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I. FRAME OF REFERENCE

A. General context

1.1 Argentina is emerging from a major financial, economic, political and social crisis that took place during the beginning of this decade. Since 2003, the economy has been growing at annual rates of close to 9%. Gross Domestic Product (GDP) rose 9.2% in 2005, recovering pre-crisis levels, while private consumption expanded by 9%, mainly due to higher wages and falling unemployment. Exports grew 29% in the year to August 2005, the fastest pace in eight years.

1.2 Today, the greatest challenge faced by Argentina is to make this recovery a sustainable one. This will require a concerted effort to move forward on several fronts in order to create the conditions for sustainable growth in the long term. Some of the key challenges faced by the country involve the need to strengthen its institutions, the incentives faced by investors and the productive sector, and the level of human capital and social protection of its citizens.

1.3 An objective that is critical in setting the conditions for long-term economic and social development is productivity growth, which is largely determined by the level of scientific development and innovation capabilities within a country, as well as its ability to adopt and adapt knowledge and technology generated elsewhere. In this respect, Argentina's workforce and scientific community are

among the most highly educated in the region, and in the developing world.[1] In the past decades, the country has consistently been among the region's leaders in most indicators measuring human capital, workforce skills, and science capabilities.

1.4 Despite these relatively high levels of domestic science capabilities, Argentina considerably lags developed nations in the production of technological outcomes.[2] Moreover, while Argentina's capabilities and performance have remained relatively stable in the past two decades, the same period has seen several developing countries make dramatic improvements, both in development of domestic capabilities and in the performance of their science and innovation sectors (eg, China, India, Chile, Brazil). Argentina's highly educated workforce and stock of capabilities in science are seemingly underutilized, and their potential for contributing to economic growth is not being fully realized. The country has seen unimpressive results in the production of patents, technological applications and linkages with the productive sector and, more worryingly, a relative depreciation of capabilities due to insufficient investment in the sector and continued brain drain. Institutionally, the National Innovation System (NIS) of Argentina is inefficient in transforming research activities into commercial and practical applications, due to limited collaboration with the private sector and the potential users of technologies.

1.5 In the face of the crises experienced by the country in the past decade, the fact that there hasn't been a major drop in the absolute levels of domestic capabilities is a positive sign, which points to their strength and resiliency. The national consensus regarding the importance of the sector, expressed in the country's Science and Technology Policy (2005-2015), which is one of the main pillars of Argentina's socioeconomic development strategy[3], has allowed a basic level of investment to be sustained, even under great fiscal constraints. However, continued underinvestment and further loss of relative advantage could eventually erode Argentina's scientific strengths and capabilities, thus affecting one of its greatest assets for sustained development. Alternatively, under stable macroeconomic, institutional, and social conditions, greater investment in the sector could lead to the development of products and technologies with direct benefits to users, which in turn could lead to the creation of new industries and economic growth.

1.6 In the past decades, the Bank has closely supported Argentina's efforts to further the skills of its workforce and strengthen its science and technology capabilities. More recently, the Bank has financed a series of loans to establish competitive funding to support science and technology projects in Argentina, especially those that seek to link the private sector and final users with researchers and scientists[4].

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[1] Argentina has 1.6 researchers for every 1000 economically active inhabitants, higher that the Ibero-American average (1.1) and greater than Brazil (0.84), Chile (1.08), Uruguay (0.61) and, Mexico (0.55).

[2] The level of scientific publications and commercial patents in Argentina, two important innovation outputs, are below the average for economies with similar characteristics (World Bank 2004).

[3] Ministry of Economics, (2003): "Macroeconomic, sector, and microeconomic components of a national development strategy: Guiding principles to strengthen the sources of economic growth."

[4] One of such projects is Argentina's US$510 million Technological Modernization Program III (AR-L1012), with Bank financing of US$280 million, currently in its final stages of approval.

These investments have helped to maintain the domestic skill base, while creating mechanisms to improve the linkages between scientists and the productive sector. However, for Argentina to move closer to the world technological frontier and to better articulate the relevant actors of the NIS, a concerted and focused effort will be needed to capitalize on its capabilities,[5] with an emphasis on its areas of strength and private sector collaboration. Remote sensing and satellite Earth Observation (EO) is precisely one of the areas where Argentina has a relevant skill base and science foundation, where potential applications could be of great benefit, and where its industrial base can collaborate meaningfully.

B. Advanced remote sensing and earth observation technologies and applications

1.7 Remote sensing is the science and technology of obtaining information about objects or phenomena from a distance (i.e., without physical contact, for example from airplanes, balloons, or space satellites). Remote sensing can be a less costly and more rapid means of data collection over wide geographic areas than field observation, and can be used to extend the knowledge gained from point measurements to larger geographic areas.[6] Remote sensors carried in earth observation satellites can provide a range of environmental measurements over areas too large to be collected by other means. Sea-surface temperature, crop condition, chlorophyll concentration of near-surface waters, meteorological data on cloud temperature, and the advance of desertification are but a few examples.[7]

1.8 EO satellites are usually operated by national space agencies, due to their technological complexity and the public nature of most of their applications. EO satellites can have geostationary or low earth orbits. The former orbit at a distance of almost 36,000 km above the equator at a given longitude, keeping pace with the speed of the earth's rotation and providing constant coverage, but their images usually do not provide much detail. The latter are more common and orbit the Earth at distances of 200 to 2,000 km, typically in orbits that pass over the poles. Since they are closer than geostationary satellites, they provide images with greater detail, which are then downloaded to ground stations when the satellite flies over the stations' line of sight.[8] Unlike EO satellites, telecommunications satellites relay telephone, television, and other signals, and usually operate in geostationary orbits, are more numerous and technologically simpler, and tend to be built and operated by private sector companies, as their applications are commercially feasible.

1.9 Satellite EO as a technique for environmental mapping and monitoring was first established in the 1970s with the launch of the Landsat program by the United States (US). Satellite images taken in the optical range of the electromagnetic spectrum have thus been in use for over 30 years, helped by a heritage of

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5 The term "mission-oriented" technology policies is used to describe the type of programs where the technology objective and the economic applications are clearly defined (Canter and Pyka 2000).

6 The effective use of remote sensing data requires some field data for verification and calibration.

7 Canadian Center for Remote Sensing (CCRS): http://www.ccrs.nrcan.gc.ca/.

8 Built-in recording capacity may allow for limited satellite storage of information in orbit, which is later relayed to a ground station.

experience in interpreting aerial photography and by the fact that interactions between visible light and land surfaces are well understood. Since the early Landsat missions, there have been over 50 civil EO satellites with instruments providing measurements in the visible and infra-red spectrum.[9] All of these work on the same principle, measuring reflected sunlight from the earth's surface to form an image. These images are produced after a series of processing stages of the raw data collected by the satellite. Images can be obtained at various levels of resolution or detail (from several kilometers to under 10 meters), based on the size of objects readily identifiable in them.

1.10 More recently, scientists have begun to develop more useful applications of EO based on data collected by active instruments that operate in the microwave part of the spectrum. Unlike optical sensors, these instruments collect reflected microwave energy from the earth that has been generated by the instrument itself, and are commonly known as radars.[10] One particular form of imaging radar known as Synthetic Aperture Radar (SAR) is commonly used for space instruments. SAR sensors, and the potential applications of the resulting data, have important advantages over optical instruments for a number of reasons: i) different physical parameters can be measured due to the interactions of microwave radiation with surface materials (e.g., moisture content); ii) the sensor generates its own energy and thus does not rely on reflected sunlight, allowing for measurements to be taken at any time of the day or night; and iii) clouds are "invisible" at the wavelengths used, so data can be collected through cloud-cover.

1.11 SAR sensing systems can operate at different frequencies. The choice of frequency is a trade-off between the nature of the physical surfaces of interest, the intended applications, and the cost of the satellite. SAR EO systems have operated at X, C, and L-bands (respectively, 4 cm, 9 cm, and 23 cm wavelengths). In the past, C-band systems have been launched as a compromise between the extremes and because this wavelength is useful for mapping sea ice and ocean characteristics. However, the experience with C-band data has led to the understanding that L-band data would represent a superior data source in some cases and, in particular, that combinations of different radar frequencies would be highly valuable.

1.12 Since the launch of Europe's ERS-1 satellite in 1991, considerable experience and success has been gained in collecting environmental data using satellite based SAR sensors, including measurements of ocean state, sea ice maps, detection of oil spills, detection of ships and icebergs, and mapping vegetation and topography. More recently, a technique known as interferometric SAR processing has allowed for the detection of small movements in the surface between passes of the satellite.

[9] In recent years, as costs have declined and collaboration increased, nations like Taiwan, Malaysia, Thailand, and Korea, as well as developing countries like India, China, Brazil, and Argentina have emerged as important players in the international EO arena, by developing EO satellite missions and applications. The Indian space program has achieved significant success since its inception in 1962, by orienting its objectives toward national development needs, through remote sensing. Likewise, Thailand has used satellite remote sensing to provide more accurate estimates of crop acreage and patterns.

[10] The power requirements of the active instrument reduce the time that it can operate during each orbit (i.e., data can only be collected during 10% of the time it takes for each orbit).

This technique has valuable applications in monitoring buildings' subsidence and movement in other structures (for example, bridges, dams, etc.), and in modeling seismic and volcanic risk.

C. Relevance of satellite earth observation technologies for Argentina

1.13 Technologically advanced EO satellites are being designed and launched by a series of developed countries, as well as developing nations with sufficient resources and domestic capabilities. The benefits from these investments can be considerable, both in terms of the applications that are eventually implemented, the capabilities that are developed and the spillovers that ensue.[11] In Argentina's case, involvement in the EO sector has three objectives:

1.14 **Strengthening existing science and technology skills to build competitive world-class capabilities.** Argentina possesses significant skills and expertise in areas that constitute the scientific and technological foundations for the development of EO satellites, specifically, physics and material sciences.[12] It is one of only two countries in the region, with Brazil, that has the skills and capacity to support advanced space activities. During the past decade, and in partnership with space agencies from developed countries, Argentina has developed a series of increasingly complex satellite missions carrying optical equipment (see ¶1.18) and has successfully positioned itself to approach the world technological frontier in this sector, and eventually become a world-class player.

1.15 **Specializing in specific areas of knowledge and positioning the country in a technological niche that leads to important economic benefits and practical applications.** The inherent benefit of EO satellites is that they are a cost effective way of acquiring knowledge about various environmental and physical parameters for large geographic areas. Given Argentina's size and the economic importance of natural resources and food production for the country, remote sensing satellite technologies could be applied effectively to develop economically beneficial applications for more productive and sustainable management of those resources. As the experience of Canada demonstrates, sustained commitment to remote sensing satellites can yield substantial benefits, especially for large countries with abundant natural resources, as efficient management of those resources can lead to important economic benefits for the productive sector and for society as a whole.

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[11] There are few examples of studies that have been able to quantify such benefits for recent space projects. A study of NASA's spending on space R&D and its impact on GDP (Chase Econometrics, 1975), calculated a return of 14 to 1, which translated into an annual discounted rate of return of 43%. Canada (Amesse et al, 2002) is expecting C$972 million in direct sales of EO data and export sales (technology diffusion), as well as spin-off products and services based on the technologies involved during the lifetime of its Radarsat 2 mission (sensor development, image analysis, data processing and storage, expert systems, artificial intelligence, GIS and GPS applications).

[12] R&D in physics and material sciences led to the development of technologies and human resources that allowed Argentina to become the first country in the region to develop nuclear reactors for electricity generation, through joint efforts between the National Commission for Atomic Energy (CNEA), the Balseiro Institute, the University of Cuyo, and technology firms, like *Investigación Aplicada* (INVAP).

1.16 **Strengthening and seeking meaningful collaboration with the country's domestic industrial base and NIS.** In developing a technologically advanced EO satellite mission, a series of "upstream" and "downstream" research and development (R&D) relationships must be established with suppliers of services and products that are necessary for its design, construction and operation, as well as with public institutions and firms that can provide end users with value-added information services based on satellite imagery. As shown by the experience of various space agencies in the developed world, these relationships can generate significant benefits, through the creation of new industries and spin-offs, and closer cooperation between industry and other actors of the NIS.[13]

1.17 For most developing countries, this type of collaboration is not possible, as they do not have a suitably trained workforce or a sufficiently advanced industrial base. Moreover, only a handful of companies in the world can supply the advanced systems integration services required of a prime contractor for an EO satellite. In Argentina's case, the country possesses these necessary elements. It has a relatively advanced industrial base and an educated workforce that can supply many of the services and products required for the design and implementation of complex EO satellite missions, as well as for developing the practical applications based on the resulting imagery. In addition to this, INVAP, a national firm that is certified by NASA as an eligible contractor for satellite design, construction, and operation, has already acted as prime contractor for the SAC-A mission and all Argentine parts of the SAC-B and SAC-C satellites (see ¶1.18).[14] In this sense, the country's previous experience with EO satellite missions has allowed it to develop and strengthen its relationships with industry and other actors of the NIS, placing it in a position to undertake more technologically complex projects.

D. Argentina's track record in the sector

1.18 The National Commission of Space Activities (CONAE) is the agency responsible for Argentina's civil R&D initiatives for space-based activities. Its mission is to design, control and manage all projects and ventures relating to space activities in the country, applying space science and technology for peaceful ends. CONAE was created in 1991, as a civil entity attached to the Ministry of the Presidency and was transferred to the Ministry of Foreign Relations in 1996. With the 1995-2006 Space Plan, CONAE initiated its space activities, successfully developing three satellite projects, which reached their orbits between 1996 and 2000: i) SAC-A: a small science satellite for solar astrophysics R&D, launched in 1996; ii) SAC-B: a technical model for the SAC-C mission, launched in 1998; and iii) SAC-C: the first Argentine EO satellite, launched in 2000 and still in operation, as part of the Morning Constellation, with NASA's Landsat 7, EO1, and the Terra satellites.

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13 Space programs can yield considerable indirect benefits to firms. For example, the NASA Life Sciences Program estimated that for a sample of 15 US firms, close to US$200 million in R&D investment was added by these firms to the initial NASA R&D contracts (US$64 million). As a result of this, Hertzfeld (1998) estimated a cumulative added value of U$1.5 billion (1960-1997), on sales of US$2.3 billion.

14 INVAP has about 360 employees, 70% of whom are engineers, scientists, and technicians. If associated local firms, contractors, and suppliers are included, the total number of workers is close to 700.

1.19 During the same period, CONAE has gradually developed its ground infrastructure for the reception and processing of satellite images, as well as its capabilities in the development of applications and user training. CONAE's Teófilo Habanera Space Center in Córdoba, which supports these activities, houses the following facilities:

a. The Córdoba Ground Station: responsible for satellite command and data reception, for CONAE and other space agencies (supporting Landsat 5 and 7, Radarsat 1, Spot, the NOAA series, EROS, Orbview 2, Terra, and ERS).

b. The Mission Control Center and Test and Integration Facilities: responsible for controlling, planning and executing commands for satellite missions, and for integration, testing, and qualification of CONAE's satellites.

c. The Mario Gulich Institute for Advanced Space Studies: inaugurated in 2001, it is responsible for R&D for potential applications of EO satellite imagery, as well as training of human resources. The Institute is a joint effort with the University of Córdoba and is backed by various international space agencies.

1.20 The satellite images received at the Córdoba Ground Station are distributed by CONAE's Unit for Distribution of Satellite Images and Promotion of its Applications (DISPA) to a portfolio of over 600 clients, including those in Brazil and Europe. Since its creation, DISPA has delivered a total of 33,443 images and products. In 2000, CONAE won an international tender to supply Landsat images to the US Department of Agriculture and issued an Announcement of Opportunity (AO) inviting the scientific community, universities, and businesses to present R&D proposals for applications based on the optical instruments on the satellites of the Morning Constellation (including SAC-C), resulting in awards to over 150 proposals. In 2004, CONAE sold 5,765 products, with an average price per image of US$500.[15] The demand for DISPA products has doubled every year since 1998, and its delivery capacity will soon reach 3,000 images per month.

1.21 Since its creation, CONAE has worked closely with space agencies from around the world (e.g., the National Aeronautics and Space Administration of the US (NASA), the European Space Agency (ESA), the Italian Space Agency (ASI), the Brazilian Space Agency (AEB), and the National Center for Space Studies of France (CNES)), both in the joint implementation of its satellite missions and in the development of applications based on the imagery generated by them.[16] As a result, CONAE has begun to develop advanced mission assurance methodologies and capabilities, by developing skilled human resources and through the systematic implementation of practices and procedures that are consistent with NASA's protocols. The successful SAC-C mission provides clear evidence of these increasing capabilities, as the overall mission has been managed by CONAE, with responsibilities shared with a series of national and international partners, including CNES, ASI, and INVAP.

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15 More information about CONAE's products can be found in http://ggt.conae.gov.ar/Catalogo/preciosi.htm.

16 For a full listing and description of CONAE's international agreements and collaborative efforts with other countries and space agencies, see: http://www.conae.gov.ar/coopinstitucional/convinter.html.

1.22 As a result of sustained efforts during the past 15 years, consistent government support, and intense international collaboration, CONAE has increasingly become an internationally respected space agency, focused on EO satellite technologies, and is now seen as a competent and reliable partner by many international space agencies. The experience gained through its previous satellite missions has allowed CONAE to train specialized human resources, build a capable base of suppliers, and develop management methods that are consistent with international best practice. CONAE is poised to become a truly global player in EO satellite technologies, capable of undertaking more complex, cutting-edge missions in the coming years. This will require the development of world-class capabilities and practices within the space agency itself, and in collaboration with Argentina's industrial base, the NIS, and the users that can benefit from potential applications.

E. Argentina's strategy in the sector[17]

1.23 Argentina's National Space Plan (NSP)[18] establishes the activities and actions to be undertaken to further the country's space capabilities. It is revised periodically, maintaining a planning horizon of 11 years. The first revision of the NSP covered the 1995-2006 period; the revision for 2004-2015 was completed recently. Through the NSP, CONAE promotes Argentine satellite missions focused on EO while fostering an intense exchange with the scientific community. A key principle of the NSP is that its satellite mission need to provide information that is complementary to and compatible with information available internationally.

1.24 The primary goal of the National Space Plan of Argentina is to generate Complete Space Information Cycles (*Ciclos de Información Espacial Completos* – CIEs), in order to gather timely and adequate space information from the national territory, both land and sea, that combined with information from other sources, can contribute to the optimization of key socio-economic activities. The six CIEs are: i) agriculture, livestock, fishing and forest activities; ii) weather, hydrology, and oceanography; iii) management of natural and human-induced disasters; iv) environmental and natural resource monitoring; v) cartography, geology, mining production, and land use planning; and vi) health applications, in particular related to epidemiological data. The CIEs are implemented through international cooperation between CONAE and other space agencies (see ¶1.21).[19]

1.25 As part of the NSP, CONAE plans to increase its portfolio of satellite missions for EO through the following projects: i) Aquarius/SAC-D, a joint development with NASA, comprised of instruments and a space vehicle (SAC-D) made by CONAE, and of NASA's Aquarius instrument, whose mission it will be to provide

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17 In the area of telecommunication satellites, NahuelSat, a consortium of national and international firms, owns and operates the Nahuel-I satellite, which provides communications services since 1997 to Argentina, Brazil, Chile and Uruguay. A new orbital position, originally given by Argentina to NahuelSat for the operation of a second regional communications satellite, is now to be handed to ArSat, a soon-to-be-created mixed ownership firm. The creation of ArSat is awaiting approval from Argentina's Congress, which needs to occur before the right to use the allotted orbit expires.

18 For a full presentation of the NSP, see: http://www.conae.gov.ar/planespacial/planespacial.html.

19 CONAE is also leading the initial efforts to establish a South American Space Agency.

information about ocean circulation and its effect on the Earth's climate (launch expected in 2008); ii) SAC-E, a mission that will be part of a cooperative effort between CONAE, AEB, and the Brazilian National Institute for Space Research (INPE), to provide information about water use and agriculture, for environmental monitoring of the MERCOSUR area (launch in 2013); and iii) SAC-F and SAC-G, two satellites carrying optical cameras, passive microwave sensors, and laser systems. Other planned missions, which are more advanced in relation to the optical technologies of the SAC series of satellites, are: i) SAOCOM, the first Argentine space platform to carry a L-band SAR sensor (launch in 2010); and ii) SARE, a high revisit frequency satellite mission (launch after 2010).

1.26 SAOCOM is a satellite based monitoring system intended for environmental monitoring and applications in the fields of agriculture, flood management, seismic risk assessment, and disease prevention, among others. The SAOCOM satellite mission is in the critical path to achieving CONAE's objective of becoming a global player in the field of EO, as it constitutes an important step in deepening its technological capabilities. The application of EO data has yielded considerable benefits to other countries, by improving agricultural productivity, through better management of natural resources, and by allowing more efficient responses to natural emergencies. Its potential for Argentina and the region could be substantial, and could yield a set of L-band SAR data of great international interest, making CONAE an attractive partner for other agencies seeking collaboration.

1.27 In order to fulfill some of the target applications, and as a means of gaining technical assistance, CONAE signed an agreement with the Italian Space Agency (ASI) to link the SAOCOM mission with ASI's COSMO/Skymed mission, which includes four satellites carrying SAR sensors operating in the X-band (4 cm wavelength and maximum resolution of 1m). The combination of the two programs, known as the SIASGE Constellation (Italo-Argentine Satellite System for Emergency Management),[20] will provide data recorded at L-band and X-band, which is intended to deliver more reliable and useful data for emergency management and other civilian applications than would be possible using a single wavelength. The agreement between the two countries calls for ASI to provide the development of one of the key technical components of the SAOCOM satellites (T/R modules), the launch of the two satellites, and technical assistance for application development, in exchange for the images generated in the SAOCOM orbits that pass over Europe. CONAE also signed an agreement with Belgium, which specifies activities for joint development of applications and software, in return for access to part of the data generated by the SAOCOM satellites.

1.28 The Program for the Development of a Satellite System and Applications based on Earth Observation (PROSAT), for which CONAE has requested Bank financing, encompasses the full range of investments and activities that would be necessary to develop, test, construct, launch and operate the two SAOCOM satellites, as well as

[20] The orbits of the COSMO/Skymed and SAOCOM satellites are to be synchronized, so that there are only a few minutes of delay between passes of the Italian X-band SAR and the Argentine L-band SAR.

funding the research and development activities needed to develop and implement high-impact applications based on the data generated by the satellites.

F. Justification for the development of L-band SAR satellite technology

1.29 Satellite monitoring offers a unique capability for wide-scale data collection, which can be a less costly and more rapid means of data collection than field observation. The low-resolution imagery generated by L-band SAR (e.g., registering parameters such as soil moisture) is especially well suited for agricultural and natural resource applications that are highly relevant to Argentina and its productive sector. Moreover, L-band SAR technology can operate in any weather condition and at night, making it ideal for disaster management and gathering information in areas of high precipitation and cloud cover, such as the Humid Plains of Argentina. For large developing countries such as Argentina that, unlike many developed countries, lack a dense network of land-based measurement stations, L-band SAR technology constitutes a low cost alternative (see ¶4.8 for a cost comparison of land-based and satellite technology).[21]

1.30 There is general international recognition that the availability of L-band SAR data will fill an important gap and make a significant contribution to servicing important applications at the regional and global levels.[22] There are no civilian L-band SAR satellites in orbit at present and the expected launch of the Japanese L-band SAR satellite in 2006 (ALOS mission) will produce a limited volume of data, dedicated primarily to scientific research.[23] For soil moisture monitoring, ESA is planning the SMOS (Soil Moisture and Ocean Salinity) mission, with a launch in 2007. But it is a one-off scientific mission with a lifetime of only three years, with no guarantee of adequate data provision for operational monitoring or continuity beyond this period, and with applications that would be limited to operational hydrological forecasting.

1.31 Although there have been several previous proposals for L-band SAR missions, all in developed countries, only Japan's JERS-1 was actually funded and launched.[24] Other proposals have not been carried out because funding for other missions was considered a higher priority. A recent proposal for ESA's Earth Explorer program (EVINSAR), received an excellent technical and scientific evaluation, but the bid

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21 There are various examples of this type of "technological leapfrogging", where less advanced nations skip certain steps of the technological development trajectory in a specific field, by adopting state of the art technologies that short-cut the path taken by developed countries (e.g. some nations have adopted mobile telephony for rural areas, "skipping" technologies like fixed telephony). Thus, in the context of sunk costs related to implementation of previous technologies in developed countries, the incremental benefits resulting from adoption of state-of-the-art technologies can be greater in developing countries that have not yet made considerable investments in older, previous-generation, technologies.

22 There is no doubt that there is a significant gap in the provision of SAR data at L-Band, as there are no operational L-band satellites at present. This gap has been explicitly identified by CEOS (Commission for Earth Observation Satellites) and IGOS (UNESCO's Integrated Global Observation Strategy).

23 Although ALOS could not be relied upon for operational monitoring, the data could be of great use in contributing to the process of developing applications for CONAE´s L-band satellites.

24 Although successful in its launch and initial deployment, the JERS-1 mission encountered technical problems (due to degradation of its solar panels), which considerably reduced its useful lifetime.

was ultimately unsuccessful due to lack of funding. Competition for EO mission funding is always extremely intense. In the latest round of funding for ESA's Earth Explorer missions, there were 30 proposals for just one flight opportunity.

1.32 SAR data can also be collected from airplanes, but this option is unsuitable for many applications due to the relative instability of airborne platforms compared to satellites. Airborne campaigns are also subject to disruption from weather or other environmental hazards that can prohibit data collection at exactly those times when they are most needed. Furthermore, while the capital costs of airborne sensing are much lower than for a satellite approach, the operational costs are much higher.[25]

G. PROSAT applications, benefits and data distribution

1.33 The justification of technologically advanced satellite missions like SAOCOM is based on a combination of anticipated benefits, including: i) a set of high impact applications with significant socioeconomic benefits that can effectively be made available to users at the national level; ii) provision of data for regional and global public goods (e.g., information for disaster and environmental management); iii) new applications that emerge through the R&D efforts of the scientific community (national and international); and iv) value-added services based on satellite imagery that result from innovation in the private sector.

1.34 For the SAOCOM mission, three high impact strategic applications (HISAs) were selected based on their high potential socioeconomic benefits, the feasibility of achieving their implementation when the satellites are launched, the existence of public institutions that can adequately deliver these applications to the end-users, and the willingness of the end-users to utilize these new information products.[26] The three high impact strategic applications selected for implementation through PROSAT are: i) soil humidity maps for improving agricultural productivity through optimized timing of the decisions to sow and/or apply fertilizers in wheat, maize and sunflower crops (with INTA, the National Institute of Agricultural Technology); ii) plant and ground cover humidity maps for the reduction of crop losses through more precise prediction of plagues (e.g., *fusarium)* and more efficient applications of pesticides (also with INTA); and iii) hydrology models and risk maps for early warning and better management of floods in the *Plata*, *Salado*, and *Bermejo* river basins (with INA, the National Institute of Water). Implementation plans and cost-benefit analysis for the three HISAs are being

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[25] Cost-benefit studies have been undertaken in Canada comparing the costs of satellite and airborne SAR data as part of the evaluation of the Canadian Radarsat program. These showed that for equivalent data quality and resolution, a satellite program was a more cost effective option for mapping and monitoring Canada's Northern territories and oceans. A similar analysis conducted by CONAE also showed that the satellite based system would be more cost effective than the airborne SAR.

[26] End-user participation in the specification of the SAOCOM satellite system, through a series of workshops to define the mission requirements, has led to modifications specifically designed to accommodate their needs. Additionally, the selection of the HISAs also took into consideration a report prepared by ESYS Consulting, undertaken as part of a major review of a similar proposed satellite system in Europe, which resulted in a full list of potential applications for L-band data, based on factors like uniqueness of L-band's contribution, global significance, local relevance, and data continuity.

prepared by CONAE, to confirm the Program's economic viability (see ¶4.1-¶4.9 for initial results based on the first two applications).

1.35 In addition to implementation of the HISAs, the Program will provide support for the development of new applications, through public Announcements of Opportunity (at the national and international levels) that will provide grants and free images to research proposals aimed at developing novel uses and applications of the imagery generated by the SAOCOM satellites. A series of potential proposals have already been identified, for example: i) landscape epidemiology maps, for more efficient response to disease outbreaks, through early detection and focused public health responses; ii) ground movement maps, to identify and evaluate subsidence or damage to buildings and other structures; and iii) seismic risk mapping, for better urban planning and emergency management. Finally, the Program will also include funds to support special Announcements of Opportunity, which will provide grants and free images to proposals from the private sector, for developing and marketing innovative value-added services based on the images generated by the SAOCOM satellite system.

1.36 As a result, the end users of the images that are eventually generated by the SAOCOM satellites will include, among others: i) national and international public sector and scientific institutions that regulate, supervise, and study natural resources, infrastructure, weather, and health; ii) small and medium producers who access databases and information products supplied by public agencies and local providers of advisory services; and iii) agri-food producers, petrochemical and hydrocarbon industries, mining firms, and logistics and financial service providers.

1.37 The various applications that have been identified, as well as others that may emerge, will demand a significant number of the images to be generated by the SAOCOM satellites. Given the fact that these satellites will only be able to collect data during 10% of each orbit, due to power constraints, and that they have several different imaging modes (e.g., depending on image resolution and mode), there could be conflicts between users requiring data from the same orbit, or from the same location but requiring different modes. A Data Policy is thus necessary to differentiate between users on the basis of need, economic benefits derived from the applications, potential for development of novel applications at the national and international levels, and possible income that could be generated from image commercialization (see Annex 3 for a case study of Canada's experience).

1.38 The PROSAT Data Policy for distribution of SAOCOM images would provide access to users according to the following priorities: i) data for emergency and natural disaster response, in accordance with CONAE's national mandate and obligations under general international space law, the International Charter for disaster relief, and other international agreements; ii) data for development and implementation of the three HISAs with INA and INTA; iii) data for national and international Announcements of Opportunity for proposals to carry out R&D into new applications by the scientific community and support development of innovative value added services in the private sector; and iv) data available for

commercial purposes and sold to users through wholesalers at prices that will be comparable to SAR imagery from satellites working in other wavelengths (eg, Canada's Radarsat, which operates in C-band).

1.39 As a result, data required to respond to emergency situations in Argentina and anywhere else in the world will have the highest programming priority, although in overall terms, the proportion of data falling into this category is expected to be relatively low. Data for developing the three HISASs and for planned AOs will have the next priority, with acquisition planning and service undertaken directly by CONAE. Initially, these data would be free of charge to facilitate development and uptake of applications, and the resulting socio-economic benefits. In the longer term, modest charges for some of the data could be considered, as some willingness to pay would signal perceived value by end users. Finally, a specific amount of data will be ring-fenced for sale through commercial distributors in Argentina and throughout the world, to ensure they can offer sufficient images and the levels of customer service that will be required, as it can generate a stream of income to cover at least part of the future operational and maintenance costs of CONAE's ground infrastructure.

1.40 In addition to this, as part of the commitments made by CONAE and ASI through the SIASGE agreement, ASI will receive all the L-band images generated by the SAOCOM satellites in their orbits over Europe, while Argentina will have access to the X-band images generated by the COSMO/Skymed satellites over Argentina.[27] Joint activities call for international scientific data-sharing, with each country retaining control of its respective satellites, but agreeing to operate them as a constellation that can be used for emergency management and other civilian applications in Europe and Argentina. For images over the rest of the world, once the system is operational, specific common agreements will be established with international commercial wholesalers, for joint commercialization of X and L-band data. As stipulated in the SIASGE agreement, a detailed set of procedures and practices for data distribution and joint commercialization will be established between ASI and CONAE in the coming months.

H. Justification for Bank involvement

1.41 The Bank's Country Strategy 2004-2008 (GN-2328) seeks to support Argentina in achieving sustainable and more equitable growth through actions in three strategic areas: i) institutional strengthening to improve governance and fiscal sustainability; ii) growth in investment and productivity to increase national competitiveness; and iii) poverty reduction, reconstruction of human capital, and promotion of sustainable social development. The Program will directly contribute to the second strategic area, capitalizing on the country's scientific and technological capacities and building new ones, while developing practical linkages with society and the

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[27] The COSMO/Skymed system of X-band satellites has dual use characteristics, as Italy plans to use it in civilian/commercial applications, as well as for defense purposes. The system is designed to manage both operational modes in a completely separate fashion. The SIASGE agreement only allows access to the civilian operational mode of the COSMO/Skymed mission.

productive sector through applications that generate significant socioeconomic benefit and greater collaboration with industry.

1.42 The Bank's Science and Technology (S&T) Strategy (GN-1013-2) stresses the importance of increased support for technological development in the private sector, and its main goals are to: i) ensure closer linkages between the NIS and the global knowledge society; ii) increase the amount, effectiveness, and productivity of investments in S&T; iii) strengthen regional and international cooperation in S&T; and iv) promote capacity building and ensure critical mass in strategic areas for economic and social development, in which there is close proximity between science and sectors where there is installed capacity and high potential of contributing to economic growth. The strategy also states that all projects that include technological investments should be considered S&T projects, with potential opportunities for increasing national capabilities. This Program is consistent with the Bank's S&T strategy, as it focuses on a specialized area of high economic impact and existing capabilities, and promotes linkages between the NIS, the productive sector, and other countries. The Program is also consistent with the Information and Communications Technology (ICT) for Development Strategy being prepared by the Bank, as it will promote the use of remote sensing to support environmental and natural resource management.

1.43 The Bank's experience with projects involving satellite systems is limited to applications that use data generated by satellites and does not include the actual development of satellites. Since 1973, the Bank has financed projects that, through the use of Landsat satellite data, apply EO satellite information to the assessment of renewable and non-renewable natural resources in Brazil, Central America and Ecuador (20/CD-BR, ATN/SF-1550-RE, and TC-8006026-EC). In Peru and Belize (PE-0017 and MIF/AT-64-BL) the Bank funded projects that supported the use of satellite imagery to monitor land occupation. In the field of commercial telecommunications satellites, the Inter-American Investment Corporation has financed the construction and installation of satellite ground stations in different countries of the region (Argentina, Venezuela, Colombia, and Chile). There are no previous instances of EO satellites funded by multilateral financial agencies and only a few examples of funding for telecommunications satellites.[28] Until now, most agencies have focused on projects that promote the use of EO satellite data, the development of ground stations and, in the case of the US Export-Import Bank, the provision of loan guarantees for international sales.

1.44 **Sector trends and lessons learned**. Based on the experience of space agencies like NASA and ESA, the following are the main trends and lessons that the Program has incorporated: i) increased investment in applications and services, as well as in capacity building and greater awareness of end-users, is critical for positive project impact; ii) solid pockets of world-class EO infrastructure and skills have been created in developing nations with sufficient capabilities, so it is realistic for some developing nations and regions to attempt to catch-up to

[28] For instance, the International Finance Corporation (IFC), together with GE Capital, Publicon and Antel, financed the construction, launch and operation of the telecommunications satellite Nahuelsat.

developed nations in certain niches of space technologies applied to terrestrial problems. For example, China and India are developing satellites to meet a wide array of domestic, regional, and international needs; iii) international cooperation for technology transfer and development are critical, since over 100 EO satellites from more than 20 nations could be launched in the next decade; and iv) performance management and peer reviews, specially in advanced space technology programs, are necessary conditions for risk management, efficient use of resources, capacity building, and transparency, which can in turn be a powerful tool in solidifying a space agency's base of support.

1.45 The Bank's additionality in this Program is based on its experience in working with the S&T sector in Argentina, which will facilitate articulation of PROSAT with other ongoing efforts to strengthen the National System of Innovation (e.g., the Technological Modernization Program III, AR-L1012), and on its capacity to help advance the application development objectives in parallel with the space technology activities by supporting the implementation of applications, user training, and an airborne-SAR and data collection campaign.[29] The Bank is also in a position to help CONAE promote greater private sector involvement in the development of value-added satellite information services, as well as fostering regional and global cooperation for information sharing and joint development of applications that can be of socioeconomic interest to Argentina and other countries in the region and the rest of the world (see ¶1.48-¶1.49). The Bank's participation also presents some potential risks that will have to be addressed, as it lacks previous experience and in-house technical capacity in the field of EO satellite projects. In addition, since procurement practices commonly utilized in space projects differ significantly from the procedures used by the Bank, the standard application of those procedures could affect the implementation of the project, as well as certain key technical aspects of the Program, and could potentially increase its risks by disrupting the sole source and joint developments that have been successfully established between CONAE and its network of suppliers during the design phase.

I. Program Strategy

1.46 The Program's strategy is to capitalize on Argentina's advanced science capabilities through the implementation of a system of EO satellites, in collaboration with space agencies from other countries, that will allow the country's scientific community to continue to specialize and move closer to the world technological frontier in an area where it has sufficient skills and comparative advantage, which in turn can lead to significant economic benefits through the development of practical applications and collaboration with industry.

1.47 Through its previous collaborative space missions, CONAE has acquired a base of mission assurance skills and practices. Its suppliers and the national science

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[29] An airborne-SAR is a scaled-down version of the SAOCOM satellite's L-band SAR, which is carried on an airplane. It allows for the collection of data over areas nominated by potential users, so that they can validate the usefulness of the data and contribute to the process of developing operational applications.

community have been able to interact and support each other in providing some of the necessary products and services required for those missions, and are beginning to develop relevant applications for the images generated by the satellites managed by CONAE. As it embarks on a new, more complex satellite mission, CONAE seeks to maximize the level of interaction with its suppliers, the national science community, potential users, and service providers. The objective is to **strengthen further CONAE's capabilities in the delivery of space-based services and in effective management of a complex space project according to international best practice, in support of its economic and scientific objectives.** To achieve this objective without incurring unacceptable levels of risk, the Program will seek to ensure a high level of external review and continuous benchmarking with methodologies and practices used by other space agencies.

1.48 The Program will also seek to **ensure a high degree of readiness in the user community and in research institutions that are well positioned to develop and implement practical applications for the information generated by the satellites**. To this end, the Program will fund the development and implementation of a set of high impact strategic applications, in parallel with the space technology development related to the prototyping, construction, testing and launching of the satellites.[30] In order to maximize their feasibility, the selection of the high impact applications was based on their potential economic benefits, the preparation of well-defined implementation plans (action plan, budgets, etc), and the existence of institutional capacity to develop and implement these plans with final users in the medium term. This will ensure that once the satellites are operational, there will be a set of applications that can quickly utilize the newly generated data. Moreover, given the fact that R&D is intrinsically an exploration process, and its nature typically leads to the emergence of unforeseen applications with high potential benefits, the Program will also implement a mechanism to fund research proposals for the development and implementation of emergent applications, as well as innovative private sector proposals to develop value added services based on satellite imagery.

1.49 Finally, and in addition to the existing agreements with ASI and Belgium, the Program will seek to foster a high level of international cooperation with other space agencies, the international research community, and potential users and application developers throughout the world.[31] Collaboration with other space agencies will allow CONAE to accelerate its process of technological upgrade and to continue building partnerships throughout the world. More important, Argentina's user and application development community will also benefit from collaboration with researchers and users from other countries, as opening out the data for wider scientific analysis on a co-operative basis will help to build information extraction techniques and capacity across the user community.

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[30] A US$1.5 million Project Preparation and Execution Facility (AR-L1024) was approved to help CONAE and its partner institutions jump-start the development of the HISAs and ensure user readiness.

[31] The importance of this type of collaboration is illustrated by the fact that NASA is the federal agency that accounts for the largest share of US International Cooperation in R&D (ICRD). In 1997 NASA spent more than US$3 billion in international collaboration, which represented 70% of total US ICRD.

J. Selection of lending instrument

1.50 Space agencies have traditionally developed highly complex and risky technology programs through a project management process comprised of a series of phases organized around the achievement of specific engineering goals and review milestones.[32] This highly standardized structure, the result of years of experience in the implementation of space missions by agencies around the world, is designed to minimize risk, reduce complexity, facilitate transparency, and ensure a results-oriented culture in project management teams. Thus, the process maximizes the probability of success of a space mission and requires considerable skills and capabilities to implement. Once these skills and capabilities are developed and put into practice in the context of a highly technical and complex project, their standardized nature allow space agencies to successfully implement increasingly demanding projects with greater ease and efficiency. As a result, CONAE's mastery of this project management structure allows it to advance to the league of the world's best space agencies.

1.51 Given the Program's characteristics and the goal of advancing the applications objectives in parallel with the development of space technology, risk management and development effectiveness will be optimized by structuring the operation as a Performance Driven Loan (PDL), based on the achievement of standard engineering phases and review milestones, as well as indicators that measure the process of application development and user readiness, according to international best practice in space technology and specific guidelines for each application. Due to the complexity and specialized nature of the proposed project, the assessment of compliance with the established results indicators will need to be made by an External Panel of Experts (EPE) comprised of a team of highly specialized international aerospace consultants, ideally under the umbrella of a leading space agency. This EPE would advise the Bank in assessing compliance with the indicators of the Results Matrix and in determining if the standard SAOCOM project reviews, which are based on critical assessments made by a team of internal and external experts selected by CONAE, abide by space-sector best practice and by agreed guidelines for application development.

1.52 The Program meets the rationale and criteria set forth in document GN-2278-2, which describes the Bank's policy and practices for PDLs. The Program will be designed to provide incentives and simplify procedures in order to create a greater focus on results and development effectiveness, while managing risk in a more efficient and transparent manner. As a result, each loan disbursement will be made when specific results are achieved, as defined by the targets and indicators presented in the Results Matrix (Annex 1). The loan will have six separate disbursement tranches. The first will amount to 20% of the loan and will be made

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[32] Each phase is designed to advance the system from one baseline to another after successful completion of its activities. During these phases (mostly at the end) project reviews are planned as milestones in the project phasing, as critical examinations performed by a team not responsible for the activities covered by it and including participation of experts from other space agencies. Reviews aim to: i) assess the validity of outputs in relation with requirements; and ii) decide to start the next phase.

when the Loan Contract is made effective and conditions pursuant to first disbursement are met. This advance will allow for the financing of the various design and testing activities of the first year of the Program. The remaining disbursements will constitute re-imbursements of the costs actually incurred after loan approval, according to the activities described in section II and the limits established in Table II-1.

II. THE PROGRAM

A. Program objectives

2.1 In line with the country's Science and Technology Policy and the National Development Strategy, the long-term goal of the Program is to contribute to increasing the productivity and sustainability of the Argentine economy by positioning the country in a technological niche that can lead to significant socioeconomic benefits and spin-offs. The immediate objectives of the Program are: i) to strengthen the delivery of space-based services and scientific and engineering capabilities to successfully design, build, and operate an advanced EO satellite system; and ii) to strengthen and consolidate the capabilities in a technological niche of EO to successfully develop and implement applications with high socioeconomic impact using data gathered with the SAOCOM system.

B. Program description

2.2 The SAOCOM mission is comprised of two polar orbiting low earth-orbit satellites (SAOCOM 1A and 1B) with a design lifetime of 5 years, each equipped with a SAR instrument operating in the L-band (wavelength of 23 cm and maximum resolution of 10 m). The two satellites will also carry an optical imaging instrument and a data relay transponder that will be used to collect measurements from ground sensors and relay them to operational control centers.[33]

1. Structure and expected results

2.3 The Program is structured around the achievement of the two specific objectives described in paragraph 2.1. Given the nature of these objectives, the outcome indicators to be used will not be based on simple numerical measurements, but in the case of the first objective, on critical assessments of CONAE's demonstrated and increasing capabilities to design, construct, and operate a satellite system (including ground infrastructure). This assessment will be made by an External Panel of Experts (EPE) on the basis of standard international best practice in the space industry. A similar approach will be adopted for measuring progress in achieving the second objective, through critical assessments of CONAE's capabilities to design, develop, and implement applications with high socio-economic impact using the data gathered by the satellites. It is important to note that the targets to be achieved for the disbursement of each tranche will include a combination of targets for both objectives, since an important part of the rationale

[33] For more details, see SAOCOM Mission Requirements.

behind the operation is the achievement of a minimum level of user and application readiness.

2.4 For the satellite technology objective, the EPE will assess the satisfactory completion of key review milestones based on a standard, internationally-recognized evaluation process that will track progress in the engineering phases of design, manufacturing, assembly, commissioning, and start-up of operation of the satellite system. The key review milestones in this process are: i) Preliminary Design Review (PDR), in which the design requirements of the satellite system are identified and evaluated; ii) Critical Design Review (CDR), which leads to the detailed design and definition of the satellite system (including production of test elements and components); iii) Pre-Shipment Review (PSR), taking place after qualification testing, allowing for verification of technical conformity of components against requirements (design qualification) and operational aptitude (operational qualification); iv) In-Space Test Review (ISPR), which generally comprises launch activities, in-flight qualification, and acceptance testing of the system, allowing for measurement of performance levels, as well as the level of service attained and in-flight qualification; and v) Operational Review (OR) in the 12th month of operation of the satellite, where its major parameters are reviewed in order to improve operations, while generating feedback for future projects and the redevelopment of certain products (e.g., ground support equipment or software).[34]

2.5 For the application development objective, specific guidelines will be prepared with the support of technical consultants, in order to assess CONAE´s capabilities to coordinate the design, development, and commissioning of applications that use data gathered by the SAOCOM satellites, based on key evaluation milestones. These assessments will analyze progress in building the following capabilities: i) coordination of data acquisition with development of applications, initially through the data collection and airborne SAR campaign; ii) development of applications, specifically three High Impact Strategic Applications (HISAs); and iii) implementation of applications, in conjunction with other institutions, agencies, and firms, especially the three HISAs.

2.6 The key activities related to this second objective will begin with the execution of the Implementation Plan of the three selected HISAs and the initiation of an airborne SAR and calibration campaign to collect data for their development. Other key activities include two international Announcements of Opportunity (AO), the first one for the airborne SAR data and the second for SAOCOM 1A data, in order to support R&D proposals to develop new applications. Progress in the development of applications will be assessed through review milestones that will coincide with the review milestones for the first objective and be based on specific guidelines that will be defined in upcoming stages of project preparation.

[34] See Annex 1 for the Results Matrix of the Program.

2. Eligible financing

2.7 The expected results of the Program will be achieved through investments in three components:

a) Space segment: development, construction, testing, launching, and operation of satellites SAOCOM 1A and 1B

2.8 The objective of this component is to develop, launch and operate two EO satellites that can transmit and receive information through an L-band SAR, as well as an optical imaging instrument and a data relay transponder. To this end, the Program will fund: i) detailed engineering of the satellites; ii) construction of qualification models; iii) construction of flight models; iv) integration and testing services, including environmental testing; v) launching, through a third party, and insurance of the two satellites; and vi) operational verification of the satellites. This will require the acquisition of electrical components, materials, equipment, software, adaptations of existing infrastructure, consulting and engineering services, and insurance coverage for the launch and satellites.

b) Ground segment: upgrading of earth stations and antennas for reception, processing, and dissemination of data

2.9 The objective of this component is to strengthen existing capabilities of CONAE's ground stations so that they can adequately meet the technical requirements of the SAOCOM satellites. The following activities will be financed: i) improvement of data reception and transmission systems, including the acquisition and installation of antenna systems; ii) adjustments in infrastructure for command and control of the satellites; and iii) development of planning and image processing software and other related services. This will entail the acquisition of equipment, computer systems, software, modifications to existing infrastructure, and consulting services.

c) Applications and user segment: conceptualization, development and implementation of applications

2.10 The objective of this component is to increase readiness of the user community and develop and implement a set of applications with high socioeconomic benefits (HISAs and new applications). The following activities will be funded: i) implementation of an airborne-SAR and data collection campaign; ii) development and implementation of three HISAs; iii) development of new applications based on proposals received at AOs; and iv) training of users and support to institutions transitioning from other data-gathering mechanisms to satellite-based information systems. This will entail funding research activities, equipment, materials, software and computers, consulting services, and training of human resources.

3. Administration and external financial and performance audits

2.11 The Program will also include costs associated with general administrative expenses, which may be eligible expenditures under each of the three components. The annual external financial audits and the performance audits of the Program's

execution, through the EPE's assessment of compliance with the targets of the Results Matrix, will be treated as standard eligible items of an investment loan.

C. Costs and financing

2.12 The estimated cost of the project is US$180 million, with an additional provision equivalent to approximately 10% for contingencies. Thus, total costs of the Program are budgeted at US$200 million, of which the Bank will fund US$50 million and the remaining US$150 million will be contributed as counterpart funds by CONAE, as shown in Table II-1.[35]

Table II-1: Budgeted Costs and Indicative Estimate of Sources of Financing (US$ thousands)

Investment Category	Source		Total	%
	BID	Local[36]		
Direct Costs	**48,000**	**132,000**	**180,000**	**90%**
1. Component 1: Space segment	40,000	126,000	166,000	83%
2. Component 2: Ground segment	4,000	3,000	7,000	3.5%
3. Component 3: Applications and user segment	4,000	3,000	7,000	3.5%
Indirect Costs	**2,000**	**18,000**	**20,000**	**10%**
4. Financial and performance audits	2,000	0	2,000	1%
5. Contingencies	0	18,000	18,000	9%
Total	**50,000**	**150,000**	**200,000**	**100%**
%	25%	75%	100%	

2.13 A technical expert from an independent space-sector consulting firm hired by the Bank conducted a detailed cost analysis of the Program's total budget. Based on labor budget estimates of the total number of hours to be committed to the project, including the design efforts conducted in the past years and excluding the launch costs,[37] the ground segment, and the applications development segment, the analysis concluded that the total cost of the SAOCOM satellites are lower, in US dollars, than that incurred by comparable missions of other space agencies. This is because of the substantially lower cost of skilled labor in Argentina (estimated at between 20% and 35% of the unit cost of equivalent skilled labor in the US) and to the existence of sunken development costs already incurred by CONAE for program management and design of key components. After adjusting for these two factors, the resulting comparator budget for a single SAOCOM satellite resulted in

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35 Table II-1 presents an indicative breakdown by source of funds of the contributions made by each component to the Program's costs. The final breakdown could differ, depending on the items that are eventually selected by CONAE for submission to the Bank as eligible expenditures realized towards the achievement of the targets associated to each disbursement, as presented in the Results Matrix.

36 This category includes US$50 million as ASI's contribution, which values the launch services for the two satellites at US$30 million and the development of the T/R modules at US$20 million.

37 As a reference, the cost of a Russian *Dnepr* launcher of the class needed to lift one SAOCOM satellite into low earth orbit would be close to US$15 million. Since ASI will be negotiating multiple launches, discounts would be expected, so there is some contingency in the budget assumptions for the launches.

a value of US$345 million, which is about the same as the US$350 million benchmark figure that would be expected at international costs.

2.14 As a result, the main source of possible budget pressures to the Program would be schedule over-runs, which always constitute a risk in space programs, especially when they involve new technological developments. In order to mitigate this risk, an additional provision for contingencies, equivalent to 10% of total costs, has been included in the budget. Moreover, the budget has also been adjusted so that several new developments being undertaken by domestic providers are valued at the cost of acquisition from international providers, as a contingency in case the domestic suppliers are not able to produce them on time and/or within budget.

2.15 Looking to the two other components of the Program, a typical rule of thumb for EO programs is that 10% of costs are allocated to the ground segment, so the 3.5% assigned in the proposed budget could be considered somewhat low. However, CONAE already has highly efficient and modern antennas and reception capabilities that require only minor modifications to deal with the SAOCOM satellites, so in this case the budgeted figure can be considered appropriate. Possible concerns over the user and applications development budget have also been mitigated, as the already approved US$1.5 million PROPEF will help to jump-start application development and promote end-user readiness (see ¶5.11). Concerns in this area are allayed further by the fact that the Results Matrix of the Program includes triggers that will track progress in space technology activities in parallel with the advances made in developing the HISAs and other applications.

III. PROGRAM EXECUTION

A. Borrower and executing agency

3.1 The borrower will be the Republic of Argentina and the executing agency will be the National Commission for Space Activities (CONAE), which is an autonomous entity under the Ministry of Foreign Relations. CONAE has a Board of Directors, whose president is the Minister of Foreign Relations, and its operations are conducted by an Executive and Technical Director. Its day-to-day business is managed by four different units: Institutional Relations, Projects, Technology Management, and Planning, Administration and Finance. CONAE's budget for 2005 was US$17 million, an 87% increase from the previous year, and its total staff was in excess of 150 personnel.

3.2 CONAE seeks to maximize the efficient use of financial resources assigned to space activities by acting as a coordinating agent of all the parties that can contribute human and economic resources to the execution of space projects (i.e., institutions of the NIS, technology-based firms, researchers, users, and international partners). For each mission it undertakes, CONAE creates specific internal project teams composed of technical and management specialists that assume responsibilities for all aspects of the mission. From a technical standpoint, CONAE, in collaboration with its prime contractors, acts as a procurement agency,

sets forth the basic definitions, and elaborates the concept and systems engineering for its space projects. Through the appointment of private and public contractors, universities, and other research entities, it establishes the necessary linkages for the execution of each project, acting as the project planning and effort coordination unit and, at the same time, supporting the development of space-related technology firms in the country. In terms of dissemination of information and development of applications, it tends to act as an information wholesaler, promoting the development of applications by third parties, either private or public. However, CONAE maintains a close relationship with users and developers, through training and promotion of satellite information and products, and through specific agreements to directly conduct joint developments with public sector institutions, the scientific community, and private sector firms.

B. Execution and Program administration

3.3 Execution and administration of PROSAT will be led by the SAOCOM Mission Project Team, which has already been established by CONAE to be in charge of executing, monitoring, and evaluating all activities related to the implementation of the SAOCOM satellite system and coordination and implementation of application development and user readiness. The details of the institutional design for Program implementation are currently being developed with the assistance of a specialized consultancy that is assessing CONAE's institutional capacity through the Bank's Institutional Capacity Evaluation System (SECI), in order to establish a detailed execution mechanism, as well as the necessary institutional strengthening activities for the implementation of the Program.

3.4 **Monitoring and evaluation.** Since the performance framework and indicators set forth in the Results Matrix need to be adequately tracked during execution, a performance measurement and monitoring system will be established for the execution of the Program, based on the practices used by international space agencies and the indicators for user and application readiness. Using this framework, external performance audits will be conducted prior to each disbursement. These performance audits will coincide with CONAE's review milestones for each of the engineering phases for satellite development, and will be conducted by an External Panel of Experts (EPE) created for the specific purpose of acting as a technical auditor of each of the reviews conducted by CONAE, as well as for the assessment of progress in reaching triggers associated to application development.[38] Finally, CONAE will also commit to maintaining the necessary records on results indicators and to make that information available to the Bank, so that an ex post evaluation may be prepared at a later date, if so desired.

3.5 **Procurement.** The procurement of goods and services to be financed by the Program will be carried out according to Argentina's national procurement procedures, which CONAE follows under national law. An independent analysis

[38] It is important to note that CONAE's own internal reviews include participation of external and internal experts. The role of the EPE would be to audit these reviews and the progress in developing applications, in order to confirm that they adhere to international best practice and agreed guidelines.

of how these procedures are implemented by CONAE is being conducted by the Bank, to ensure that they are governed by the principles of competition, economy, transparency, equity, publicity, and due process, and that a legal framework that allows for the presentation, processing, and settlement of protests by firms participating in bidding processes is adequately implemented, as set forth in the Bank's GN-2278-2 document. Since the ex post modality would be used to review expenditures, as required by the PDL modality, the analysis also includes a review of CONAE's financial management, accounting, and control systems. External financial audits will be carried out according to Bank requirements for investment operations, which include an ex post review of a procurement sample.

IV. Development Impact

A. Socioeconomic viability

4.1 An extensive economic evaluation of the project was undertaken in order to assess the expected value of the discounted flow of future net benefits generated from key selected applications of the L-band SAR satellite system. The expected benefits of these selected applications was compared with the discounted flow of expected costs associated with the development, construction, launching, and operation of the satellites, plus the expected costs associated with the development and implementation of the applications, using a stochastic model.[39] The resulting likelihood estimates for net present value and internal rates of return are then used in analyzing the decision of whether or not it is worth undertaking the project from a social point of view. The methodology used to conduct this evaluation relies on risk analysis, to reflect the possible margin of uncertainty in the estimates of both benefits and costs, as well as to test the robustness of the analysis.

4.2 The implementation and adoption of a series of applications is expected to yield some of the project's economic benefits, once the satellites become operational. Although CONAE has identified multiple potential applications in many sectors, the economic analysis was based only on a set of highly viable high impact strategic applications in agriculture for which reliable data series are readily available (see ¶1.34). Assuming that other applications will not have negative net effects, the hypothesis is that the estimated benefits resulting from the implementation of these high impact strategic applications will be sufficient to cover the project's total costs, in which case the project would be considered to be economically viable.

4.3 The following are key aspects of the two applications for which net incremental benefits have been calculated:

a. **Soil moisture map for fertilization of wheat, corn, and sunflower production.** The optimal timing and amount of fertilization are strongly

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39 A more detailed presentation of the calculations and methodology for economic evaluation, including risk analysis, is presented in the document: "Preliminary Economic Feasibility Analysis."

correlated with soil moisture at the time of application. In this regard, INTA provides advice on fertilization to farmers for specific grain crops, based on simulation models that link soil moisture at the time of seed sowing, cost of fertilizing, and subsequent expected gains in crop productivity. Current soil moisture data is obtained through on-site samples from INTA's research stations, which are then extrapolated for areas within a 100 to 400 km radius. The individual measures are subject to error due to differences between real soil moisture values *in situ* and the extrapolated values calculated by INTA. Moisture estimation errors result in two types of flawed recommendations to farmers, which generate economic losses at the farm level: (i) underestimation error from not fertilizing when fertilization was advisable; or (ii) overestimation error from fertilizing when no fertilization was required.

b. **Soil moisture map for phytosanitary control of *fusarium* fungus in wheat production.** Agricultural production is affected by a variety of pests and plant diseases, the incidence of which are known to be linked to soil humidity levels. In order to assist farmers in biotic agent prevention, INTA provides recommendations on the appropriate timing and intensity of phytosanitary measures. As in the case of their assistance on fertilization, INTA's recommendations are derived from simulation models that link soil moisture at the time of seed sowing and expected disease appearance. As these models are based on the extrapolated soil moisture data from INTA's relatively few research stations, the individual advice is subject to error due to differences between real soil moisture values *in situ* and the extrapolated values calculated by INTA. Moisture estimation errors result in two types of flawed recommendations from INTA to farmers, which generate economic losses at the farm level: (i) underestimation error from not applying disease control measures when such measures were required; or (ii) overestimation error from applying disease control measures when such measures were not required.

4.4 Using INTA's decision-models for fertilization in wheat, corn, and sunflower, and for phytosanitary measures to control *fusarium* in wheat, and based on 30-year time series data collected in its research stations, simulations were conducted to calculate the probability of occurrence and the economic costs of each type of error for each application. Since the soil moisture maps that will be generated by the project will provide more precise information to INTA, the probability of error in its recommendations to fertilize or apply pesticides will be significantly reduced. For the crop area that will receive assistance from INTA,[40] the project's expected reduction in the probability of error will result in fewer economic losses, compared to the losses under the current situation (without the project). The resulting difference is the net incremental economic benefit of each application.

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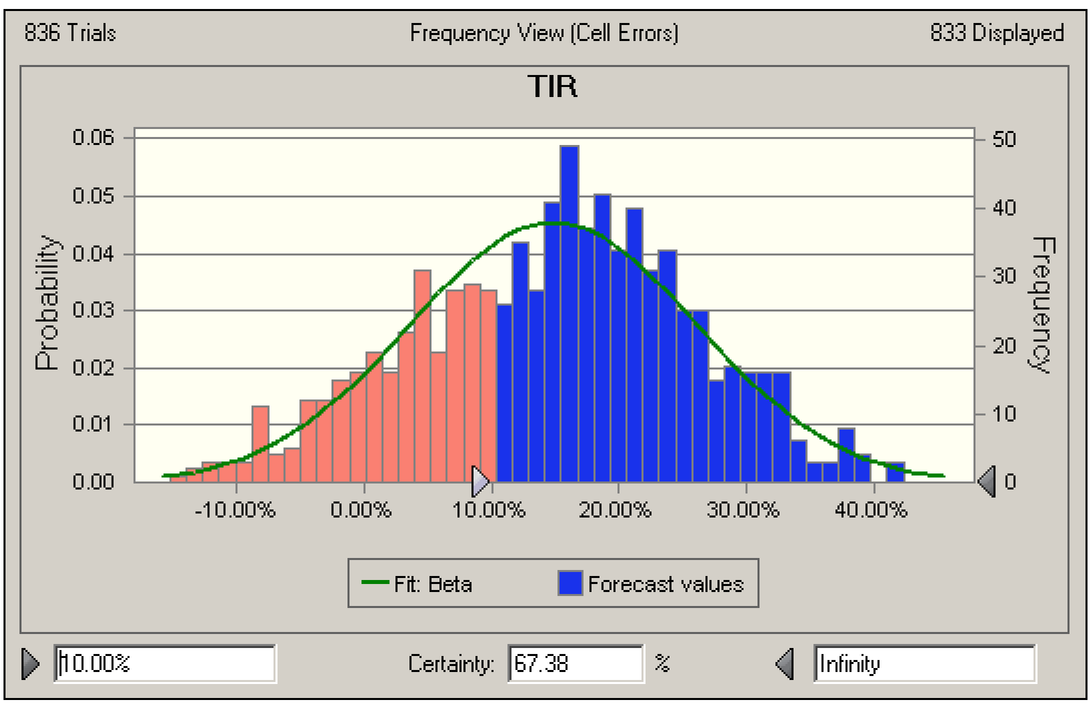
[40] Under a conservative technology diffusion scenario, for the first year each application is implemented, it is assumed that only 30% of total cropland currently attended by the agency will receive advise from INTA. After that year, it is expected that the attended cropland will increase by five percentage points every year to reach 50% of total cropland in the fifth year.

4.5 Total project costs include labor and non-labor costs associated with the design, development and construction of the two SAOCOM satellites, including insurance costs, as well as the operation costs during the envisaged lifetime of the satellites (five years), including costs of developing and implementing the applications.[41]

4.6 A project horizon of ten years was used in the analysis, which includes five years for the construction and launching of the satellites and a five-year operational lifetime. Benefits are projected to begin in year six, one year after launch of the satellites. A 10% discount rate was used to calculate the net present value. In order to take into account the uncertainty inherent in the assumptions and calculations described above, probability distributions were assigned to the flows of benefits and costs, in order to estimate, using Montecarlo simulation, the relative likelihood of the resulting values of net present value and internal rates of return.

4.7 Figure IV-1 shows the range and probability distribution of the simulated results, considering only the economic benefits derived from two applications. In this context, the best estimate of the project's rate of return is 16% (i.e., the median rate of return), with a probability of over two-thirds of being above the 10% rate of return threshold level. Similarly, the expected net present value would be US$16 million, with an expected opportunity loss of not implementing the project when it turns out to be feasible that is almost 1.6 times greater that the opportunity loss from implementing the project when it is turns out not to be feasible.

Figure IV-1: Frequency Distribution of Simulated Internal Rates of Return



41 Cost details and comparative analysis are presented in: Styles, Jonathan, "SAOCOM System Technical Orientation Review." Consulting report, January 2006.

4.8 The economic evaluation also included a minimum cost analysis of alternative technologies that would yield similar benefits to those expected from the two agricultural applications (i.e., reproduce precise soil humidity maps that will reduce the error margins of INTA's recommendations to fertilize or apply phytosanitary controls). The alternative solutions considered were: (i) the dielectric parameter method, based on the installation and operation of sensors to measure soil humidity based on its conductivity properties; and (ii) the hydro-balance method, based on the installation and operation of automatic weather stations (AWS) to measure soil humidity. In order to achieve benefits comparable with those of the SAOCOM system, in both cases, one of these devices would need to be installed per hectare. The installation of the devices was assumed to occur on the fifth year of the 10-year project horizon. Results showed that, compared with these other technologies, the SAOCOM system represents the minimum cost alternative. Using a 10% discount rate, the present value of the investment, operation, and maintenance costs of the satellite system is US$132 million, while those associated with the dielectric parameter method and the hydro-balance method correspond to US$902 million and US$197 million, respectively.

4.9 Based on the analysis presented in this section, the project is considered to be economically viable, as the expected benefits resulting from the development and implementation of just two of its possible applications would be sufficient to cover the entire expected cost of the project. Moreover, for these two applications, other alternative solutions would be more costly in net present value terms. Using risk analysis, it is shown that, within a range of estimates considered to be reasonable, this result has a relatively high likelihood of occurrence. It is also important to note that these results are obtained under a highly conservative scenario, in which: i) the benefits resulting from the implementation of other potential applications are considered to be non-existent; ii) the benefits associated to a third high impact strategic application (risk maps and hydrology models for flood management) are not included[42]; and iii) the benefits calculated for the two selected applications do not take into account their possible uses in decision-making for fertilization of other important crops (e.g., soybeans) and for phytosanitary measures related to other significant plagues (e.g., sunflower's *sclerotinia sclerotiorum* and wild oats).

B. Expected impact and beneficiaries

4.10 As a result of the Program, it is expected that the country will be able to strengthen its capabilities to test, construct, and operate two EO satellites carrying an L-band SAR instrument. It is expected that this will also contribute to an increase in the productivity and sustainability of the Argentine economy, through the development and implementation of applications and technologies based on EO, which could be used either by the country's private sector to develop new and increasingly more sophisticated products and services, or for society's benefit in general, in areas like agriculture, natural resource management, public health, and

42 Preliminary estimates indicate that this application could be expected to yield additional discounted net incremental benefits in the order of US$15-20 million. The robustness of these estimates will be reviewed in the next phases of project preparation.

flood prevention (see ¶1.34 and ¶1.35). This operation does not qualify as a social equity-enhancing or a poverty-targeted operation (AB-1704).

4.11 The ultimate beneficiaries from the development and use of EO applications and technologies will be the country's productive sector and society in general, as well as the international community. In terms of direct socioeconomic benefits, the implementation of the high impact applications to be developed by the Program is expected to lead to higher agricultural productivity of the country's main crops, more efficient use of pesticides and fertilizers, and damage prevention and reduction of economic losses during floods and other natural disasters. Additionally, since R&D is essentially a trial and error process with high degrees of uncertainty, the Program also considers funds for the development of new applications, which, if implemented, could also lead to significant socioeconomic benefits in areas like seismic risk management, planning and management of natural resources, and response to disease outbreaks.

4.12 The successful development and operation of the SAOCOM satellites will also enable CONAE to contribute to the global effort to close the gap in the provision of L-band SAR data, which has been identified as a significant challenge in the Integrated Global Observing Strategy (IGOS) of the United Nations. Argentina is committed to this effort and will provide data gathered with the SAOCOM satellites as part of its participation in the Global Earth Observation System of Systems (GEOSS).[43] Thus, other countries in the region and throughout the world will also reap potentially significant benefits from the information generated by the SAOCOM satellites, through CONAE's participation in GEOSS, the collaborative R&D efforts for application development with regional and international partners, and the commercial delivery of L-band data to users and firms who can apply them and/or develop new products and services, both nationally and internationally. In addition, the experience of other countries and the evaluations conducted by their space agencies show that private sector participation in the development of advanced technology projects like satellite EO, as suppliers and/or users, can also lead to considerable direct and indirect benefits that result in higher productivity and considerable positive socioeconomic effects (see ¶1.6 and ¶1.16).

C. Social and environmental impacts and strategy

4.13 The Program has no major direct negative environmental or social effects. The investments to be financed by the Bank deal with the R&D activities to construct, operate, and utilize two EO satellites, which do not involve dangerous or environmentally sensitive technologies, as the satellites are basically composed of electronic systems, solar panels, and small metallic structures. No major building or construction activities are considered in the Program. If necessary, the Program will fund modifications and adaptations of existing infrastructure, as well as the installation of equipment for the reception, processing, and dissemination of satellite data. The launch of the satellites will be procured internationally by ASI,

[43] An agreement for a GEOSS 10-year implementation plan was reached by member countries of the Group on Earth Observations at the Third Observation Summit held in Brussels in 2005.

and does not pose any special environmental risks, as the launch sites that are used and the orbits in which the satellites are injected are designed so as to avoid potential negative effects from the launch itself and from possible space debris.[44]

4.14 Argentina is a signatory to all relevant international treaties dealing with possible negative effects of activities in space, which address the following issues: i) basic principles for space activities, exploration, and use of space, including the moon and other celestial bodies; ii) rescue and return of astronauts and restitution of objects launched into space; iii) legal responsibility for damage caused by objects in space; and iv) registry of objects launched into space. All of these treaties have been ratified and are upheld by Argentina through its responsible agency, CONAE.

4.15 CONAE is also a member of a series of multilateral organizations related to space activities, and is an active participant in the Missile Technology Control Regime (MTCR), the International Astronautical Federation (IAF), and the Committee on the Peaceful Uses of Outer Space (COPUOS). Additionally, CONAE is a member of the International Charter on "Space and Major Disasters", through which satellite data generated by the countries that are signatories are provided without cost to regions affected by natural disasters, and of the UNESCO/ESA Open Initiative in Support of the World Heritage Convention, which brings together international space agencies in order to assist developing countries in monitoring their World Heritage sites through satellite imagery (e.g., CONAE has a leading role in projects related to Iguazú National Park, the Inca Trail, and the Galapagos Islands). Finally, CONAE participates actively in the Global Earth Observations System of Systems (GEOSS), which is a multi-government initiative that seeks to facilitate to all countries access to information generated through EO satellites.

4.16 Space activities can have significant social and environmental benefits, by providing information that can inform policymakers and public institutions responsible for: i) management of natural resources, emergencies, and health; ii) supervision of extractive activities in the forestry, agriculture, and fishing sectors; and iii) planning of use of land, water, and air. The benefits include improved regulatory design, better responses to natural emergencies, and more effective enforcement of laws dealing with environmental and social concerns. In addition, the agricultural applications of satellite information can lead to a more effective utilization of land resources and reduced use of pesticides and fertilizers (e.g., by providing information for implementing integrated pest management strategies).

4.17 The Program's Environmental and Social Strategy (ESS) is based on ensuring compliance with the set of international laws and treaties dealing with possible negative effects of space activities and promoting international collaboration, through Announcements of Opportunity, for use of satellite data to develop "global public goods" (e.g., response to natural disasters and conservation of world

[44] No serious injury, environmental effect, or significant property damage caused by satellite debris has been confirmed in the past 40 years. Reentry into the atmosphere results in extreme forces and temperatures that cause satellites to disintegrate as they de-orbit and fall to Earth, although small fractions of some of the satellite's titanium-based parts could eventually withstand re-entry.

heritage sites). Additionally, the prime contractor for the development of the SAOCOM satellites, INVAP, fully conforms to national environmental and labor laws.[45] Finally, the Program's overall strategy is designed to facilitate the realization of its potential economic benefits, which are primarily based on use of satellite information for environmental and social applications (see ¶4.11-¶4.12).

V. PROGRAM RISKS AND SPECIAL ASPECTS

5.1 This section is based on the SAOCOM System Technical Identification Review and the SAOCOM System Technical Orientation Review, both of which were carried out by a specialist from ESYS Consulting PLC, an independent space sector consulting firm that is assisting the Bank in conducting the technical due diligence of the Program and reviewing the Mission Implementation Plan.

5.2 Like any project involving the development of advanced technologies and especially those related to space activities, this Program entails a series of inherent risks that will require a comprehensive mitigation strategy, both for CONAE and the Bank. CONAE is employing procedures to manage these risks in keeping with standard space industry practices, including extensive prototyping and testing, and the use of redundant systems for critical components. For overall risk management, CONAE has designated a Mission Assurance Manager who is in charge of developing and maintaining the Risk Management Plan, as well as implementing CONAE's Assurance Requirements, in keeping with industry best practice. Nevertheless, the risks in space missions can never be completely eliminated, as these projects' characteristics constitute an inherent risk. Consequently, it is crucial to manage risk effectively through a risk management strategy that is continuously updated, in order to constantly mitigate and partially insure against possible risks.[46]

5.3 It is important to note that the SAC-C mission (with a launch mass of 485 kg and power capacity of 460W) was successfully integrated and operated by CONAE. The SAC-D satellite, which is currently under construction with the same main suppliers as the SAOCOM satellites, and with NASA as a main partner, has a launch mass of 1,600 kg and a power capacity of 1.3 KW, which are comparable to those of the SAOCOM satellites (each with a mass of 950 kg and power capacity of 2.5 KW). In this sense, although the SAOCOM satellite system is a technically challenging mission, in principle, the methodologies and skills that will be applied in its implementation and in managing its risks are comparable to those applied by CONAE and its prime contractor INVAP in previous and ongoing projects.[47]

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[45] The prime contractor for the development of the SAOCOM satellites (INVAP) is ISO9001 certified and is included in NASA's registry of eligible contractors for space projects. Moreover, it is currently undergoing external audits to obtain ISO14001 certification, and has recently implemented a series of preparatory measures, among them an Environmental Policy and an Environmental Operating Manual.

[46] The specific risks of the SAOCOM mission are identified, assessed, mitigated, tracked, and reported through Risk Reports that are continuously and frequently updated.

[47] It should be noted that INVAP has demonstrable skills and experience in the development of nuclear research and power facilities. Although the application area is different, there is also a high degree of risk, and safety considerations require high standards of engineering management and quality assurance.

5.4 The technical risks of the Program include those of launch failure and satellite failure subsequent to launch, as well as the possibility that the design or manufacture of one or more components fails to meet required specifications and, therefore, reduces the performance and/or expected lifetime of the mission.[48] Projects like the Hubble Telescope and Japan's complications with its L-band mission, among others, demonstrate the inherent technical risks of space-related projects, even for the best and most experienced space agencies. Similarly, there are also risks relating to the actual development and implementation of the potential applications based on the new information generated by the satellites, and the ensuing realization of their benefits. The main issue is the extent to which those technical and development risks are identified, mitigated, and reduced in all stages of the project, by applying best practice in risk management and by learning from previous experience.[49] The main risks and mitigation measures identified in the Program's Risk Management Plan are:

5.5 **Launch failure.** This is the most commonly noted risk in satellite projects, due to its public visibility. However, launch statistics show that between 1990 and 1999, Russian, American, and European launch vehicles (the most commonly used) had a success rate of 95%. Moreover, insurance is generally included in the service agreement, so that if there is a launch failure, the cost of a replacement launch vehicle is reimbursed to the satellite owner by the launch service provider.[50] The satellite can also be covered for the replacement costs (or part of them), if it is destroyed during a failed launch, with a premium of about 15%.

5.6 Since CONAE plans to build two satellites, the overall risks of the launch phase of the mission are relatively small, as insurance for the launch will be included in the Program.[51] In the event that the first launch fails, the second satellite should be

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48 With respect to the critical components of the SAOCOM satellites, other missions have successfully deployed larger antennas, more powerful transmitters, more sensitive receivers, and higher capacity solar panels than those proposed for the SAOCOM satellites. Their power capacity requirement is relatively modest compared to the power needs of its instrument and this is reflected in a relatively small duty cycle (10%) for the SAR. In this sense, the SAOCOM satellites are within the technical bounds of what other agencies have planned and/or accomplished after detailed analysis and design.

49 Over the past two decades all four planned civilian satellites carrying C-band SAR instruments were launched and operated successfully. The European ERS1, ERS2, and ENVISAT satellites, as well as the Canadian Radarsat, all performed as intended. ERS1 and ERS2 both significantly exceeded their planned lifetimes (ERS-1 operated for 8 years and ERS2 still operates 10 years after launch) and delivered data that have gone far beyond what was anticipated. In terms of L-band SAR missions, the Japanese Space Agency successfully developed and launched the JERS1 mission in 1992. However, it was curtailed after 12 months due to problems with the solar panels (the L-band SAR instrument itself operated properly and collected useful data).

50 Third party liability insurance is usually included in the launch cost by the launch service provider.

51 CONAE will have insurance coverage for either of the two satellites on the basis that both launches would be covered, but the maximum payout would be the cost of one replacement. If the first launch failed then the cost of the replacement would be paid, but there would be no coverage for the second launch. Conversely, if the first launch was successful, the second launch would be covered in the event of failure. CONAE is contacting launch insurance providers to establish the premium of the insurance (currently estimated at 15% of the replacement cost). At the same time, CONAE is negotiating a binding option price from INVAP for the construction of a spare satellite, to ensure that it will be possible to construct a spare satellite within the budget of the insurance payment, should the need arise.

ready after six months, bearing in mind the time required to schedule a new launch and prepare the satellite. The insurance coverage would then provide for the construction of a third satellite (excluding non-insurable costs). Assuming the first launch was successful, should the second launch fail, there would be a slightly longer delay in adding the second satellite to the constellation, due to the construction lead time; however, one satellite would be operational and providing data, so the benefits of the Program would still be partly realized.

5.7 **Operational failure during satellite design life.** Experience shows that the risk of failure once the satellite is properly injected into its orbit remains relatively high in the early operation phase, and then significantly declines, once 10-15% of its design life has elapsed. Insurance against the functionality of the satellite failing after launch is often taken out for communications satellites, where the technology is fairly well known and replicable, allowing operators to insure against the costs of the satellite and lost revenue. However, it is unusual for EO satellites to be insured in this way. NASA and ESA never insure externally, and rely on the rigorous mission assurance review processes and milestones to minimize the risk of on-orbit failure.

5.8 In the case of CONAE, it would not be economically feasible to insure for operational failure of the SAOCOM satellites, as the insurer would need to establish the risk it was taking through a heavily involved due diligence program and, even if prepared to do so and offer cover, CONAE's limited track record would make the premium prohibitively high. Initial reviews of internal product assurance and supply chain validation processes, as well as inspections of the risk management plan and quality assurance documentation kept by CONAE and its Quality Assurance Manager, have been carried out by a space sector consulting firm hired by the Bank. These efforts will be complemented and sustained by thorough reviews to be conducted through CONAE's own external review processes, which will be supervised by the EPE during project implementation, to ensure that correct standards and best practice are being applied both within CONAE and its prime contractor, and in other parts of the supply chain.

5.9 **Component failure.** Two other factors contribute to the Program's technical risks: i) space is a harsh environment, and in addition to the forces and vibrations generated by the launch and high radiation exposure once in space, polar orbiting satellite in sun synchronous orbits must endure extreme temperature fluctuations, with limited scope to diffuse heat in the vacuum of space; and ii) unlike high technology developments on the ground, there is virtually no opportunity to replace or repair faulty components of a satellite after launch. To mitigate these risks, the SAOCOM satellites have been designed according to established principles for reliability in a space environment and the use of redundancy (duplicate sets of equipment on board), to reduce the risks associated with a single point of failure. This approach has been used in components such as the SAR instrument electronics, the data down-link, and key aspects of the satellite bus management. However, there are particular components of the SAOCOM satellites where risks may be concentrated, specifically in the following key structures:

a. **SAR antenna.** There are two critical issues regarding the antenna structure. First, the antenna must achieve a high degree of flatness in order to maintain the quality of the data received: tolerance is 23 mm across the entire area. Second, the antenna (measuring 10 m by 2.5 m when fully deployed) has to be packed within the fairing of a launch vehicle that has a maximum diameter of 2.7 m. This means that the antenna must be tightly folded for launch, then carefully unfolded once the satellite is in orbit. This aspect of the Program has undergone significant research and prototyping since March 2002. Lessons learnt from other agencies have led to the choice of actuator driven hinges to unfold the antenna. Overall, it would appear that the risks regarding this aspect are being well managed. However, the SAR antenna structure will remain a key technology development risk, which will continue to be a focus for future validation reviews (starting with the upcoming PDR).

b. **Solar arrays and associated power equipment.** The SAR requires high power since it is an active transmitting instrument. Power is generated from solar panels through the orbit and stored in batteries for use during active instrument operation. Solar panels are subject to deterioration throughout their lifetime and there are several examples of satellite missions that have been severely disrupted due to failures in their solar panels. The solar arrays for SAOCOM are being produced by the Solar Energy Group of the *Constituyentes Atomic Center*, where work has been ongoing since 2001 under a series of cooperation agreements with CONAE. Since there are a number of established international suppliers of solar panels, construction in Argentina could be open to question. However, these concerns are mitigated by the fact that de-risking has been ongoing since 2001, the Solar Energy Group has had support from NASA in developing and manufacturing the solar panels for the SAC-D mission, which has comparable electrical requirements to SAOCOM, and the basic photo-voltaic cells will be purchased from an established solar panel supplier. This aspect of the Program will remain as a focus of subsequent mission reviews (starting with the upcoming PDR).

c. **High speed downlink.** The data collected from the SAR instrument are stored on-board and transmitted to the ground station using an X-band downlink. A line-of-sight link is required to transmit data between the satellite and the ground station. Given the altitude of the satellite, its maximum visibility per pass is approximately 10 minutes. The speed of the downlink is therefore designed to allow the data from the on-board store to be transmitted within this timeframe. The SAOCOM satellite design considers two down-links that are being designed and implemented by an Argentine company (Consulfem). Since this equipment is frequently used on remote sensing satellites and is readily available abroad, the value of sponsoring a new supplier to develop a capability to manufacture new equipment may be open to question. Although it is anticipated that the development will be a success, in order to address this possible risk, CONAE has identified alternate suppliers from whom this equipment could be procured, should Consulfem run into technical problems or significant cost overruns. Progress in the development of the down-link will continue to be analyzed at future program reviews (starting with the PDR).

d. **Antenna electrical equipment.** Electrical equipment mounted on the physical antenna structure is required to produce the radar signal. The Transmit/Receive (T/R) modules are at the heart of the SAR antenna. They transmit the microwave pulses to the ground and receive the return echoes that are processed by the electronics of the SAR instrument. The overall electronic system is being integrated in Argentina, but the T/R modules themselves are being acquired from AleniaSpazio, an Italian firm, as their development is part of ASI's contribution to the project. Alenia is manufacturing the equivalent T/R modules for the X-Band SAR on Italy's COSMO/Skymed and was also contracted to manufacture the T/R modules for the C-band SAR on Canada's Radarsat 2, so this aspect can already be considered to be handled in a low-risk manner. A review of the SAR core electronics module will be included as part of the upcoming PDR, to ensure the adequacy of the design with respect to the performance requirements and the practicality of its implementation with space qualified hardware that is not subject to export limitations.

5.10 **Application development and implementation risk.** There are no L-band satellites operating at present and few L-band data have been available in the past. Hence, practical use of L-band data is at a lower level of maturity that for other types of earth observation imagery. As a result, there are no off-the-shelf solutions that can be easily acquired and the high impact applications to be implemented through this Program are at differing stages of development. Therefore, there is some risk that since their viability is uncertain, eventually it might not be possible to develop the applications that would be necessary to realize the Program's full potential net benefits. Moreover, the full benefits of the Program will only be available if the target operational users are able to incorporate the information generated by the SAOCOM satellites into their regular working practices. Given the typical predilection of space agencies to focus on the engineering and technical aspects of their projects, there is a risk that the development of applications and capacity in the user segment could be neglected. Similarly, there is also a risk that the potential applications might not be used properly or to their fullest extent, due to the possible institutional weakness of the agencies involved.

5.11 In order to mitigate these risks, the Program will focus on the development and implementation of three high impact strategic applications (HISAs), which were selected due to their high viability and significant potential economic benefits (see ¶1.34). In this sense, a detailed Application Development and Implementation Plan was prepared by CONAE to coordinate with its partners (INTA and INA) the efforts required to achieve operational delivery of the HISAs once the satellites are in orbit. These applications also constitute the basis of the economic justification of the project (see ¶4.1-¶4.9) In addition, the Program will also provide images and/or grants for a series of Announcements of Opportunity, well before the satellites are in orbit, in order to facilitate the development of new applications in the scientific community and the private sector (see ¶1.35). Furthermore, CONAE is already addressing these risks with support from the Bank, through a US$1.5 million Project Preparation and Execution Facility (AR-L1024) approved in early

2006, to jump-start CONAE, INTA, and INA's efforts to achieve timely development and implementation of the HISAs and to promote user readiness.[52]

5.12 The potential application development and implementation risk is further mitigated by the Program's strategy and choice of lending modality, which seek to create proper incentives and mechanisms to advance application development in parallel with the space technology development. Moreover, it is hoped that, given its consistency with standard practice in the space industry, the choice of a Performance Driven Loan will result in better overall risk management and smoother execution of the Program, with confirmation of results in the space technology and application indicators adjudicated with support from the EPE. Additionally, this loan modality would allow CONAE to continue to use procurement procedures that are in accordance with best practice in the industry.

5.13 **Financial risks.** The technical complexity and risk of space activities and the difficulty in anticipating problems can frequently result in a tendency toward cost overruns. This implies an additional risk in terms of the possibility that the amount of Bank financing and counterpart funds may eventually not be sufficient to cover all the costs associated to the SAOCOM Project, and that the potential net benefits of the project would be adversely affected by potentially significant cost overruns.

5.14 CONAE has provided a detailed description of the Program's budget, clearly establishing projected costs, as well as what has been spent, committed, and achieved for the space and ground segments of PROSAT. Detailed cost analyses have led to the conclusion that, after making the relevant adjustments, total budgeted costs are in line with similar missions from other space agencies. Moreover, provisions for contingencies have been included in the most recent budget and conservative cost estimates have been used in order to mitigate the risk associated to domestic development of certain components (see ¶2.14).

5.15 **Possible legal issues.** Given the timing and intrinsic characteristics of projects involving space activities, the specific types of contracts that will need to be signed to procure insurance for the satellites have not yet been established. There could also be an eventual need for export licenses for certain technological components for the construction of the SAOCOM satellites that could be subject to export restrictions in their country of origin. Also, given the fact that the SAOCOM satellites have a global recording capacity (i.e., the ability to capture data on a global scale), at this stage it is still unclear how this information would be offered to other interested countries in the region or throughout the world.[53]

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[52] The PROPEF also includes funding for data calibration activities that will run in parallel with an airborne-SAR campaign to collect data over areas nominated by potential users, so that they can validate its usefulness and contribute to the process of developing applications.

[53] Principle XII of the Remote Sensing principles adopted by the UN in 1986 states that "as soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms. The sensed State shall also have access to the available analyzed information concerning the territory under its jurisdiction in the possession of any State participating in remote sensing activities on the same basis and terms, taking particularly into account the needs and interests of the developing countries."

5.16 CONAE is contacting insurance providers to spell-out the details of the planned arrangement to secure coverage for the satellites in the event of launch failure (see ¶5.6). The risk of schedule delays due to export license rejection is being mitigated by using parts and components from a Preferred Parts List that comply with possible restrictions, and by obtaining early approval of purchasing orders for key components of the flight and engineering models. Finally, CONAE has defined the general principles of the Data Policy that will govern the use and distribution of the images generated by the SAOCOM satellites (see ¶1.38-¶1.40). CONAE is developing further the PROSAT Data Policy, as discussion with ASI regarding the information sharing implications of the SIASGE agreement continue to progress. This Data Policy will include considerations relating to data access for countries in the region and throughout the world; commercial distribution plans for some of the images; the data sharing implications of the SIASGE and Belgian agreement; and the ground segment design for the reception and processing of COSMO/Skymed X-band SAR data in Argentina.

5.17 **Time constraints.** One restriction affecting the viability of the risk-mitigating actions proposed in the preceding paragraphs is the tight timetable that CONAE is facing, given the commitments it has already entered into under its agreement with the Italian Space Agency (ASI), through which the SAOCOM 1A and 1B satellites would be part of the SIASGE constellation of six satellites that would also include 4 Italian X-band satellites. This is due to the need to have a relatively simultaneous launch of the satellites in the SIASGE constellation, in order to capitalize on the increased potential benefits of the coordinated action of all six satellites. Taking into consideration the fact that space missions require extensive time and effort in order to reduce the risks involved and that, generally, the better such risk-mitigation and quality-assurance effort is, the higher the ultimate chances of success will be, the tight timetable faced by CONAE could constitute an important restriction. This restriction could be further intensified by the fact that CONAE is concurrently undertaking another important satellite project (SAC-D, with NASA as its main partner), which could strain CONAE's resources and capabilities.

5.18 To address these risks, CONAE has included a provision for contingencies in the budget, in order to deal adequately with possible schedule over-runs. Additionally, the overlap between CONAE's parallel satellite missions has been considerably reduced, as the launch of the first SAOCOM satellite is now programmed for two years after the launch of SAC-D. This will reduce a possible source of overlaps and resource constraints, while still allowing for considerable synergies between both missions, specifically in the development of shared components, training of personnel, implementation of common processes, and better equipment utilization.

5.19 **Institutional reputational risk.** From the Bank's perspective, the high visibility and the possible all-or-nothing characteristics of the Program mean that it may face a particularly high level of institutional reputational risk in its development and implementation. Several of the potential risk factors mentioned before could result in limited or complete non-achievement of the Program's objectives and benefits, in the context of extremely high public visibility.

5.20 In order to best mitigate this institutional reputational risk, the External Panel of Experts (EPE) should ideally be established under the umbrella of a leading space agency, in order to advise the Bank on technical matters related to the Program's preparation and subsequent implementation. To assess compliance with the Program's targets, as presented in its Results Matrix, the EPE would also participate in CONAE's performance reviews of the SAOCOM mission.[54] Alternatively, should the participation of a leading space agency prove to be unfeasible, this risk could be partially mitigated with an EPE comprised solely of high-level consultants from reputable aerospace firms that provide similar services to other international space-sector organizations.

5.21 Finally, to further mitigate this risk, and to highlight the innovative qualities of the operation and its potential to contribute to the technological and economic development of Argentina, the Project Team has involved the Bank's Office of External Relations and CONAE's Office of Institutional Relations, in order to implement a strategy to address the public relations aspects of the Program.

VI. PROGRAM PREPARATION AND ACTION PLAN

6.1 In the previous stages of preparation, the Project Team and CONAE have worked to develop a series of documents and studies to analyze the technical viability of the Program and to refine its design. In conducting the technical due diligence of the Program, the Project Team, with the support of a high-level consultant from a specialized independent firm, has obtained favorable external opinions regarding the technical viability of the project. A detailed cost analysis also confirmed that, after making the pertinent adjustments, the Program's budget is comparable to those of similar satellite missions developed by leading space agencies. In parallel with this, CONAE has developed a Project Implementation Plan, a Risk Management Plan, and Quality Assurance Requirements for the SAOCOM mission, all of which are consistent with best practice in the space sector and are being regularly updated. Additionally, a complete Application Development and Implementation Plan has been designed, the general principles of the Program's Data Policy have been defined, three high impact strategic applications have been selected, and a cost-benefit analysis of these applications has been conducted. In order to jump-start the development of the applications and ensure end-user readiness, a Project Preparation and Execution Facility (AR-L1024) was recently approved by the Bank. Finally, an institutional consultant is currently conducting an Institutional Capacity Assessment, which includes a specific procurement analysis that has confirmed that CONAE's procurement practices conform to the Bank's general requirements for Performance Driven Loans.

6.2 The Project Team has also made considerable efforts to secure the participation of a leading space agency in the EPE. This has involved initial discussions with

[54] Despite the fact that CONAE is exposing the project to standard space-sector external reviews at critical project milestones, this External Panel of Experts would be necessary to advise the Bank in all related technical matters, as this capacity does not exist in-house.

NASA's Office of External Affairs and the Science Applications Directorate, which have concluded with the identification of two concerns regarding the proposed collaboration. One was a serious resource constraint being confronted by NASA, which indicated having insufficient manpower to engage in the type of technical review that could be required. Concern was also expressed about the possible sensitivities resulting from commenting on another country's space project. To ensure a minimal burden on NASA's staff resources, the Bank has proposed to secure technical assistance from qualified independent aerospace firms with experience in the provision of services to international space agencies, and to include these consultants as part of the EPE. In addition, CONAE has explicitly agreed to NASA's involvement, indicating that this does not pose a problem to them.

6.3 NASA's involvement in the EPE, with contractor support for detailed review of the Program's development, would provide much needed assurance to the Bank with respect to the technical and policy soundness of this project. If, however, this proves unfeasible, the EPE could be comprised solely of high-level consultants from reputable aerospace firms that provide similar services to official space-sector organizations. This would provide some mitigation of the institutional reputational risks, and would allow project preparation to continue as planned.

6.4 In continuing with project preparation, the Project Team and CONAE are currently working to: i) complete the Results Matrix for the Program, including targets and baselines for all results indicators, as well as detailed guidelines for assessing their compliance; ii) finalize the Institutional Capacity Evaluation and propose any necessary institutional strengthening activities; iii) finalize the economic evaluation of the Program; iv) continue discussions to establish the feasibility of creating the EPE under the umbrella of a leading space agency such as NASA; and v) define the Terms of Reference for hiring the team of high level consultants that will form the EPE, preferably under the umbrella of a leading space agency.

6.5 Tentative dates for the following stages in Program preparation are: i) Analysis Mission, II trimester 2006; and ii) Loan Document to the Board, III trimester 2006.

Annex 1

Program for the Development of a Satellite System and Applications based on Earth Observation (PROSAT) AR-L1017

Preliminary Results Matrix

PROGRAM FOR THE DEVELOPMENT OF A SATELLITE SYSTEM AND APPLICATIONS BASED ON EARTH OBSERVATION (PROSAT AR-L1017) PRELIMINARY RESULTS MATRIX						
Objectives	**Outcome Indicator**	**Requirements for Initial Disbursement**	**Targets for 1st Tranche**	**Targets for 2nd Tranche**	**Targets for 3rd Tranche**	**Targets for 4th Tranche**
Objective #1: To strengthen the delivery of space-based services and the scientific and engineering capabilities to successfully design, build, and operate an advanced EO satellite system carrying an L-band SAR (SAOCOM).	Outcome Indicator #1: Assessment by External Panel of Experts (EPE) of the achievement of key review milestones in a standard, internationally recognized evaluation process for the design, manufacturing, assembly, commissioning and operation of the satellite system and all of its supporting ground infrastructure.	Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the Preliminary Design Review (**PDR**), in which the design requirements of the satellite system are identified and evaluated.	#1. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the Critical Design Review (**CDR**), which leads to the detailed design and definition of the satellite system (including production of test elements and components, as well as final make/buy decisions).	#1. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the Pre Shipment Review (**PSR**) of SAOCOM 1A satellite, which takes place after qualification testing, allowing for verification of the technical conformity of components against requirements (design qualification) and operational aptitude (operational qualification).	#1. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the In-Space Test Review (**ISPR**) of SAOCOM 1A satellite, which comprises launch activities, in-flight qualification and acceptance testing of the system, allowing for measurement of performance levels, as well as level of service attained, and in-flight qualification of the satellite. #2. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the Pre Shipment Review (**PSR**) of SAOCOM 1B satellite.	#1. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the 12th month **Operational Review** of SAOCOM 1A satellite, where its major parameters are revised in order to contribute to improvements in operation, while generating feedback for future projects and the need for redevelopment of certain products (eg, ground support equipment or software). #2. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed by the EPE in the In-Space Test Review (**ISPR**) of SAOCOM 1B satellite.

PROGRAM FOR THE DEVELOPMENT OF A SATELLITE SYSTEM AND APPLICATIONS BASED ON EARTH OBSERVATION (PROSAT AR-L1017) **PRELIMINARY RESULTS MATRIX**						
Objectives	**Outcome Indicator**	**Requirements for Initial Disbursement**	**Targets for 1st Tranche**	**Targets for 2nd Tranche**	**Targets for 3rd Tranche**	**Targets for 4th Tranche**
Objective #2: To strengthen and consolidate the capabilities in a technological niche of EO to successfully develop and implement applications with high socio-economic impact using data gathered with the SAOCOM system.	Outcome Indicator #2: Assessment, according to specific guidelines evaluated by an external review[1], of the achievement of key milestones in the design, development, commissioning and operation of applications developed to use data gathered with the SAOCOM satellites system.	Airborne SAR campaign initiated. Selection of 4 High Impact Strategic Applications with the highest socio-economic impact, as evaluated using cost-benefit analysis.	#1. Successful completion of at least xx hours of airborne trials and production of at least XX airborne SAR images. #2. Implementation of a pre-launch, international research Announcement of Opportunity (AO) for airborne trial data. #3. Preparation of preliminary of Implementation Plans for each of the 4 High Impact Strategic Applications.	#1. Successful completion of at least xx hours of airborne trials and production of at least XX airborne SAR images. #2. Successful achievement of xxx, xxx, and xxx as assessed in an external review of the technical readiness of at least 2 of the 4 High Impact Strategic Applications. #3. Successful initiation of at least 2 Implementation Plans of the High Impact Strategic Applications.	#1. Successful production of at least XX SAR images from SAOCOM 1A. #2. Successful achievement of xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed in an external review of the technical readiness of all 4 High Impact Strategic Applications. #3. Successful initiation of all 4 Implementation Plans of the High Impact Strategic Applications.	#1. Successful production of at least XX SAR images from SAOCOM 1A and XX SAR images from SAOCOM 1B. #2. Implementation of a post-launch, international research Announcement of Opportunity (AO) for SAOCOM 1A data. #3. Successful achievement of xxx, xxx, xxx, and xxx, and demonstrated ability to xxx, xxx, and xxx, as assessed in an external review of the development impact of the High Impact Strategic Applications implemented by the beneficiary agencies, institutions, or firms.

[1] Detailed guidelines for the external reviews of the capability development objective in the area of satellite applications will be prepared and agreed with CONAE during project preparation.

Program for the Development of a Satellite System and Applications based on Earth Observation (PROSAT)

AR-L1017

Preliminary estimates of project preparation and execution costs (weeks/professional)

Category	Until PCD	Until approval	During execution	Total
Headquarters	**28**	**18**	**15**	**61**
Team Leader	10	6	6	22
Economist	8	4	4	16
Agriculture and Natural Resources Specialist	4	2	2	8
Science and Technology Specialist	4	2	2	8
Lawyers	2	4	1	7
Country Office	**2**	**4**	**35**	**41**
Sector Specialist	2	2	30	34
Financial Specialist	0	2	5	7
Consultants	**30**	**26**	**60**	**116**
Technical Satellite Specialist	8	6	10	24
Cost Analysis Specialist	4	0	0	4
Applications Development Specialist	4	2	0	6
Data Access and Policy Specialist	2	2	0	4
Institutional and Financial Analysis Specialist	4	2	0	6
External Panel of Experts	0	10	50	60
Research Assistant	8	4	0	12
Total	**60**	**48**	**110**	**218**

Preliminary estimate of cost of missions (US$)

Category	Until PCD	Until approval	During execution	Total
Headquarters	**$ 45,000**	**$ 42,000**	**$ 45,000**	**$ 132,000**
Team Leader	$ 14,000	$ 14,000	$ 15,000	$ 43,000
Economist	$ 14,000	$ 14,000	$ 15,000	$ 43,000
Agriculture and Natural Resources Specialist	$ 10,000	$ 7,000	$ 7,500	$ 24,500
Science and Technology Specialist	$ 7,000	$ 7,000	$ 7,500	$ 21,500
Lawyers	$ 10,000	$ 14,000	$ -	$ 24,000
Consultants	**$ 39,000**	**$ 71,000**	**$ 150,000**	**$ 260,000**
Technical Satellite Specialist	$ 10,000	$ 10,000	$ 25,000	$ 45,000
Cost Analysis Specialist	$ 5,000	$ -	$ -	$ 5,000
Applications Development Specialist	$ 3,000	$ 3,000	$ -	$ 6,000
Data Access and Policy Specialist	$ 5,000	$ -	$ -	$ 5,000
Institutional and Financial Analysis Specialist	$ 10,000	$ 5,000	$ -	$ 15,000
External Panel of Experts	$ -	$ 50,000	$ 125,000	$ 175,000
Research Assistant	$ 6,000	$ 3,000		$ 9,000
Total	**$ 84,000**	**$ 113,000**	**$ 195,000**	**$ 392,000**

Annex 3

Program for the Development of a Satellite System and Applications based on Earth Observation (PROSAT)

AR-L1017

Application Readiness in Canada's Radarsat-1 Satellite

The Canadian government invested significant funds in preparation for the launch of the Radarsat-1 mission in the form of user and application development programs. The first of these, the SURSAT program, was launched in 1979 and started the process by specifying the requirements for Radarsat. After that, a series of application development projects proceeded both before and after the launch of RADARSAT in 1995. The main development program was the Radar Data Development Program (RDDP) which ran from 1986-1998. The content and results of the program are described as follows by the Canada Centre for Remote Sensing:

> "Led by the Canada Centre for Remote Sensing (CCRS), Natural Resources Canada, the main goal of the Radar Data Development Program (RDDP) was the preparation of Canadian synthetic aperture radar (SAR) data users for the effective investigation of resource management and environmental monitoring. This goal was achieved via a balanced agenda of applications and technology development, involving universities, other government departments, user agencies, and industry.
>
> RDDP activities focused on encouraging the utilization of information derived from Radarsat-1 imagery by relying heavily on the Airborne C/X SAR, operated by CCRS at the time, as a data source for research and development projects. However, to maximize the usefulness of remote sensing to the end user, applications developers were encouraged to evaluate SAR data in combination with existing sources of information, such as field data, air photos, Landsat Thematic Mapper, SPOT HRV or NOAA AVHRR imagery obtained in the visible and infra-red portions of the electromagnetic spectrum.
>
> The RDDP provided SAR imagery for over fifty geological test sites across Canada. The data was used for improving lithological, structural and lineament maps; and the exploration for base metals, precious metals, industrial minerals, as well as oil and gas deposits. Data were also used for geobotanical studies and the analysis of quaternary landforms, recent seismic disturbances, and meteorite impact craters. Investigations included the effects of look direction and view angle on radar image interpretability, reducing speckle in SAR images, developing algorithms to combine radar with geological and geophysical datasets, models of mineral deposits, and digital techniques for analyzing lineaments.
>
> Much of the work under the RDDP regarding oceans applications was for testing optimum sensor configurations. In co-operation with the Department of Fisheries and Oceans and private industry, a major milestone was the development of an ocean wave spectra algorithm, which was incorporated into an operational wave forecast model of Environment Canada's Atmospheric Environment Service.
>
> The sea ice applications development effort was the most advanced in terms of its actual progress towards operational use and integration in existing data and information distribution systems. Work focused on three main goals: preparation of ice forecast charts by Environment Canada's Ice Centre; tactical ice reconnaissance for ship navigation in ice infested waters; and delivery of value-added ice information products to end users, such as offshore operators."

The focus on sea ice reflects the primary mission of Radarsat-1 which was for mapping of sea ice around Canada's Northern seaboard in support of maritime navigation – the primary economic benefit justification for the program was the replacement of airborne SAR reconnaissance with the satellite. The Canadian Ice Centre was in a high state of operational readiness to use the data, partly due to the development programs and partly due to the long history of using similar airborne SAR data. Even so, after launch the development continued, particularly into techniques for automatic ice classification to reduce the amount of human intervention required.

The RDDP was followed by the Application Development and Research Opportunity from 1996-1998 and the Remote Sensing Data Development Program from RSDDP 1998–2001. The former program distributed free Radarsat-1 data to almost 250 separate projects to encourage application development.