

Report of the External Evaluation Committee

for

Institute of Space and Astronautical Science,
Japan Aerospace Exploration Agency

January, 2013

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Preface

ISAS became a part of JAXA, the independent administrative agency responsible for space development in Japan, in October 2003 as a result of a restructuring of three space organizations, ISAS, NASDA and NAL.

As an independent administrative agency, JAXA is evaluated by the independent administrative agency evaluation committee of the Japanese government every year and at the end of each medium-term plan period. This medium-term plan of JAXA requires the activities of ISAS to be reviewed by an external evaluation committee before the end of the medium-term plan period. The first external review as a JAXA institution was held in 2007 for the JAXA's first medium-term plan period. Fiscal year 2012 is the last year of the second medium-term plan period (April 2008 through March 2013).

The members of the ISAS External Evaluation Committee were invited by Dr. Junjiro Onoda, Executive Director of ISAS/JAXA, to take responsibility for reviewing ISAS basic research and related activities with a view to the long-term future of space science in Japan.

As a first step in the review process, ISAS prepared a "Report of ISAS Activities" that was provided to the committee, together with other related documents. The committee found the report well arranged and helpful. In preparing for the committee meeting, members studied the report and submitted assessments to ISAS by e-mail.

The External Evaluation Committee meeting was held on October 24 and 25, 2012, at the Sagamihara Campus of ISAS/JAXA. All sixteen committee members, eight from Japan and overseas, respectively, attended.

After opening remarks by the Executive Director, the committee members discussed the procedure of the review. Subsequently, senior ISAS members described current research activities, achievements, future plans, and some statistical data of ISAS, and responded to questions by committee members.

The committee continued its evaluation on the second day and some of committee members also inspected the facilities at Sagamihara. In the morning of second day, ISAS answered some of the questions raised in the first day. The committee members divided into subgroups and worked on the first draft of "Comments and Recommendations" and "Executive Summary". It was agreed that final adjustments would be made after the meeting when comments from the entire External Committee were in hand.

The comments on the Executive Summary from committee members were gathered by the end of November and reflected revisions to the original draft compiled by the Co-Chairpersons. The revised draft was critiqued by the whole committee, was opened to the ISAS senior staff for comments, and was finalized by the committee in English.

The Japanese version was drafted by ISAS staff representing a translation of the final version written in English. The accuracy of the translation was checked by the Japanese committee members.

As the central organization for space science and engineering in Japan, ISAS has, since its inception, pursued world-class original research both in science and engineering. Work on truly interesting space projects involves difficulties and risks. It takes courage to tackle such missions, but unless the necessary risks are responsibly taken the work soon becomes routine and obsolete. The External Committee has concerns that some of the support that has led to the excellent record ISAS has accumulated over the years is may undergo some changes. It is the External Committee's sincere hope that ISAS, working with its parent organization JAXA, will find ways to extend its fine past performance well into the future, with the help of an ISAS staff that has always exhibited pride and responsibility in carrying out its assigned role.

January, 2013

Chair and Vice Chair of the Review Committee,

A handwritten signature in black ink, appearing to read "Tetsuo Yasaka". The signature is fluid and cursive, with a long horizontal stroke at the end.

Tetsuo Yasaka

A handwritten signature in black ink, appearing to read "C. Megan Urry". The signature is cursive and stylized, with a large, looped initial 'C'.

C. Megan Urry

The Member List of the External Evaluation Committee

Members from Overseas

BAUMJOHANN, Wolfgang	Director, Space Research Institute, Austrian Academy of Sciences
BONNAL, Christophe	Senior Expert, Deputy to the Technical Director, Technical Directorate, CNES
GU, Yidong	Professor, Senior Consultant, General Establishment of Space Science and Application, Academician of Chinese Academy of Sciences
MINSTER, Olivier	Head of Physical Science Unit Directorate of Human Spaceflight and Operations, ESA
SCHRIMPF, Ron	Orrin Henry Ingram Professor of Engineering, Electrical Engineering and Computer Science Department, Vanderbilt University
SQUYRES, Steve W.	Professor, Department of Astronomy, Cornell University
URRY, Megan C.	Israel Munson Professor of Physics and Astronomy, Chair of Department of Physics, Director of Yale Center for Astronomy and Astrophysics, Yale University
ZARKO, Vladimir E.	Professor, Head of Laboratory of Condensed Systems Combustion, Institute of Chemical Kinetics and Combustion, Russian Academy of Sciences

Members from Japan

HOTATE, Kazuo	Professor, University of Tokyo
KAMAE, Tsuneyoshi	Professor Emeritus, University of Tokyo Professor Emeritus, Stanford University
KAWAMURA, Hiroshi	President, Tokyo University of Science, Suwa
KOBATAKE, Hidefumi	President, Institute of National Colleges of Technology
MUROYAMA, Tetsuya	Executive Commentator, NHK (Japan Broadcasting Corporation)
OKANO, Shoichi	Professor Emeritus, Tohoku University Institute for Astronomy, University of Hawaii
SOMA, Yoshie	Special Adviser to President, Kobe University
YASAKA, Tetsuo	Professor Emeritus, Kyushu University

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Executive Summary

- 1) **Achievement:** The level of achievement of ISAS is very high, both in absolute terms and in comparison to researchers throughout the world. Evidence of this conclusion:
 - (a) high production of scientific and technical papers;
 - (b) competitive missions, in many cases world-leading;
 - (c) increasing international collaborations , with Japanese leadership in some cases.
- 2) **Bottom-up process and large missions:** We note the success of the long-standing ISAS bottoms-up process using inter-university system for developing projects, which has led ISAS to choose the optimal research direction for Japanese space science. At the same time, the more top-down call for expertise to foresee and mitigate scientific and engineering challenges may also be effective. In either case, large, L-class missions will pose a challenge, since the fixed (or decreasing) ISAS budget means a decreasing launch frequency. In any case, closer coordination between scientific and engineering groups is needed to ensure that new activities and missions reflect the highest scientific priorities as well as feasible technologies.
- 3) **Inter-university system – further improvement:** ISAS has pioneered the inter-university model of cooperative research in space science. This brings many professors and students to work on space projects collectively, in a bottoms-up process that collects the largest possible set of ideas.
 - (a) Considering the effective available human resources, many of the tasks currently performed in ISAS could be performed by or in close collaboration with researchers in universities, which could take responsibility at a much higher level. Among other advantages, it compensates somewhat for the decline in manpower.
 - (b) Not all professors working in collaboration with ISAS are duly recognized (for their collaboration) by their own universities, where they might be seen as working for ISAS. Clearly, to be successful this inter-university scheme needs equal cooperation from the university side.
- 4) **International cooperation:** ISAS has an established and laudable tradition of international cooperation, with increasing leadership from the Japanese side. The participation of ISAS in ESA and NASA projects, and vice-versa, attests to the prominent role of Japan in international space science. It is important that Japanese priorities and interests be discussed in bilateral talks between ISAS/JAXA and ESA, NASA, etc., in order to enable an effective international planning process.
- 5) **The International Top Postdoctoral Fellows program:** The International Top Postdoctoral Fellows program has been a great success. It brings talented scientists to ISAS, increases the scientific productivity of the Institute, and increases international visibility of ISAS through more visitors and exchanges. This has been an extremely cost effective way to internationalize Japanese space science and engineering.
- 6) **External research funding:** ISAS has been quite successful in bringing in external funding for research, especially from the Japan Society for Promotion of Science (JSPS) through Grant-in-Aids. However larger-scale grants like the World Premier Institution program is directed more toward universities. If a university collaborating closely with ISAS is selected for such a major program, ISAS will also receive benefit indirectly.

- 7) **Public outreach – telling stories to the public:** ISAS has much increased public visibility during the past years, yet even more exposure of ISAS activities to the public remains necessary. Visibility into the actual process of how space science projects progress is likely to be interesting and informative to the general public. We suggest that ISAS consider telling this story to the public, to improve their understanding of the broad scope of space science and to impress upon taxpayers the extreme selectivity with which their Yens are carefully used. It might even be possible to open internal committee deliberations that are now closed.
- 8) **Decline of budget and research personnel:** In the 2007 report, a steady decline of the budget, in real terms, was noted as a major concern. We echo that concern. Moreover, the effective number of ISAS research personnel has decreased further because of their involvement in other JAXA directorates. These two trends combined present serious risks to completing on-going missions successfully and carrying out research after launch.
- 9) **Relationship to higher-level organizations:** The relationship of ISAS to other JAXA directorates/sections, MEXT and the larger Japanese government remains confusing to the committee, in part because of overlapping roles and personnel among the various entities. Although we note that ISAS performance is extremely high, clarifying the relationships would be valuable in various aspects. We have concerns that major reforms in space development/utilization structure might endanger this well-established level of success. We recommend clarifying the roles of ISAS and the Lunar Exploration group in carrying out planetary missions.
- 10) **ISAS within JAXA:** Increasingly ISAS is asked to adopt a JAXA-wide practice of rotating new personnel through multiple assignments. This has many virtues in general, but can be damaging to projects where sustained expertise is needed, as demonstrated by past successes. In Japan, the “rotation scheme” has been executed uniformly in the government offices and major corporations. If a similar “rotation scheme” is enforced in ISAS, key expertise sustained by a very few people — or even a single person — will be easily lost. It is vital to have knowledgeable technicians, engineers and scientists to ensure project success. ISAS’s role for training graduate students can be expanded to the training and education of young engineers and scientists in JAXA in general. Specific examples are scientific ballooning and sounding rocket projects which enable young people to learn end-to-end space project procedures. Duplications on basic research exist among different JAXA branches. Players of each R&D items should be identified at JAXA level and ISAS should take the role to do the basic research on behalf of JAXA.
- 11) **Conclusions:** The External Committee recognizes that ISAS has, since its inception, pursued world-class original research in both science and engineering, with its unique structure for decision making, management and collaboration with other universities. The structure continues to prevail today under the parent organization JAXA, however with certain changes necessitated. The Committee found a number of elements that will enable ISAS continue the high-level performance in pursuing space programs, as well as other elements that could further its already-established fame as a leading international space science institute. The Committee expects that the expertise and dedication of the ISAS staff will ensure that fine past achievements extend well into the future, revealing the wonder of space science that benefits all mankind.

1 Comments and Recommendations

1.1 Achievements

1.1.1 Overall activities

The ISAS report includes a very impressive list of achievements in a significant number of domains, both scientific and technological, and serving and benefitting a no less impressive number of successful missions. For an institution of its size, with the given funding and manpower, the overall activities at ISAS can only be summed up as excellent.

ISAS has successfully “internationalized” its activities even further and most research is done in international collaboration, with ISAS in a leading role in several important projects. The committee believes that the ISAS Director General and his/her leadership team continue to emphasize the highest level of internationally competitive science.

1.1.2 Scientific activities

The scientific output¹ of ISAS has grown steadily during the past years. Normalized to size it is on par with that of other prominent space agencies, and the citation rate is well above world average. Thus, the scientific activities must be rated excellent.

It should be noted, however, that those groups/projects at ISAS with stronger international collaboration contribute more to this success.

1.1.3 Engineering activities

The engineering activities are very impressive (keeping the size and budget of ISAS in mind) and the final success of the Hayabusa mission, after overcoming several difficulties and hurdles, is a prominent example of the excellent quality of the engineering activities at ISAS.

However, the ISAS report did not present a clear programmatic path for these activities as a whole. The committee is concerned about stronger coordinated planning efforts between “Engineering” and “Science,” which could enhance these already very impressive activities even further. Furthermore, ISAS is suggested to have stronger collaboration with Japanese universities and industries in engineering activities.

1.2 Graduate Education and Inter-University System

The academic mission of ISAS is central to the identity of ISAS within JAXA. Indeed, the committee believes the strong academic spirit of the Institute is vital to the originality and excellence of its space science activities.

Specifically, researchers at ISAS are appointed and evaluated on the basis of their research performance and leadership, like faculty at world-class universities. This practice contributes to the academic environment and to the high morale among ISAS researchers.

The inter-university cooperative system, which capitalizes on the academic culture of ISAS, benefits both ISAS and JAXA, with ISAS serving a valuable function as the focus of academic contact for JAXA. The committee recommends ISAS build on this connection, exploring ways to fund R&D activities for ISAS projects at universities.

In addition to connecting leading scholars working across Japan, ISAS provides preeminent training opportunities for students and postdoctoral scholars, who represent the future. The excellent reputation of ISAS helps attract the strongest possible young people, and their participation in advanced research projects contributes to the quality of their training. We note that the number of Ph.D. students per faculty member at ISAS is somewhat small by international standards. One

¹Here, “scientific output” refers to output of “space science” in the narrow definition, according to footnote 2 in section 1.1 of “Report of ISAS/JAXA Activities Prepared for the Visiting Evaluation Committee”.

way of enlarging the graduate student cohort would be to create new opportunities to bring visiting graduate students from abroad.

The International Top Postdoctoral Fellows program has been extremely successful in attracting the most promising young researchers to ISAS. The advantage to ISAS is obvious: they bring broad expertise from other top international laboratories. However, the number of participants remains relatively small, whereas we believe the role of ISAS in training and mentoring post-docs should be strengthened.

In general, ISAS benefits greatly from interactions with visiting scientists. Accordingly, ISAS should provide more research space and accommodation facilities for such visitors. This is a very cost-effective way of extending the reach and influence of ISAS and JAXA.

1.3 General education and public outreach

General education and public outreach are organized and conducted by ISAS in an excellent and efficient manner, and their activities are at an adequate level. There are many activities such as open houses, free campus tours, exhibitions, public lectures, etc. Beautiful, readable and easy-to-understand materials including video disks provide visitors with useful and attractive information. ISAS open house days introduce the public and school children to space science. For example, after the ISAS exhibition hall opened, the citizens of Sagamihara and other cities learned firsthand about Japanese achievements in space research, including the history and design of satellites and spacecraft. Unfortunately the exhibition room is a little small.

It would be very useful for ISAS to generate educational materials that would help school teachers introduce space science into their classrooms. This could in principle leverage the ISAS public outreach activity to more schools than can visit the exhibition hall. Another way to increase leverage would be to hold occasional workshops for school teachers, with ISAS lecturers presenting ideas that can be taken back to large numbers of students in their classrooms.

Of course, annual festivals on space exploration topics are valuable for inspiring young children directly. Similarly, 1– 2 advanced public schools could be invited to attend lectures by ISAS professors, some of whom might then choose to supervise summer research projects for particularly talented students.

1.4 Space projects

1.4.1 Does basic research at ISAS lead to important new space science/engineering missions?

The basic research done at ISAS appears well focused on the ongoing and future program.

For possible future missions, basic research activity is strong in areas where ISAS has a long tradition of success (e.g., X-ray astronomy), but less strong in possible new areas (e.g., Mars exploration). Also, given the success of Hayabusa and the future emphasis on Hayabusa 2, the lack of basic research in planetary materials at ISAS is noteworthy and should be corrected. ISAS could perhaps benefit from adopting a strategic planning approach in which high-priority areas of research and potential associated missions are identified and developed in parallel.

Because ISAS researchers are increasingly busy even as projects grow bigger, it would be valuable to engage more researchers outside ISAS in the projects. On the engineering side, such efforts have been modest to date.

1.4.2 Are space projects generating significant scientific and engineering results in basic research?

Using bibliometric analyses of scientific impact, the average impact of ISAS scientific papers is significantly above the global average. ISAS greatest impact by far is in the area of Astronomy and Astrophysics. The normalized research productivity at ISAS is good relative to other Japanese research institutions.

ISAS researchers are somewhat oversubscribed with administrative duties and sometimes cannot spare the substantial amount of time required for analyzing data. On some occasions, ISAS will have to seek cooperation from non-ISAS scientists in order to respond to growing demands for expertise.

1.4.3 Are space projects conducted with sufficient international collaborations and is ISAS taking significant roles in the international space science progress?

ISAS has maintained a strong record of international participation in space missions. This is particularly true in areas where ISAS is traditionally strong, including astrophysics and space physics. Typically this participation has taken the form of moderate-sized contributions to missions led by other partners, or moderate-sized contributions by international partners to ISAS missions.

For ISAS-based international programs, these interactions are going quite well. For US or Europe-based projects, they rely heavily on postdoctoral scholars and non-ISAS collaborators. It would be good to see senior ISAS scientists taking leading roles in data analyses.

Some areas of space science can be addressed only by large projects that require broader international collaboration. Valuable steps are being taken in this direction with missions like the MMO contribution to BepiColombo. Some hoped-for future projects may require the forging of major new international partnerships in order to come to fruition. In order for this to happen, ISAS should identify specific potential international partnerships that can then be discussed at bilateral meetings between JAXA and other major space agencies.

1.4.4 Are the science/engineering areas covered by ISAS projects appropriate compared to its purpose and resources?

ISAS is doing its best to carry out its main responsibilities of ISAS-based projects, within the present constraints. In the future it will be necessary to collaborate more with outside laboratories or organizations, and/or to develop greater in-house capacity through an increasing budget.

1.5 Important features of ISAS

1.5.1 Autonomy of researchers in selection of research topics

The committee feels strongly about maintaining the autonomy of researchers in selecting their theme of research, as this enables the initiation of new, original ideas. This is particularly true for young and brilliant researchers who should be encouraged to follow their excellent ideas while at the same time being coached in defining and developing new missions. Every mission must eventually pass the filter of a thorough and competent review in terms of both scientific excellence and technology feasibility and affordability. The independent review system to monitor and advise ISAS activities should ensure that all aspects of a proposed mission are thoroughly assessed.

The committee believes that these basic principles are adequately respected in the current ISAS organization and procedures.

1.5.2 Bottom-up system for the mission selection

Working Groups, which can be proposed and selected by the steering committees at any time, have the responsibility for performing pre-phase A studies followed by fully-fledged proposals in response to an ISAS Announcements of Opportunity. The proposals are then reviewed by the relevant steering committee, which presents its recommendations to ISAS, where the final decision is made. This approach leads to the highest scientific quality and most ingenious technology because it leverages the expertise and vast knowledge of a broad array of researchers in formulating new approaches and projects.

The committee nevertheless felt that more Working Groups deserve to be supported and at the same time, that the budget allocated to each Working Group should be enhanced so as to provide

a better chance of success to bolder ideas.

The committee also stresses that the review process should as far as possible involve both science and engineering steering committees, in order to avoid the selection of missions that are too challenging technologically or of technologies with low scientific priority. The current composition of the steering committees — half internal, half external — ensures both competence and relative independence in these reviews.

1.5.3 Collaboration with universities - inter-university research system

Institutes without walls are very effective in attracting additional (external) resources to a common project, and the Working Groups efficiently achieve this goal in a natural way. The wisdom of researchers from both space science and engineering fields is required.

The committee therefore strongly recommends extending the ISAS-established inter-university research system to other basic research and mission planning activities within JAXA. All Japanese universities with appropriate expertise should be invited to participate, as this would facilitate the progress of science and increase public awareness of space science.

ISAS should also consider developing ways to involve institutions outside of Japan in similar collaborations.

1.5.4 International collaboration and exchanges

International collaboration and recognition is a valuable metric for assessing the impact of ISAS programs. Specifically, the extent to which the international science and engineering community adopts ISAS innovations and recognizes ISAS achievements reflects the Institution's impact.

Furthermore, the eagerness of international researchers to spend time at ISAS, either as visitors or as employees (for example, the International Top Postdoctoral Fellows) is a reflection of the international standing of ISAS in the research hierarchy.

Therefore, ISAS leadership should have the goal of achieving the highest possible level of international recognition, by emphasizing internationally competitive science endeavors. Internationalization of personnel is likely to enhance this global recognition.

1.5.5 On-site advanced education in space-science program

The success of ISAS in training graduate students is highly commendable. The committee therefore recommends that this graduate education program be continued and, if possible, increased in size. The committee further applauds ISAS for its role in training and mentoring postdoctoral scholars.

The committee would like to see more young researchers come to ISAS from Japan and beyond, as this increases the Institute's international visibility, brings it new expertise and energy, and leads to the highest possible quality.

Tracking postdoctoral scholars following their ISAS appointments, at least through the next appointment, will be useful for evaluating how effectively the ISAS experience prepares young researchers as scientists and/or engineers.

1.6 ISAS in JAXA and relations to higher-level organizations

1.6.1 Is ISAS producing enough results as an institution in JAXA?

ISAS is producing outstanding results as the main space science research institution in Japan.

This is particularly true when considering the amount of funding and the number of staff of ISAS. ISAS productivity is clearly very high, no matter how one measures scientific production, quantity and quality.

Notably, at the international level the prominence and visibility of ISAS are very clear. Just one obvious sign is the impressive number of ISAS-involved publications in international journals done by international collaborators.

We believe the international reputation of ISAS adds value to JAXA. Indeed, JAXA can be proud of the quality of the work of ISAS and may wish to take advantage of its success by continuing, and if possible extending, the domain of activities of ISAS to other areas of science and engineering at JAXA.

Some research items are pursued by more than one branch of JAXA, for instance, propellant movement in zero gravity is done at least in 3 different branches. It is recommended at JAXA level to know who is doing what in R&D, and it would be advised that ISAS does basic research on behalf of JAXA.

1.6.2 Is ISAS contributing to other organizations of JAXA and/or conducting enough collaboration with other organizations in JAXA?

1.6.2.1 Relation between ISAS and the Lunar and Planetary Exploration Group

JAXA has reorganized its structure so that the current and future lunar and planetary exploration missions are managed by the Lunar and Planetary Exploration Group.² At the same time, ISAS has carried out several solar system exploration missions (*Sakigake/Suisei*, *Hiten*, *Nozomi*, *Hayabusa*, and *Kaguya* until 2008); is presently operating *Akatsuki* (Venus climate mission); and is developing *MMO* for the

BepiColombo mission to Mercury. The Department of Solar System Science at ISAS is carrying out solar, solar-system and planetary science research and studying future missions. The scientists in this department and in the departments of space flight systems and spacecraft engineering at ISAS have been and will be involved in the future solar system missions.

The committee understands that many (both the public and government) wish to see more solar system exploration missions, which along with concerns about an increasing number of cancellations helped motivate the reorganization. However, it is not clear how responsibility for future planetary exploration missions is shared between the Lunar and Planetary Exploration Group and ISAS. For example, some missions such as *BepiColombo* are currently the responsibility of ISAS, while *Hayabusa-2* is the responsibility of the Lunar and Planetary Exploration Group.

We understand that roughly 40 ISAS researchers are working partially for the Lunar and Planetary Exploration Group while continuing their work at ISAS. The unclear lines of responsibility inherent in this arrangement adds risk to the lunar and planetary exploration program for both the Lunar and Planetary Exploration Group and its partner department in ISAS.

The committee recommends that ISAS and JAXA together:

- (A) clarify the mission of the Lunar and Planetary Exploration Group, and
- (B) show a clear management structure that allows experience accumulated at ISAS be fully utilized in the future missions such as *MMO*, *Hayabusa 2* or *Selene 2*.

1.6.2.2 Expansion of ISAS

ISAS has a demonstrated record of success in space science and engineering. Accordingly, the committee believes JAXA would benefit from expanding (or at a minimum, maintaining) the current ISAS portfolio. The committee further believes that, in order to keep its world-class standing in carrying out scientific missions, ISAS should receive an increased budget from the government.

According to the “JAXA vision” for the next 25 years, science represents 8.9% of the JAXA budget, which is small compared to other world-leading space agencies (e.g., for ESA the budget fraction devoted to science is 12%). Therefore the committee feels the fraction of the JAXA budget dedicated to science, at ISAS, should be increased. Furthermore, it is important that the budget be stable, to enable long-term planning and execution of missions.

The committee recommends that:

²The Lunar and Planetary Exploration Group was created at the Directorate level of JAXA in 2007. It was previously called JAXA’s Space Exploration Center, and is sometimes referred to as JSPEC, an abbreviation of the old name.

- (A) JAXA secure a higher budget for Space Sciences from government;
- (B) ISAS, within JAXA, secure a larger share of the budget for sciences;
- (C) a clear vision be developed for the space science budget over the medium term, based on program plans;
- (D) ISAS and JAXA seek more international cooperation to enable more ambitious projects.

1.6.2.3 Visibility of Space Science and ISAS at National level

The visibility of Space Science and ISAS at the national level is not enough. As the financial situation in Japan is more and more severe, there should be an increased effort to explain to politicians and taxpayers the importance and relevance of space science in general, and ISAS and JAXA projects in particular. The required funding can be motivated by explaining the important role played by the space sciences in building a prosperous society. Increasing outreach efforts by ISAS, especially in highly leveraged ways (e.g., through the media), is therefore a wise investment.

1.7 Other comments

1.7.1 ISS and Earth observation

The committee proposes that ISAS strengthen its collaborations with other organizations within JAXA, to expand and obtain more support for space science activities. Research on microgravity environments using the International Space Station is conducted by ISAS under the inter-university research system, while the ISS itself is the responsibility of the Human Space Systems and Utilization Mission Directorate within JAXA.

The committee recommends that ISAS participate more actively in the ISS program, to increase opportunities for space environment utilization science and new technology demonstrations using the ISS.

ISAS is not involved in Earth observations so far. The committee suggests ISAS start collaborations in this area with the related JAXA organizations.

1.7.2 Scientific ballooning and sounding rockets

Scientific ballooning and sounding rockets are a very cost effective research tool and a valuable test-bed for developing new technologies. ISAS has been conducting scientific ballooning missions in the Antarctic since the 1990s; this should be continued and expanded. A balloon facility has been built in Inner Mongolia by the Chinese Academy of Sciences. It is hoped that discussions with the Chinese Academy of Sciences concerning possible collaborations could be successful.

In the past, sounding rockets established a foundation of space science and technologies in Japan. At present they still play a role as an efficient tool not only for technology advancement but also for training personnel in broad fields of science, technology and management. It is recommended that this area should be augmented, enabling more launch opportunities with the addition of extra funding, which will be small compared to those in other activity areas of ISAS and JAXA.

1.7.3 Relation with industry

The importance of close contacts between ISAS and industry must be emphasized, since this collaboration is essential for successful space missions. The feedback from the space engineering activity of ISAS to Japanese industry is also important.

1.7.4 Organization

The committee would like to suggest a few steps that might be considered by ISAS for furthering recognition as a world-leading space research institute:

- (1) Add senior researchers who have extensive international experiences and will lead large-scale international collaborations. These scientists may be recruited from outside of ISAS or outside of Japan.
- (2) Increment the number of woman researchers, as their absence suggests a potential waste of available talent.

2 Comments by the Individual Members

Evaluation Items

- (1) Has ISAS yielded sufficient results so far? Please evaluate items (a)-(c) individually.
One of important aspect is international collaborations. Please also comment on this; e.g. whether basic research is conducted with sufficient international collaborations and whether ISAS is taking significant roles in the international space science and space engineering researches.
(just rating excellent (S), good (A), fair (B), poor (C), and/or comments)
 - (a) Overall activities (please see sections 4-9 of the ISAS report.)
 - (b) ‘Scientific’ activities (please see sections 4, 5 and 9 of the ISAS report.)
 - (c) Engineering activities (please see sections 6-9 of the ISAS report.)
- (2) Graduate education is one of the important missions of ISAS. Has ISAS yielded sufficient results in graduate education? (please see section 1.7 of the ISAS report.)
(just rating S A B C and/or comments)
- (3) General education and public outreach (E&PO) are also important to promote space science. Has ISAS yielded sufficient results in E&PO? (please see section 1.8 of the ISAS report.)
(just rating S A B C and/or comments)
- (4) Space projects are most important elements in promoting space science. Please comment on ISAS activities with emphasis on the following aspects:
(just rating S A B C and/or comments)
 - (a) Are basic researches conducted aiming at future important space science/engineering missions?
 - (b) Are space projects generating significant scientific and engineering results in basic research?
 - (c) Are space projects conducted with sufficient international collaborations and is ISAS taking significant roles in the international space science progress?
 - (d) Are the science/engineering areas covered by the ISAS projects appropriate compared to its purpose and resources?
- (5) How do you evaluate the following important features of ISAS, which were highly recommended to keep by the visiting review committee in 2007?
ISAS considers it important to keep and enhance those features.
 - (a) Autonomy of researchers in selection of research topics (please see Executive Summary 2 of 2007 evaluation report, and section 1.6 of the ISAS report.)
 - (b) Bottom-up system for the mission selection (please see Executive Summary 3 of 2007 evaluation report, and section 1.6 of the ISAS report.)
 - (c) On-site education in space-science program (please see Executive Summary 4, 5 of 2007 evaluation report, and section 1.7 of the ISAS report.)
 - (d) Collaboration with universities - inter-university research system (please see Executive Summary 5 of 2007 evaluation report, and section 1.6 of the ISAS report.)

- (6) ISAS in JAXA (please see Executive Summary 6, 11 of 2007 evaluation report, and sections 1.4, 1.5, and 1.6.4 of the ISAS report.)
 - (a) ISAS is producing enough results as an institution in JAXA?
 - (b) ISAS is contributing to other organizations of JAXA and/or conducting enough collaboration with other organizations in JAXA
- (7) Other comments

2.1 Comments by BAUMJOHANN, Wolfgang

Two comments from my side to begin with

(A) The statistical data (summary data on personnel, budget, intl. collaboration, “output”, etc.) are only given for ISAS as a whole. Reading the report, I got some impression that ratings would be different for different departments/divisions, but cannot substantiate for lack of information.

(B) It is unclear to me why ISAS covers human spaceflight activities on the ISS but not unmanned “Exploration”, which would be closer to the “classical” ISAS activities

- (1) (a) S,
very impressive for an institution of its size.
(b) Overall S,
but there might be groups with A. (see comment A above)
(c) To a non-engineer like me, the engineering activities look very impressive (keeping the size and budget of ISAS in mind). Thus I would rate a somewhat unqualified S.
However, I do not always see a clear programmatic path: perhaps a closer cooperation between ”Engineering” and ”Science” in planning would help.
- (2) S
- (3) S,
very impressive, in particular the steep positive gradient (see p.32 of report)
- (4) (a) S,
in general.
(b) S, in general.
(c) Overall S, but there seem to be projects with little international collaboration (see comment A above).
(d) S, but see my comment A above.
- (5) (a) S,
but selection of SPICA might endanger that (since it will need a large fraction of ISAS ’ resources and might endanger the highly successful 1 launch/year tradition)
(b) S,
but selection of SPICA might endanger that
(c) S
(d) S
- (6) (a) S,
but see comment A above
(b) Cannot really judge based on the information available
- (7)

2.2 Comments by BONNAL, Christophe

- (1) (a) S
Exceptional quality of activities for the given funding and manpower.
Impressive reputation at international level
 - (b) S
Excellent scientific program in both Astronomy & Astrophysics, and Solar System domains
 - (c) A
Excellent results, mainly thanks to the quality of demonstrations (propulsion, RRV, ...)
Potentially lack of international cooperations Potentially duplication of activities within JAXA; ISAS should be more clearly in charge of Research on basic technologies such as propulsion, aerodynamics,...
- (2) S
The structure of the links between ISAS and University is excellent, second to none, giving remarkable results. To be noted, the exceptional reputation of ISAS among the Students
- (3) S
Outstanding results according to the report on JAXA Space Education Center, distributed wednesday evening.
- (4) (a) A
All the selected subjects appear to be of prime interest, but some other key domains could benefit from research at ISAS (mainly heavy liquid propulsion, GNC...); it should be clarified why ISAS is not in charge more generally of all the technical topics of JAXA with low TRL (1 to 5 for instance), JAXA being then in charge of developments. The sharing of activities between JAXA and ISAS should be clarified
 - (b) S
Yes, undoubtedly, the results generated by ISAS are references at world level, in both scientific and engineering domains.
 - (c) A
Several domains could benefit from a larger opening to international cooperation in the engineering domains, mainly in the domain of technologies, aerodynamics, propulsion, RRV, ...
 - (d) A
Some domains have unclear boundaries with JAXA, and I would like to discuss this during the evaluation meetings. ISAS should be in charge more generally of all activities of science, research and technology, technological demonstrators in all the fields covered by the Agency, the pre-development, development, exploitation being of JAXA responsibility. Associated to this, the resources should be increased (or rebalanced from JAXA) to cope with this general span of activities.
- (5) (a) A
The report seems to cover correctly the concern of the evaluation in 2007, even though I am not convinced there should be full autonomy of “young” professionals. It shall be “based” on their interest, but with a re-centering coming from the strategic orientations and roadmaps from Steering Committees of ISAS (and JAXA)
 - (b) A
The selection process is well described, and appears quite classical. The profile of the members of Advisory Council for Research and Management is not clear, and it could be good to have at least one representative of students in the Steering Committees. It is not

clear who performs the first evaluation after proposal to President of JAXA, is it the Board of Councilors ? The kind of file proposed after a Phase-A study to the Committee is not clear: what means “similar to a MDR and SRR” ? Is it normalized within ISAS of JAXA ? Do you hold formal reviews at this step (and after) ? In the Steering Committee for Space Engineering, there could be representatives of Space Industry (MHI, IHI, ...) as they will be the end users.

(c) S

On site education appears perfect, and clearly increasing compared to previous years

(d) A

Collaboration with universities appear very good, but the evaluator is not in position to judge the relevance of the selected universities. How do you select them ? Do they cover all the network of space-related high education in Japan, or only a sub-share ?

(6) (a) S

ISAS is producing outstanding results, both in the absolute and when considering funding + staff. JAXA shall be proud of the quality of the work of ISAS. It is proposed to consider an extension of this work and structure to other JAXA topics relevant to science, R&T and demonstrators Relation with JSPEC is very unclear

(b) A

During the meeting, links between ISAS and JAXA on topics such as Propulsion, GNC, Avionics were clarified... mainly in the frame of the Epsilon launcher and of the RRV technologies, but it clearly shows that a larger role should be given to ISAS for low TRL technologies

(7) I have the feeling the border of the ISAS activities with other JAXA activities is not clear. The are similar domains of research in the engineering field with apparent duplications (liquid propulsion, aerodynamics, ...).

It could be useful to state clearly the ISAS shall be in charge of the Science and R&T for JAXA globally, pushing the technologies to TRL 5 or so, including in-orbit demonstration is applicable; then, projects shall be led elsewhere in JAXA, for instance in Space Transportation Directorate.

2.3 Comments by GU, Yidong

- (1) (a) During the past 40 years, including last four years since 2008, ISAS has made significant achievements in many important areas of space science. ISAS also achieved outstanding results in all aspects of its activity, which makes ISAS a world-famous, highly-efficient, unique, active and high-level space research institution. I am impressed by its obvious virtues of:
- In general view, layout of space science activities at ISAS is rational, also with clear context, reasonable strategies and roadmap for future development. The major focuses of science are highlighted.
 - ISAS has developed modern space exploration technology involving spacecraft, launcher, especially advanced main instrument for science mission with his own distinguished features. The projects have achieved significant results.
 - It is rare in the world, that the means of satellites and carrier rockets, sounding rockets and scientific balloons, are jointly used for science exploration and technology test in one institute. This is one of the advantages of ISAS, thus it becomes an institute that attracts the scientists.
 - ISAS has deep research in space science and engineering. Active and innovative thinking make it a world-class institution. The leading role of the academic research is obviously. The academic research, science missions and the technology development join closely and promote each other, so that virtuous circle is formed.
 - ISAS activities measured from bibliographic materials show, that science & engineering output is significant. Considering the number of staff and constraint of budget, ISAS is an institution of high efficiency, and it has made great efforts for the existing achievements.
- Excellent-S
- (b) I highly evaluate scientific activities at ISAS. They cover most of areas of space science. Scientific research aims at the direction of the forefront of space science and serious scientific challenges.
- Space science research with high quality is closely dependent on space observation and experiment. ISAS has launched and planned a number of advanced X-ray, infrared, radio astronomical satellites, solar space observatories, moon, planets, asteroid probes, as well as the facilities on board of the ISS / JEM for astronomy, micro-gravity science and life science, etc. These observations and experiments either fill the observation gaps, or face new challenges. These missions provide latest data to scientific community. Furthermore, the future satellite programs and other space missions indicate that its effort will be continued and extended.
 - The scientific satellite program at ISAS is sustainable, practical, smart and rich in scientific output.
 - Active, free atmosphere of academic research and in-depth study lead ISAS to be a top-level institution.
- Excellent-S
- (c) - Engineering activities at ISAS is effective. A number of new technologies are developed. The impressive ones are: Sample-return and re-entry technology for asteroid exploration, Solar sail technology is used for the deep space exploration for the first time, etc.
- ISAS take care on advance arrangement of exploration and detecting technologies for the important scientific task, pre-study of key technologies for future missions, as well as new materials and up-to-date IT utilization in space engineering.
 - In the scientific balloon activities that I'm familiar with, a very thorough study has done for the R&D and experimental verification on the super pressure balloons from "Pumpkin", "Tawara" to the balloon with diamond-shaped net. It seems to be a correct solution to super pressure balloon technology.
- Excellent-S

- (2) -ISAS emphasis on graduate education, with a notable achievement.
- Graduate student education benefits both students and researchers. The advantages of such system, compared with that in a University, is that graduate education is more close to the frontier of science and engineering practice, in favor of cultivating professional talents.
 - The scale of graduate education at ISAS is smaller. There is no increasing for doctor and master degree number for recent years.
- Good-A
- (3) - General education and public outreach of ISAS is diversity. Beautiful, readable and easy-to-understand materials including the video desk provide the visitors necessary and attractive information.
- ISAS open door days attracted public and children to be involved. Well-designed website provides plenty of information and interpretation. The exhibition in front gate with physical models and practical devices demonstrates vividly. Unfortunately the exhibition room is a little small.
 - A suggestion is that to call for proposal from young student, or prepare educational project & scientific experiment which could interact with students in, so that they can personally involved and better motivated in science.
- Excellent-S
- (4) (a) - Profound fundamental research and nice scientific thought are the most important element for achievements in space projects. Basic researches at ISAS have guided its space project planning and selection.
- In space astronomy and astrophysics, solar system sciences, microgravity science and space life science, ISAS has the clear scientific target, in-depth study and quite good continuity in the research. Aiming at future space mission, ISAS carried out in-depth the theoretical studies, modeling, data analysis (including the data of international satellites), and so called explorative physics research, as well as a series of simulation.
 - On space engineering, focusing future space exploration mission requirement, ISAS conducted a series of research to solve the technique problems for the missions.
- Excellent-S
- (b) The completed and running space projects at ISAS, including satellite, lunar and planetary probes, as well as research facilities on the ISS/JEM, have achieved remarkable results in the science and engineering.
- In the field of space astronomy and astrophysics involve solar physics, cosmic X-ray sources, solar terrestrial physics, plasma physics of planet and earth atmosphere. ISAS has developed and implemented an upgrading series of satellites. Significant basic scientific research achievements are obtained.
 - In the lunar and planetary science, ISAS conducted a series of exploration of planets, asteroid and comets in solar system. It is very impressive in SELENE, the lunar orbiter mission, including its hard landing, is quite successful, as well as HAYABUSA (MUSES-C), the asteroid sample-return mission, etc. These are also significant basic research achievements
 - In scientific exploration and technological method, ISAS has its imagination, and has made significant achievements.
- Excellent-S
- (c) - ISAS international collaboration has further developed both in breadth and depth for recent years, which makes ISAS become an active and more important partner in the international space research. It has played an important role in international projects, such as the future mission of IXO, SPICA, EXCEED, BepiColombo, etc. It will be a significant contribution to science.
- International collaboration activities at ISAS are practical and effective, in academic

exchange, in future space project and in integrating resources of previous partners.
Excellent-S

(d) ISAS activities involve both science and engineering area, and it is just the advantage of ISAS. Combining the two aspects makes space science in ISAS achieve excellent results. Science and engineering coverage and distribution at ISAS are reasonable compare with its purpose and resources in general.

Excellent-S

(5) (a) - Autonomy of researchers in selection of research topic is necessary. It is also the basis of research progress. As a research institution, ISAS should continue to maintain his tradition such as academic environment, freedom discussion. The new idea and innovative thought should be encouraged.

- As a research institution, ISAS should keep appropriate independence in scientific project selection.

(b) - Bottom-up system for the scientific mission selection is the best method. The ISAS project selection process is reasonable, that is, AOs - Proposals - Working groups - review committee - Director General, enter to pre-phase etc. The committee needs to organize the assessment, including scientific concept, technique concept and method, as well as the risk and budget.

- It would be helpful to invite more projects to enter Pre-phase A or phase-A, to cultivate excellent but not mature project and to make the process more competitive. Excellent space projects then could be selected.

(c) A suggestion is that the number of doctor degree could be increased up to 50% of master degree in average.

(d) - ISAS is main special organization for Space Science in Japan. Due to its scale limitation, collaboration with universities is necessary, and it is also an important responsibility. ISAS maintain a close collaboration with the University system in Japan including academic research, important projects and graduate education.

- When ISAS was belonging to Ministry of Science and Education, there was a “common utility” concept, which I believe is a very clearly presentation regarding the collaboration with universities. This time, the review document has not stressed on that. I suggest ISAS could still continue to adhere to this concept and take it as a principle.

(6) (a) ISAS as an sub-organization in JAXA, basically keeps the scientific and engineering area and layout. The space science and engineering achievement increases the overall JAXA science, engineering and technology output, promotes the strength of JAXA as Japan’s national space agency.

(b) ISAS make larger contribution to other organizations of JAXA, and have enough and effective collaboration in satellite missions, lunar exploration mission, microgravity science and life science on ISS/JEM with other divisions of JAXA.

(7) 1. More than 40 years since it was established, ISAS has formed its own characteristics and advantages. I suggest that ISAS should maintain his tradition as a research institution, maintain it in the direction of scientific research, project and mission selection of relative independence, and maintain its vigor in the space science and engineering. On this basis, strengthen the collaboration with other organizations of JAXA, to take more technical choice and support in space projects, and to get more opportunities by using ISS/JEM for space mission and new technology demonstration.

2. The study of solar physics and solar-terrestrial physics, actually are associated with earth science, including the global change that international communities are concerning of. As earth observation does not involving on the area at ISAS, it seems that relationship between earth science and space physics have not been built up. Suggestion is that proper organization and

arrangement could be considered.

3. whether ISAS is responsible with mission organization tasks on satellite, lunar and deep space probe. If so the effective engineering management is very important to ensure the quality and reliability. Report for evaluation should be involved with project management and standard system for hardware and software development.

4. In the future plan, there are many candidate projects. It appears that the majority is of very good idea and exciting projects. Some plan is with large scale, so the increasing of budget and manpower may be considered, or the projects plan should be optimized.

5. Scientific ballooning is a very effective and low-cost research tool, to strengthen the scientific balloon activities is proposed. Antarctic balloon flight could take very long duration time say several ten days. ISAS begin Antarctic scientific ballooning since 1990's. It could be continued and expended. In the terrestrial flight, discussion with Chinese Academy of Sciences for collaboration could be considered in reasonable chance. A balloon facility has been built in Inner Mongolia by Chinese Academy of Sciences.

2.4 Comments by MINSTER, Olivier

(1) (a) S:

Judging whether the results are sufficient is a very difficult task that would require quantitative criteria, nevertheless the report includes a very impressive list of achievements in a significant number of domains, both scientific and technological and serving or benefiting from a no less impressive number of successful missions. Seeing from the bibliometric analysis provided in the report (of which some graphs would necessitate additional explanations), the output has grown steadily over the last decade, with a citation rate above world average. It is also noticeable that the number of paper co-authored with institutions outside of Japan is growing steadily as a result of the efforts invested by ISAS into developing international cooperation. JAXA-ISAS have taken a very pro-active position in developing international coordination and cooperation in the utilization of the International Space Station and in seeking partnership with foreign entities for the realization of ever more complex - and costly space missions.

(b) S:

For most activities, and in particular those that this particular reviewer feels more competent in, the scientific output resulting from the projects endeavored by ISAS is excellent and is broadly referred to in the communities concerned with them.

(c) There is a large number of very impressive engineering achievements described in the report pushing forth new high performance, miniaturized technologies to enhance the performance of future spacecraft and space instruments.

(2) S:

The link with external higher education universities and the joint involvement of students together with ISAS as described in the report is a very sound and efficient way of tying ISAS activities with those of other researchers in Japan and of contributing to the formation of students to space activities.

(3) S:

ISAS appears to have a very active and very efficient programme to inform the public and to engage young students into space research, or STEM. The figure announced for the number of public lectures is truly impressive!

(4) (a) In the fields that this reviewer feels competent to comment on, the research performed by ISAS are key to defining the objectives and requirements of future space missions. A space programme running without this body of ground based research would without any doubt not have the same scientific impact as the one reached by ISAS. This is a must and that must was surely not missed by ISAS.

(b) S:

Again, the bibliometric analysis included in the report shows in a compelling manner that the science and engineering level achieved by ISAS is above average. One should not forget though that the true impact of such activities take much longer to be realized than the time span of activities presented in the report.

(c) A:

Space projects are becoming increasingly complex and the more brains and resources they engage, the higher their true chance of high impact. Besides, the future of space as mankind is visiting farther from Earth is inevitably international. Several initiatives taken by ISAS in this direction will surely lead to building solid and long term cooperation. This reality is still confronted with the PI culture that prevails in many countries, but again complexity and costs will eventually call for larger international teams to define, prepare and run projects. The further upstream this concept is brought in, the higher the chance of success of the team and of the mission. In that respect, the concept of leadership is also to be

challenged as it contradicts cooperation and team spirit. That ISAS encourages Japanese scientists in this direction is a very promising move; that Japanese scientists take a leading role or not could be a matter of cultural background. The experience of this reviewer is that excellent scientists do not need that kind of stimulation and naturally take the lead.

(d) S:

It seems to this reviewer that ISAS is pretty much covering all of the fields that require studies and developments for a broad range of topics and is successfully pursuing unique capabilities for future space projects. Since there is no mention of limitations in resources that impede on-going developments, and thereby no question relating to setting up priorities, it is difficult to fully answer this question.

- (5) (a) Autonomy is key in research as long as it is guided by proper peer reviewing.
- (b) Bottom up is also key to successful scientific programme. A top down approach is seldom marked by scientific excellence and innovation.
- (c) Hands-on experience at the heart of a project or a mission is undoubtedly the best education a student can receive. This reviewer has however doubts about the student-only projects with regards to the inevitably high costs incurred with space projects.
- (d) This is the guarantee of scientific excellence as it pulls together the brains of pure scientists and of those of ‘ professional ’ space scientists who, with experience, naturally tend to constrain themselves.
- (6) (a) What is the quantitative criterion to define enough? The real question is rather, were the space results genuinely unique in acquiring new knowledge and were they exploited to the fullest possible extent by a team of scientists with complementary expertise? The teaming of ISAS scientists with partner Japanese universities or with international partners are key factors to increasing the results and maximizing the scientific return on investments.
- (b) It so appears from the report that increased collaboration of ISAS with other divisions of JAXA is taking place so that the pool of competences present within the JAXA organization is adequately contributing to successes.

(7)

2.5 Comments by SCHRIMPF, Ron

- (1) (a) S.
Remarkable productivity for the size of the organization.
 - (b) S.
Wide ranging activities that cover the key aspects of space science.
 - (c) A.
Very good quality, although it is difficult to have comprehensive engineering activities in an organization of moderate size.
- (2) S.
This is one of the strengths of ISAS. Having multiple ways for graduate students to be involved in the research is very valuable. The productivity is high.
- (3) A.
The number of visitors is very high and the breadth of the outreach is good.
- (4) (a) S.
The basic research is well defined and should lead to useful results for future missions.
 - (b) S.
The quality of the work is high and is well regarded by the international space community.
 - (c) A.
Very good involvement. It may be possible to increase collaboration with international universities.
 - (d) S.
The number of distinct projects is very large for the size of the ISAS team and budget.
- (5) (a) I agree that this is very important, as it leads to more creativity and diversity if research topics.
 - (b) This seems to be working very well. There may be circumstances in which strong disagreements could arise, but this does not seem to have been a problem so far.
 - (c) This is an important part of the ISAS mission. The research should be the highest priority, but educating people about the results and the process is central to the research process.
 - (d) This is essential. Without leveraging university connections, it would be difficult for ISAS to have sufficient breadth of expertise to cover all relevant aspects of space science/engineering. Involvement of graduate students promotes technology transfer.
- (6) (a) The productivity is very high.
 - (b) This is important and it appears that ISAS is working to increase its collaboration within JAXA.
- (7) ISAS/JAXA is an extremely strong and productive organization, especially taking into account its size and budget. Strong collaborations with other organizations and involvement of universities are key elements of the success.

2.6 Comments by SQUYRES, Steven W.

- (1) (a) Rating: S
(b) Rating: S
(c) Rating: A
- (2) Rating: S
for graduate education, but...
Where I think there is some room for improvement is in the area of training and mentoring postdocs. This is as important as graduate education, and could be a strength for ISAS as well. Currently, mentoring of postdocs appears to be mostly ad hoc, rather than done in any organized way.
- (3) Rating: S
Given the small size of ISAS, the work in the area of E&PO is excellent. I am particularly impressed by the way in which the success of the Hayabusa excited and energized the Japanese public regarding space exploration.
- (4) (a) Rating: A
The basic research done at ISAS appears well matched to the ongoing program of exploration. When comparing the basic research program to possible future missions as represented by the working groups in Table 1.2, the record is more mixed. ISAS research is strong for missions in ISAS ' s traditional areas of strength (e.g., x-ray astronomy), but less strong in possible new areas (e.g., MELOS). ISAS could perhaps benefit from taking a strategic approach in which high-priority future areas of research strength and potential related future missions are identified and then developed in parallel.
(b) Rating: A-
Using bibliometric measures of scientific impact, the average impact of ISAS scientific papers is 60% above the global average. This is a good number, but it is also half the value of the equivalent metric for NASA, so there is room for improvement. ISAS ' s greatest impact by far is in the area of Astronomy and Astrophysics. ISAS ' s normalized research productivity is good relative to other Japanese research institutions.
(c) Rating: A
ISAS has maintained a strong record of international participation in space missions. This is particularly true in areas where ISAS is traditionally strong, including astrophysics and space physics. Typically this participation has been in the form of moderate-sized contributions to missions led by other partners, or moderate-sized contributions by international partners to Japanese missions.
In order to make major advances in some areas of space science (planetary surface exploration is an example), involvement in larger projects will be important, necessitating broader international collaboration. Valuable steps are being taken in this direction with missions like the MMO contribution to BepiColombo. Some hoped-for future projects (MELOS is an example) may require the forging of major international partnerships in order to come to fruition.
(d) Rating: S
- (5) (a) Researchers appear to have considerable autonomy in selection of their research topics.
(b) The process by which missions are selected for flight is strongly bottoms-up. It is also very strongly committee-driven. The working groups have PIs and budgets; they are essentially pre-projects. These pre-phase A studies are extremely important - they are essential for minimizing technical problems and cost growth in projects after they enter phase A.
I am somewhat concerned that there are many working groups and relatively little funding

for the working group studies. Perhaps it would be good to increase the amount of funding per working group, either by increasing total funding for working groups or by having fewer working groups.

- (c) ISAS's strong emphasis on graduate education is important and seems unique within JAXA. It should be preserved and strengthened. While there clearly is a strong program in place for training of graduate students, it was less clear that there is a comparable program for mentoring postdocs.
 - (d) Collaborations with the University of Tokyo appear to be strong, as would be expected given the historical relationship there. There may be an opportunity to forge stronger relationships with other universities in the country, however.
- (6) (a) Given the small size of ISAS, its contributions within JAXA are substantial. Given that the integration of ISAS (and NASDA) into JAXA was fairly recent, there are some historical relics of pre-JAXA times that persist in the organizational structure today. In the interest of efficiency, it will be good to try to eliminate duplication of effort over time.
- (b) ISAS is clearly making important contributions to JAXA. The relationship between ISAS and JSPEC, which are both located on the Sagami-hara campus, is particularly crucial. In order to make the most effective use of the limited ISAS/JSPEC workforce as projects evolve through their life cycle, it is critically important that individuals be able to move between ISAS and JSPEC as necessary.

(7)

2.7 Comments by URRY, Megan

- (1) (a) Rating: S
Impressive activities in X-ray astronomy (the field I know best), where ISAS has become a world leader, as well as in other focus areas.
- (b) Rating: S
Publications are impressive, especially in astronomy and astrophysics. Although the presentation is modest, the citations are substantial.
- (c) Rating: S
Development of key technologies.
- (2) Rating: S
At a summer school in Kyoto in August 2012, where I taught on X-ray astronomy, I was highly impressed by students from all the ISAS-affiliated institutions. The graduate students are very smart and well trained.
- (3) Rating: S
- (4) (a) Rating: S
ISAS has carried out a prudent program based on steadily increasing capabilities, now reaching the world-leading level.
- (b) Rating: S
Major ISAS projects have succeeded in having an impact.
- (c) Rating: S
ISAS activities have extensive international collaborations, and in many case, projects are led by Japanese scientists.
- (d) Rating: S
- (5) (a) Tentative rating: S
Organizational structure looks effective to an outsider but I look forward to learning more.
- (b) Rating: S
This approach seems designed to produce the most capable missions with the strongest scientific output.
- (c) Rating: S
Students are impressive.
- (d) Rating: S
Cooperative system seems to work very well for the missions I know best.
- (6) (a) Rating: S
Very strong institution which brings recognition to JAXA.
- (b) Rating: S
- (7)

2.8 Comments by ZARKO, V. E.

Actually, the scientific and engineering achievements of ISAS are highly recognized in the world scientific community. Probably, the most distinctive results were recently obtained after accomplishment of successful flights of Hayabusa and Kaguya spacecrafts. The representatives of ISAS permanently take part in organization of important conferences and symposia, delivering there papers and submitting articles to international journals.

(1) (a) Rating: S

Total estimation of the ISAS activity is very high. However, it is difficult to evaluate independently the results of “scientific” and engineering activity. In some extent it looks like difference between “fundamental” and “applied” sciences which could not be found easily. At the same time when we talk about the results of engineering activity of ISAS I have to underline the scientific content of this work. Obviously, the progress in development of propulsion issues is based on the achievements in the fields of chemistry and physics (combustion of energetic materials, hydrodynamics, etc.). I believe that the high level of ISAS accomplishments in engineering activity is the result of proper planning of research, hard work and high professional level of the researchers.

(b) Rating: S

(Comment is combined with c.)

(c) Rating: S

In accordance with my background I can evaluate mostly the results in propulsion related fields. The ISAS researchers took part in formulation of Roadmap of solid propulsion for space applications working together with leading scientists of USA and Europe. They really know the current trends in solid propulsion and make essential contribution to its development. There can be underlined the results on computer simulated internal ballistics of solid rocket motors with use of 3D data of coarse AP particles orientation in the propellant. The calculations give the values of local burning rates and the shape of burning grain. Promising results are obtained on replacement of costly X-ray inspection method by newly developed ultrasonic method and on replacement of HTPB binder with energetic binder GAP (glycidyl azide polymer). In studying liquid rocket propulsion the candidate for next generation of green propellants the HAN (hydroxyl ammonium nitrate) has been used in combination with ammonium nitrate and methanol and first promising results were obtained. In hybrid rocket propulsion the highest in the world regression rates with new multi-section-swirling method were achieved.

There exist impressive achievements in development and use of advanced electric propulsion principles. The microwave discharge $\mu 10$ ion engines have provided the safe return of the re-entry Hayabusa capsule to Earth over 40,000 hours in 7-year deep space flight. There are also plans to realize a spacecraft propulsion system utilizing the energy of the solar wind. However, in addition to this work it would be necessary to continue research in developing most efficient hybrid rocket engines. Actually, this is a real world trend in contemporary chemical propulsion engineering and ISAS activity in this direction has to be approved and increased.

(2) Rating: S

Graduate education system of ISAS looks very efficient. During period of more than 10 years I was able to interact with graduate students of ISAS and edit their publications. The level of student works and their interest to studying space engineering were permanently high. I believe that the direct contact with very qualified researchers in ISAS and participation in conducting advanced research projects provide strong basis for high education level. Similar system effectively works for years in Novosibirsk scientific center of Russian Academy of Sciences.

(3) Rating: S

General education and public outreach are organized and conducted by ISAS in excellent and efficient manner. After opening the exhibition hall the citizens of Sagami-hara and other cities got a great chance to obtain from the first hands the information about Japan space achievements and children to become familiar with the history and current state of space research, with design of spacecrafts and satellites, etc. This work is under continuous progress and I was personally pleased to visit in November of 2011 the exhibition hall in ISAS main building. At the same time I watched (on weekend) a sort of Open House in the neighbor Fuchinobe park with special attractions for children. Spreading information through the mass media, public lectures and special exhibitions is also highly effective. I can additionally mention that ISAS presented a “Pencil rocket” and “M-5” models to Novosibirsk space museum thus informing Russian citizens about Japan space activity and history.

(4) (a) Rating: A

In the space engineering science the important role belongs to the search of non-toxic, non-debree and energetically powerful propellants. Part of this work is doing in ISAS, more or less efficiently. It seems that research in the field of hybrid rocket engines may give some gain in the final payload of rocket thus increasing the propulsion system efficiency.

(b) Rating: S

Space projects directed to the atmospheric and solar system sciences as well as astrophysics certainly generate important results in basic science. As for engineering science, the demands of developing most efficient propulsion systems and efforts in solving relevant problems generate the results which are very important for scientific background of our knowledge (e.g., combustion theory, stability of combustion, etc.) and for practical applications.

(c) Rating: A

The ISAS international collaboration is mostly evident in basic space science projects. In engineering science it often faces with certain security problems but the activity in this direction has to be strengthened.

(d) Rating: S

On my knowledge the number and quality of ISAS projects are very reasonable and high if one takes into account the scientific staff size and funding volume.

(5) (a) Rating: S

The scheme and procedure of making decisions in Space Science Activities by ISAS, described in Section 1.6 of the ISAS report, looks attractive and reasonable. It provides thorough discussions and evaluation of new projects, facilitates the natural collaboration between different research groups and individual researchers. The procedure of staged evaluation and performance of the projects gives good basis for current control of the project development.

(b) Rating: A

The meaning and value of this system in project initiation is undoubtedly high. It really provides the best opportunities for involving expertise and vast knowledge of various researchers in formulation of new approaches and projects. However, as it is shown in the ISAS report this system looks as the only way to initiate new projects. Because ISAS as a part of JAXA is the major player in Japan space activity it is doubtful if only bottom-up system may work as unique source for planning new missions.

(c) Rating: A

The graduate education in ISAS plays important role in training qualified researchers for ISAS itself as well as for Japan educational institutes and industrial organizations. The system of such education is well arranged and gives excellent results. Taking into account large number of high level researchers I would suggest that ISAS increases the number of

postdoctoral positions in order to attract more talented young researchers from Japan and also from abroad.

(d) Rating: S

Inter-university research system is well constructed and works efficiently as it is seen from the results of planning the space activities of ISAS.

(6) (a) Rating: S

(Comment is combined with b.)

(b) Rating: S

It is difficult to answer on this question without detailed information about structure of JAXA, existing links and collaboration within total organization, etc. The merger of JAXA made strong effects on the scale of space projects and modified the role of ISAS in Japan space activity. The participation in large-scale projects implies essential increase in the portion of management and may decrease the portion of scientific research. The same can be expected regarding the volume of educational and public outreach ISAS activity. At present, ISAS serves as a center of space science and space engineering researches in Japan and this situation has to be preserved in the future because of great value of the team of very qualified experts working and scientific approaches developed. The statement in JAXA 2025 vision of necessity to contribute to advancing knowledge of the universe has direct relation to ISAS activity and maintaining this activity should be important task for JAXA.

(7) Small comments regarding aspects of chemical propulsion development, contacts with industry and international activity.

(a) The concept of reusable sounding rocket system looks attractive and reasonable. However, stated in the report (p.451) reduction of the transport cost in more than 100 times is not justified clearly and takes special substantiation.

(b) When planning development of solid propellants based on ammonium dinitramide (ADN, p. 455), it can be useful to take into account statements made in 1990s in USA (L. Caveny, AIAA conferences in 1994-95). It was formulated that the use of ADN is justified only as an additive to propellant formulation, i.e. as a burn rate modifier. It shows that the concept of using ADN in solid propellant has to be carefully examined and discussed.

(c) Obviously, the close contact between ISAS and industry is the necessary condition for success of space missions. At the same time there should exist the feedback from ISAS space engineering activity to Japan industry. This is not clearly described in the report.

(d) The effective tools for advertising the leading role of ISAS in space science are international conferences in professional areas. The activity in this direction has to be supported and encouraged by the Institute (and JAXA) directorate.

2.9 Comments by HOTATE, Kazuo

(1) (a) Rating: S

Many results of activities were published in English academic articles. Number of publications with referees is 1/8 of NASA's ones. Considering budget condition of ISAS(1/100), it should be evaluated well. Number of citation per publication is about 17(NASA is about 25), this is also evaluated well. There are many co-author publications with foreign institutes such as NASA and Stanford University. This means ISAS is conducting many international cooperation. In fact, several international space programs have been already designed and promoted, and also future projects are also planned.

(b) Rating: S

For example, 22 out of 27 highly-cited papers are in the field of Astronomy & Astrophysics. Comparing with NASA, overall ratio is 27:272, while the ratio of A&A is 22:124. This is considered to be remarkable.

(c) Rating: A

Number of English papers in space engineering, normalizing by international research papers of field, is the largest one. This should be evaluated well. Considering HAYABUSA's sample return, ISAS has plenty of ability in space engineering field.

(2) Rating: S

ISAS has graduate education scheme in 4 categories and produces 50-80 master degree holders and 10-25 Ph. D holders every year. Regarding graduate education and research, science and engineering are practiced through practical research site, and ISAS educates students in the real research site and students contribute to real research. It should receive high recognition.

(3) Rating: S

There are several schemes such as open house, free campus tour, and anniversary lecture. ISAS actively conducts outreach activities which brought major results in promotion of space science. Especially return of HAYABUSA added impetus to these activities.

(4) (a) Rating: S

In ISAS, by developing and utilizing satellites and spacecrafts, space science and engineering collaborate in coordination and implementation of space project in order to acquire the knowledge which cannot be obtained from observation and theory study on the Earth. In addition to X-ray astronomy satellite, which produced many achievements in the past, ISAS launched the first infrared astronomy satellite "AKARI", and also obtained achievements from "KAGUYA", and "HAYABUSA". I am confident that ISAS will further achieve with important missions such as BepiColombo, SPICA and so on.

(b) Rating: S

As for HAYABUSA mission, sample return was achieved and scientific results were obtained. This is based on the result of engineering achievement. Challenge of Venus orbit insertion of "AKATSUKI" is also expected. It is expected that ISAS lead the world with developing original technologies such as solar power sail technology and this promote accumulation of achievements.

(c) Rating: S

ISAS's spacecrafts are launched in foreign countries, there are many co-author papers with foreign research institutes; therefore ISAS has made worldwide achievements. BepiColombo is full scale Europe-Japan joint mission, SPICA is also JAXA-ESA joint program. ISAS fully promote international cooperation and contribute to promote development of space science.

(d) Rating: S

. With limited budget, ISAS performs distinctive missions which started from the establishment of ISAS. This realized unique results by original technology developments. In the

future, challenging missions such as HAYABUSA2 and SELENE2 etc, which are expected to promote space science and engineering, are planned

- (5) (a) Rating: S
Major role of ISAS is to promote ingenious space science. For this purpose, it's important that researchers can propose research theme with freewheeling thinking. This is essential part of ISAS's origin which ingenious research is incubated in the universities. Researchers' autonomies in selection of research themes shall be sustained and strengthened.
- (b) Rating: S
Bottom up selection of research theme should be a pair with keeping researchers' autonomies in theme selection. This should be maintained in order to keep producing ingenious research results on a global basis.
- (c) Rating: S
Graduate education is essential to cultivate human resources of next generation in the field of space science. ISAS's graduate education provides real academe to students and it is valuable to develop outstanding human resources. The aspect of graduate education organization of ISAS shall be maintained and promoted
- (d) Rating: S
Designing research theme with originality is a key to global contribution to space science research. For this, wisdoms of researchers both from space science and engineering fields shall be gathered together, and also cooperation by Co-operative Graduate School System shall be maintained and promoted.
- (6) (a) Rating: S
In JAXA's various missions, promoting "space science" is ISAS's mission. ISAS has made achievements in development of science and cultivation of excellent human resources for next generation in space science and engineering field. Achievement in each space projects and publication activities in ISAS are evidence for that.
- (b) Rating: S
Results of space engineering and science by promoting space science are applied and contributing in utilization of space.
- (7) Seeking truth in space and realization of useful advanced technology in space give us a dream and bring major merit for daily life. Moreover, such knowledge and accumulation of technology could become a key factor to produce innovation to society. ISAS's activities including development of human resources in Science and Technology for next generation is expected to be promoted from now on.

2.10 Comments by KAMAE, Tsuneyoshi

(1) (a) Rating: A

In general, it's excellent, but, linkage with researchers of universities in Japan or neighboring countries should be improved. Also, allocation of resources of personnel and budget is not adequate for almost all missions to support the entire activities from the design stage to publication of the scientific and engineering results.

(b) Rating: A

Due to the limitation in the number of staffs, ISAS members are forced to work on weekends to which I pay great respects. As almost all projects grow bigger and more complicated, ISAS has to add resources (personnel and budget). Otherwise the scientific results obtained in the projects will not be exploited fully.

(c) Rating: A

This is outside of my expertise, so my comment may miss important points. I hope cooperative research with universities will expanded to universities other than university of Tokyo. Under the current flat-budget flat-man-power climate, cooperation with other universities is becoming ever more important.

(2) Rating: B

Compared to KEK and other accelerator laboratories, the facility to assist visitors is not adequate. ISAS should provide more research space and better accommodation for visitors. Also, budget to fund non-ISAS researchers in participating to ISAS projects (including data analyses) should be increased

(3) Rating: A

HAYABUSA has made a huge impact in this area. Educating teachers of elementary/junior/high schools and providing materials to them should be also promoted.

(4) (a) Rating: A

Although ISAS members are quite busy, members are conducting basic development and research. In my mind ISAS can invite more researchers from other universities and institutions or cooperate with them. This is related to (2), (3). I note that most ISAS researchers are already used up all of their time in fulfilling ISAS duties.

(b) Rating: B

Within the current limitation in the number of researchers and engineers, ISAS should set some limit to the number of projects. ISAS should reserve resources to carry through the publication phase.

(c) Rating: S

Although ISAS is not large institute, ISAS hosts many international projects and take important responsibilities of partners. This must be highly recognized. However, facilities to support guests from abroad are not perfect.

(d) Rating: S

It is covered very broad areas of research. Considering the size, there is some limit in the number of projects. Hence projects must be carefully selected from the early development phase. One of Japanese characteristics is not to criticize projects proposed from other field. Because of this trait, the screening process especially in the early phases of projects leaves room for improvement.

(5) (a) Rating A

I do not think absolute "autonomy of research" or "academic freedom" is not the best policy. ISAS should maintain two things:

1. Nurture culture where the research theme is contemplated well so that it survives severe

criticism,

2. Nurture custom to monitor its progress carefully with critical eyes.

(b) Rating: A

Bottom up method of mission selection is important, but in Japanese research institutes or communities, efforts of leaders to go back to their key objectives and think about "what is most important" are often inadequate.

(c) Rating: S

I see that many efforts have been made by ISAS. However, "right out of the box" experiments for high-school teachers may be worthy to be tried. Efforts made by ISAS until now have started to bring impacts to many high-school students.

(d) Rating: A

Regarding inter-university research system, some smaller universities may not have professors involved in the ISAS projects. Many students in such universities are interested in space science and professors need guidance from experts in the field. Some mechanism to support such universities may be possible by mobilizing retired scientists.

(6) (a) Rating: S

ISAS has produced more than scientific enough results. ISAS overwhelmed other department of JAXA in international visibility, quality and number of cooperative researchers and so on.

(b) I do not have enough information to evaluate this point.

(7) It may be worthwhile to "evaluate" all completed projects of ISAS and list areas where things could have been done better. The valuable experiences the first generation scientists and engineers had may be quickly lost otherwise. Also ISAS staffs (and university professors) need to play more active role beyond the bounds of organizations.

2.11 Comments by KAWAMURA, Hiroshi

- (1) (a) Rating: S
In terms of overall activities, ISAS has produced good results.
 - (b) Rating: S
ISAS has produced significant achievements in space science field.
 - (c) Rating: S
ISAS also has produced significant achievements in space engineering field. One of the achievements is that HAYABUSA overcame several difficulties and returned to the Earth with the sample from Itokawa. It shall be recognized as one of the significant results in the space engineering field. On the other hand, some major instruments of HAYABUSA lost their functions in the course of the mission. In addition, there were several missions which were not able to achieve their targets. They shall be treated as engineering issues to be verified and their results to be reflected to future missions.
- (2) Rating: A
Graduate education is effective system not only for the students but also to ISAS. Graduate students can participate in the first-line research of space, and ISAS can receive revitalizing effects from less experienced but young students to mission teams. However, from the report, numbers of graduate students and awarded degrees were described but it was not mentioned nor clarified in the review meeting if this system was functioned well; i.e. whether students grew up through receiving efficient education or not, whether participation of students contributed to ISAS's researches or projects well. Thus, A is rated to this item.
- (3) Rating: S
Recently, ISAS promoted PR activities such as opening the HAYABUSA's capsule to the public, performing open lectures or appearance of ISAS members. These activities contributed significantly to increase public interests to space science and space development, to give dream to public and to rebuild Japanese peoples' confident on future of Japan. Additionally, ISAS is promoting to send lecturers to "Space School" in many towns, which contributes to space education and general science in young generation.
- (4) (a) Rating :A
Basic researches conducted in ISAS are aiming at future important space science/engineering missions, and they have made major contributions to past missions. There are, however, some basic researches whose intensions are not clearly related to the future missions. On the other hand, in general, the basic research does not always have to lead directly to the missions.
- (b) Rating: n/a
It is favorable if basic research is inspired by the results of projects. I think this is not always necessary matter.
- (c) Rating: S
Regarding this point, there are always competitive and cooperative aspects. In general, ISAS has been leading the world with its projects and also participating intensively in international cooperations.
- (d) Rating: N/A
ISAS's projects cover space science and space engineering fields; however, it is not appropriate to evaluate whether current situation is the best or not.
- (5) (a) Autonomy of researchers in theme selection is important for conducting original and advancing researches, and it should be sustained. On the other hand, because ISAS is not general research institute but the institute with the defined missions, research themes, which are autonomously proposed by each researcher, shall be fully considered and strictly

selected from the views of academic, pioneer technological as well as the resource aspects. Role of the responsible committees or councils to make linkage between proposed themes and existing or future projects are very important and requires a broad vision and high professional aspects.

- (b) Bottom up selection of mission has worked effectively in order to promote ingenious and leading-edge missions. It should be emphasized that the structure and budget to promote the bottom up system is important. If these are not well prepared, researchers outside are disposed to leave from the space researches because tends to require long term. On the other hand, as the singular organization which covers both space science and engineering in Japan, bottom up selection system should not be the unique selection system but another route be also provided in parallel.
 - (c) Field education (graduate education) is effective system not only for the students but also to ISAS. Graduate students can participate in the first-line research of space, and ISAS can receive revitalizing effects from less experienced but young students to mission teams. Therefore this should be maintained and expected to be broadened to not only in ISAS but also in JAXA.
 - (d) Inter-university research system brings power of outside to ISAS and can provide potential of ISAS to outside. This is recognized as important role and should be maintained. Although, in the personal level of the scientists, the outcomes by inter-university research system belong also to the outside researchers, in the institutional level, the outcomes should belong not only to ISAS but also to the outside institutions depending on their contributions.
- (6) (a) As one of institute of JAXA, which is the singular aerospace agency in Japan, ISAS has been producing enough results so far.
- (b) One of ISAS's major contributions to JAXA is outreach activities that were mentioned in the previous question. Results of "HAYABUSA" and JAXA's manned space activities are working together to heighten public attention in space science and space development. Moreover they reflected credit on overall JAXA including ISAS.
- On the other hand, about linkage between ISAS and JAXA, as certain amount of time has passed since the merger, there must be areas where ISAS can provide cooperative activities to support other departments of JAXA. For example, "science research in microgravity environment by using satellites (incl. ISS)" is defined as the space science now, so ISAS, as JAXA's institute with the responsibility of the space science, should actively participate in structure, budget, personnel positioning and personnel treatment with the related departments.
- (7) ISAS successfully possesses the inter-university research and relating professorship systems, which are very effective to promote research works. ISAS should help to diversify these systems to other parts in JAXA, in which there exist not a few parts quite suitable to those systems. It would be a great contribution of ISAS to the promotion of research works in the whole JAXA.

2.12 Comments by KOBATAKE, Hidefumi

(1) (a) Rating: S

The productivity of excellent paper (highly cited paper and hot paper), in normalizing by the number of researchers, is fewer than that of NASA, but it still can be judged that ISAS is keeping the highest standard in the world. Also, comparing “the number of hot papers per 1000 researchers” between ISAS and top Japanese universities, ISAS is always keeping the highest productivity, and normalized citation impact of ISAS is 60

(b) Rating: S

I am not eligible to make judgment about scientific research as I have no back ground in this field; however, I would like to mark an S as the science field accounts for at least half of the above rating.

(c) Rating: S

-As shown in ISAS report, ISAS carries out strong basic research in extremely broad areas. It is determined that these research achievements are incorporated into the actual program such as “Hayabusa” and have made great contributions to complete mission and obtain excellent results. Space project, in general, possesses an element of danger where single vulnerability can bury the whole project; therefore, I have concluded that ISAS is producing an excellent research achievement when considered in the aggregate. Moreover, despite the constraints of limited human and financial resources, ISAS, by setting and implementing high quality research project, manages to deliver impressive result that is highly-regarded worldwide.

-Each aerospace program can be referred as integrated science and integrated engineering. Given that each single advanced field has made steady progress, I have become confident that Japanese Space Science and Space Engineering have made consistent progress.

(2) Rating: A

-It is determined that there is a profound effect on education because ISAS is achieving excellent results on high quality missions with involvement of graduate students. This cultivates human resource who play a major role in researching Space Science and Engineering fields, and the graduate students, as researchers and engineers that assume a large role in general industry, have potential of making a great contribution to the society. It can be stated that the graduate students are great assets in research promotion at ISAS.

-Comparing the number of faculties (professors/associate professors) and the number of graduate students, the number of students is approximately twice as many of the faculties. Also, it looks like one third of master’s degree holders go on to doctorate. Graduate school education is crucially important to develop and maintain researchers in next generation and engineers in space industry, and ISAS serves an important function in this extent. ISAS’s environment is relatively favorable for the students; therefore, I expect more graduate students, especially the doctorate students, will conduct research at ISAS.

(3) Rating: S

In the light of effort to fulfill programs such as Open House and Guided and Free Campus tours, it can be said that the public outreach activities are at sufficient level. While there is a trend where more young Japanese are moving away from the science, the activities to generate interest in science and technology to the next generation would stop this trend, and furthermore, it will lead to promote space science and space engineering. It is expected that these activities will be promoted and continued proactively.

-As human and financial resource are limited, I hope these activities will not interfere with the stakeholder’s first duties.

(4) (a) Rating: A

-It is determined that space project is functioning effectively. There is a system where

various committees in ISAS, in association with specifically categorized working groups, to define the mission of ISAS and to examine the outcome.

-It is determined that space project is planned and implemented by keeping overall balance in space science field. Moreover, compared with overseas, there is a Japanese originality and uniqueness. Research outcome is remarkable considering citation impact per number of researchers.

-Based on above points, basic research at ISAS is implemented accurately and adequately from a long-term standpoint

(b) Rating: S

-In space science, it can be inevitable at certain extent of probability to incomplete the mission by launch failure or malfunction of equipments. Considering the circumstance, ISAS has completed many of its space project missions, and meaningful science and engineering achievements have been produced. I am not eligible to make a comment in the area outside my realm of expertise, but it can be determined from published data of citation impact and number of hot papers.

-Successful achievement of “Hayabusa” and “Kaguya” moved and excited many Japanese citizens. It can be assumed that engineering and scientific result is remarkable as accomplishing such challenging mission. This is the reason why I marked an “S”.

-As for countless glitches Hayabusa encountered, the actions taken by the Japanese scientists to overcome the problem are admirable. The system is elegantly designed with redundancy to overcome the crisis, and the process to bring a successful conclusion is truly impressive; however, this type of impressiveness is not meant for. I urge ISAS to learn lessons from this trouble and consider it as a benchmark for pursuit of more reliable and high level space technologies.

(c) Rating: S

Japanese space science has a great presence in the world, and it can be stated as advanced country in space science. In the lean budget, there are remarkable and unique projects. Space projects are conducted with sufficient international collaborations by sharing observation equipment and sharing observational data. ISAS is taking significant roles in the international space science progress.

(d) Rating: A

-ISAS as an institute that holds researchers from various fields, there are programs which researchers can plan and implement on their specialty. Consistency and development is fully considered in the future planning project. -In above program, despite the constraints of limited human and financial resources, optimized project planning is implemented. -There seems to be nothing that is missing or insufficient.

(5) (a) -ISAS should take operation that regards highly the autonomy of researchers. In general, for the researcher that produces excellent research outcome, it is expected to guarantee the environment to exploit abilities to the full extent under curiosity-drive research. Such environment considered to bring about excellent research out come.

-At the same time there is a mission as JAXA, and it is inevitable that ISAS take a responsibility in this mission. Denying this means ISAS loses its position as research institute in JAXA.

-Autonomy of researchers should not contradict with JAXA ’ s mission.

It is expected to have the attitude to realize and respect both points. It is necessary to sustain and strengthen 1) the system that above mentioned points are incorporated into mission selection process, and 2) scheme which members of mission selection committee are appointed in balance. I am expecting that the current situation is somewhat acceptable.

(b) -Bottom-up system for the mission selection is appropriate because the real excellent project is produced from freewheeling thinking of excellent researcher.

-It is also important and appropriate that both external and internal ISAS members are equally dealing with the selection committee or review committee.

- (c) ISAS is taking a significant role in developing human resources to lead space science and space engineering by educating graduate students through practical R&D field. Especially real experience is very important as it brings educational effect that classroom lecture cannot realize.

-Not only for the educational effect, it is great empowerment for research promotion in ISAS.

-As mentioned in (2) the number of graduate students should be increased.

- (d) Cooperation with universities through Inter-University Research system resulted in having researchers from wide range of researching fields, also the collaboration of researchers had a great effect in promoting researchers. It results in contribution to the progress of Japanese space science and space engineering.

- (6) (a) Current space program is becoming enormous and complex, and it requires the support from basic research in broad fields. Therefore JAXA without ISAS is unable to complete sufficient mission. JAXA ' s mission can be accomplished through ISAS, as a research institute, deeply engaging with JAXA ' s mission.

- (b) I am not eligible to make a comment on this statement as I do not have substantial information regarding the relationship between internal organizations in huge agency such as JAXA.

(7)

2.13 Comments by MUROYAMA, Tetsuya

- (1) (a) Rating: A
ISAS deserves acclaim for its enormous effort, but there are some issues such as the autonomy of “Space Science” versus the national space policy (e.g. merger of JAXA). It is considered that further discussion for autonomy of research is necessary.
 - (b) Rating: S
Scientific activities are highly appreciated for its internationally high level research.
 - (c) Rating: S
As it can be seen from example of Hayabusa, engineering activities are sustaining high standard internationally. A revival Akatsuki is expected as it is overcoming many challenges.
- (2) Rating: S
ISAS endeavors to facilitate close cooperation with universities, and the quality and efficiency of published papers are high; however, unfortunately, the system to foster young scientists is not well organized in Japan. It is necessary to develop strategy to counter such defect.
- (3) Rating: S
The remarkable performance by Hayabusa has resulted in 3 movie titles and massive media coverage. The public attention to the space science has increased. By attractive characteristics of the professors who present various information, it is considered that ISAS is uncommonly doing well for the Japanese science organization. Space Education Center has a large presence. In the future, my expectation for ISAS is to have influence on universal theme such as “What is Man?” and “What is Life?” through “space and universe”.
- (4) (a) Rating: S
Many of the concepts of basic research are unique and appreciated; however, formulation of the sustainable system to maintain post merger quality of missions and to execute them in to effect is anticipated. As can be seen in Hayabusa II project, decision making procedure (top down versus bottom up) needs to be improved.
 - (b) Rating: S
”Failure is just a stepping stone to success.” Failure teaches us what actions we should change in order to achieve success. The quality of research papers is very high, and the research outcome seems to be significant as for now.
 - (c) Rating: S
ISAS is one of the best scientific research organizations in Japan.
 - (d) Rating: A
There is an impression that the science / engineering areas covered by ISAS projects are mostly appropriate.
- (5) (a) Rating: A
The autonomy of research seems to be mostly realized; however, confidence in researchers and specificity in outcome are essential in sustaining autonomous research. Public and political outreach is important, but unfortunately, there is an impression that it is not enough. (Enthusiasm for Hayabusa by public was merely generated by its cinematic and dramatic process rather than importance of scientific research by Itokawa.)
 - (b) Rating: A
Autonomy of researchers are origin of all the missions, it has to be valued highly. At the same time there is a public (political) comment such as “some of scientists are conducting self-indulgent research regardless of social situation.” It is urged to sustain bottom-up system by enhancing external accountability.

- (c) Rating: A
There is an impression that it is going well though I am not quite familiar with the on-site education in space-science program.
 - (d) Rating: A
There is an impression that it is going well though I am not quite familiar with the collaboration with universities - inter-university research system.
- (6) (a) Rating: A
It is considered that ISAS is conducting autonomous and high level scientific research; however, there is an impression that ISAS has issues to resolve in the context of the merger with JAXA. Organizational measures are needed for issue resolution. (e.g. aiming at a role like JPL in NASA)
- (b) Rating: B
ISAS has tendency to pursue autonomy in the organization, and there is a fact that ISAS holds dual structure as seen in Japanese Experiment Module “Kibo” Project. ISAS needs JAXA ’ s organizational measures for issue resolution.
- (7) Effort to evangelize the importance of basic science in society to public and politicians is not enough. Complaining without action will not solve anything. Proactive action is needed. The discussion in evaluation committee tends to be indulgent on fellow insiders. By taking external critics and pressure, sustaining report should be compiled.

2.14 Comments by OKANO, Shoichi

- (1) (a) Rating: S
Considering the number of researchers, engineers, and administration staffs, and scale of its budget, ISAS is performing quite well in its activity, when compared with NASA, ESA, or IKI.
- (b) Rating: S
In the field of solar physics and astronomy, activity of ISAS is recognized to be leading the world. Further growth is expected also in the field of planetary science.
- (c) Rating: A
Japanese own engineering researches are being performed well with limited budget. But it may be uncertain if technologies accumulated so far will be maintained in the future due to decrease of number of field engineers.
- (2) Rating: A
Graduate education at a site where space science is actually going on should be highly evaluated as it can produce competent scientists and engineers. But when considering the position of ISAS, it is recommended to have more students from abroad.
- (3) Rating: S
This is a field in which quantitative evaluation of the outcome against activity is difficult. Still, they are doing quite well when the number of full-time staffs is considered.
- (4) (a) Rating: A
Basic research at ISAS should be highly valued in both science and engineering as they have been doing these activities with looking the future. The current of the times is going toward exoplanets, and a little concern remains if they do follow up with this trend.
- (b) Rating: S
Mission projects have been producing sufficient outcome with stimulating ISAS in both science and engineering. They have been functioning also to foster young researchers.
- (c) Rating: A

In the field of solar physics, astronomy, and space plasma, sufficient international collaborations have been made and ISAS played a significant role. Also in solar system science, BepiColombo is now going on in collaboration with ESA and its outcome should be expected. Further collaborations are desired for other solar system bodies and even for exoplanets. Activity of ISAS on JUICE project and next Mars mission should also be highly expected.
- (d) Rating: A
We should expect further growth in the future, but more human and budgetary resources are desired to be put in the field of planetary and exoplanetary science.
- (5) (a) Rating: S

The basis of the process starting from discussion in the working group, project evaluation at the committee, to execution of the project is autonomy of researchers at ISAS, including collaboration with external researchers. Such autonomy of researchers should be highly valued and maintained.
- (b) Rating: A
Bottom-up system for the mission selection is important and, formally, it looks such system is functioning. But it looks not completely certain that there is a rule or standard to judge if the decision of the committee is really reasonable or not.

- (c) Rating: A
Graduate education at ISAS on the site of space development should absolutely be maintained for the future. Further internationalization of students and postdocs will contribute for promoting the position of ISAS.
 - (d) Rating: A
When a system that guarantees research activity by external researchers staying at ISAS for short or medium term is established, collaboration will be further augmented.
- (6) (a) Rating: S
It is not too much to say that the activity of ISAS does support JAXA. ISAS should be proud of its important role within JAXA.
- (b) Rating: S
As collaboration with the Lunar and Planetary Exploration Group demonstrates, ISAS is activating JAXA. Japan has been making space development without military aspects so far. This situation may change in the future. Still, ISAS is desired to represent JAXA, and we hope it is recognized as a strong point of Japan and ISAS becomes worthy of world respect.
- (7) It is desired that international reputation of ISAS will be more augmented by maintaining good tradition from the time of Tokyo University 's ISAS, and it seems possible to accomplish this.

2.15 Comments by SOMA, Yoshie

- (1) (a) Rating: S
Not only miraculous HAYABUSA's return, but also 7 scientific satellites are under operation. This means ISAS has produced sufficient results.
- (b) Rating: S
The scientific activities must be excellent, as the number of papers has grown steadily during the past years.
- (c) Rating: S
It is a great achievement that HAYABUSA was operated with ion engines for 7 years, touched down on Itokawa, and returned with its sample.
- (2) Rating: A
Many student have opportunities to study space and astronomical science, as ISAS has 4 systems for graduate education. Many students obtained Master and Doctor degree.
- (3) Rating: S
People who are interested in space science are significantly increasing.
- (4) (a) Rating: S
Result of Ikaros mission is expected.
- (b) Rating: S
Success of HAYABUSA was splendid.
- (c) Rating: S
HAYABUSA project demonstrated that it was feasible to bring back a sample to the earth from an asteroid, operated with ion engines for 7 years.
- (d) Rating: A
I guess that ISAS is doing their best to cover scientific and engineering fields.
- (5) (a) Rating: S
Although all scientific activities begin with the interests of individual researchers, researchers with similar interests collaborate each other.
- (b) Rating: A
A bottom-up system from advanced study A phase, working group to project team is well organized.
- (c) Rating: A
It is wonderful that many students have an opportunity to undertake laboratory research at ISAS through 4 systems.
- (d) Rating: A
Many projects are carried out by inter-university research system.
- (6) (a) Rating: S
ISAS has produced great results such as HAYBUSUA, IKAROS, and so on.
- (b) Rating: A
' ISAS cooperates to JAXA through cooperative research.
- (7) I have a concern that JAXA allocated enough resources (personnel and budget) to ISAS.

2.16 Comments by YASAKA, Tetsuo

- (1) (a) Rating: S
ISAS is conducting proactive research and development, and it is achieving satisfactory outcomes.
 - (b) Rating: S
ISAS is showing top-level performance. The plans are made in long term point of view, and the resource is devoted to the area of strength. The collaboration with the domestic universities is successful, and the plan is practiced by taking advantage of international collaboration.
 - (c) Rating: A
ISAS is conducting research and development in the area of strength, and the research infrastructure to respond to demand from the mission. Each area has proactive goals, and research is engaged toward this goal; however, it was not on clear on this report whether there is a long-term goal in engineering field as a whole. It is important to extend and promote inter university collaboration as well as international collaboration.
- (2) Rating: A
The graduate education is unique and highly regarded for its interconnection with the projects. ISAS accepts the graduate students regardless of faculties' affiliation, and it brings full educational effects.
- (3) Rating: A
Outreach activities toward general public are highly active and admirable. In order to expand research arena, it is suggested that ISAS to promote publicity to obtain public support regarding the choice of specific project and the constraints namely budget.
- (4) (a) Rating: A
That is how I understand it.
 - (b) Rating: A
Space projects and basic research are in harmony. Especially in scientific research, the results of projects provide the means to strongly generate and back up and generate the basic theory. In engineering research, projects contribute in backing up the basic engineering technologies. Meanwhile, the question is what should be done to nurture the basic research that is yet to be developed to the projects.
 - (c) Rating: A
International collaboration is engaged sufficiently. If I am allowed to ask for more, I would like to see a project led by Japanese to be set out, especially in the field of engineering and planetary probe.
 - (d) Rating: B
Scientific research as represented by Astronomy and Solar System is conducted systematically. Space Flight mission and satellite mission are considered to take an important role in the project.
- (5) (a) Rating: S
Researchers themselves bring up the goal of research and project, and they study and work hard together to select more effective research topics; therefore, autonomy of researchers in selection of research topics is solidly sustained.
 - (b) Rating: A
Research topics are selected effectively by utilizing the function of Inter-University Research institute. At the same time, it make sense that the number of selected topics is subject to the restriction of budget; however, the situation, where budget has not been expanded for

past several years, cannot be overlooked. Because the system is bottom-up, the researchers are encouraged to make a move toward expanding their own budget.

(c) Rating: A

It is worth noting that many inter-partnership universities and special research students, in addition to University of Tokyo and The Graduate University for Advanced Studies, are involved in research. Practical education based on actual project makes the student to recognize the value of research and to increase the motivation for research.

(d) Rating: S

Having inter-university research system built into the space development leads not only to facilitate the progress of science, but also to have space science to take root in general public. I hope this effort will be sustained and enhanced.

(6) (a) Rating: S

Recent achievements by JAXA are mainly brought by ISAS 's achievements; therefore, ISAS as JAXA 's organization deserves higher evaluation. On the other hand, it is natural for ISAS to request more resource for such great achievements and potential to bring more substantial results.

(b) Rating: A

In the field of space transportation system and solar system exploration, integration with JAXA is promoted. This is a great model case of JAXA activities being driven by collective expertise of ISAS. On the other hand, it can be seen that ISAS is losing its working field and identity. JAXA expects ISAS to take a risk and sustain strong aspiration of pioneering new fields. An important premise to meet this expectation is to request and execute out-of-the-box resource allocation.

(7)

Appendix

A Activities of the External Evaluation Committee

August, 2012

The External Evaluation Materials are sent to the committee members.

September, 2012

Initial comments are submitted from the committee members.

External Evaluation Committee Meeting

Day - 1: Wednesday, October 24, 2012

09:30-09:40	Welcome Address and Remarks	Junjiro Onoda
09:40-10:00	Introduction of Members	Kozo Fujii
	Appoint of Chairperson and Vice Chairperson	
	Discussion on process of the committee	

Overview of ISAS (130 min)

10:00-11:00	General Introduction of ISAS	Junjiro Onoda
	Overview of Research Activities	Masato Nakamura
11:00-11:50	Space Science Programs	Yoshifumi Inatani
11:50-12:10	ISAS's Responses to Comments of the Previous External Evaluation in 2007	
12:10-13:00	Luncheon	

Introduction of Research Depts. (300 min)

13:00-13:30	Dept. of Space Astronomy and Astrophysics	Kazuhisa Mitsuda
13:30-14:00	Dept. of Solar System Sciences	Masaki Fujimoto
14:00-14:30	Dept. of Flight Systems	Yasuhiro Morita
14:30-14:45	Break	
14:45-15:15	Dept. of Spacecraft Engineering	Tatsuaki Hashimoto
15:15-15:45	Dept. of Interdisciplinary Space Science	Tetsuya Yoshida
15:45-15:55	ISAS's Activities Analyzed from Statistics	Toru Shimada
16:00-18:00	Poster Sessions on ISAS activities	
18:00	Adjourn	

Day - 2: Thursday, October 25, 2012

09:30-12:00	Free Discussion	Committee / ISAS Members
12:00-13:00	Luncheon	
13:00-14:30	Sagamihara Campus Tour	Escorted by Seiichi Sakamoto
14:30-16:00	Drafting the Summary Report (Closed)	Committee Members Only
16:00-16:10	External Evaluation Comments	Chairperson
16:10-16:20	External Evaluation Comments	Vice Chairperson
16:20-16:25	Submission of Draft Evaluation Report	Chairperson
16:25-16:30	Closing Remarks	
16:30	Adjourn	

December, 2012

Submission of the final comment from the committee members.

January, 2013

Compilation of the External Evaluation Committee Report.

March, 2013

The official publication of the External Evaluation Committee Report.

B List of Materials to the External Evaluation Committee

1. Report of ISAS/JAXA Activities 2012
2. Initial Comments from the Committee Members
3. Slide Decks of the Committee Meeting
4. Handouts for the Poster Session