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A Position Paper Prepared for the
The Center for Management and Strategic Studies (CGEE) – Brasilia – DF, Brazil
and The National Institute for Space Research
(Instituto Nacional de Pesquisas Espaciais) – INPE of Brazil

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INTERNATIONAL COOPERATION OPPORTUNITIES IN SPACE PROGRAMS FOR BRAZIL

A Position Paper Prepared by

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INTERNATIONAL COOPERATION OPPORTUNITIES IN SPACE PROGRAMS FOR BRAZIL

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1.0 Introduction

The National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais – INPE) in cooperation with The Center for Management and Strategic Studies (Centro de Gestão e Estudos Estratégicos – CGEE) has undertaken to develop a Strategic Plan that particularly covers INPE's policies and activities for the next 5 years. Wisely, this strategic planning process also targets the longer term and also looks 10 to 20 years ahead. This planning process has been divided into ten areas and in this particular case this Position Paper covers the area of international cooperation. The topic of international cooperation is of fundamental importance to INPE since space projects are by their very nature international in scope. Further, scarce resources available for space exploration, research and applications can in many cases be more wisely invested if human and financial resources are spread among international partners.

At this time the following space program are active around the world: Argentina, Brazil, Canada, China, Europe (ESA), France, Germany, India, Italy, Indonesia, Korea, Malaysia, Pakistan, Spain, Russia, Taiwan, Ukraine, and the United States. Some of these programs are more limited than others, but all of the above have annually funded and separately managed space program.

In addition to these national space programs new commercial space ventures have emerged in recent years and offer new ways for INPE to find international partners for future space programs. Working with such commercial partners may lower cost, shorten the schedule for planning and launch, and provide much more flexibility than was the case with past international cooperative programs. Also there may be new opportunities for cooperation with countries with space programs that have parallel goals and objectives, such as nations like the Republic of Korea.

After coordination with INPE and CGEE it was agreed that the major topics that would be considered in this Position Paper include:

- Is it possible to establish, for a substantial period of time—extending up to 15-years - partnerships with countries, space agencies and programs/projects (including commercial and academic ventures) that might be willing to cooperate with Brazil?

- Which topics/areas seem to be more rewarding for international cooperation to a country like Brazil?
- Which might be the main obstacles for international cooperation to Brazil?
- Which international financing sources might be used for international cooperation by Brazil?
- Which "niches" in international cooperation Brazil might fill?

2.0 Methodology

Strategic Planning is unlike forecasting, heuristic or scientific modeling, and other forms of extrapolative projections. Strategic planning is concerned with setting new goals for the future and finding ways to achieve these goals. Thus strategic planning is very much what might be called a “normative” process. In short it is about “Where do we want to go and how do we get there?” One starts with an envisioned future and then works backwards to develop a strategy to get to the desired end. This is the reverse of forecasting where you will go if current trends continue.

Thus instead of using a variety of forecasting techniques to assess where your organization is currently going, and then devising projections of where you will be in five years or ten years, we do the exact opposite.

In short, strategic planning is concerned with defining new goals and strategies to achieve these new objectives by doing things differently.

Thus a strategic plan undertakes to develop new plans, methods and technologies in order attain these new goals. This is not to say that new goals cannot or should not be achieved by building on the base of past accomplishments or current strengths.

Strategic plans must also be tied to reality. Goals that are unrealistic and without credible strategies to achieving them are ultimately of no value. Also the strategic plans that succeed are usually the ones that have a high degree of input from within the organization after considering fresh ideas from outside. It is important that new plans have substantial input from within the organization or the “Strategic Plan” becomes the unrealistic dreams of the outside agency or strategic planning team that devised unrealistic goals.

In the case of setting new goals in the area of international cooperation one must have a clear idea of what other space organizations and entities want. Thus one needs to seek understanding of the strategies and goals of these potential partners and what challenges they perceive in meeting their own goals and objectives.

This may be the most difficult element of strategic planning because one must consider not only what space technologies, sciences and applications are of the greatest interest to Brazil, but also consider what are the strategic needs of its potential partners going forward. In short, an analysis of opportunities must examine if the technical, operational, applications or scientific payoff are sufficient to warrant the time and resources that would be required by both Brazil and its potential partners to participate.

An analysis of substantive goals and objectives with regard to technology, exploration, scientific goals and new and improved applications from both the perspective of Brazil and potential partners along the lines of that set forth above should be carried out not only with regard to other space agencies, but also with international space programs, academic organizations and universities, research programs and even private space ventures. It is particularly important to stress the potential of governmental-private cooperative space ventures across international boundaries, given the fact that private space entities now have clearly in mind to engage in the sub-orbital and orbital space tourism business beginning in 2008-2009.

Further, private organizations such as Space X and Rocketplane-Kistler plan to provide Commercial Orbital Transportation Services to the International Space Station in 2008-2009 while other entities plan to launch international space stations (i.e. Bigelow Aerospace) or construct a space elevator using the latest in nano-tube technology and climber robots (The Space Elevator Corporation). In short, cooperation with private ventures may be as productive as cooperation with traditional space agency partners in terms of payoffs in relation to the cost, human resources, and speed of completion of cooperative projects. Likewise cooperation with universities or international agencies involved in space science, technology, or applications can also pay dividends. Two of the most likely new partners might be the Surrey Space Center, associated with the University of Surrey in the United Kingdom, and the Smallsate program at Utah State University.

Within the confines of this Position Paper the ability to assess specific projects in depth is not possible. Nevertheless a couple of potential international projects are provided as examples (see attachments to this study) using the following analytic process. (See Figure 1).

Figure 1

Mapping Space Technologies, Processes, Sciences and Applications for International Cooperation

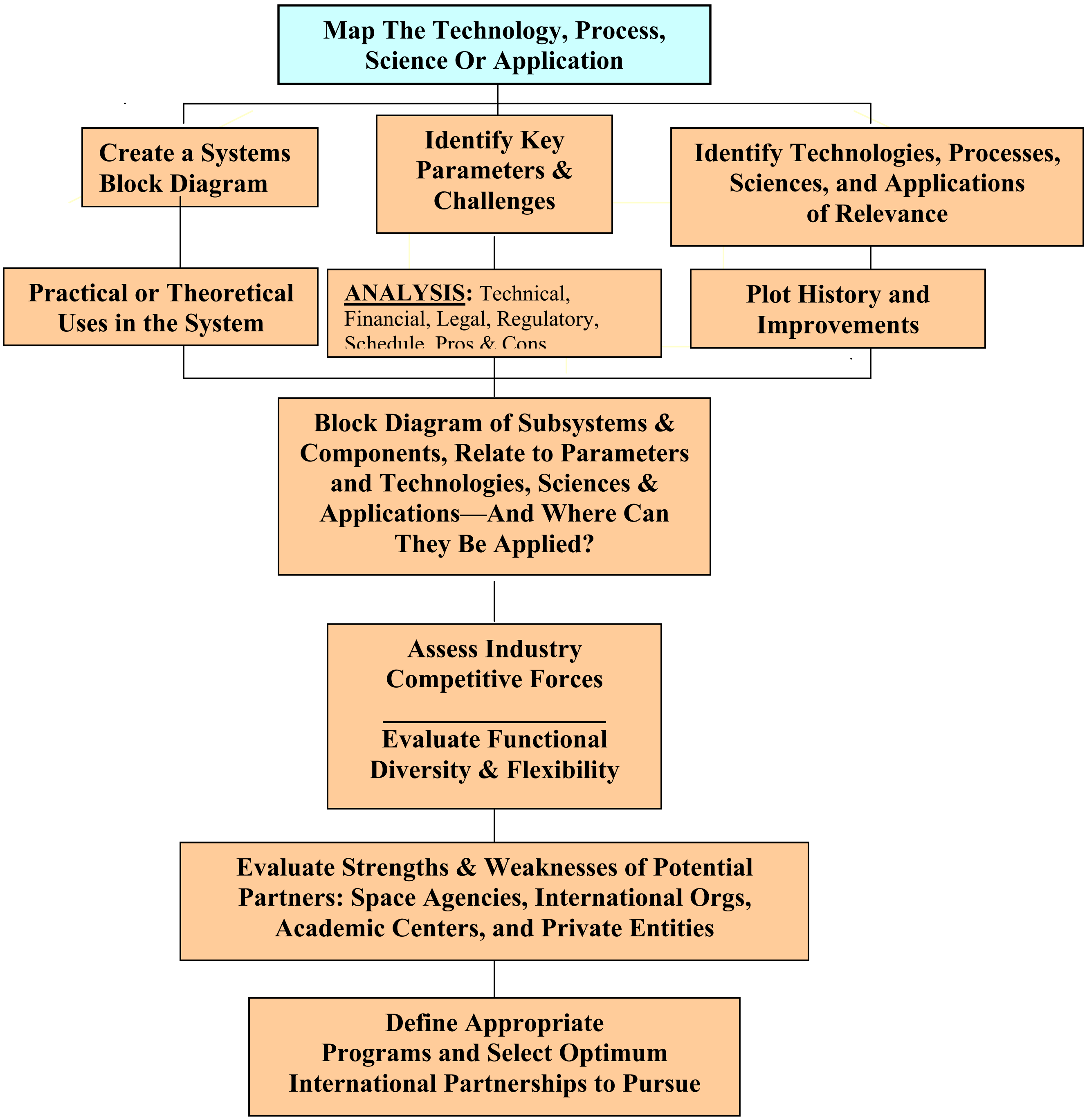

Figure 1: Framework for Systematic Analysis and Assessment of Candidate Projects for International Space Cooperation by INPE

3.0 Analysis of Past Trends in INPE International Cooperation

INPE of Brazil has been an active participant in the world of space exploration, science and application for many years. Its various space programs, including its international projects, have largely focused on space applications, space technology and space science as opposed to space exploration and manned space programs. This is because the return on investment is more clearcut and investments produce useful results in terms of identifable Brazilian societal and scientific needs. Further cooperation on space projects in these areas typically involve much less investment of financial and human resources. These projects seem to have been consistently well planned to leverage Brazilian needs as well as INPE resources and investment. Thus a significant return has been achieved based on the investment that has been involved. The exception to this rule may have been the ISS project that has been delayed and unexpectedly altered due to the problems stemming from the grounding of the Space Shuttle.

The following chart (Figure 2) represents many of INPE's past international cooperative projects.

Figure 2: Brazilian International Space Cooperation

Recent International Cooperative Projects Involving INPE-Brazil

Name of Project	Key Partners with Brazil	Time Span	Key Elements & Objectives	Issues
INPE Tracking of ERS-1 & HIPP-ARCOS Satellite	**European Space Agency-Earth Station Operations Center & INPE**	1987-through early 1990s	Calibration of the INPE ground facilities at Cuiaba and Alcantara by tracking of the ERS-1 (Close-Earth Polar Satellite) and HIPPARCOS. Gaining of satellite and operational tracking experience through cooperation with ESA-ESOC. This was to prepare for the 1989 launch of the INPE SCD-1 data collection satellite. **Web Reference:** http://adsabs.harvard.edu/abs/1994RBrCM..16..485P	ESA LCT ranging format had to be adapted for use by INPE
The Global Rain Forest Mapping Project (GRFM) project	**JAXA (NASDA), NASA, EU, INPE, INPA** JAXA (NASDA)/Earth Observation Research Center with NASA/Jet Propulsion Laboratory (JPL), the Space Applications Institute of the Joint Research Centre of the European Commission (JRC/SAI), the Earth Remote Sensing Data Analysis Center of Japan (ERSDAC), Remote Sensing Technology Center of Japan (RESTEC), Univ. of California Santa Barbara (UCSB), plus INPE & National Institute for Research of the Amazon	1994-2002	Use of the Japanese Earth Resource Satellite (JERS-1) Synthetic Aperture Radar Satellite (L-band) to map the world's rain forests including the Amazon at 100 meter resolution **Reference:** **http://www.eorc.jaxa.jp/JERS-1/GFMP/SEA-1A/docs/html/grfm.htm**	Inter-agency coordina-tion. Distribut-ion of data and data formats

	(INPA).			
Joint China-Brazil Earth Resources Satellite Program	**China Space Agency and INPE**	1994-2002 CBERS launch in 1997.	The China-Brazil Earth Resources Satellite (CBERS) program is a joint Chinese/Brazilian initiative to develop a satellite to monitor natural resources and the environment. **Reference**: **http://www.esa.int/esapub/bulletin/bullet85/melt85.htm**	Funding Issues. Compatible standards for Brazilian and Chinese programs
AQUA/ AMSR-E	**JAXA, JMA, NASA, INPE**	2000-to date Launch July, 2002	Aqua is a joint project for ocean- observation with the United State, Japan, and Brazil. The AQUA Satellite, and especially Advanced Microwave Scanning Radiometer (AMSR-E), acquires atmospheric and marine data in order to study water/energy circulation mechanisms. AQUA also collects data from broader areas on the earth, especially in the middle of the oceans where it is difficult to set up observation stations. Data from AQUA is provided to the Japan Meteorological Agency (JMA) to improve the accuracy of the weather forecast, such as movement of typhoon and cold/warm front, and to the Fishery Information Service Center to inform fishing boats of conditions **Reference:** **http://www.nasda.go.jp/projects/sat/aqua/launch/index_e.html**	Funding of the project
Flight Equipment and Payloads for the ISS	**NASA and ISS Partners and INPE**	1997- to present Pact signed between NASA & INPE-in Oct. 1997. Revised in 2002-2003	INPE to Develop and manage six specialized research systems on the International Space Station: ExPS - Express Pallet System; TEF - Technological Experiments Facility; WORF-2 - Window Observational Research Facility Block 2; ULC - Unpressurized Logistic Carrier; CHIA - Cargo Handling Interface Assembly; Z1-ULC-AS - Attach System **Reference:** **http://www.iss.inpe.br/ingles/partic/Default.htm** **http://www.inpe.br/programas/iss/ingles/default.htm** **http://www.boeing.com/news/releases/2000/news_release_000428s.html**	Delays due to the Shuttle grounding, changes to the ISS and the non-flight of the CAM. Brazilian govern-mental mandates.
French-Brazilian Microsatellite Project CNES-INPE	**CNES and INPE**	2002-2003 (Canceled)	French CNES Myriad Micro-satellite project was envisioned to have at least six projects with No. 2 to be the INPE micro-satellite with five scientific instruments and five experiments. **Reference:** **http://www.inpe/apex**	Project canceled due to major CNES Budget reductions in 2003. No backup option available.
SAC-C Earth Observation Project	**NASA, CONAE, INPE, ASI of Italy and DSRI of Denmark**	1999-early 2000s	NASA in cooperation with CONAE, INPE, ASI and DSRI launched an earth observation satellite SAC-C with partners developing instrumentation. Successfully launched on a Delta II on Nov. 21, 2000. The 10 instruments on board studied atmosphere, ground & sea ecosystems and geomagnetic characteristics. **Reference:** http://www.conae.gov.ar	Complexity of project with 10 instruments can lead to delays. If a launch failure there was no backup.
Cooperative Study on Clear Cutting of Amazon Rain	**Carnegie Institution's Department of Global Ecology, Washington, NASA and INPE and**	2000-to present	Analysis of NASA Landsat, EO-1 and other satellite data to see impact of Amazon logging on rain forest. This has led to an initiative for INPE to develop an enhanced remote sensing analysis system to monitor logging. This	Cooperation between Govern-mental and

Forest	**<u>IMAZON in Brazil</u>**		involves cooperation between NASA, the Carnegie Institution, the Brazilian non-governmental organization, IMAZON, and the INPE-PRODES Program	non-govern-mental orgs

In reviewing these projects several conclusions seem to be of particular interest.

- The most common projects involved remote sensing and understanding of trends involving the health of the Amazon rain forest--especially the partial and clear cutting of the forest and related environmental issues. Other space-faring nations see Brazil as an important partner in terms of preserving the Earth's biosphere because of the criticality of the Amazon rain forest.
- Brazil's location on the equator, its large area and population and its considerable capabilities in the remote sensing and geomatics areas make it a likely partner for cooperative projects in these areas.
- Projects that allow Brazil to develop its tracking, telemetry, command and data processing capabilities while utilizing the space assets of other countries or organizations, especially in the areas of space science, meteorology, remote sensing, telecommunications, space navigation, or other such projects has had many benefits. In particular, this approach has allowed INPE to increase its space-related capabilities, increase its space-related knowledge and skill sets while avoiding the cost of designing, manufacturing, launching and operating its own space systems.
- Involvement in large-scale projects in partnership with other countries entail certain risks that should be minimized or allow for alternative achievement of goals and objectives. These risks can often be minimized by signing agreements that allow programmatic launches by more than one vehicle, escape clauses if there are major program delays, and modular program designs so that assets and space facilities can be reapplied to other space initiatives if there are program delays or unexpected problems in the project as originally defined.
- Cooperative programs are perhaps most likely to be successful when they are based not on financial contributions or building a sub-unit for some one else's program but when INPE is providing a particular capability, service or component on a clear-cut program that can be reapplied elsewhere if need be.
- Brazil and INPE, because it has a much smaller space program and smaller budget than the major space agencies such as NASA, ESA, JAXA, CNES, etc., tends, within most cooperative space projects, not to be the lead participant.
- Not being the "lead partner" can result in both advantages and disadvantages. Advantages can be that INPE's investment is highly leveraged and can produce high return per dollar invested, it does not have to create expertise in all areas of the project, and launch services are provided by the partner. Disadvantages tend to be that INPE cannot usually take the lead in defining or managing the project or its mission and its technological gains may be less than that of its partner(s). If the overall

project is delayed or put on hold (e.g. the INPE participation in the ISS project and the French-Brazilian Microsatellite) then losses of time, money and resources can be incurred.

- Most Brazilian international cooperative space projects, at least in the past, have begun as a joint venture with another space agency such as NASA, ESA, CNES, or the Chinese Space Agency. These projects then evolved in some cases to include universities or other research agencies. In the future, it might be useful and cost-effective to explore and even initially define cooperative projects with universities, international research agencies or private space ventures and then follow these initial efforts by concluding an agreement with the space agency or agencies in the appropriate country or countries that apply. Also these programs may allow more extensive participation and scientific from the Brazilian academic and research community and thus produce better results in terms of enhancing domestic capabilities.
- If joint international projects were not always seen as very large-scale, multi-year projects with other major space agencies envisioned as much smaller undertakings could result in much different outcomes. These mini-international joint projects could be designed as components or modules in the range of $100,000 to $1,000,000 projects that do not involve multi-year undertakings and complex arrangements with space agencies. These "mini" to "micro" projects could involve working with commercial companies, universities, research institutes, etc. Many of the projects analyzed in Section 4.2 could be initiated in this fashion. They still might need to address intellectual property export control issues such as the US ITAR processes. Even here one might seek to work out some sort of blanket research agreement with governments to help streamline this process and reduce the cost of such "mini" or "micro" R&D projects.

4.0 What topics/areas might be more rewarding for international cooperation to a country like Brazil?

It is important to note that the nature of space exploration, application and science are all currently in a stage of rapid change. This is due to the commercialization of space activities, the widening number of countries that are participating in space activities, the end of the era of the Space Shuttle and ISS construction and the start of many new space initiatives. Thus it is important in the strategic planning process to establish short, medium and longer-term goals. This is to suggest that both rewards and opportunities concerning future space activities can and indeed will change over time. In the discussion in Sections 4.1, 4.2 and 4.3 below a number of possible areas for rewarding international cooperation are outlined. Clearly much more detailed study, analysis and evaluation as well as discussions with prospective partners would be needed to convert a menu of "possibly rewarding projects" into viable plans for possible implementation.

4.1 Shorter-term goals and objectives that would seem appropriate and rewarding

for Brazil.

- International cooperative projects that involve remote sensing, meteorology and geomatics—especially activities that involve the gathering and processing of information involving Brazilian geography and the Amazon rain forest. International cooperative program that could strengthen or leverage the INPE-PRODES program and help implement the Brazilian Timber Concessions Laws would seem to be of perhaps highest priority. (This will presumably be addressed in the paper by Dr. Donald Hinsman of the WMO and cover other possible projects in remote sensing, meteorology or geomatics.)
- International cooperative space communications and IT programs that might assist in the provision of health, education and training programs in the interior of Brazil and especially the Amazon rain forest would also seem to be worthy of exploration. (There may well be sufficient Brazilian satellite capacity to provide broadband interactive health and education services to the interior, but other aspects of such services such as more cost efficient ground stations connected to Wi-Fi or Wi-Max wireless systems, radio and television based learning systems, etc. would thus seem to be of particular interest to explore. This could be done in cooperation with the Canadian Space Agency (CSA) and the Canadian Research Centre or even with commercial partners in Canada, the US, Europe or Japan. These R&D projects would, of course, likely be carried out in partnership with Telebras, Embratel, or Hispamar in terms of organizing the Brazilian component of tests and demonstrations.

  Such an R&D test and demonstration project might be quite productive as well as low in cost to implement—especially as demonstration or trial programs. (This type of undertaking might also be addressed in the paper by Dr. Donald Hinsman of the WMO)

- In the area of space science undertaking, one might first consider extensions of programs similar in scope to those undertaken on previous INPE joint projects. Thus the types of projects that were to be undertaken with the ISS, and particularly the types of instruments that flew on the SAC-C or might have flown on the French-Brazilian Microsatellite project that were to have been a part of the French Myriad microsatellite experimental project, could be extended and updated.

  Such measurement instruments on a microsatellite could fly not only with NASA, JAXA, Chinese, Russian or ESA projects, but perhaps also on commercial flights. The various options in terms of commercial flights are expanding greatly. The recent Ariane 5 launch in October 2006 launched not only the DirecTV 9 (5,545 kgs) and the Optus D1 satellite (2,299 kgs) but also the JAXA LDREX-2 experimental satellite (211kgs). This type of relatively small experimental package might be launched economically if it were flexibly designed so that it could ride with other larger missions. For an experimental satellite to LEO, this might be accomplished as an adjunct to a supply mission to the ISS (such as on an

ATV or HII TV) or on one of the many commercial launches to GEO (such as on an Atlas V or Ariane 5 or one of the Chinese, Russian or Ukrainian vehicles.) The concept would be to have a microsatellite that might be small enough to be essentially ballast to the larger missions. Thus a microsatellite in the 50 kg to 100 kg range might be ideal.

An even more innovative and even more cost effective strategy might be to launch one or more micro-satellites on board the many new space planes or rocket systems that that are being built to support the new orbital space tourism business. On the order of 20 to 30 such new systems are being developed and tested prior to being qualified for actual launch of human passengers. It might be possible to arrange for a nearly free launch using one of these vehicles to launch a micro-satellite as a test cargo. Although these vehicles are being designed to human launch standards there is of course a risk of losing a micro-satellite in such a launch. An active survey of the companies engaged in qualifying their vehicles for launch could produce several possible candidates for detailed discussion.

4.2 Medium-term goals and objectives that would seem appropriate and rewarding for Brazil.

- There are a number of space technologies of interest that would seem to merit consideration by INPE in terms of cooperative space projects. Many of these projects can be undertaken in conjunction with universities or research centers at relatively low cost. Some of these that seem to be particular interest include: (a) phased array antennas and/or phased array feed systems; (b) high tensile strength nano-tube materials, (c) inflatable space systems, (d) high performance solar cell technology (including so-called rainbow solar cells with multi-gap junctions and quantum dot converter technology); (e) unitized and regenerative fuel cell technology; (f) electrical ion thruster technology and FEEP Thrusters; (g) pieso-electronic materials; (h) space robotics and robotic climber systems; (i) electromagnetic power generation from low orbiting systems; and (j) high altitude platform systems. These technologies all have potential applications either to new communications and IT satellite systems, to solar power satellite systems or they can be applied to future scientific and/or applications systems. There are, of course, many other technologies that could be considered such as laser transmission systems, very advanced propulsion systems such as nuclear or metallic hydrogen, etc. but these involve massive investments, highly specialized facilities and a very long time to actual implementation. The following list of technologies, however, has merits as noted below. Thus the following chart (Figure 3) provides a high-level review and analysis of these technologies.

Figure 3

Analysis of New Space Technologies for Possible Joint Development by INPE				
Technology	**Possible Application**	**Time to Appli-cation**	**Pros**	**Cons**
Phase array Antennas/ Feeds	Multi-beam satcom systems	5-7 yrs	Phase array feeds can form many beams and be reconfigured to meet changing demand. Many potential research partners	Currently quite expensive technology
Nano-Tube Materials	Lightweight & strong materials for many space systems	5-7 yrs	Rapid advances. Many universities and small companies potential partners	Conversion of technology from lab to affordable commercial production
Inflatable space systems	Many applications from antennas to spacehab structures	1-5 yrs	Cost efficient technology. Many applications. Many potential partners. Can reduce launch mass.	Likely partners limited to US. Micrometeorite problems.
Advanced Solar Cells (Multigap junctions & Quantum Dot Converter Tech.)	Could be used in comsats, remote sensing, navigation, solar power sats (SPS) & space stations	2-5 yrs	Much higher efficiencies. Longer life for satellites. Reduced satellite mass. These technologies could help not only application sats but also SPS projects.	Time to commercial application not clear. Need additional technology to apply to Solar Power Satellites (SPS).
Fuel Cell Technology	Can be used in all applications satellites. Could be used in HAPS	2-5 yrs	Can improve power performance for application satellites. Can extend life.	Currently very expensive. Will be developed by others.
Advanced Thrusters (Ion/FEEP Thrusters)	Could be used in comsats, remote sensing, solar power sats (SPS) & space stations (See Appendix F)	2-10 yrs	Allows larger aperture antenna systems. Can extend satellite life. Can reduce launch mass	Development will be evolutionary and in stages. Depends on other material development to realize advantages.
Pieso-	Can be used in	2-10	Allows larger	Tests of technology

Electric Materials	advanced comsats, SPS, & many space systems	yrs	aperture antenna systems. Can greatly reduce required launch mass.	will need to be based on scale-models to be cost effective.
Robotics Technology	Can be used in a great diversity of space applications. Space Elevator systems of particular interest	2-20 yrs	Robotic systems evolve to become more & more capable and intelligent.	Complex systems become increasingly expensive and require sophisticated facilities.
EM Electric Power Generation	Tether systems can be deployed to generate electricity	2-5 yrs	Cheap & efficient way to generate electrical power. Potentially very long lived system. Constant & cheap energy source	Only of value if one proceeds to deploy High Altitude Platform Systems.
High Altitude Platforms (HAPS)	Can be used for communications, broadcasting, remote sensing, security, mapping, military.	4-8 yrs	Cost effective supplement to communications and remote sensing	Many different technologies (dirigibles, high altitude jets, solar powered planes EM tethered systems.)

4.3 Longer-term goals and objectives that would seem appropriate and rewarding for Brazil.

- One of the more interesting longer-term commercial projects that might hold special interest for Brazil is the space elevator project that is being pursued by the Space Elevator Corporation headed by Dr. Brad Edwards. NASA also recently held a competition with regard to robotic climber systems in New Mexico. Such a system if deployed could reduce the cost of raising mass to GEO orbit as well as making the launch of satellites and probes beyond Earth orbit suddenly affordable for even small scale space programs. (Research on tether systems, robotic systems, etc. could help set the stage for longer-term investment in this area.)
- The Italian and Chinese backed project to deploy, via a robotically-controlled deployment system, a radio telescope observatory on the surface of the Moon within an existing lunar crater. This particular initiative might be more ambitious for INPE to consider, but robotics-based longer term space probes using ion-thrusters might be able to undertake many space-based experiments or science-based projects. A cluster of smaller telescopes such as NASA has envisioned could produce a major capability for new astrophysics.
- Many of the technologies indicated in section 4.2 could be applied to an advanced design for the so-called "String of pearls" equatorial circular orbit system for

broadband communications and television and radio broadcast services for the entire equatorial region of the world. It could also apply to the above projects as identified above.

5.0 What might be the main obstacles for international cooperation for Brazil?

INPE and Brazil have a long history of international cooperation in space programs that date from the Communications Test Satellite experiments carried out in cooperation with NASA and the CSA in the 1960s. Valuable experience has been gained from such projects and lessons learned with regard to delays, misunderstandings and programmatic problems. In short, there are really very few obstacles to international cooperation on space projects beyond the fact that there has been a general scaling down or leveling of space budgets by major space agencies around the world and the fact that NASA has placed all of its budgetary emphasis on the Project Constellation Moon/Mars Mission. The obstacles are thus really more in the form of finding the right opportunities that maximize the goals and objectives of the Brazilian Government and INPE. The following observations derive from the analysis of earlier international programs and problems that have occurred in these projects.

(i) Risk Minimization and Program Flexibility

As noted in section 3 above it is important to achieve agreements covering international cooperative space agreements that will: (i) minimize risks; (ii) provide for alternative ways to proceed in the case of launch, satellite or programmatic delays; (iii) avoid direct financial investments in the programs of others but instead contribute hardware or expertise that can be redeployed if need be; and (iv) provide for cancellation of projects on a no-fault and no-penalty basis. Note that if future agreements explore arrangements with universities, research institutes or foundations or private commercial organizations it might be easier to negotiate agreements that more easily cover issues of risk or program flexibility.

(ii) Compatible Safety Standards and Measurement Systems

It is, of course, important to plan all programs, including international programs so as ensure the highest level of safety. Sometimes, however, difference in measurement systems, independent verification and validation systems, or difference in the definition and implementation of safety standards can lead to problems in international cooperative programs. There are efforts currently underway within the International Association for the Advancement of Space Safety (IAASS) to try to develop uniform and effective safety standards that can be broadly applied within international cooperative projects. Working within ISO standards and following the practices of high reliability organizations would help to minimize these types of incompatibility with partners on cooperative space projects.

(iii) Political, Legal or Institutional Barriers

For a variety of reasons there can be differences that arise within international cooperative space programs. These may involve restrictions related to the protection of intellectual property, issues of national security and technology that is seen as needing to be protected for strategic or national defense reasons. Also it is the case that partnerships with one organization might complicate additional partnerships with other countries or space entities. INPE's previous experience, however, has successfully coped with such issues in the past.

This past experience has typically been in the context of cooperative agreements with national or regional space agencies as the partner. To the extent that INPE sought to establish research contracts or partnership agreements with universities, research centers or private space ventures, the issues of intellectual property rights, the export or licensing of strategic technology to Brazil and INPE may indeed raise new issues and concerns, particularly with regard to the United States. The Virgin Galactic project, that is a subsidiary of Sir Richard Branson's Virgin Airways, has been slowed due to a time consuming licensing process to export the technology developed by Scaled Composites and which is the applied to the Virgin Galactic craft being developed by the so-called Spaceship Corporation. The structure of the corporation and the use of funds provided directly from the UK parent corporation has had to be restructured. It has been indicated that the launch of the first spacecraft (to be known as the VSS Enterprise) has been delayed at least one year due to the international licensing of technology issues. (Irene Klotz, "US Export Ruels Frustrate Virgin", BBC On line. http//newsvote/bbc.co.uk)

The first Virgin vehicle will be called VSS-Enterprise

(iv) New US Space Policy Directive

The U.S. Government issued a new National Security Policy Directive as of August 31, 2006 that addresses U.S. Space Policy and this updates and modified the Presidential Decision Directive/NSC-49/NSTC-8, National Space Policy that was dated September 14, 1996. This new directive makes several changes in US Space policy. It particularly notes the strategic importance of space and announces that the U.S. will particularly support the development of commercial and entrepreneurial approaches to Space. It also indicates a continued interest in international space cooperation. The language from this directive seems to narrow this interest to space exploration and space observation technologies. The new directive states:

"The United States Government will pursue, as appropriate, and consistent with U.S. national security interests, international cooperation with foreign nations and/or consortia on space activities that are of mutual benefit and that further the peaceful exploration and use of space, as well as to advance national security, homeland security, and foreign policy objectives. Areas for potential international cooperation include, but are not limited to:

Space exploration; providing space surveillance information consistent with security requirements and U.S. national security and foreign policy interests; developing and operating Earth-observation-systems."

This language is more tightly crafted than the US Space Policy Directive promulgated in September 1996 and thus might serve to limit the scope of potential cooperation with NASA in future projects. Since this new US policy has just been publicly announced and since no clarifications have been made by NASA on the subject of the new Security Policy Directive one should not conclude that a narrowing of scope of international cooperation will ensure. Further, this new policy would appear to open up new opportunities for cooperative projects with US commercial space initiatives and entrepreneurial space organizations.

In the mean time, the European Space Agency, CNES of France, DLR of Germany, the Italian Space Agency, the Canadian Space Agency, the Chinese Space Agency, JAXA of Japan, the Russian Federal Space Agency, The South Korean space initiative, and the Indian Space Research Organization among others, seem to continue to be well focused on space sciences and space applications and have a very open attitude to international space cooperative projects.

6.0 What assets do Brazil and INPE possess that might make international cooperation most attractive to overseas partners?

Over the past four decades INPE has steadily increased its standing in the space world. It has now fully established a long, productive and widely admired space program. Its research campus at São José dos Campos, Brazil has a wide range of facilities and research scientists and engineers. It has experience with a number of international cooperative space projects. There are today a number of reasons why potential partners would wish to explore cooperative space projects. These reasons include the following:

a. INPE considerable previous experience with joint space programs.
b. Brazil’s critical location in terms of containing a vast amount of the World’s rain forests that is critical to the global ecology.
c. Brazil’s direct access to a considerable length of the equator that is useful with regard to many space missions, spaceport operations, and related Tracking, Telemetry, Command, Monitoring and Data Relay Services.
d. The considerable resources (in terms of highly trained personnel and facilities) available at the São José dos Campos facilities.

It is true, however, that many other countries also now have well established or emerging space programs and that to achieve the most desirable, cost effective, and productive cooperative space projects, Brazil and INPE should have a clear and proactive program that identifies opportunities and maximizes their potential. In this respect several strategies are recommended.

- Identify funding opportunities from regional or world banks (i.e. the InterAmerican Development Bank (IADP) and the World Bank (IBRD), large foundations or national aid organizations that would provide “anchor funding” for space projects that involve developmental projects in the sectors of education, training, healthcare, ecological preservation, emergency warning and recovery, or other areas where financial support may be provided. (**Note**: These agencies are for the most part not interested in technology or space, but rather they support programs that can provide new and cost efficient capabilities in the above identified sectors. If there are jointly supported new space programs that have the support of several countries (i.e. at least two) and there is a direct request from the “host” national government that puts the project on a “priority” basis then it is likely to be funded. The same advice applied to UN Specialized Agencies.)
- Stay current with the programs of the United Nations Specialized Agencies and the United Nations Organization. This is to identify particular opportunities for space-related opportunities. These may be related to education, health, training, ecological preservation, disaster warning and recovery, or could even provide for overseas training programs for INPE scientists and engineers or other similar educational or learning opportunities. In particular one should be aware of the various developmental programs of the International Telecommuncation Union, the UN Development Programme, UNESCO, UNIDO, the Program Office of Committee on the Peaceful Uses of Outer Space (COPUOS) in Vienna, The World Health Organization, the World Food Program, the World Meteorological Organization, the International Bank for Reconstruction and Development and its related entities, The Economic Commission for Latin America, UNICEF, and various organizations directly under the United Nations Organization that address the Digital Divide and disaster warning and relief issues.
- Stay current on programs of national and regional aid or international support. These programs include the Canadian International Development Agency, the various programs of the European Union, the two major Aid Foundations of Germany, the Japan International Cooperation Agency (JICA), the Swedish

International Development Agency, the US AID, plus the major Foundations such Gates, Kellogg, Ford, etc.

- Be aware of opportunities that commercial space organizations with operating networks might be willing to offer in terms of experiments with new types of ground systems, interactive space and ground facilities and data processing capabilities. (There are many opportunities that might be available to experiment with so-called “smart farming”, forest fire monitoring, emergency warning capabilities, combined satellite communications and Wi-Fi/Wi-Max communications systems in rural and remote areas, etc.) The combination of Wi-Fi/Wi-Max technology with communications satellites seems to be a very productive area for potential collaboration with Embratel, Telebras, or Hispasat in terms of trials that might be carried out in remote area of Brazil to bring telephone and higher speed Internet services to areas that are currently not served or greatly underserved. (See Appendix F) for a discussion of research, development and demonstration opportunities in the telecommunications satellite area.
- Explore possible partnerships with new commercial organizations that are developing space planes and new orbital access capabilities that need to test vehicles with non-manned cargo before flying passengers to orbit. (A partial list of these organizations include: Aera, American Space Corporation, Armadillo, Bigelow, Blue Origin, Canadian Arrow/Planetspace, the DaVinci Project, InterOrbital Systems, Rocketplane/Kistler, Scaled Composites/The Spaceship Company, Space Adventures, Space Dev-Dreamchaser, Space X, Starchaser, t/Space, Virgin Galactic, and Xcor.) Partnerships might involve the free or nearly free launch of micro or mini satellites, investment opportunities in exchange for launches, training or joint development projects—typically on an overseas basis, etc.

7.0 What international financing sources might be used for international cooperation on the part of Brazil?

There are today many different ways of finding international funding or financial support for international cooperative space projects. Further, the range of options will continue to expand and become more diverse as there are more and more commercial space ventures. In addition, parallel development in cooperation with universities, research organizations should be considered. The following different categories of support exist.

a. International and Regional Banking Institutions
b. Specialized Agencies of the United Nations
c. National and Regional Aid Organizations and Non-Governmental Organizations
d. Major Foundations that provide International Aid in various sectors
e. Commercial Organizations engaged in operational services
f. Commercial Organizations engaged in development of new types of launch services

a. International and Regional Banking Institutions

International and regional banks have clearly defined guidelines for providing soft loans for various types of development programs. In areas such as telecommunications proposed projects must, for instance, apply to areas where there is less than one telephone per hundred population and the target area must also very likely be very rural, poor and unable to get commercial loans for the project. Thus any proposed space-related joint project would thus likely need to target the population of the Amazon Rain Forest and possibly extend to other countries of the Amazon region and show that many of the resources needed for the project are coming from the proposed partners in the project. Thus the low interest loan would be in the form of "matching monies". Preliminary meetings with World Bank, International Development Corporation, and Inter-American Development Bank officials very early in the planning process would be advisable. Only projects involving health care, rural education and training, disaster warning and recovery or ecological research and recovery projects should be targeted for such types of financial support.

b. Specialized Agencies of the United Nations

The type of guidelines used by the World Bank and the IADB generally apply to Specialized Agencies of the United Nations. A joint cooperative space project would clearly have to target the program focus of each UN agency. Thus space or space and terrestrial-based delivery systems for "health care" would go to the World Health Organization (and possibly the UNDP). A project for "education" would go to UNESCO and the "Digital Divide" program of the UNO. A project for "smart farming" or "ecological control" would go to the World Food Program, the World Meteorological Organization (for letters of support), UNICEF (for letters of support) and the UNDP. In all such initiatives "matching funds" and "leveraged financing" is key. Thus if one could obtain a parallel commitment from the Gates Foundation with regard to a space-based health delivery project, or a parallel commitment from the Frederick Ebert Foundation of Germany for an education and telecommunications development project then the chances of obtain additional support is proportionately increased. (There is a danger in having too many entities involved in a project because of the administrative reporting requirements. Thus two international funding or support agencies is probably ideal. This is because one many not fund or provide enough funding and three might require too much administrative overhead.) In all cases, direct contact with the funding agencies and the personnel that review proposals is key. Also lead time is typically one to two years for funding.

c. National and Regional Aid Organizations and Non-Governmental Organizations

Support from these types of organizations would likely come only as supplements for specific activities related to education, health care or training, or relief related activities. The national aid organizations such as AID, CIDA, JICA, SIDA, etc. have clear procedures and these take time and also require the national government to specifically declare a requested aid project to be declared a "priority" undertaking. Thus any project seeking such support will need to be coordinated within the Brazilian government so that the satellite-based education, health or relief would be so prioritized over other potential projects.

d. Major Foundations That Provide International Aid in Various Sectors

Most foundations have clearly defined goals and objectives. The Gates Foundation focuses on health care, the Kellogg and Ford Foundation on Education, etc. Some of the Japanese foundations such as those operated by the major Japanese Corporations such as NEC, Mitsubishi, etc. are among the most approachable for technology-based projects. The NEC Foundation, for instance, provided $500,000 in funding to support a two-satellite, low earth orbit store and forward system that provided health and medical related information to doctors and clinics in remote parts of the world. These satellites were designed and built by the Surrey Space Center. The project was called the Lifesat system. This project might be considered as a model for not only funding projects but as an international project that was supported by a number of countries that included Japan, the U.K. and the U.S.

e. Commercial Organizations Engaged in Operational Services

Many commercial organizations such as Intelsat operate projects such as the Project Share activity that lasted from 1984 through the early 1990s and involved many dozens of countries in carrying out test and demonstration projects. Intelsat still supports a number of projects such as the African Virtual University, the University of the West Indies and the University of the South Pacific in a variety of ways. Currently Embratel, Hispamar and Telebras may offer sufficient coverage and satellite networking and broadcasting capability to the Amazon region for educational and health care services. Nevertheless Intelsat, SES Global or others might be approached with regard to supporting early tests and demonstrations of a hybrid satellite and Hi-Wi / Wi-Max networking capability to serve a number of villages in the Amazon region. These could be done in conjunction with Embratel and Telebras and INPE’s involvement might only be in design and coordinating such tests and demonstrations. National aid or foundation grants might support the cost of on-ground equipment, and operational programs might be fund by the IADP or the IBRD, especially if they were involved in the initial tests and demonstrations.

f. Commercial Organizations Engaged in Development of New Types of Launch Services

Corporations involved in developing new commercial launch systems to support flying “tourists” on sub-orbital or orbital flights are focused on this particular task. Nevertheless INPE might be able to cooperate with one or more of the nearly two dozen organizations that are involved in such development. This might be done in a variety of ways so as to reduce or eliminate INPE expenditures, create partnerships that could provide free or low cost access to space for certain micro-satellites, or even attract certain new space industries to Brazil. The first step is to inventory the various private space ventures underway and survey their needs and interests to see if they might be interested in a Brazilian space port, need TT&C types of support services, have test flights planned that might somehow support the low or no cost launch of a micro-satellite, or involve potential partnership investment opportunities that could lead to future flights by Brazilian scientists and engineers or future micro-sat payloads.

An important aspect to note is that the future of space applications, space science, space transportation and exploration may very likely involve an increasing amount of private space venture activity. Within another decade it is likely that more "private astronauts" and tourists will have flown at least 100 kilometers into space than all of the astronauts that have flown up to this time in history.

This shifted environment is something that NASA, INPE, and indeed all of the national space agencies, will need to adapt to over time. A pro-active approach that seeks to identify opportunities and partnerships early in this transitional time period will likely serve INPE well. Such an active approach can lead not only to cost savings but also to new opportunities and objectives that would not occur unless an active attempt is made now to carve out cooperative relationships.

8.0 Is it possible to establish, for a substantial period of time – extending up to a 15-years – partnerships with countries, space agencies and programs/projects (including commercial and academic ventures) that might be willing to cooperate with Brazil?

The issue of longer-term cooperation on space projects is important to address because very short-term cooperation can often be less productive. This is especially true if special infrastructure, test labs or highly specialized training is involved. There can, unfortunately, be no definitive answer about such an issue and the likelihood of longer-term cooperation varies from country to country and by agency or institution or cooperating entity. On the opposite side longer-term agreements can clearly have significant down-sides.

Many of the entities that entered into longer-term "franchise" agreements with respect to the International Space Station, for instance, have experienced major difficulties as a result of program delays due to the stalled ISS construction resulting from the Space Shuttle groundings (covering a period of over six years). There have also been concerns about the inflexibility in the program deployment plans due to the fact that major construction depended on essentially one vehicle. The International Association for the Advancement of Space Safety has noted the safety concerns that arise from the fact that there is no "unified international control" of safety related matters, and the financial implications of being committed to an international program that greatly increased in price since the completion date for the ISS extended from 1994 to the currently estimated date of 2010. The significant Japanese investment in the design and manufacture of the Centrifuge Accommodation Module that was cancelled is a clear case in point where a long-term commitment was perceived by Japan as being a negative factor. In short, this is to say that any decision by INPE to enter into longer term cooperative agreements with regard to space programs should benefit from lessons learned from the ISS. The primary lessons learned include: (a) Avoid program commitments for large scale and longer-term programs where there is not strict control of cost and schedule with ability to escape from commitments when expectations are not met; (b) Avoid franchise agreements that might compromise safety or unified program quality; (c) Smaller scale test projects or preliminary trial should precede large scale implementation plans with the purpose of the trials being to generate more flexible, cost effective and better engineered solutions.

Although Brazil might indeed explore involvement in longer-term space exploration programs with the United States, Europe, Japan, or others, the selection of the form and nature of such participation should be made very carefully.

In light of the new efforts by private space ventures to fly vehicles and "space tourists" into orbit, many new opportunities may present themselves. The strategies that might be undertaken in this respect might actually differ widely. At one extreme INPE might actually form a longer-term partnership with one or more such commercial organization and co-invest in their development of one or more space plane or cargo launch vehicles in exchange for opportunities to fly Brazilian scientists and engineers into space or to launch mini or micro-satellites into orbit. At the other end of the spectrum, one might make a "one-off" contractual arrangement with such an organization to launch a particular payload into low earth orbit as part of their initial launch testing operations. Of course, there are many potential options that are in between.

9.0 What particular "niches" in international cooperation Brazil might be especially qualified to fill? Do these opportunities vary with regard to space agencies, international organizations, academic institutions, or private entities?

Brazil and INPE does have a number of special attributes and capabilities that make it well suited to international cooperation.

Previous Successful Space Cooperative Experience. Among the so-called emerging market countries, Brazil has perhaps the most highly skilled and certainly the most long-lived space programs. This expertise and INPE's previous experience with international cooperation makes it an ideal candidate for cooperative enterprises with Canada, China, Europe (especially France, Germany, Italy and the UK), Japan and the U.S. Other space programs such as the Russian Federated Space Agency, Australia, Israel, Argentina, etc. would also see advantage in working with a space organization that has successfully cooperated on previous joint space programs.

Brazil's Special Location and Unique Requirements Related to the Amazon. Brazil, because of its vast Amazon region has special needs to provide education, health care, emergency warning, and telecommunications and information services. Also because of the considerable ecological importance of the Amazon Rain Forest there is a need for special monitoring and controls of this region using space-based assets. Further, because of Brazil's location across a large arc of the Equator it is well suited for location of Tracking, Telemetry and Command Facilities, Control of Equatorial Circular Orbit space assets, and possibly a spaceport or even a terminal point for a space elevator system.

Brazilian Space-Related Skills and Facilities. Brazil's decision to invest considerable resources in developing the space research campus at São José dos Campos, its expertise in telecommunications, remote sensing of the Earth, oceans and polar regions as well as the tropical regions, space radiation studies, space based astronomy (including solar and planetary studies), the Earth's stratosphere and upper atmosphere, etc. makes it a well-suited partner for many types of R&D related space applications as well as for many space science projects. Even in the area of space exploration there are skill sets where INPE could fill a special niche capability.

New Technical Capabilities Built Through Partnerships With Universities, Research Centers and Commercial Organizations. Section 4.2 discussed a number of new capabilities related to space technologies that might be used in next generation space systems in the area of space applications and space sciences. Some of these technologies could be applied toward helping Brazil become more energy independent, better able to deliver rural and remote services in health, education, training and other vital service areas. There are more possible technologies than INPE might reasonably take on, but choices are offered for careful evaluation and a narrowed selection process. In many cases there are universities and research centers working on these technologies in the U.S., Europe, Japan, Canada

The international cooperative initiatives of INPE, as it moves well into the 21st century, can be refocused to build from these assets. This suggests that INPE should have a pro-active program where it announces, through its web site, special brochures and mailings, presentations at the International Astronautical Federation Conferences, and visits to selected sites its capabilities and willingness to consider new and creative partnerships. So-called micro-research projects, might be undertaken with Universities such as Technical University of Delft in the Netherlands, Sup'Aero in Toulouse, France, the University of Stuttgart, the University of Turin, the University of Texas at Austin, Rice University, Houston, Texas, the University of Colorado, Boulder, Colorado, Carnegie-Mellon Tech, the University of Michigan, the Jet Propulsion Lab/Cal Tech, MIT, the University of Tokyo, the National Institute of Information and Communications Technology of Japan, and the National Aerospace Lab of Japan. Promising research around the world can now be monitored through university and research center web sites. A team of researchers at partner universities can work with an INPE scientist or engineer to pursue research in diverse areas such as those related to new space fabrication materials (i.e. pieso-electric materials, nano-tube structures & tethers, inflatable polyimide materials, etc.) or to phased array feed systems, or advanced "rainbow" solar cells, or quantum dot converter technology, or advanced high resolution optical or radar sensors, or artificial smart robotic devices.

Beyond partnerships with universities and research centers, exploration of potential partnerships with commercial organizations can also discover particularly well-suited joint development projects. Areas of cooperation can again be very diverse. These might include some form of partnership with the Space Elevator Corporation involving advanced materials or robotics, with the Intelsat, Telebras and/or Embratel organizations in terms of demonstrations related to earth terminals that connect to Wi-Fi or Wi-Max systems for rural and remote telecommunications services, or work with environmental non-governmental organizations in terms of better ways to monitor changes in flora or fauna in the Amazon Rain Forest. There might be particularly interesting partnerships available through Foundations with regard to using new space systems to deliver health care or education and training programs where a variety of techniques are tested and evaluated.

The opportunity represented by new private space ventures seeking to develop and test new launch vehicles and spaceplane technology could lead to opportunities to launch micro or mini-satellites for a number of experimental missions. The listing of potential commercial partners as listed at the end of Section 6.0 represents only a preliminary list of potential partners that might be approached for discussions as to partnership possibilities. A consultant or faculty member from a national university should probably be retained to help refine the list and develop an in-depth list of survey questions aimed at identifying possible areas of cooperation, potential pros and cons of such a relationship in terms of costs, benefits, risks, liabilities and time to fruition. These discussions could not only examine relevant space technologies, applications, and costs to access space, but even more creative relations that might involve barter relationships such as investment in exchange for launch operations or other quid pro quo arrangements related to locating a new spaceport in Brazil at an obsolete airport facility, etc.

10.0 What type of methodology might be used to evaluate potential candidate programs and international cooperation opportunities

The approach to evaluating candidate programs could be done in a variety of ways. The first level of analysis might simply involve undertaking a number of surveys of space agencies, international organizations, regional and international banks, non-governmental organizations, universities and research institutes, commercial operating organizations and commercial firms seeking to develop new private launch capabilities to identify potential targets of opportunity as matched against a preliminary list of projects of interest to Brazil and INPE or driven by new Brazilian legislation or governmental mandates. Consulting support to help identify these opportunities and assist with initial access to potential partners would be recommended at this stage. Suggested types of projects are identified in Sections 4.0 and 9.0, but these only represent a point of departure for a systematic review and analysis process.

The next stage would be to apply an analysis and evaluation process that more or less follows the analytic methods set forth in Figure 1 above. Appendix A provides a rudimentary analysis of such a review process that seeks to identify pros and cons of possible partnership. Clearly the review and analysis process should be more and more stringent and detailed as one moves from a $50,000 to $100,000 micro-project to monitor a space technology, application or science experiment, to a $500,000 to $1,000,000 joint research project, to a full scale multi-year space program in partnership with one or more different entities.

11.0 What special opportunities do joint ventures involving private space entities potentially offer to Brazil?

If there is one single element of change that will impact the future of space exploration, applications and even science going forward over the next decade it will be the commercialization of space. This will impact the number of people that go into space, as a result of the reduced cost of access to space. In short, the privatization of space initiatives will ultimately change the course of space history. Enterprises such as Rocketplane-Kistler, American Satellite Corporation, Virgin Galactic, Space Adventures, SpaceDev, Space X, Bristol Spaceplanes, the Canadian Arrow, IL Aerospace of Israel, the Genesis SpaceHab projects of Bigelow Aerospace, offer low cost and flexible access to low earth orbit or sub-orbital test flights. There are also a wide range of spaceports around the world that offer flexible and low cost services as well. These include the Ansari spaceport venture in Dubai, the more than a dozen commercial spaceport projects in the United States, such as the California Spaceport (Vandenburg, Air Force Base), The Florida Space Authority Spaceport (Cape Canaveral, Florida), Mid-Atlantic Regional Spaceport (Wallops Island, Virginia), etc. In addition there are spaceport initiatives in Australia, Canada, Russia, and many more projects that will redefine how space research, exploration and applications occur going forward and how much such activities will cost. Private space vehicles can provide Brazil and INPE with a wide range of new options for accessing space with greater flexibility and lower cost. (See Annex D for listing of various private space initiatives and new lower cost space vehicles.)

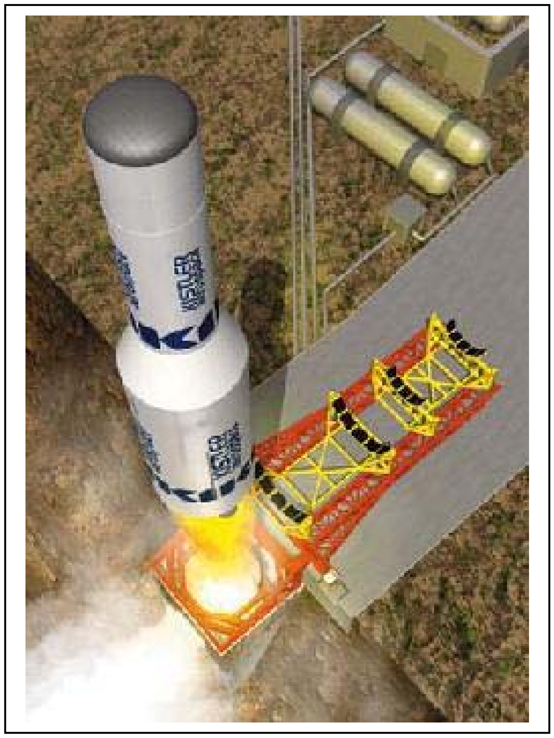

Figure 4:
The Rocketplane-Kistler K-1 Rocket
(Launches 5700 kg to Leo or 900-1400 to GTO)

Even more daring projects, beyond private rockets and space planes are also now evolving, such as the efforts of the Space Elevator Corporation. This project is headed by Dr. Brad Edwards who is seeking to build a lift system from earth to GEO orbit. Bigelow Aerospace is seeking to create inflatable space structures that can house space tourism. These and other ventures suggest a host of new horizons for space activities around the world. In short, the advent of private space entities will entail change in the space research and applications arena for decades to come. These space initiatives will include not only those of the United States but also of Europe, Australia, Canada, Russia, China, Japan, India, Israel and others that adapt to this new space environment as well. Brazil will have many opportunities in this regard if it so wishes. These changes to the world of space will impact not only the most publicized element of space tourism, but will also make space science more affordable and will allow new progress in space applications from space navigation to solar power satellites.

It is because this is an area of such rapid innovation, and because many of the new space entrepreneurs are open to international investment and participation in their ventures, that special opportunities seem to present themselves to Brazil and INPE in this regard. Specific opportunities that might be explored, by way of example, are as follows:

i. Bigelow Aerospace

The Genesis 1 Inflatable Space Hab project of Robert Bigelow's company has been able to move swiftly by taking technological development abandoned by NASA and combining it with Russian launch systems. The first Genesis launch of a spacehab unit was successfully launched and inflated in June 2006 and the second launch of an improved unit is expected in 2007. Experiments involving the use of the Bigelow Aerospace LEO spacehab units could be initiated through Joseph N. Pelton or by contacting directly Courtney Statt or Robert Bigelow, Bigelow Aerospace, 1899 N. Brooks Ave., North Las Vegas, Nevada 89032 Telephone: 702 639-4440 web site: www.bigelowaerospace.com

ii. UP Aerospace (Hartford, Connecticut) and Spaceport America-New Mexico) USA

UP Aerospace of Hartford Connecticut operates out of the commercial spaceport known as Spaceport America, located in New Mexico. It has recently launched its small carrier rocket SL-1 in October 2006. What UP Aerospace has characterized as a small anomaly came within 3 seconds of burn of reaching low earth orbit. Its next two rockets -- SL-2 and SL-3 -- are already built, checked out, and ready to fly. The next launch of the SL-2 is planned to take place before the end of this year. UP Aerospace has indicated the goal of "getting into a nice launch rhythm at Spaceport America -- with up to two space-launches occurring there per month."

UP Aerospace's SpaceLoft XL vehicle can launch up to 110 pounds (50 kilograms) of scientific, educational, and entrepreneurial payloads into space, with an altitude capability of up to 140 miles (225 kilometers). The company is currently scheduling up to 30 space launches per year from New Mexico's Spaceport America and offers a low cost launch for small experimental packages. This group indicates that it can provide a launch on a time scale of about two months from contract. It can fly a payload with a length of something just over 2 meters with a diameter of 25 centimeters. Later systems will likely be able to deliver small satellites to Low Earth Orbit. Contact address is UP Aerospace, 9249 S. Broadway Blvd, Unit 200 #112 Highlands Ranch, Colorado 80129 Telephone: 1 877-878-7321. website: http://www.upaerospace.com

iii. Utah State University Smallsat Program

The Utah State University Smallsat Program that is closely associated with the University's Space Dynamics Lab has now been in being for over two decades. In August 2006 the USU Smallsat Program hosted the 20th Smallsat Conference that is one of the premiere events in this field. See http://ususat.usu.edu/smallsatprog.htm The vision of the USU Smallsat Program and its areas of particular strengths are summarized below.

- Strengthen USU's presence in the small satellite community to attract partners, customers, funding and accumulate flight heritage and hardware autonomy development to control lead time and costs.
- Provide the first USU modular micro-satellite platform for USU's Space Dynamics Lab (SDL) that can adapt to multiple missions.
- Provide a platform that can be fabricated in < 1 yr at low cost in an academic, semi-professional or professional environment according to customers' needs.
- Creation of sub-system hardware that can be integrated to the platform on a continuous improvement basis.
- * Subsystems that can be integrated to the platform with C&DH, Communication, Power, Software, Deployable Mechanism, ADCS, Decking Capability and Thermal Control. Establish a platform that can be integrated to ESPA, Lightband or other international launcher standards

This group has a good deal of experience in developing small satllite systems for scientific and applications purposes. Their modular micro-satellite platform is easily adaptable to many different missions with production of a satellite within a year's time. This group can be contacted directly through their website or through Joseph N. Pelton.

This USU Smallsat program is the closest approximation in the United States to the Surrey Space Centre (as discussed below). Both could be potential partners. It is strongly recommended that INPE consider sending a representative to the USU annual Small Satellite Conference. Once one identifies a candidate program in remote sensing, or disaster detection, or telecommunication, or tele-education it is recommended that one contact both the USU Smallsat Program and the Surrey Space Center to determine which program might be best suited to INPE and Brazil's needs and purposes.

iv. Surrey Space Centre

The Surrey Space Center, associated with the University of Surrey in the U.K. has now participated in the design and manufacture of 25 micro satellites for a variety of telecommunications, IT, navigation, remote sensing, scientific and other applications missions. It's indicated areas of expertise are provided in the summary chart below.

Compentencies and Interests of the Surrey Space Center	
Astrodynamics	**The study of the dynamics of spacecraft. This subject includes mission analysis, satellite orbital motions; spacecraft attitude, guidance, navigation and control and estimation.**
Remote Sensing	**Fire Risk, Monitoring and Detection, Volcanic Monitoring, Oceanography using GPS Reflectometry**
Planetary Environments	**Space Science, Magnetospheric models, radiation effects on electronics.**
Propulsion	**Bipropellant engines, Solar Thermal, Green propellants**
Signal Processing	**GPS, Coding, Estimation**

Space Robotics	**In orbit servicing of satellites. Mars rovers.**
VLSI Design and Embedded Systems	**FPGAs, hardware accelerated compression and signal processing**
Autonomy	**Autonomy in Space**

This Center headed by Sir Martin Sweeting can be contacted via their web site: http://www.ee.surrey.ac.uk/SSC/ or by mail at:

Surrey Space Centre
University of Surrey
Guildford, GU2 7XH
United Kingdom

Also if INPE should wish I can provide a direct introduction since I know both Martin Sweeting as well as Prof. Barry Evans the founder of the Surrey Space Center. Projects that have already been undertaken with other countries or organizations have included South Korea, Israel, the Lifesat (that deployed two store and forward IT satellites that provided medical information to doctors operating in remote locations) and VITA that involved a joint venture to provide e-mail access in remote locations.

Joint partnerships involving INPE with university based research centers (such as Surrey or the Utah State University Smallsat Program) or newly emerging space companies would appear to be prime candidates for cooperative partnerships for INPE. These cooperative projects involving micro satellites or low cost launch arrangements could provide leveraged payoffs for the Brazilian space program and move projects from conception to actual realization within a two year period rather than a much longer period of time and a much reduced costs.

A systematic process of evaluating commercial and entrepreneurial projects and identifying a list of the top five to ten candidate opportunities through applying the type of analysis suggested in Figure 1 above would be a logical way to consider such opportunities. The following list (See Figure 5) is provided as a possible point of departure for the process. The idea would be to spread these joint ventures with commercial partners in several ways. One perspective would be a spread that addresses shorter term, medium term and longer-term projects and the other perspective would be to spread them over different countries or regions of the world.

Figure 5

Possible Candidate Joint Venture or Investment Opportunities for Brazil-INPE		
Example of Potential Partner	**Nature of Project**	**Comment**
	LONG-TERM	
Space Elevator Corporation (U.S.), Rice University, NASA,	**Design and deploy space funicular to GEO. (Needed Technology: Develop Nanotube and lt. weight robotic climber technology to deploy a space elevator to Geo Orbit**	**Brazil could be a possible terminus point. Investment in the project is possible. Interesting technology for other space application. Space elevator could dramatically change cost of access to Geo Orbit, the Moon and even Mars.**
Many potential partners (Mitsubishi, NEC, TRW, JAXA)	**Solar Power Satellite (SPS) project. (Needed Technology: Rainbow solar cells, quantum dot converters, concentrator reflectors, robotic systems.)**	**As the cost of oil rises and supply diminishes, the need to find low cost and clean energy increases. The right combination of new technologies might make SPS systems technically & economically feasible within 10 yrs. Brazil might specialize in one or more of the key technologies to be a partner in such an SPS project.**
	MEDIUM TERM	
Bigelow Aerospace, Lockheed Martin, EADS, ESA, CSA	**Pieso-electric and/or polyimide antenna systems with phased-array feeds (5 to 7 yrs)**	**The next breakthrough in applications satellites will likely depend on new technology that either produces power more efficiently or allows larger and higher gain antennas, of lower mass, to be designed, built and deployed.**
	SHORTER TERM	
JAXA-NICT-NAL, ESA, Scaled Composites, Raytheon, NASA-Aeroeniviroment	**High Altitude Platform Systems (2 to 5 yrs)**	**There are many ways to deploy HAPS as well many technologies (Dirigibles, solar cell/fuel eternal aircraft, high altitude jets with automated avionics, etc.) The applications include broadcasting, communications, remote sensing, fire detection, public security. Japan is most heavily invested and most advanced at this time.**
U. Cal Berkeley, Lawrence-Livermore, etc.	**Regenerative and unitized fuel cell technology (2 to 5 yrs)**	**Many spacecraft of the future (as well as HAPS) will depend on reliable Fuel Cell technology.**

Bigelow Aerospace, Andrews	**<u>Inflatable Space Structures</u> (2 to 5 yrs)**	**Inflatable polyimide and other materials can be used for space antennas, structures, etc. These need to function reliably despite radiation, micro-meteorites, etc. Reliable deployment systems also needed. Brazil could develop experiments that could be carried out within the spacehab inflatable structures.**
USU Smallsat or Surrey Space Center	**<u>Medium resolution remote sensing, sun synchronous satellite for collection of data on Amazon Basin. Alternatively this could be a Geo satellite to provide tele-education or tele-health services to remote areas of Brazil.</u>**	**Design and deployment of one or more remote sensing satellites or communications/broadcasting satellites could be accomplished in 12 to 16 months. Arrangements for launch could be negotiated with many new commercial launch systems.**

No attempt has been made to define specific space science experiments since these really will depend on INPE's internal competency and the desires of INPE experimental partners. There is a wide range of space science related to the Earth's Space Weather, the Earth's Ozone layer, changes to the Earth and Polar Cap Reflectivity, Solar Storms and eruptions, cosmic radiation levels, Global Warming, etc. that are central to the survival of the human species that would seem particularly productive to explore. INPE might indeed wish to consider an international conference to explore potential areas of technical collaboration and space experimental programs that might be of mutual interest to other governments and research centers. Although mechanisms such as COSPAR, the International Astronautical Federation, the International Academy of Astronautics, the International Institute of Space Law, COPUOS, the International Space University, etc. exist to coordinate space research activities, these mainly operate on a very informal basis. In the case of COPUOS the coordination that takes place is most often in the form of reporting on projects underway or completed.

There have really been few efforts over the years to explore truly meaningful space cooperation projects on a global basis. One can recall Unispace I and II and the International Space Year but, in fact, only the International Geophysical Year produced a truly world effort to coordinate scientific cooperation and experimentation on a global level. This, however, was at the very dawn of the space age in 1956-1957.

INPE might, in consultation the other space agencies, the IAF, IAA, IISL, COSPAR, JUSSTAP, ISU, IAASS and COPUOUS, seek to create a special forum whereby opportunities for space cooperation and international space experimentation might be discussed and initiated. In the age of the Internet, it might be that such a global forum could be held in conjunction with the once-in-a-decade World Space Congress. This special world space event, however, might be organized in such a way that participants could link into the meeting remotely via text messaging or even electronic voice or video conference. The purpose of such a world space event would be to link a number of new space initiatives together. This might be in the context of the largest space agencies seeking to share initiatives and projects with the rest of the space agencies of the world as well as even non-spacefaring nations to address the most pressing world problems of the day. These projects could thus be designed to address the digital divide, global warming, the ozone hole, preservation of the oceans and polar caps and rain forests and other projects that could be undertaken to preserve the Earth's biosphere.

Finally a series of teleconferences could be set up with officials of the Canadian Space Agency and the Communications Research Centre to discuss possible cooperation or collaboration with Canada in areas where there is special interest and expertise. This would be in the area of remote tele-education and tele-health services or in the area of remote satellite sensing and geomatics to address the needs of remote land and water management or environmental protection. Dr. Veena Rawat, President of the Commmunications Research Centre of Canada, 3701 Carling Avenue, P.O. Box 11490, Station H, Ottawa, Ontario K2H 8S2 Telephone 613 949-0179 e-mail: veena.rawat@crc.ca would be the person that I would recommend as the first line of contact.

A similar type of approach might be made to South Korea or Israel but in this case I would suggest that arrangements might be best made through Dr. Martin Sweeting of the Surrey Space Centre, since this organization has helped to design several of their satellite projects for these countries.

12.0 Findings, Conclusions and Recommendations

INPE is in an excellent position to use its strategic planning exercise as a means to open up new, important, and cost effective opportunities for space cooperation. This cooperation can be with other countries' space and research organizations, international and regional banks, international organizations, non-governmental organizations, universities, private companies that operate space systems as well as private companies that are developing new space transportation launch systems or space infrastructure. If initiated soon and effectively it can broaden the scope of INPE activities, while actually reducing its net cost of achieving a range of new space initiatives. In proceeding forward INPE must use a careful methodology so as to advance the most important projects to meet Brazilian needs and to ensure that the projects undertaken have the best chance to be accomplished effectively, on time and on schedule. Past experience is a useful guide as to how this might be accomplished and the types of problems that might be encountered.

It is recommended that several of the possible undertakings as outlined in Figures 3 and 4 of this report be considered. Further it is recommended that the potentially most attractive of these options be analyzed and evaluated along the lines as set forth in Figure 1 above. Annex C to this report provides an illustration of how this methodology might be applied to help consider advantages and disadvantages and help to establish priorities in selecting areas of greatest interest. This is not to say that one might also simply survey the plans of programs of other space agencies to determine their own interests and pick from among these alternatives, but it is hoped that some new options—carefully considered—might lead to entirely new opportunities.

It is particularly recommended that attention be devoted to finding ways to undertake cooperative projects with international research centers or at key universities that have special capabilities and that are open to international partnerships. Organizations such as the Surrey Space Centre and the Utah State University Smallsat Project illustrate this type of potential partnership or cooperative relationship. Likewise partnerships with start-up space corporations with a variety of space-related initiatives should be systematically surveyed as to partnership or other types of cooperative relationship.

In terms of working with these organizations it might be of great value to attend the annual Small Satellite Conference at Utah Sate University. It might also be a good idea to set up teleconferences with key people around the world to discuss areas of potential interest and collaboration. These could be set up with colleagues at the University of Surrey, Utah State University, within Canada, South Korea, Israel, etc. Finally after reviewing the chart in Appendix D, it might be useful to visit the web sites of organizations where potential partnership or some form of agreement might appear promising. Some consulting support to set up teleconferences or to answer preliminary questions as to mutual interest would appear desirable.

Finally an Appendix E has been added to this report. This Appendix provides additional background on the Korea Aerospace Research Institute (KARI) that carries out the space program of the Republic of Korea and on the Canadian Space Agency. This additional information is provided since KARI has a program that is in many ways parallel to INPE and because they have indicated in their own plans an active desire for international cooperation and because they have drawn on the expertise and consulting support of the Surrey Space Centre in developing their current applications satellite program. The information on the Canadian Space Agency is provided because its research program is heavily oriented toward space applications development programs, space science programs and activities that have a special emphasis on tele-education and tele-education. There is also a strong emphasis on international cooperation. (See Appendix E for further details.).

It is recommended that an initiative be considered to work with the world's space agencies to organize a mechanism so as to create new and better opportunities to undertake international cooperative space projects, experiments, or even data sharing on a useful standardized format.

Annex A

Acronyms

CNES:	**National Center for Space Studies of France**
COPUOS:	**UN Committee on the Peaceful Uses of Outer Space**
CSA:	**Canadian Space Agency**
DLR:	**German Space Agency**
ESA:	**European Space Agency**
ExIm Bank:	**Export Import Bank of the U.S.**
FES:	**Frederick Ebert Schiftung or Frederick Ebert Foundation**
IADB:	**International Development Bank**
IBRD:	**International Bank for Reconstruction and Development**
IDC:	**International Development Corporation**
INPE:	**Brazilian Space Exploration Agency**
ISRO:	**Indian Space Research Organization**
ISU:	**International Space University**
ITU:	**International Telecommunications Union of the UN system**
JAXA:	**Japanese Space Exploration Agency**
JICA:	**Japanese International Cooperation Agency**
NASA:	**National Air and Space Administration**
NGO:	**Non Governmental Organization**
NICT:	**National Institute for Information & Communications Tech of Japan**
NO_2:	**Nitrous Oxide**
OAS:	**Organization of American States**
RosCom:	**Russian Federal Space Agency**
RpK:	**Rocketplane Kistler**
UNDP:	**United Nations Development Programme**
UNESCO:	**United Nations Educational, Scientific and Cultural Organization**
UNICEF:	**United Nations Childrens Emergency Fund**
UNIDO:	**United Nations Industrial Development Organization**
UNO:	**United Nations Organization**
WHO:	**World Health Organization**

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International Space Station World International Space Station Team
http://www.boeing.com/defense-space/space/spacestation/overview/worldwide_team.html

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ARCA Space, http://www.lunar.org/docs/LUNARclips/v11/v11n1/xprize.shtml

Blue Origin and New Shepherd Launch Vehicle, http://www.blueorigin.com/index.html

The Canadian Arrow, http://www.canadianarrow.com/

C&Space and AeroBoss Aerospace, Inc. Join Forces,
http://www.hobbyspace.com/nucleus/index.php?itemid=207

The DaVinci Project, http://www.davinciproject.com/

Korean Aerospace Research Institute http://www.kari.re.kr

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Appendix C

EXAMPLE OF ANALYSIS

Evaluating Various Candidates Projects for Brazilian International Cooperation

Option No. 1: Possible Collaboration with a Private Space Venture for Launch of a Micro-Satellite

Identify Key Parameters and Challenges:

- Identifying all likely potential partners and their strengths & weakness (Narrow list of candidates)
- Seek partners that have proven technology, low or no cost launch capability, and attractive schedule and lift capability—desirably from at least two different countries or regions.
- Determine if there are any political, cultural, language or social issues to overcome
- Other parameters or challenges that become obvious from analysis process.

Identify Technologies, Processes, Sciences and Applications of Relevance

- Identify intended objectives for project and separately identify and give relative weight to these in terms of: Technology, Space Science or Application, Operation Processes, etc.
- Does Brazil gain in several areas and is their "sharing" in one or more categories
- Is their schedule, financial, and "learning" value in the project as opposed to alternatives?
- Who will be in control and does Brazil and INPE have leverage and process say so?

Create a Systems Block Diagram

- Diagram the proposed project from start to finish with regard to all key elements
- Indicate in the diagram: management and control, direct & indirect costs, schedule and GANTT chart (that becomes a PERT chart if project moves to implementation), project goals & objectives, legal and regulatory concerns, potential obstacles and critical paths, escape routes & major options.

Plot History and Improvements

- Plot the history of improvements, technical innovations, and trend line for all aspects of the candidate launch vehicle. Note all progress and problems for last 5 years or more.
- Examine for all aspects of the satellite experimental package for the project in terms of technical, scientific and/or applications, or process issues. This plot would be associated with all aspects of the candidate micro-satellite payload--both within Brazil and abroad).
- Assess history and trend line to see if there are unexpected problems or issues or even opportunities that have not been overlooked when viewed from a timeline and key trends basis.

Practical or Theoretical Uses

- This is the part of the exercise whereby it is determined if the purpose of the project is to provide a practical tool, address a specific objective such as use of space for education, health care, monitoring ecological changes, or answer a specific and clearly defined technical, scientific or operational issue that is of importance to Brazil, INPE & the world space or scientific community.
- This is the part of the process where it is answered "why the project important, necessary, cost efficient, unique, and provides value" to a broader Brazilian and/or world scientific community.
- Key questions are: Why would Brazil/INPE want to do this as opposed to something else? Does it duplicate something that others have done or could do better? Do we have special expertise?

OVERALL INITIAL ANALYSIS

- The other steps leading up to are essentially the basis of the project analysis. The key here is to put all of the factors together in terms of technology, science, application, cost, risks & opportunities.

- Essential the step here resembles very much what is called a SWOT analysis. This is to look for strengths, weaknesses, opportunities and even threats that the previous steps would have exposed.
- The other part of the process is to undertake what might be called an environmental analysis for the project. Who else is working in this field? Will our project be timely and supplement what the world community may wish to know? Or does it develop a new application needed by Brazil.

PHASE TWO

Block Diagram of Subsystems & Components

- Develop a detailed block diagram of the overall project that covers launch vehicle, experiments, TTAC, all experimenters, all partners and launch facilities, safety constraints and regulation, etc.
- Organize in terms of reporting and financial relationships

Final Assessments

- Undertake competitive industry assessments as to value of proposed projects versus alternatives
- Consider the "opportunity costs" (What is the cost and value of this project versus alternatives?)
- Evaluate for strengths and weaknesses of partners and responsible experimenters, points of potential failure, time to achieve desired results.
- Organize program schedule as a PERT diagram to identify critical paths.
- Why does INPE and Brazil want to do this? Rank all options on a priority basis over other options.
- Examine to what extent short, medium and longer term projects as well as smaller and larger scale projects have synergies and reinforcing aspects.

Selection of Final Projects for International Cooperation—Short, Medium and Longer Term

- Decide on top priority projects, discuss with all interested parties (internal and external) and make a decision after thorough evaluation and interaction with potential partner or partners.
- Document decision process and record anticipated outcomes, costs, schedule and expectations. (This should be used as part of the final evaluation process.)

Appendix D

Inventory of Private Space Ventures http://rocketdungeon.blogspot.com/ http://home.comcast.net/~rstaff/blog_files/space_projects.htm http://www.spacefuture.com/vehicles/designs.shtml http://www.hobbyspace.com/Links/RLV/RLVTable.html and numerous other sources as listed below.				
Company	**Rocket-Launch Vehicle**	**Intended Markets**	**Capabilities and Status**	**Launch Site**
Advent Launch Services	Advent 1 stage. (VTHL from ocean)	**Sub-orbital. 300 kg to 100 Km**	Full scale liquid engine tests.	Ocean launch & landing.
Aera Space Tours/Sprague Corp.	Altairis. (VTHL)	**Sub-orbital**. Space tourism	2 stage, RP-1/LOX propulsion . 7 passengers to 100km sub-orbital flights in 2007.	US Air Force Cape Canaveral Launch Facility-. 5 year agreement.
Alliant ATK	Pathfinder ALV X-1 http://www.astroexpo.com/news/newsdetail.asp?ID=27882&ListType=TopNews&StartDate=10/9/2006&EndDate=10/13/2006	**Orbital.** Launch to LEO of scientific packages. Upgradable to manned flight in time. ORS mission	**Upgraded Alliant sounding rocket.**	Mid Atlantic Spaceport, Wallops Island
American Astronautics	Now Renamed Sprague Corp. See Aera Space Tours. http://www.lunar.org/docs/LUNARclips/v11/v11n1/xprize.shtml	**DEFUNCT**. Formed to seek X-Prize. Crew to LEO.	**DEFUNCT**	**DEFUNCT**
Andrews	Gryphon Aerospaceplane	**Sub-orbital** space tourism	6360 kg to 100Km and return. LOX/RP-1. Less than $1 M/flight (in design)	N.A.
ARCA Space	Romanian project—Now Defunct http://www.lunar.org/docs/LUNARclips/v11/v11n1/xprize.shtml	**DEFUNCT**. Formed to seek X-Prize. Crew to LEO.	**DEFUNCT**	**DEFUNCT**
Armadillo Aerospace	Black Armadillo.(VTVL)	**Sub-orbital** spaceflight.	1 stage. LOX/ethanol engine. (Limited capital investment). Vertical Takeoff and land. (Like Delta Clipper design.)	White Sands, New Mexico

Benson Space Company	See Space Dev and Dreamchaser. Benson Space Company will market Dreamchaser vehicle. http://www.spacedev.com/newsite/templates/subpage_article.php?pid=583	Marketing company for Dreamchaser.	Not Applicable	Not Applicable
Blue Origin	New Shepard http://www.blueorigin.com/index.html	**Sub-orbital**. Space Tourism to 100 km.	Reusable Launch Vehicle. Hydrogen Peroxide and Kerosene fuel. Abort system.	Culberson County, Texas. HQs in Seattle, Washington
Blue Ridge Nebula	**DEFUNCT**. Small Family Enterprise.	**DEFUNCT**	**DEFUNCT**	**DEFUNCT**
Bristol Space Planes Ltd	Ascender (not the same as JP Aerospace Ascender) (Subscale flight models (VTHL) Space Bus (Concept only) 50 persons or 110 tons Space Cab (Concept only) 8 persons or 2 + 750kg	**Sub-orbital**. 3 people or 400 kg on space tourism flight	Jet. 2 turbofans to 8 Km. RL-10 liquid rocket engine to 100 Km	United Kingdom
C & Space (of Rep. of Korea) and AirBoss Aerospace Inc. (AAI)	Proteus space plane(VTHL) http://www.hobbyspace.com/nucleus/index.php?itemid=207	**Sub Orbital**. Space Tourism. 3 crew. members	LOX/Methane engines. ITAR approval pending.	To be decided.
DaVinci Program	DaVinci (Balloon launch and vertical landing) http://www.davinciproject.com/	**SubOrbital.** Space Tourism. 3 crew members	Balloon to 40,000 ft. Twin LOX/Kerosene engines to 120,000 ft. parachute landing.	Can be launched from any balloon launch site.
DTI Associates	Terrier-Orion (Terrier is surplus Navy missile motor and Orion is surplus Army missile motor)	**SubOrbital.** Cargo to LEO (290 kg to 190 Kilometers)	Motors and vehicle FAA-AST licensed.	Woomera, Australia
Energia Rocket & Space Corporation	Clipper (VTOL) http://www.astroexpo.com/news/newsdetail.asp?ID=25688&ListType=TopNews&StartDate=5/15/2006&EndDate=5/19/2006	**Orbital.**	In conjunction with Soyuz and Agara Launch Vehicles.	Baikinor and Russian Northern Cosmo-drome
HARC Space	Balloon Launch Reusable Vehicle	**SubOrbital.** Sounding and Targeting Vehicle to sub-orbital	Balloon and and liquid fuel rocket engines	Can be launched by balloon at many sites.

IL Aerospace (Israel)	Balloon launch and then Negev vechicle to Suborbital space http://web1-xprize.primary.net/teams/ilat.php	**SubOrbital.** 10 km by ballon and then Negev rocket launch to 120 km.	Balloon and Negev solid fuel rocket with parachute to water landing	Can be launched by balloon at many sites. Israel base.
Inter Orbital Systems (Mojave, California)	Sea Star (13 kg to LEO) Neptune (4500 kg to LEO) http://www.interorbital.com/	Sea Star. Microsat Launch Vehicle.	Stage and a Half. Liquid bi-propellant rocket. FAA-AST licensed	Off shore. Pacific Ocean. Los Angeles and Tonga
Japanese Aerospace Exploration Agency (JAXA)	HII Transfer Vehicle (Unmanned but in time might be upgraded to manned and pressurized vehicle.)	Unmanned Cargo resupply to the ISS. Launched on the HII vehicle.	Conceptual studies	To be decided.
Japanese Rocket Society	Kankoh Maru (Latest version of earlier Phoenix design)	**Orbital.** 50 passengers to 200km LEO.	Single Stage to Orbit. Vertical Takeoff	No hardware designs.
JP Aerospace (Rancho Cordova, Cal 95742)	Access to Orbit-Ascender Balloon System http://www.jpaerospace.com	SubOrbital. High Altitude experiments or rocket launch.	Very High Altitude Ballon. Can be used as Launch Platform to LEO using ion engines	California sites
Kelly Space & Technology Inc (San Bernadino, California)	Space plane http://www.kellyspace.com/	Crew and Satellite and Cargo launch. sub-orbital	Tow launch of reusable space plane	San Bernadino Airport
Lockheed Martin-EADS	Autonomous Transfer Vehicle (ATV) (Unmanned but could be upgraded to manned and pressurized vehicle.) http://www.lockheed.com/ http://www.eads.com/	Unmanned Cargo resupply to the ISS. Launched Ariane 5 but can also be launched on Atlas 5.	Could be upgraded to become a manned vehicle. Not yet funded.	Atlas 5 site at Cape Canaveral.
Lorrey Aerospace (Grantham, NH 03753)	X 106 Hyper Dart Delta http//www.lorrey.biz/	**Orbital**. Pilot + passenger and 220 kgs. To LEO or Bigelow space station. Orbital data haven.	(Conversion of F 106 Delta Dart to include ramjet to create a spaceplane.)	To be decided.
Masten Space	XA 1.0 (VTVL) XA 1.5 (VTVL) XA 2.0 (VTVL) http://www.masten-space.com/products.html	**Suborbital**. XA 1.0 100kg to 100km, XA 1.5 200kg to 500 km, 2000kg (5 people) to 500km.	Liquid reusable internalized engines.	To be decided.
Planet Space (See also Canadian Arrow)	Silver Dart Spaceplane and Lifting Body (VTHL) http://www.thestar.com/NASApp/cs/ContentServer?pagename=thestar/Layout/Article_Type1&c=Article&cid=1155678611503&call_pageid=968332188492 http://www.planetspace.org/lo/	**Orbital.** Crew of 8 ______ **Suborbital.** Crew of 3	First stage liquid propellant + OX. Second stage 4 JATO rockets-Abort	Nova Scotia, DaVinci Spaceport

	index.htm ________________ Canadian Arrow http://www.canadianarrow.com			
Rocketplane-Kistler	K-1 (5700 kg to LEO, 900-1400 kg to GTO) ___________________ Falcon ___________________ Rocketplane XP Pathfinder	**Orbital.** Payloads to LEO, MEO, GTO, ISS Cargo resupply &return missions. **Sub.Orbital.** Cargo & Microsats _____________. **SubOrbital.** 4 seat fighter-sized vehicle. Up to 4 or 410 kg to 100 Km. Or microgravity experiments	Various propulsion systems for K-1, Falcon and Rocket plane XP Pathfinder.	Woomera, Australia and Nevada Test Site.
Scaled Composite-Spaceship Corporation Virgin Galactic (Mojave, California)	SpaceShip Two-SS (HTHL)	**Sub-orbital.** Space Tourism 7 people to 100Km	Neoprene & NO2 as oxidizer.	Mojave Airport, South West Regional Spaceport (SRS)
Space Adventures with Myasishchev Design Bureau & Federal Russian Space Agency	Explorer Space Plane (C-21) and MX-55 High Altitude launcher plane (HTHL)	**Sub-orbital** Space Tourism	Liquid fuel motors. Horizontal Takeoff and Horizontal Landing	To operate from a number of international spaceports including Dubai, Singapore, US et al
Space Dev (California)	Dreamchaser (VTHL)	**Sub-Orbital.** Space Tourism (1 stage) 6 passengers **Orbital** (2 stage manned access to ISS)	Single Hybrid Engine. (Neoprene and $N0_2$) for suborbit. Launch of spaceplane on the side of 3 large hybrid boosters to reach LEO orbit & ISS.	To be decided.
Space Hab (Contract agreement with NASA to support COTS)	Apex 1 Apex 2 Apex 3 http://www.astroexpo.com/news/newsdetail.asp?ID=27197&ListType=TopNews&StartDate=8/21/2006&EndDate=8/25/2006	**Orbital.** Launch to LEO orbit. (300 kg (Apex 1) to 6000 kg (Apex 3) Apex 1&2 unmanned. Apex 3 can be manned.	Open architecture to support different missions and NASA's COTS Program.	To be decided.
Space	Rubicon 1 &2 and N-SOLV	**Suborbital.** 2	Design and status	To be

Transport Corp. (Forks, Washington)	now to be replaced by Spartan vehicle.	passengers to 80-100km. Spartan can launch 5 kg to LEO.	of project, and financing not clear	decided.
Space Exploration Technologies (Space X)	Falcon 9, Dragon Space plane http://www.spacex.com/	**Orbital.** Commercial Orbital Transport Service to ISS	Cluster of 9 Merlin engines on Falcon 9.	Kwajalein Atoll launch complex
Starchaser Industries (UK and Rocket City New Mexico)	Thunderstar-Starchaser 5	**Suborbital.** Space Tourism. Launch to 60 km.	Bi-liquid. LOX & kerosene rockets. Parachute recovery.	To be decided.
Sub-Orbital Corp. and Myasishchev Design Bureau	M-55X and Cosmopolis XXI	**Suborbital**. Two stage to 100km. Pilot and 2 passengers. Space Tourism.	1st Stage M-55X Geophysika. 2nd stage. C-21 a rocket-powered lifting body with parachute landing.	Flexible launch and takeoff sites.
Transformation Space Corp. t/Space (Allied with Scaled Composites)	CXV (Crew Transfer Vehicle)	**Orbital.** Crew of 4 to LEO or ISS & ISS resupply missions	Launches at high altitude from a large cargo carrier aircraft.	To be decided.
TGV Rocket	Michelle B Rocket (Modular Incremental Compact High Energy Low cost Launch Experiment)	**Sub-Orbital.** Small crew or scientific instruments.	Single Stage to orbit. Modular.	White Sands, New Mexico
Triton Systems	Stellar-J (HTHL)	**Orbital**. 440 kg of cargo to LEO	Launches via a cargo jet and LOX-Kerosene	To be decided.
UP Aerospace	Sl-1 Carrier Rocket-Space Loft XL.	Launch of small scientific packages of 50 kg in 220 km Leo Orbit.	Liquid fueled rocket. (Licensed by FAA-AST)	Spaceport America, New Mexico
Vela Technologies	Spacecruiser	**Suborbital**. Space plane. Up to 8 people	Jet plus Propane/$N0_2$	To be decided.
Wickman Spacecraft & Propulsion	WSPC Small launch Vehicle And SHARP Space plane (VTHL) http://www.space-rockets.com/sharp.html	**Orbital**. Cargo and in time Crew to LEO. Eventually spaceplane to carry passengers.	Phase Stablized Ammonium Nitrate solid fuel rocket. 900 kg to LEO.	To be decided.
XCOR Aerospace	Sphinx (Sub-orbital space) (HTHL) Xerus (Sub-orbital space) (HTHL)	**Sub-Orbital**. Space Tourism and nanosatellite launch. Xerus can also launch 10kg kg microsatellite to LEO orbit.	Isopropyl alcohol/LOX Sphinx is FAA/AST licensed.	White Sands, New Mexico

Appendix E
Information Concerning Potential Partners

The Korea Aerospace Research Institute (KARI)

The Korea Aerospace Research Institute (KARI) was established in 1989. The R&D activities at KARI are divided into three areas: (i) the development of cutting edge aircraft technology; (ii) the development of satellites; and (iii) the development of space launch vehicles. KARI also performs quality certification of aircraft and space products for the government.

The main programs in the area of cutting-edge technology aircraft development include the Smart Unmanned Aerial Vehicle (UAV) Development Program and the Korean Helicopter Development Program. This is work that would be usefully considered in terms of work on High Altitude Platform Systems (HAPS) if Brazil considered this to be an area of interest for future work.

KARI is currently working on the KOMPSAT-2 (Korea Multipurpose Satellite-2) and it is is near completion. There is also work now underway on the KOMPSAT-3, KOMPSAT-5 and COMS (Communication, Ocean, Meterological Satellite). The first satellites that KARI developed were in partnership with the Surrey Space Centre.

In the area of space launch vehicles, basic technology enhancement programs such as the KSR-III (Korea Sounding Rocket-III) Program, are following on from the successfully test launching of the liquid-fueled scientific rocket KSR-III in 2002. Based on the technology acquired from these programs, present efforts are being concentrated on the development of KSLV-I, a space launch vehicle capable of launching a 100kg class small satellite into low-earth orbit. This vehicle is currently planned for launch in the year 2007. Construction of a space center and a launch site are also in progress and these are to be completed by 2007.

KARI's state goal within its strategic plan is to become an internationally-renowned aerospace research institute within the next 10 years by leading the development of aerospace technology in Korea and by strengthening the competitiveness of Korea's aerospace industry. It has also indicated a strong interest in international cooperation in space as its own development moves forward. KARI’s web site is: http://kari.re.kr. Its address is 46 Eoeun-dong Yuseong, Daejon, Korea Telephone: 042-860-2114 (Note: Selected web information is available in English on request.)

Finally it was thought useful to share the strategic plan that KARI and the Government of the Republic of Korea has developed looking ten years into the future.

Republic of Korea Strategic Objectives for Aerospace Development

Overall Objective: To Rank Among the Top 10 Aerospace Industry Countries by 2015:

- Independent development of multi-purpose satellites, and space launch vehicles for entering the world market
- Acquire the capability to independently develop UAV and helicopters
- Become an manufacturer of small to medium aircraft and export core components and materials.

Satellites: Develop 13 Satellites by 2010

- Establish the capability to domestically develop multi-purpose MEO and GEO satellites
- Acquire the capability to process and utilize satellite data

Launch Vehicles: Acquire the Capability to Independently Develop a LEO Space Launch Vehicle

- Launch a 100 kilogram satellite into Low Earth Orbit
- Launch a 1.5 ton satellite into Low Earth Orbit
- Establish a space and launch center

Aircraft: Develop a number of capabilities related to UAVs, Heliocopters and a National Certification System

- Develop an innovative “smart” UAV
- Develop a Korean transport heliocopter by 2011
- Develop to ability to independently develop helicopters and small aircraft by 2015
- Develop a national quality certification infrastructure.

The Canadian Space Agency

The **Canadian Space Agency Act** is the Act of the Parliament of Canada under which the Canadian Space Agency was established and currently operates. The Act received royal assent on May 10, 1990 and came into force on December 14, 1990. The legislated mandate of the CSA is:

> "To promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians".

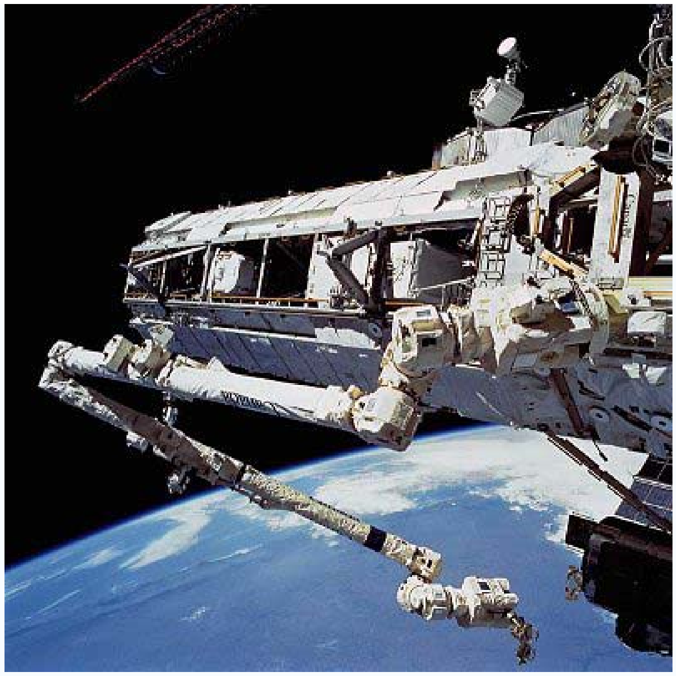
The Canadian Space Agency's mission statement says that the agency is committed to leading the development and application of space knowledge for the benefit of Canadians and humanity. To achieve this goal, the CSA attempts to promote an environment where all levels of the organization:

- pursue excellence collectively
- advocate a client-oriented attitude
- support employee-oriented practices and open communications
- commit themselves to both empowerment and accountability and
- pledge to cooperate and work with partners to mutual benefit

The CSA has several formal and informal partnerships and collaborative programs or agreements with space agencies in other countries, such as NASA, the European Space Agency (ESA) the Japanese Space Exploration Agency (JAXA), and the Chinese National Space Agency.

Since January 1, 1979 Canada, prior to the establishment of the current Canadian Space Agency has had the special status of a cooperating state with the ESA, paying for the privilege and also investing in working time and providing scientific instruments which are placed on European probes. On June 21, 2000 the accord was renewed for a fourth period, this time for 10 years. By virtue of this accord Canada takes part in ESA deliberative bodies and decision-making and in ESA's programs and activities. Canadian firms can bid for and receive contracts to work on programmes. The accord has a provision specifically ensuring a fair industrial return to Canada. CSA is a relatively small organization with approximately 600 employees and thus operates on a scale comparable to INPE. It has produced many effective programs during its history.

The CSA visited the China National Space Administration in October 2005 and plans to put Canadian scientific instruments in two Chinese satellites. There is also speculation about China in the future perhaps wanting the Canadarm2 technology for its planned space station. CSA has had a wide range of space related activities related to remote sensing, satellite telecommunications, space exploration, and has become known particularly for its Canadarm used on the Space Shuttle and Canadarm 2 for the International Space Station.



The Canadarm from Space

Canada is a very reliable partner and keeps its international commitments. It has focused its international cooperation largely on ESA and the US. It did sign an international joint statement with the Indian Space Research Organization (ISRO) in 2003, but this was a statement of principle concerning space cooperation and did not result in any specific cooperative program.

Name	Launched	Retired	Purpose
Alouette 1	September 29, 1962	1972	Explore the ionosphere
Alouette 2	November 29, 1965	August 1st, 1975	Explore the ionosphere
ISIS-I	January 30, 1969	1990	Explore the ionosphere

ISIS-II	April 1st, 1971		Explore the ionosphere
Hermes (Also known as Communications Technology Satellite (CTS) in partnership with NASA.	January 17, 1976	November, 1979	Experimental communications satellite
RADARSAT-1	November 4, 1995	Still in use	Commercial Earth observation satellite
MOST	June 30, 2003	Still in use	Space telescope
SCISAT-1	August 12, 2003	Still in use	Observe the Earth's atmosphere
RADARSAT-2	Scheduled for 2006		Commercial Earth observation satellite
CASSIOPE	Scheduled for 2007		CAScade, Smallsat and IOnospheric Polar Explorer

Appendix F

Special Opportunities for Cooperation Related To Telecommunications Satellites and Ion Thrusters

Worldwide revenues from all types of telecommunications satellites (i.e. their manufacture, launch, operation, insurance and various service revenues) now top $100 billion (U.S.) Thus, this activity is by far the largest and most lucrative of all of the space-related applications. Despite the growth of space navigation, remote sensing, and other space activities, telecommunications is clearly likely to remain the biggest space industry for some time to come. New activities such as space tourism, in studies conducted by companies such as Futuron, suggest that even this activity will be only a small fraction of the communications industry in terms of revenues for many years to come.
(Joseph N. Pelton, Future Trends in Satellite Communications: Markets and Services, (2005) International Engineering Consortium, Chicago, Illinois.)

INPE should likely view opportunities for cooperation in the satellite communications field from several perspectives: (a) Joint development of new technologies for the communications satellite field with various international partners; (b) Tests and demonstrations of new telecommunications satellite applications; and/or (c) Joint projects with operators of commercial satellite networks including provision of TTC&M services. These opportunities will be discussed below in this order.

(a) Joint development of new technologies for the communications satellite field

The development of new technologies for the communications field has been transferred almost entirely to industry in countries such as the U.S., but the European Space Agency, JAXA, South Korea, Canada, and China still have active R&D programs. Further entities such as the Surrey Space Centre and Utah State have active interest in developing key technologies (that can in many cases be effectively applied to all types of applications satellites such as systems related to power, power management, thrusters, etc.).

(i) Currently the Surrey Space Centre is working in the area of bi-propellants and green thrusters but to my knowledge do not have an ion thruster program. The same is true for KARI in the Republic of Korea and the Utah State University program. It would seem useful to explore whether any or all of these programs would be interested in collaboration with INPE in the development of a reliable ion thruster that might be used on a small satellite. The objective would be to extend lifetime and to reduce the mass required for station-keeping. This program could even explore the use of ion engines to achieve slow deployment of a geosynchronous satellite from low earth orbit to GEO using ion engines. (These all seem to be possibilities that could be explored in 2007).

(ii) Another possibility would be to explore with Japan and JAXA and NICT, in particular, whether they would be interested in exploring the test of materials for a larger scale deployable antenna system (that could be used for communications satellites or even as a lens for a solar power satellite) by use in a scale model test via their small satellite test program. The types of deployable antenna material that might be explored in such a manner might be either a polyimide (inflatable very thin plastic) antenna or a pieso-electric material. This could be explored with contacts in JAXA and NICT in Japan to see if there is possible interest in such a project and the size and cost of such an undertaking.

(b) Tests and demonstrations of new telecommunications satellite applications

It seems that it is true of most space programs that their public support is increased if their activities seem to have some relationship to local needs of their own people. It would seem that a demonstration of how one or more telecommunications satellite could send digital voice (voice over IP), digital video, and broadband Internet to a remote VSAT antenna and then inter connect with a Wi Fi/Wi-Max system to provide such services in remote and underserved areas such as the Amazon rain forest might be supported by other elements of the government. This demonstration could also provide information in near real time derived from remote sensing satellites providing coverage of the Amazon region as well.

This type of demonstration project would involve cooperation with providers of VSAT and Wi-Fi/Wi-Max equipment, solar power systems, educators and health care providers equipped to provide various forms of tele-services, and even entertainment companies and broadcasters. This would also involve cooperation with Embratel, Telebras, Hispasat, Intelsat or others. In this case INPE's role would not be to develop new technology, but rather to play the role of coordinator to combine various technologies, remote solar power generating systems, and tele-service providers together to demonstrate new ways of offering services to remote areas. Part of the exercise would be to examine an economic model to see how the new systems could generate new jobs, lower the cost of education or medical services, or otherwise generate revenues that would help to cover the cost of such services on an operational basis. This exercise would likely need to request support from the InterAmerican Development Bank (IADB), CIDA, AID, etc.

(c) Joint projects with operators of commercial satellite networks including provision of TTC&M services.

There are many telecommunications satellite systems that need support in terms of the provision of tracking, telemetry, command and monitoring services. Also some satellite systems have space capacity that can be used for tests and demonstrations related to the environment, education or health care. Some organizations might even be willing to fly experimental packages (such as 48/38 GHz beacons for propagation measurements, or other small packages or allow micro-satellites to share a launch. Unfortunately there is no single registry where one might determine where such opportunities might exist. Thus the key to seeking such opportunities involves talking to high level personnel within these organizations or talking to high-level government officials in selected countries or high level officials within international organizations.

In all of these activities such consulting support to survey opportunities and to make introductions will be needed. In considering all of the above possibilities it is important to explore not only the possible projects, areas of likely collaboration, estimated costs and schedule, but also to examine regulatory constraints with regard to the flow of intellectual property information and other similar legal issues. The most likely partners in such undertakings may well be KARI in the Republic of Korea, JAXA and NICT in Japan, CIDA, CSA and CRC in Canada, the Surrey Space Centre, the Utah State University Small Satellite Program, Intelsat, Eutelsat, SES Global, Hispasat, the European Space Agency plus the most active space programs of Europe such as DLR of Germany, CNES of France, the Italian Space Agency and the Spanish Space Program.