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“International Cooperation Opportunities in Space Programmes”

by

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CHAPTER 1 EXECUTIVE SUMMARY

This position paper explores five major topics concerning International Cooperation Opportunities in Space Programmes for Brazil as indicated below with major findings included:

1. *Is it possible to establish, for a 15-year period, countries, space agencies and programmes/projects that might be willing to cooperate with Brazil?*

   The Brazilian Space Programme should include components (or sub-programmes) for space systems, easy access to those space systems' data and products, and enhanced data utilization through sponsorship of appropriate workshops and seminars as well as through a focused education and training programme.

   INPE should make a formal commitment to WMO that its satellite missions should be considered as part of the R&D and/or operational constellations of the GOS.

2. *Which topics/areas seem to be more rewarding for international cooperation to a country like Brazil?*

   Major topic is that Brazil should consider including operational geostationary imaging missions for South America and the Caribbean, operational humidity sounding capabilities in LEO in support of the Global Precipitation Measurement Mission, operational land remote sensing missions with high-resolution imagers and SARs in support of land use and disaster risk management, and demonstration missions within IGeoLab for GEO Microwave.

3. *Which might be the main obstacles for international cooperation to Brazil?*

   If Brazil seeks to establish a new intergovernmental South American organization for the exploitation of environmental satellites, then it should evaluate the EUMETSAT model with the assistance of WMO.

4. *Which international financing sources might be used for international cooperation by Brazil?*

   If Brazil seeks international funding for international cooperation, then it should evaluate the EUMETSAT model with the assistance of WMO. Furthermore, it should evaluate WMO's existing mechanism with the European Commission to develop projects to exploit satellite data and products for Members in Africa since there would be many similarities with comparable projects in South America.

5. *Which "niches" in international cooperation Brazil might fill?*

   Brazil and/or a regional intergovernmental organization should become an operational meteorological satellite operator providing imagery (and sounding) from geostationary orbit for Central and South America.

CHAPTER 2 INTRODUCTION

Background:

This Background Chapter describes the origins of a request for a position paper from the Permanent Representative of Brazil with the World Meteorological Organization (WMO) on behalf of the Center for Management and Strategic Studies in which five specific major topics were indicated for “International Cooperation Opportunities in Space Programmes”. The author’s current responsibilities are summarized in Annex I. A brief status report for WMO’s World Weather Watch (WWW) Global Observing System (GOS) and major activities within the WMO Space Programme are included in Annex II. The status report and major activities are considered relevant to the development of recommendations in the each of the five major topic areas and are thus included in the position paper.

Letter of invitation

By formal correspondence, Dr Donald Ernest Hinsman was invited to develop a position paper on “International Cooperation Opportunities in Space Programmes” for the Center for Management and Strategic Studies (CGEE) in Brasilia, Brazil. The National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais – INPE), located in São José dos Campos, Brazil, of the Brazilian Ministry of Science and Technology, with the cooperation of the Center for Management and Strategic Studies (Centro de Gestão e Estudos Estratégicos – CGEE), located in Brasilia-DF, is developing a Strategic Plan embracing INPE’s policies and activities for the next 5 years and considering a time span of 10 to 20 years ahead. To carry out this project a working plan is being implemented under the guidance of advisors in Strategic Planning and including 10 working (thematic) groups. In this context, it is of fundamental importance to gather qualified and updated information on all aspects related to present and future world demands for space products and services by industry, government, academy and business in general. The position paper concerning International Cooperation Opportunities in Space Programmes for Brazil considers the following major topics:

1. Is it possible to establish, for a 15-year period, countries, space agencies and programs/projects that might be willing to cooperate with Brazil?

2. Which topics/areas seem to be more rewarding for international cooperation to a country like Brazil?

3. Which might be the main obstacles for international cooperation to Brazil?

4. Which international financing sources might be used for international cooperation by Brazil? And,

5. Which "niches" in international cooperation Brazil might fill?

Chapters 3 through 7 address each question with the views and opinions of the author.

CHAPTER 3 IS IT POSSIBLE TO ESTABLISH, FOR A 15-YEAR PERIOD, COUNTRIES, SPACE AGENCIES AND PROGRAMMES/PROJECTS THAT MIGHT BE WILLING TO COOPERATE WITH BRAZIL?

There are neither barriers nor impediments to establish projects and or programmes in which other space agencies and/or countries would be able to cooperate with Brazil spanning a 15-Year period. There are only challenges. The answer is best presented not in the form of "if" but rather "how". There are several options. Three will be explored in more depth in this chapter. The options also cover a spectrum of possible configurations and these will be elaborated from a historical perspective using other space agency's experiences.

First, it would be possible for Brazil to cooperate with another space agency or agencies in the development of a single instrument or a joint collaboration to operate another space agencies. This would not require a change in mandate for Brazil but merely the establishment of a Memorandum of Understanding even without any exchange of funds.

As an example, Brazil could consider establishing a cooperation agreement towards operating a geostationary satellite over South America, noting that the geographical location of Brazil is optimal to benefit from GEO observations. Annex I describes the efforts by NOAA/NESDIS to move GOES-10 to 60 degrees West longitude to provide better temporal coverage over Central and South America. Brazil could enter into an agreement with NOAA/NESDIS to take over operation of GEOS-10. It should be noted that the author has not approached NOAA/NESDIS for such an agreement. However, if Brazil would wish to further explore this possibility, then it could do so unilaterally or WMO would be pleased to assist in such discussions. In so doing, Brazil would gain valuable experience as a geostationary satellite operator. Such a scenario (continued utilization of satellites nearing retirement by other space agencies) has been envisioned by WMO and discussed and endorsed by CGMS. Brazil would also benefit by increased regional responsibilities and its associated required coordination with other countries.

A second possibility for a project in which Brazil could participate with other space agencies in geostationary orbit is through the concept developed by WMO and endorsed by CGMS for an International Geostationary Laboratory (IGeoLab) (Annex III contains a more detailed description of the IGeoLab concept.) Brazil could enter into a partnership for a demonstration mission within the IGeoLab concept. In the case of geostationary coverage over the Americas, there is excess capacity on the future GOES-R platform for demonstration missions. It is understood that CONAE is working on a geostationary imager. Certainly, Brazil has considerable experience in polar-orbit for medium to high-resolution imagers. Either directly with NOAA or through a partnership with CONAE, Brazil could work to establish a geostationary imaging capability for the Americas. While, it is possible that the new GOES-R imager will provide adequate temporal coverage of the Americas, it is not a mandatory requirement. Furthermore, the GOES-10 support activity is based on a satellite that was launched in April 1997 and has already far exceeded its expected end of life. GOES-R scheduled launch is 2014. While any effort by Brazil to embark on a new geostationary imager would in all likelihood not be ready before 2014, unless a concerted long-term plan was developed and implemented, the Americas

would always be dependent on contingency plans and availability of other satellites for operational coverage.

The proposed Brazilian activities described above would further strengthen the recognition by Central and South American countries to have a national or regional space agency with a mandate to meet regional requirements. This could be accomplished through a Brazilian National Space Plan with specific goals for the 15 to 25 year time frame. It is totally realistic for space-faring nations to have national programmes for the betterment of the global community. Each of the present space agencies contributing to the space-based component of the Global Observing System (GOS) do so voluntarily to the best of their ability. Data from space missions are in accordance with WMO Resolution 40 that states free and unrestricted access for essential data. Additional data beyond essential can have qualifications and in the case of satellite data and products, data access is based on an agreement between WMO and the space agency. In the case of EUMETSAT, essential data are declared to be six-hourly imagery and more data are made available on a sliding scale for a country based on GDP per capita. All data for research, climate monitoring, training and natural disasters are free. Since Brazil already has environmental missions .e.g., CBERS series (and has had smaller data collection missions), it is strongly suggested that Brazil make a formal commitment to WMO for access to existing Brazilian missions in accordance with Brazilian data policies. It should be noted that the CBERS series of satellites provide data and products of direct importance to many WMO Programmes including the World Climate Programme and Natural Disaster and Prevention Programme. The present Brazilian satellites are environmental and not operational meteorological in the WMO definition and thus should become a contributor to the R&D constellation.

Recommendation 1: INPE should make a formal commitment to WMO that its satellite missions should be considered as part of the R&D constellation of the GOS.

If INPE's new space policy includes operational (see description of "operational" in the third paragraph below) satellite systems that have guaranteed continuity of service through a replacement policy for a series of satellites, then INPE should become part of the operational constellations (polar-orbiting and/or geostationary).

Recommendation 2: INPE should make a formal commitment to WMO that its satellite missions should be considered as part of the operational constellations of the GOS.

A variant of the second possibility for a project in which Brazil could participate with other space agencies is in Low Earth Orbit (LEO). Brazil already has considerable expertise and experience with LEO satellites through its CBERS series. Additionally, Brazil previously developed a humidity sounder instrument (HSB). Brazil could reinvigorate the development of humidity sounding instruments in a joint project with another space agencies. HSB-Next would be vitally important for participation in the Global Precipitation Measurement (GPM) Mission. GPM depends on a constellation of microwave humidity sounding instruments in order to achieve global three-hourly precipitation rate observations. Brazil could also further expand its efforts for LEO satellites with Synthetic Aperture Radar (SAR) in a joint programme with other space agencies, for example with DLR. Use of SAR data is applicable in many applications

such as cartography, forestry, geology, geomorphology, hydrology, agriculture, disaster management, oceanography, urban studies and security.

With regard to humidity profiles, one of the existing test proposals for IGeoLab includes a demonstration mission in geostationary orbit for a microwave sounder. Brazil already has considerable experience in building a humidity sounder for the polar-orbit. Humidity sounding from the geostationary orbit requires an instrument with a very large antenna (greater than 3 metres) and one that would work in new frequencies higher than utilized in present humidity sounders (greater than 275 GHz). China has indicated a willingness to act as a partner within an IGeoLab context for GEO Microwave and could provide a satellite bus and launch. A partnership between Brazil and China for a GEO Microwave sounder would take advantage of Brazil's expertise and address a known and as yet unfulfilled WMO requirement for high temporal humidity profiles.

The third possibility for Brazil to establish a 15-25 year space plan would be through the establishment of an intergovernmental organization from countries in Central and South America. This approach has been very successfully implemented in Europe by both the European Space Agency (ESA) (an R&D space agency with many areas of interest including environmental satellite systems) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) (an operational space agency dedicated to meteorology and climate monitoring). Here the use of "operational" does not imply that ESA satellites do not operate but rather EUMETSAT develops series of satellites with a guaranteed replacement policy to achieve operational continuity of data, product and services. EUMETSAT is also unique amongst all space agencies contributing to the space-based component of the GOS, in that it is not a WMO Member but has as part of its convention a main article that says EUMETSAT should meet the needs of WMO Members wherever possible. Also, there is a strong connection between ESA and EUMETSAT. For new satellite series, ESA is committed to developing the first satellite and instruments, or at least making a substantial contribution. ESA, as a R&D space agency, has made a firm commitment to WMO Members for access to ERS-1 and –2 and ENVISAT. Future ESA missions, such as ADM-Aeolus are also expected to join the space-based component of the GOS. Formal Working Arrangements exist between both ESA and WMO and EUMETSAT and WMO thus allowing WMO to participate in high level ESA and EUMETSAT meetings and conversely ESA and EUMETSAT in WMO meetings. To establish a new regional intergovernmental organization is a major initiative with political necessities. However, the pooling of resources and expertise at a regional level allows the new intergovernmental organization to approach large and challenging projects that would most probably be too large for individual countries. This was Europe's experience when France found it too difficult to fund the first geostationary satellite alone. Together, EUMETSAT has been most efficient and now is a full service space agency with both operational geostationary and polar-orbiting satellite.

The three possibilities cited above could be undertaken in a progressive manner and in a phased approach. First, work with another space agency to develop a single instrument or operate another space agency's satellite, second enter into a partnership for geostationary or LEO mission(s) and finally establish a new intergovernmental organization.

It should be recognized that a space agency should have explicitly in its charter the need to not only build, launch and operate satellite missions but also to make data available to its user community. For an operational space agency, data access should meet the timeliness requirements of its user community. Additionally, an operational space agency should maximize the utilization of the data and products its satellite missions produce through an active training programme and widespread user involvement. As an example, EUMETSAT has decentralized the production of products based on satellite data into a series of focused Satellite Application Facilities (SAFs). By placing SAFs in recognized Centres of Excellence, data utilization is greatly enhanced. EUMETSAT's SAFs include those for NWP, Climate, Ozone and Nowcasting. All EUMETSAT Members benefit from the concentration of expertise in a few centres of excellence. And due to the Formal Working Arrangement between EUMETSAT and WMO, WMO Members also benefit from SAF efforts and activities.

Recommendation 3: The Brazilian Space Programme should include components (or sub-programmes) for space systems, easy access to those space systems' data and products, and enhanced data utilization through sponsorship of appropriate workshops and seminars as well as through a focused education and training programme.

CHAPTER 4 WHICH TOPICS/AREAS SEEM TO BE MORE REWARDING FOR INTERNATIONAL COOPERATION TO A COUNTRY LIKE BRAZIL?

The most rewarding topics for international cooperation will be those for which Brazilian and regional requirements exist. During June 2005, a Satellite Data Users Workshop for the Earth Observation Partnership of the Americas was held in Buenos Aires, Argentina. Annex IV contains the communiqué from the Workshop that identifies specific regional requirements. In attendance at the Workshop were Directors of NMHS from Central and South America. Noteworthy were two recommendations to explore joint ventures for the development of satellite sensors for the next generation satellites and to develop instruments to be included as payloads onboard future NOAA Missions, and invites other countries of the region to join this endeavour. Clearly, the NMHSs looked towards international cooperation in the field of meteorology. Chapter 3 already highlighted a recognized need for an indigenous capability for an imaging geostationary satellite providing adequate temporal coverage over Central and South America. The WMO vision for the space-based component of the GOS includes not only imaging capability from SEVIRI-like instruments in all geostationary positions but also sounding capability. Hyper-spectral sounding instruments in geostationary orbit have the potential to greatly improve numerical weather prediction through better temporal sampling of meteorological and hydrological processes impacting weather and micro to synoptic scales. The prominence of Brazil when viewed from geostationary orbit guarantees optimum coverage.

A second and as important area that will be rewarding to Brazil for international cooperation will be an expanded programme for land monitoring with medium to high-resolution satellites. The CBERS (or a unique Brazilian) programme should be expanded. Operational requirements for Earth remote sensing data now exist in many application areas, especially for land use and disaster risk management to

include the complete life cycle of disasters (i.e., risk identification, risk transfer and risk reduction) for the entire cycle of DRM (prevention, preparedness, response and relief operations) would be evaluated. There is an emerging and compelling need for an operational disaster risk management series of Earth remote sensing satellites (here "operational" is used in the WMO definition) and thus a constellation of satellites with quick access to critical areas will be required. The present approach by the select few space agencies with high-resolution imagers in disaster events to limit available data based on monetary consideration is not appropriate for those experiencing the disaster. A more rapid approach is required and can only be addressed by a space agency with operational responsibilities.

Recommendation 4: Major topic is that Brazil should consider including operational geostationary imaging missions for South America and the Caribbean, operational humidity sounding capabilities in LEO in support of the Global Precipitation Measurement Mission, operational land remote sensing missions with high-resolution imagers and SARs in support of land use and disaster risk management, and demonstration missions within IGeoLab for GEO Microwave.

CHAPTER 5 WHICH MIGHT BE THE MAIN OBSTACLES FOR INTERNATIONAL COOPERATION TO BRAZIL?

From the viewpoint of a national Brazilian space agency or a new intergovernmental regional space agency, similar obstacles will exist. However, there will be no obstacles for international cooperation from the end-user communities. All obstacles will be organizational. Regardless of a national or a new intergovernmental organization, the ability to convince governments to provide and maintain the required level of funding will be the primary obstacle. If a new intergovernmental organization is to be established, then there will be a need country ratification which can be a long process. In the case of EUMETSAT, this obstacle has been overcome through the use of main programme approvals that span the life cycle of the satellite system. An overall financial envelope is agreed at the country level. Countries commit to providing the annual funding for the duration of the programme. Approval is a long process but once achieved, the programme has country guarantee for financial continuity. Other satellite operators do not benefit from such a strong long-term commitment and that sometimes cause unnecessary expenditures.

A second obstacle will be data policy especially if it will be implemented by an intergovernmental organization. Aligning a data policy for an intergovernmental organization with national policies can be a challenge especially if some members prefer a free and unrestrictive policy versus one that is restrictive.

Finally, for a new intergovernmental organization, staffing (appropriate national representation) and headquarters site will be subject to national scrutiny.

Recommendation 5: If Brazil seeks to establish a new intergovernmental South American organization for the exploitation of environmental satellites, then it should evaluate the EUMETSAT model with the assistance of WMO.

CHAPTER 6 WHICH INTERNATIONAL FINANCING SOURCES MIGHT BE USED FOR INTERNATIONAL COOPERATION BY BRAZIL?

There are several sources for international financing sources that could be utilized for the three cited possible scenarios described in Chapter 3. International financing could be in-kind with existing North American space agencies (NOAA, NASA or CSA). The IGeoLab concept is based on partnership with no exchange of funds. However, a demonstration mission could easily be in the 500 Million USD range when spacecraft, instrument, launch, ground control and data exploitation are included. If five participating space agencies each contribute one portion, the cost could be reduced to 100 Million USD.

Participating as an international contributor has the added advantage of quid pro quo access to other space agency's data. For example, EUMETSAT has Memorandum of Agreement with all the other major space agencies providing data access at no cost in exchange for free access to the other space agency's data even if the GDP per capita indicates a charge should be levied.

The second source of funding could be by international funding agencies for large-scale projects. It is doubtful if the IMF or World Bank would fund a space agency directly. However, they would be interested in funding large projects that benefit capacity building especially in developing countries. As an example, the European Union funded a project called the Preparation of Users of Meteosat Second Generation in Africa (PUMA) that installed high-resolution MSG satellite receivers in every African country. Based on this success, the European Union is now embarking on a follow-on project called African Monitoring of the Environment for Sustainable Development (AMESD). PUMA was a 12 Million Euros project and AMESD will most probably be 21 Million Euros. If international funding agencies were to invest comparable sums for capacity building in Central and South America that would be based on access to environmental satellite data from a Brazilian satellite, then the government of Brazil could be more easily persuaded on the justification for Brazilian satellite missions. Additionally, other national governmental agencies would be potential donors to missions that provided data of value to their mandates, such as agriculture, environmental protection, health, etc.

The third source of international funding would be from members that establish an intergovernmental organization. For demonstration purposes only, I hypothesize the establishment of a South American Organization for the Exploitation of Environmental Satellites. Its membership could include thirteen countries. A scale of contribution would need to be established and followed. One based on GDP has been accepted in other intergovernmental space agencies such as ESA and EUMETSAT. Voting rules would also need to be established. Major programmes would most probably need to be agreed upon by a unanimous decision since the programme length would be for total cost of the satellite over its expected life, or in the case of operational satellites over the life of a series. The former could be a 5-7 year life and the latter 15-20 years. The financial envelope for the overall cost would be agreed and ceilings for unexpected overruns should also be established. EUMETSAT uses 10%. Any overrun exceeding 10% would require unanimous approval. Thus, each member in the intergovernmental organization is protected while at the same time guaranteeing to the space agency the availability of funding for the annual budget. An additional benefit from an intergovernmental organization

is the industrial return to its Members through the development of space industries in the region. An investment in the satellite program is also an investment in a country's industry.

If a consortium of Central and or South American countries were to express an interest to establish a regional space agency, WMO would be pleased to provide more information on its established relationship with ESA and EUMETSAT. The author is also confident that both ESA and EUMETSAT would be equally pleased to interact directly with the consortium in sharing its knowledge and experiences.

Recommendation 6: If Brazil seeks international funding for international cooperation, then it should evaluate the EUMETSAT model with the assistance of WMO. Furthermore, it should evaluate WMO's existing mechanism with the European Commission to develop projects to exploit satellite data and products for Members in Africa since there would be many similarities with comparable projects in South America.

CHAPTER 7 WHICH "NICHES" IN INTERNATIONAL COOPERATION BRAZIL MIGHT FILL?

There are several vitally important areas where Brazil could make a substantial contribution through international cooperation. Before elaborating on several areas, it is necessary to note the process through which WMO Members identify their observational data requirements. The space component of the WWW GOS is based on two primary actions, first a statement of requirements by WMO Members and secondly voluntary contribution by space agencies in meeting those requirements. Observational data requirements also define contingency requirements for operational continuity. The full set of requirements requires cooperation and coordination that must be actively maintained. Annex II describes the various fora in which WMO maintains active dialogue with the space agencies for coordination. The Coordination Group for Meteorological Satellites (CGMS) is the primary forum for coordination issues. If Brazil were to make a formal commitment to the space-based component of the GOS, WMO would recommend to CGMS that Brazil become a member of CGMS and thus help foster the high level of required coordination.

Annex V describes WMO's process for the Rolling Review of Requirements. Observational data requirements are established by WMO Members and compared against expected performances for present and planned observing systems both in situ and space-based. Based on an objective comparison, experts develop a Statement of Guidance for a particular application area. WMO experts then coalesce the set of Statements of Guidance into an implementation plan for the GOS. A database exists with observational data requirements and detailed information can be obtained to further identify potential areas where Brazil could satisfy a niche. From a broad perspective, there are two primary areas that Brazil should consider, first as an operational meteorological satellite operator and second as an operational environmental satellite operator.

The WMO observational requirement goal for imagery from geostationary orbit is 15 minutes. Chapter 3 describes the efforts by NOAA/NESDIS to fill a gap where

imagery over South America is available every 3 hours and not at all during severe weather over the United States. The movement of GOES-10 is deeply appreciated by WMO but it is only a stopgap and not a long-term solution. Brazil and/or a regional intergovernmental organization should become an operational meteorological satellite operator providing imagery (and sounding) from geostationary orbit for Central and South America. The goal for temporal coverage for soundings is 30 minutes and can only be satisfied from geostationary orbit.

It has been said that "Satellites are the best Ambassadors". A contribution by Brazil to the geostationary constellation covering Central and South America would be a highly visible Ambassador.

Since INPE has activities both in satellite development and operation and in applications such as NWP, it would be very appropriate for Brazil, through INPE to pay particular attention to the adequate transition from R&D instruments to operational status. This implies in particular provision for "preparatory missions" to evaluate the operational impact and initiate pilot applications, with close user involvement.

Recommendation 7: Brazil and or a regional intergovernmental organization should become and operational meteorological satellite operator providing imagery (and sounding) from geostationary orbit for Central and South America.

Brazil already has considerable experience with land remote sensing. Although the traditional needs in the past by the meteorological community has not extended into extensive demands for high-resolution land remote sensing data, that has changed and will change dramatically in the near future. Horizontal resolution for the meteorological satellites has moved downscale from 1 km to 250-500 metres. Other application areas are now of significant importance to WMO Members and these application areas have an insatiable need for high-resolution land remote sensing. In May 2003, the Fourteenth WMO Congress established a new major Programme, the Natural Disaster Prevention and Mitigation Programme (NDPM). NDPM has an emerging set of observational requirements for high-resolution data covering the full spectrum of the disaster cycle from preparedness to relief. Agro-meteorology is another emerging application area with a demand for high-resolution data.

WMO is a founding Participating Organization in the Group on Earth Observations (GEO) and its Global Earth Observation System of Systems (GEOSS). There are nine societal benefit areas within GEOSS of which weather, water, climate and natural disasters are four. WMO Members have formally committed its observing systems to be contributors to GEOSS. A contribution through remotely sensed observations to WMO's mandate for weather, water, climate or disasters is a contribution to GEOSS.

At present, there are insufficient land remote sensing satellites to meet revisit times in a rapidly changing world especially for agriculture and forest management.

A third area that a Brazilian space agency could make a substantial contribution is by serving as a Data Collection and Processing Centre for WMO's Integrated Global Data Dissemination Service as described in Annex II. While there are plans by Brazil to consolidate ATOVS soundings as part of a Regional ATOVS Retransmission

Service (RARS), at present, there is no DCPC in the South America region with an established DCPC contributing to reducing the timeliness of global data to less than 30 minutes. ATOVS soundings made off the coast of New Zealand are available to ECMWF in less than 30 minutes. Improvements in forecast skills are already being realized due to the improved timeliness. The WMO goal is to have complete global coverage by a set of contributing DCPCs. It should be noted that as a contributor to IGDDS, Brazil would also be a contributor to the new WMO Information System (WIS).

As an established space agency, Brazil would also seek to increase the utilization of satellite data and products through education and training. WMO's Virtual Laboratory for Education and Training in Satellite Meteorology (VL) is based on the concept of a small set of recognized "Centres of Excellence" co-sponsored by a space agency contributing to the space-based component of the GOS. WMO seeks to have a Centre of Excellence in each of the major WMO languages. Brazil has agreed to serve as a Portuguese-speaking Centre of Excellence as part of the VL and the recent Extraordinary session of the Commission for Basic Systems (CBS Ext 2006, 9-16 November 2006) approved VL expansion. It will be a major contribution for capacity building in the region. INPE should continue its efforts as a VL Centre of Excellence and expand its potential throughout South America. In so doing, it will further strengthen its potential to contribute to the international community especially in South America as well as to the global community.

ANNEX I

Current responsibilities of the author

Dr Donald Ernest Hinsman received his Doctor of Philosophy in Meteorology from the U.S. Naval Postgraduate School in 1982. He is presently the Director of the WMO Space Programme at the World Meteorological Organization in Geneva, Switzerland where he has responsibility for implementation of the WMO Space Programme as described in its Implementation Plan as approved by the WMO Congress. Additionally, he is the principal coordinator within the WMO Secretariat with all relevant WMO Programmes, Technical Commissions and Regional Associations for the planning and implementation of the intergovernmental Global Earth Observation System of Systems (GEOSS) including interactions and negotiations with countries, the GEOSS Secretariat, other intergovernmental organizations, international organizations and non-governmental entities.

As the Director of the WMO Space Programme, he is responsible for activities related to the establishment of the space component of a single integrated WMO global observing system comprised of all existing WMO observing components both in situ and space-based in all WMO sponsored and co-sponsored Programmes and in so doing he coordinates with space agencies contributing, or with the potential to contribute, to the space-based component of the World Weather Watch's Global Observing System (GOS). In October 2002, Dr Hinsman was awarded the Russian Federation's prestigious "World's First Cosmonaut Yuri A. Gagarin Gold Medal" by the all-Russian public organization Cosmonautics Federation of Russia (FKR) "for significant contribution to the development of the Global Satellite Observing System and consolidation of the international cooperation in the field of Satellite Meteorology".

ANNEX II

WMO Global Observing System, space-based sub-system

The WWW's GOS space component is comprised of three types of satellites: operational meteorological polar-orbiting and geostationary, and environmental Research and Development (R&D) satellites. With regard to both polar-orbiting and geostationary meteorological satellites, they remain the mainstay for WMO NMHSs through the provision of invaluable data, products and services including imagery, soundings, data collection and data distribution. In particular, the present operational meteorological satellites include the following geostationary and polar-orbiting missions: GOES-11, GOES-12, NOAA-17 and most recently NOAA-18 operated by the United States; MTSAT-1R operated by Japan; METEOR-3M N1 operated by the Russian Federation; Meteosat-5 and Meteosat-8 (formerly MSG-1) operated by EUMETSAT; INSAT-3A operated by the Indian Meteorological Department and FY-2C and FY-1D operated by China. Additional satellites in orbit include: GOES-9, GOES-10, GOES-13 (in commissioning) NOAA-15 and NOAA-16 operated by the United States; Meteosat-6, Meteosat-7 and Meteosat-9, and Metop-A (launched 19 October 2006) operated by EUMETSAT; and KALPANA-1 operated by India. With regard to R&D satellites, NASA's Aqua, Terra, TRMM, NPP, QuikSCAT and GPM missions, ESA's ENVISAT, ERS-1 and ERS-2 missions, JAXA's GCOM series, data from Rosaviakosmos's research instruments on board ROSHYDROMET's METEOR 3M N1 satellite, as well as on its future Ocean series and CNES's JASON-1 and SPOT-5, either are, or will be after launch, part of the R&D constellation. The most recent additions to the space-based component of the GOS is HY-1B satellite to be operated by the China National Space Administration (CNSA). All satellite operators contributing to the GOS are also members of the Coordination Group for Meteorological Satellites (CGMS). The nominal space-based component of the GOS comprised of three constellations (operational geostationary; operational polar-orbiting; and R&D satellites) is shown in Figure 1.

It should be noted that NOAA/NESDIS has initiated activities to move GOES-10 to 60 degrees West in order to enhance coverage of Central and South America. By significantly improving satellite detection of such natural hazards as severe storms, floods, drought, landslides, and wildfires, the move would help to protect lives and property in Central, the Caribbean and South America. GOES-10, once operational in its new position, would provide for imagery data as frequently as every 15 minutes. With the move of GOES-10 and its increase in temporal resolution over South America the space-based component of the GOS would now meet the full set of WMO global requirements.

User interface and coordination

On a more technical level and to ensure direct connections to various user communities, WMO participates in the Space Frequency Co-ordination Group (SFCG) as an observer, the International Precipitation Working Group (IPWG), the International Winds Workshop (IWW) and the International TOVS Working Group (ITWG). WMO co-sponsors sessions of the IPWG, IWW and ITWG. Each group has a Rapporteur that reports through WMO to the Coordination Group for Meteorological Satellites (CGMS).

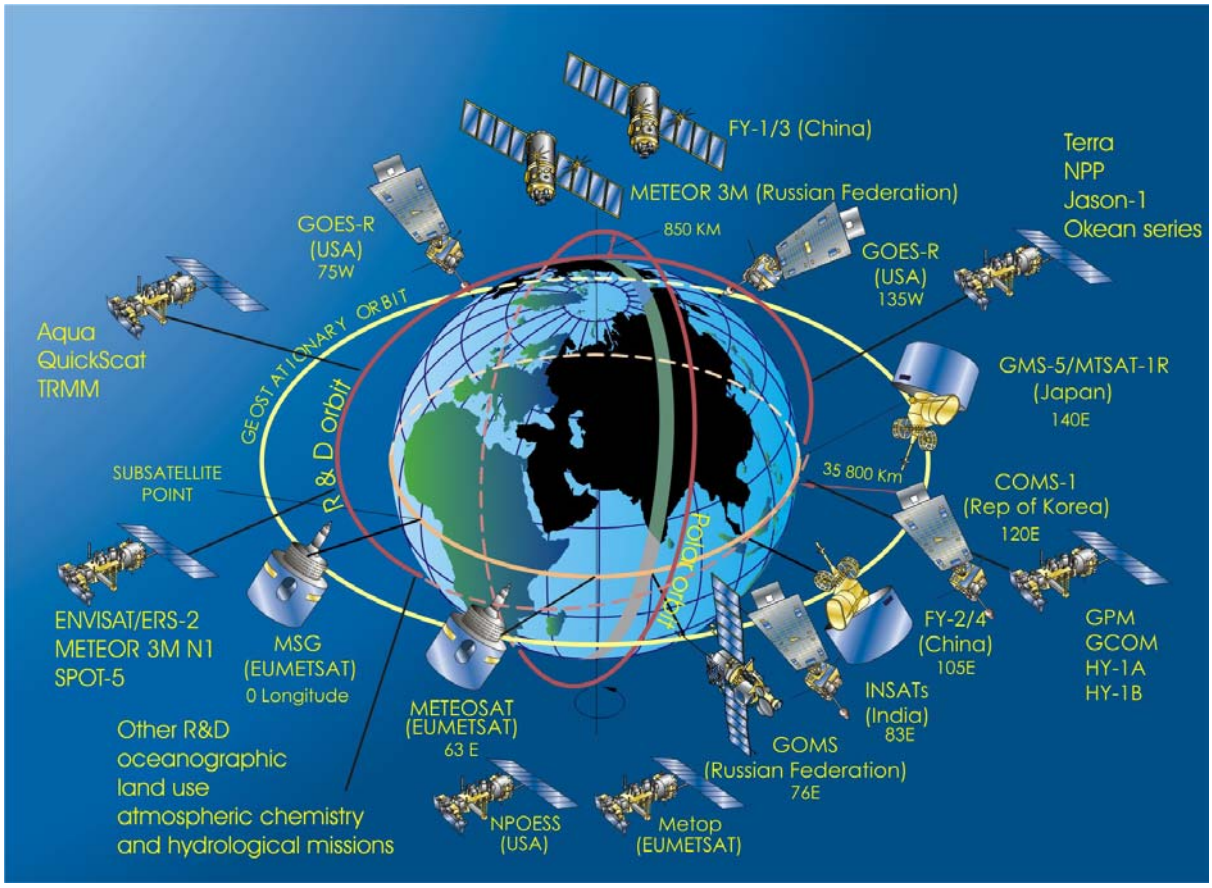

Figure 1 Space-based component of the Global Observing System

Space agency interface and coordination

In order to promote closer and more effective cooperation with international bodies WMO places particular emphasis on its participation in:

- CGMS; and,
- WMO Consultative Meetings on High-level Policy on Satellite Matters (established by the Fourteenth WMO Congress).

These two fora, together with any subsidiary working group, play a central role in the coordination and implementation of the WMO Space Programme, and in discussions on the future evolution of the space-based component of the GOS.

In order to ensure the maximum degree of international alignment with the objectives of the WMOSP, WMO also places considerable emphasis on its participation in the Committee for Earth Observations (CEOS) and the Integrated Global Observing Strategy (IGOS) Partnership.

Co-ordination of Geostationary Meteorological Satellites (CGMS) [Co-ordination Group for Meteorological Satellites]

In 1972 a group of satellite operators formed the Co-ordination of Geostationary Meteorological Satellites (CGMS) that expanded in the early 1990s to include polar-orbiting satellites and changed its name – but not its abbreviation – to the Co-

ordination Group for Meteorological Satellites. The Co-ordination Group for Meteorological Satellites (CGMS) provides a forum for the exchange of technical information on geostationary and polar orbiting meteorological satellite systems, such as reporting on current meteorological satellite status and future plans, telecommunication matters, operations, inter-calibration of sensor, processing algorithms, products and their validation, data transmission formats and future data transmission standards. At the beginning of the new millennium, CGMS further expanded it membership to include those R&D space agencies with formal commitments to the WWW GOS. Thus CGMS now represents all space agencies contributing to the WWW GOS.

Since 1972, the Co-ordination Group for Meteorological Satellites (CGMS) has provided a forum in which the satellite operators have studied jointly with the WMO technical operational aspects of the global network, so as to ensure maximum efficiency and usefulness through proper coordination in the design of the satellites and in the procedures for data acquisition and dissemination. The specific design of each of the satellites is based on national and regional requirements for data and services and, therefore, some differences in design and mission are inevitable. However, the regular meetings of the group have permitted a gathering and exchange of results during the course of the development of each system and a considerable measure of coordination has been achieved.

WMO Consultative Meetings on High-level Policy on Satellite Matters

The Fourteenth WMO Congress agreed to build a new and closer partnership under the auspices of WMO between the meteorological and hydrological services and environmental satellite communities. It agreed that a mechanism for such discussions should be provided through the convening of Consultative Meetings on High-level Policy on Satellite Matters. Congress was convinced that the now established dialogue between WMO and the environmental satellite communities in the sessions of the Consultative Meetings had matured rapidly to the great benefit of all and that they should be continued and institutionalized. Thus, Congress considered it appropriate to institutionalize the sessions as WMO Consultative Meetings on High-level Policy on Satellite Matters in order to establish more formally the dialogue and participation of environmental satellite agencies in WMO matters.

Congress was unanimous in that the WMO user community should be represented at the highest level at the sessions and that the space agencies should also be represented by their Directors. Future sessions of the Consultative Meetings on High-level Policy on Satellite Matters should be chaired by the President of WMO as had been the case for the first three sessions. The Consultative Meetings would continue to provide advice and guidance on policy-related matters and would maintain a high level overview of the WMO Space Programme. Congress agreed that Commission for Basic Systems (CBS) should continue the lead role in full consultation with the other technical commissions for the new WMO Space Programme.

Global space-based inter-calibration system (GSICS)

The goals for an operational Global Space-based Inter-calibration System (GSICS) are to improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of the space

component of the WWW's GOS and to provide for the ability to retrospectively re-calibrate archive satellite data climate studies.

A GSICS objective is to quantitatively relate radiances from different sensors viewing the same target to allow consistent measurements to be taken over the globe by all elements of the space-based observing system. The establishment of an operational global space-based inter-calibration system also provides a means to retrospectively inter-calibrate satellite data.

The thirty-third session of the Co-ordination Group for Meteorological Satellites (CGMS-XXXIII) reviewed the concept and strategy for an operational GSICS. CGMS Members agreed that an Implementation Plan for GSICS should be developed. CGMS-XXXIII established a Task Force led by NESDIS with participation by EUMETSAT, JMA, CMA and assisted by the WMO Space Programme to prepare a draft Implementation Plan for GISICS. A first meeting of the Task Force was held on 15-16 March 2006, hosted by EUMETSAT and a draft Implementation Plan was prepared. On 23 June 2006, the GSICS Implementation Plan was adopted by CMA, EUMETSAT, JMA, NOAA and ROSHYDROMET and formal commitments made to contribute to its implementation. The Plan was formally approved by CGMS-XXXIV in November 2006. An Executive Panel was nominated and met on 11-13 October 2006 in Geneva to start developing the GSICS Operational Plan defining detailed technical activities for the first years of operation, starting in 2007. GSICS will become a new component of the space-based sub-system of the GOS, in addition to the constellations for GEO, LEO and R&D satellites.

Data access through the Integrated Global Data Dissemination Service (IGDDS)

The fifty-seventh session of the WMO Executive Council (EC-LVII) held in June 2005 noted that the EUMETSAT ATOVS Retransmission Service (EARS), as an Advanced Dissemination Method (ADM), had increased real time access (within 30 minutes) to ATOVS data three- to four-fold in much of the Northern Hemisphere. Near real time access to ATOVS data was important for WMO Members with NWP capability. EC-LVII recalled that the WMO Space Programme Implementation Plan contained a description of an IGDDS that would connect regional ADMs into a global service. The first CGMS/WMO Regional ATOVS Retransmission Service (RARS) workshop had been held on 16-17 December 2004 and hosted by EUMETSAT at its Headquarters in Darmstadt, Germany to discuss possibilities towards the development of Regional ATOVS Retransmission Services (RARS) and IGDDS. At the workshop, a number of currently unfulfilled user requirements for ATOVS data were identified around the globe. In order to meet some of these unfulfilled user requirements, EC-LVII agreed that at least two RARS (South American RARS; and Asia-Pacific RARS) should be further considered and developed. The Council was informed that the People's Republic of China would continue its cooperation with other WMO Members towards the establishment of a RARS in the Asia-Pacific region. JMA noted that it would also continue its efforts to establish the Asian-Pacific RARS including the insertion of satellite data into the GTS and possible reception of satellite data from its station in Antarctica. EC-LVII also noted that IGDDS had the potential to be a core component of GEOSS as described in the following axioms.

Also in June 2005, a High-Level Meeting of Heads of NMHSs in RA III (South America) agreed, in principle, to establish a RARS in RA III that could serve as the core for an ADM in RA III. Almost simultaneously, a meeting of the Asia Pacific

Satellite Data Exchange and Utilization (APSDEU) agreed, in principle to establish a RARS in the Asia Pacific. In September 2005, Argentina hosted a meeting towards further development of the RA III RARS.

A WMO Expert Team meeting in October 2005 emphasized the need to proceed with the implementation of the regional ADMs. Since Europe, Africa and North Atlantic were already covered by the EUMETCast service operated by EUMETSAT, it was highly advisable to aim for an operational implementation of the remaining ADMs for the other regions by 1 January 2007. The implementation of an ADM in the Asia-Pacific Region was seen as the next priority for implementation because in that area different satellite systems existing or were planned (e.g., FY-2, MTSAT, Korean COMS). A single dissemination system would be a distinct advantage to RA II and RA V Members, where a large user community could take benefit of these different systems at minimum cost and effort.

The second CGMS/WMO global RARS Workshop was held in Geneva in December 2005. Major steps were taken towards the implementation of a RARS in South-America and in the Asia-Pacific area. As concerns the South American RARS, both the architecture and the implementation schedule for the South American RARS starting with a pilot RARS in 2006 and a fully operational RARS by the end of 2007 had been agreed. With regard to the Asia-Pacific area, a target implementation schedule was adopted with a pilot RARS established by April 2006 and an operational RARS by June 2006. The draft GEOSS Work Plan for 2006 contains explicit reference to IGDDS. In particular, Task WE-06-04, as part of the Weather Societal Benefit Area, is to "support the development of Advanced Dissemination Methods (ADM) as part of an operational Integrated Global Data Dissemination Service (IGDDS) as a component of the WMO Information System (WIS). Substantial and rapid progress has been made during the last months on issues related to RARS, ADM and IGDDS implementation, thanks to the very active contribution of WMO Members and satellite operators, as well as close interactions with other relevant WMO Programmes and Secretariat Departments. ADMs were now operational in Europe, Africa and soon parts of South America through EUMETCast. A test phase is planned for early 2007 (?) in the Asia Pacific region. Plans are in place for ADM to be established in North, Central and South America by NOAA with initial operational capability in 2006/2007 and full operational capability by the end of 2007. WMO has established a goal for full global coverage by the beginning of 2007. Implementation and coordination groups are in place to develop standards and data exchange requirements, and a commitment exists to establish a global system. Thus, the specific role of the WMO Space Programme in respect of IGDDS will continue to be:

- to assist in the planning and to monitor and facilitate the implementation of the various components of IGDDS;
- to ensure that IGDDS addresses global and regional data access requirements from all WMO Regions and for all WMO and supported Programmes;
- to support harmonization and the adoption of standards as appropriate towards achieving a globally coordinated system, to ensure in particular that IGDDS serves in the broader framework of the WMO Information System.

Enhanced Data Utilization through Education and Training

The Virtual Laboratory for Education and Training in Satellite Meteorology (VL) is a collaborative effort between five operational satellite operators and seven training centres (five are WMO Regional Meteorological Training Centres). Two research and development satellite agencies are also members of the VL. The concept of a Virtual Laboratory was initially developed during a 1995 Regional Satellite Training Seminar at the RMTC in Costa Rica. In 2001, the twenty-ninth session of the Co-ordination Group for Meteorological Satellites (CGMS-XXIX) formally adopted the VL as a joint WMO-CGMS initiative to improve the utilization of satellite data and products by WMO Members and became the core component of the WMO Strategy for Education and Training in Satellite Meteorology. In May 2003, the Fourteenth WMO Congress (Cg-XIV) expressed its pleasure with the VL. The Virtual Laboratory had already made a tremendous impact throughout WMO Regions through its six "centres of excellence". Congress was pleased to see the integration of the new R&D constellation into education and training activities. The activities and direction of the Virtual Laboratory are overseen by the Virtual Laboratory Management Group (VLMG) that is composed of at least one representative from each partner. The VLMG elects two Co-chairs, one from a satellite operator and one from a Centre of Excellence.

Firm plans were developed for the global or High Profile Training Event held 16-27 October 2006, in conjunction with the APSATS workshop in Melbourne, and the Regional Training Seminar in Nanjing. Conceptually the HPTE worked on three levels:

- providing a focus for a number of face to face training events around the globe;
- Linking the face to face events for some sessions (global image discussion and key presentation(s);
- providing a mix of face to face and online training with the NMSs in the area of each Centre of Excellence.

The HPTE demonstrated strengthen networking between the various Centres of Excellence around the globe. It not only involved the VL partners but also three science groups (IWWW, ITWG and IPWG) and other interested parties. An IPWG workshop that was conducted in Melbourne at the same time as the APSATS workshop provided key lectures to APSATS participants.

ANNEX III

IGEOLAB

Monitoring of the Earth's environment is an international endeavour. No one nation has the observational systems necessary to provide the data it needs for its environmental monitoring and prediction operations. In the past decade, and even more so in the coming decades, satellite remote sensing contributions to the space-based component of the World Weather Watch's Global Observing System (GOS) are being and will be made by an increasing number of international partners. The collaboration and coordination among the international satellite community continues to increase.

The geostationary orbit is most often used to achieve high temporal resolution; it allows frequent measurements over the same region necessary for nowcasting and synoptic meteorology applications. The geostationary view allows the dynamics of rapidly developing storm systems to be observed, the wind distribution to be defined, and the interaction with synoptic weather patterns to be described. Over 40 times higher than a polar orbit, achieving the geostationary orbit is technically more challenging and requires greater financial investments. This makes geostationary demonstrations of new capabilities imperative; the necessary research and development must be demonstrated to assure success in operational geostationary satellite applications.

The International Geostationary Laboratory (IGeoLab) developed out of a need to address the requirements expressed by CBS while recognizing that demonstration missions to date have not yet materialized. The IGeoLab concept is focused on sharing the benefits of geostationary demonstration missions across several space development agencies, operators of operational meteorological satellites, and users.

The fifty-seventh session of the WMO Executive Council (EC-LVII) held in June 2005 agreed that the IGeoLab was of utmost importance to: space agencies; WMO Members' NMHSs and user communities; as well as to the further growth and enhancement to the space-based component of the Global Observing System (GOS). Such further growth would also increase the WMO Space Programme's importance to WMO Members.

During 2005, the WMO Space Programme Office has been involved in facilitating the development of two test proposals for IGeoLab, specifically on GIFTS (Geostationary Imaging Fourier Transform Spectrometer), an IR temperature-humidity sounder, and on GEO-Microwave, a demonstrative mission for frequent precipitation observation from geostationary orbit by millimetre-submillimetre wave radiometry. There have been three focus group meetings, one for GIFTS and two for GEO-Microwave.

The IGeoLab GIFTS test proposal achieved considerable progress at the 1st Focus Group meeting held in June 2005. Specifically, the importance of a GIFTS space mission for the development of the next generation satellite component of the WMO World Weather Watch Global Observing System, particularly in the context of the GEOSS, was reaffirmed by all space agency participants. Moreover, considerable progress had been made in the GIFTS instrument completion, with ground tests of the instrument soon to be underway to demonstrate the radiometric measurement capabilities of this revolutionary remote sensing technology. Technical discussions

at a meeting held in Moscow in October 2005 between personnel of the Space Dynamics Laboratory (responsible for the instrument) and representatives from the Russian Federation's RosKosmos, TSNIIMash, Planeta Science and Research Center and Lavochkin Association concluded that, from a technical viewpoint, it was feasible to accommodate GIFTS on Elektro-L, provided that a number of activities were quickly embarked upon. In addition to working on the platform, work was also necessary on the payload since the currently available Engineering Demonstration Unit (EDU) was not suitable for flight. At the first meeting of the IGeoLab GEO Microwave Focus Group held in June 2005, WMO, EUMETSAT and NOAA identified a strong requirement for frequent precipitation observation, in the framework of their respective process of defining the WMO observational data requirements, and the Meteosat Third Generation and GOES-R missions. The 2nd meeting of the GEO Microwave Focus Group held in October 2005 reviewed scientific advancements and challenges and noted that GOMAS was an ESA Earth Explorer candidate and final selection amongst all the candidates would be made in mid-2006. WMO has encouraged ESA to give positive consideration to GOMAS as an important new instrument for demonstration in geostationary orbit that would help meet very important WMO observational requirements. The two test proposals have made considerable progress and positive results may soon be achieved.

ANNEX IV

Earth Observation Partnership of the Americas – Satellite Data Users Workshop
Buenos Aires, Argentina
2-3 June 2005

"Toward Further Cooperation on Environmental Data in the Americas"

At the Earth Observation Partnership of the Americas (EOPA) Satellite Data Users Workshop in Buenos Aires, Argentina on 2-3 June 2005, the participants agreed to the following lines of action:

1. The formation and growth of Earth observation partnerships in the Western Hemisphere will promote the successful development of the Global Earth Observation System of Systems (GEOSS). Regional partners commit to continue their work to enhance availability of and access to data and information from their respective Earth observing systems, both satellite and in situ.

2. Remote-sensing Earth observing systems perform a critical role in meeting the research and operational requirements of users in the Americas, and as new generations of satellite systems are developed, there is a need to upgrade and improve the ground systems to receive, process and archive the data and train users of the data, and also to upgrade and improve the data communication and distribution systems. To that end, regional partners recommend:

   - Provide guidance as to the need for upgrades to ground equipment and training for the next generation of satellites.

   - Recognizing the importance of strengthening human resources for Earth observation, in the ground stations and monitoring networks as an indispensable complement of GEOSS.

   - Explore joint ventures for the development of satellite sensors for the next generation satellites.

   - Argentina expresses its intention to develop instruments to be included as payloads on-board future NOAA Missions, and invites other countries of the region to join this endeavour.

3. In order to share data resources and create linkages between these two environmental data centre of the Americas, EOPA participants will work in partnership with meteorological data users of the Costa Rica ground station, with the non-meteorological users of CCAD of the Central American Environmental Information System currently located in Panama, where the SERVIR visualization and monitoring component has been implemented, as well as with satellite receiving stations of the Montevideo Group University Association (AUGM). This could be an effort that can be replicated in other areas of the Americas.

4. EOPA participants will work in partnership with other data users to ensure the ongoing utilization of satellite resources throughout their complete operational

life cycle. EOPA participants, specifically RA III national meteorological and hydrological services have requested that NOAA consider the possibility of operating a retired geostationary satellite over South America to ensure data availability when the operational satellite's observations are limited during extreme weather events. A separate one page recommendation will be sent to NOAA.

5. The promotion of these partnerships will increase the education, training, scientific exchange, and related environmental sustainable development efforts with other agencies and organizations of the region. In the case of meteorological data users, NOAA and other space agencies will work closely with the WMO on training issues.

6. Partnership efforts to improve the quality and quantity of *in situ* and upper air observations reported by WMO members will contribute to improve medium and long-range weather forecasts using the global and Ensemble models.

7. EOPA participants should partner to develop a robust, cost-effective, and timely system for the communication of Earth observation data.

8. Education and training are key for effective use of satellite data. Fostering education and training is a regional necessity that must receive priority support from governments and international scientific organizations.

ANNEX V

WMO's Rolling Review of Requirements Process

Background

The CBS Working Group on Satellites (WG-SAT) established a procedure whereby the WMO can assess how well satellite capabilities meet their user requirements. Pursuing that work the Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS) within the Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) of the Commission for Basic Systems (CBS) has been continuing the collection of the requirements for observations to meet the needs of all WMO Programmes and also cataloguing the current and planned provision of observations from environmental satellites and *in situ* systems. The database resulting from these efforts is called the Database on User Requirements and Observing System (Space and *In situ*) Capabilities. The ET-ODRRGOS has been following a procedure called the Rolling Requirements Review (RRR) within which user requirements and observing system capabilities are compared in an objective way using analysis tools established for the purpose. This Critical Review is conducted for each application area and precedes the drafting of a Statement of Guidance. CBS has requested that ET-ODRRGOS document the review process in order to maintain a heritage as well as an ability to provide feedback to the technical commissions.

ET-ODRRGOS is starting a RRR of space based and *in situ* observing systems. This document records the initial Statements of Guidance (SOG) concerning the results of the combined observing system RRR.

Purpose of the Statement of Guidance (SOG)

The SOG, together with the output of the Critical Review, is intended:

- to inform WMO Members on the extent to which their requirements are met by present systems, will be met by planned systems, or would be met by proposed systems. It also provides the means whereby Members, through the Technical Commissions, can check that their requirements have been correctly interpreted and can update them if necessary, as part of the Rolling Requirements Review process;

- to provide resource materials useful to WMO Members for dialogue with satellite and other agencies regarding whether existing systems should be continued or modified or discontinued, whether new systems should be planned and implemented, and whether research and development is needed to meet unfulfilled aspects of the user requirements.

Rolling Requirements Review (RRR)

The RRR procedure consists of four stages:

(i) a review of users' requirements for observations, within areas of applications covered by WMO programmes,

(ii) a review of the observing capabilities of existing and planned satellite and *in situ* systems,

(iii) a "Critical Review" of the extent to which the capabilities (ii) meet the requirements (i); and,

(iv) a "Statement of Guidance" based on (iii).

Activities (i), (ii) and (iii) have been undertaken within CBS/OPAG-IOS/ET-ODRRGOS, in consultation with related activities of the Global Climate Observing System's (GCOS) Global Observing System Space Panel (GOSSP) and CEOS. Only a selected number of application areas have been addressed; many applications remain to be analyzed by the ET-ODRRGOS and other expert groups.

Results from RRR

The RRR

- has generated a database compendium of WMO user requirements and observing system capabilities that is proving useful to a broad community;

- has addressed both *in situ* and satellite observing systems;

- identifies gaps and overlaps in existing and planned observing system capabilities, and indicates the user requirements satisfied by these satellite systems;

- strives to address user requirements in a technology free way giving little consideration to measurement characteristics, observing platforms, or data processing systems; and

- offers some cost benefit considerations, but does not include cost in the review process.

Guidelines relating to the Statement of Guidance (SOG)

The SOG:

- relies on interpretation and analysis by observing system and applications experts;

- is guided by the critical review of the database of user requirements compared with satellite and *in situ* system capabilities; and

- sets out the role for satellites, balloons, aircraft reports, buoys, ships, etc., without pre-empting judgements on the best or most cost-effective mix of observations.

Scope and Limitations

It is recognized that guidance provided by WMO to satellite and other agencies will be only one of many inputs affecting their decisions on future systems, which will be required to

meet national or regional objectives and will be constrained by available resources. However, it is hoped that guidance at this level will be helpful in promoting an integrated global observing system that provides the maximum benefit to the WMO Members.

It is not intended that the process of reviewing requirements and providing guidance in this way should replace the need for detailed activities on the design of instruments and systems, but rather that general guidance should be provided on the users' requirements for these systems. The detailed specification of instruments and systems will remain a task for relevant agencies, with appropriate technical advice from specialists in the user community.