Report of the External Evaluation Committee (EEC) for the

NAOJ Advanced Technology Center

May 2022

Executive Summary

The Advanced Technology Center (ATC) is defined as a research and development center for advanced technology development in NAOJ. The missions are to support technology development and engineering for astronomical projects (ground and space), to research and develop new technologies for astronomy, and to contribute to young scientist training with the development opportunities.

For the evaluation of the ATC over the period FY2016 to FY2021, an External Evaluation Committee (EEC) has been established by NAOJ. The main findings and recommendations of the Committee can be summarized as follows:

1. Overall, the committee was extremely impressed by the results and achievements of the ATC. The ATC covers an impressively broad range of technologies and projects and delivers internationally outstanding results.
2. The committee's evaluation was "Excellent" for two evaluation criteria and "Excellent/Good" for the other three criteria.
3. The ATC is very well managed; in fact, the current management demonstrates great skill and ability to manage the complex ATC in a demanding environment.
4. The committee found the third mid-term goals of NAOJ to be well defined, and the ATC goals are appropriately defined and in line with the NAOJ goals.
5. In all three major areas of NAOJ's third mid-term plans, i.e., (1) astronomical project support, (2) development of new technologies and (3) young scientist training, ATC contributes strongly to the results.
6. Concerning the size of the ATC, it became apparent to the committee that the ATC experiences a shortage of staff particularly in two main areas: maintenance and servicing of the clean room, and too few engineering staff in the area of electrical engineering. To maintain and strengthen the world-leading role of the ATC, the panel recommends considering improvements in these two areas of staff shortage.
7. Considering that good systems engineering is a key element in handling technically complex instrumentation, the committee encourages the ATC and NAOJ to consider establishing and strengthening a common system engineering effort within ATC.
8. The ATC labs seem very well equipped covering a wide range of capabilities and technologies and there is no question that the ATC has a wonderful compliment of highly skilled, dedicated and motivated staff.
9. The committee was impressed by the achievements for ALMA with the development, delivery and maintenance of more than 200 receiver cartridges for three ALMA bands.
10. The committee has seen a good and close collaboration between ATC and universities and other organizations with a significant number of project proposals accepted and served by the ATC.
11. The ATC plays a very important role in the education of undergraduate and graduate students. The number of accepted students increased in 2021 by the efforts of ATC staff, and the committee encourages the ATC to continue this effort.
12. On the other hand, there have been no students at SOKENDAI in the last few years, The committee encourages the ATC to more pro-actively and aggressively advertise to undergraduate students the opportunities at ATC. ATC could also increase the number of master students in engineering disciplines.
13. The ATC responded very well to the past evaluation results. The panel was impressed by the detailed analysis of the previous panel recommendations and the actions taken.

14. While the new matrix management structure with an established steering committee and a direct link to NAOJ top management is a good step and very welcome, the committee felt that it is too early to evaluate the impact and the result of this new structure, given the short experience.

1 Introduction

As an Inter-University Research Institute, the National Astronomical Observatory of Japan (NAOJ) is a core research center for astronomy operated under the advisories of the research community, providing research opportunities to both domestic and overseas researchers, and conducting cutting-edge joint research. One of the basic roles (missions) of NAOJ is to contribute to the development of the entire astronomical community through the open use of NAOJ facilities and flexible international cooperation.

It is therefore necessary for NAOJ to properly verify each project office or center which is a framework for the open use, from the following viewpoints: Does the project office or center (i) produce or have a high possibility of producing science with high international research competitiveness, (ii) improve the research capabilities of universities, and (iii) contribute to the development of young researcher human resources?

NAOJ has invited outside experts to conduct project evaluations on a regular basis. Starting from FY 2021, the project evaluation is conducted as international external evaluation for all individual projects under the new evaluation policy.

For the evaluation of the Advanced Technology Center (ATC) over the period FY2016 to FY2021, a committee of seven reviewers from outside NAOJ (three from overseas and four from Japan) has been established by NAOJ. Annex A presents the members of the External Evaluation Committee.

This document is the evaluation report of the external committee.

2 Charges to the External Evaluation Committee

The following two main evaluation items were given to the External Evaluation Committee (EEC):

[1] Status and achievements of the ATC, where the status of ATC includes objectives and long-term goals set by the ATC, and management and activities to improve its development environment; and
[2] Responses to the results of previous evaluations and reviews.

The two evaluation items were broken down to the following five evaluation criteria.

[1] Status and achievements of the ATC
  (1) Are the goals of ATC appropriately defined in line with the third mid-term goals of NAOJ, and is the organization being managed in an appropriate manner?
  (2) Does ATC produce internationally outstanding results, especially when compared to the size of the center?
  (3) Does ATC contribute to the creation of results in accordance with NAOJ's third mid-term plans?
  (4) As an Inter-University Research Institute, does ATC cooperate with universities and other organizations to contribute to their achievements and developments of young researchers?

[2] Response to the results of previous evaluations and reviews
  (5) Does ATC respond appropriately to the evaluation results?

In Section 4, the results of the evaluation of each of the five criteria by the EEC are given.

3 Evaluation Procedure

The evaluation procedure consisted of three steps:

1. Distribution of the ATC reports from the ATC,
2. On-line evaluation meetings between the EEC and ATC representatives with presentations, Q&A sessions and a virtual lab tour, and off-line poster sessions, and
3. Writing of the evaluation report.

The ATC reports were distributed ahead of the on-line evaluation meetings.

Taking the time differences of the EEC member locations into account, it was decided to hold three hours of meeting per day, and three days of meetings in total. The on-line meetings took place on 17 March, 30 March and 31 March.

In parallel, a poster session was held off-line between 17 March and 31 March (day 1 and day 3 of the meeting). The posters of individual R&D items explaining perspective and criteria (3) were made available on a web site and on MS Teams, and poster discussions were conducted via MS Teams communication channels.

Annex B gives a complete list of the provided material, i.e., ATC reports, reference documents, presentations, posters, poster discussions and other documents.

Annex C presents the detailed agenda of the on-line evaluation meetings.

4 Evaluation Results

4.1 General Remarks

The provided material was comprehensive and of high quality. Questions by the committee members arising before or during the evaluation meetings were answered by the ATC Director and ATC staff in writing and to the full satisfaction of the committee. The ATC demonstrated a professional and very open attitude addressing all topics raised by the committee.

The committee would like to thank the ATC management and staff as well as the Research Evaluation Support Office and Coordinator for the professional and efficient organization of the external review which was carried out remotely spread over many time zones.

4.2 Criterion 1

Are the goals of ATC appropriately defined in line with the third mid-term goals of NAOJ, and is the organization being managed in an appropriate manner?

Overall evaluation: Excellent/Good

The committee found the third mid-term goals of NAOJ to be well defined, and the ATC goals are appropriately defined and in line with the NAOJ goals. The goals are quite specific and cover the underpinning of Japan’s ground and space-based astronomy major projects, blue-sky technology development and lastly student training and education. As they are so specific, it is straightforward to answer that the ATC has embraced these goals and answers each one extremely well and completely.

The ATC is very well managed; in fact, the current management demonstrates great skill and ability to manage the complex ATC in a demanding environment.

The ATC has started a new matrix structure system to manage the technical support efficiently and effectively to projects which are different divisions in NAOJ. The committee was pleased to see that ATC management has clearly recognized the challenges of the matrix system.

While the new matrix management structure with an established steering committee (formally introduced in April 2021) and a direct link to NAOJ top management is a good step and very welcome, the committee felt that it is too early to evaluate the impact and the result of this new structure, given the short experience. Time will tell if some adaptions may be needed, and the panel encourages ATC management to continue this path.

The committee also notes with satisfaction that the ATC matrix management defines percentages for staff members' own research and project work which is very good practice.

Concerning the size of the ATC, it became apparent to the committee that the ATC experiences a shortage of staff particularly in two main areas: maintenance and servicing of the clean room, and too few engineering staff in the area of electrical engineering. Staff shortage on the maintenance and servicing of the clean room is critical in the maintenance of the ALMA receivers. The servicing of the clean room is also essential to the development of space-based instruments planned at the ATC in the coming years. The lack of an electrical engineering team in the new organizational structure results in an imbalance of supporting the technical development of projects. To maintain and strengthen the world-leading role of the ATC, the panel recommends considering improvements in these two areas of staff shortage.

As in any multi-project environment and considering the number of projects handled by the ATC, prioritization of projects is of utmost importance for the success of the projects and ultimately the organization. The committee is aware of the challenges to set priorities and wonders whether the chosen mechanism fully serves the purpose, or whether further actions need to be taken, such as consciously deciding to postpone certain activities or projects. At the same time, it is important to set priorities in a timely manner, and the panel was not sure if this has been done in all cases in the past.

Being aware of the limited resources, the committee sees a risk of possibly serving too many projects at the same time, with the (undesirable) consequence of distributing effort over too many small and fractioned pieces. Prioritization of projects is important to mitigate the risk.

Given the success of ATC over the past 15+ years and its ability to develop and adapt to the project needs and stakeholder demands, the panel was wondering what the future funding model and strategic direction of ATC would and should be. In other words: where does the ATC want to go from here? One aspect which was mentioned to the committee concerned the ATC expanding more into space projects. While the committee has no doubts about the skills and organization of the ATC being able to do so, the committee would like to point out that such a decision would have quite some impact on the ATC in terms of number of required staff, establishing and following strict processes in systems engineering including quantity assurance, and the schedule pressure usually encountered in space projects, among others.

Astronomical instrumentation, and in particular space instrumentation, has become more powerful in performance, larger in size and increasingly complex in development (requiring the use of many areas of technology) and construction (often carried out in geographically distributed international collaborations). One key element to technically handle such demanding projects is good systems engineering. Concerning the ATC, the committee is aware that there is no single system engineering group at ATC but rather each project has its own system engineering effort. This may be driven by different demands and technologies of the various projects, but nevertheless the committee can see enough commonality in systems engineering topics (e.g., documentation management, configuration and change

management, interface definition and management, standards and best practices) to see a possible advantage of an ATC systems engineering group in combination with project-specific systems engineering. The committee encourages the ATC and NAOJ to consider establishing and strengthening a common system engineering effort within ATC.

Concerning the collaboration with JAXA/ISAS, the committee realizes that ATC and JAXA/ISAS have coordinated their efforts in several space projects (e.g., JASMINE and Solar-C) and detector development (e.g., near-IR image sensors). The committee welcomes the coordination and complementarity with JAXA/ISAS rather than replicating areas where JAXA/ISAS is strong.

4.3 Criterion 2

Does ATC produce internationally outstanding results, especially when compared to the size of the center?

Overall evaluation: Excellent

The committee was extremely impressed by the results and achievements of the ATC. The ATC covers an impressively broad range of technologies and projects and delivers internationally outstanding results. The breadth of projects sets the ATC apart globally, likely only the NRC HIA (Canada) is comparable in scope. This is a remarkable achievement as technical expertise is not automatically shared between these different technologies. It takes very good management to make this work.

The technologies and activities at ATC cover areas as diverse as radio/THz, infrared/optical, UV, gravitational wave detectors and superconducting detector microfabrication for ground-based, balloon-based and space-based instrumentation, as well as enabling R&D and developing and building complete instruments, even in large quantities as demonstrated for ALMA.

The results of the ATC are even more impressive given the size of the ATC and comparing this to the number of projects, both large and small, and the needed technologies and skills.

The ATC labs seem very well equipped covering a wide range of capabilities and technologies and there is no question that the ATC has a wonderful compliment of highly skilled, dedicated and motivated staff. The facilities include a mechanical machine shop, additive manufacturing shop, ALMA detector and receiver lab, microfabrication clean room, and an optical-IR lab.

The numbers of papers from activities to which the ATC contributed (around 50+ every year refereed), the quality of the instrumentation, and the science impact are all excellent.

The committee was also impressed by the achievements for ALMA with the development, delivery and maintenance of three ALMA receiver bands (a total of 3 x 73 = 219 receivers). The ALMA receivers use very special and difficult to manufacture detection elements: superconducting tunnel junctions of (sub-)micron dimensions which are fabricated successfully in ATCs microfabrication lab. The fabrication technologies of the receivers are highly sophisticated and have a high-level of controllability and reproducibility. The next generation ALMA receivers, multi-beam arrays, needs integrated SIS mixers on a chip and correspondingly one step more sophisticated device fabrication processes. It is worth pointing out that world-wide only very few microfabrication facilities exist which can produce the required SIS junctions with the required quality and reproducibility, and NAOJ should ensure that the ATC facility remains at the fore front of technology.

Concerning the achievements of the ATC when compared to the size of the center, the committee was very impressed but also wondering if this high level of productivity can be maintained.

4.4 Criterion 3

Does ATC contribute to the creation of results in accordance with NAOJ's third mid-term plans?

Overall evaluation: Excellent

In all three major areas of NAOJ's third mid-term plans, i.e., (1) astronomical project support, (2) development of new technologies and (3) young scientist training, ATC contributes strongly to the results.

Regarding (1) astronomical project support, the results and achievements are outstanding and a large number of projects is served. A major achievement was the development and production (and now maintenance) of three ALMA receiver bands, amongst which the most demanding high frequency band 10 deserves special mention. Indeed remarkable is ATC's contribution to the start of ALMA observations in the current mid-term period which have been giving impacts not only to the science community in Japan but also world-wide. In addition, the committee sees important and commendable ATC contributions to on-going projects during the design and development phase, including TMT as one of the next generation large IR/visible telescopes, KAGRA for gravitational astronomy, JASMINE and Solar-C with sounding rocket/balloon instruments for space.

Regarding (2) development of new technologies, ATC develops leading edge technologies and the results are excellent using a broad range of technologies. Concerning the microfabrication facilities, it is worth noting that very few laboratories exist world-wide which have the capabilities to produce the superconducting tunnel junction as needed for ALMA. Supporting and maintaining this facility is of great importance for the continued development of ALMA and other projects. As already mentioned above, the committee, however, noticed a lack of personnel to maintain the clean room equipment and recommends looking into improving the situation.

Regarding (3) young scientist training, the ATC spends great effort with good success but seems to be hampered by the general situation of diminishing student numbers in science and technology fields. More remarks by the committee are given under the evaluation of criterion (4).

4.5 Criterion 4

As an Inter-University Research Institute, does ATC cooperate with universities and other organizations to contribute to their achievements and developments of young researchers?

Overall evaluation: Excellent/Good

The committee has seen a good and close collaboration between ATC and universities and other organizations with a significant number of project proposals accepted and served by the

ATC. Such collaboration is an excellent example for Inter-University Research Institute Corporation in the field of natural sciences. The collaboration is also reflected in strong publication results especially in recent years.

The ATC plays a very important role in the education of undergraduate and graduate students through the open use and acceptance of special research students. The number of accepted students from inter-partnership and special research students increased in 2021 by the efforts of ATC staff, and the committee encourages the ATC to continue this effort.

On the other hand, there have been no students at SOKENDAI (which is one of the three graduate education systems at ATC) in the last few years, and efforts are needed to increase the number of students who are interested in developing instruments at ATC. The committee encourages the ATC to more pro-actively and aggressively advertise to undergraduate students the opportunities at ATC, its staff and their excellent work. After all, ATC can offer a unique environment for interested students and young scientists. ATC could also increase the number of master students in engineering disciplines, e.g. via strengthening the collaboration with engineering faculties at universities or other suitable ways.

The panel was made aware that it is sometimes difficult for the outside users to interface with the ATC on specific projects. A defined contact person for each project at ATC, or alternatively - taking into account the manpower of ATC - a help desk for outside users, might be worth considering to enable efficient communication between the ATC and outside users.

The panel also notes with satisfaction that the ATC matrix management defines percentages for the staff members' own research and project work which is very good practice. Given the importance of student education, it may be worthwhile to extend the definition of effort percentages also to this aspect – in other words, an ATC staff member would have a defined and agreed percentage of effort for student training.

4.6 Criterion 5

Does ATC respond appropriately to the evaluation results?

Overall evaluation: Excellent/Good

The ATC responded very well to the past evaluation results. The panel was impressed by the detailed analysis of the previous panel recommendations and the actions taken by the ATC.

Some of the recommendations in the previous external evaluation in 2016 were related to the structure of the ATC organization and the relation with projects. The ATC has responded appropriately by reorganizing with the matrix structure system and also greatly improving the transparency within ATC and the communication with the NAOJ top management.

While the new matrix management structure with an established steering committee and a direct link to NAOJ top management is a good step and very welcome, the committee felt that it is too early to evaluate the impact and the result of this new structure, given the short experience. Time will tell if some adaptions may be needed, and the committee encourages ATC management to continue this path.

The previous evaluation has pointed out that there is a continuing need to focus staff resources on the scientifically highest ranked project. In the last 5 years, the ATC has attempted to allocate staff resources more to high-priority projects, i.e., TMT, ALMA, Subaru, KAGRA, JASMINE and Solar-C EUVST, defined as the ATC goals.

ANNEX A – External Evaluation Committee Members

Name		Affiliation
Dr. Hidaka, Mutsuo		Invited Senior Researcher, Superconducting Device Research Group, National Institute of Advanced Industrial Science and Technology (AIST)
Dr. Iyomoto, Naoko		Associate Professor, Radiation Physics and Measurement, Department of Applied Quantum Physics and Nuclear Engineering, Kyushu University
Dr. Kuno, Nario		Director and Professor, Tomonaga Center for the History of the Universe, Faculty of Pure and Applied Sciences, University of Tsukuba
Dr. Lee, Adrian		Professor, Physics Department, University of California, Berkeley USA
Dr. Moore, Anna		Director and Professor, Australian National University (ANU) Institute for Space, Australia
Dr. Shimizu, Toshifumi	(Vice Chair)	Professor, Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)
Dr. Wild, Wolfgang	(Chair)	Project Manager, Cherenkov Telescope Array (CTA), CTA Observatory, Italy

Prof. Kazuhisa Mitsuda, Project Professor of ATC and Director of Engineering at NAOJ, served as both the Evaluation Coordinator of ATC (supporting the evaluation together with the Office of the Project Review Committee) and the NAOJ Executive of ATC (who participated in the evaluation to answer questions about NAOJ).

Ms. Kuniko Hori, Senior Specialist of Research Evaluation Support Office, served as the secretary of Office of the Project Review Committee, supporting documentation and logistics of evaluation activities of the EEC.

ANNEX B – Documents, Presentation Files, and Posters provided by the ATC

ATC reports

(A) ATC Report Document A (Main document)
Preliminary version 7 March 2022
Final version 25 March 2022

(B) ATC Report Document B (Achievement of status of each ongoing project in accordance with NAOJ mid-term plan)
Final version 11 March 2022

(C) ATC Report Document C (New technology development)
Final version 11 March 2022

(D) ATC Report Document D (Supplementary data)
Preliminary version 11 March 2022
Final version 25 March 2022

(E) ATC Report Document E (ATC paper list, excel file)
Final version 14 March 2022

Reference documents

(R1) Missions and Goals – Advanced Technology Center, ATC-TD-001 (Sep 2020) (ATC technical document)

(R2) Organization Structure of the Advanced Technology Center (ATC), ATC-TD-002 ver1.1 (28 Feb 2022) (ATC technical document)

(R3) Mid-term Goal and Plan of NINS (An abridged English version for the ATC external evaluation)

Presentation files

Day1 – Session 1	Introduction of Advanced Technology Center (ATC), March 17, 2022
Day1 – Session 2	ATC Activity Report for FY2016 – FY2021, March 17, 2022
Day2 – Session 1	ATC Activity Report for FY2016 – FY2021 (2), March 30, 2022
Day2 – Session 2	Answers to selected questions (Answers to all questions were provided in a separate document), March 30, 2022

Other documents

Questions and answers (Questions as of 29 March 2022), March 30, 2022

Posters

B-2 TMT WFOS

B-3 ALMA

B-4 KAGRA

B-5 Solar-C

B-6 Solar Science Observatory

B-7 JASMINE

C-1 Development of large format high speed CMOS for astronomical observations

C-2 R&Ds toward a slicer-type integral field unit for WFOS/TMT

C-3 Development of low-noise and large-format near-infrared image sensor for wide field astronomical observation

C-4 Study on a microwave low-noise amplifier by frequency conversion gain based on quasiparticle mixing

C-5 Study on multiband heterodyne receiver technologies aiming at octave instantaneous bandwidth

C-6 Development of broadband and wide field of view direct detector camera/spectrometer

C-7 Development of correlation polarimeter with a superconducting circuit for radio adaptive optics

C-8 Development of Terahertz Intensity Interferometry for High Angular Resolution Imaging

The poster session exchanges and conversation between ECC members and ATC staff are documented in the 20-page document “Poster-session conversations in the MS-Teams ATC review channels”.

Annex C – Agenda of the On-line Evaluation Meetings

Meeting Day 1 – 17 March 2022

JST		Agenda	ATC participants
14:00	14:15	Introduction of ECC members and ATC participants	Yoshinori Uzawa (Director) Kentaro Motohara (Vice director) Masayuki Hirabayashi (Group leader of System design group) Yukiko Kamata (Group leader of Management & administration group) Mitsuhiro Fukushima (Group leader of Manufacturing design group) Shinobu Ozaki (Advanced mission instrumentation group [TMT]) Takafumi Kojima (Advanced mission instrumentation group [ALMA]) Wenlei Shan (Advanced mission instrumentation group [Microfab. lab]) Yukio Katsukawa (Solar Group [outside ATC]) Tomotada Akutsu (Gravitational Wave Science [outside ATC]) Kazuhisa Mitsuda (Coordinator of the evaluation)
14:15	15:15	Introduction of ATC (presentation)	
15:15	16:50	Presentation from ATC and discussion on perspective and criteria (1) and (2)	
16:50	17:00	Committee closed meeting	

Meeting Day 2 – 30 March 2022

JST		Agenda	ATC participants
14:00	14:05	Opening	Yoshinori Uzawa* (Director) Kentaro Motohara (Vice director) Masayuki Hirabayashi (Group leader of System design group) Yukiko Kamata (Group leader of Management & administration group) Mitsuhiro Fukushima (Group leader of Manufacturing design group) Shinobu Ozaki (Advanced mission instrumentation group [TMT]) Takafumi Kojima (Advanced mission instrumentation group [ALMA]) Wenlei Shan (Advanced mission instrumentation group [Microfab. lab]) Yukio Katsukawa (Solar Group [outside ATC]) Tomotada Akutsu (Gravitational Wave Science [outside ATC]) Kazuhisa Mitsuda (Coordinator of the evaluation)
14:05	15:00	Presentation from ATC and discussion on perspective and criteria (4) and (5)	
15:00	16:00	Questions and answers (1) Questions from Day1 (2) Questions about Day2 presentations	
16:50	17:00	Committee closed meeting	

Meeting Day 3 – 31 March 2022

JST		Agenda	ATC participants
14:00	14:05	Opening	Yoshinori Uzawa* (Director) Kentaro Motohara (Vice director) Masayuki Hirabayashi (Group leader of System design group) Yukiko Kamata (Group leader of Management & administration group) Mitsuhiro Fukushima (Group leader of Manufacturing design group) Kazuhisa Mitsuda (Coordinator of the evaluation)
14:05	16:50	Virtual lab tour	
14:05	14:15	Mechanical machine shop	Kenji Mitsui
14:15	14:25	Additive Manufacturing shop	Keiko Kaneko
14:25	14:35	ALMA detector lab	Takafumi Kojima
14:35	14:45	Microfabrication clean room	Wenlei Shan
14:45	14:55	Opt-IR lab (IFU)	Shinobu Ozaki
14:55	15:05	Opt-IR lab (Image sensor)	Hidehiko Nakaya
15:05	16:45	Committee closed meeting	
16:45	17:00	Briefing to ATC members	Yoshinori Uzawa* (Director) Kentaro Motohara (Vice director) Masayuki Hirabayashi (Group leader of System design group) Yukiko Kamata (Group leader of Management & administration group) Mitsuhiro Fukushima (Group leader of Manufacturing design group) Kazuhisa Mitsuda (Coordinator of the evaluation)