Lessons from Surrey' Microsatellite Projects

(サリー大学小衛星プロジェクトからの教訓)

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This paper describes the salient features of small satellite projects developed by the University of Surrey. It refers mainly to the socio-economic aspects of Surrey's small satellite projects rather than their technical aspects. The Surrey project proved that a public school with superb technological leadership and international perspective could manage to develop satellite projects even without much assistance from the government. Surrey's success case provides valuable insights toward space development and application projects in Japan. In addition, several policy proposals will be made for sound space development and its application to policy formulation in Japan.

Key Words : microsatellite, University of Surrey, space policy

Introduction

The Ministry of Education, Science, Sports and Culture (MEXT) announced in August 2001 that three space-related organizations in Japan, specifically the National Space Development Agency of Japan (NASDA), the Institute of Space and Astronautical Science(ISAS), and the National Aerospace Laboratory(NAL), would be integrated into one new agency, Japan Aerospace Exploration Agency(JAXA), in October 2003 . This will become a part of the restructuring of existing government systems which has been taking place throughout various governmental agencies over the past several years.

JAXA's long-term space plan in its draft form has been publicly announced, following for the most part past space development and application patterns in Japan. There is no denying that Japan has attained substantial progress in the space development and application projects, as demonstrated by development of H-II launch vehicle along with a number of weather and earth observation satellites. Yet, Japan's major space development and application projects have been characterized by a bias toward a few big and expensive projects, such as ADEOS-II and ALOS. Such projects have exhibited a preference for technology-push orientation, lack of a cost-effectiveness criterion, limited commercial efforts, and inadequate technology-transfer to developing countries.

In contract, Surrey's microsatellite projects have demonstrated an alternative space development pattern, which are substantially different from the projects by the established large space agencies in the space-faring nations.

According to the University of Surrey (UoS), satellites could be classified as follows ①:

Class	Mass(kg)	Cost(£M)
Large satellite	> 1000	> 100
Small satellite	500 − 1000	30 − 100
Mini-satellite	100 − 500	7 − 20
Micro-satellite	10 − 100	2 − 4
Nano-satellite	1 − 10	0.2 − 1
Pico-satellite	< 1	< 0.2

The UoS has been pursuing microsatellite projects since the beginning of UoSAT programme in 1979. These microsatellite projects in the UoS have been carried out with the strong leadership of Sir Marting Sweeting and the teamwork of his competent staff. By the beginning of 2001, the UoS had launched a total of 19 small satellite missions whose accumulated export sales exceeded US $100 million ②. Surrey's microsatellite missions are illustrated in table 1.

While UoS is a public school, Surrey Satellite Technology Ltd (SSTL), a private company mostly owned by the University, was established in 1985 in order to meet the expanded activities and commercialization of small satellites. SSTL has been almost entirely funded by commercial contracts, mostly from foreign partners. UoS's microsatellite technology transfer and training programmes between Surrey and a number of emerging space nations have been implemented intensively and globally. At present Surrey's programmes encompass the Republic of Korea, Portugal, Pakistan, South Africa, Chile, Singapore, Malaysia, Thailand, China, Algeria, Nigeria, and Turkey. Small satellites have been provided by SSTL to developed countries such as USA, France, and Germany.

Reflecting steady development of microsatellites for the past two decades, Surrey has established an international reputation by the development of innovative microsatellites. These have been successful due to a unique combination of academic research and development, educational training, and commercial marketing activities.

1. Specific features of the Surrey projects

There are a number of specific features connected with the Surrey projects, which led to their success story.

Cost-effectiveness

Surrey has developed a series of cost-effective microsatellites since 1979. Each microsatelite costs approximately US$3 million, which is very inexpensive and affordable even for developing countries. When UoS started their microsatellite projects, it did not have enough capital, manpower, and equipments. UoS's factor endowments with limited production factors except for the brain power, which ironically brought about their choice of knowledge intensive microsatellite production. To initiate satellite development was a big challenge for Surrey in view of the limited funds available at UoS. Once UoS had entered into and concentrated on the specifically microsatellite field , they were eventually able to find their own niche.

Surrey's microsatellite projects had a distinct advantages over big space projects. Since microsatellites did not require a large space for building, they were able to be constructed in a small shop located on the ground floor of the Surrey Space Center building. In addition, it did not require long time to build the microsatellites, which enabled many scientists and engineers from developing countries to remain in Surrey for about 18 months. Low cost of microsatellite production meant low risk involved in the project. Moreover, microsatellites could be launched as a 'piggy-back' payload to save the launching costs. In Surrey's case, various launch were used such as those, Delta, Ariane,Tsyklon, and Zenit. Thus cost effectiveness has consistently been the basis for Surrey project.

Another advantage for Surrey microsatellites lies in the simple design of satellite configuration, and adherence to standardized Surrey models. Simplicity in design made the assembly process easier, reducing the number of mistakes in integrating and checking parts and components.

Off-the-shelf

Surrey fully used commercial off-the-shelf technologies (COTS) in building their microsatellites. According to Surrey, after testing commercial off-the-shelf components, COTS proved to be usable and durable in the harsh environment of outerspace. By utilizing off-the-shelf components, Surrey could save time for testing components and succeeded in reducing costs. On the contrary, in the case of big and novel scientific satellite missions as seen in so-called developed space-faring nations, a substantial percentage of parts and components tend to be produced and tested individually. Inevitably, this results in expensive finished products due to the lack of an economy of scale and extended production period.

Technology transfer

Surrey's microsatellite projects contributed a great deal to emerging space developing countries through the transfer of their microsatellite technology. By doing so, Surrey itself could improve its technological base. Other major space agencies in developed countries have tended to pursue their own technology development and been reluctant to provide technological know- how to developing countries. There has been a dichotomy between developed space-faring nations which have wanted to remain as space technology developers and the majority of other countries in the world which do not have access to such technology. The role Surrey played represents an historical breakthrough role in bridging the gap between these two groups of countries. Since Surrey is a university, its activities are open to public as an educational institution, it could negotiate with any country. An example of this privileged status occurred

Table1: University of Surrey Microsatellite Missions

Microsatellite	Launch	Orbit	Customer	Payloads
UoSAT-1	1981-D	560 km	UoS	Research
UoSAT-2	1984-D	700 km	UoS	S&F,EO,rad
UoSAT-3	1990-A	900 km	UoS	S&F
UoSAT-4	1990-A	900 km	UoS/ESA	Technology
UoSAT-5	1991-A	900 km	SatelLife,	S&F, EO,rad
S80/T	1992-A	1330 km	CNES	LEO comms
KitSat-1	1992-A	1330 km	Korea	S&F, EO, rad
KitSat-2 *	1993-A	900 km	Korea	S&F, EO, rad
PoSAT-1	1993-A	900 km	Portugal	S&F, EO, rad
HeathSat-2	1993-A	900 km	SatelLife	S&F
Cerise	1995-A	735 km	CNES	Military
FASat-Alfa	1995-T	873 km	Chile	S&F, EO
FASat-Bravo	1997-Z	835 km	Chile	S&F, EO
TMSAT	1997-Z	835 km	Thailand	S&F, EO
UoSAT-12	1999-S	650 km	SSTL& Singapore	EO, Comms
Clementine	1999-A	735 km	CNES	Military
SNAP-1	2000-C	650 km	SSTL	Remote inspection
Tsinghua-1	2000-C	650 km	China	EO, Comms
TiungSAT-1	2000-S	650 km	Malaysia	EO, Comms
PicoSAT	2001-Ath	650 km	USAF	Military
AISAT-1	2002-C	650 km	Algeria	EO (DMC)
NigeriaSAT-1	2003-C	650 km	Nigeria	EO (DMC)
BILSat	2003-C	650 km	Turkey	EO,Comms (DMC)
UK DMC	2003-C	650 km	UK	EO (DMC)
Topsat	2003-C	650 km	UK MoD	Military

*built in Korea using SSTL platform & KAIST payload

D=Delta, A=Ariane, T=Tsyklon, Z=Zenit, S=SS18/Dnepr
C=Cosmos, Ath=Athena
(Source) "30 years of Space at Surrey – Pioneering Modern Microsatellites", SSTL, Oct. 2002,

when Surrey initiated a microsatellite project with China in the 1990s. While the USA was not happy with this technology transfer, it could not be stopped.

In the process of building microsatellites, many scientists mostly from emerging space developing countries, could receive training and learn real satellite technology at the UoS. With Surrey's technology transfer, the Republic of Korea could learn microsatellite technology in KitSaT 1 which was launched in 1992. Following year, KitSaT 2 was built in Korea using on SSTL platform and KAIST payload. Today, SaTReC Initiative Co., Korean private company under the strong leadership of Dr. Soon Dal Choi, is providing technology for assembling Malaysian Razak Sat.

Global network

SSTL is a cosmopolitan company. In March 2000, about one fifth of almost one hundred staff member of SSTL were foreigners. This cosmopolitan atmosphere stimulated a cooperative spirit and enhanced professionalism among their staffs.

Surrey' projects encompass various regions, extending into Asia, Africa, South America, and Europe. Based on Surrey's extensive microsatellite projects, the Surrey Space Club was formed. Surrey contributed greatly to technology transfer as well as international cooperation between the UK and many developing countries, including those involved in their projects.

In addition, the Disaster Monitoring Constellation, which covers daily imaging anywhere in the world, was established in 2002, through the collaboration of five microsatellites from Algeria, China, Nigeria, UK, and Thailand. This contributed considerably to global disaster management. The total cost of this international partnership project has been amazingly inexpensive; presumably less than one tenth of cost of ADEOS-1, Japan's single large earth observation satellite.

Marketing and management

Surrey's microsatellite projects have expanded to cover mostly developing countries in which such projects are considered a big expense. In order to persuade and finalize the contract with these countries, it is certain that Surrey devoted strenuous marketing efforts. The customer-oriented space development by SSTL is quite different from that employed by the big space agencies. Moreover, the Surrey project had been extended to socialist countries like China, manifesting Surrey's flexible marketing strategy and patience in negotiation. A well balanced combination of scientists and merchants characterizes the unique nature of Surrey Space Center.

Leadership

The most crucial factor responsible for the Surrey projects' successful scenario lies in its key staff members. Prof. Sweeting and his carefully selected team have proven that they can formulate a successful matrix with a combination of consistent project formulation, innovative ideas, strenuous efforts in building satellites, good leadership, good management, and marketing skills. The role of real professional staff members is very important. Thus, it is safe to say that SSTL has recruited only the right staff members both domestic and foreign. It should be noted that crucial factors in space development project are not necessarily a shortage in budget, capital, and manpower as is often advocated by scientists in big space agencies but the ability of staff members and correct policy formulation. Prof. Sweeting is not only a great scientist, but also a good manager and a strategic negotiator.

2. Future Task for Surrey

Needless to say, Surrey's microsatellite project for more than two decades has been a success story. Surrey's future activities will be based upon a deepening of microsatellite projects on one hand and a diversification or widening of space development and application projects on the other.

As for deepening of the microsatellites project, Surrey has developed SNAP-1, a nanosatellite weighting only 6.5kg, in 2000③. This has demonstrated outstanding performance, including the use of advanced micro-miniature GPS navigation camera technology, onboard computing, propulsion and altitude control technology. SSTL has been contracted to supply the USAFA (United States Air Force Academy) with the SNAP bus system on their FalconSat-2 program. The development of nano-satellites has crucial military implications. It is almost impossible to trace this nanosatellite in outerspace with existing technologies, along with the capability of approaching large reconnaissance satellites and jamming their functions. At the same time, it could check the condition of satellites and Space Shuttle in space which might help to avoid future Columbia-type incidents. SSTL was also awarded a NASA study contract to investigate the potential for the Surrey minisat-400 spacecraft to operate across communications networks using Internet Protocols. In addition SSTL was awarded a study contract by NASA for Magnetospheric

Multiscale(MMS) Mission Study. NASA selected SSTL as the only non-US supplier for its Rapid Spacecraft Acquisition contracts. Thus, SSTL is able to bid its full range of microsatellite products to all US government customers. SSTL is, and should be one of the forerunners in microsatellite technology.

Regarding the diversification of SSTL activities, it has engaged in a luner mission with demonstration of low cost interplanetary platform, and a mission to Mars. Surrey plans to initiate low cost interplanetary exploration. mission, Surrey's basic philosophy persists by using affordable small and medium-sized satellites even for these ambitious interplanetary; specifically the spacecraft mass is 400kg for the Moon mission, and 580kg for Mars mission. In order to carry out these projects, SSTL seems to rely on fund from government or space agencies. Most challenging project for SSTL in coming years is GSTB-V2/A, a pioneer satellite project which is a part of the gigantic Galileo system, Europe's own civilian global navigation system.

The other task for SSTL is the application role of the Surrey satellites. Surrey's microsatellite project in its early development stage had been oriented toward technology development and demonstration. Then SSTL in the early 1990s developed optical sensors with its satellites and started earth observation activities. The importance of this application was recognized fully by Surrey since a number of their network countries countries are developing nations. Surrey's initiative for global disaster monitoring is an important step toward establishing a space application sphere.

Development of the real application of satellite data has been a weak area in all big space agencies including NASA and NASDA. In this regard it is expected for SSTL to provide training and develop space application technologies, including remote sensing and GIS, for the needs of each developing country. For this purpose, SSTL does not currently have an adequate staff. If SSTL could expand its activities toward meaningful space applications, they will be evaluated as a space agency aimed at contributing to the social, economic, and environmental needs of developing countries.

The last issue is related to management and marketing. Surrey used to be a very efficient institution. With the compact structure of the Surrey Space Center building, a SSTL staff numbering around one hundred to one hundred and fifty might be most efficient. With rapid expansion of its space activities and staffs, it will be an uneasy job to manage SSTL well as in the previous period. SSTL needs real management staffs. Besides many space agencies, institutes which includes universities, and private companies have been increasingly engaged in small satellite projects. The market competition for microsatellites has been keen at the global level. Thus, SSTL has to strengthen its marketing sector.

In spite of the foreseeable hardship which SSTL is facing, its strong technological advantage, could render it a world leading space company in this decade.

3. Problems in Japanese space development

Japan is one of the major space-faring nations in the world. It has its own world-class launch vehicle, both for solid and liquid fuel. Japan is capable of building a variety of scientific and application satellites, having constructed a diversified space development infrastructure including launch sites, ground stations, and test facilities. Besides Japan has a strong industrial base including electronics and other numerous components. It has passed the stage of import substitution in space development and is in a position to initiate its own space development and application projects.

Recently Japan has started information gathering satellite projects which are and will be one of the major space activities in the country. In addition Japan has joined the International Space Station (ISS) project. So far Japan has spent around 320 billion yen for ISS. Japan's total development cost for ISS would amount to around 680 billion yen. Although the output of ISS projects utilizing JEM is not yet clear, it is estimated that the economic return from that project might remain marginal considering the various past micro-gravity experiments in the Space Shuttle.

A critical barrier to Japan's space activities is the Super 301 imposed by the USA, which restricts Japan's satellite manufacturing only for scientific purposes. Since military demands for satellites had not existed in Japan until recently, due to the adherence to peaceful space development based on national space development guideline. Super 301 in fact has almost killed Japanese satellite industries.

In order to formulate Japan's sound space development, application programmes, and projects, it is important to identify the inherent problems for space development.

Space Divide

The most fundamental problem underling space development is the issue of the "space divide". " Space divide" means that since space development and application activities encompass various diversified activities in space agencies, few space experts possess the ability to think about the meaning of each space project within the total space plan. A launch vehicle expert is absolutely different from a satellite expert. Furthermore, even among experts of launch vehicles, each expert has his/her own narrow or specified field, such as material, propulsion, structure, fuel, flight control. The experts of launch vehicles have very limited knowledge concerning space applications. The leading positions in the space agencies tended to be leaders in launch vehicle and big projects. This has led to the technology- push type space development in Japan within the past and in the coming decade.

T-system

Japan's economic system is more or less a form of bureaucratic capitalism. Japan's economic system today still reflects the authoritative development pattern engineered in Meiji-era, which is prevalent in developing countries. Bureaucrats play a key role in policy making and implementing each project. The most influential group in most central government agencies are still the graduates of Tokyo University and several major universities. Tokyo University even now focus most of its attention on producing elite government officials for their own interests, rather than on improving the people's welfare. The aim of Japanese bureaucracy is to expand their activities even with little economic and social justification. They try to create new rules and regulations, and new institutions for bureaucrats to "descend"(Amakudari) while protecting their vested interest and resisting any real restructuring. The large and prolonged economic slump since the early 1990s in Japan, coupled with a huge accumulated fiscal deficit today in the central government is, to a great extent, attributable to the mistakes in policy decisions by top bureaucrats. They tend to be reluctant in accepting transparency and democratic decision. Besides many of these bureaucrats are corrupted according to a Singaporean standard. This kind of bureaucratic behavior pattern has been analyzed by Niskanen④. Regarding the space sector, Collins has argued that the same problem exists in policy making by decision makers ⑤. The decision-makers in the space agency focus their efforts upon the big technology-push type projects which do yield little economic return. Besides they tend to exclude the participation of various experts from outside the space agency and pay little attention to projects such as space tourism which is expected to yield more economic benefits.

Space development should be pursued in a more democratic and open manner. In order to have innovative ideas in space development, more decentralization is necessary inside the space agency. In order to develop innovative ideas and projects, a more flexible space development system should be established according to the contents of each project. Participation of NGO's and various citizen in space policy making are also important for sound development.

Isolation

Japan has been promoting the APRSAF (Asia-Pacific Regional Space Agency Forum) since its establishment in 1993. APRSAF-9 was held in March 2003, and still remains as a forum for an exchange of ideas among participating countries. Japan has not proposed any vigorous projects which are beneficial to a number of developing countries in Asia.

As for the UNOOSA(United Nations Office for Outer Space Affairs) and UNESCAP, so far, Japan has not positively supported their space projects. This negative attitude toward international cooperation has brought about frustration and disappointment in many developing countries in view of Japan's great economic power. Unless Japan is willing to change from inward-looking space development to more globally oriented space development and cooperation, Japan's own space development will suffice merely to satisfy peculiar interests of its space scientists. This approach is very far from focusing upon the betterment of people in developing countries through the application of space technology. Japan's "going my own way" style is also seen in the case of development cooperation. Space technology with its global nature could be more widely utilized to meet the needs of the people in developing countries through Japan's ODA.

Less transparency

Transparency is the key for sound civilian space development. The Japanese space agency should provide information on the procurement of parts and equipment, and cost and benefit of each project. It should request the participation of top space scientists from all over the world in formulating policies and programmes.

Since accidents are common in space development, the agency should set up an investigation committee comprised of outside professionals in case of accidents. The big issue is the extent of transparency regarding data obtained by the Information Gathering Satellites. The activities of these satellites should be open to the public as much as possible. Too much protection and secrecy have already cast doubts not only among Japanese but also among citizens of other countries as to its activities and effectiveness under a democratic socio-political system.

4. Policy recommendation

We have examined the Surrey projects and identified problems associated with Japan's space development activities. Based on past experience and performance of various space agencies, the following proposals will be made for implementation of a sound space development projects and application programmes.

Space education

In order to solve the "space divide" problem, there is an urgent need for space education, for space scientists, space experts and space bureaucrats. The space experts have to study basic space development and application sciences. They should study at top graduate school abroad before joining JAXA. They also need to study fundamental economics, business management, and public policy. With continued education and training, Japan could efficiently direct its efforts for more meaningful space development and application.

Application-pull

Japan's past, present and ongoing space development tend to focus on technology-push type approach. This trend should be reversed toward more application-pull type approach. In the case of Kobe's earthquake which occurred in January 1995, Japan' s space technology had not contributed much toward the prediction and mitigation of this natural disaster. Japanese space agencies should seriously consider the importance of space technology for the benefit of people both in developed and developing countries. Space experts should not waste much money from peoples' taxes to satisfy their own interests. As for the application of space technology, unfortunately there are few world-level experts and institutions for remote sensing and GIS in Japan. To create world-class institutes with internationally recruited top-level instructors in the field of remote sensing and GIS, is needed for tackling the global environmental problems, disaster management, urban planning, agricultural development. This is the most important prerequisite for development of application technology in Japan. With institutes such as these, Japan would be able to assist developing countries in space activities, which in turn would further contribute to the development of application technologies. In this connection, space application projects should be recognized as one of the important areas of technical cooperation projects in the ODA. For instance, Netherland's ITC has contributed considerably to the education and training of space application technologies. Japan should create its space education infrastructure as soon as possible.

Space tourism

Space industries have been stagnant in recent years due to the sluggish satellite market, and to the amazing terrestrial digital communication made possible by optic fiber and incredible technological advancements in mobile phones. However there is an enormous potential market yet untapped, namely space tourism. Of course, the orbital space flight amounting to around US $20 million is still too expensive for a private person. Yet, already two persons have ventured forth as space tourists so far.

The X PRIZE competition is now taking place on a global level. The X PRIZE is a US$10 million prize awarded to the first team that: (1) Privately finances, builds & launches a spaceship which is able to carry three people to 100 kilometers, (2)Returns safely to Earth, and (3) Repeats the launch with the same ship within 2 weeks. Since its inception in 1996, more than 20 teams from seven countries have been registered to compete for the prize. This X PRIZE was inspired by the US $25,000 Orteig prize, which was won by Charles Lindbergh in his historic flight across the Atlantic in 1927.

Space tourism by sub-orbital flight will be realized after successful winners of the X PRIZE. This milestone event will enhance the expectation of sub-orbital as well as orbital space tourism. Unfortunately, major space agencies in developed countries are not interested in space tourism regardless of its technological feasibility attested to by space experts. Strangely enough, several space agencies are considering development of reusable launch vehicles without any idea of what they will carry. Space agencies should initiate research on the development of reusable launch vehicles for orbital space tourism. With the development of commercial passenger flights, the aeronautical industry will become one of the major industries within a century. Japan should take the space tourism initiative, since no other space agencies are involved in space tourism projects at present.

To join ESA

Japan has been hosting APRSAF since its establishment in 1993. As mentioned above this will remain as the typical forum without concrete tangible results.

As for regional cooperation, several scientists have advocated creation of the Asian Space Agency including Dr. Doo Hwan Kim ⑥. While regional cooperation sounds verbally attractive, it cannot not develop smoothly as illustrated by the Small Multi-Mission Satellite (SMMS) project which was proposed at the 6th Asia-Pacific Conference on Multilateral Cooperation in Space Technology and Applications: (APC-MCSTA). Six countries have signed the MOU for SMMS in 1998, yet it may take at least another several years to complete the project. Nearly comprehensive space development and application projects already exist in three countries in Asia: China, India, and Japan. They are in a position to pursue their own space development projects. These three countries differ from one another in socio-economic systems, people's feelings and philosophy.

In view of cultural similarities and people's interests, we propose that Japan should join the ESA (European Space Agency) as an associate member like Canada. Canada is already a member of ESA regardless of its geographical location. Australia once invited to join ESA. Yet, strangely enough, Australia turned down this constructive request. It seems that ESA may once again try to persuade Australia to join them. Japan is one of the major space-faring nation, and with its participation of as an associate member of ESA, all member countries could mutually benefit through international cooperation projects. As a member of ESA, Japan may boost its bargaining power and loosen the fetters binding it , such as Super 301 imposed by the United States. Another advantage for Japan in joining ESA is that it can spend money in proportion to its contribution. Moreover, Japanese space scientists and engineers can learn various European cultures through space development projects.

Establishment of a global research network

In order to promote research and development activities, the Japanese space agency should positively establish a global research network. In the socio-economic fields related to space research, Japan could engage in more joint projects with the Space Policy Institute of George Washington University, John D. Odegard School of Aerospace Sciences at the University of North Dakota, Asian Institute of Technology, International Space University, and a number of thinktanks such as the Rand Corporation and CSIS (Center for Strategic and International Studies). At the same time, Japan should cooperate and assist in projects at UNOOSA and the Space Technology Applications Section of UN ESCAP (United Nations Economic and Social Commission for Asia and the Pacific) by providing experts and funds to promote regional and international cooperation in space development and application.

Establishment of a new academic association

The present academic association related to space seems to focus on technological aspects of space projects. In order to examine space activities from a social scientific perspective, and to analyze space policies and space law as well as drafting effective space policy proposals, it is of the utmost urgency to establish something along the lines of "Japanese Association on Space Policies and Space Law" (JASPSL). This academic association should cover diversified fields encompassing space: policy, commercialization, space tourism, solar power from space, law, culture and space ethics. Such an academic association could also supervise under its aegis, environmental issues such as space debris, and solid fuel emission, national security, history of space development, international cooperation and many other areas. With the establishment of this new association, young researchers and scholars could make presentations, and publish in the association's journal, circulating their contributions which could be evaluated objectively. International cooperation in the area of space research would be facilitated. The views of social scientists, specifically in space, will definitely contribute to formulating national space policies. Lastly, members of this association could work together with staffs of the space agency in policy formulation.

Formulation of Alternative Space Plan and Space Law

As mentioned earlier, Japan's long-term space policy is biased toward a few big technology-push type. In order to develop more efficient space projects, mixture of small, medium and large projects is desirable. Additionally in view of rapid advancements in micro-and nano-technologies, small yet efficient projects should be encouraged.

Another point to be stressed is the shift from technology-push to application-pull approach in space activities. Space exploration is important, but it's activities should be considered within their limited resources. At this stage we have to present alternative space policy.

Moreover, in order to specify our space activities, so as to protect our space industry, retain our interests, maintain our national security under foreseeable politically unstable circumstances, while promoting international cooperation in space, Japan has to consider its own space law. With sound space policy and space laws in place, Japan can take the space initiative at a regional as well as global level.

Concluding remarks

Japan's past space developments are impressive. Yet it is time to shift its space policy toward more of an application-pull approach, emphasizing cost-effectiveness. Surrey's case provides various clues and prototypical guidelines for alternative space development. The most important factor for further space development lies not in mere funding but in sound policy formulation and an effective space development system.

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References

① Sweeting, M N, (Sep.1999) "Space at Surrey, micro-mini-satellites for affordable access to space", Surrey space Centre,

② "Surrey Space News, summer 2001", Space Satellite technology Ltd.

③ "30 years of space at Surrey—Pioneering modern microsatellites", Surrey Satellite Technology Limited, A paper presented at the IAF in Houston, 15 October 2002

④ Niskanen, William A. Jr.,(1994), *Bureaucracy and Public Economics,* Edward Elgar Publishing Limited.

⑤ Collins, Patrick,(Oct. 2000),"Public Choice Economics and Space Policy: Realising Space Tourism", A paper presented at 51st International Astronautical Congress. Paper No: IAA-00-IAA. 1.3.03

⑥ Kim, Doo Hwan,(March, 2002) "The Possibility of Establishing an Asian Space Development Agency", Journal of the Institute of Social System, Chuogakuin University, Vol.2, No.2, pp45-56.