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# HIGH RESOLUTION REMOTE SENSING: NEW ASPECTS AND PROBLEMS.

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## Abstract

The discussion about high resolution remote sensing data must consider today's situation and prospective for the distribution of 2-meter and better ground spatial resolution data. 2-meter resolution space survey data first appeared internationally in 1992. This data quickly became a part of everyday use. Today significant need for this data and significant new prospects for its use in the future are obvious. High resolution remote sensing data is becoming more and more popular, and the field of its application is becoming wider and wider. Within the last years several possibilities for development of better than 2-meter resolution space survey systems appeared. Realization of these possibilities in conjunction with the modern information technologies will change radically the image of Remote Sensing. Data accessibility, its technological variety and diverse application potential will require new efficient mechanisms of cooperation. For further effective progress with respect to high resolution Remote Sensing this is extremely important. Taking into consideration substantial experience accumulated in a framework of international cooperation in the field of space communication, civil aviation and other aspects of international economic cooperation, it seems to be now time to utilize that experience in the field of remote sensing, especially high resolution remote sensing. Creation of specialized international organization is considered as one of possible ways. In establishing mechanisms of international cooperation the guiding principle should be cooperation for peaceful purposes and for the benefit and in the interests of all countries.

## Introduction.

Today remote sensing of the Earth from Outer Space is an extensive branch of industry, who has in possession various technical means and applications. The whole complex of these technologies is developing rapidly and dynamically. It is also reality, that space remote sensing of the Earth constitutes integral part of the world economy, having passed from the phase of scientific research to an application tool used to resolve several social tasks. At the same time, the pace of development of remote sensing has not slowed down. The end of the cold war and "total warming" open the way for application of former military technologies for the benefit of the world community. Each new step of technical progress causes diverse opinions on its necessity, usefulness and degree of danger. Automobiles were also declared as "harmful"

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sometimes, because they frightened horses. High resolution remote sensing does not escape from this fate.

The first question occurred was "is the high resolution necessary at all, is it justified to spend great resources of the world community for further increasing space data resolution?". Existing satellite systems resolve many tasks. There are various aerial survey technologies. Some may argue there is no absolute necessity for high resolution spacecraft for Earth observation since new international relations do not require such expensive kind of observation as space observation is. Nevertheless the events of the last years show that high resolution data is not only needed, but that it can impart new features for remote sensing as such. Not substituting and not forcing out aerial photography, space data has a number of advantages: large observation areas, accessibility for the surveying of any region of the Earth, variety of spectral bands, economic efficiency. Life shows that different technologies coexist updating and enriching each other.

The prospects for the appearance in the nearest future of 10 - 20 varied remote sensing satellites including commercial and governmental are quite real. Having different operational characteristics in terms of resolution (from 20 m to 1 m and better), spectral band, revisit time, information delivery time, swath, accuracy, etc., they will mutually complement or support each other for different applications. At the same time quality changes are taking place in on-ground data processing infrastructure. One can say that it becomes a sub-space of the international information space. Due to development of newest telecommunication technologies, already today technically it becomes possible to obtain and deliver the data to the user within 24 hours, or may be in real-time mode. On the other hand methods of data processing and deriving of value-added product offer a wide range of services. Already today modern technology allows the user to apply remote sensing data without special training, having only the most common technical equipment. From the point of view of the user, remote sensing would be rather not a type of space exploration and complexity, but a branch of industry like communication, which is used in different spheres of everyday life, from scientific research to education and entertainment. Thus, practice gives a positive answer to the question about improving of remote sensing data resolution.

At the same time, another fundamental question may be asked: where is the limit of the information spatial resolution improvement? We speak of physical, optical limits, as well as juridical limits protecting private information and the privacy of individuals and legal entities. What are the rules and regulations of obtaining and providing of high resolution remote sensing data? And in this field high resolution represents practically a new situation. Until now on the international level experts and lawyers were talking about the states interests and protection of nations and Sates. The main problem was the correlation of the state protection and freedom of information exchange. In the future, because of the high level of details of space information on the one hand, and its easy availability on the other hand, the problem will include an adequate level of personal "privacy". This article does not contain the answers to this questions, but proposes a way to develop and draw up these answers in new economic, technical and political conditions for remote sensing existence as a way of life.

## What Is the High Resolution Remote Sensing.

The definition of the concept "high resolution remote sensing" includes "remote

sensing", "resolution" and "high resolution". Let's start from the terms "resolution" and "high resolution".

Resolution

Resolution is one of the basic parameters being used in developing of the systems and data application. There are different types of Resolution: spatial, spectral, photometric, etc. Hereinafter as the Resolution we understand the size of the minimum distinguishable point object of the Earth surface visible on the picture taken from Space. This definition is quite conditional and it does not pretend to any degree of perfection. It is necessary to mention that there is not any definition generally accepted in the world, neither technical, nor juridical[1]. The term "resolution" was the main technical parameter during the discussion of the problem of the satellite information distribution in the 70's and early 80's , as well as within the last years. The new growth of interest to the resolution of remote sensing data was caused by the appearance of data with 2-meter resolution[2]. We call this data "high resolution data" like many other people do. Nevertheless, here the situation is also undefined in a sense of what "high resolution" means. The term "high resolution" is in often used between the specialists, but the meaning that is understood is different.

The term "high resolution" appeared a long time ago, probably together with the appearance of observation from Space in the 60's. It seems to be useful here to review briefly the history of remote sensing from the point of view of the resolution improvement and its "striving to zero".

Brief historical review.

The first Earth observation spacecraft "Corona" was launched by USA in august 1960[3]. Initially its images had 25 ft (approximately 8 meter) and were improved later to 6 ft (approximately 2 meter). On April 26, 1962 the Soviet Union launched its first Earth observation satellite "Zenith"[4] which had approximately the same characteristics. So, already in the 60's there was data with 2-meter resolution , which we call today "high resolution", and some people use an expression "ultra-high" or "super high" resolution.

At the same time the idea to use Earth observation satellites for a wide range of civil applications was born. Further improvement of resolution has been made in two ways: "hidden" improvement of observation systems for military purposes; and "open" development of remote sensing systems for natural resources research and environment monitoring. Satellites for the study of atmosphere, oceans surface and glaciers became a separate type of vehicle. In this field onboard sensors with resolution from 100 meters to dozens of kilometers are usual. Thus, for the specialists in meteorology 20 meter resolution is "high", and 2 meter resolution is "super high". The same situation in terms takes place among the specialists in a field of other planets exploration.

Wide civilian use of remote sensing data began in 1972 with the launch of the first spacecraft of Landsat series. Its best resolution is estimated at approximately 30 meters. Starting from 1975 in the USSR remote sensing satellites "Fram" for civil applications came to be in use. And later "Resurs F1" and "Resurs F2" came to be launched. Resolution of the data supplied by these satellites was about 5 meters.

The next step was the launch in 1986 of the French "SPOT-1" satellite with 10-meters resolution in panchromatic spectral band. Generally speaking, for remote sensing the middle of 80's was the second important milestone after the launch of first Earth observation satellites. Some

events played a key role. In 1984 in the United States the Land remote sensing commercialization act was adopted[5]. In 1986 - the launch of SPOT-1 satellite and the adoption by the U.N. General Assembly of the Principles relating to remote sensing of the Earth from Outer Space. In 1987 - the appearance of free-accessible Soviet 5-meter resolution data. Today it is obvious that exactly at that time Earth remote sensing started its road to commercialization.

Finally, in the 90's three events took place. In August 1992 the Government of Russian Federation allowed open use of 2-meter resolution data for international cooperation. At the present time this data, both archival and newly acquired, is the best resolution data available for international usage. In February 1995 the President of the United States of America has issued a directive about declassification of archive 2-meter resolution data, acquired in the 60's-70's[6]. In 1994 the Department of Commerce of the United States of America has granted licenses for development of non-governmental Earth observation systems with 1-meter resolution[7].

The concept of High resolution remote sensing.

It is necessary to mention that all kinds of data with different resolution (1, 2, 5, 10, 20, 30-120 meters) listed above and a lot of other data already have and will have their own application value for resolving different types of civil tasks. The main purpose of the resolution criteria development was the national security considerations. The main role here belongs to national legislation regulating distribution of information, particularly space data. On the international level in the Principles relating to remote sensing of the Earth from Outer Space there is only the criteria that activities (remote sensing) shall not be conducted in a manner detrimental to the legitimate rights and interests of the sensed State[8].

There were a lot of other proposals: to distinguish data as "global", "regional", "local", or to distinguish resolution as "high", "medium", "low"[9]. There was a proposal to divide the resolution as: low resolution (approximately 1 km), high resolution (about dozens of meters), very high (better than 10 meters)[10], and some other systems.

The words "very", "ultra", "super" and others were mainly tended to be used because of the effect of sensationalism. Especially as with the word "spy" or "reconnaissance" they may cause some concern and even fear. Our conviction, confirmed by a five year experience, is that high resolution data brings benefit to the world community. The very fact that such information is now available gives evidence of positive changes in the world, mutual trust and, correspondingly, helps nations to come together.

Taking into particular account the needs for regulation of remote sensing activities we think that high resolution remote sensing data is data with ground spatial resolution less than two meters.

The term of "remote sensing".

As was already mentioned, remote sensing will radically change in the future. One of the aspects of this change is the appearance of two new categories of the participants to this activity. These two categories are non-governmental providers of data and numerous, practically unlimited group of individuals as data users. Consequently, the legislation should protect legal rights and interests of not only governments but private persons. In the same context the meaning "remote sensing" itself should be considered. Legal definition of the term "remote sensing" is given in the Principles relating to remote sensing of the Earth from Outer

Space. It has remote sensing function having a particular purpose: "...for the purpose of improving natural resources management, land use and the protection of the environment;"[11]. These fields continue to be of practical importance for high resolution data. But it is a particular feature of only high resolution data that the range of its applications is significantly wider. But this fact does not diminish public significance of the "Principles...". From our prospective, taking into consideration the changes now taking place in the field of remote sensing, application and interpretation of the Principles should be broader, at least until special regulations appear. But definitely with the generally accepted exclusions like meteorology and Earth observation for national security conducted by governmental organizations.

Today it seems that there is not any need for additional legislation or regulations for distribution of the data which became normal (2-, 5-, 10-meter resolution). May be in the future data with better than 2-meter resolution will become normal. But, now it seems that its distribution may contribute to possibilities of conflict occurring.

The principle of freedom in collection of remote sensing data is generally accepted and, obviously, should remain the same with respect to high resolution data. At the same time, the problem of high resolution data distribution, as well as remote sensing data distribution generally, remains open. All the more, in respect of high resolution data the problem is broadening due not only to resolution sharpening but also to the development of the modern information transmission channels and technologies. Consequently, other conflicts of interests may occur. For example, private person being a citizen of one state can receive from a foreign operator remote sensing information relating to government or private activities in his country. The current laws of different countries offer different ways of how to resolve these questions. And in the laws of many countries these issues are not regulated at all. Future norms should expand to high resolution remote sensing with respect to its distribution.

Another topic is commercialization, which is rapidly increasing. As are the matters of liability and intellectual property rights. Insurance requires international regulations. Also, space activity has to become a subject of not only International Public Law, but International Private Law. Nevertheless all these questions should be considered taking into account sharing benefits of space activities.

So, new remote sensing requires new definitions and new approaches differentiated on the industrial and inside of the industry branch levels. The development of these approaches will be done by different means. From our point of view time has come for the institutionalization of international cooperation in remote sensing. For high resolution remote sensing it is not only possible, but it is necessary to do.

## Institutional mechanism of international cooperation in remote sensing of the Earth.

Preliminary considerations

The assumption that it is necessary to develop a constantly working mechanism of cooperation of high resolution remote sensing participants is based on the following considerations. Roughly they can be grouped under three headings - technical, economic, political. In the future an international fleet of remote sensing satellites and corresponding ground facilities will offer to users great opportunities. Cooperation of the operators in managing of the satellites will allow to make surveys more effective and reliable in case of malfunctioning, bad weather conditions,

natural or ecological disasters. In addition to that, coordinated technical policy will allow joint advantages of different systems, which significantly differ from each other in technical parameters, to the good of the international community. Although here we are talking about pure civil use of the data, it was already mentioned in the media, that during crisis situations, even existing civilian systems working together to resolve one and the same task achieved much more efficiency, despite the apparent power of defense systems[12]. Probably, there is no need to mention the high level of expenses and, correspondingly, the necessity to fund the costs rationally and in the most optimal way by both developing and developed countries.

No less important is the development of coordination and cooperation in political and legislative spheres of remote sensing. Distribution of high resolution data has already caused a number of international law discussions[13]. Today, main reasons, probably, is that the technical specialists from different countries are not prepared yet to discuss all the technical details regarding the use of high resolution information both because of the political motives and for the reason of commercial competition. Nevertheless, it is necessary to look for a common approach. The best but most difficult way is to harmonize national rules. As like in other fields it can be done through the acceptance of international agreements, through the development of model laws, recommendations, specific standards, procedures, etc. Widening of industrial use of Space requires working out in detail of space law depending on type of space activity. The specifics of remote sensing, as has been mentioned earlier, are that this activity is carried out in close connection both on the Earth and in space. With respect to future high resolution remote sensing this particular feature becomes even more typical. Further widening of the use of this information requires the mechanism of consultations for finding a balance of different interests: the balance between sensing and sensed parties (states, entities, individuals), between developed and developing countries, between users and investors, etc.

Thus the development of a constantly working and evolving mechanism of international cooperation in the field of high resolution remote sensing would be extremely desirable, i.e. mechanism of joint activity in scientific, technical, economic, political and legal fields of high resolution remote sensing, aimed to provide peaceful activity in the field of high resolution remote sensing in the interests and for the benefit of all countries and nations.

Common approach

Earlier, the ways of establishing of such a mechanism were proposed. For example, there was a proposal of founding of an International Agency of Space Observation[14]. There were more global proposals to create World Space Organization, one of directions of which could be remote sensing[15]. There was also proposal to use the Secretariat of the United Nations as a World center of remote sensing[16].Two comments in this connection.

First. In our case more preferable, at least at this stage, would seem to be an organization that is engaged in high resolution remote sensing only but on a permanent basis and over the complete set of questions, including those which are in connection with current space and on-ground operations. An International Space Organization could become a basis for cooperation. But its establishing would seem to be a much more complicated task and the functions proposed here would make the solution more complicated. In the future, when the International Space Organization will be established all or at least part of the functions

can be transmitted to it, such as informational, administrative, etc.

Second. Main purposes for creation of the International Agency for Space Observation are the political purposes. That means international agreements fulfillment control, armament restriction, decreasing of international tension[17]. But the main purpose of the institutional cooperation mechanism proposed here is the development of conditions for further development of international high resolution remote sensing in the interests of economic and social development of all countries and all people in the world. The main purpose is economic cooperation. It is also necessary to take into consideration changes in international relations and the world economy, which have taken place within the last years.

The most attractive model seems to be the critical use of the experience of Inmarsat, Intelsat, ICAO and MAGATE. The two first ones provide a convenient way of how to separate foundation documents to an intergovernmental treaty and an operational agreement, whose participants can be governments, as well as national organizations duly authorized by states. The first document provides legal status for the organization, and the second document provides conditions for everyday functioning issues. But, unlike the above said organizations, the international organization proposed is not to be aimed to create and operate its own space segment. Probably in the future, when this form of cooperation will be tested and will prove its effectiveness, the issue of its own satellites launch will be raised. Ground information infrastructure should exist including, probably, its owned or rented receiving stations and communication channels. At the first stage the main goal should be coordination of action in technical and political areas in order to operate remote sensing systems in the most effective way to the interest of the world community.

The experience of ICAO and MAGATE demonstrates proper work organization for distribution of information and consulting for a wide circle of questions, in training and for support of developing countries.

It is possible, that the establishing of a permanently acting entity could begin from the signing of an operational agreement or any other similar document establishing the order of interaction of the parties when operating remote sensing systems. In addition it should create a basis for deepening cooperation in all directions and involvement of the majority of providers and users.

Of course, detailed working out of questions of accession, participation, working organs, procedural, financial and many other components requires significant efforts from the specialists from different countries. At the same time, in making detailed proposals it is necessary to keep in mind tendencies of our reality. Particularly, the tendency of commercialization which is manifested in a most significant degree in the use of high resolution remote sensing. In this connection it seems to be possible that the parties of the operational agreement would be not only the states and their entities, but non-governmental organizations also. Definitely, they should be properly authorized by the government and work under state control in accordance with the provisions of space law.

## Conclusion.

Obviously, the mechanism of cooperation proposed above is not the only possible way. What is more, it should not be the only one. The procedure of bilateral and multilateral relations, the work in COPUOS, UN organizations for the use

of remote sensing data should be continued in the future. Establishing of an international specialized organization is not a simple task. Nevertheless, the experience of Russian organizations working with all the existing kinds of remote sensing data, including high resolution data, demonstrates significantly higher efficiency in joint and coordinated use of the data, technique and technology. As it was said, this approach allows us to open new horizons for space remote sensing of the Earth surface. Application of this approach on an international scale will lead to much greater effect.

As it is obvious, high resolution Earth remote sensing appeared practically at the same time with the beginning of the space era. Since that time international space law has made considerable progress in the creation of a basis for international cooperation, but provides no specific regulation for particular fields of space activity. Some directions, such as meteorology, space communications, even legal theory and practice of orbital settlements, which appeared much later, have now a much stronger real fundament for cooperation development than does Earth remote sensing.

Basic principles of international space law, despite the significant scientific and technical progress and dramatic changes in international life taking place within a last years, still remain constructive basis for development of progressive industrial models of space activity. All the many years of history for Earth remote sensing, its latest development in the field of high resolution deserves more attention. Having more than thirty year experience it is necessary to apply to high resolution remote sensing international cooperation in all the spheres, for cooperation for peaceful purposes to the benefit of all states, all nations and all people.

## Endnotes

1. See, Doc. A/AC.105/250 and Add.1, A/AC.105/251,A/AC.105/260, A/AC.105/358

2. See, Space News, 1993, 26/4-2/5,v.4, n.17, p.7, Space News, 1996, 11-17/3, v.7,n.10, p.7, New Scientist, 1987, 5/11, v.116, n.1585, p.28,29, Aviation Week & Space Technology, 1987, 2/11, v.127, n.18, p.26,27.

3. Remarks by Admiral William O. Studeman, ADCI Speech, 2/24/95 and General information of EROS Data Center.

4. See, Maxim V. Tarasenko "The Military aspects of the Soviet Cosmonautics", Moscow, 1992 (in russian).

5. Land Remote Sensing Commercialization Act of 1984//Public Law. 98-365 (H.R.5155). 17 July 1984.

6. US President Executive Order on Imagery Declassification, White House, 02/23/95.

7. See, Space News, 1994, 3-9/10, v.5, n.40, p.8,17, Aviation Week & Space Technology, 1995, February 13, v.144, n.7, GIS World, February 1995, p.p.42-47.

8. G.A. Res. 41/65, adopted on December 3,1986, and, see, Doc. A/AC.105/572.

9. See, a proposals of Soviet Union at 1978-1981 sessions of the Scientific and Technical Subcommittee, also review of this issue, see, Doc. A/AC.105/176 and A/AC.105/358

10. Earth Space Review, 1993, v.2, n.4, p.p.20-25.

11. See, supra note 8, at Principle 1(a).

12. See, Aviation Week & Space Technology, 1991, July 13, v.137, n.2, p.p. 46,47,50,51,53-59,61-65, Earth Space Review, 1993, v.2, n.3, p.11-19.

13. See, Space News, 1996, v.7: 17-23/6, n.24, p.p.1,18, 1-7/7, n.26, p.p.1,18, 5-11/8, n.31, p.p.3,35, 12-18/8, n.32, p.2.

14. See, for example, Doc. UN A/S-10/AC.1/7, A/S-15/34, and Doc. of the Conference on Disarmament CD/OS/WP/.39 ( Soviet proposal on creation of International Agency of Space Observation) CD/OS/WP.40 (French proposal on creation of International Satellite Monitoring Agency), CD/PV.410.

15. See, in particular as review E.Kamenetskaya "Outer Space and International Organizations. Problems of International Law.", Moscow, 1980 (in russian).

16. See, Doc. UN A/AC.105/C.2/L.73 of June 26,1970.

17. See, supra note 15 Doc. CD/OS/WP/.39, and CD/OS/WP.40.