Report of the Visiting Evaluation Committee

Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

January, 2008

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. This has brought a number of changes to ISAS which are still evolving.

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 the first medium-term plan period (October 2003 through March 2008). This medium-term plan of JAXA requires the basic research of ISAS to be reviewed by an external evaluation committee before the end of the medium-term plan period.

The members of the ISAS Visiting Evaluation Committee were invited by Dr. Hajime Inoue, 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 and space engineering 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 Visiting Evaluation Committee meeting was held on October 31 and November 1, 2007, at the Sagamihara Campus of ISAS/JAXA. All thirteen committee members, eight from Japan, and five from overseas, 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 also inspected the facilities at Sagamihara, although some of committee members had to leave ISAS before the beginning of the day or during the discussions.

On this second day ISAS also distributed copies of the assessments submitted by committee members prior to the meeting. In the afternoon, the Executive Summary of the ISAS Visiting Committee was drafted by the committee members, using comments from Dr. Elachi as a starting point. It was agreed that final adjustments would be made after the meeting when comments form the entire Visiting 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-Chairperson Harwit. The revised draft was critiqued by the whole committee, was open to comments from the ISAS senior staff, and was finalized by the committee in English.

The Japanese version was drafted by ISAS staff and represents 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 is difficult and involves risk. It takes courage to tackle such missions, but unless the necessary risks are responsibly taken the work soon becomes routine and obsolete. The Visiting Committee has concerns that some of the support that has led to the excellent record ISAS has compiled over the years is gradually eroding. It is the Visiting 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.

December, 2007
Chair and Co-Chair of the Review Committee,

Michikata Kono

Martin Harwit

The Member list of The Visiting Evaluation Committee

Martin Harwit	Professor Emeritus, Cornel University, USA
Sadanori, Okamura	Managing Director, Executive Vice President, The University of Tokyo
Lev Zelenyi	Director, IKI (Space Research Institute of Russian Academy of Science), Russia
Hiroshi, Oya	Professor, Fukui University of Technology Professor Emeritus, Tohoku University
Hiroko, Nagahara	Professor, The University of Tokyo
Charles Elachi	Director, Jet Propulsion Laboratory of NASA, USA Vice president of the California Institute of Technology
Elaine S. Oran	AIAA Journal Chief Editor Adjunct Professor, University of Michigan, USA Senior Scientist, Naval Research Laboratory, USA
Robert Farquhar	Charles A. Lindbergh Chair for Aerospace History National Air and Space Museum, USA
Yoichi, Hori	Professor, The University of Tokyo
Michikata, Kono	Professor, National Institution for Academic Degrees and University Evaluation
Shin, Takeuchi	President, Tokyo University of Science
Teruo, Kishi	President, National Institute for Materials Science
Yuichi, Takayanagi	Director, Tamarokuto Science Center

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Executive Summary

1) **General View:** The Evaluation Committee is highly impressed by the range and quality of the basic research and missions undertaken by ISAS. The scope of space science and engineering research undertaken is very impressive, especially considering the size and budget of ISAS. Japan is clearly a major player in space physics, astrophysics, and more recently planetary science as a result of the work at ISAS. This success owes much to the staff of ISAS, who understand the organization's mission well and have worked hard to raise activities of space science and space engineering to the highest international levels. The Evaluation Committee hopes that ISAS will continue to maintain this great tradition, but notes that the budget of ISAS has not grown in a decade. ISAS will need to be allotted increasing resources if Japan aspires to remain a major player in space science and exploration.

2) **The Environment of Academic Research — The importance of maintaining a bottom-up approach:** ISAS should continue to maintain an environment of academic research and freedom of inquiry driven by researchers within its organization and the broad academic community. This bottom-up strategy has served ISAS well in the past. This priority should be one of the main imperatives to pursue.

3) **Mission Selection and Implementation Strategy:** The committee endorses the bottom up strategy that ISAS has traditionally pursued in arriving at a selection of suitable space missions. We recommend that this policy be continued.

4) **Predoctoral and Postdoctoral Program:** ISAS has a good mix of young and more experienced people, and should be complimented on its program of letting students and postdocs build a small satellite — INDEX. But it is important to also expand the postdoctoral program that brings a regular flow of new ideas and will expand Japan's base for future scientific research in space.

5) **Collaboration with Universities in Space Science and Engineering:** ISAS is the sole space science agency in Japan. The great expertise built up within ISAS therefore needs to be shared effectively with the system of universities in Japan, in order for ISAS to fulfill the responsibilities it has been assigned by JAXA and the Japanese government. As part of this responsibility, ISAS should continue its program of on-site education and training of graduate students at ISAS.

6) **Change is Challenge — The Merger of ISAS into JAXA:** Change is always challenging and normally resisted. However it is also an opportunity for improvement. ISAS should forge a strategy to proactively work to capitalize on capabilities available at its sister organizations within JAXA. These might be tapped for resources such as launch vehicles, operations, data systems, etc., while ISAS focuses its efforts on becoming even better in its areas of priority, such as scientific spacecraft and instruments development, mission planning and design, critical technology, science data analysis, etc.

7) **Outreach:** The Committee appreciates the public outreach program developed at ISAS. It recommends that ISAS become even more productive in outreach to the public and government officials. ISAS must make an effort to point out that the furthering of scientific knowledge and advances of technology are of national importance for Japan. This is particularly true when it comes to encouraging young people to study science and engineering, technological payoff, national and international prestige, and peaceful relationships with other nations. ISAS should expand its lecture series to the public and at universities.

8) **Diversity:** It is important for ISAS to increase the diversity of its students and staff. An effort should be made to recruit more foreign and women scientists and engineers at all levels.

9) **International Collaboration:** ISAS is a major player in space science, along with NASA and ESA. Greater efforts should be made to participate in international collaborations both in having ISAS scientists and instruments fly on other nations' missions and vice versa, as well as in data sharing.

10) **Risk:** ISAS should not shy away from taking risks when the payoff could be high. Space missions, particularly planetary missions, are both difficult and risky. There should, therefore, be tolerance for failure as long as the appropriate lessons are always extracted if failure does occur. ISAS has learned a great deal, and become a much stronger organization by undertaking excellent Solar System and astrophysics missions, despite the risks that these might entail.

11) **JAXA's Space Exploration Center:** JAXA is creating a new Space Exploration Center. We understand that there are many good reasons for this, but it also may pose problems for the future of ISAS. If funds and other resources are reduced at ISAS to initiate the new Center, this may raise the possibility that ISAS will not be able to adequately continue to fulfill its mission. JAXA will need to make sure that, to succeed in their respective missions, both the Space Exploration Center and ISAS have the critical mass of manpower and budget they require.

Comments and Recommendations

1. Achievements

a. Overall activities

- ISAS is a world-renowned space research organization with an excellent record of scientific and engineering achievements. The overall activities appear to be well coordinated and are very impressive. This is especially true for an organization with a relatively small budget and less than 150 permanent research staff, though effective support is provided from science communities through the inter-university system. The work done in ISAS is at the forefront of scientific research, and in selected areas, it is definitely leading the way.
- ISAS space programs in the last five years have generally been successfully implemented. The achievements in Space Science and Space Engineering in this period are reflected in the bibliographic data.
- ISAS is yielding sufficient results, not only in academic research, but also in developing a base of young scientists and engineers. The fact that these activities are well coordinated is important.
- An organization does not have to be large to be a high achiever and have high impact. It can be smaller, focused, and do high quality work. ISAS maintains this standard.

b. Scientific activities

- Scientific work of ISAS is focused on areas where Japan has carved out important niches for itself. ISAS either carries out missions on its own, or cooperates internationally with other countries as a full partner on ventures that are too expensive for any one nation.
- Observations of magnetospheres, cosmic X-rays and solar X-rays, and cosmic infrared radiations are highly rated internationally. The recent orbital operations at the asteroid Itokawa were outstanding. Considering the size of ISAS, it has produced a considerable amount of high-level results.
- Research paper productivity is reasonably good. The citation data show the world average in the corresponding field, and the number of highly cited papers normalized with the number of researchers is comparable to those of the best five universities in Japan, which indicates the high level of scientific activities at ISAS as a Japanese institute.

c. Engineering activities

- Engineering efforts underway look to the future to discern technologies and infrastructure that will have to be in place for anticipated scientific missions to become possible.
- The high level of competence and experience in spacecraft systems and operations has enabled high scientific productivity. In particular, the mission to Itokawa was possible due to the rapid development of a viable ion-propulsion system.
- The staff working in space vehicle technologies have been doing good work with a limited budget and with limited staffing. Recent successes of the vehicle launched to implement space projects is indicative of their excellence.

d. Graduate education

- The rigorous training that work on space missions entails will permit graduating students to join a broad range of industrial organizations, where hands-on experience gained at ISAS would permit young scientists and engineers to evolve into valued staff members.
- The quality of this education is so high that ISAS should make this educational experience available to foreign students and post-docs.
- ISAS has the responsibility to be the center of education in the field of space science and engineering. It should therefore expand its graduate education system to support a larger number of excellent and motivated students The ISAS plan of coordination with multiple universities throughout the country sounds like a good start in this direction.
- Young people working at ISAS now are all active and their numbers are growing. In order to keep them active and interested, and to let them broaden their research fields, future visions of ISAS must be attractive and very clear to them.

e. General education and public outreach

- It is important to maintain outreach and education programs enthusiastically and carefully. ISAS is making an effort to do this.
- Outreach by ISAS is producing significant results in general education and may be one of the best public outreach programs in Japan related to space technologies. ISAS is trying many different approaches, and they are sometimes regarded as models of scientific public-outreach activities. For example, activities such as Open House, Lectures, and Schooling are evaluated highly by people pursuing science education in Japan.
- The outreach activities of ISAS are highly rated compared to the size of the organization.

2. Academic research and space projects

a. Are space projects generating significant academical results?

- Work being pursued at ISAS has a strong influence on academic research in broad areas of science and engineering. The space projects being carried out in Japan are yielding a rich infusion of scientific and engineering results. Japanese space projects have strong influence on space research world-wide, not only within Japan.
- Excellent results have been obtained in various fields of space science. Particularly noteworthy are ISAS contributions in the fields of X-ray, infrared, and radio astronomy. Solar space physics and space plasma physics also have superb records of achievement. The failure of the *Nozomi* was more than offset by the spectacular success of the *Hayabusa* mission to the primitive body, Itokawa. On the engineering side, ISAS has demonstrated that it has world-class capabilities in the fields of mission and trajectory design, deep-space navigation, and interplanetary mission operations. There are outstanding achievements in spacecraft design in the areas of attitude control systems, propulsion, and data handling. Results from microgravity space projects are influencing science in a variety of fields.
- ISAS projects are generating significant academic results.

b. Is academic research directed towards the important space science and engineering missions of the future?

- The long-term goals currently being pursued at ISAS, both in science and engineering, are well-conceived and aimed at solving problems that are broadly agreed to be of importance. In astronomy, the X-ray, infrared, and radio missions being planned are of great interest to the international astronomical community. On the engineering side, progress made at ISAS in the design and deployment of space sails, the development of other more economical propulsion schemes, and research on more efficient solar panels is being watched with great interest. All of these ventures attest to a healthy plan for the future, and a significant participation in furthering international efforts at novel engineering approaches to important efforts in space.

- Future ISAS space missions aim at future important science, and are planned based on current scientific achievements.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

- ISAS has a record of successful international collaborations in which ISAS has played significant roles. A long-standing partnership between the United States and Japan on X-ray astronomy missions, most recently on *Suzaku*, has yielded rich results over the years and is promising to continue doing so. Excellent sensors were provided by foreign partners for *Yohkoh* and *Hinode* for solar physics. European colleagues have recently announced a preliminary study of contributions they could make to the planned Japanese mission *SPICA*, which is of interest also to South Korea and many researchers in the United States. The results of the first Very Long Baseline Interferometry (VLBI) radio mission in space, *HALCA*, have raised interest in following up with another Japanese-led international mission *Astro-G*.

- *Geotail*, which is part of NASA's ISTP Program, is one of the outstanding missions in space plasma physics in which ISAS is playing a significant role. Excellent international collaborations are ongoing or planned, such as the Mercury Magnetospheric Orbiter with ESA's *Bepi Colombo* Project, the *Laplace* Jupiter probe, and *Scope*, and ISAS will take significant roles in these.

- Many of the research topics being pursued by the microgravity science group have been conducted through international collaboration. Some projects will be implemented using facilities in other agencies as international projects.

3. The important features of ISAS

a. Conducting academic and basic research, space projects, and graduate education in one institute.

- ISAS has developed a unique and highly successful system for combining these types of work in one institution. It should be nurtured.

- No national space agency can — or should perhaps even try to — launch demanding space missions and simultaneously engage in the type of academic work required of graduate students. ISAS has recognized that it can pursue both research and graduate education only by cooperating with leading research universities.

- The total number of permanent members of the research staff (146) may be enough for sixteen sections, but the number of supporting staff of technicians (80) and postdoctoral fellows (24) is not adequate for conducting leading-edge research and missions in various research areas.

b. Inter-university system in basic research and mission implementation

- The current system is important and has played an important role in extending the size of the community in Japan. It should be maintained, nurtured, and improved in the future.

- In the present system, university staff members join a project as individuals, where there are no rewards and their accomplishments are not well recognized by the universities except for scientific outcome. This must be changed to a system based on an institution-to-institution contract.

c. Bottom-up system for the mission selection

- This is important and there should always be a significant amount this type of project initiation in any high-level research organization.
- ISAS pursues a bottom-up system for mission selection that is only occasionally overruled when extremely large international collaborations, such as the collaborative efforts on the International Space Station, come under consideration. The rigorous bottom-up process more generally in place ensures that only the very best projects are selected, and these are chosen only when they have developed to a state of readiness that assures a high probability of success.
- There are concerns that the process is controlled too much by a few committees. Innovative mission concepts may not be studied in enough detail, committee work might take up too much time, or the decision might be made without considering the feasibility and strategy of the research field.
- It is important to watch mission implementation under the bottom-up system which selected mission.

d. Close cooperation between space science and space engineering

- It takes equal contributions from scientists and engineers to achieve science results. Fortunately at ISAS, scientists and engineers have always had a productive working relationship.
- There have been many essential engineering efforts, particularly in support of ISAS Solar System research. Visits to asteroids, comets and planets and their magnetospheres all benefit from ongoing research on more efficient chemical and electric propulsion.
- Researchers in space engineering at ISAS must pursue not only leading-edge space projects but also leading-edge engineering research in basic science. The requirements of space science missions can be used to generate new insights in engineering. Engineers at ISAS can take advantage of their location where new space missions are developed.

4. The merger to JAXA with NASDA and NAL

- The merger of ISAS with NASDA and NAL in October 2003 brought a number of changes to ISAS, and the situation is still evolving. The statistical figures cited in the "Report of ISAS/JAXA Activities (October 2007)," suggest that little has changed in these four years. However, almost every ISAS staff member who gave an oral report to the Evaluation Committee appeared greatly distressed by the changes that have taken place. They feel that ISAS is losing its traditional bottom-up approach to science and engineering, and approach in which many good ideas come up from the working level and compete for the attention of and acceptance by the leadership at the top. This is at variance with JAXA's top-down approach, where staff at the bottom of the organization is told what to do by leadership at the top. These two approaches are both understandable. Other parts of JAXA and ISAS have different responsibilities to the Japanese establishment, and these responsibilities require quite different approaches if they are to work well. It is time now, four years after the merger of NASDA, ISAS and NAL, for the JAXA staff, at every level in all parts of the organization, to resolve this issue in a diplomatic fashion. Any delay in this will not be helpful.

- Now ISAS has a much more extensive job than it had before: it must not only maintain a high level of activity in science and engineering research, and a high profile in international science and engineering research, but it must now coordinate its activities with a broader agency that could have quite different objectives. In one way, this gives ISAS the opportunity to extend its research and take on even larger projects. In another sense, it can dilute its activities and this would not be good. This will take work to establish and maintain good relations and coordinate the ISAS work with the JAXA framework.

- The present attitude within ISAS is to maintain the good qualities of the previous ISAS structure, and there is no very clear plan to take advantage of the merger. The ISAS system should be maintained in the future. Some parts of the institution, however, will likely be able to merge with other institutions of JAXA, and the remaining parts of the institution should expand. It is important to spread the "ISAS style" and "ISAS atmosphere" in all JAXA.

- ISAS must maintain its uniqueness and basic research. The relation between engineering research at ISAS and R&D in other parts of JAXA is somewhat similar to the relation between the advanced development and product development in car companies. The important issue is to balance two different types of developments. Those companies which do not have their own technologies but depend on others always become weak and disappear. In JAXA, most "product development" may be done by other institutions. ISAS should continue engineering research to be prepared for future requirements and educating personnel, and JAXA must tolerate the type of risks that arise at the leading edge of research and technology.

5. Other comments

- The balance between large projects in exploration, as driven by JAXA, and small projects for research, which is more in the ISAS tradition, is delicate and both need to be maintained.

- One potentially alarming factor is that the budget does not seem to have changed significantly. In fact, it seems to have decreased somewhat recently. This is not a good trend. It is possible that there is more budget than apparent through ISAS collaborations with other institutions, but at a time like this, with even more responsibilities on its shoulders, ISAS needs a clear increase in resources.

- In evaluating a research institute from the international standard, the level of internationalization of the institute is one of the important items. ISAS carries out large projects through international collaboration, but the number of foreign permanent staff and postdoctoral fellows is too small according to international standard. ISAS needs to increase foreign staff members.

- Lunar-A was canceled 16 years after the approval in 1991. Although the cancellation of the project was evaluated by the Space Activities Committee of the government, ISAS is recommended to re-analyze the project from the mission selection to the mission implementation, to reflect it as lessons learned in future projects.

- The new "Space Exploration Center" is a fine idea as long as it complements ISAS space science activities and does not replace them. It is essential for JAXA to make sure that both the Space Exploration Center and ISAS have the critical mass of resources they require in order to succeed in their respective missions.

- ISAS should keep track of former students who studied at ISAS. Such statistical data must be updated continuously.

Comments by the individual members

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Evaluation Items

(1) Has ISAS yielded sufficient results so far?
a. Overall activities (just rating S A B C and/or comments)
b. Scientific activities
S A B C
c. Engineering activities
S A B C
d. Graduate education
S A B C
e. General education and public outreach
S A B C

(2) The academic research and space project
a. Space projects are generating significant results in academic research?
S A B C
b. Academic researches are aimed at future important space science/engineering missions?
S A B C
c. Are space projects and academic research conducted with sufficient international collaborations?
Is ISAS taking significant roles in the international space science and engineering development?
S A B C
(3) How do you evaluate the following important features of ISAS?
Those features were highly recommended to keep by the visiting evaluation committee in 2001.
ISAS considers it important to keep and enhance those features.
a. Conducting academic/basic research, space projects, and graduate education in one institute.
b. Autonomy of researchers
i. Selection of research topics
ii. Inter-university system and bottom-up system for the mission selection
c. Close cooperation between space science and space engineering

(4) How do you evaluate influence of the merger with NASDA and NAL?
Could you give us suggestions how we should proceed in this aspect?

(5) Other comments

Comments by Martin Harwit

1. Has ISAS yielded sufficient results so far?

A meaningful evaluation can be given only in comparison to the results obtained by other nations. In this context:

a. Overall activities

The overall activities appear to be well coordinated at ISAS. The following points support this conclusion.

(S).

b. Scientific activities

Scientific work is focused on areas where Japan has carved out important niches for itself, in which it either carries out missions on its own, or cooperates internationally with other countries as a full partner on ventures that are too expensive for any one nation.

(S).

c. Engineering activities

Engineering efforts underway look into the future to discern technologies and infrastructure that will have to be in place for anticipated scientific missions to become possible. Good examples are work on higher-bandwidth telemetry systems that will be required for downloading data from the many space missions with rapidly escalating data gathering capabilities that now are being planned. Another example is the long-term ongoing work to design and life-test cryomotors that will endow space missions with longer lifetimes in space than a massive reservoir of liquid helium will provide.

(S).

d. Graduate education

The number of graduate students being trained appears to be appropriate. The number is much larger than could be absorbed by ISAS itself. But the rigorous training that work on space missions entails will permit graduating students to join a broad range of industrial organizations, where the hands-on experience gained at ISAS will permit young scientists and engineers to evolve into valued staff members. The quality of this education is so high, that ISAS should make available this educational experience also to foreign students or post-docs.

(S).

e. General education and public outreach

The results of efforts in general education and public outreach are unusually difficult to measure. School children and interested adults are exposed to many competing influences. Rarely will one organization be able to clearly demonstrate its own accomplishments and contributions. But it is important to maintain this effort both with enthusiasm and with thoughtful preparation, and ISAS is clearly doing this. This is as much as any organization that has many other urgent responsibilities can be expected to do.

(A).

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

Work being pursued at ISAS undoubtedly has a strong influence on academic research in broad areas of science and engineering. The space projects being carried out in Japan are yielding a rich infusion of scientific and engineering results. Japanese space projects have a strong influence on space research world-wide, not only within Japan. ISAS should not expect itself to carry out the same functions that a university does. The great strength of ISAS is the organization's ability to provide students the best apprenticeship available to help them attain strength as independent space researchers.

(S).

b. Academic researches are aimed at future important space science/engineering missions?

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

b. and c. The long-term goals currently being pursued at ISAS, both in science and engineering are well-conceived and aimed at solving problems that are broadly agreed to be of importance. In astronomy, the X-ray, infrared and radio missions being planned are of great interest to the international astronomical community. A long-standing partnership between the United States and Japan on X-ray missions, most recently on *Suzaku* (ASTRO-E2), has yielded rich results over the years and is promising to continue doing so. European colleagues have successfully participated on the Japanese infrared astronomical space observatory *Akari* (ASTRO-F) and have recently announced a preliminary study of contributions they could make to the planned Japanese mission SPICA, which is of interest also to South Korea and many researchers in the United States. The results of the first Very Long Baseline Interferometry (VLBI) radio mission in space, *Halca* (*VSOP*), have raised interest in following up with another Japanese-led international mission ASTRO-G (*VSOP-2*). On the engineering side, progress made at ISAS in the design and deployment of space sails, the development of other more economical propulsion schemes, and research on more efficient solar panels is being watched with great interest. All of these ventures attest to a healthy plan for the future, and a significant participation in furthering international efforts at novel engineering approaches to important efforts in space.

(S).

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

b. Inter-university system

a. and b. ISAS has shown itself adept at conducting academic research, space projects, and graduate education, in one institute. No national space agency can — or should perhaps even try to — launch demanding space missions requiring meticulous attention to detail, while also engaging in the kind of broad academic thought to which graduate students at leading academic institutions should be exposed. ISAS has recognized that it can pursue both research and graduate education only by effectively cooperating with leading research universities. It has done this with great skill by affiliating itself not only with the University of Tokyo, which has always had an important role in ISAS activities, but also with Kyoto and Nagoya Universities, the Tokyo Institute of Technology and many other academic institutions in Japan. On the European Space Agency's Infrared Space Observatory (ISO) mission, where Japan was a participant, leading researchers at ISAS, the University of Tokyo, and Nagoya University made important findings. This collaboration has extended to the current Japanese-led *Akari* infrared mission, where again the cooperation with leading research universities in Japan has been central. In addition, ISAS has joined forces with the National Astronomical Observatory of Japan on three successful solar physics satellite projects, *Hinotori, Yohkoh* and

Hinode producing increasingly incisive X-ray images of the Sun. As part of this collaboration rocket and balloon launches have also been carried out.

(S).

c. Bottom-up system for the mission selection

ISAS pursues a bottom-up system for mission selection that is only occasionally overruled where extremely large international collaborations, such as the collaborative efforts on the International Space Station, come under consideration. The rigorous bottom-up process more generally in place ensures that only the very best projects are selected, and are chosen only when they have developed to a state of readiness that assures high probability of success. Many of the missions actively competing for selection have been waiting in line for many years. During those years, ISAS has provided support to permit each of the competing missions to mature to a point where risks are minimized. On rare occasions, a mission that has long been a serious contender for launch has been abandoned, as happened with the Lunar-A mission when it no longer appeared viable. Cancellations like this are always difficult; but it is a sign of the strength of ISAS that they can be taken where necessary in order to maximize and maintain the overall health of the Institute's programs. Four years after the merger of ISAS, NAL and NASDA into JAXA, the ISAS staff still appears to have difficulty in accepting that some decisions have to be made top-down. A set of negotiations should be initiated between ISAS and JAXA leadership, which also extends down to the level of scientists and engineers, so that a rational resolution to the top-down/bottom-up problem may be reached, and that everyone in the two organizations can accept this as necessary, reasonable, and efficient. This debate has gone on for too long and should be quickly settled so that smoothly coordinated efforts can best proceed.

(B).

d. Cooperation between space science and space engineering

Some of the cooperative efforts between space science and space engineering have already been mentioned. But there have been many other essential engineering efforts, particularly in support of ISAS Solar System research. Visits to asteroids, comets and planets and their magnetospheres all benefit from ongoing research on more efficient chemical and electric propulsion. Electric propulsion was the key to success of the *Hayabusa* asteroid explorer, whose rendezvous with asteroid Itokawa in 2005 was a major success, after a two year flight during which the spacecraft distance from the Sun ranged from 0.86 to 1.7 AU. Space robotics, penetrator technologies, and reentry engineering studies in support of Solar System exploration are other key technologies being developed that promise great future gains.

(S).

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

The merger of ISAS with NASDA and NAL in October 2003 has brought a number of changes to ISAS which are still evolving. A first impression gained from statistical figures cited in the 'Report of ISAS/JAXA Activities (October 2007)', suggests that little has changed in these four years:

- The number of graduate students at ISAS has increased by about 20% to a level of roughly 225, since the merger, primarily through additional students coming from Inter-partnership Universities and the Graduate University of Advanced Studies, both of which first joined in 2003.
- The permanent research staff level has increased by about 10% to a current level of 146, the number of post-docs has roughly doubled to a level of 24 over the same interval, while the administrative staff has declined from an average of about 65 before the merger to 42 today.

- The number of papers published each year on the Web of Science, WOS (Fig. 3.1 of the Report) has remained nearly constant since 1999.
- The average funding of ISAS has also been fairly constant, at a level of about 23 billion Yen over the years 2004 to 2007, comparable to funding between 2000 and 2003, but significantly lower than funding available in 1998 and 1999, when ISAS was funded at a level of 30 billion Yen.
- Taken together, these figures suggest that the performance of ISAS has been fairly steady since before the merger.

However, almost every ISAS staff member who gave an oral report to the Evaluation Committee appeared greatly distressed by the changes that have taken place. In the new relationship of ISAS within JAXA, they feel that ISAS is losing its traditional bottom-up approach to science and engineering, where good ideas come up from the working level and compete for the attention of and acceptance by the leadership at the top. This is at variance with JAXA's top-down approach, where staff at the bottom of the organization is told what to do by leadership at the top.

These two approaches both are understandable. JAXA and ISAS have different responsibilities to the Japanese establishment, and these responsibilities require quite different approaches if they are to work well. It is high time now, four years after the merger of NASDA, ISAS and NAL, for the JAXA and ISAS staffs, at every level in the two organizations, to sit down and settle this issue in a diplomatic fashion. Any delay in this will not be helpful.

(B).

One more potential organizational difficulty should be mentioned. JAXA is creating a new Space Exploration Center. Presumably this has many good reasons, but it also may pose problems for the future of ISAS. If funds and other resources are taken away from ISAS to initiate the new Center, this may raise the possibility that ISAS will not be able to adequately continue to fulfil its mission. It is essential for JAXA to make sure that both the Space Exploration Center and ISAS will have the critical mass they require in order to succeed in their respective missions.

(B).

Comments by Sadanori Okamura

1. Has ISAS yielded sufficient results so far?

a. Overall activities
S

b. Scientific activities
S

c. Engineering activities
S

d. Graduate education
A

e. General education and public outreach
A

2. The academic research and space projects

a. Space projects are generating significant results in academic research?
S

b. Academic researches are aimed at future important space science/engineering missions?
A

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?
A

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.
A

b. Inter-university system in basic research and mission implementation.
S

c. Bottom-up system for the mission selection
S

d. Cooperation between space science and space engineering
S

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

It is inevitable but the present general attitude of ISAS seems to keep the good characteristics of previous ISAS and the strategic plan to capitalize the resources which became newly available by the merger is not clear to me (coming from outside ISAS). Please positively follow the recommendations written in executive summary item 6 and spread the 'ISAS style' and 'ISAS atmosphere' in all JAXA.

Comments by Lev Zelenyi

1. Has ISAS yielded sufficient results so far?

a. Overall activities

ISAS produced an outstanding contribution to the world science and contributed immensely to the prestige of Japanese science and technology all over the world. It also gave an attractive example of economic and effective management providing excellent scientific results for relatively small financial spending.

Excellent-S

b. Scientific activities

ISAS was involved in numerous multidisciplinary studies. Based on my expertise I could mostly comment on ISAS research in a fields of solar - terrestrial and space plasma physics.

YOKHOH was one of the most successful solar missions and, in fact, pioneered the X-ray vision of solar dynamics. It enabled to look inside the solar active regions, revealed multiscale nature of energy conversion processes and emphasized the importance of magnetic reconnection for solar corona.

Already early results from HINODE are very impressive. They should open new epoch in Solar physics due to excellent resolution of instruments and their possibility to reveal unprecedentally small spatial details.

GEOTAIL due to its ingenious trajectory, reliable and complete set of instruments produced a real wealth of results in magnetospheric physics. Geotail studied practically unexplored distant parts of the Earth's magnetotail which represent the real laboratory for studies of nonlinear, high - beta, turbulent plasma.

Another achievement of Geotail was its investigation of global dynamics.

Of magnetosperic plasma in conjunctions with other IACG (interagency) spacecraft: POLAR, WIND, INTERBALL, CLUSTER.

These studies allowed to reveal cause-effect relationships in substorm dynamics and contribute to building up the scientific background for the new practical discipline - Space Weather.

Excellent-S

c. Engineering activities

This part of ISAS activity could also be ranked very high.

Launching of more than 30 spacecraft with only very small number of failures is already a significant achievement. One should take into account that both spacecraft, its instrumentation and launcher were developed by the same Institute. I do not know any such examples in other countries.

This combination of all responsibilities under 'one roof' is probably the unique Japanese experience and could explain thus far very successful scientific program of JAPAN. Most ISAS missions were innovative in design and were at the upper edge of available technology. This usually is related with significant but justified risk when one is attempted to do the top - level science.

Excellent-S

d. Graduate education

The number of educational activities carried by ISAS is also impressive.

Even without going into details one could see the result. Practically all Japanese space physics scientists I met thus far were associated with ISAS at one or another stage of their career. As far as I understand, these scientists, being excellent specialists in their fields, learned both practical experimental skills and broad expertise in space sciences very significantly due to their ISAS work or practice. In Russia we also follow this Scheme of teaching students of master level in real research institutes.

Excellent-S

e. General education and public outreach

Activity of ISAS is very visible outside: Very well written informational booklets, attractive WEB site with very good content, small but informative exhibition of ISAS projects. Very important are ISAS open door days when many visitors (including politicians) get acquainted with the achievements of modern space science. We (IKI) are learning from ISAS how to run the outreach.

2. The academic research and space projects

(Please give comments and/or S,A,B,C rating* on each item.)

a. Space projects are generating significant results in academic research?

Modern space science is an experimental science and the only way to get new knowledge is to organize complicated and relatively expensive space projects. ISAS since its formation was very in this activity. Sakigake, SUISEI, YOKHOH, AKEBONO, GEOTAIL, HINODE, – this is only part of ISAS missions which produced outstanding scientific output and shaped our knowledge of the near Earth space, comets Sun and X-ray universe and providing thus far background for academic and theoretical research.

b. Academic researches are aimed at future important space science/engineering missions?

Significant part of ISAS activity is related with preparation of future scientific and technological breakthrough. Very perspective line of investigations was opened by small auroral satellite REIMEI, which demonstrates the appearance of new modem experimental tools for ISAS investigations.

Another example is KAGUYA mission also attempted to verify new experimental; concepts.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

Most of principal ISAS projects were done with significant international involvement. This happens even two levels – within the project (international instruments, like it was at e.g. YOKHOH, Geotail) and by coordination and data exchange with other Agency spacecraft (e.g. INTERBALL - GEOTAIL - POLAR : Sakigake - SUISEI - VEGA - GIOTTO)

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

It is excellent and very rewarding approach. It is not only ISAS invention – Russia (since 1960-ies) also practice the training of master level students beyond their academic universities – in real Scientific Research institutes.

Comparison with classical University system clearly shows that it is much less effective in comparison with teaching by real research experts.

So our experience fully confirms that ISAS approach of conducting academic research, space projects, and graduate education in one institute is fully justified.

Excellent-S

b. Inter-university system in basic research and mission implementation.

According to description I got it is very reasonable and important system for JAPAN with the one major Space center and many universities all over the country. Involvement of scientists from various Universities to the work over the results of space missions is good idea which is beneficial both for ISAS and University researchers who get chance to work with leading experts at the scientific frontiers.

c. Bottom-up system for the mission selection

Judging on results of this selection (list of the launched ISAS spacecraft) system is well organized: involve vast expertise of entire scientific community, take into account plans of other agencies and is aimed on achievement of original and pioneering scientific findings.

d. Cooperation between space science and space engineering

Very important and unique feature of ISAS strongly contributing thus far to the impressive list of its space achievements. Unfortunately due to different historic roots between Academy and space Industry in Russia we does not have the numerous advantages of such close cooperation.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

Generally speaking each process has its advantages and disadvantages. I could only say that ISAS as it is visible from outside is a national property of JAPAN substantially contributing to national prestige. (From this point of view it was very wise decision to keep the name of ISAS)

ISAS as a mature and successful organization has its Style of doing top-level science, well recognized and respected all over the world. Science is a subtle thing and the main recommendation could only be 'HANDLE WITH CARE'. Criteria of success and risk are different for practical space applications (communications, navigation, meteorology, military..) and scientific space missions.. Without weighted risk in space science one will always remain behind. It is enough to remember the history of Mars investigations with a long list of spacecraft lost by all space agencies. But without these losses we could not be that far in understanding MARS and its environment as we are now..

Another unique feature of ISAS style is its close association with space education and providing educational space practice to students and researchers from various Japanese universities. This important and very successful mode of Science-education interaction, I think, is also necessary to conserve.

Otherwise merger with NASDA I suppose might help to even strengthen close links between science and engineering typical for ISAS before.

Comments by Hiroshi Oya

1. Has ISAS yielded sufficient results so far?

a. Overall activities

Rating: A

In general, activities are evaluated to be good considering the number of researchers, technicians and supporting administrative staff and the budget size.

b. Scientific activities

Rating: S

Overall, the activities are evaluated to be excellent. This evaluation is, however, mostly due to the results in the fields of Astronomy and Solar Terrestrial Physics. There remains a significant defect in the field of Planetary Science. The achievement in the planetary science is in the level appropriate for the potential capability of ISAS. Some contradictory issues seems to be existing in ISAS system which may be required to improve to manage large integrated, complicated missions such as missions for Lunar and Planetary science.

c. Engineering activities

Rating: A

In total the activities are evaluated to be good. In individual activities, the successful ion propulsion and encounter with an Asteroid are excellent achievements, However systematic organization to pursue space missions is weak for the execution of consolidated routine-type work due to a lack of technical field staff.

d. Graduate education

Rating: A

Generally speaking the graduate education system is not good; this is not progressing well and has the same character as after the start of previous ISAS, which was biased to relations with the University of Tokyo.

It should be opened towards view point of international competition after the unification (NASDA and ISAS) to the absolutely single space agency in Japan. In this context, ISAS has responsibility to be center for educations in the field of space science and engineering. ISAS graduate education system has responsibilities to educate all young students who possess quality and a willingness to make outstanding, excellent, or good achievement in space science or engineering field without depending on the university from which they graduated.

e. General education and public outreach

Rating: A

Activities are good, making efforts to provide information to outside and providing chances to high-school students to make experiences of designing spacecraft; more efforts however may be needed with the concept that funding is originally provided by tax payers. In this context, NASA outreach activities are a good target for the efforts of ISAS outreach activities.

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

Rating: S

(I) Science

1) Astronomy and Astrophysics

Excellent results have been obtained, including some of outstanding discoveries. Although one X-ray astronomy mission failed due to malfunction of the first stage booster, 6 spacecraft launched between 1982 and 2006 effectively achieved their purposes. This field was originally biased to X-ray astronomy, but has been expanded to include infrared astronomy, although the field of ultraviolet astronomy has not been included.

2) Space plasma physics

Two solar missions are providing outstanding data for studies of solar plasma physics. The Geotail mission, carried out on a collaborative basis with NASA, has also achieved excellent results providing a good counterpart to solar plasma physics, by seeking proof of magnetic reconnection. Results from Akebono, however, were not included in the ISAS report for evaluation. This is related to some aspect of defects in the inter-university system in ISAS.

3) Lunar / Planetary science

The Lunar penetrator has is the subject in which related persons have been involved almost 20 years not as basic study but as mission-oriented works without any result. With abandoning the Lunar-A mission, the Lunar penetrator subject becomes serious problem if ISAS will not investigate and analyze the origin of trouble and responsibility for the trouble, from standpoints of healthy operation of ISAS system.
The failure of Nozomi mission may be not be independent from the selection of Lunar-A mission. The selection of Mars in that period was rather unreasonable because there was no continuation of technical feasibility. Due to the selection of the Lunar-A mission, possible planetary missions which could have been more easy to achieve than Mars, such as Venus for example, were not selected.
There is now hope to recover the activities in this field by the Kaguya mission that is presently running successfully. The Hayabusa mission provides a good illustration of ISAS's potential, but that cannot be counted as scientific achievement until sampled material is returned, contrary to the ambitious achievement of engineering side.

4) Atmospheric Science

After Ohzora, there have been no satellites prepared for atmospheric science. This could be ISAS policy. After the start of JAXA, however, it should be not allowed to be narrow in selection of science fields. It is particularly urgent and inevitable to make a responsible contribution to the observation of the global atmospheric environment. It is not clear how the ISAS science team commits to this subject within the environment-related projects of JAXA. The ISAS report of 2007 October only describes basic studies of the upper atmosphere carried out using sounding rockets.

(II) Engineering

1) Development of solid propellant rockets

This traditional field, which has achieved a unique and worthwhile heritage, has completed the establishment of M-3-SII and M-5 series rockets. All activities related to the M-3-SII and M-5 series rockets are evaluated to be outstanding.
However, at the stage of continuous usage of such heritages, it is embarrassing that they have been considered as if only experimental objects for engineering development. Less attention may have been paid with regard to these being products applicable to space observations; i.e., reliability, and the costs for launching and production seem to have been unreasonable — space observations are then limited in ISAS.

2) Other projects

New original concepts in product and production, i.e., academic efforts in engineering, are evaluated as to be excellent; the many research results accumulated by Planet-A, HALCA, Nozomi, and Hayabusa projects, for example are outstanding.

3) Lunar-A problem

No description is given of engineering efforts to achieve the Lunar-A mission, especially for the efforts to develop penetrators. To clarify that some plans of lunar seismology scientists were illusory, or unrealistic, in the early 1990's, researchers in the engineering side should have been more earnest and rigorous. It is suspected from past activities that desk-bound design engineers who do not have a good grasp or experience of real issues abandoned their problems to contractors.

b. Academic researches are aimed at future important space science/engineering missions?

Rating: A

In general, the fields of 1) Astronomy and Astrophysics, 2) Solar system science, and 3) Space engineering try to have the best future missions. The field of Astronomy and Astrophysics is revealing comprehensive and practical goals, while further investigations are required for some projects of Solar system science. Straw-man design may be required for mission planning until 2025 to see whether planned missions are feasible within the framework of the ISAS budget and manpower.

1) Astronomy and Observations

1.1 X-ray Observations

After the successful achievement of past and on-going missions the next target is set to observe high energy X-ray with high resolution by designing the NeXT mission and considering participation to XEUS missions.

1.2 Infrared Observations

Looking at the results of AKARI, the SPICA mission is being considered. It is a very ambitious plan, but the feasibility of "warm-launched cooled telescope" is not clear.

1.3 Radio Observations

A succeeding mission to HALCA is quite a natural target with specifications which achieve higher sensitivity and improved angular resolution.
Although no attention has been paid to it, low frequency radio astronomy will be important in the future, becoming feasible by utilizing a lunar base cooperating with one of SELENE series missions.

2) Solar system science

2.1 Planetary probes

The Laplace mission to Jupiter is quite important. ISAS should have its own spacecraft to arrive at Jovian magnetosphere, even if the total mission will be carried out on an international collaborative base.

2.2 Space Plasma physics

The description in report is simply philosophical; no practical image is presented except for group flight of multiple spacecraft, and lecturing on the Plasma Universe, which H. Alfven had emphasized throughout his life works. It is important what has been achieved by the Geotail mission, and also it is very important that the plasma universe including magnetized rotating bodies, such as pulsars and rotating black holes, is investigated. From this context, studies of Akebono results are also important to plan future missions in the field of space plasma.

2.3 Atmospheric science

After the Planet-C mission, a follow-on mission may be needed because Planet-C is the first mission to study planetary atmosphere and unexpected subjects will be raised, if the team complete their responsibilities.
The TOPS project looks to be in danger because the space telescope requires a highly accurate pointing capability; a small satellite may not be able to satisfy the specification. Before the start of the project, a feasibility study should be done practically so that it will not be trapped on a treadmill, like the Lunar-A mission.

2.4 Solid planetary science

Having SELENE missions is important, using landers which are an orthodox approach to studies of the lunar body and origin.

3) Space Engineering

All planning may stimulate the activities in space engineering field. The individual future missions raised in the field of science also include subjects required new technology.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?
Rating: A

International collaborations in ISAS are excellent, in the past, present, and future, homogeneously in all academic sides of activities. In all collaboration activities ISAS has taken on significant roles. In astronomy and astrophysics, to the established framework of missions, suitable sensors were invited as in the cases of Solar-A and Solar-B. In the case of HALCA, the formation of an international network for correlation of data was excellent. In the field of Space Plasma, achievement had on the contrary been made with a NASA launcher with an ISAS designed spacecraft; even significant instruments were invited from US-side initiative to mission control was ISAS side always. In Akebono, Canadian team was also invited for special mass spectrometer which was well advanced. The motivation to invite international participation was to offer the opportunity to countries who have no spacecraft. Missions planning for the future with ESA, such as BepiColombo and Laplace and Scope related missions, is considered to be excellent international collaboration activities where ISAS will take significant roles.

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.
The present situation of ISAS where professors in ISAS are in charge of academic research, space projects and graduate education has historical origins. In all organizations, functions are mixed in the initial "primitive" phase, and carried out by personal energy which is easy to generate because the system itself is simple although the kinds of work are multiple. When the system grows too large and complicated, discrepancies start to become apparent.
Seeing ISAS future projects and responsibilities as members of JAXA, which is the single

space agency in Japan, some discrepancies will be revealed. Persons responsible for management and planning and coordination of projects should not be selected from researchers and professors for education even from the same institute.

b. Inter-university system in basic research and mission implementation.

Because ISAS has responsibility as member of JAXA which is the single space agency in Japan, maintaining the Inter-University system is essential. However many points to be improved have not been taken care of since the period of old ISAS.

The present system, where university staff join the projects as individuals, contains a basic discrepancy. University personnel receive no rewards or insurance except for the scientific outcome even if they devote themselves to the tremendous side works to pursue the mission, while their positions are not evaluated at their university. Thus young persons have a tendency not to participate in ISAS projects. From the opposite side, ISAS is neglecting the contribution of outside personnel, stating that ISAS does not evaluate the contribution of individual persons.

Only way to improve this issue is to change the policy of the inter-university relationship to an "institution (ISAS) to institution (University)" basis from the current "individual to ISAS" basis. Big ISAS projects may broken down into sub-systems which will be carried out by each participating university. In this case the functions of the Inter-University steering committee should be established to achieve organized activities. For this context it is also noted that management and planning and coordination of projects should be separated from researchers and professors for education even within ISAS.

c. Bottom-up system for the mission selection

Philosophically the present system can be evaluated as not bad, but not excellent; and for some cases, the system does not work well. The bottom-up process is important but the recommendations of the steering committee are not reliable because of their lack of constitution. Selection by the scientific steering committee is made on a competitive basis between fields by professors who cannot have a deep understanding of other fields. When interesting topics appear, for example, the vote may concentrate to such a subject without considering the feasibility and strategy of missions in that field. Without an established constitution, when someone agitates, for example, "let's select a unique and interesting theme", the committee members of different fields think that it is reasonable, without knowing the background details hidden under the presented information. ISAS should establish a constitution for the selection by investigating and evaluating all past missions including the case of Lunar-A.

d. Cooperation between space science and space engineering

This subjects has the flavor of historical consequence of the development of academic side of space exploration activities in Japan. It is quite true that collaboration is quite close between space science and space engineering as described in the report of ISAS/JAXA activities (October 2007). However, the harmony of collaborations between these two major fields depend on the stage and situation of the development. In the past, in the 1980s and 1990s, the development of space science and engineering activities was quite unique; and the M-3S-II system completely matched the ISAS system of expanded university involvement which consists of the internal collaborations of multiple "kouza" laboratories.

When the era of M-5 rockets arrived, it starts to become apparent that the extended university system contains a lot of difficult points to implement in a large integrated system where many complicated practical works that are not suited to academic minds and thought processes.

Now, ISAS is required to switch the concept to manage large and significant projects, such as planetary explorations and large space telescopes, for example. Without losing the academic character of ISAS, many ISAS tasks could be merged to the new JAXA management operation strategy.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

I do not have detailed information on how ISAS has been affected by the merger. The description here is, thus, mainly based on the description given in the report of ISAS/JAXA activities (October 2007).

From an outward looking impression, it can be stated that ISAS has kept its original framework completely, having a clean interface to the old NASDA organization except for the merging of several programs such as the SELENE mission, and small satellite project. The new position of ISAS is then authorized to live in academic territory for both science and engineering.

In this new position then, ISAS has the responsibility to conduct academic research, space projects and graduate education in parallel in one institute within the force balance of JAXA, a single absolute organization for Japanese space activities and development.

In this situation, the effects of the merger are evaluated as insufficient to improve the system. There may be advantages because new routes are opened for the use of HII type large launcher by merger. From the standpoint of seeking reasonable and optimum utilization of the system due to the merger, many subjects are left without improvement.

1) The facilities for launching and spacecraft operation are controlled by independent control systems of ISAS and other JAXA organizations. And operation and management of space projects are running under different systems as if no merger has taken place between the former NASDA and former ISAS. By organizing a new office or directory to cover the entire JAXA system for launching and operation of space missions, the operation of large projects will become reasonable. In this case, ISAS activities will be concentrated to more academic features in basic research related to space and the universe, together with graduate education also for inter-university corporations.

2) The present graduate education system in ISAS remains as the result of a traditional historical heritage. It is required to investigate the allocation of the function of graduate education in the new JAXA; even though it will turn out that ISAS will be the most suitable institution for education, eventually. By this investigation, the concept for the graduate education system will be improved with a wider scope in which all suitable students from all universities in Japan are covered without restricting participation to students from the university of Tokyo.

3) Planetary exploration will become a significant subject in JAXA in the near future. It is inevitable that the organization to be the center for planning, operation and data acquisition for the planetary exploration activity will not only belong to ISAS. It would be natural to be the JAXA organization. In this case, ISAS should join planetary science as the leading member of JAXA.

5. Other comments

There is no detailed report for the cancellation of the Lunar-A project even though the mission had continued for 16 years after the official approval by the ministry of education in 1991. If ISAS accepts the cancellation, just stating that the reason is the deterioration of the main instrument due to the passage of time, without analyzing the real source of problem, the important chance to improve the selection system for future missions in ISAS may be lost. I recommend making an analyses of the real origin of problems associated with Lunar-A mission selection, which are related to the development of the ‘penetrator’.

Comments by Hiroko Nagahara

1. Has ISAS yielded sufficient results so far?

a. Overall activities

S

ISAS has made a great contribution in leading Japanese space, astronomical, and planetary sciences through successes in missions for twenty years. Successes have been brought by the "bottom-up system", collaboration with universities, and strong collaboration between scientific and engineering communities. It also developed human resources in space scientific and engineering fields, which resulted in development of large communities in Japan.

b. Scientific activities

S

ISAS has made excellent scientific achievements, particularly in the field of high energy, plasma, and infrared sciences on the basis of observations.

c. Engineering activities

S

The engineering activity of ISAS has been excellent under restricted human and financial resources, which has led many missions to success.

d. Graduate education

A

ISAS has carried out excellent education in developing scientists and engineers who will lead the missions and science of the next generation. On the other hand, it has been so tightly focused, at least the young scientists could be active only at ISAS, but often had difficulty in moving to universities. In future, more general education will be necessary to promote personnel exchange between ISAS and universities.

e. General education and public outreach

A

ISAS has strengthened its activity in public outreach, and many people have become interested in the missions. They can be better known if they advertise their activity in schools, which is very important to arouse the interest of children and young people in space sciences.

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

S

Space projects have continuously stimulated academic activity of ISAS, which is without doubt one of the most important parts of ISAS. Graduate students have developed their ability in projects including scientific, engineering, managing and collaboration.

b. Academic researches are aimed at future important space science/engineering missions?

S

Academic researched at ISAS has been tightly related to future missions, and therefore, good results have come through the mutual progress.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space

science and engineering development?
S

Space projects at ISAS have been carried out through intimate relationship between international projects, which also resulted in the case in academic research.

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

This is a unique and excellent system of ISAS, which has produced many excellent scientists and engineers. Therefore, the system should be kept in the future.

b. Inter-university system in basic research and mission implementation.

This is an important system, which has played an important role to enlarge the size of the community all over Japan, and it should be kept in the future. In order to do so, it needs improvement of the educational level of ISAS. It is because universities in Japan have been carrying heavier responsibility in education than before. If ISAS does not have the capability at a similar level, personal exchanges will become difficult. If personal exchanges become less active, the size of the community will be reduced.

c. Bottom-up system for the mission selection

It is really an important system in space and planetary sciences in Japan. It increases the activity of research community, and should be kept in the future.

d. Cooperation between space science and space engineering

It is very important to maintain excellent missions. Without mutual understanding at a deep level, missions will not get satisfactory results. The system should be kept in the future.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

Four years have already been passed since the merger: ISAS should accept this change. The good systems shown above should be maintained in the future, but some parts of the institution will probably be able to merge with NASDA or NAL. By reducing the size, residual parts of the institution will become larger and be able to expand scientific activities.

Comments by Charles Elachi

1. Has ISAS yielded sufficient results so far?

a. Overall activities
S

b. Scientific activities
S

c. Engineering activities
S

d. Graduate education
S

e. General education and public outreach
B

2. The academic research and space projects

a. Space projects are generating significant results in academic research?
S

b. Academic researches are aimed at future important space science/engineering missions?
S

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?
B

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.
S

b. Inter-university system in basic research and mission implementation.
S

c. Bottom-up system for the mission selection
S

d. Cooperation between space science and space engineering
S

Comments by Elaine S. Oran

1. Has ISAS yielded sufficient results so far?

ISAS is a world-renowned space research organization with an excellent record of scientific and engineering achievements. The work done in ISAS is at the forefront of scientific research, and in selected areas, it is definitely leading the way. There is impressive coordination between engineering and science, and this seems to be one of the keys to its success. Another basis for success is maintaining a very high quality of scientists and engineers. A third reason is the talented cadre of students at all levels that work at ISAS.
An organization does not have to be large to be a high achiever and have high impact. It can be smaller, focused, and do high quality work. ISAS maintains this standard.

Rating: S

a. Overall activities

As with any research organization, the work at ISAS is continually changing to meet new challenges. The work done at ISAS has very high impact.

Rating: S

b. Scientific activities

The scientific research at ISAS covers the entire range of topics from studies of cosmological or universal questions to questions of our solar system.

Rating: S

c. Engineering activities

There are impressive efforts to coordinate engineering development with science. They appear to be working.

Rating: A+

d. Graduate education

I do not have a good feel for this. I do know that ISAS has high standards for its students and they are well thought of in the outside world. The ISAS plan of coordination with multiple universities throughout the country sounds good. I do not have the experience or good enough understanding of the process give it a rating.

e. General education and public outreach

I believe that this is done very well by ISAS, and this is in contrast to NASA who I believe overdoes it with respect to spending for publicity and perhaps less effectual outreach. ISAS seems more reserved and thoughtful about it.

Rating: A+

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

Rating: S

Atmospheric Science: I do not see where the current research is headed. A clear plan proposed by the head of this group would be useful. I see this field merging with climate work and magnetospheric physics. Solar-System Science: These are large projects and much could be gained by collaboration within the JAXA framework. Studies of solar physics and space weather are extremely important for basic science and for practical decisions about future missions. This is an area in which ISAS can excel. Astrophysics: This is a truly top field in ISAS, and should be supported.

The history of engineering projects that have succeeded or failed have taught us a lot and are truly important. ISAS has exceeded in this by starting small and building gradually. This is obviously a successful approach that might be difficult (but important) to continue with the JAXA context.

b. Academic researches are aimed at future important space science/engineering missions?

From my point of view, it is hard to know what is the most important type of mission. There is just so much that we need to know at every level. There are some big questions, such as water or fuel content of the moon and mars, the nature of space weather, our climate ... Any information that is carefully obtained is important.

Rating: A+

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

International collaboration is some place between very good (A) to excellent (S). ISAS has been able to do this effectively and maintain a clear identity. More international collaboration at every level would be useful, particularly in the atmospheric work. I think there needs to be a clear plan for tying this to climate and interplanetary work.

Rating: A+

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

ISAS has developed what seems to be a unique and highly successful system for combining all of this work in one institution. It should be nurtured. I am not sure how well it is working generally, but the graduates are highly respected and the atmosphere that we saw seemed very productive.

Rating: A+

b. Inter-university system in basic research and mission implementation.

I did not get enough information about how this was really working.

c. Bottom-up system for the mission selection

This is important and there should always be a significant amount this type of project initiation in any high-level research organization. The number of committees does seem overwhelming, and I have some concern about whether committee work might take up too much time.

Rating: A

d. Cooperation between space science and space engineering

There appears to be close collaboration, and this is excellent. It is true that any inadequacies in one of these directly one diminishes the work of the other, even if the fields are quite different.

Rating: S

4. The merger of ISAS with NASDA and NAL?
Could you give us suggestions how we should proceed in this aspect?

Now ISAS has a much more extensive job than it had before: it must not only maintain a high level of activity in science and engineering research, and a high profile in international science and engineering research, but it must now coordinate its activities with a broader agency that has could have quite different objectives. In one way, this gives ISAS the opportunity to extend its research and take on even larger projects. In another sense, it can dilute its activities and this would not be good. This will take work to establish and maintain good relations and coordinate the ISAS work with the JAXA framework. It would be best if personnel in the other organizations of JAXA felt they had an investment in ISAS, and something clear to be gained by interactions. I believe that it will take a lot of concentrated work by everyone affiliated with ISAS, both now and in the past, to ensure that the unification that JAXA intends is achieved without diluting the quality of work in ISAS.

5. Other comments

One potentially alarming factor is that the budget does not seem to have changed significantly. In fact, it seems to have decreased somewhat recently. This is not a good trend. It is possible that there is more budget than apparent through ISAS collaborations with other institutions, but at a time like this, with even more responsibilities on its shoulders, ISAS needs a clear increase in resources.
Every effort should be maintained to increase this diversity and internationalization. ISAS could be a model for this in Japan.

Comments by Robert Farquhar

1. Has ISAS yielded sufficient results so far?

a. Overall activities

Rating: S

Results to date are very impressive by any standard of measurement. This is especially true for an organization with less than 150 permanent research staff and a relatively small budget.

b. Scientific activities

Rating: S

Scientific productivity is quite good throughout the history of ISAS. The recent orbital operations at the asteroid Itokawa were outstanding.

c. Engineering activities

Rating: S

The high level of competence and experience in spacecraft systems and operations has enabled high scientific productivity. In particular, the mission to Itokawa was possible due to the rapid development of a viable ion-propulsion system.

d. Graduate education

Rating: A

This area appears to be adequate. The experience of involvement with real missions cannot be underestimated.

e. General education and public outreach

Rating: A

Record is OK, but ISAS could make substantial improvements by studying the accomplishments of the European Space Agency and NASA/JPL in this field.

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

Rating: S

Excellent results in all fields of space science. Particularly noteworthy are ISAS contributions in the fields of X-ray, infrared, and radio astronomy. Solar space physics and space plasma physics also have superb records of achievement. The failure of the Nozomi was more than offset by the spectacular success of the Hayabusa mission to the primitive body, Itokawa.

On the engineering side, ISAS has demonstrated that it has world-class capabilities in the fields of mission and trajectory design, deep-space navigation, and interplanetary mission operations. Outstanding achievements in spacecraft design include the areas of attitude control systems, propulsion, and data handling.

b. Academic researches are aimed at future important space science/engineering missions?

Rating: A

The planning of future missions in astronomy is quite reasonable — NeXT (2013) and XEUS (2018) for X-ray astronomy, Astro-G (2012) for radio astronomy, and SPICA for infrared astronomy. Because SPICA is in an early planning stage, I would strongly recommend that ISAS study the desirability of placing this spacecraft in a 'halo orbit' around the Sun-Earth L2 libration point where thermal and observational constraints are minimized while keeping communication distances relatively small. I would also recommend that the next solar physics mission (SOLAR-C) consider the use of a halo orbit around the Sun-Earth L1 point. At this location, the SOLAR-C spacecraft could carry out solar-wind measurements that would provide input data for ISAS spacecraft that are inside the Earth's magnetosphere.

With regard to future lunar and planetary missions, I feel that there is too much emphasis at ISAS on missions to the Moon. In my opinion, there are already too many lunar missions under consideration by NASA and other space agencies. It is a fact that lunar science is not the highest priority planetary science. Moreover, given this situation, the ISAS contribution to lunar science is likely to be somewhat redundant. On the other hand, ISAS can play a significant and unique role in the exploration of comets and asteroids.

On the engineering side, the ISAS technology studies on solar sails could lead to an important new capability for deep-space exploration. I would recommend that more resources should be allocated to this endeavor to speed up its availability for use in future missions. I'm less enthusiastic about the development of a 'low-cost flexible standard bus'. This is an old idea that has been tried many times before without success.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

Rating: S

ISAS has a good record of international collaboration. Among the outstanding mission examples are GEOTAIL (with NASA's ISTP Program) and the Mercury Magnetospheric Orbiter (with ESA's Bepi Colombo Project).

I have noted ISAS' interest in a mission to a deep-space asteroid located beyond Jupiter's orbit. Of course, this mission will require a nuclear power source and a large launch-energy capability — which ISAS does not currently have. However, several groups in the United States are proposing missions to Centaurs and KBOs under NASA's Discovery Program. I would strongly recommend that ISAS investigate the possibility of participating in one of these proposals. Possible participation would include a science instrument and/or an additional spacecraft.

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

This policy has worked well for many years. I see no reason why it should not continue.

b. Inter-university system in basic research and mission implementation.

I have no opinion on this issue.

c. Bottom-up system for the mission selection

I am concerned that the process is controlled too much by a few committees. With this process, innovative mission concepts may not be studied in enough detail, and could be discarded prematurely. I would recommend that a fairly large number of mission concept studies be conducted in some depth before making a final decision.

d. Cooperation between space science and space engineering

In the United States, I often hear the phrase that 'scientific space missions are done for the scientists'. This is not true — scientific space missions are done for SCIENCE. It takes equal contributions from scientists and engineers to achieve science results. Fortunately at ISAS, scientists and engineers have always had a productive working relationship.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

It would make sense to allocate about 30% of the total JAXA budget to space science. This would be consistent with many other national space agencies (e.g., ESA and NASA). ISAS will need to fight hard for its fair share of the JAXA budget.

5. Other comments

* The development of the next-generation solid-fuel launch vehicle should be accelerated. Currently, ISAS does not have a cost-effective way to launch important low-cost missions such as Hayabusa-2.

* The new 'Space Exploration Center' is a fine idea as long as it complements ISAS space science activities and does not replace them.

Comments by Yoichi Hori

1. Has ISAS yielded sufficient results so far?

a. Overall activities
yes

b. Scientific activities
yes

c. Engineering activities
yes

d. Graduate education
yes

e. General education and public outreach
yes

2. The academic research and space projects

a. Space projects are generating significant results in academic research?
yes

b. Academic researches are aimed at future important space science/engineering missions?
yes

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?
yes

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.
See separate "Comments on mid-term and long-term visions of space engineering" on following pages.

b. Inter-university system in basic research and mission implementation.
See separate comments.

c. Bottom-up system for the mission selection
See separate comments.

d. Cooperation between space science and space engineering
Researchers in space engineering at ISAS must pursue leading-edge engineering researches as basic science. The demands from space science can be utilized as new subjects in engineering. Many fields in engineering started in such a way. Engineers at ISAS can take advantage of their location where the users are designing their new missions.

In regard to the relation with universities, it is important to convey the message to young generations that many fields of engineering are connected to space. Students with a base in electronics, mechanics, chemistry, material science can do space engineering in their graduate

course. Such messages that there are many starting points in space engineering should be sent to not only university students but also high school and junior high school students. There is leading-edge engineering in space. This includes high reliability, practical leading-edge engineering. Thus the space engineering at ISAS should generate new ideas and give them to universities. This will activate engineering and becomes a significant contribution to the general public.
See also the separate comments.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

ISAS must keep its uniqueness and keep basic research. This is a kind of duty as a research institute in which the inter-university system is working.

The relation between the engineering research at ISAS and R&D in other institutions of JAXA is somewhat similar to the relation between the advanced development and product development in car companies. For those companies product development is more important for immediate reasons, and by orders of magnitude more resources are put into it.

There are areas in between the two. The important issue is to find a balance between advanced development and product development. There are many good, and also bad, examples in car, semiconductor, railway, and electric power companies. For example, those companies which do not have their own technologies but depend on others always become weak and disappear. In JAXA, developments which are immediately useful may be done by other institutions. ISAS should keep doing engineering research for the future and to grow in size, and JAXA must be tolerant against risks.

The relation between ISAS and other institutions of JAXA is also similar to the relation between the grant-in-aid of JSPS and the investment of NEDO. NEDO decides themes by a top down process and concentrates a large amount of budget to it. Thus any failures are fatal. Researches supported by grants-in-aid of JSPS are different and can be more challenging. See also the attached sheets.

5. Other comments

As to questions 1 and 2, I answer supportively that ISAS is doing well. As to questions 3 and 4, please refer to the attached document which I sent to the steering committee of space engineering in response to a request from the chair of the committee, Prof. Inatani. This document will answer question 3 in particular. (This document, “Comments on mid-term and long-term visions of space engineering,” follows these comments) As to question 4, the relation between NASDA and ISAS is similar to that between the R&D support by NEDO and the grant-in-aid scheme of MEXT. I hope ISAS keeps its originality and does not forget fundamental research which may not be useful immediately. In relation to the inter-university system, it is also important to convey a message to younger generations that not only the space and aeronautics but also that of the electronics and other fields of engineering have connections to space.

Comments on mid-term and long-term visions of space engineering
— as members of steering committee of space engineering

Yoichi Hori (electric engineering) and Kazuo Hodate (electronics engineering)

We hereby answer the questions from Prof. Inatani, the chair of the steering committee of space engineering on September 4.

Both Hori and Hodate are relatively new members of the committee. Hori's major is control engineering and Hodate's major is optical electronics. Both have close relationships with researchers at ISAS in graduate education. We share supervising students, and evaluations of theses. Our students often obtain jobs at ISAS, and students who complete a masters degree at ISAS often come as our doctor-course students. We would like to summarize here issues related to future visions of space engineering which we have observed during those interactions with ISAS activities. And we will express our hope for future.

1. Balance between the activity which are closely related to space science and the research activity which space engineering conducts by itself.

This issue is related to the fundamental identity of engineering. Engineering must be useful to society. Thus, demands from society override the curiosity of a researcher. Demands to space engineering is not only from space science. However, space science so closely exists at ISAS. On the other hand, space science mission can be realized only if engineering establishes the necessary technology. Top science can be realized only with new technology.

However, if you limit the range of engineering which ISAS covers to research from demands, challenging researches will go away and Japan will just follow China and India in the near future.

Engineering research based on seeds from space science have supported space science. We should not throw this away, but should also strengthen the relations. Space engineering should stay near the fields of space science which requires the most cutting-edge technology. Space science must cover an area as wide as possible, because seeds cannot be found effectively.

2. Collaboration with universities and uniqueness of ISAS in relation to universities Collaboration with universities, in particular with top-level universities like university of Tokyo should not be regarded as mere participation to graduate education, but should be regarded as raising world top-level researchers.

The research themes of space engineering are very attractive to young, highly-capable researchers. It can show the needs of research explicitly and demandingly. Space engineering, whose brand new research can be found around the corner of space development, is a very attractive place to study. We can make use of this situation to make students understand the very essence of engineering.

Sometimes it is said that ISAS is using students as a cheap labor to develop space equipment and satellite operations. However, this is totally wrong. Top level students aim at space research, and laboratories at ISAS provide a unique opportunity for selected top-level students. It is not wise to neglect this fact.

3. Relation between the bottom-up research scheme from community and the top-down research scheme in JAXA.

Steering committees of space science and space engineering are important mechanisms which make the opinions of researcher communities in Japan known to the management of ISAS. To outsiders, it sometimes look as if it is a cozy relationship. However in any system, since top-level people cannot plan all the details of missions, a small-size working group must make strategic plans in a bottom-up way. In JAXA, this may involve not only researchers in the fields of space science and engineering. This could work positively.

‘Top-down research scheme in JAXA’ may mean that management of ISAS could be affected not only by the relatively narrow view of space science and engineering, but also affected by some new points of view. For example, space science missions may be selected not only from the scientific values but also international relations such as with the US. This could increase the budget of space science because this is closer to what the general audience wishes.

This approach may be worth considering. However, we must note the risk in accepting this approach. For example, the JAXA space exploration center, which is presently under discussion, may place planetary exploration, which was previously a pure science, outside ISAS. If the Japanese contribution to manned lunar missions is decided in a top-down way, the budget may increase but the management could be out of our control. For example, moon science could go away.

4. Differentiation from and cooperation with engineering R&D in other institutions of JAXA.
The relation between the engineering research at ISAS and R&D in other institutions of JAXA is somewhat similar to the relation between the advanced development and product development in car companies. For those companies product development is regarded as being more important and more resources are put into it. However, if it stop advanced development, the company becomes weak and disappears.

It is important to make it understood widely in JAXA that research at ISAS is aimed at the future and that this raises a new generation of researchers and sometimes results in new unexpected achievements.

There is always a gray zone between the two categories. It is most important to keep balance between advance development and product development. In industry, there are many good examples, but also many bad examples. A company which does not have its engineering base in itself and is dependent on other companies always declines in the end.

5. Balance between project, research in preparation to a project, and basic research.

Basic research should be done by basic research funding or external funding. The issue is the range and size of researches in preparation to a project. An example is the research funding controlled by the steering committee of space engineering. The themes of this research funding is selected by a bottom-up approach. Hori, who was a member of the selection committee, felt that the selection was done very correctly and appropriately. However, at the same time he found that the boundaries of the three research categories are not clear and that the fields are actually continuous.

Comments by Michikata, Kono

1. Has ISAS yielded sufficient results so far?

a. Overall activities

S

b. Scientific activities

S

c. Engineering activities

S

d. Graduate education

S

e. General education and public outreach

A

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

S

b. Academic researches are aimed at future important space science/engineering missions?

S

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

S

Comments by Shin Takeuchi

1. Has ISAS yielded sufficient results so far?

a. Overall activities

Rating: S

Although I am familiar only with the field of microgravity science, I judge from the Report of ISAS/JAXA Activities that ISAS space programs in recent years have generally been successfully implemented and that good achievements in Space Science and Space Engineering in these years can be recognized in the bibliographic data.

b. Scientific activities

Rating: S

The scientific activities can be evaluated from resulting publications. Productivity is reasonably good. The quality of the published papers can be judged from the citation data. The overall results show the world average in the corresponding field, and the number of highly cited papers normalized with the number of researchers is comparable to those of the best five universities in Japan, which indicates the high level of scientific activities at ISAS as a Japanese institute.

c. Engineering activities

Rating: A

I am not familiar with the space vehicle technologies, but my impression is that the staff in this area have been doing good work with the limited budget and a limited number of staff. Recent successes of vehicle launch to implement space projects clearly indicate their excellent activities. From the point of the space utilization, the support of Space Engineering looks to be quite reliable.

d. Graduate education

Rating: B

In section 1.6, four categories of graduate students are presented. It is not clear what the definition of 'Special Research Students' is, but it does not seem to be appropriate to count them as graduate students in ISAS. The number of Ph D students graduating every year is 10 to 20, which does not seem to be sufficient in a research institute with 90 professors and associate professors. More effort is needed to increase the number of doctoral students.

e. General education and public outreach

Rating: S

Public outreach is an important role of ISAS in fulfilling the curiosity in natural science of young people and in fulfilling the accountability of activities of ISAS to the tax payer. Activities for these purposes such as the Open House, Lectures, and Schools can be highly evaluated. Good news in the mass media about successful space projects implemented by ISAS is the most effective public outreach. From this point, recent successes of the ISAS space projects, such as the SELENE Project, are quite valuable.

2. The academic research and space projects

I will confine myself to the field of space utilization in the field of Microgravity Science, because I am not familiar with other fields.

a. Space projects are generating significant results in academic research?

Rating: S

Space projects in Microgravity Science include a variety of fields. The activities in ISAS in this field are divided into the field of materials science and fundamental science. Taking advantage of containerless and convection-free process under microgravity conditions into account, the activities on materials science are focused on novel material synthesis, crystal growth mechanism investigation, thermal properties measurements, Marangoni convection mechanism investigation and combustion mechanism investigation. The selection of these research topics is quite appropriate, and various valuable results have already been obtained by ground-based experiments or short duration microgravity experiments. In particular, the pioneering research in thermal properties measurements of the melt of refractory metals, above and below the melting point, by use of electrostatic levitation furnace is notable. In many of these topics, further progress is expected by the future ISS space experiments. As precursory experiments for JEM, the selection of the topics was quite appropriate. As a fundamental science research, the topic of Coulomb crystal formation in dusty plasma was selected two years ago in ISAS. This topic is becoming popular in the microgravity community in Russia and Europe. Combined with the theoretical work, elucidation of Coulomb crystal formation mechanism can be a second stage JEM flight project. Frankly speaking, however, I am not sure if this project can have a large enough impact on the fundamental science to justify the high cost of JEM utilization.

b. Academic researches are aimed at future important space science/engineering missions?

Rating: A

All the topics mentioned in (a) have been conducted aiming at future effective utilization of ISS.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

Rating: A

Many of the research topics being pursued by the microgravity science group have been conducted by international collaboration. Some projects are to be implemented by use of facilities in other agencies as international projects. The electrostatic levitation furnace being developed by the microgravity science group is strongly recommended to be set up in JEM in the future. The furnace is expected to be used internationally.

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

The three kinds of activities, academic research, space technologies and education, should jointly be conducted collaboratively in one institute with sufficient staff members. ISAS consists of eleven departments and five centers, which cover quite a vast area concerning space — not only of science fields but also technology fields. The total number of permanent professors, 146, may be enough for sixteen total sections, but the number of supporting staff of technicians (80) and postdoctoral fellows (24) does not seem to be enough. Particularly, the number of postdocs and the number of doctoral course students are too small to conduct leading-edge projects in every section.

b. Inter-university system in basic research and mission implementation.
The previous ISAS, before the merger with NASDA and NAL, as an institute attached directly to Ministry of Education, Science and Culture, executed its inter-university supporting role properly. This role has been adequately succeeded to new ISAS after the merger, keeping the culture of the university.

c. Bottom-up system for the mission selection
As far as the microgravity field is concerned, microgravity experimental opportunities are offered by ISAS to all Japanese researchers. Most of the applications are approved by the selection committee to establish a variety of working groups. Though the budget for this system is very limited, this system surely serves for the bottom-up of the mission selection.

d. Cooperation between space science and space engineering
To conduct in-space experiments, collaboration between scientists and space engineers is indispensable. I believe that the projects selected for microgravity experiments are properly assisted by the staff of Institute of Aerospace Technology.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

I had been totally unfamiliar with NAL and had been familiar only partly with NASDA and ISAS. So, it is not possible for me to evaluate the overall influence of the merger. I believe that the merger makes it possible to execute a large scale project much more effectively than before by their collaboration. I have been familiar with Department of Space Biology and Microgravity Sciences. Among eight laboratories in the Department, four had moved to ISAS from NASDA after the merger. From the point of the space utilization in space biology and microgravity science, the unification of the laboratories in common fields to ISAS is better than the situation before the merger so as to effectively organize the space utilization program. However, the budget having been used by the former microgravity science group in NASDA does not seem to be duly shifted to ISAS after the movement to ISAS of the microgravity science group in NASDA. Another problem is that offering of the fund for ground-based preparation experiments for space utilization (Koubo Chijou Kenkyu) has been organized by Space Environment Utilization Center in Human Space system and Utilization Group, independently from the working groups organized by the above Department of ISAS. This independent system after the merger may not be appropriate for the effective and efficient use of funds. In any case, in order to make the most of the research money, it seems necessary to unify the research budgets in various sections in JAXA, spent by the microgravity science community, totally of the amount of the order of 500 million yen including the cost of utilizing microgravity facilities such as rocket, airplane and drop tube, into a part of the budget of ISAS.

5. Other comments

(1) In evaluating a research institute from the international standard, the level of internationalization of the institute is one of the important items. It is sure that ISAS is implementing big projects under international collaboration, but the percentages of foreign permanent staff and postdoctoral fellows are too small compared to the international standard. It seems necessary to make efforts toward increasing foreign staff.

(2) The budget for JEM utilization is strictly limited. However, in order to acquire the highest level results corresponding to the enormous amount of investment for the JEM construction and not to waste a large amount of money and man-power spent in the past ten or more years for preparatory ground-based research, it is strongly recommended to Government Officials to increase the budget for JEM utilization so as to be able to execute effectively the most valuable JEM experiments.

Comments by Yuichi Takayanagi

1. Has ISAS yielded sufficient results so far?

a. Overall activities

The ISAS activities which started from the pencil rocket experiment in 1955 have obtained high-level achievement in space science and space engineering, which matches the size of the organization. The Japanese original engineering activities in space started with *Ohsumi* grew to scientific activities by the *Kyokko* and *Jikiken* satellites and established the unique space activities where space science and space engineering are closely cooperating. The comet Halley missions, *Sakigake* and *Suisei*, which were parts of international observation network of the comet, bred the background for space education and space public outreach, and contributed to raise interest in space in young generations. Presently, *Hayabusa*, *Suzaku*, *Akari* and other ISAS scientific spacecraft are contributing to international space science and attracting a general audience. ISAS is yielding sufficient results not only in academic research but also growing young scientists and engineers. I especially appreciate the fact that those activities are well organized with each other.

b. Scientific activities

In the fields of space science, observations of magnetospheres, observations of cosmic X-rays and solar X-rays, observations of cosmic infrared radiation, and others are highly rated internationally. Considering the size of the organization as an institution of Japan, ISAS has achieved sufficient high-level results and plenty of results.

c. Engineering activities

I am not rather familiar with this field. However, I appreciate the fact that the above scientific results were achieved by support of engineering research using ground developments and engineering test spacecraft. *Hayabusa* is the very good example of cooperation between space engineering and space science in ISAS.

d. Graduate education

I have corresponded with many researchers in ISAS for long time. Based on this experience, I feel that young people working now are all active and young generations are growing well. In order to keep them active and to let them spread their research fields, the future visions must be attractive and very clear. ISAS is trying to keep them so.

e. General education and public outreach

A

Outreach of ISAS is producing significant results in general education and may be one of the best among public outreach related to space technologies. ISAS is trying many different approaches, and they are sometimes regarded as models of scientific public-outreach activities. It is important to consider the community to which you are talking. The outreach activities of ISAS is highly rated compared to the size of the organization.

2. The academic research and space projects

a. Space projects are generating significant results in academic research?

I see results of *Hayabusa*, *Suzaku*, *Akari*, and *Hinode* often in the mass media. I believe ISAS projects are generating significant academic results.

b. Academic researches are aimed at future important space science/engineering missions?

The moon is attracting international attention now. A scientific mission like *Kaguya* was planned as ISAS's original mission. Space science missions which aim at the future are planned based on scientific achievement.

c. Are space projects and academic research conducted with sufficient international collaborations? Is ISAS taking significant roles in the international space science and engineering development?

I believe ISAS is taking international role, even central roles in some case.

3. How do you evaluate the following important features of ISAS?

a. Conducting academic research, space projects, and graduate education in one institute.

ISAS's activity is highly evaluated.

b. Inter-university system in basic research and mission implementation.

As above.

c. Bottom-up system for the mission selection

The bottom-up system is functioning well and the environment in which new imaginative trials are picked up is kept well.

d. Cooperation between space science and space engineering

This feature worked well to obtain the achievement so far.

4. The merger of ISAS with NASDA and NAL? Could you give us suggestions how we should proceed in this aspect?

I had some concern how communities of different cultures are merged. But, they are merging in organization, and in the results we can find good features.

However, I still have a few concerns; how the result of merger works in the development of new solid rockets, how the creativeness which was generated by close collaboration of space science and space engineering and which supported the ISAS activities is kept in JAXA.

I hope the good features of ISAS which were recognized by the international community will not be lost.

Appendix

Activities of the Visiting Evaluation Committee

Early October, 2007

Sending of the external evaluation materials to the committee members.

October 31 – November 1, 2007

Submission of the interim report from the committee members.
The external evaluation committee meetings at ISAS.
The Visiting Evaluation Committee Meeting at the ISAS Sagamihara Campus

Day - 1: Wednesday, Octber 31, 2007

09:30-09:40	Welcome Address and Remarks (Executive Director : Dr. Inoue)
09:40-10:00	Introduction of members
	Election of Chairperson and Vice Chairperson
	Discussion on proceeding of the committe
10:00-13:00	Presentations on ISAS Activities
	General (Prof. Nakatani)
	Space Science (Prof. Nakamura)
	Space Engineering (Prof. Inatani)
13:00-14:00	Lunch Break
14:00-17:15	Presentations on overviews of basic achievements and future plans
	Space Science (Prof. Murakami)
	Space Science (Prof. Kato)
	Space Science (Prof. Fujimoto)
	Space Engineering (Prof. Abe)
	Space Engineering (Prof. Saito)
	Space Environment Utilization (Prof. Kuribayashi)
	Statistics of Research and Educational Activities (Prof. Mitsuda)
17:15-18:00	Poster Sessions on ISAS activities
18:00	Adjourn
	Announcement on the reception (Executive Drector)
	Move from ISAS to Hotel by the chartered bus
19:00-21:00	Reception

Day - 2: Thursday, November 1, 2007

09:00-11:30	Free Discussion
11:30-12:30	Lunch Break
12:30-13:40	Sagamihara Campus Tour (Prof. Takahashi)
	Closing Session
13:40-15:00	Drafting the Summary Report (Closed)
15:00-15:10	Comment by the Chairperson
15:10-15:20	Comment by the Vice Chairperson
15:20-15:25	Submission of the draft summary report from Chairperson to Executive Drector
15:25-15:30	Closing Remarks (Executive Drector)
15:30	Adjourn

Nov, 2007
Submission of the final report from the committee members.

Jan, 2008
Compilation of the external evaluation report.

Mar, 2008
The official publication of the external evaluation report.

List of Handouts to the Visiting Evaluation Committee

1. REPORT OF ISAS ACTIVITIES

2. Preliminary Comments from the members of he Visiting Evaluation Committee

3. Presentation at the Visiting Evaluation Committee Meeting

4. Institute of Space and Astronautical Science 2007