minimal investment of resources.

Solar C is Japan's next step in space solar physics. As a world leader in this area, NAOJ is fostering planning for Solar C in Japan and is also openly and strongly inviting input from the international community. At this time, two plans are under consideration. Plan A would observe the solar poles from out of the ecliptic for the first time in order to investigate the internal structure and dynamo processes at high latitudes using helioseismology and magnetic field measurements. Plan B would explore in detail the physics and dynamics of the solar atmosphere between the visible surface and the high temperature corona building on the instrumental heritage of Hinode. From a science perspective either plan is certain to add important new knowledge about the sun and to strengthen Japan's leadership position. The committee strongly endorses Solar C.

4. Synopses of the evaluation reports of the NAOJ projects, centers and divisions

In this section the NAOJ International Review Committee provides a synopsis of the evaluation reports submitted by the committees, which have reviewed NAOJ's individual projects, centers and divisions. (Those committee reports are to be considered incorporated as part of our report.)

a) Subaru Telescope and Extremely Large Telescope Project

This report is extremely positive. It characterizes the design, construction and science operation of Subaru as a remarkable story of success.

"In a world of strong international competition with other 8-m to 10-m class telescopes such as the Keck Observatories, the ESO Very Large Telescope, and the Gemini Observatories the Subaru Telescope has made important and in many cases fundamental and outstanding contributions to the dramatic advancement of modern astronomical science. This is the result of an impressive amalgam of three components: a dedicated team of observatory staff provides a telescope, which delivers the best image quality in the world, advanced instruments,

which are world-class and in some cases unique, and a vibrant community of scientists, which has made excellent use of this unique science opportunity. This is the result of careful strategic planning and consideration of the important new directions of astronomy."

The report summarizes some of the outstanding science accomplishments, which cover a wide range of astronomical science from the solar system, star and planet formation, stellar physics to extragalactic astronomy and cosmology. It describes the observatory operation as efficient and up to the highest standards and the instrument development as innovative, comprehensive and well-planned and as an outstanding accomplishment.

The report also comments on the aspects of national and international collaboration.

"The decision to build the Subaru Telescope on Mauna Kea in Hawaii was the most essential for the success of the Project. Not only did it provide with access to the best observatory site in the world, it also encouraged the Japanese astronomers to take on the challenge of world wide competition on the highest scientific level. The community of Subaru users in Japan has done this through the very successful initiation of inter-university collaboration, which built on the existing strengths and also activated and included many local university groups…In addition, international collaborations were established, which proved to be very valuable and effective…As a result, many of the excellent scientific results have been obtained in Japanese inter-university or international collaborations. This has made Japanese ground-based astronomy world –wide competitive. It will be very important to continue and to expand this successful system of national and international collaboration in the future for the larger and even more ambitious missions to come."

The only somewhat critical remark concerns the human resources aspect of the Subaru operation: "While the operation is smooth, efficient and very successful, the committee has realized that the workload on the staff is generally very heavy resulting in a situation in which it is difficult for them to accomplish progress with their own scientific work. It is important that this issue is recognized by the Subaru management and NAOJ. In the long run, competent users and instrument support can only be accomplished with support astronomers who see a clear opportunity for scientific and professional development in their work for the observatory. It is, therefore, very important that operation budget and the support staff man power is kept at the appropriate level."

The future plans for the Subaru Telescope are discussed in detail and fully supported. The report agrees with the self-evaluation provided by the project.

The accomplishments of the Extremely Large Telescope Project period are perceived as a remarkable. The report views the decision to join the TMT very positively and "urges the Japanese community to use the full weight of its considerable influence to ensure that the TMT ***is*** built on Mauna Kea". It discusses the potential for the involvement of Japanese industry, in particular for the production of the over 600 1.4m mirror segments needed for the TMT primary mirror and concludes "the opportunity build on the success of Subaru in the areas of instruments, archives and operations offers the potential for Japan to contribute to TMT across almost all the important facets of the project".

The report urges to adopt the TMT as the highest priority: "In the immediate future the ELT project office needs to engage the wider Japanese community to endorse participation in TMT as the highest priority following the completion of ALMA. The aspiration for Japanese astronomers to build two instruments for TMT will be an effective tool in engaging the community. Scientific workshops and technical studies are needed to make proposals for specific TMT instruments. These should get underway as soon as possible to identify this crucial contribution to the project. In parallel, by 2011 a comprehensive proposal needs to be developed to secure funding. The committee recognizes that work involved requires a substantial expansion of staff effort in the project office and strongly supports this development."

The self-evaluation of the ELT project is endorsed by the report, except that higher marks are given for research outputs and mid-term plans.

b) Optical/Infrared Division

The report concludes "the Optical/Infrared Division of NAOJ is very successful across a broad agenda. The exploitation of Subaru has positioned the group at the forefront of some of the most critical topics of contemporary astrophysics. The performance of the Division over the review period has been good; in many areas world leading or close to it. The Division is the section of NAOJ where new ideas and concepts originate, grow and are transformed into new projects. It is therefore a critical group for the future of the Observatory." The activities of the 'Division proper' are valued to be at a high level: "They are the glue that holds together much of the other activities. The group is productive and research outputs are world leading or very close to that level across a broad scientific canvass. They are pursing the ambitious goal of opening a new scientific frontier."

However, the report expresses some concern about the prioritization of science projects: "We note that almost all the activities we reviewed are being undertaken by small groups of highly committed researchers who, in this context, are making outstanding contributions. We recommend that the Division should consider focusing more resources (both staff and capital) on a smaller number of

activities. This will be necessary to achieve the goal of opening a new scientific frontier."

This concern is repeated in the evaluation of the Okayama Astrophysical Observatory (OAO): "OAO offers a wide range of facilities, is well supported and has an effective and innovative group developing new instruments which keep the facility competitive despite the limitations of the site and small telescopes. We recommend that the Division consider whether a simpler, more focused operating model for OAO could retain much of the scientific productivity with fewer staff and capital resources that might be redeployed in other areas. The committee expresses concern about the range of motivations the different stakeholders have for building the OAO 3.8m telescope. NAOJ and Kyoto University need to agree to explicit performance requirements, a project schedule and the division of the operating costs so that the project team can focus on specific goals."

The report highlights the important accomplishments of the extra-solar planet group: "The extra-solar planet detection group is very successfully exploiting both Subaru and OAO. Greater co-ordination of these two efforts should be considered as a way of increasing impact in this exciting field. This group is playing a leading role in the preparations for SPICA and when it is timely we recommend that this effort be expanded." It also discusses the status of the Gravitational Wave group: "The Gravitational Wave group are moving from the stage when they operated the most sensitive instrument in the world, through global collaboration with other detectors and on to the next generation of GW detector. The group has provided some innovative technical developments that are of value to leading groups worldwide and are well connected with the international GW detection effort. This group stands at a crossroads. To remain at the forefront they should either pursue LCGT or engage formally in one of the other next generation detectors."

The preparatory work for the Jasmine is seen as innovative and imaginative. It is acknowledged that this is young project, where the work just has started and that it has a very interesting science potential. Important advice is given for the future management of the project: "To be successful this group needs to adopt a systems approach which will require a tighter focus on addressing the specific technical challenges Jasmine poses. More generally the activities of the Division and Observatory will increasingly require co-ordination with Japan's space agencies (ISAS & JAXA). We recommend that a formal agreement should be developed with these agencies that will facilitate a more direct involvement of space agency staff in Observatory projects at an early stage. This will be particularly important for the success of SPICA, a mission that the committee judges to be particularly promising."

The report's evaluation agrees with the self-evaluation provided, except in a few

cases where somewhat higher scores are suggested.

c) Radio Astronomy Division

The report summarizes the accomplishments of the radio astronomy division as follows. “Japan has a proud record of world class achievements in radio astronomy and the committee was impressed to see this record maintained with a number of truly exceptional achievements.” It discusses the Nobeyama Radio Observatory (NRO) and states “since its establishment Nobeyama has performed pioneering roles in many areas of radio astronomy by producing excellent results and creating advanced key technologies, many of which have contributed to new research and projects such as VERA, ASTE and ALMA. We expect that Nobeyama can continue to be the nursery of radio astronomy into the future. As the Mecca of radio astronomy in Japan, it is fully agreeable and appropriate that Open Use and Education & Public Outreach are included in the major activities to give further importance in the future role of Nobeyama.” The important role of the NRO 45m telescope for future science related to ALMA and VSOP-2 is pointed out and “the ongoing interaction with the ALMA technology development group” is endorsed. The very successful start of the Atacama Submillimetre Telescope Experiment (ASTE) science operation is highlighted and the synergy with Subaru observations is noted: “This collaboration, bringing together two first class instruments, will produce exceptional results in this area with a high level of activity and strong international competition.”

The comments on VERA as the only VLBI array designed specifically for astrometry are very positive. While the team has yet not fully achieved the very challenging astrometric accuracy, the early science results are impressive. The report critically notes that “an issue of concern to the committee is the current restricted manpower available to work on the flood of data that is emerging from VERA, this is illustrated by the limited number of refereed VERA publications that have appeared to date. In order to achieve the ambitious goal of determining the overall dynamics of the Galaxy, additional skilled manpower is required to analyze the data from the several hundred maser sources which will be observed. Unless a reliable pipeline can be constructed then the work will have to be done by graduate students and post-docs. This may mean that moves should be made to open up the VERA archive to international groups, possibly in collaboration with Japanese astronomers. This will ensure that the science that should be achieved by the investment made in VERA is delivered in a timely fashion.”

The report also discusses NAOJ’s engagements in the Japanese and the East Asian VLBI Networks. The importance of these activities for VSOP-2 is stressed but it is also evident that scientific staff is spread thinly. A strong recommendation is made in order “to ensure full scientific exploitation of the expensive facilities … to open them up to the world’s astronomical community”.

The accomplishment by the RISE Project producing a gravity map of the far side of the moon with unprecedented accuracy is regarded as an outstanding science highlight. “This unprecedented result will be a milestone event in the study of the origin, evolution, and present status of the moon. We highly commend their achievement which required a rare combination of space and radio astronomy techniques.”

The approval of VSOP-2 by the Japanese Space Agency is “an outstanding achievement”. The report discusses the exciting science aspects of this space mission in detail and concludes “this project will surely achieve a high level of performance”. It also raises the concern about the organizational change of the space agencies in Japan. “NAOJ needs to watch carefully to ensure that the same flexibility in operation as achieved in VSOP/Halca can be realized with VSOP-2.”

The report is extremely positive about the NAOJ contributions to the ALMA project: “…when Japan re-joined the ALMA project in 2004 it was in a good position to contribute advanced technology and to add an important extension to ALMA called ALMA-J. This includes two additional frequency bands and a more compact array of smaller dishes which provides brightness sensitivity and short baselines that will be critical for ALMA imaging of larger structures and is now a key part of the enhanced ALMA project. Technology developed for ALMA-J is impressive and is having impact on the entire ALMA project with high and positive visibility for Japan. For example, the advanced correlator design used for ALMA-J influenced the other ALMA partners to adopt more advanced and more powerful technology. The construction and on-time delivery of the first three ALMA-J dishes to the ALMA site is a very impressive milestone and sets a benchmark for the project.”

A very important additional contribution is the development of a technologically very advanced photonic local oscillator system. The report says “one of the very high technical risk items identified in the ALMA project has been the photonic local oscillator system. This has been under development at NRAO in the US but the NRAO design has not yet met the required specification. A photonic local oscillator system was independently developed at NAOJ's discretion as a backup. This involves a different and innovative design which has achieved very impressive performance. We understand that discussions between Japan and NRAO are underway and the Japanese design may be incorporated in the production version of the local oscillator system. This is not only a great technical achievement by the NAOJ group but an excellent example of how involvement in a large international project like ALMA can lead to ongoing technology collaboration and Japanese visibility.”

The report formulates concerns about the lack of long-term planning in the

NAOJ radio astronomy division as ALMA and RISE move to an operational phase and VSOP-2 becomes a funded development: "There is one aspect of this concern, which is shared by all the members of the committee, which seems to be a more general issue. It is observed that some of the research institutions and researchers in Japan tend to hesitate or refrain from discussing projects openly, especially internationally, until the project has been officially approved or the budget is allocated. Most advanced and challenging research projects today, especially in astronomy, require large budgets and long time scales. If Japan continues in this manner, it may lose the chance to propose ideas and influence directions for better research and may even lose the opportunity to join. These are serious lessons that could be learnt from the ALMA case. It is the responsibility of today's researchers, especially managers, to understand the issues and to make a break-through for future generations. The committee notes that this planning gap could be very well filled if Japan became involved in the international collaboration to develop the Square Kilometre Array (SKA). Japan is involved in many key SKA technologies and could become involved in both planning and technology developments without the need to make any long term commitment ideas at this stage."

At its end the report offers a number of additional comments about the NAOJ structure, technology development and international impact of Japanese technology and the need to open the use of Japanese facilities and radio astronomy technology to an international community. In the final recommendations of this report we will come back to these issues.

d) Solar and Plasma Astrophysics Division

The report fully endorses the self evaluations, resisting a desire to raise some of them, and commends the division "for its outstanding, world-leading accomplishments". It takes note of the strong efforts of the senior staff of the division "to cultivate and encourage young researchers and to welcome international collaborations as ways of maximizing the scientific output of the DSPA investments". It also acknowledges the enormous success of the Hinode Project: "The success of the Hinode project should be a source of pride for NAOJ and the nation of Japan. It is the premier facility for study of small-scale details about the Sun and has opened a new chapter of astrophysical research." Further very positive comments are given on the development of the instruments and the spacecraft of the Hinode mission and the scientific operation as well as on the successful planning of the next Japanese solar physics space mission.

"The high-resolution optical telescope assembled on Hinode satellite is a very powerful instrument that has enabled investigations of detailed structures dominating multi-scale nonlinear phenomena in the sun. It has already produced interesting data showing Alfven wave propagation, micro-flare reconnections,

etc. The ADS bibliographic system currently lists 196 publications involving Hinode. Of these, more than 64 are based on data from the SOT. This is an outstanding level of scientific productivity from a new facility little over a year old." (In the subsequent four months these numbers have increased to 281 and 78 respectively.)

"Development, launch and successful operation of the Hinode spacecraft constitute a world-leading accomplishment. In terms of solar science achievement it is highly likely to outstrip both of its illustrious predecessors - Yohkoh launched 1991 and SOHO launched 1995. This observational capability has been a goal of solar observers for decades. Its outstanding realization as Hinode is a dream come true."

"The Hinode mission is operationally relatively young. Its success will ultimately be measured against the scientific research based on observations by its instruments. However, it is certainly the case that instrument performance, reliability, and accessibility will play a significant role in enabling scientific research with Hinode. In this regard, the scientific operation of Hinode has been exemplary. We explored the resources available to scientific users of Hinode, the ease of their use, the accessibility of the data, and the transparency of the documentation, and find that it is outstanding. The appearance of nearly 200 publications in little over a year from launch is a testament to careful and smooth operation of Hinode."

"Two possible solar missions - a helioseismology and magnetic field observatory that will orbit well above the ecliptic plane and an advanced version of Hinode, are now being considered with one to be selected for launch in 2015. The former project offers the particularly exciting prospect of sub-surface flow observations in the polar regions; results from this admittedly ambitious mission could finally solve the difficult question of solar dynamo origin. The second builds on the success of Hinode. Both are well conceived, welcome international collaboration, and either would provide important new information about the sun."

The report also discusses the activities of the Solar Observatory (SO) and the Nobeyama Solar Radio Observatory (NoSRO) and confirms the self evaluations.

"A long record of regular measurements of solar activity is essential to the study of long-duration phenomena such as the solar cycle. The SO has a large and unique collection of good vector magnetograms, the only such collection freely available for research. These data have led to new discoveries about the important role of helicity in solar activity. Careful and detailed analyses of solar MHD phenomena have made essential contributions for the understandings of solar phenomenology (such as solar activity cycle), as well as basic plasma

physics (such as helicity and reconnection).The committee notes that several important discoveries about the corona have been made with Norikura facility and is concerned about the planned closure of this coronal research capability. The facility had strong connection with the international and university communities. Our concern is mitigated by the opportunities that this closure will afford to explore the development of next generation ground based instruments in Japan and to engage with other major international ground based projects."

"The NoSRO provides sustained high-resolution microwave imaging of the sun. This unique capability has enabled science to have a comprehensive view of solar activity that would otherwise be impossible. The value comes in providing observations of emissions from non-thermal electrons, observations that complement those provided by hard X-ray observations. These bring additional constraints to bear on models of solar activity as demonstrated by the research output listed earlier. As noted at the end of this report, the committee is concerned about a possible loss of such a capability for several years. The high-quality long-term data produced by NoSRO have a unique scientific value—combinations with other new measurements will open up a new regime of interest."

e) Theoretical Astronomy Division

The report characterizes the Division of Theoretical Astronomy and the Center for Computational Astrophysics (DTA/CfCA) as " truly an international center of excellence in computational astrophysics, one of the most important centers of that type in the world." The high scientific productivity, international visibility and leadership of DTA are highlighted. The development of the GRAPE system by CfCA is regarded as an outstanding success, which "will make NAOJ the most powerful computational astrophysics center in the world". The 4D2U group is commended for their invaluable contribution for public outreach and their innovative use of hardware and software.

The report also identifies a few weaknesses: "Given the unique situation of DTA/CfCA as the only national institute for theoretical astrophysics in Japan, we have noted as its major weakness the rather modest scales of the current visitor program and of the current program for workshops and summer schools…As a final weakness we have noted that the current organizational structure of DTA/CfCA is far from transparent, to the point that we could not neither understand the structure that is in place now, nor the plans for modification."

The report continues with an extensive list of recommendations aiming at the establishment "of a national theory center which will serve as an intellectual environment to foster broad collaboration and complimentarity between experts with different specialties." In this report we will come back to these recommendations in the following section.

f) Astronomical Data Center

The report agrees with self evaluation in almost all areas except a very few where higher scores are proposed. The overall evaluation is very positive: "Excellent achievements of the overall objectives have been made… The ADC has performed excellent overall work. The staff is highly dedicated, working effectively within the constraints. We commend them to remain engaged in research and in a variety of community support activities. They bring significant contributions and expertise on national priorities such as Subaru and they make major technical contributions to the international Virtual Observatory initiative. The high level expertise on data quality assessment is extremely important to encourage easier use and broader reuse of data, in particular of the very valuable Subaru data. We commend ADC's interest in improving data usability and accessibility for Japan's national research facilities. This activity is critical for improving the visibility and international impact of Japan's investment in world class astronomical telescopes and instrumentation."

However the report also identifies "several challenges and opportunities which require action to fully exploit the remarkable capabilities of Subaru and Alma in the near future". It continues "…improving Subaru data products and availability is obviously a priority target. The Subaru Science Center should allow ADC data quality assessment expertise, data, and tools to be included at an earlier stage in the Subaru data pipeline. The distribution of Subaru data to observers should be rationalized, and the importance of the Subaru pipeline analysis should be recognized, and its versions strictly controlled." Several concrete suggestions for improvements are made and it is pointed out that "the Subaru data centre is also required as a prototype for proper management of ALMA: the nature and volume of ALMA data necessitates such an integrated approach."

g) Advanced Technology Center

The review panel of the ATC was "extremely impressed with the achievements of the ATC as visible in the material presented both during and prior to the review. It is clear that much has been accomplished in the last four years and all the staff at the ATC should be very proud – the ATC looks good on a Global Stage." The self evaluation is supported, but higher marks are given for the developments of the ALMA cartridge test sets and Subaru Hyper Suprime-Cam as outstanding accomplishments.

The report discusses a number of important issues. The first area concerns the internal structure, organization and management of the ATC. The lack of professional engineers is seen as a substantial weakness, which needs to be addressed. It is found that many times scientific project staff also carry out project management functions and the introduction of a Project Manager/

Project Scientist model is suggested. In general, the staffing level is considered insufficient given the broad mission of the ATC. This might be a problem in the "transition from the heroic success of the last four years into a future of sustainable excellence." The report suggests a careful strategic planning process for NAOJ in general and for the ATC in particular.

h) Public Relations Center

This is a very positive review which with a few exceptions agrees with the self evaluation. The PCR review panel "is very impressed with the scale of operations and output of the PRC. The PRC is a leader in Japan and also has several activities that are world-class. The operations are effectively set up, and the return on investment very high. Of the many outstanding results reported above it is especially commendable how closely connected the PRC is with the Japanese public through their Open Campus, observing campaigns, astronomy pub, astronomy call centre and other activities. This is probably unique. It is also remarkable how the PRC focuses on a research-oriented approach to science communication and education – i.e. focusing on measurable outcomes, continuously improving the flow of public communication according to the outcome and finally publishing its experiences."

The report suggests to enhance the synergy between the Subaru outreach and PR group and the PCR and to improve the contacts with the many small public observatories and planetariums in Japan. It is also noted that while many excellent press releases about Subaru detections have appeared other "public relation gems" coming from the other NAOJ project could be better exploited with a somewhat increased staff level.

5. Key Recommendations

In this section the committee summarizes the key recommendations which are important for the organization as a whole. These recommendations address the plans for future large projects, ongoing projects of large scope, the role of theoretical astrophysics within NAOJ, graduate education and general aspects regarding the infrastructure and management of the organization. We emphasize that the individual evaluation reports of the divisions, centers and projects contain many additional recommendations, which are not mentioned here. Our committee has reviewed them all and agrees with them. We urge NAOJ to consider them carefully and to implement them, wherever possible.

5.1 Large Future Projects of Ground-based Astronomy

TMT

The committee strongly endorses the plan to join the Thirty Meter Telescope

project (TMT) should that telescope be sited on Mauna Kea. In this way, Japanese astronomers will gain access to the first ELT to be built, while being able to use the already existing infrastructure and Subaru as a unique wide field 8m-class telescope. The committee urges NAOJ to use the full weight of its considerable influence to ensure that the TMT ***is*** built on Mauna Kea. This is now a matter of the highest priority and greatest urgency.

As a back-up strategy for the case that the TMT project will decide not to select Mauna Kea as its site the committee recommends that NAOJ keeps all options open and carefully investigates possible partnerships with ESO and the GMT alternatively to the TMT. Another option is a somewhat de-scoped version of an ELT, for instance a 20m telescope, with new partners on Mauna Kea.

In the immediate future NAOJ needs to engage the wider Japanese community to endorse participation in TMT as the highest priority following the completion of ALMA. The aspiration for Japanese astronomers to build two instruments for TMT will be an effective tool in engaging the community. A substantial expansion of staff in the ELT project office is required and a comprehensive proposal needs to be developed as soon as possible to secure funding.

SKA

Of concern to the committee was the evident lack of a long-term plan in the NAOJ radio astronomy division. The committee, and senior NAOJ staff, recognise that it takes many years for a project to move from its conceptual phase, through Category A to B and then C. It is therefore of concern that there is no new Category A project to take the place of VSOP-2 for the radio astronomy division. There is a danger that the long-term future of radio astronomy in Japan will be threatened if this planning activity is neglected.

The committee notes that this planning gap could be very well filled if Japan became involved in the international collaboration to develop the Square Kilometer Array (SKA). Japanese astronomers and industry are already involved in many key SKA technologies and could become involved in both planning and technology developments without the need to make long term financial commitment at this stage.

5.2 Ongoing Ground-based astronomy

Subaru

The committee endorses the Subaru plan for future instrumentation, both short and long term. FMOS, Hyper-Suprime-Cam and HiCIAO will be unique instruments opening the perspectives for a scientifically exciting future and PIAA has the potential to revolutionize high resolution optical/infrared astronomy in space and on the ground. While scientifically tremendously attractive, in

particular in regard of future synergy with the TMT on Mauna Kea, a decision on WFMOS requires a more careful consideration of the tradeoffs for Japanese astronomical community.

The new paradigm of swapping observing time with other large telescopes on Mauna Kea rather than continuing to provide a comprehensive set of first class, very expensive instruments together with frequent instrument changes for observations is very attractive in the long term. The committee encourages a detailed investigation of such an operational model.

Nobeyama 45m radio telescope

The NRO 45m telescope will continue to play an important and complimentary role in millimeter astronomy. Its powerful array receivers will provide zero-spacing information for ALMA projects which observe large-scale structure in the 3 (and maybe the 2) mm window(s) and it will be a most important ground-based element of VLBI arrays involving VSOP-2. The 45m telescope also serves as an excellent resource for the training of students in mm-wave and radio astronomy; this is an essential activity that must continue for Japan to obtain the scientific return on its substantial investment in ALMA. To guarantee efficient future operation, however, major investments must be made: foremost here is refurbishment of the 45m telescope. Failing to do so will cause irreversible damage to its structure.

Solar astronomy

The ground-based facilities of NAOJ's Division of Space and Plasma Astrophysics are unique and powerful. We recognize the difficulties of continuing to operate the coronagraphs at Norikura and reluctantly concur with the closure plan. This is painful because of the recent confirmation of Alfven wave-like motions in the solar corona, first clearly seen at Norikura, and the resulting excitement that has followed. With confirmation of new discoveries being a fundamental part of doing science, the loss of the facility seriously jeopardizes future work on the corona. We recommend that the imminent closure be widely advertised and that investigators be invited and supported to make unique observations at Norikura.

The solar radio heliograph at Nobeyama is a brilliant and unique facility with a distinguished record of discoveries. The committee is concerned by a gap that the planned closure will cause in our ability to observe high energy activity. After the RHESSI satellite ceases functioning, a physics window will close on solar flare processes without the NoSRO. This window will remain closed during the next solar activity cycle until (and if) new facilities planned in Russia and the United States are funded and constructed. This closure of a window on high energy processes is a serious reversal of progress. We recommend that alternatives to closing the NoSRO should be vigorously pursued. For example,

partial operational funding from other countries whose scientists have enjoyed the free use of NoSRO data may be a viable option. Similarly, the solar radio polarimeter costs might be taken over by another Japanese agency because of its importance in space weather observations. Again we recommend that if alternatives to closure of the NoSRO cannot be found, that international scientists be invited to use it for its unique characteristics before it vanishes.

We are happy to endorse plans to capitalize on the long and successful history of vector magnetograph work in Japan.

Our distress over the planned closures is mitigated by the hope that funds made available may become available for new ground-based solar research, perhaps by joining with one of the new international solar observatories under construction or consideration. We recommend that a roadmap for the future of ground-based solar research in Japan be developed under the sponsorship of NAOJ.

5.3 Space Astronomy Missions

Solar C

Based on the continual success and evolution towards more ambitious missions, the committee strongly endorses NAOJ's development of Solar C as highly appropriate to enhance and maintain Japan's leading position in space solar physics. We assume that once a decision is made between its two possible paths later this year, it will become a Type A Project.

General Remarks

NAOJ has a major role in astronomical research from space. In addition to the ongoing Hinode Science Center (a Type C project), NAOJ currently has Type B and A projects, Space VLBI (VSOP-2 (Astro-G)) and JASMINE (infrared astrometry) respectively, and study projects such as Solar C. These projects are done with JAXA and international partners. Past and present successes of NAOJ's involvement with space astronomy are obvious and highly commendable. As the typical scope of these projects grows and the science goals become more ambitious, the way these projects are conducted within NAOJ should be critically examined. The committee detected signs of stress in the form of chronic overwork by scientists doing project management, engineering and operational activities. One unfortunate result is less time for all scientists to do research and for senior scientists to mentor younger persons. We recommend that NAOJ consider employing professionally trained project managers and engineers to be assigned to space missions so that scientists can concentrate on extracting the maximum scientific yield from these missions while attracting and training the next generation of astronomers. The committee also notes that funding of space mission within the NAOJ/JAXA framework could be streamlined if funds were transferred, as appropriate, from JAXA to NAOJ.

5.4 The role of theoretical astrophysics within NAOJ

We understand that there are two main goals for the Department of Theoretical Astronomy and the Center for Computational Astrophysics (DTA/CfCA): (1) Leading research in theoretical astrophysics in Japan, (2) providing computer resources to Japan's research community of theoretical astrophysics.

For the first goal, we recommend a strong visitor program, with allocation of extra funding resources for temporary positions, for national as well as international visitors. Nationally, it would be great to attract astrophysicists currently employed by smaller universities, who can then visit NAOJ for a few months. They can be asked to assist international visitors; this will be interesting for them and it will at the same time prevent a growing burden to form for the current NAOJ staff. We are especially encouraging NAOJ to focus on China and other East-Asian countries, to attract medium-term visitors.

In addition, for longer-term visitors, national as well as international, DTA/CfCA would be very well served by adopting the model that is used by institutions such as the Yukawa Institute at Kyoto University and the new Institute for the Physics and Mathematics of the Universe at the University of Tokyo. In both cases, researchers receive long-term appointments, for a duration of the order of 5-10 years. Along these lines, we recommend DTA/CfCA to create several positions with 5-10 year duration.

For the second goal we recommend the formulation of R&D programs designed around specific mid-term scientific goals. We recommend additional funding for several carefully selected projects in this direction. Examples are GRAPE hardware development and the ongoing Milky Way project for large-scale simulations.

On the level of permanent positions, we recommend three extra positions to be created. One extra position should be created for the GRAPE initiative. Given their success in attracting of order a billion Japanese yen over the last several years, and the scope of their plans to proceed with Petaflops scale computing, a single additional position would be very modest, really a minimum level commitment by NAOJ for this important initiative that is the most internationally visible component of DTA/CfCA.

A second permanent position should be reserved for a Chief Technical Officer for 4D2U, the highly successful outreach program of NAOJ, responsible for continuing development of new software products used for visualization, not only for outreach but for research as well.

A third permanent position should be created for CfCA/DTA, to act as a kind of

'glue', or liaison, between the computational group there and the observational groups elsewhere at NAOJ. Such a person should act as a kind of bridge between the various groups, but it is also important that this person would be active in carrying out his or her own program in simulations in some area of theoretical astrophysics, to avoid playing only a manager role. Hands-on knowledge is definitely needed to play this inter-project communication role.

5.5 Graduate Education

NAOJ plays an important role in the education of graduate students by giving them on-site training at world-leading modern research facilities. NAOJ hosts about 70 graduate students, mostly from the University of Tokyo and Graduate University for Advanced Study, and a smaller fraction from several other universities. The number 70 is about 10% of all the graduate students in Japan in the field of astronomy. On the other hand, there are 33 professors and 38 associate professors within NAOJ, i.e., about 20% of all the professors and associate professors of Japan in astronomy. Considering that NAOJ is an interuniversity research institute which has projects to carry out and services to provide in order to support universities, the Committee feels that the present 10% level of NAOJ commitment to graduate education is just right and close collaboration with universities should be maintained as a key component of its activities.

5.6 Specific issues of Japanese Astronomy

It is observed that some (but not all) of the research institutions and researchers in Japan tend to hesitate or refrain from discussing projects openly, especially internationally, until the project has been officially approved or the budget is allocated. Most advanced and challenging research projects today, especially in astronomy, require large budgets and long time scales. If Japan continues in this manner, it may lose the chance to propose ideas and influence directions for better research and may even lose the opportunity to join. These are serious lessons that could be learnt from the ALMA case. It is the responsibility of today's researchers, especially managers, to understand the issues and to make a break-through for future generations.

The committee is also concerned with the fact that there seems to be no clear mechanism to prioritize the future projects in terms of science. This is not only the case within NAOJ but also the nation wide. In particular, big projects may well conflict with each other at the level of funding agencies. Some mechanism should be worked out to evaluate and prioritize them from scientific point of view. The new initiative towards a long-term future plan in astronomy and astrophysics by the subcommittee under the Physics Committee of the Science Council of Japan would certainly improve the situation. We encourage this activity.

5.7 NAOJ infrastructure and Project Management

A general concern and common theme found in many of the individual reports is the staffing level in relationship to the width and ambition of the NAOJ mission. NAOJ has been extremely successful over the past years. Much of this success has been accomplished, because the NAOJ staff is extremely dedicated and committed and is used to deliver results even in situations where manpower is spread extremely thin. In the long run under such circumstances, there is a risk of burn-out. Thus, there is a clear need to manage the transition from the heroic success of the last years into a future of sustainable excellence. It is very important that this issue is recognized by the NAOJ management.

A common theme in all the committee reports is the very small number of professional project engineers in NAOJ and a lack of emphasis on system engineering skills.
NAOJ has been making a rapid transition from a structure in which most instrumental developments and project management had been contracted to industry, to one having direct involvement in instrumental developments and project management. This change has been achieved within a fixed operating budget by assigning these roles to scientific staff already employed in NAOJ. While this has been successful on the short term it may not be sustainable into the future.

Some compartmentalization still exists in the NAOJ structure even though remarkable progress has been made integrating the previously disparate groups which became NAOJ. The committees saw potential opportunities for further cross fertilization between divisions, especially in the areas of technology development. This is particularly relevant when considering the future strategic plan for the ATC.