DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK

ARGENTINA

PROGRAM FOR THE DEVELOPMENT OF A SATELLITE SYSTEM AND APPLICATIONS BASED ON EARTH OBSERVATION (PROSAT)

(AR-L1017)

LOAN PROPOSAL

This document was prepared by the project team composed of: Nicolás Uauy, Team Leader (RE1/FI1); Gregorio Arévalo, Cristian Quijada, and Juliana Parahyba (RE1/FI1); Marta Cehelsky (SDS/EST); Héctor Malarín (RE1/EN1); Valnora Leister and Dana Martin (LEG/OPR); Dino Caprirolo and Mario Ferreira (COF/CAR); Jon Styles and Hernán Aspiazu (consultants). Annabella Gaggero (RE1/FI1) was in charge of document production.

CONTENT

Electronic Links and References	
Basic Socioeconomic Data	http://www.iadb.org/RES/index.cfm?fuseaction=externallinks.countrydata
Status of Loan in Execution & Loans Approved	Argentina
Tentative Lending Program	Argentina
Information Available in Technical Files of RE1/FI1	IDBDocs referencia #763862
Indicative Procurement Plan	IDBDocs referencia #764629
Indicative Budget by Results	IDBDocs referencia #764582
Draft PPMR	IDBDocs referencia #764633

ABBREVIATIONS

AEB	Brazilian Space Agency
AO	Announcement of Opportunity
ASI	Italian Space Agency
AWS	Automatic Weather Stations
CDR	Critical Design Review
CEOS	Commission for Earth Observation Satellites
CIE	Complete Space Information Cycles
CNEA	*Comisión Nacional de Energía Atómica*
CNES	National Center for Space Studies of France
CONAE	National Commission for Space Activities
COPUOS	Committee on the Peaceful Uses of Outer Space
CSA	Canadian Space Agency
DISPA	Unit for Distribution of Satellite Images and Promotion of its Applications
ECSS	European Cooperation for Space Standardization
EO	Earth Observation
EPE	External Panel of Experts
ESA	European Space Agency
ESS	Environmental and Social Strategy
EXR	Office of External Relations
GDP	Gross Domestic Product
GdP	Projects Department
GEOSS	Global Earth Observation System of Systems
GGT	Technology Management Department
GIS	Geographic Information System
GP	Projects Manager
GPAF	Planning, Administration and Finance Department
GPS	Global Positioning System
GRI	Institutional Relations Department
HISA	High Impact Strategic Application
IAF	International Astronautical Federation
ICT	Information and Communications Technology
IGOS	Integrated Global Observation Strategy
INA	National Institute of Water

INPE	Brazilian National Institute for Space Research
INTA	National Institute of Agricultural Technology
INVAP	Investigación Aplicada
IP	Lead Researcher
ISTR	In-Space Test Review
JP	Project Chief
MERCOSUR	*Mercado Común del Sur*
MTCR	Missile Technology Control Regime
NASA	National Aeronautics and Space Administration
NIS	National Innovation System
NSP	National Space Plan
OAS	Organization of American States
PDL	Performance Driven Loan
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PROSAT	Program for the Development of a Satellite System and Applications Based on Earth Observation
R&D	Research & Development
S&T	Science and Technology
SAR	Synthetic Aperture Radar
SECI	Institutional Capacity Assessment System
SIASGE	Italo-Argentine Satellite System for Emergency Management
SMOS	Soil Moisture and Ocean Salinity
T/R Modules	Transmit/Receive Modules
UEPEX	System for External Project Execution Units
US	United States
WBS	Work Breakdown Structure

PROJECT SUMMARY

ARGENTINA

PROGRAM FOR THE DEVELOPMENT OF A SATELLITE SYSTEM AND APPLICATIONS BASED ON EARTH OBSERVATION (PROSAT)

(AR-L1017)

<table>
<tr><th colspan="5">Financial Terms and Conditions [1]</th></tr>
<tr><td colspan="3" rowspan="3">Borrower: Republic of Argentina
Executing Agency: National Commission for Space Activities (CONAE)</td><td>Amortization period:</td><td>20 years</td></tr>
<tr><td>Grace period:</td><td>7 years</td></tr>
<tr><td>Disbursement period:</td><td>7 years</td></tr>
<tr><td>Source</td><td>Amount</td><td>%</td><td>Interest rate:</td><td>Option based on Libor</td></tr>
<tr><td>IDB/OC</td><td>US$ 50 MN</td><td>(33%)</td><td>Supervision and inspection fee:</td><td>0%</td></tr>
<tr><td>Local</td><td>US$ 100 MN</td><td>(67%)</td><td>Credit fee:</td><td>0.25%</td></tr>
<tr><td>Total</td><td>US$ 150 MN</td><td>(100%)</td><td>Currency:</td><td>US dollars of the Bank’s single currency facility</td></tr>
</table>

Project at a Glance

Project objective:

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 with 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.

Special contractual clauses:

Special conditions prior to the first disbursement (advance) of the loan resources:

The coming into effect of CONAE’s institutional cooperation agreements with the National Institute of Water (INA) and the National Institute of Agricultural Technology (INTA) - (see ¶3.9).

The implementation and operation of the External Project Executing Units (UEPEX) accounting system at CONAE for this program (see ¶3.13).

Special conditions prior to disbursement of the first tranche of the PDL:

The contracting of the financial auditing firm in accordance with terms of reference agreed upon with the Bank (see ¶3.30).

The hiring of the specialized consulting services that will conduct the Performance Audits of the Program, according to Terms of Reference agreed with the Bank (see ¶3.25).

Special conditions prior to disbursement of each of the five tranches of the PDL:

Achievement of the targets indicated in the Program’s Results Matrix for each one of the five tranches (see Annex 1).

Exceptions to Bank policies: None

Project consistent with Country Strategy: Yes [X] No [ ]

Project qualifies for: SEQ[NO] PTI [NO] Sector [ ] Geographic[ ] Headcount [ ]

Procurement: See ¶3.15 -¶3.17.

Verified by CESI on: November 4th, 2005.

[1] The interest rate, credit fee, and inspection and supervision fee mentioned in this document are established pursuant to document FN-568-3 Rev. and may be changed by the Board of Executive Directors, taking into account the available background information, as well as the respective Finance Department recommendations. In no case will the credit fee exceed 0.75%, or the inspection and supervision fee exceed 1% of the loan amount (*) (*) With regard to the inspection and supervision fee, in no case will the charge exceed, in a given six-month period, the amount that would result from applying 1% to the loan amount divided by the number of six-month periods included in the original disbursement period.

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 long term economic growth. 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 its relatively high scientific 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 decades, in the same period several developing countries have made 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 science capacity are seemingly underutilized, and their potential for contributing to economic growth is not being fully realized. The country's performance in the production of patents, technological applications, and linkages with the productive sector has been unimpressive. More worrying is a relative depreciation of capabilities, compared to other countries, due to insufficient investment in the sector and continued brain drain. Institutionally, the National Innovation System (NIS) is inefficient in transforming research activities into commercial and practical applications, due to limited collaboration with the private sector and potential users of technologies.

---

[1] Argentina has 1.6 researchers per 1000 economically active inhabitants (RICYT 2003), the highest in the region, and higher than the Latin American average (0.6), Brazil (0.7), Chile (1.2) and Mexico (0.7).

[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).

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), one of the main pillars of Argentina's socio-economic 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] These investments have helped to maintain the domestic skill base, and created mechanisms to improve the linkages between scientists and the productive sector. However, for Argentina to achieve greater social and economic development, it needs to move closer to the world technological frontier and to better articulate the relevant actors of the NIS, through a concerted and focused effort 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 an important area where Argentina has a relevant skill base and science foundation, where potential applications could be of great socio-economic 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, through the use of instruments aboard 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

---

[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, which was approved in April of 2006.

[5] The term "mission-oriented" technology policies is used to describe the type of programs where the technology objective and the socio-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.

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 typically operated by national space agencies, due to their inherent risk, their technological novelty, and the public nature of their applications. These satellites usually orbit the Earth at distances of 200 to 2,000 km (low earth orbit), in trajectories that pass over the poles, generating detailed images that are then downloaded to ground stations when the satellite flies over the stations' line of sight.[8] EO satellites differ in several respects from communications satellites. Telecommunications satellites tend to be built and operated by private sector companies, as their applications are commercially profitable. They relay telephone, television, and other signals, and are also more numerous and technologically simpler.[9]

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 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.[10] 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.

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.[11] One particular form of imaging radar, 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

---

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

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

9 Telecommunications satellites usually operate in geostationary orbits, 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.

10 In recent years, as costs have declined and collaboration increased, nations like Taiwan, Malaysia, Thailand, and Korea, as well as less developed 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.

11 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).

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 conclusion that L-band data would represent a superior data source in some cases and, in particular, that combinations of different radar frequencies yield data of higher utility.

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. 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 several 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 once the satellites are launched, the capabilities that are developed during the design, construction, and testing of advanced satellites, and the spillovers to the rest of the economy resulting in the development of new products and services.[12] In this sense, Argentina's 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

[12] 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).

development of EO satellites, specifically, physics and material sciences.[13] It is one of only two countries in the region, with Brazil, that has the skills and capacity to support advanced space activities, which can considerably contribute to national social and economic development. During the past decade, 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 agriculture, natural resources, and food production, remote sensing satellite technologies can be applied effectively to address key economic challenges, by developing applications to increase the productivity and sustainability of those resources and reduce potential losses from frequent natural disasters like flooding. As the experience of Canada demonstrates, sustained commitment to remote sensing satellites can yield substantial social and economic benefits, especially for large countries with abundant natural resources and competitive agricultural sectors, as efficient management of those resources can lead to important economic benefits for the productive sector and for society as a whole (see ¶4.26).

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 economic benefits, through the creation of new industries and spin-offs, and closer cooperation between industry and other actors of the NIS.[14]

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

---

[13] 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).

[14] 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.

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).[15] 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[16]: 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.

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 Tabanera 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

---

[15] 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.

[16] For more details on each of these missions, see: "International participation in SAC series missions."

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 over 150 awards. In 2004, CONAE sold 5,765 products, with an average price per image of US$500.[17] 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.[18] 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 various national and international partners, including NASA, CNES, AEB, ASI, and INVAP.[19]

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.[20] 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.

---

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

18 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.

19 In addition to NASA instrumentation, SAC-C carries sensors provided by the Danish, Italian and French space agencies. For more details, see "SAC-C Mission, an example of international cooperation."

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

E. Argentina's strategy in the sector[21]

1.23 Argentina's National Space Plan (NSP)[22] 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 missions 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).

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 a space vehicle (SAC-D), constructed by CONAE, and instruments including NASA's Aquarius sensor, whose goal it will be to provide 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

---

[21] 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 was recently conferred to ArSat by the Argentine government. ArSat is a mixed ownership firm that will provide telecommunications services.

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

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),[23] will provide data recorded at L-band and X-band, which in combination are more reliable and useful than a single wavelength, for various civilian applications and specially emergency management. ["Two sentences omitted at the request of the borrower"]. CONAE also signed an agreement with Belgium, that 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 to fund 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 ¶4.21 for a cost comparison of land-based and satellite technology).[24]

---

[23] 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.

[24] 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

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.[25] Except for a Japanese L-band SAR satellite, (ALOS mission launched in early 2006), which will produce a limited volume of data dedicated primarily to scientific research, there are no civilian L-band SAR satellites in orbit at present.[26] 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 Until now, although there have been several previous proposals for L-band SAR missions, all in developed countries, only Japan's JERS-1 and ALOS were actually funded and launched.[27] Other proposals have not been carried out because, in a highly competitive environment, 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 was ultimately unsuccessful due to lack of funding. L-band missions are currently being planned or considered by several countries based on the assessment that this technology is now more mature and that involvement in its development can lead to significant benefits and a position in the world technological frontier.

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.[28]

---

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.

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

26 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.

27 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.

28 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.

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 capable of delivering these applications to the end-users, and the interest of the end-users in utilizing these new information products.[29] 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 were prepared by CONAE, to confirm the Program's economic viability (see ¶4.13-¶4.24 for results of the economic feasibility analysis).

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 (AOs) (at the national and international levels) that will provide grants and free images to research activities 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 AOs, which will provide grants and free images to proposals from the private sector for developing

[29] 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.

and marketing innovative value-added services based on the images generated by the SAOCOM satellite system.

1.36 As a result, the 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 (see ¶4.26-¶4.29).

1.37 The various applications that have been identified (strategic and new), 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, there could be conflicts between users requiring data from the same orbit, or from the same location but requiring different modes. A Data Policy will provide guidance for differentiating among users on the basis of need, economic benefits derived from 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 summary of Canada's Radarsat experience).

1.38 The PROSAT Data Policy for distribution of SAOCOM images will 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 AOs for proposals to carry out R&D into new applications by the scientific community and other institutions, and to support the development of innovative value-added services in the private sector; and iv) data available for commercial purposes and sold to any interested users, through a specialized service provider or established wholesalers, at prices that will be comparable to SAR imagery from satellites working in other wavelengths (e.g., 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 minimum

of 10% of the satellite's capacity will be ring-fenced by CONAE for sale through commercial distributors in Argentina and throughout the world, to ensure the amount of images and the levels of customer service that will be required by value added users and private clients, and to generate a stream of income to cover part of the future operational and maintenance costs of CONAE's ground infrastructure.

1.40 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.[30] 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. In addition, as stipulated in the SIASGE agreement, procedures and practices for both joint and separate commercial utilization and exploitation of X and L-band products will eventually be established between ASI and CONAE, as both of their missions continue to progress.

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's principal contribution will be 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 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. 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

[30] 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.

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 has been limited to supporting applications that use data generated by 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). The Bank has not, to date, financed the development of satellites. There are no previous instances of EO satellites funded by multilateral financial agencies and only a few examples of funding for telecommunications satellites.[31] In related activities, other multilateral agencies have funded projects that involve the use of satellite data, the development of ground stations, and the provision of loan guarantees to private firms that provide commercial launching services (eg, the Sea Launch project funded by the World Bank in 1997).

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 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.

[31] 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.

1.45 The Bank's additionality in this Program is based on its ability to contribute to ensuring that the social and economic benefits of the project are obtained. The Bank can make this contribution due to its experience in working with the S&T sector in Argentina, which will facilitate articulation of PROSAT with other ongoing efforts to strengthen the NIS (e.g., the Technological Modernization Program III, AR-L1012), and its capacity to help advance the application development objectives in parallel with the space technology activities, by supporting the implementation of strategic applications, user training, and an airborne-SAR[32] and data collection campaign, in order to ensure that these applications are operational when the satellites are launched. 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).

I. Program Strategy

1.46 The Program's strategy is to capitalize on Argentina's advanced science capabilities as a source of social and economic development, through the implementation of a system of EO satellites in collaboration with space agencies from other countries. This 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 social and 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 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**

[32] 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.

and implement practical applications of high socioeconomic benefit 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 (HISAs), in parallel with the space technology development related to the prototyping, construction, testing and launching of the satellites.[33] 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 new 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.[34] 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.

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.[35] Unlike in other types of programs, the nature of the project management process of space programs is such that it is based on an iterative process of successive approximations, through testing and qualification of models and prototypes, until the design is finalized, constructed and made operational. This highly standardized structure, the result of years of experience in the

---

[33] 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.

[34] 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.

[35] 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. Project reviews aim to: i) assess the validity of outputs in relation with requirements; and ii) decide to start the next phase.

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 allows 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 leading 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 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 be made by an External Panel of Experts (EPE) comprised of a team of highly specialized international aerospace consultants that provide similar services to official international space-sector organizations and include expertise in the development of applications. The EPE will advise the Bank in assessing compliance with the indicators of the Program's Results Matrix and in determining if the SAOCOM project reviews conducted by CONAE, 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-2278-3 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 first disbursement will be an advance in the amount of 20% of the loan and will be made 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 be made in five tranches and will constitute re-imbursements of the costs actually incurred to achieve the results under each tranche, according to the activities described in section II and the indicative breakdown established in Table II-2.

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 with 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).[36] The two satellites would also carry instruments like an optical imaging sensor and a data relay transponder that would be used to collect measurements from ground sensors and relay them to operational control centers.[37]

1. Results Matrix

2.3 The Program is structured around the achievement of the two specific objectives described in paragraph 2.1. The Program will track the progress being made towards reaching the specific objectives with a series of reviews scheduled to take place at key milestones of the project. The specification of the outcome indicators and the associated targets to be achieved at each milestone are presented in the Results Matrix (Annex 1). Given the nature of these objectives, the outcome indicators used are not based on simple numerical measurements. Instead, the outcome indicators will, in the case of the first objective, assess CONAE's demonstrated and increasing capabilities to design, construct, and operate a satellite system (including ground infrastructure). The milestone reviews will also assess CONAE and its partners' increasing capabilities to design, develop, and implement applications with high socio-economic impact using the data gathered by the satellites, for the achievement of the second objective. These assessments will be made by an External Panel of Experts (EPE), which will participate in each one of the reviews and will assess and confirm that the outcome indicators and their targets have been met.

---

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

[37] The secondary objectives of the mission (e.g,, optical imager and data relay transponder) would only be included as satellite instrumentation after the primary objective (the SAR) is fully accommodated. The technical characteristics of the sensors that could be included as secondary objectives are presented in the document: SAOCOM Mission Secondary Objective Instruments.

2.4 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 behind the operation is the achievement of a minimum level of user and application readiness, in parallel with the space technology development.

2. Project reviews to be conducted by CONAE

2.5 The accepted practice in space system development calls for verification of progress for the satellite system development based on the verification of project management and system engineering outputs at key project milestones. This general framework for the reviews has also been selected and adapted by CONAE for the verification of progress for the Program's applications development. Therefore, CONAE will be conducting its own review process, which includes the active participation of international space systems experts, according to internationally recognized standards, for both the satellite system and the applications development activities. Table II-1 indicates the project reviews that CONAE will conduct during the implementation of PROSAT.[38]

Table II-1. CONAE project reviews for PROSAT

Review Acronym	*Review Title*	*Estimated Date*
SRR	System Requirements Review	Q2 2006
PDR	**Preliminary Design Review**	**Q2 2007**
IPR	Interim Progress Review	Q1 2008
CDR	**Critical Design Review**	**Q4 2008**
PIR	Pre-Integration Review	Q2 2009
MOR	Mission Operation Review	Q3 2009
PER	**Pre-Environmental Review**	**Q4 2009**
PSR	Pre-Shipment Review	Q2 2010
FOR	Flight Operation Review	Q3 2010
FRR	Flight Readiness Review	Q4 2010
ISTR 1	**In-Space Test Review 1**	**Q2 2011**
ISTR 2	**In-Space Test Review 2**	**Q4 2012**

2.6 The milestones highlighted in bold in Table II-1 are the reviews against which CONAE and the Bank have agreed to assess the Program's results and consequently trigger disbursements of the PDL's tranches. The primary purpose of CONAE's project reviews will be to provide a comprehensive assessment of the project's progress and, through independent participation, to obtain additional support at crucial stages. This independent assessment is achieved by the selection of a Review Group that will participate in each one of the reviews, and whose role

[38] CONAE conducted the Systems Requirement Review (SRR) in June of 2006. The Project Team and the Bank's satellite consultant participated in the SRR, which was led by a Review Group that included experts from ASI, ESA, and Argentina's Council for Scientific and Technical Research (CONICET). The SRR included a full review of the mission's requirements, planning, assurance methodology, and risk management practices (see SAOCOM SRR Presentations). Other preliminary design reviews of the SAOCOM mission have included participation of experts from NASA, CNES, ESA's European Space Research and Technology Center (ESTEC), Belgium's Liege Space Center (CSL), and ASI.

will be to assess the achievement of technical progress for both the satellite system and the applications development part of the Program, providing recommendations for improvements when needed. A description of the methodology for how these reviews are conducted can be found in the document "SAOCOM Mission Review Plan," which is based on NASA standards and the European Cooperation for Space Standardization's (ECSS) "Organization and Conduct of Reviews."

3. Performance audits to be conducted by the EPE

2.7 The Program's Performance Audits will consist of assessments made by an External Panel of Experts (EPE), whose main role will be to verify that the project reviews included in the Results Matrix have been conducted with sufficient depth, expertise, and rigor to ensure that the system development will meet the mission requirements and that the applications development will meet its goals. The EPE will not replace or duplicate the role of CONAE's designated Review Groups in each project review. It is expected that EPE's members will attend all the reviews defined in Table II-1, in order to keep up to date with the Program's progress. In assessing whether each milestone has been met, the EPE will base its decisions on the definitions of the reviews and the requirements for proper conduct of them (using NASA and ECSS standards), and on the detailed definition of the indicators of the Results Matrix, described in the Milestone Review Guidelines (Annex 2).

4. Expected results

2.8 The expected final results of the Program (see ¶2.1) are twofold: (i) to strengthen the country's capabilities to successfully design, build, and operate an advanced EO satellite system carrying an L-band SAR, thus strengthening the capability to deliver space based services in general; and (ii) to strengthen and consolidate the country's capabilities to successfully develop and implement applications with high socio-economic impact using data gathered with the SAOCOM system in particular and with satellite data in general.

2.9 For the satellite technology objective, the EPE will assess that the following key project reviews have been adequately conducted: i) Preliminary Design Review (PDR), which will confirm that the preliminary designs and processes meet the requirements and are sufficiently defined and documented to proceed to detailed design; ii) Critical Design Review (CDR), which will confirm the validity of the proposed technical solutions to meet the mission requirements, as demonstrated by analysis and by construction and testing of representative models of the final configuration; iii) Pre-Environmental Review (PER1) of SAOCOM 1A proto-flight model, which will verify its functional conformance against requirements, adequacy of test plans, and readiness to proceed to environmental tests; and iv) In-Space Test Reviews (ISTR) for each satellite, which will confirm that the deployed systems have the capability to meet the Mission Requirements.

2.10 For the application development objective, the EPE will assess progress towards building the desired capabilities, measured by successful achievement of the following targets: i) implementation of SAR data acquisition and delivery strategy to support development of applications; ii) implementation of adequate reference

systems and capability to collect all non-SAOCOM data required to develop and test applications; iii) development and implementation of applications, specifically the three High Impact Strategic Applications (HISAs); iv) coordination with other public institutions, universities, and firms in the implementation of applications, especially the three HISAs; and v) implementation of a mechanism to support wider benefits through the development of other applications, pursuing a strategy that involves calls for proposals to receive data (AOs), both for SAR and SAOCOM data, followed by selection and execution of projects.[39]

5. Eligible financing

2.11 The Program's results will be achieved through investments in three components:

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

2.12 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 a possible 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

2.13 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 Program will fund: 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

2.14 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 Program will fund: i) implementation of an

[39] In order to support the implementation of the AOs and leverage additional resources for R&D projects related to the development of new applications, CONAE intends to conduct the AOs using competitive co-financing mechanisms managed by Argentina's National Agency for Scientific and Technological Promotion (ANPCyT), such as the Targeted Programs for Scientific and Technological Research (PICTOs), which are part of the Bank's Technological Modernization Program (AR-L1012).

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.

6. Administration and external financial and performance audits

2.15 The Program will also include costs associated with general administrative expenses, which may be eligible expenditures under each of the three components. In addition to this, general administrative expenses, the external financial audits, and the Performance Audits of the Program, 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. This will entail funding all the necessary services related to both the financial and the technical audits, as well as the costs associated to their logistics (e.g, travel, accommodation, *per diem*).

C. Costs and financing

2.16 The estimated cost of the project is US$150 million, including a provision equivalent to approximately 10% for contingencies. Thus, total costs of the Program are budgeted at US$150 million, of which the Bank will fund US$50 million and the remaining US$100 million will be contributed as counterpart funds by CONAE, as shown in Table II-2.[40]

Table II-2: Budgeted costs and indicative estimate of sources of financing (US$ thousands)

Investment Category	Source		Total	%
	BID	Local[41]		
Direct Costs	**46,500**	**82,000**	**128,500**	**85.7%**
1. Component 1: Space segment	39,500	76,000	115,500	77.0%
2. Component 2: Ground segment	4,000	3,000	7,000	4.7%
3. Component 3: Applications and user segment	3,000	3,000	6,000	4.0%
Indirect Costs	**2,000**	**18,000**	**20,000**	**13.3%**
4. General administration and financial audits	500	0	500	0.3%
5. Performance Audits	1,500	0	1,500	1.0%
6. Contingencies	0	18,000	18,000	12.0%
FAPEP (1715/OC-AR)	**1,500**	**0**	**1,500**	**1,0%**
Total	**50,000**	**100,000**	**150,000**	**100%**

[40] Table II-2 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 the disbursement of each tranche, as presented in the Results Matrix. The eligible expenditures of the PROPEF (1715/OC-AR) are included in this indicative breakdown, for an amount of up to US$1.5 million.

[41] An additional contribution ["five words omitted at the request of the borrower"] will be made by ASI, in the context of the SIASGE agreement, ["two words omitted at the request of the borrower"] the launch services for the two satellites ["three words omitted at the request of the borrower"] and the development of the T/R modules ["three words omitted at the request of the borrower"].

2.17 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. In order to assess the adequacy of the total budget and the associated risk of significant cost over-runs, a comparator was constructed between the Program's budget and what could be considered an international norm for a similar system if it were developed in the US or Europe. A benchmark budget for a single satellite (excluding launch, ground and applications segments) was calculated using data from similar SAR missions developed in Europe, USA, Japan, and Canada, resulting in an estimate of US$350 million. Then, using the detailed budgetary figures of the Program, including labor budget estimates of the total number of hours to be committed to the SAOCOM project, a comparator budget was constructed for a single SAOCOM satellite, excluding the launch costs,[42] the ground segment investments, and the applications development activities. Additionally, the comparator budget was adjusted to take into account 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 the existence of sunken development costs already incurred by CONAE for program management and design of key components. After adjusting for these factors, the resulting comparator budget for a single SAOCOM satellite resulted in a value of US$345 million, which is equivalent to the US$350 million benchmark figure that would be expected at international costs. This points to the adequacy of CONAE's budget estimates, once the proper adjustments for comparison have been made.

2.18 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.

2.19 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 4.7% 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 ¶4.46). 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.

---

[42] 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.

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). CONAE was established by Decree 995/91 of 28 May 1991 as a body with technical, operational, and financial autonomy with two basic goals: (i) to serve as the sole government agency with jurisdiction over the design, management, control, and administration of space-related projects and undertakings; and (ii) to propose the National Space Plan (NSP) and its funding mechanisms and, once it has been approved by the executive branch, to centralize, administer, and implement that plan. The 2004-2015 National Space Plan, which includes the SAOCOM satellite mission, is currently in effect.

3.2 CONAE was originally set up under the Office of the President. In 1996, after a few months as part of the Ministry of Culture and Education, it was transferred to the Ministry of Foreign Affairs, where it remains. CONAE has a staff of 150 and in 2005 had a budget of US$17 million, an increase of 87% over the previous year. CONAE is headed by an Executive-Technical Director who reports to a Board chaired by the Minister of Foreign Affairs. The Director is responsible for the Commission's executive, technical, and administrative activities, while the Board is responsible for setting annual milestones for NSP implementation, evaluating CONAE's activities, and approving the budget proposal.

3.3 CONAE's basic structure consists of two technical departments—the Technology Management Department (GGT) and the Projects Department (GdP)—and two support departments: the Planning, Administration and Finance Department (GPAF) and the Institutional Relations Department (GRI). CONAE has its headquarters in Buenos Aires and also runs the Teófilo Tabanera Space Center in the province of Córdoba (see ¶1.19). The GdP is responsible for activities relating to project execution, and the GGT is responsible for operation of the Earth Station and the Mission Control Center and for supervising the distribution of satellite information products. The GPAF provides support services in the budget, accounting, procurement, and personnel administration areas. The GRI works to encourage the participation of members of the scientific and technological sector in the projects and activities of the NSP.

3.4 As regards technical issues, CONAE's organizational methods, control procedures, and execution mechanisms follow phases and procedures that are universally accepted in the space sector. The Institutional Capacity Assessment System (ICAS)[43] gave relatively high scores to CONAE's support functions (81% to 95%), indicating the existence of adequate organization, procedures and resources and, consequently, low levels of risk in the performance of its duties.[44] The ICAS

---

[43] The following functions were assessed: administrative organization, planning, personnel administration, administration of goods and services, financial administration, and internal control.

[44] Further details on the institutional assessment of the program can be found in the document: Institutional Analysis of Support Functions within the National Commission for Space Activities.

exercise also revealed opportunities for improvement in the update or expansion of manuals covering the financial and procurement areas. These improvements are being made with the support of consultants hired during program preparation with PROPEF resources under operation AR-L1024. Given the findings of the ICAS assessment, coupled with the aforesaid institutional improvements, CONAE is considered to meet the Bank requirements for a PDL operation.

B. Program execution and management

3.5 For each satellite mission, CONAE sets up internal project teams of technical experts who take charge of all aspects of the mission. CONAE establishes basic definitions of its space projects, prepares the engineering designs and systems, and coordinates the related purchasing and procurement. Through contractors, universities, and other research centers, CONAE makes the necessary connections for the execution of each of its projects, acting as a planning and coordination unit and supporting the use and development of national technological capabilities in the space sector. For the dissemination of space data and the development of applications, CONAE acts as an information wholesaler, promoting the development of applications by other organizations, both public and private. Nonetheless, CONAE maintains very close relationships with the users and developers of applications, organizing courses and events to promote its satellite information products and establishing cooperation agreements for joint activities with public institutions, the scientific community, and the private sector.

3.6 **Execution structure**. In line with the way CONAE organizes the execution of all its satellite projects, the PROSAT program will have a matrix-based technical structure, to which personnel from its permanent staff will be assigned, as well as external personnel in accordance with specific requirements.[45] The basic technical structure will consist of two independent offices: those of the Lead Researcher (IP), who will report directly to the Executive-Technical Director, and of the Project Chief (JP), who will report to CONAE's Projects Manager (GP). Accounting and payment functions will be performed by the Administration and Finance Subdepartment, budgeting activities by the Planning Office, and purchasing and procurement by the Procurement Office.[46]

3.7 The JP's office will have six technical units for tasks relating to systems engineering; quality assurance; radar design, development and integration; service platform development and integration; ground control system design and integration; and development and negotiation of launch requirements. The IP's office will be responsible for establishing and reviewing the technical and scientific specifications necessary to meet the PROSAT program's objectives, including applications development issues.

---

[45] The matrix-based structure is similar to that of a project team made up of personnel from the regular structure during project preparation and execution (see Organizational Structure of PROSAT).

[46] In order to facilitate the Program's hiring process for certain services, it is foreseen the possibility to extend the agreement signed by CONAE and the OAS for the execution of the PROPEF AR-L1024. The administrative costs for this possible extension of the agreement would be financed by CONAE.

3.8 The GP will supervise the technical activities described in the preceding paragraph, and perform the necessary administrative activities. The GP's administrative responsibilities will include: (i) triannual and annual scheduling of activities; (ii) monitoring and supervision to ensure compliance with work plans and variation analyses, and timely compliance with the indicators and targets established in the Results Matrix; (iii) preparation of technical reports; (iv) preparation of financial reports, including the program's annual financial statements, in coordination with the Administration and Finance Subdepartment; (v) scheduling and coordination with the Bank in order to carry out the performance audits in a timely manner and in accordance with the Results Matrix; and (vi) establishing and maintaining Program's records and information to facilitate audits of documentation related to eligible expenditures and their relationship to meeting targets. The GP will serve as the Bank's liaison to the program and will have professional support to assist in its duties.[47]

3.9 CONAE will enter into institutional cooperation agreements with the National Institute of Water (INA) and the National Institute of Agricultural Technology (INTA) for the development and implementation of the program's three strategic applications. These agreements will set out responsibilities, objectives, and joint work plans, in accordance with the targets set in the program's Results Matrix. The Project Team has reviewed draft versions of the cooperation agreements prepared by CONAE. **The coming into effect of CONAE's institutional cooperation agreements with INA and INTA will be a special condition prior to the first disbursement (advance) of the loan resources.**

3.10 **Execution mechanism.** Program execution will be based on work plans prepared by the GP and the IP's office, following the work breakdown structure (WBS) methodology. In this methodology, similar to a decision tree, the execution responsibilities of each of the units under these two offices are broken down successively into subactivities and components. When no further breakdown is possible, cost accounts, expected deliverables, and timetables are assigned, and these then serve as inputs for the accounts, deliverables, and timetables of the levels immediately above. This system serves as a control tool for technical and financial execution, and is the basis for preparation of the budget. Although the initial technical scheduling covers the expected life of the project, annual updates will be made as part of budget preparation.

3.11 The fact that the work plans involve all the levels means that they coordinate and integrate execution at those different levels. Since the outcome at one level serves as an input for the next, a relationship exists that provides an incentive for control and monitoring. With the WBS methodology, the most basic unit has a plan indicating what the expected outcome is, and how it is to oversee its own execution. CONAE has detailed manuals to facilitate the execution, monitoring, and control process such as: Implementation Plan, Quality Assurance Requirements, and Risk Mitigation Plan.

---

[47] This professional has already been hired, with PROPEF funds, and the position will be financed with program resources during execution.

3.12 **Financial management of the program:** Program financial and accounting management will be the responsibility of the GPAF, to which both the Administration and Finance Subdepartment (accounting and payments) and the Planning Unit (budget) report. The loan resources will be channeled through bank accounts in the name of the program, which CONAE will maintain at *Banco de la Nación Argentina* (BNA). In budget terms, CONAE will make payments in the following two ways: (i) directly, when the loan proceeds are the payment source; and (ii) though the mechanisms established by the Ministry of Finance and Production, when the payment is made with funds from the national budget.

3.13 The accounting system to be used in the program is the System for External Project Executing Units (UEPEX). This system is used regularly for operations with the IDB, the World Bank, and FONPLATA. It allows accounts to be kept in dollars and in Argentine pesos, provides expense information broken down by funding source, and generates interim and year-end financial statements for programs. CONAE already has an agreement with the Ministry of Finance for implementation of the UEPEX accounting system. **The implementation and operation of the UEPEX accounting system at CONAE for this program will be a special condition prior to the first disbursement (advance) of the loan resources.**

3.14 For management of the accounting system, CONAE will strengthen the Administration and Finance Subdepartment with a professional accountant and an accounting assistant.[48] This subdepartment will also be responsible for financial internal control over the program. The internal controls that already exist, are being introduced, or are planned for the program include: (i) separation of budgeting, accounting, and payments functions; (ii) making reconciliation of program bank accounts the responsibility of CONAE's Internal Auditing Office; (iii) strengthening of finance manuals; (iv) specific guidelines for processing disbursements of the loan proceeds; (v) quarterly operational and financial internal audits; and (vi) an effective filing system (already in existence) for program operational and financial documents.

C. Procurement

3.15 The program includes procurement of the goods and related services necessary to meet the targets agreed upon with the Bank, as set out in the Results Matrix. A preliminary and indicative list of these goods and services and the method for their procurement was drawn up during program preparation.[49] In accordance with Bank policies for Performance Driven Loans (GN-2278-3), procurements of goods and services with program resources will be conducted observing practices in keeping with the principles of competition, economy, transparency, equal treatment, publicity, and due process, through Argentina's government procurement rules governing public tenders. Exceptions to this will be the hiring of the accountancy

---

[48] The UEPEX system is currently being introduced at CONAE as part of the PROPEF operation. The hiring of the additional professional accountant is also in process.

[49] The list can be seen in the documents "Indicative Budget of Results-based Financial Execution" and "Indicative Procurement Plan," which can be found in the Program's technical files.

firm responsible for the external financial audit (see ¶3.30) and the hiring of the Performance Audits of the Program (see ¶3.25).

3.16 Assessment of Argentina's procurement policies and their alignment with Bank policies, and of CONAE's procurement system revealed that, in summary:[50] (i) Argentina's government procurement rules, which govern public-sector procurement in Argentina, were developed in keeping with the same principles as the Bank has deemed necessary for its own procurement policies and procedures. However, the Bank's rules will have to apply in certain cases where exceptions to those principles have been detected within Argentina's national rules, therefore specific provisions will be added to the loan contract;[51] (ii) given the high degree of specialization of CONAE's technical work, there are instances in which direct contracting will be essential; the assessment revealed that the agency's direct contracting procedure had adequate internal controls to ensure its proper application when strictly necessary; and (iii) CONAE has the areas and procedures necessary for a procurement system, and those areas and procedures function effectively. The assessment also revealed opportunities for improving those functions by preparing a procedure manual (see ¶3.4).

3.17 An assessment of the implementation of procurement practices and procedures at CONAE shows that they are compatible with the principles of competition, economy, transparency, equal treatment, publicity, and due process, as described in the following paragraphs:

a. *Competition.* CONAE invites to participate various suppliers in the area covered by the bidding process and also sends invitations to associations and chambers of manufacturers, producers, service providers, and sellers, to foster competition and thereby obtain the best terms available on the market.

b. *Economy.* CONAE conducts its procurement procedures in accordance with timely planning, and follows procedures to ensure that procurement requests and the selection of suppliers are carried out with minimal expenditure of time and resources. CONAE also follows procedures that ensure the prompt resolution of disputes and differences that arise in the prequalification, selection, and execution of procurement contracts.

c. *Transparency and publicity.* CONAE sends, with the required advance notice, all its invitations to tender to the National Procurement Office for publication on its website. CONAE also publishes all its procurement procedures on its own website for free access by any interested party. The same channels are also used to publish the selection and procurement criteria.

d. *Equal treatment.* CONAE's procurement processes seek to ensure the highest possible participation of suppliers, by ensuring equal treatment and avoiding any kind of privileges or discriminatory conditions that could benefit or harm interested participants. In addition, the bidding conditions are carefully drafted to ensure that the conditions are equitable for all potential suppliers.

---

50 For further details, see document: Report on the Review of CONAE's Procurement Area.

51 These exceptions have been included in the loan contracts of recent Bank operations in Argentina.

e. *Efficiency.* CONAE plans its procurements so that the requesting departments have the goods and/or services within the necessary timeframe, with the required quality, and through a procurement process conducted under optimal conditions and obtaining the lowest costs.

f. *Due process.* CONAE has procedures for interested and participating suppliers to file protests in relation to its procurement processes.

D. Disbursement system

3.18 The program will involve an advance payment equivalent to 20% of the loan amount and five tranches. The advance will be released upon the coming into effect of the loan contract, once the contractual conditions prior to first disbursement have been met. The amount of the advance will be deducted gradually from the five subsequent tranches.

3.19 The five tranches will be tied to meeting the targets agreed upon with the Bank, as set out in the program Results Matrix, which will be part of the loan contract. Each tranche will be released on the basis of target verification by the PROSAT External Panel of Experts and the Bank's subsequent verification of expenditures to meet those targets.[52] The verification of outcomes by the External Panel of Experts will take place during performance audits (see ¶3.25 and ¶3.26), to be conducted concurrently with the project reviews scheduled by CONAE.

3.20 As part of program preparation, CONAE provided the Bank with a results based Program Execution Indicative Budget and an Indicative Procurement Plan. These documents establish a preliminary list of the kinds of expenditures associated with meeting the agreed targets. The list is indicative of the eligible expenditures for each program disbursement. Prior to the start of each fiscal year and as part of its budgeting process, CONAE will send the Bank an updated version of these documents, in order to inform the Bank of its planned expenditures to meet the targets set for the coming fiscal year. The updated versions of those documents will remain consistent with the original versions agreed upon during program preparation.

3.21 The general procedures for tranche disbursements will be as follows: (i) CONAE assesses progress toward the targets set for a given tranche and, based on that assessment, schedules and coordinates the Performance Audit with the Bank, concurrently with the project reviews scheduled by CONAE for the SAOCOM satellite mission; (ii) CONAE prepares a list of actual expenditures made to meet the targets, which are therefore eligible for reimbursement. The list is consistent with the updated version of the Indicative Budget of Results-based Financial Execution and the Indicative Procurement Plan. If the list contains new expenditures not covered by those documents, the External Panel of Experts will determine whether the expenditures are eligible and necessary to meet the targets; (iii) the External Panel of Experts assesses whether the targets have been met and

[52] Provided that those eligible expenses are incurred after the approval date of the Project Abstract (25 July 2005) and no more than 18 months before the date of the loan's approval by the Bank's Board.

makes a decision on new expenditures in the expenditure list; (iv) if the Bank confirms the evaluation of the External Panel of Experts and has no objection to the list of expenditures, the tranche is disbursed, after deduction of the corresponding portion of the advance payment; (v) as part of the external auditing process, the firm of independent auditors carries out six-monthly operational and financial audits, including assessments of the internal control system and examination of a sample of program procurements and expenditures;[53] and (vi) if the financial audit findings include qualifications relating to ineligible program expenditures, if there is a difference between the disbursement made and the verified expenditures, it will be returned to the Bank (in the case of the last tranche) or deducted from the next tranche (in the event that the amount was included in the list of expenditures already verified by the Bank) or it will not be accepted for disbursement (in the event that the amount in question has not yet been verified by the Bank). The Supplement to the Disbursement Guidelines contains a detailed description of the program disbursement procedures using the PDL method.

E. Program monitoring system

3.22 The program monitoring system will comprise: (i) CONAE's internal procedures for quality control and assurance; (ii) the Performance Audits, to be conducted concurrently with the project reviews scheduled by CONAE for the SAOCOM mission; and (iii) the Bank's regular systems for project supervision.

1. Quality control and assurance

3.23 Since it is not possible to correct problems that arise on a satellite that has technical defects or fails to meet standards once in orbit, the quality control and assurance system is a basic and integral part of satellite projects. CONAE's quality control and assurance system is integrated at all levels and is an ongoing process. It begins by identifying the requirements and standards for the satellite mission. It continues with the use of procedures set out in detailed manuals dealing with operations, risk control, and quality assurance that are widely used in the space sector. Using work plans based on the WBS methodology (see ¶3.10), detailed control activities are assigned. Because this system links activities together, this involves continuous monitoring of activities between the members of the chain who receive a product and those who produce it. Additionally, the Principal Researcher (IP) ensures that the scientific or technical solutions most appropriate to the program's requirements are used.

3.24 At the same time, since the execution of a satellite program involves several clearly defined phases as milestones, the planning and tracking process is sequential, i.e. it repeats for each phase, and the next phase does not start until the results of the previous phase have been analyzed through project reviews scheduled by CONAE, with the participation of expert peers called upon to conduct a close examination and give the go-ahead for the project to continue. This

[53] The external auditing firm will select the sample to be taken in accordance with international practices.

review and approval procedure represents, within CONAE's procedures, the final quality control and assurance activity for each phase.

2. Performance audits

3.25 Performance audits will be conducted concurrently with the project reviews scheduled by CONAE for the SAOCOM satellite mission, by an External Panel of Experts to determine whether the targets agreed upon with the Bank have been met as set out in the program's Results Matrix. These audits will need to be carried out, preferably, by an independent space agency, or, alternatively, by a specialized consulting firm from the aerospace sector with proven institutional and technical capabilities to conduct the task. In light of this, it was agreed that CONAE would hire the ["one word omitted at the request of the borrower"] Space Agency ["one word omitted at the request of the borrower"][54] as a sole-source contractor, to conduct the performance audits. ["Two sentences omitted at the request of the borrower"].[55] The Panel's activities will be governed by Terms of Reference agreed upon between the Bank and CONAE, which include a detailed description of the activities to be carried out and of the composition and skills required of the Panel and its members.[56] **The hiring of the specialized consulting services that will conduct the Performance Audits of the Program according to Terms of Reference agreed with the Bank will be a special condition prior to disbursement of tranches of the PDL.**

3.26 The External Panel of Experts will be the Bank's advisor in evaluating whether the targets set in the Results Matrix (Annex 1) have been met, and as such will report to the Bank and to CONAE, through monitoring reports to be produced at each of the intermediate revisions during execution of the Program and through Performance Audit reports to be delivered after the reviews against which CONAE and the Bank have agreed to assess the Program's results and consequently trigger disbursements of the PDL's tranches. The detailed methodology to be used by the External Panel of Experts in evaluating those targets is described in the Guidelines for the Review of Outcomes (Annex 2), which was developed and agreed upon by the project team and CONAE.

3. Monitoring and supervision

3.27 Program supervision will be based on: (i) semi-annual progress reports; (ii) annual Program financial statements, prepared by CONAE and certified by a firm of external auditors, who will also prepare their own semi-annual and annual audit reports (see ¶3.30); and (iii) intermediate monitoring reports and performance audit

---

54 Discussions ["four words omitted at the request of the borrower"] are at an advanced stage, with the aim of formalizing the hiring of the space agency's services for the Performance Audits.

55 In the event that, for reasons beyond the control of the Bank or CONAE, it is not possible to continue to have ["one word omitted at the request of the borrower"] support, CONAE would hire, using Bank procedures (e.g., GN-2350-6) and loan resources, an international consulting firm with an ample and widely recognized experience in the aerospace sector and a proven track-record in the provision of the services required for the Performance Audits, thus ensuring the necessary technical and operational capabilities to perform the required tasks.

56 Refer to document: Draft Terms of Reference for the External Panel of Experts.

reports prepared by the External Panel of Experts. The semi-annual reports to be delivered by CONAE to the Bank will contain information on program progress in terms of the indicators and targets reflected in the Results Matrix, emphasizing on problems encountered and solutions adopted. The supervision will focus on evaluating compliance with indicators and targets in the Results Matrix, as well as identifying problems and their solutions.

3.28 CONAE will compile and maintain an updated and continuous record of information on the outcome indicators defined in the Results Matrix, such that: (i) the Bank can prepare the project completion report (PCR); and (ii) the Bank's Office of Evaluation and Oversight (OVE) can determine the impact of the operation through an ex-post review, if required, in accordance with the guidelines established in document GN-2254-5.

F. Execution period and disbursements timetable

3.29 Table III-1 shows the timetable for net program disbursements, with an initial advance payment of 20% and five tranches, once the installments for recovery of the advance payment have been deducted. The disbursement period will be 7 years. The table also shows the funding of general administrative costs, Performance Audits and financial audits, whose disbursements will not be subject to target achievement and will be disbursed following traditional investment loan procedures.

Table III-1: Timetable for net program disbursements (US$ million)

	Advance Payment	**Tranche 1**	**Tranche 2**	**Tranche 3**	**Tranche 4**	**Tranche 5**	**Total**
Tranche amount		11	14	13	6	4	48.0
Advance	10.0						10.0
Recovery of advance		2	2	2	2	2	10.0
PROPEF deduction	1.5 *(a)*						1.5
Net disbursement	8.5 *(b)*	9	12	11	4	2	46.5
Administration, Performance and Financial Audits							2.0

(a) Or the amount actually incurred and charged to the PROPEF prior to loan approval.

(b) Or the amount resulting from subtracting from the advance the amount of PROPEF resources actually used as of the date the project is approved.

G. External financial audit

3.30 The program's annual financial statements will be delivered to the Bank within 120 days after the close of each fiscal year. In addition, CONAE will submit semi-annual operational and financial audit reports on the program within 60 days after the close of the first semester. Both the annual and semi-annual audits will be done

by a private firm of certified public accountants acceptable to the Bank. As part of the financial and operational audits, the firm will review: (i) the soundness of the financial management system; (ii) the internal control systems; and (iii) an integrated evaluation of a sample (to be determined by the auditing firm in accordance with international standards) of procurement expenditures and processes, including how they relate to the program targets. The operational aspects to be included as review parameters will be defined in the terms of reference for the audit. This audit will be carried out in accordance with the Bank's policies and requirements (AF-100 and AF-300), and will follow standard hiring procedures (AF-200). **The contracting of the financial auditing firm in accordance with terms of reference agreed upon with the Bank will be a special condition prior to disbursement of the first tranche of the PDL**.

3.31 To satisfy the requirements of the external auditors or of any other reviews that the Bank may require, CONAE will keep proper records of background and supporting documentation for disbursement requests, cross-referenced with the requests submitted to the Bank.

IV. VIABILITY AND RISKS

A. Institutional viability

4.1 In a program as technically complex as PROSAT, institutional viability largely depends on three factors: experience, organization, and human resources. Since it began operations in 1991, CONAE has gained valuable experience in the sector after putting three satellites in orbit. More importantly, that experience was developed in partnership with respected space agencies from around the world, which in turn has enabled CONAE to gain knowledge about best practices applicable to the space sector's organization, procedures, and controls (see ¶1.21-¶1.22). In this regard it should be noted that the matrix-based structure adopted for the execution of the PROSAT program is an organizational structure that has already proven to be successful.

4.2 CONAE possesses trained scientific personnel to conduct its programs and can cover its specific staffing needs through external contracting or agreements with academic institutions or specialized government agencies. Given that in the coming years, in addition to the PROSAT program, CONAE will be carrying out the SAC-D project in partnership with NASA, an assessment was made of the adequacy of its personnel and technical resources. This review concluded that the personnel and technical resources were adequate for executing the two projects, if the current schedule is maintained with no overlaps between the main phases of the two projects. In terms of adequate staffing in support areas, CONAE has strengthened its financial area by adding personnel, in line with the needs identified during program preparation (see ¶3.14).

4.3 Given this experience and its quality, the existing organizational structure and human resources available, the PROSAT program is deemed to be institutionally

viable. The program's institutional viability was confirmed through the ICAS methodology, and a series of specific institutional strengthening actions were developed to help build CONAE's organizational capacity (see ¶3.4).[57]

B. Financial viability

4.4 Table IV-1 shows CONAE's average annual expenditure levels by funding source for the immediate past (2001 to 2005) and for the projected period (2006 to 2011).

Table IV-1: Annual expenditure average by funding source (US$000s)

	Average 2001-2005		Average 2006-2011	
	Amount	**%**	**Amount**	**%**
National Treasury	20,158	77.8	33,458	39.3
IDB	-	-	8,333	9.8
Subtotal	20,158	77.8	41,791	49.1
Other external sources	5,762	22.2	43,448	50.9
Total	25,920	100.0	85,239	100.0

4.5 It should be noted that the "other external sources" item represents the technical appraisal of the assets utilized by partner agencies in CONAE projects; in other words, those amounts have no financial impact on CONAE. Partner agencies in the immediate past have included NASA and others, and, once again, NASA (SAC-D satellite mission) and ASI (SAOCOM satellite mission) in the projected period.

4.6 The total average annual expenditure in the projected period shows a considerable increase on account of investments in the PROSAT program and in the SAC-D project. Nevertheless, from the viewpoint of the counterpart's financial viability, the item of greatest interest is the increase in the contribution of the National Treasury, from an annual average of US$20.1 million to an average of US$39.3 million. Although this is a material increase in absolute terms, the increase is modest in terms of total national spending. Thus, the historic average represents 0.08% of the nation's total spending for 2005, while the projected average represents 0.11% of the total expenditures reflected in the 2006 national budget. Consequently, it can be expected that the counterpart contribution to the PROSAT program will represent a relatively modest financial effort within the finances of the nation.

C. Technical viability

4.7 The SAOCOM mission concept is for two space-borne Synthetic Aperture Radar (SAR) instruments operating at L-band, collecting data aimed at resource management applications, especially in agriculture and hydrology. The SAOCOM mission is being coordinated with the COSMO/Skymed mission implemented by the Italian Space Agency (ASI), under the combined initiative known as SIASGE. This will enable the coordinated collection of data at X and L-band in order to increase the reliability and value of information extracted from the data.

---

[57] Additional details can be found in the documents: ICAS Results Matrix and ICAS Improvements Matrix.

4.8 **Requirements and technical specifications.** The overall mission requirements are summarized in the requirement to reliably collect information of relevance to Argentina's geographic and economic context to contribute to environmental, natural resource, and risk management. The technical specifications of the satellites and ground segment are well suited to meeting this requirement. L-band SAR data are internationally recognized as a valuable observation type for measuring parameters such as soil moisture, crop conditions, delineation of water bodies, and ground movement. The system including two SAR satellites will allow regular re-visit with the capability to make observations in all weather and illumination conditions. Thus the system has the capacity to collect sufficient volumes of data at frequent intervals to meet the intended applications needs.

4.9 **Technical capacity.** The technical capacity to implement the system has been developed by CONAE and its contractors through involvement in previous satellite missions. CONAE has acted as customer authority and INVAP (the SAOCOM platform contractor) acted as prime contractor on previous missions, including SAC-C and SAC-D. SAC-C is an EO satellite launched in 2000 and still operating successfully beyond the end of its original design life. SAC-D is a collaborative mission with NASA for a science satellite of similar complexity to SAOCOM that will be launched in 2009. Through these satellite missions, technical skills in design, manufacture, integration, and testing of space qualified components have been developed. Specific capacity development and technology transfer in SAR engineering will also occur in the course of the SAOCOM mission, through the cooperation agreement between CONAE and ASI.

4.10 **Project management capacity.** Capacity in project management, system engineering, and associated skills in risk, procurement, and quality management have all been developed over previous satellite missions, alongside CONAE's technical capacity. Close collaboration with other space agencies, notably NASA, but also including ASI, has enabled this capacity to be built. In the early stages of SAOCOM, CONAE has demonstrated the required levels of management process and documentation in the materials prepared for the System Requirements Review (SRR). The conclusions of the Review Board of the SRR recently conducted confirmed that, while there are some improvements that could be made, the fundamental capabilities and processes are in place to make the SAOCOM mission a success.

4.11 **Independent technical assessment by a leading space agency.** Finally, in order to confirm further the technical viability of the Program, the Bank requested an independent technical assessment from the Italian Space Agency (ASI), a leading space agency, with a worldwide reputation.[58] The main conclusions of the assessment prepared by ASI in July 2006 were:

[58] For more information, see the ASI SAOCOM Mission Technical Assessment Executive Summary Letter and ASI SAOCOM Mission Technical Assessment Report.

a. The Mission/System Requirements are considered adequate to continue with project development, not having identified any critical problems. Only some alignment and verifications are needed to ensure everything is consistent;

b. Early design achievements are promising, with no critical issues having been identified thus far, despite the fact that the design is challenging;

c. The Project/Program organization looks adequate and suitable to manage such a complex work; the responsibilities have been clearly identified and correct management procedures are being followed;

d. The management of risks are expected to be effectively implemented; the plans and procedures set forth are suitable for managing a project of this complexity;

e. The project's Application Development Plan is very well structured and complete, and fits with the mission's objectives;

f. The Program's budget is in line with what can be expected for a project of this scope, after making the necessary adjustments to allow for lower comparative labor costs in Argentina, the development work already done by CONAE, and its cost-effective design and qualification approach.

4.12 ASI also expressed its intention to continue supporting CONAE along the course of the Program, as it has already done during the initial phase of the project and in accordance with the Cooperation Agreement between the two agencies. Strong support by ASI will help to ensure the realization of the SIASGE initiative through the provision of technical and management expertise as well as technology advice, as may be needed along the overall project development and implementation phases. Adequate funds have been allocated by ASI to cover these needs. This will be realized through support to all levels of the design, by holding a series of design review meetings prior to all the scheduled project review meetings (Delta-PDR, CDR, PER, ISTR1, and ISTR2). Future ASI collaboration and participation is also envisaged in the area of applications development, in which CONAE and ASI will work together through a joint SIASGE application development project.

D. Socio-economic viability

4.13 As is the case in many mission-oriented science and technology projects such as this one, many, if not most, of the economic benefits can be expected to arise from unforeseen applications and spin-offs over the medium and long-term. In addition, to this, the considerable benefits arising from a strengthened domestic skill base, from improved linkages between scientists and the productive sector, and from a better articulated NIS, are difficult to quantify ex-ante and do not lend themselves to rigorous and robust economic analysis. This being the case, a reliable economic analysis can only be based on the quantifiable benefits that are expected to arise from the implementation and adoption of specific applications once the satellites become operational. Thus, the economic evaluation of PROSAT is based on the set of net benefits that can be quantified ex-ante, and will at best provide a lower bound of the total benefits likely to be generated by the project.

4.14 Although CONAE has identified multiple potential applications in many areas, the economic analysis could only be conducted for some 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.

4.15 Therefore, the economic evaluation based on the expected outcomes that have already been identified for the project, by assessing the expected value of the discounted flow of future net benefits arising from key selected applications of the L-band SAR satellite system, provides a lower-bound estimate of the project's expected net present value. The expected benefits of these strategic applications were 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 these applications, using a stochastic model.[59] The resulting likelihood estimates for net present value and internal rates of return were then used in analyzing the decision of whether or not it would be worth undertaking the project from a social point of view. The methodology used to conduct this evaluation relied 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.

4.16 The following are key aspects of the three 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 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 are obtained through on-site samples from INTA's research stations and extrapolated for areas within a 100 to 400 km radius of those stations. 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) moisture underestimation error, resulting in advice not to fertilize when in fact fertilization was required; or (ii) moisture overestimation error, resulting in a recommendation to fertilize when no fertilization was advisable.

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 is known to be linked to soil humidity levels.

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

To assist farmers in biotic agent prevention, INTA provides recommendations on the appropriate timing and intensity of phytosanitary measures. Similar to the case of fertilization, INTA's recommendations are derived from simulation models that link soil and surface plant moisture and expected disease appearance under certain specific climate conditions, including relative humidity, precipitation, and ambient temperature. As these models are based on the extrapolated moisture data from INTA's relatively few research stations, the individual advice is subject to error due to differences between real 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 resulting in not applying disease control measures when such measures were required; or (ii) overestimation error, resulting in the application of disease control measures when such measures were not required.

c. **Flood risk and emergency management**. The biggest natural disasters in Argentina have been associated with periodic flooding. River basins susceptible to flooding put under risk large urban and rural areas in the country. Just in the Plata Basin (Parana, Uruguay, and Paraguay rivers) and the Salado Basin in the Pampas Region, the risk area represents almost 30% of the total area of the country. Economic losses associated with major floods in Argentina in the past 20 years are estimated to have been some US$14 billion. The National Institute of Water (INA), a federal agency, has developed a flood forecasting and early warning system for the Plata Basin and the Pampas Region. This system currently relies on data provided by traditional optical satellite images and geographic information systems, as well as field data, sources that are subject to restrictions on the level of coverage, precision, and timing. In this regard, soil moisture maps from SAOCOM could become a valuable tool in improving INA's forecasting and warning system, since they would provide more precise, reliable, and timely information on the susceptibility of multiple watercourses to generating floods for a given level of precipitation. The flood guidance algorithm used by INA takes into consideration not only the runoff needed to fill a stream channel at a particular location, which depends on the geophysical properties of the channel and its drainage network (threshold runoff), but also initial soil moisture conditions. A more reliable flood forecasting and early warning system would generate economic benefits equivalent to a reduction in the losses that could be avoided from flooding disasters, compared to current forecasting and warning systems.

4.17 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 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 are expected to be significantly

reduced. For the crop area that will receive assistance from INTA,[60] 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 provides the basis for the net incremental economic benefits of each application. For the analysis of flood risk and emergency management application, benefits could only be estimated for Goya, a city on the banks of the Paraná River and its tributary, the Santa Lucia River, using available flood-frequency maps and the corresponding damage costs.[61]

4.18 Total project costs include incremental labor and non-labor costs associated with the design, development, and construction of the two SAOCOM satellites, including insurance costs, as well as the operational costs during the envisaged lifetime of the satellites (five years), including the costs of developing and implementing the applications.[62]

4.19 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 minimum operational lifetime. Benefits are projected to begin in year six, one year after launch of the first satellite. A discount rate of 10% was used to calculate the project's net present value. 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 simulations,[63] the relative likelihood of the resulting values of net present value and internal rates of return.

4.20 Figure IV-2 shows the range and probability distribution of the simulated results, considering only the economic benefits derived from three applications. In this context, the best estimate of the project's rate of return is 21.5% (i.e., the median rate of return), with a probability of over 77% of being above the 10% rate of return threshold level. Similarly, the expected net present value would be US$40.5 million, with an expected opportunity loss of not implementing the project when it

---

60 Under a conservative technology diffusion scenario, for the first year each application is implemented, it is assumed that only 30% of total cropland 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 by the fifth year.

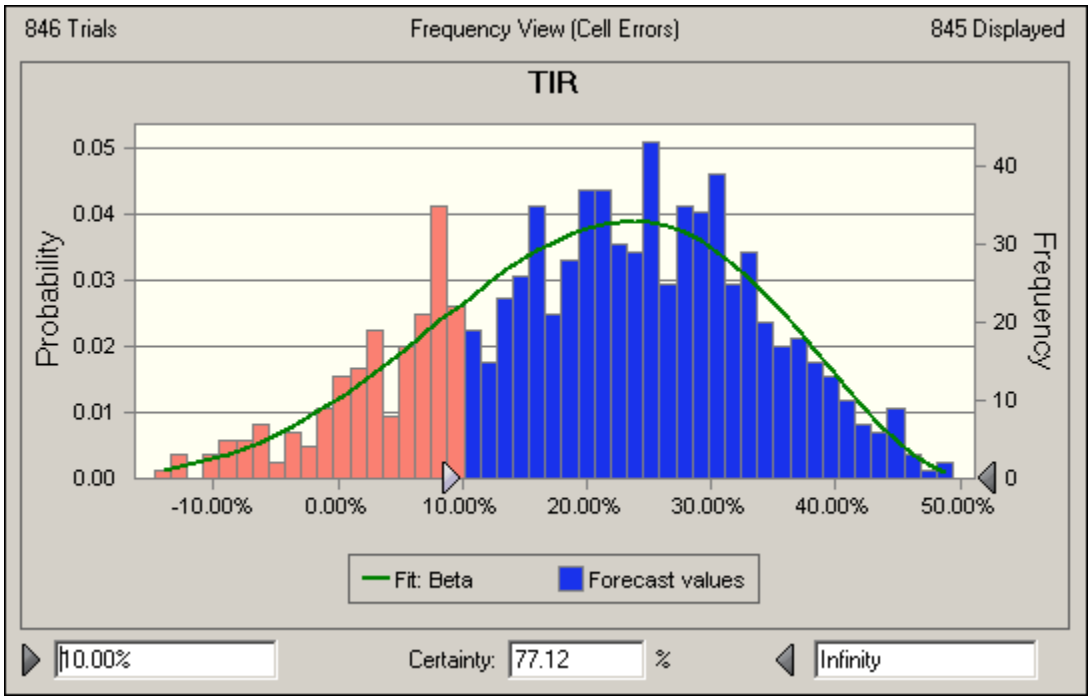
61 Lack of similar information for other cities prone to periodic floods at the time of the analysis precluded the inclusion of economic benefits from reduced losses in those cities. In this regard, the economic benefits calculated for the corresponding application are extremely conservative, and should actually just be considered as an illustration of the kinds of benefits that can be derived form emergency management applications akin to this one, and not as providing an order of magnitude of the potential benefits, which are expected to be much greater than those included in this analysis.

62 Cost details and analysis are presented in "SAOCOM System Technical Orientation Review."

63 This method describes the range of each cost and benefit as a probability distribution. A software package selects one estimate from the probability distribution that describes each assumption about benefits and costs and uses the set of selected assumptions to calculate one net present value or internal rate of return. Having finished one economic calculation, the software selects a second set of assumptions and repeats the calculations for a set of 1,000 results, each one based on the relative likelihood of the assumptions. The probability distribution of these calculations characterizes the range and relative likelihood of the different sets of results.

turns out to be feasible that is over three times greater that the opportunity loss from implementing the project when it turns out not to be feasible.

Figure IV-2: Frequency distribution of simulated internal rates of return



4.21 **Minimum cost analysis**. 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.

4.22 **Sensitivity analysis**. Sensitivity analysis was performed on two key assumptions that were considered as given in the previous assessment, but which are also subject to uncertainty: (i) the year in which economic benefits are expected to occur; and (ii) the systematic increase in the cropland area attended by INTA over

the project horizon from 30% to 50%. In the former case, the feasibility analysis assumed that benefits are not expected to occur until year 6, one year after the satellite is launched. However, delays in the implementation of applications may happen, which may result in benefits not occurring until later. To measure the economic implications of this scenario, risk analysis was carried out under two more conservative scenarios: benefits not occurring until years 7 and 8, respectively. In the case of the assumed systematic increase in cropland area attended by INTA, sensitivity analysis was conducted in order to measure the economic consequences of lifting this assumption (i.e., cropland area attended by INTA remains constant over time). Fixing cropland area attended by INTA to the current level would imply assuming that no new farmers, besides the current ones, adopt INTA's improved wheat fertilization and *Fusiarium* control recommendations under the project, an unlikely situation. For this analysis, only wheat cropland was assumed fixed over time, given that most of the project's benefits are derived from the soil moisture map application for fertilization and *Fusiarium* control in wheat.

4.23 The results of the previously described sensitivity analysis demonstrate the project's economic robustness, as it remains feasible for one and two-year delays in the implementation of all strategic application after satellite launch has occurred, with the probability of the project's net present value being greater than its threshold level reaching above 60% in both cases. Similarly, the analysis also shows that the project is feasible even in the unlikely event that wheat cropland area responding to INTA's improved advise under the project remains constant over time, with mean and median net present values of approximately US$14 million, and with probability of achieving a positive economic value of 58%.

4.24 In conclusion, 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 highly conservative scenarios, 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 limited to just one city; and iii) the benefits calculated for the two selected agricultural 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).

E. Expected socio-economic impact and beneficiaries

4.25 As a result of the Program, 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 contribute to an increase in the productivity and sustainability of the Argentine economy, through the implementation of applications based on EO, which can 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 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).

4.26 The primary beneficiaries from the development and use of EO applications and technologies will be the country's productive sector and society in general. In terms of direct socio-economic benefits, the implementation of the key strategic applications to be developed by the Program is expected to lead to higher agricultural productivity of the country's main crops (i.e, wheat, corn, sunflower) and a more efficient use of pesticides and fertilizers. As agriculture contributes almost 10% of GDP and half of total exports, improvements in productivity and input use in key crops will directly contribute to growth in investment and overall productivity, and an increase in national competitiveness, one of the strategic areas defined in the Bank's Country Strategy. Likewise, the Program's applications will contribute to damage prevention and reduction of economic losses resulting from floods and other natural disasters. Estimated economic losses associated with flooding in Argentina in the past 20 years reached US$14 billion. Additionally, since R&D is essentially a trial and error process with high uncertainty, the Program also considers funds for the development of new applications, which could lead to additional significant socioeconomic benefits in areas like seismic risk planning, management of natural resources, and response to disease outbreaks.

4.27 The successful development and operation of the SAOCOM satellites will also benefit the international community and 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 by the Committee on Earth Observations Satellites (CEOS)[64] and 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).[65] 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

---

[64] CEOS is a is an international coordinating mechanism charged with coordinating international civil space-borne EO missions. Comprising 25 members (most of them space agencies) and 20 associates (national and international organizations), CEOS is recognized as the major international forum for the coordination of EO satellite programs and for interaction of with users of satellite data worldwide. CONAE is an active member of CEOS and has acted as the chair agency of this initiative during 2006.

[65] 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.

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).

4.28 The benefits of the Program will be obtained at different times and phases of the Program. During the construction and testing of the SAOCOM satellites, the direct benefits that will arise through involvement in the project will be a strengthened domestic skill base, improved linkages between scientists and the productive sector, and a better articulated NIS. These benefits will continue to be obtained after the satellites are launched (the estimated launch date for SAOCOM 1A is 2010), as these skills and better articulated capabilities will lead to the development of more sophisticated space missions and to spin-offs and spillovers in other sectors of the Argentine economy. Although these benefits are not easily quantifiable, based on the experience of other developed and developing countries, it is expected that they will be significant. In contrast, the quantified benefits arising from the implementation of applications (strategic and new) will be obtained during the operational lifetime of the satellites (minimum of 5 years starting in 2011). However, the skills and capabilities to develop these applications will be obtained before the launch of the satellites, and well beyond their operational lifetime, as other space missions are implemented and various unforeseen applications are developed in the future.

4.29 In order to ensure that the Program's full potential is realized, the Results Matrix of this Performance Driven Loan includes various indicators to track progress on the achievement of its benefits. For all three strategic applications, which account for a significant share of the Program's total benefits, intermediate targets have been set so as to ensure that the applications are developed and implemented in parallel with the space technology objective. Several of the targets that will trigger disbursements have been set using the assumptions made in the economic evaluation (e.g., obtaining an accuracy target of ten percentage points of soil moisture content for output maps), to ensure that the socioeconomic benefits are eventually obtained and to create a framework of incentives compatible with that goal. In addition to this, the Milestone Review Guidelines set out requirements for CONAE to continue a strong and systematic focus on application development and benefits evaluation, by requiring proposals that are presented to the AO process to include an ex-ante calculation of these benefits and a system of targets and indicators for evaluating these benefits as they accrue over time.

F. Social and environmental impacts and strategy

4.30 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, 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.[66]

4.31 Argentina is a signatory of 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.

4.32 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 space agencies together 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.

4.33 Space activities have significant social and environmental benefits by providing information that informs 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

[66] 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.

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).

4.34 The Program's Environmental and Social Strategy (ESS) is based on ensuring compliance with 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 heritage sites). Additionally, the prime contractor for the development of the SAOCOM satellites, INVAP, fully conforms to national environmental and labor laws.[67] 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 ¶4.26-¶4.27).

G. Risks and special aspects

4.35 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,[68] an independent space sector consulting firm assisted the Bank in conducting the technical due diligence of the Program and reviewing the Mission Implementation Plan.

4.36 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 and the SAOCOM Mission Assurance Plan, 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

---

67 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.

68 ESYS Consulting provides project management, technology assessment, and systems engineering services to clients ranging from research organizations to government bodies and commercial entities. With more than 15 years experience in the EO satellite sector, ESYS's clients include the European Space Agency, the British National Space Center, the European Commission, the Galileo Joint Undertaking, the British Ministry of Defense, the Dutch Institute for Space Research, Eutelsat, Alcatel, Alenia Aerospazio, EADS Astrium, General Dynamics, and Telesat (see: http://www.esys.co.uk/).

management strategy that is continuously updated, in order to constantly mitigate and partially insure against possible risks.[69]

4.37 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).[70] 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.[71]

4.38 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.[72] 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 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.[73] The main risks and mitigation measures identified in the Program's Risk Management Plan are:

---

69 The specific risks of the SAOCOM mission are identified, assessed, mitigated, tracked, and reported through Risk Reports that are continuously and frequently updated by CONAE.

70 For a detailed description of the Aquarius/SAC-D mission, see: "Aquarius: An Instrument to Monitor Sea Surface Salinity from Space."

71 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.

72 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.

73 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 (JAXA) 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). In early 2006, JAXA successfully

4.39 **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.[74] 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%.

4.40 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.[75] In the event that the first launch fails, the second satellite should be 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.

4.41 **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, then declines significantly 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.

4.42 Similarly, 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

---

launched the ALOS mission, which carries an L-band SAR sensor that recently delivered its first test images and is on track to successfully enter its operational phase by the end of 2006 (see ¶1.30).

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

75 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 has negotiated a binding option price from INVAP for the construction of a third satellite, to ensure that it will be possible to construct a spare satellite within the budget of the insurance payment, should the need arise.

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 project review process, 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.

4.43 It is also important to note that the proposed insurance structure and the fact that two satellites will be constructed considerably reduce the risk of not achieving the Program's estimated benefits due to launch failure or early operational failure. Using data from previous launches and EO satellite missions to estimate the likelihood of launch failure and early operational failure, the estimated returns of various scenarios were calculated, ranging from successful launch and early operation, in which the complete impact of the project as estimated in the economic evaluation could be obtained, to one year delays, two year delays, or even total non achievement of estimated benefits, due to launch failure or early operational failure in both satellites.[76] The expected value of the project's net present value, adjusted according to the relative likelihood of these different adverse scenarios, was only 10% lower than originally estimated (US$37 million), demonstrating that the proposed insurance cover and the two satellite alternative allow for effective management of launch and early operational launch risks.

4.44 **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

[76] For a detailed presentation of the calculations, see: "Risk analysis of launch and early operation phase"

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 project reviews conducted by CONAE (starting with the 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 project reviews conducted by CONAE (starting with the 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 project reviews conducted by CONAE (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, as well as in subsequent project reviews, 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.

4.45 **Application development and implementation risk.** There is only one L-band satellite operating at present (ALOS mission launched in mid 2006) and few L-band data have been available in the past (see ¶1.30). Hence, practical use of L-band data is at a lower level of maturity than 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.

4.46 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). These strategic applications also constitute the basis of the economic justification of the project (see ¶4.13-¶4.24). In this sense, a detailed Application Development and Implementation Plan was prepared by CONAE and institutional cooperation agreements are being signed with INA and INTA, in order to coordinate the necessary efforts required to achieve operational delivery of the HISAs once the satellites are in orbit. 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 other new applications in the scientific community and the private sector (see ¶1.35). Finally CONAE is already addressing these risks with support from the Bank, through a US$1.5 million Project Preparation and Execution Facility (1715/OC-AR) 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.[77]

4.47 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.

4.48 **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.

4.49 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 ¶2.17-2.19).

4.50 **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), it is important to ensure that information is offered to other interested countries in the region or throughout the world.[78]

---

[77] 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.

[78] 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."

4.51 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 ¶4.40). 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 a Data Policy that will govern the use and distribution of the images generated by the SAOCOM satellites (see ¶1.38-¶1.40). The implementation of key aspects of this Data Policy has been included in the Program's Result Matrix, for example, through an indicator to assess that at least 10% of the SAOCOM satellites' L-band capacity is made available to commercial users. As CONAE and ASI's respective satellite missions continue to progress, both agencies will eventually define specific arrangements and procedures for joint commercialization of X and L-band products.

4.52 **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.

4.53 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.

4.54 **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.

4.55 In order to mitigate this institutional reputational risk, an External Panel of Experts (EPE) will advise the Bank on technical matters related to the Program's implementation. The EPE will be comprised of high-level consultants from a specialized space agency or a reputable aerospace firm that provide similar services to official international space-sector organizations and include expertise in the field of application development. The EPE will participate in CONAE's project reviews, and would assess compliance with the Program's targets at each of the agreed milestones, as presented in its Results Matrix.[79]

4.56 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 (EXR) and CONAE's Office of Institutional Relations, in order to implement a strategy to address the public relations aspects of the Program.[80]

[79] Despite the fact that CONAE is exposing the project to standard space-sector project 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.

[80] An initial communications strategy has been prepared by the Project Team, EXR, and CONAE.

ANNEX 1

PROSAT Results Matrix (AR-L1017)

Objectives	Outcome Indicator[1]	Targets for 1st Tranche	Targets for 2nd Tranche	Targets for 3rd Tranche	Targets for 4th Tranche	Targets for 5th Tranche
Objective #1 (Satellites and ground infrastructure) 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).	Assessment by External Panel of Experts (EPE) of the achievement of key review milestones according to standard, internationally recognized evaluation procedures for the design, manufacturing, assembly, commissioning and operation of a satellite system and all of its supporting ground infrastructure.	1. Preliminary Design Review confirms that the preliminary designs and processes meet the requirements and are sufficiently defined and documented to proceed to detailed design **(Delta PDR).**	2. Critical Design Review confirms validity of technical solution, to meet the mission requirements as demonstrated by analysis and by construction and testing of representative models of the final configuration **(CDR).**	3. Pre-Environmental Review of SAOCOM 1A proto-flight model confirms functional conformance against requirements, adequacy of test plans, and readiness to proceed to environmental tests **(PER 1).**	4. In-Space Test Review of 1st SAOCOM confirms that the deployed system has the capability to meet the Mission Requirements **(ISTR 1).**	5. In-Space Test Review of 2nd SAOCOM confirms that the deployed system has the capability to meet the Mission Requirements **(ISTR 2).**
Objective #2 (Application development) To strengthen and consolidate the country's capabilities in a technological niche of EO, and successfully develop and implement applications with high socio-economic impact using data gathered with the SAOCOM system.	Assessment, according to reviews conducted by the EPE, of the achievement of key milestones in the stages of design, development, commissioning and operation of applications (strategic and new) developed to use data gathered with the SAOCOM satellites system.	1. Design of the three strategic applications complete. 2. SAR data delivery plan for applications development support complete.	3. Implementation of the GIS reference frame. 4. Implementation of capability to collect in-situ data 5. Operational Capability of delivering SAR data achieved. 6. Pre-operational readiness for three strategic applications using SAR data achieved.	7. Two of the three strategic applications are operational, using SAR data.	8. Third strategic application is operational, using SAR data. 9. Pre-operational readiness for three strategic applications using SAOCOM 1 data.	10. Three Strategic applications are operational, using SAOCOM data.

[1] The External Panel of Experts will follow specific procedures for the Performance Audits to be conducted prior to the disbursement of each tranche, in order to evaluate the achievement of the targets described in the Results Matrix. These specific procedures are detailed in a separate document (Milestone Review Guidelines) that accompanies this Matrix. This document also presents the detailed description and definition of each expected target to be reached before each tranche, as well as the description of the means of verification to confirm their achievement.

ANNEX 1

PROSAT Results Matrix (AR-L1017)

Objectives	Outcome Indicator	Targets for 1st Tranche	Targets for 2nd Tranche	Targets for 3rd Tranche	Targets for 4th Tranche	Targets for 5th Tranche
		11. Design of AO Program complete.	12. Successful Publication of the SAR Announcement of Opportunity (AO). 13. Selection and launching of at least 10 SAR AO projects. 14. Delivery of at least 30 SAR images to SAR AO Projects.	15. Successful communication and dissemination of SAR AO final results.	16. Successful implementation of mechanism to commercialize and distribute at least 10% of the satellite data for commercial uses and applications.	17. Successful Publication of the SAOCOM AO 18. Selection and launching of at least 10 SAOCOM AO projects. 19. Delivery of at least 30 SAOCOM images to SAOCOM AO Projects.

DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK

PROPOSED RESOLUTION

Argentina. Loan /OC-AR to the Argentine Republic
Program for the Development of a Satellite System and Applications Based on Earth Observation (PROSAT)

The Board of Executive Directors

RESOLVES:

That the President of the Bank, or such representative as he shall designate, is authorized, in the name and on behalf of the Bank, to enter into such contract or contracts as may be necessary with the Argentine Republic, as Borrower, for the purpose of granting it a financing aimed at cooperating in the execution of a program for the development of a satellite system and applications based on earth observation. Such financing will be in the amount of up to US$50,000,000, from the resources of the Single Currency Facility of the Bank's Ordinary Capital, and will be subject to the Financial Terms and Conditions and the Special Contractual Conditions of the Project Summary of the Loan Proposal.