Space Japan Opinion

National Security: How We Should Push Forward R&D of Satellite Communications Technology As a Nucleus of Network Centric Defense System

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Summary

The importance of satellite communications for national security and how to lead the research are discussed, based on that the Space Basic Law is concluded recently in Japan. First, it is described that the Revolution in Military Affairs (RMA), that might change the characteristic of war, advances and the satellite communications increases its importance as a pivotal technology of the RMA referring to its utilization of the United States armed forces based on unclassified documents. Second, it is described that the different points from conventional method in research are not to let researchers to think how to use their research results, not to squeeze the research items, and to become more important for the government to conduct the research of satellite communications. Finally, the study items of the National Institute of Information and Communications Technology are reviewed as an example of a national laboratory, and it is described that the research items conducted so far covers almost all of necessary items, but it needs to evaluate their significance.

1. Introduction

This article discusses the importance of satellite communications as a part of national security and how to conduct the research and development (R&D), based on that the Space Basic Law is concluded recently in Japan. The related topics were taken up with a Space Japan Opinion column of this magazine, Space Japan Review, three times so far[(1)(2)(3)]. However, we are at a loss how the R&D of satellite communications technology related to the national security is different from the conventional R&D we have performed so far, since we have gotten used to the environment of space development which has limited to the peaceful (non-military) purpose since it was started in Japan. Therefore, the author would like to describe that a method of R&D related to national security has a performance different from conventional one and he would also like to object to the argument that the R&D of satellite communications technology by the government is already unnecessary[(4)(5)].

As for an agenda of this argument, it is described that the importance of satellite communications increases in the present and the future of the United States armed forces, based on an open source documents in Chapter 2 and a method of R&D in our country is considered in the case of the National Institute of Information and Communications Technology (NICT) as an example in Chapter 3. This is why it is not meaningless to think about a method of R&D of the satellite communications that increases its importance when space development of our country enters a new stage.

Before beginning the main subject, a background is shown that satellite communications becomes more and more important in recent years. The Cold War was terminated in 1991, and all of us expected that we would have the rosy 21st century. However, it is an actual feeling that a century of chaos was begun by the September 11 attacks and wars and terrorisms in succession[(1)]. For such a social safety and security, it is indispensable to acquire information and to convey it quickly into a necessary place. In this meaning, information and communication, in particular, satellite communications are the nucleus technology. It is described in Chapter 2 that a military revolution based on the information and communication changes a general concept of conventional wars, and it should be noted that a direction to little sacrifice of war is pushed forward. Incidentally, it is said

that one of causes to lead collapse of Berlin Wall in 1989 was satellite communications and/or broadcasting. Thus, satellite communications technology has already had a big achievement for the human. Furthermore, we should pay attention to that the way of war itself is revolutionized from a conventional way.

2. Importance of Satellite Communications Technology in National Security

2.1 Space Technology in the U.S. Armed Forces, Especially Increase of Role of Satellite Communications

The space development has been conducted under the prestige of a country since its first stage, because it is very important strategically. This is why space is an important technology originally as a part of war capability through nuclear, missile, and space[6]. At first, a reconnaissance satellite is listed as an example that space technology is applied effectively. Thanks to replacing the U-2 aircraft to the reconnaissance satellite, increasing tensions was avoided because observation from space is not regarded as provocative, while airplane overflight is regarded as a violation of a nation's sovereign airspace. These systems also helped keep the peace during the Cold War by greatly reduced uncertainty about what the Soviet Union was doing[7].

Although the use of a reconnaissance satellite at the Falkland Islands conflict in 1982 was regarded as the first example of full-scale utilization of the space technology for proof in the actual war[8], the reconnaissance satellite was developed by the Corona Strategy of RAND Corporation that satellite launching was started in 1958, and development of a reconnaissance satellite finally succeeded in the thirteenth satellite launching in 1960[9][10]. It was useful for "Six days war" between Israel and the Arabic countries in 1967 and intelligence such as the Soviet Union's invasion to Czechoslovakia in 1968[10] as well as intelligence in the Cold War,.

The information type military revolution called RMA (Revolution in Military Affairs) has been risen since the end of the 20th century. It revolutionizes how to use it and what kind of organization to be most suitable as well as weapon technology, and changes a form of war and its characteristic[11]. Namely, it changes from a war of attrition for the purpose of overthrowing of the armed forces in the industrialization times to a war of paralysis to pursue paralyzing a national function of the other country. It is demanded to achieve a purpose without killing and wounding not only the own country soldiers but also the enemy people as much as possible when war breaks out in the information age[11]. Its initial use was performed in the Gulf War in 1991, but it is said that completely new operation and formation/organization of armed forces were born in the Kosovo War in 1999, and have begun to change a form of battle[11]. Nevertheless, the equipment of the armed forces was still remained as in the Cold War era even in the 21st century, but it is said that the change was accelerated by the U.S. terrorist attacks on September 11, 2001[12]. As mentioned in Chapter 3, the way of thinking of RMA itself has been nursing in mind for a long time in the RAND Corporation[10]. It is described below that satellite communications is a nucleus of RMA by showing the U.S. armed forces as a concrete example.

The main application of space technology to RMA is a reinforcement of ability for information/intelligence and a long-distance precision attack system[7]. Thanks to the development of a precision weapon, the refugees outbreak was evaded in the beginning of the Iraqi War[7]. In addition, it is said that the military communications satellite TSAT (Transformational Satellite) is a base of the recent U.S. military transformation that makes deployment of the armed forces effective[13]. The Senator Jon Kyl, who is an influential person for the U.S. security policy, said about dependence on space, "More important, satellites underpin our military superiority. Our troops rely on satellites for reconnaissance, communications, navigation, and other functions. Almost every new military platform in development today is more satellite-dependent than the system it is replacing. None of our military operations--conventional, strategic, or missile defense--can function without space components".[14]

The Network Centric Military Communication attracts attention on the improvement of such information capability[15]. It performs the military operation including information gathering and its distribution, strategy briefing and command transmission through a network extremely effectively. Therefore, the demand for satellite communication bandwidth to support military operations has increased from 100 Mbps in the Gulf war to 700 Mbps in the Afghanistan campaign, and to 3,200

Mbps in the war in Iraq[13]. A bandwidth demand of satellite communication is enormous for operation of unmanned plane UAV, in particular. Predator requires 1.5 Mbps per one plane and Global Hawk, 50 Mbps[16]. The concrete advantage of Network Centric Military Communications is to shorten time to attack the target. In the past, such targeting took hours or days, but it sometimes took only 15 min in the Iraq War[13].

Figure 1 shows space program of the U.S. Air Force until about 2015[7]. It indicates that the space program includes Navigation, Missile Warning, Surveillance, Weather, and Communications. **Figure 2** shows a budget related to the U.S. Air Force's satellite[17], although it is a little old data. It should be noted that the budget of more than $2 Billion is consumed for the communication satellite including navigation every year and to continue still at present. The budget is so large that a budget of Japan Aerospace Exploration Agency (JAXA) is about $1.8 Billion.

Figure 3 is a very suggestive picture for indicating the character that a military communications satellite should have lasted[18]. In other words, it indicates that a commercial communication satellite regards capacity and flexibility of use as important things, while a military communication satellite is required to add the robustness as another capability. This seems to be called, "protected communication" recently to mention it later. It means ability to bear various interference including jamming, attack to a satellite and a terminal, and a nuclear explosion. When technology such as satellite destruction appears, the measure such as an anti-satellite attack weapon A-SAT becomes a big issue.

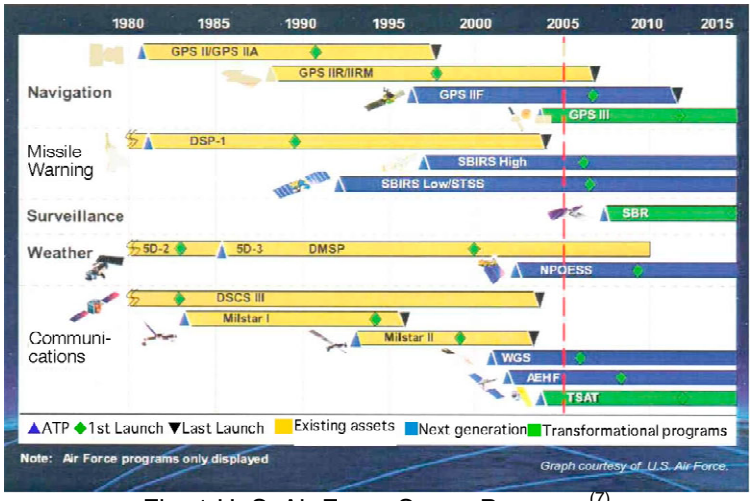


Fig. 1 U. S. Air Force Space Program.[7]

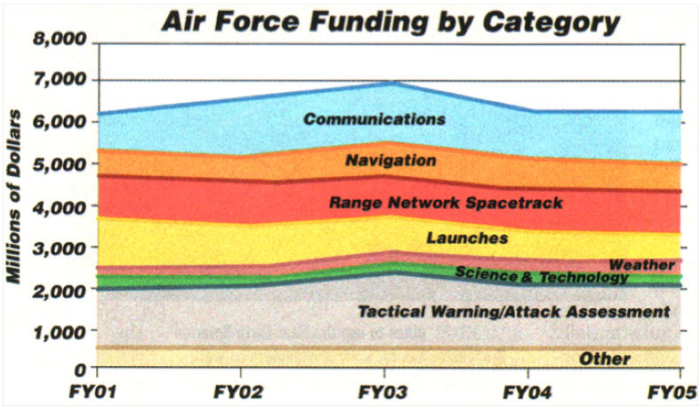


Fig. 2 U. S. Air Force Budget of Space Development.[17]

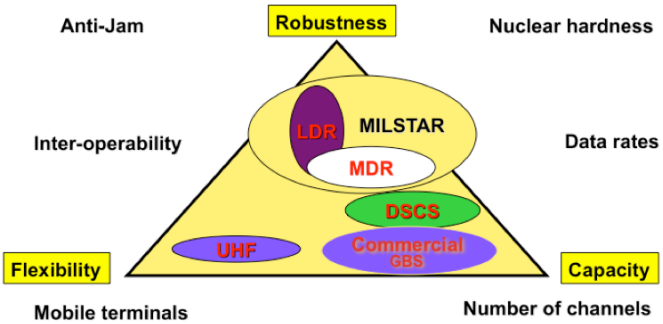


Fig. 3 Requirement of Military Satellite Communications.[18]

2.2 Military Satellite Communication System

The United States military command system C4I (Command, Control, Communication, Computer and Intelligence) includes a system called as GCCS (Global Command and Control System)[19], and the pivot of the information and communication system is a satellite communications system called as MILSATCOM.

The MILSATCOM hierarchy is divided as follows as shown in **Fig. 4**[20][21];

- Hard Core: a kernel part of Pentagon's activity

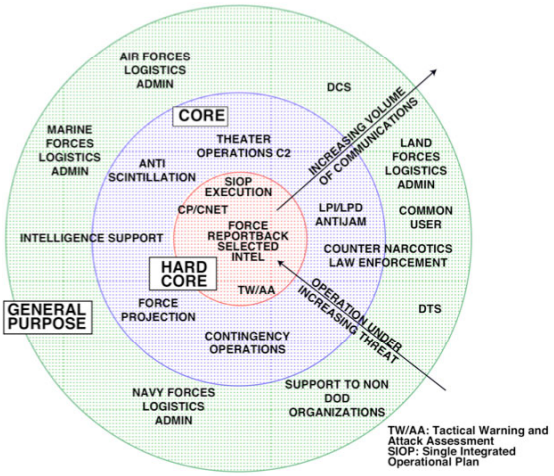


Fig. 4 MILSATCOM Hierarchy.[20][21]

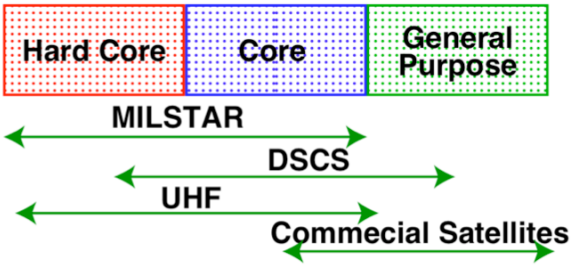


Fig. 5 Role Allotment of Military Communication Satellites.[20][21]

- Core: a part of actual strategic operation outside of Hard Core,
- General Purpose: a part of activities such as logistics outside Core

These documents are some old, but it might be useful to understand a total image of MILSATCOM. **Figure 5** shows a role allotment of each military communications satellite, MILSTAR, DSCS and UHF and commercial communications satellites[20][21].

Typical military communications satellites of the former generation are shown in **Fig. 6**. In **Fig. 6**, the U.S. Air Force launched 26 DSCS-I satellites into the geostationary orbit (GEO) during 1966-1968 and conducted X-band communication experiments. This satellite series was inherited for the DSCS-II series to be begun by launching in 1971. As for DSCS-II, 16 satellites were launched until 1989. DSCS-II was replaced by DSCS-III from 1982, and, as for DSCS-III, it was launched six satellites by 1992. DSCS-III carries a multi-beam antenna of 19 transmission beams and 61 reception beams and takes an anti-jamming measure[21].

On the other hand, the Navy applies Navy Tactics Voice communication (Navy Tactical Voice) with FLTSATCOM satellites. In addition, these satellites are applied to AFSATCOM (Air Force Satellite Communications) for the Air Force's strategic communication, Rapid Deployment Forces (RDF) for the Army and to build a wide band communication system for Department of Defense

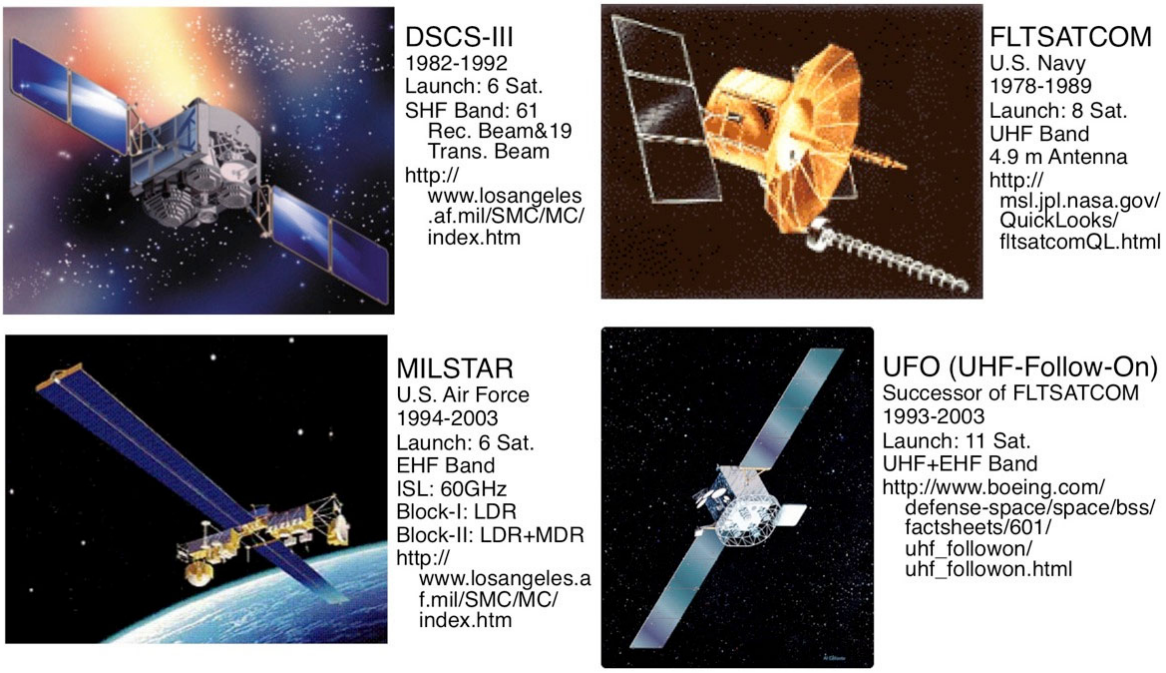
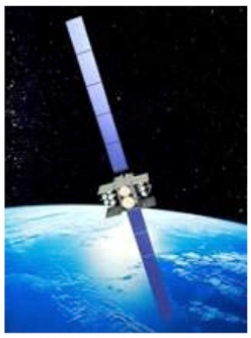
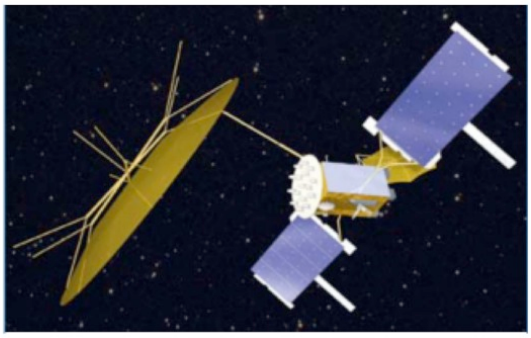


Fig. 6 The U.S. Military Communication Satellites of Former Generation.



WGS: Wideband Global Satcom
Successor of DSCS
Boeing 702 Bus
3.5 ton
X Band Xponder: 8
Ka Band Xponder: 10
4 to 5 Satellites
Launch: Oct. 2007 (1st Sat.)
http://www.boeing.com/defense-space/space/bss/factsheets/702/wgs/docs/WGS_overview.pdf

AEHF: Advanced EHF
Successor of MILSTAR
Lockheed Martin A2100 Bus
4 ton
EHF & SHF Band
75bps-8Mbps
3 Satellites
Launch: 2008
http://www.lockheedmartin.com/products/AdvancedExtremelyHighFrequencyEHF/index.html



MUOS: Mobile User Objective System
Successor of UFO
Lockheed Martin A2100 Bus
UHF Band
5 Satellites
Launch: Start in 2010
http://www.lockheedmartin.com/products/muos/MobileUserObjectiveSystemWaveForm.html

Fig. 7 The U.S. Military Communication Satellite of New Generation.

(DoD). As for the successor of FLTSATCOM calls a UFO, a mission of an EHF (44/20 GHz) band is equipped with as well as a UHF band[21].

The MILSTAR (Military Strategic and Tactical Relay) satellite was launched as a GEO satellite of world's biggest 4.5 ton in weight in those days in 1994 by Titan 4 rocket. Six satellites of MILSTAR were launched afterward by 2003. MILSTAR meets all demands of MILSATCOM hierarchy as a part of survival communication in a nuclear war. In particular, the MILSTAR was designed so that the MILSTAR satellite satisfies a demand of the Hard Core before, during and after nuclear attack and it can be operated autonomously even after nuclear attack was exchanged each other. It was also designed so that the satellite and onboard equipment can bear the direct and/or indirect nuclear attack, and the ground facilities can be operated under nuclear explosion environment. Data communications speed is low (LDR: 75-2400 bps), but it enables to use small earth stations as well as to take anti-jamming measure by operating an antenna beam. Block II improves to use medium speed data communications (MDR: 4.8 kbps - 1.5 Mbps) with maintaining ability of LDR so that a part of Core can be supported sufficiently[21]. The MILSTAR is still operated at present[22].

Figure 7 shows summary of the present and near future military communications satellites; WGS (Wideband Global Satcom), AEHF (Advanced EHF), and MUOS (Mobile User Objective System). The WGS adds the Ka-band to the X-band and has communication capacity of 2.5-3.3 Gbps – 10 times as much as DSCS, and it is used in image transmission from UAVs and telecon[23]. In addition, it can transmit the encrypted signal, and it can also make use of technology of direct broadcasting via satellite, and live broadcast of National Football League (NFL) football games is possible. The first WGS satellite was launched in October 2007 and various experiments have been conducted smoothly for more than a year. The Air Force has a plan to procure another six WGS satellites[24].The AEHF satellite is going to be launched from middle part of 2009 as succeeding the MILSTAR, but launching seems to be delayed[25].

Fig. 8 Overview of TSAT Proposed by Boeing.[26]

Figure 8 shows a concept of TSAT[26]. It is said to that the T-Sat system was devised by defense scientists in 2004 under the direction of Peter Teets, former Undersecretary of the Air Force, based on a transformational communication study of 2002[13]. A TSAT satellite plays a central role of a transformational com-

munication architecture of DoD and consists of five GEO satellite + one extras, optical inter-satellite communication, and it is a plan of launching start during 2013-2015 and operating start in 2018. It achieves the efficiency of 10 times as much as AEHF by using NGPR (Next Generation Processor/Router).

However, the cost of TSAT is estimated as $15 Billion. In order to reduce the cost, it seems that the optical communication function is deleted and TSAT Digital Core using TSAT is studied recently as a nucleus measure for improving IP (Internet Protocol) of military communication and that postponement of its launching until 2019 from 2016 is discussed[27]. However, it is not clear how to obtain function of inter-satellite link for establishing a global communication system.

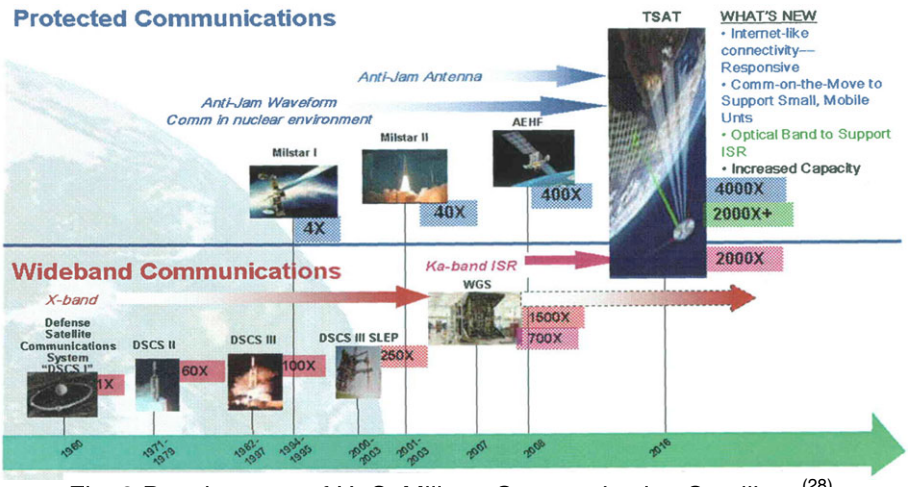


Fig. 9 Development of U. S. Military Communication Satellites.[28]

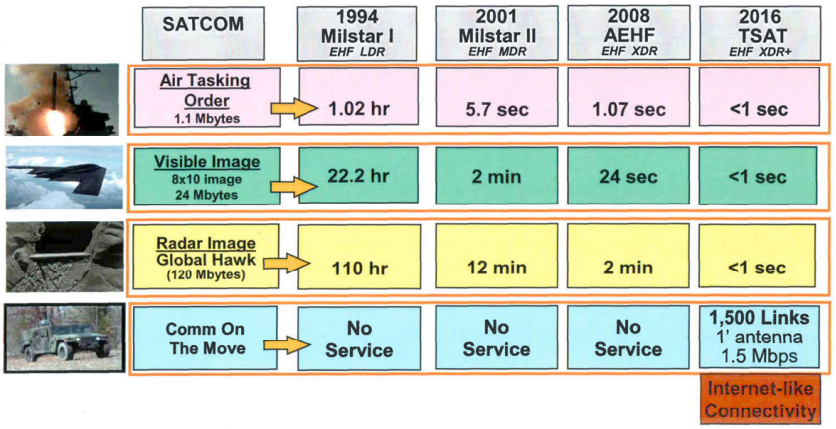


Fig. 10 Effect of TSAT Satellite.[28]

Figure 9 shows the development of the U.S. military satellite communication for 1960-2016[28]. A satellite development and approximate communication capacity from DSCS to TSAT are shown in **Fig. 9**. It shows that the capacity of TSAT is around 4000 times as much as the capacity of early stage of DSCS-I. In addition, a category of Protected Communications and Wideband Communications is shown in **Fig. 9**. The former in particular includes reinforcement of technology such as an anti-jamming measure and security of ability for communication in nuclear explosion environment, and so-called LPI/LPD (Low Probability of Intercept / Low Probability of Detection)[20]. **Figure 10** shows that handling of information in military affairs operation becomes markedly high-speed by introduction of TSAT[28].

2.3 Utilization of Commercial Communications Satellite in Military Communication

Figure 11 shows a demand prediction of militarily satellite communication[29]. Since the just military communication satellites cannot afford to

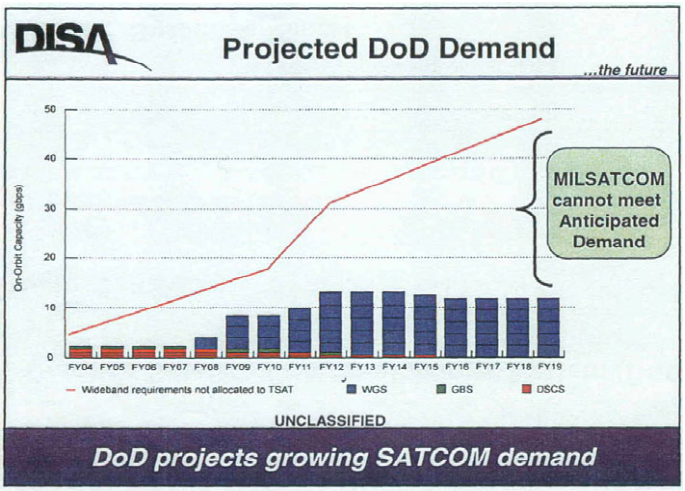


Fig. 11 Demand Forecast of DoD Military Satellite Communication.[29]

the demand absolutely, 80% of the U.S. military communication demand are provided with commercial communications satellites. And it is predicted that demand for a commercial satellite increases more and more in the future. Ms. Kay Sears, President of Intelsat General Corp. says about the utilization of commercial communications satellites in the U.S. military communication as follows:[30] Space systems have transformed military operations. The establishment of GPS as a global utility, ubiquitous access to satellite communication and imagery, the expansion of broadband services to mobile platforms have fundamentally altered the role that information plays in military decision-making. The feature of military communication satellite enumerates anti-radiation by a nuclear explosion and anti-jamming. But there are only 20 military communication satellites due to high cost and long time to deployment.

On the other hand, 200 commercial satellites are already operating and available (ubiquitous) all over the world. Around 12 satellites per year are launched. In addition, since GEO satellite is not affected by radioactive destruction due to nuclear explosion, it is available sufficiently for military communication. It is a problem that a long-term investment in private enterprise is difficult due to spot buying of communication capacity by DoD. In addition, both satellites are vulnerable to an anti-satellite weapon.

One of differences of a commercial communications satellite from a military one is that a commercial communication satellite encrypts and de-encrypts signal on the ground, while a military communication satellite encrypts it onboard the satellite[23].

2.4 Technology of Signal Intelligence Satellite

There is wiretapping satellite Sigint (Signal Intelligence) for the purpose of monitoring signals, which is regarded as the highest classified among military communication satellites[31]. **Figure 12** shows an image of satellite called Trumpet, whose weight is 4.5 ton and orbit is highly elliptical orbit (HEO). The diameter of its antenna is seemed to be 300 feet (100m)[32]. This means a size of a soccer ground or a baseball field class if an antenna of the ETS-VIII satellite is a size of a tennis court. These wiretapping satellites have been used while updating a generation from 1960's as shown in **Table 1**[33]. It should be noted that the technology of these large-sized antennas has been applied to a mobile communication satellite having a large-sized deployable antenna[32].

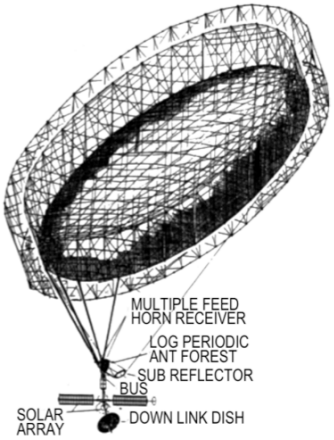


Fig. 12 Image of Trumpet Satellite.[32]

The latest large-sized Sigint satellite of the U.S. National Reconnaissance Office is an electronic intelligence satellite called as Advanced Orion NROL-26, which has an antenna of more than basketball coat size (24x15m) and weight of 6 ton. This satellite was planned to be launched in the middle of December 2008[34]. It is launched actually on January 18, 2009[35].

Table 1 History of SIGINT.[33]

SIGINT Programs	First generation 1960s	Second generation 1970s	Third generation 1980s	Fourth generation 1990s	Fifth generation 2000+
GEO - USAF COMINT		Canyon	Chalet Vortex	Mercury	Intruder
GEO - CIA ELINT		Rhyolite Aquacade	Magnum Orion	Mentor	
HEO - USAF ELINT			Jumpseat	**Trumpet**	Prowler
LEO - USAF ELINT	Ferret	Sub-Sats			SB-WASS
LEO - Navy ELINT	GRAB	NOSS		SB-WASS	

There seems to be recommend a small satellite of low orbit due to its small antenna. This is why such a large wiretapping satellite is expensive, its launching interval long, big loss in case of malfunction, and weak for A-SAT[36]. But environment to monitor calmly from GEO is necessary in the field of achieving results only after listening to very weak signals for a period.

3. R&D Method of Satellite Communications Technology for National Security

3.1 Different Points of National Security Related R&D from General One

The Space Basic Law was approved on May 21, 2008, and it was taken effect on August 27, 2008. The purpose of this law contains space development from non-military to non-aggression, national security, industrial development and R&D. The greatest change after effective of Space Basic Law is that an action on the national security assuming the non-aggression is enabled. As mentioned first, a role of space system extremely grows about national security because the world has been in chaos since the 21st century began. Actually, it becomes equal to be nothing if there is no space system, and the satellite communications technology becomes particularly important in space system, as mentioned above. Considering the method of R&D in our country on the basis of such a situation, the author would like to point out the following three points that should be noticed because of difference from the conventional study method.

(1) Don't Let Researchers Think How to Use Their R&D Result

First, it means that we should not let researchers think about how to use their R&D result. A background of the Space Basic Law is useful for it very much. The background of the Space Basic Law is written well briefly in Reference (37). According to it, a prominent sentence is described; "Has the Japanese people forced only scientists, researchers and experts to think about a method of development and utilization of space? We must now change the Japanese national policy about space from the root. We must think about significance of space development from broader point of view. Politicians have certainly the responsibility that has neglected it." In other words, as for space development, it has been always blamed the persons concerned of space so far, like "The reason why a matter of general interest is small is due to that an advertising method of the persons concerned of space is bad. Must do it better." It is necessary for the persons concerned of space themselves to perform the public information so that a general public is easy to understand. The author never intends to deny it. However, the space professionals are pointed out how result of R&D was used is obscure, and they have been made to think how to use particularly by squeezing their poor knowledge about application of space. This is not only waste of time but also takes valuable time using an professional skill away. It is necessary to think about space from broader field of vision. Because the Space Basic Law treats space issue as a problem of politics, it is epoch-making.

If such reconsideration is a motivation of the Space Basic Law, it is very important. In other words, it should be regarded as an arrogation to let researchers think how to use the result in the R&D of technology for national security. It should be jurisdiction of specialized agencies having high capability of intelligence information processing about how to utilize obtained information. Safety of our country would be in danger to be threatened in the future unless how to utilize information obtained by intelligence technology is considered by the specialized organization, for example, such as the Cabinet Intelligence and Research Office[38].

It would be a problem how to start R&D theme, when it is asserted not to let researchers think about how to use result of R&D. But judgment from a broad field of view is just demanded for this. One judgment is the "tacit consent". It seems that there was surely the tacit consent in the early period of space development in Japan. It is necessary to push forward R&D through understanding expectation to the vague future of a wide meaning instead of a detailed argument and its ground that exposes everything to the public. In late years, in spite of a very important thing, such an attitude of R&D seems to be rejected because excess transparency to the public is pursued. However, it would stand up the argument of the tacit consent that national security related R&D does not announce to the public how to use the result of R&D.

A question occurs what responsibility of atomic physicists who create atomic weapon is, when researchers should not be let think how to use result of R&D. What was mentioned above asserts that we should reflect on rather oppression on the researches due to forcing upon researchers excessively so far. It would be suitable that we argue the big problem such as an atomic bomb at the other opportunity.

(2) Don't Take Selection and Concentration of R&D Theme

Second, selection and concentration of R&D theme must not be taken. Although it takes a

command for selection and concentration to the strong field of R&D flourishingly, just these words might be the words spoiling research[39]. It is dangerous that researches related to national security are conducted under principle of concentration of investment and exclusion of repetition. Seemingly it may look idly, but it is important to invest even to the technology R&D having uncertainty in the future usefulness, because much money is not necessary in the beginning stage of R&D. In other words, it is important that the fund flows from R&D programs on national security to fundamental research. The RAND Corporation proposed that a large amount of fund for fundamental research should be invested at the time of its establishment[10].

The course of selection and concentration of R&D theme simply has a strong image of discarding the R&D theme. Rather image of picking up the good one among variously mixed crowd R&D subjects while leaving original subjects might not discourage researchers. In this meaning, how about the word “Picking up and building up R&D theme”. In other words, it is important to make the fund flow to the fundamental research in the R&D programs related to national security. It was proposed that much money should be spent for fundamental research at the establishment of the RAND Corporation[10].

What theme should the researcher do? It is basically the best choice that the researcher conducts what he wants to do. How does the researcher find his research theme? This is the most important for the research and it is the best to find it by himself. However, the leader needs to show rough goal of research theme that he is interested in. In addition, the leader prefers to be a connoisseur to foster greatly the research theme that the researcher performs with interest. Although there is a permanent problem whether the research is conducted with bottom-up or top-down, the research management should do matching between what the researcher wants to do and what the organization wants to do. The author heard from Prof. Shun-ichi Akasofu, University of Alaska, about “organized chaos” as a method to solve such a problem[40]. It means that the chaotic research themes would be organized naturally without any detailed coordination of the research themes if a comprehensive large research theme is established. In other word, it means that organization can be managed under a big purpose rather than enforced unification of individual researches. The same concept as “organized chaos” is presented in the article of Dr. Leo Esaki’s “My Personal History” of the Nikkei Shimbun, Jauary 26, 2007[41].

The R&D related to national security and defense needs to be conducted by the government, because it is difficult generally for private enterprises to perform such R&D. Research evaluation performed by independent administrative corporations needs to be reviewed now from a point of view strengthening the fundamental researches. In the present research front, the independent administrative corporations of R&D is demanded to conduct only R&D items written in its middle term plan and enthusiasm to perform any new and terrible R&D item even quietly seems to be lost now.

(3) Necessity of R&D of Satellite Communications by Government

Third, the government needs to push forward R&D of satellite communications. Considering that the government procures communication satellite related to the national security, it is necessary, by all means, for the government to keep any satellite professional who knows well not only satellite but also research. In this case, the “tacit consent” is indispensable to push forward research as mentioned above. For example, in R&D of satellite born antenna technology, the size which fits only for a commercial mobile communication satellite for the time being may be sufficient, but R&D on much larger size of antenna should be performed , because there is a possibility to apply it to the wiretapping satellite in the future as described in the previous chapter. Such a large-sized antenna is one of the technologies that the government must have without any public announcement because it is the highest classified level as mentioned above. For another example, even if a communications satellite is necessary for national security and the government orders its production to the private company, the professional who knows satellite well at the government side is necessary. The procurement is contracted without understanding detailed specification unless there is such a expert. Such a contract seemed to cause a lot of a satellite failures happened in the U.S.A. in 1990's[7].

For the opinion that the government needs to develop the communication satellite, there is a

person who says that NASA has not had any communication satellite program since the ACTS (Advanced Communications Technology Satellite) program was finished in May 2004[42]. But these information grounds are feeble. This is why there is not a communications satellite program, but NASA keeps experts of communication, and space communication research is performed including deep space communication, according to a NASA people. In fact, according to the recent news report, the renew for the deep space optical communication system and its Internet protocol between planets to the next generation are prepared [43][44].

In addition, a research about communications satellites is performed on a large scale by the armed forces, but it is not announced as mentioned above. Such a situation seems to be the same as nuclear power generation in the U.S.A. It is wondered if it is difficult to maintain accumulation of atomic energy technology from the fact that any atomic electric power generation is not founded in the U.S.A. since an accident of Three Mile Island in 1979. But the technology is kept in the armed forces in actual, and it is the U.S.A. that R&D and accumulation of atomic energy technology can be developed based on military affairs[42].

3.2 Acquisition and Handling of Information

The secret maintenance of the information is important in the national security related R&D. However, there would be no expansion of R&D and could not expect an influence effect of an investment if everything is classified in the 100 Percent. Because of research characteristics, it is always necessary to aim at improvement of performance and the next generation. In this conjunction, it should take into consideration that 95-98% of classified information can be obtained by arranging open source information[38][46]. Therefore, R&D related to the national security is not surrounded by only classified information. Rather broad activity through the institution and so on could possibly be useful to make the R&D excellent.

R&D of satellite communications should be conducted by looking at a total image of system in a field of view. However, even if it is natural to make a main part of system classified, how about is the R&D of element technology encouraged to be opened? In addition, even if a part of classified system performance its 50-70%, for example, namely the performance of the former generation, is announced, it should still aim at the top-class performance among the institutions In this instance, announcement of rather research method for obtaining optimum, maximum, or minimum than the value itself of performance is needed to level up the research.

3.3 R&D Items of Public Research Organizations

Finally, depending on a change of situation of space development of our country as described above, let's think about R&D items of public research organizations. The author suggested in Reference (1) that the R&D items of public research organizations should be concentrated on national security related items. It seems that the RAND Corporation is the most famous and has established the highest achievement among research institutes about national security.

According to Reference (10), the RAND Corporation was established in 1946. It is started under a thought that science rather than diplomacy could provide the solution needed to cope with threats to national security. New concepts came out of including a way of thinking today's RMA, packet switching technology which is the basic technology of Internet, and even study on possibility of launching artificial satellite in 1946. The RAND Corporation is hard to approach because it has the side that studied a hydrogen bomb with full-scale support of the U.S. Air Force, but it had a purpose not to scatter excellent brains after World War II, and the philosophy at the establishment that we should learn is included as follows.

- To advocate ever-greater government expenditures on fundamental researches.
- The maximum freedom must be given researchers themselves to push forward their research.
- If various limitation is held in the minimum, new and unexpected contribution to the development could be expected.
- The most effective method to promote original and creative thought is to give all the researchers the equal authority and to let them compete each other.

There seems to be no example of a research institute about national security in our country

which just corresponds to the RAND Corporation, but let's do try to consider how the space communication research should be conducted at the research organization like NICT as an example. As for the research theme about satellite communication, the principle of R&D conducted so far will be proper from now on, namely development of new frequency band and more effective utilization technology of resources. However, it is necessary to pursue system robustness technology for national security as well as communication capacity and flexibility. Technology of robustness includes anti-jamming and measure for a nuclear explosion. Signal processing and antenna beam formation technology are important for the former and satellite communications technology in the higher than millimeter wave for the latter[18]. Although the nuclear explosion seems to be studied exhaustively in the Cold War in 1960's, researchers understanding electric wave propagation under plasma environment due to a nuclear explosion are indispensable[47].

As for space communication technology for national security, it consists of:

- Communication (fixed, mobile, broadband, inter-satellite link, software defined radio technology)
- Navigation (Quasi-Zenith system, Japan's GPS system)
- Surveillance/warning (wiretapping, imaging, missile warning, the infrared detection)
- Radio propagation (ionosphere propagation, space weather forecast)

It can be noted that the most of R&D items that NICT has conducted through its former Communications Research Laboratory and Radio Research Laboratory are important for the national security. Therefore, it is important to make positioning of R&D items clear and to recognize them again as well as to prevent the scatter of researchers from national security point of view.

Finally, the word of RAND Corporation is cited "National security is an ever-receding goal requiring incessant technological improvement."[10] We should take this in our heart.

5. Conclusions

In this article, it was discussed how the R&D method of satellite communication related to national security is different from one of a conventional R&D based on change of space development environment with recent conclusion of the Space Basic Law. In Chapter 2, it was described that the RMA advances and the satellite communications increases its importance as a pivotal technology of the RMA referring to its utilization of the U.S. armed forces based on unclassified documents. In Chapter 3, it was described that the different points from conventional method in R&D are not to let researchers think how to use their R&D results, not to squeeze the R&D items, and to become more important for the government to conduct R&D of satellite communications. Finally, the study items of the NICT were reviewed as an example of a national laboratory, and it is described that the R&D items conducted so far covers almost all of necessary items for national security, but it needs to evaluate their significance.

The author would like to add the following two things: First, it is indispensable for researchers, young researchers in particular, to propose various suggestion. In order that, the research leader need to have an idea, clarification of the aim, or deep understanding for the R&D. Second, the "tacit consent" is indispensable for this kind of R&D. It is necessary to push forward the study while understanding expectation to the vague future of a broad meaning. Therefore it seems that quality of a leader influences it greatly. But it is necessary to understand the specialty sufficiently that satellite onboard equipment passed in space proof and becomes practical use. It is a big problem whether or not the person who knows space very well manages R&D. The author welcomes a further discussion of all of you. The paper condensed this article was presented at the joint workshop of Satellite Communication Committee and Space, Aeronautical and Navigational Electronics Committee, Institute of Electronics, Information and Communication Engineers, Japan, held on February 26, 2009[48].

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