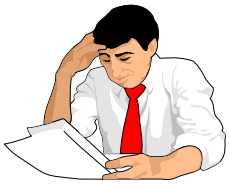

Methodology of Research and Development

From Research of Satellite Communications to General Research

❷ Research Management

Takashi Iida, JFSC Special Advisor, AIAA Fellow

In this opinion column, it is intended to argue how to conduct research and development (R&D) on satellite communication, especially for national security. This is why we step forward in the 21st century of the chaos which was determined by the terrorist attacks to the U.S.A. on September 11, 2001, and in order to deal in a century of chaos, R&D of national security, especially satellite communications becomes particularly more and more important. On that occasion, an R&D methodology in general R&D as well as one of satellite communications is argued based on experience of the management of Communications Research Laboratory of the author's former job. Therefore, the content may be based on the author's own dogmatism and prejudice, but please forgive me because of an opinion column.

At this series No. 1, under a subtitle: "Competition Predominance and Researchers' Attitude", the topics of competition dominance and innovation, researchers' attitude, and what study should be done are considered [1]. Therefore, at this Series No. 2, focusing the general R&D continuously from No. 1, it is considered how the research management should be done. In the retail, the following topics will be considered: how to ensure researchers, what the research evaluation is, how to proceed the research collaboration, world situation especially how to consider the stagnation of innovation.

◆◇What Research Management should be◇◆

Any research organization has always a researcher who does not accept any comment from others. Such one is a difficult researcher from a management point of view. However, there may be a time when this attitude can be useful. For example, destruction by fire of observation data was ordered immediately after the vanquishment of war in 1945, since Radio Physics Laboratory of a forerunner of present National Institute of Information and Communications Technology (NICT) had conducted forecast duties of radio wave propagation in cooperation with the military forces until the end of World War II. However, a researcher carried out the data secretly by a bicycle-drawn cart at midnight and hid them in his home. What he did without burning the data was praised by Major Bailey of GHQ (General Headquarters) who came to the laboratory for investigation later, and it connected for permission to continue a study of radio wave [2]. In addition, I watched TV program of "Project X" which was the history of VTR (Videotape Recorder) development of Victor Company[3]. I think that this was this kind of study.

I would like to call a research institute, that provides environment to be able to study various research items freely, as "Large Research Institute (principles)", hoping to avoid misunderstanding, On the other hand, a "Small Research Institute" is a research institute for a certain specific purpose. It is good to make a purpose clear, but it cannot afford to pay more attention besides the purpose. A "Large Research Institute" has room paying more attention to various research items and creates the next study, and it is a research institute having the power that can create new research theme by itself. This is a problem of a way of the management, not of size of a research institute.

Incidentally, in considering the purpose of the research institute, there is a tendency to write it concretely immoderately finely. Such a concrete description may make explanation for budget acquisition easier. However, I think that the description of big objective is better. That way makes easier to do portfolio of the research management as mention below. For example, according to Law of Incorporated Administrative Agency (IAA) RIKEN (a large natural sciences research institute in Japan) [4], it is written only that the RIKEN aims to improve the level of science and technology by performing comprehensive test and research activities such as science and technology.

In conjunction with "selection and concentration" of research, it is said to "squeeze" study items well. A result of research institute evaluation points out well that there are too many projects and recommends to reduce the number of projects. It may be true, but it is not clear to be able to be agreed immediately from a management point of view. In particular, it may be dangerous that the research organization depends only on limited number of focused items from a management point of view. In other words, such a research item is no longer usable if it is faded. Further, there can be a case becoming outdated very soon, because the present world changes so rapid that it is said to be "dog year". Therefore, it demands to challenge some fields of research in parallel from a view point of managing a research organization. This way can evade a risk of fading out. This is a kind of portfolio [5]. Concerning such a demand to squeeze the research items, Dr. Hiroaki Yanagida, President of Nagoya Institute of Technology, pointed out that squeezing research items is at all danger, according to an article of newspaper entitled as "My opinion: Dangerous trap of research and development, Is the selection and concentration right?" [6].

◆◇How to Ensure Excellent Researchers◇◆

It is an extremely difficult problem how to ensure excellent researchers and how to gather excellent researchers. In general, any introduction from professors of universities may be helpful. Further, the connoisseur and/or research experience of the employed side are important. As for what researcher is eligible, a viewpoint to researcher depends on whether employment term is tenure or not. In my former job, since only researchers having Ph.D. are employed, in order to adopt a tenure Ph.D.-holder, the word "I'm an expert at certain study" just is not sufficient. Because it might become outdated in several years, it is necessary to see whether one has a talent of finding the germ of the future. So to speak, one must have two ability, the problem is how to see through such a talent. On the other hand, as for a researcher employed with limited term such as a post-doctoral fellow, because the purpose is to foster a researcher, we must watch whether one can devote oneself into a study earnestly without letting one do the work for an organization management.

The next problem is how the excellent talented person, whom was found with much effort, can be prevented from leaving the organization. We must think about the making of environment that such a talented person does not run away. Because the research organization of my former job treated the field of IT that changed very rapidly and had many work places outside, its situation was that the researcher might leave quickly if one did not like. Therefore I took care considerably about maintenance of study environment.

Incidentally, concerning how to foster a researcher, it is very difficult problem even if general education is good. I described in this Series No. 1 that a researcher is not fostered by being taught [1]. So there is not a method than the researcher brings up by oneself basically. In addition, about a person, various evaluation is not so useful. Rather some people grow up in the post. Therefore, it is necessary to do drastic personnel affairs. But needless to say, it is necessary to treat immediately if there is any problem for an organization.

Furthermore, a mass of researchers (the number of researchers) need to be some large size. There is a fear that the research cannot be conducted sufficiently in the environment of too small number of researchers. Therefore in order to solve the problem, a budget is necessary, but it is not easy to make a mass of researches be big, because of an issue of persons.

According to Science and Technology Comprehensive Study Report in 1999: “Human Resource Management of R&D Personnel" [7] as described in this Series No. 1 [1], the features that the national laboratory has more peculiar than the private laboratory are as follows: At First, in comparison with the national laboratory with a private research organization,

- Running a risk of a research
- Permission of an underground study (equivalent to hidden study [1])
- Exchange of information and research collaboration with outside
  - Paper presentation to domestic and foreign and attendance to domestic and international conference
- Mid-carrier hiring
- Degree of freedom of study (budget, staff, duty time, and theme setting)

In addition, the researcher's motivations of moving to the national laboratory is as follows:

- Moving from private laboratory
  - Freedom of study
- Moving from university
  - Better research environment

A while years ago, in order to offer good environment to the person who moved to national laboratory from university, there was means to prepare the latest expensive experiment machine parts backed by larger budget in those days than a university. However, a national university becomes a national university corporation, and its budget may be little different from national laboratory, namely IAA (Incorporated Administrative Agency) laboratory. So the IAA laboratory need to focus more on the acquisition of researchers, taking advantage of the characteristic of an IAA research institute.

An IAA becomes an object of criticism in many cases in Japan recently. In this conjunction, a national laboratory or a government-affiliated corporation are changed to an IAA, and it might be meaningful to see how it changed. In the first place the IAA stems from a general idea of NPM (New Public Management) that applied management technique of a private enterprise to a public organization and was developed in the U.K. [8]. Without going into detail, the biggest changed thing is to integrate the budget into one as administration grant. The budget can be distributed to every study item flexibly. The budget does not need to be managed within a year. Therefore not to mention raising the efficiency to push forward a study of an aim, it is possible to raise incentive for the study that cannot have been realized at all so far. Thus, in my former job, I performed the following two points to raise incentive of a researcher as an IAA.

In the first, to abolish a frame of the travel expenses as much as possible. The travel expenses had been limited at a time of the national laboratory in particular. Particularly so about foreign travel expenses. Therefore after becoming an IAA, I considered so that even young researchers can present their paper in the foreign conference as many as possible. There is a target to get 30 Nobel prize winners in 50 years [9]. Even if the Nobel prize was not aimed, interchange with overseas researchers is not performed and besides a world tide in study is not be gotten, if going abroad is limited and if the name of the researcher is not known abroad. In the second, an incentive study and a challenge study were created. In the former case, especially a young researcher gets around $12,000. One can use it freely to expand one's research theme and to prepare for the future situation. In the latter, a study beyond the mid-term plan is expected to be performed by using some amount of fund. This is created based on the following issues identified by the second evaluation committee for IAA, Ministry of Internal Affairs and Communications [10]: "Do not think to be sufficient if only the items written in the mid-term plan are performed. Make challenge daringly to perform the items not written in the mid-term plan. Should carry out about studies having high risk positively." But I am not sure how these measures becomes at present. Because the criticism against the IAA seems to be increasing according to the recent news, I am fear the measure becomes severer.

◆◇What is Research Evaluation?◇◆

Because an evaluation committee of IAA was systematized, evaluation work to preparing for the committee is performed very actively including the inside evaluation. About the difference between the evaluation by the committee and the inside evaluation, in the latter how to use the result of evaluation is the responsibility of the head of organization, while in the former the organization must obey the result of evaluation. I understood at first that an IAA is evaluated the results of research target at the last time of a predetermined mid-term plan period, and depending on the evaluation result, the discontinuation of the organization or the dismissal of the head of the organization is concerned in the case of the worst. However, in reality, evaluation is performed every year, and evaluation of how to lead studies that is in the middle of the mid-term plan period is also performed. The original concept of an IAA might be entrusted to get the better research result by raising the degree of freedom of the organization a little more. Furthermore, about the administration grant, the head of an organization should be originally able to decide how to use it in order to get the best research result. However, since actually personnel expenses and the travel expenses are severely limited or checked, it is the fact that organization cannot decide how to use originally. It may be unable to get the best research result unless the organization is given the degree of freedom, even if there is no help for watching how to use finely because a budget stems from a tax.

The research evaluation includes the evaluation of a project and the evaluation of a researcher individual. The evaluation committee of the IAA performs the former evaluation, while the latter is performed in the personnel performance review. For the evaluation, it is said that "Outcome" and "Output" should be used. The output indicates the result of research like papers or patents. Incidentally, it is said recently that the outcome should be used for the evaluation. The outcome is measured by how the research contributes to the society, whether venture industries occurs, and whether many people are benefitted. However, it is common to take time till the outcome appears after the output is acquired. Because taking such a long time cannot be proper for evaluation, what kind of parameters should be watched to get the outcome seems to be an object of a study. The person studying an evaluation method is happy, but a person evaluated seems to become a situation demanded troublesome work from in various ways.

Is there a better method? There is an example that evaluation is performed by dogmatism and prejudice. I have heard that the Sony Computer Science Laboratory (CSL) is this example (but I do not know the present situation), and its evaluation is performed by dogmatism and prejudice. Thus the person evaluated must resign from one's job, if one's evaluation result is bad. Then you may think that this affect one's lives, but it is a key that any person employed by CSL has no trouble to find employment at the outside of CSL.

Is the research evaluation really possible? There is also a thought that evaluation is not possible or evaluation itsel is a mistake. This means that the minority is right as for technology, namely, most of people can not understand the technology [11]. Rather, the technology that most people can understand is neither new nor original. Because it is said that new technology is not born unless it is developed at a long-term risk. The researcher may not recognize value of the study that is carried out by oneself. As an example, the electric wave is predicted by an equation of Maxwell in 1864, and it was demonstrated by the experiment by Heinrich R. Hertz in 1888, but it is known that Hertz said "I only proved the theory of Maxwell professor, and I do not know what the radio wave is used for" [12]. It was seven years later that Guglielmo Marconi opened an application of radio wave in 1895.

Is there any way that is not necessary of evaluation? It may be an eternal problem. I have heard the Research Institute for Sustainable Humanosphere, Kyoto University, has a policy that the evaluation of an entrance is severe and no evaluation once beginning the research as described in this Series No. 1 [1]. In addition, the details are unclear, but there seems to be a research institute performing a similar way at a private research institution in the U.S.A. Furthermore, it is said that the U.S.'s NSF (National Science Foundation), which is a model system for Japan, does not evaluate severely after getting the research fund while it evaluates severely before getting it. However the researcher must do one's best by oneself, because one's results are evaluated strictly to get one's next research fund. The number of papers is usually regarded as a result of research for evaluation,

but I think that failing to put first things first is serious. But because the papers count for everything in reality, there may be no help for it to some extent. In addition, it is necessary to inspect always the way of evaluation itself. About this, Dr. Ryoji Noyori said in his address as a chairman of evaluation committee for university corporation, Ministry of Education, Culture, Sports, Science and Technology, that it cannot but be made trial and error a way of evaluation [13]. I think that his thought is an extremely right.

As well as evaluation for the IAA, there is a movement of completely redundant of evaluation like a review and prioritization of government programs recently. Speaking of the roof over roof, there are evaluations by Space Activities Commission and by the evaluation committee of IAA in the space development. I do not know the present situation, but an evaluation standard of space development project was determined in too detail beforehand in several years ago. For example, evaluation result is "A" for establishing a certain value, "S" for a certain value plus 10%, and "B" for minus 10%. Because the evaluation committee of IAA evaluates the result later, if an evaluation standard is determined in too detailed, it may be trouble how the evaluation committee of IAA can evaluate. In addition, the development person in charge will tend to think only of achievement of the evaluation standard when the evaluation standard is determined too finely. I think that a work like ozone layer discovery is hard to be generated in such a way. I hear that it took a half year in the case of ozone layer discovery until NASA elucidated whether or not it is with trouble of equipment because observation value was too outscaled. Incidentally, in the space development the launch of rocket or injection of satellite into orbit might be failed unfortunately. In this situation the evaluation of the project is the lowest rank of "F". However, the IAA that might receive evaluation of "F" is no other than space development organization. In this respect the people concerned to space development are in particular put in the severe situation. In addition, intermediate assessment at the research plan period is questionable, too. The side that offered a fund seems to be worried about a fund, so it is common to perform intermediate assessment. It is very likely that the intention of evaluation committee is reflected strongly to a way of the study, while there is a merit for the people whom are evaluated can push forward their study in relief after the evaluation because the way of study is approved by the evaluation committee. The member of evaluation committee seems to be elderly experienced great scholars in general, but it is anxious whether they obstruct a study method of young researchers.

I feel that the evaluation itself goes into too detail for some reason, increases burdens except study itself and beats the study only. Is there any way of fostering research by more large-minded and stout evaluation? In addition, the research manager should refrain from cross-examining a researcher what the study is useful for. Since this column is to say any opinion, speaking more clearly, I would like to point out that the Japan's R&D is in danger unless the evaluation method described above is improved as soon as possible.

Evaluation of a researcher individual includes difficult problems, although there is an example like a way of CSL as described above. Because the open system is recommended since 10 years ago, at first a researcher individual writes one's evaluation sheet, then the evaluation sheet is completed after discussion with a research manager of one's immediate boss. Finally it is submitted to the top of the organization. An upper research manager coordinates unevenness of each section. Even if the evaluation took such a procedure, evaluation of researcher individual includes a serious problem. Some researchers seem to be anxious about how their boss evaluates them. However, I consider such a researcher to be deplorable if one worries the organization's internal evaluation by the boss. In brief, the evaluator of the researcher exists not in the internal organization but in the world. It is important that the researcher devotes the study in such a spirit. It is also important that the research manager manages the research to be able to have such a spirit. But the people concerned must carry it out indifferently, because the evaluation of the researcher individual every year is a duty imposed on the IAA. However, it will be a shortcut to give the efficiency of the research to sometime soon that such an inconvenient way in a sense is canceled.

Incidentally, speaking evaluation, I proposed various future satellite communications missions. At that time, one person of a manufacture company said that he counted how many mission proposed by me was realized as an actual satellite project. Such action might be a kind of severe

evaluation.

◆◇About Research Collaboration◇◆

A joint research is desirable from a significance that the research should be conducted with persons as wide as possible and persons of different field. The mass media said that the space development should be performed not as a project of one country but as an international joint project. I think the reason stems from that the project expense cannot be covered by one country. But I think it is the too easy thought that does not know reality. The reason is because the technical power must balance with a partner of joint research or joint development. A joint research or a joint development aimed at reduction of a budget for a measures to raise technology is illogical. Furthermore, the development process and result must not be shared easily with other countries, because space project is technology and system connected directly with national security. In other words, it should be paid attention that no country takes seriously even if joint development is approached to the other country, forgetting that the space development has many matters related to national security in the world.

Although problems about a joint research may diverse for many matters, I describe only my thought for the present.

- Level of each other's technology must be high, because a joint research is performed under profit of each other.
- Because a country participating in a joint research makes a kind of block as for the international joint research, it is necessary to take political consistency with the country that does not participate.
- The act to expect a fund in a partner including its reverse act at a planning stage is non-appropriate and should be careful.
  - ➢ For example, an act demanding an introduction to the upper echelon of an organization.

◆◇Considering World Situation and Stagnation of Innovation◇◆

It needs incorporate the society surrounding a research and the world situation in order to push forward the research. In this meaning, two topics are described in the following.

■ World Situation

When we came in the year of 2000, various situation appeared in Japan one year before in the 21st century. It was said that the Japanese society was placed at a big turning point. In other words, the trends of society: ●From official to private, ●From prohibition in principle to freedom in principle, ●From pre-adjustment to post-monitor/sanctions/relief, were said to be similar to the Meiji Restoration or the end of the World War II [14]. In conjunction with this trend, unification of ministries and agency offices, appearance of IAA Japan Aerospace Exploration Agency (JAXA) by unifying three organizations, and IAA NICT by unifying two organizations were realized. We felt just the times of turbulence.

On the other hand, when we paid more attention to the world as of the end of the 20th century, Berlin Wall was broken and the Cold War terminated. It was said that Berlin Wall was destroyed by the main factor of the circulation of information. I think that this is just the great achievement of satellite communications/broadcasting [15]. Then the globalization began, IT innovation happened and all of us expected to have rosy 21st century. However, there was ominous omen just before the 21st century. At first diseases by inexperienced virus was generated including O-157, EBOLA hemorrhagic fever, SARS, carp herpes, West Nile virus and BSE. In addition, un-stabilization of economy happened with an explosion of IT bubble. On the other hand, the Gulf War, Bosnia and Herzegovina dispute and September 11 attacks happened. This is an opening of the 21st century of chaos. What do we perform in this situation? What we can say is for importance of space technology to increase. The space technology plays a key role about reformation of the United States Armed Forces in particular, and a military communications satellite becomes a key [15]. Of this topic, further details will be discussed in this series next time.

Warning Point in R&D

We may have demanded innovation about technical R&D so far as described in this Series No, 1 [1], but recent situation is not so for some reason; an analysis is there [17][18][19]. In other words, an easily harvest fruit (Low-Hanging Fruit) which supported economic growth is drying up now. The cause stems from decline of innovation. **Figure 1** shows the number of annual innovation per 1 billion population. The average rate reached a peak in 1873 when the modern technology like electricity or car began, but it makes a sudden drop after 1955. In addition, the growth of GDP per American person slows down after 1980's as shown in **Fig. 2**.

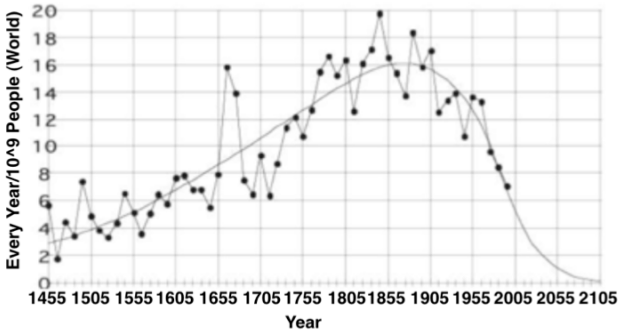

Fig. 1 The number of annual innovation per 1 billion population [17].

The drying up of innovation and low growth after 1970's are caused by the following decline [17].

- Free land
- Technological breakthroughs
- Smart, uneducated kids

Even the Internet that is a representative innovation in the current age brings less employment and less income compared with the past innovation.

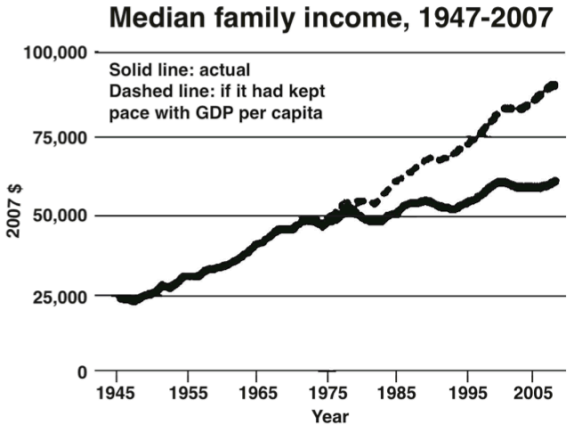

Fig. 2 Growth of GDP per American person [17].

According to such analysis, raising the social status of scientists and reducing an expectation growth rate facing new reality are proposed [16]. But, in the case of our country, too much pessimism is warned by the reasons of "There is still catch up room of innovation in Japan." and "It is necessary to raise growth expectation by the deregulation/the system reform, the trade liberalization, and the macro policies". In brief, it is necessary to eliminate the excessive pessimism and to picture the concrete idea of a growth policy [18]. It will not be meaningless to be aware that we work hard for innovation in such times. In addition, about the whole of documents [17], please refer Space Japan Book Review [19].

Epilogue

Although some topics about the research management have been described above, I think that the bottom line is to provide the environment that a researcher is easy to research. A problem of the drying up of the innovation mentioned above is serious, but it is important that the research manager keeps watching closely not only the field of specialty but also the related social conditions. Finally, the quality of the leadership as a study manager is important. I would like to recomend to read the book of the reference [20].

According to the news about a result of review and prioritization of government programs performed in November, 2011, it is reported that the strict external evaluation independent from jurisdiction of government should be performed for science and technology R&D [21]. The evaluation of R&D should consider to promote and reinforce the R&D under a silence premise. Otherwise I am afraid that R&D of our country follows a course of the decline.

References

[1] Takashi Iida: “Space Japan Opinion: Methodology of Research and Developmet—From Research of Satellite Communications to General Researchu uCompetition Predominance and Researchers' Attitude”, Space Japan Review, No.75, Aug./Sep. 2011 http://satcom.jp/75/spacejapanopinione.pdf .
[2] Memory Collection of Radio Research Lab. and Communications Research Lab. (50 Years Anniversary Issue of Communications Research Lab.), 2001 (in Japanese).
[3] NHK-TV: "Project X of challengers: 'Experienced Engineers Who are Left Out Of the Loop Made the World Standards; VHS, Tenacious Play Came from Behind'", Apr.4, 2000 (in Japanese).
[4] http://www.riken.jp/r-world/riken/law/dokuritsu/ (in Japanese).
[5] Takashi Iida: "Lead Article: Research in Portfolio Management ", Journal of Japan Society of Fuzzy Theory and Intelligent Informatics, Vol.13, No.1, p.1, Feb. 2001 (in Japanese).
[6] Hiroaki Yanagida: "My Opinion: Dangerous Trap, Is 'Selection and Concentration' Right?”, Nikkan Kogyo Shimbun, Mar.19, 2001 (in Japanese).
[7] 1999 Science and Technology Comprehensive Study Report: “Human Resource Management of R&D Personnel", Institute for Future Technology, Mar. 2000 (in Japanese).
[8] Atsushi Miyawaki and MIkio Kajikawa: "What is 'Independent Administrative Agency'", PHP Laboratory, May 23, 2001 (in Japanese).
[9] "Government Target of Nobel Prize: '30 Winners for 50 Years'", Asahi Shimbun, Oct.12, 2001 (in Japanese).
[10] "The Minutes of 2nd Meeting of Evaluation Committee, Ministry of Internal Affairs and Communications", Ministry of Internal Affairs and Communications, Mar.14, 2001 http://warp.ndl.go.jp/info:ndljp/pid/235321/www.soumu.go.jp/singi/010314_1.html (in Japanese).
[11] NHK-TV: “20 Years for Recovery”, Dec.25, 2005 (in Japanese).
[12] http://home.e01.itscom.net/ikasas/jcm/jcm09.htm
[13] "Evaluation Committee for National University Corporation First Meeting Selected Dr. Noyori as a Chair". Nikkei Shimbun, Nov.1, 2003 (in Japanese).
[14] Takashi Yasuoka: “Arrest of President Horie, Livedoor Shock", Nikkei Shimbun, Jan.25, 2006 (in Japanese).
[15] Takashi Iida, Yoshiaki Suzuki and Masato Tanaka: "Is Satellite Communication Technology Matured or Not? -From R&D Point of View-", IAC2005, Fukuoka, Japan, No.IAC-05-B3.1.01, Oct.17, 2005.
[16] Takashi iida: “[Space Japan Opinion] National Security: How We Should Push Forward R&D of Satellite Communications Technology As a Nucleus of Network Centric Defense System”, Space Japan Review, No.59, 60, Dec./Jan., Feb./Mar., 2008/2009. http://satcom.jp/English/e-59&60/spacejapanopinione.pdf
[17] Tyler Cowen: "The Great Stagnation", Penguin, 2010.
[18] Masazumi Wakatabe: "Economics School: Was Economic Trend Resources of Economic Growth Lost?", Nikkei Shimbun, Mar.7, 2011 (in Japanese).
[19] Takashi Iida: "Space Japan Book Review—From a satcom researcher point of view “Tyler Cowen: "The Great Stagnation", Penguin, 2010”, Space Japan Review, No.75, Aug./Sep. 2011, http://satcom.jp/English/e-75/spacejapanbookreviewe.pdf
[20] Masayuki Yamauchi: "Leadership—Pluck and Broader View", Shinchosha Publishing Co. Ltd., 2011 (in Japanese).
[21] "Auction of Frequency: Introduce it early, Policy Classifiction", Asahi Shimbun, Nov.22, 2011 (in Japanese).