The National Mapping Act and the Status of Cartography in the Argentine Republic

Ruben C. RODRIGUEZ and Dr. Claudio A. BRUNINI, Argentina and Albert H. J. CHRISTENSEN, USA

Key words: Argentina, Geodesy, Cartography, National Mapping Act, Ley de la Carta.

ABSTRACT

The 1941 National Mapping Act (*Ley de la Carta*), herewith called *the Act*, was intended to provide the basis for the systematic mapping of Argentina. The Act and its bylaws ordained the full coverage of the country with a dense geodetic network and with topographic mapping up to 1:25,000 scale, to be completed over a 30 years period. Regrettably, due mostly to financial and management problems of national amplitude, that momentous project remains as yet unfinished. The Act, however, resulted in significant contributions to the infrastructure and to mapping organizations of Argentina. This paper narrates in a brief manner the cartographic activities that preceded the Act and, in more detail, those came after it. As regards map production this paper cannot describe the situation as anything but unsatisfactory. On the other hand, the status of the geodetic networks, horizontal and vertical, is described in more favorable terms. Finally this paper advances some ideas for the future mapping of the country.

RESUMEN

La Ley de la Carta de 1941 proporcionó la base para la sistematización de la cartografía en la Argentina. Este documento jurídico y sus reglamentos complementarios establecieron que el país debería ser cubierto totalmente en un período de 30 años con una densa red geodésica y cartas topográficas hasta la escala 1:25000. Lamentablemente, debido problemas administrativos y financieros, el singular proyecto no ha sido terminado. La ley, sin embargo, significó una importante contribución para las entidades argentinas que requieren los productos geodésicos y cartográficos. El trabajo es una exposición breve de las actividades cartográficas que precedieron a la promulgación de la ley de la carta y continúa relatando el desarrollo de las tareas que le siguieron. Informa, luego, el número de cartas programadas para cada serie así como las cantidades publicadas. En cuanto a la producción cartográfica este trabajo no puede describir la situación como negativa pero sí como insatisfecha. En sentido opuesto, se manifiesta en términos más favorables respecto de las redes geodésicas tanto planimétricas como altimétricas. Finalmente el documento propone algunas ideas acerca del futuro cartográfico del país.

CONTACT

Ruben C. Rodriques
Luis M. Campos 1521 - 6B
C1426BPA Buenos Aires
ARGENTINA
Tel. + 34 11 4781 8901
E-mail: Rubenro@fibertel.com.ar

Claudio A. Brunini
Department of Astronomical and Geophysical Sciences
Paseo del Bosque
B1900FWA La Plata
ARGENTINA
Tel. + 34 221 423 6593
E-mail: Claudio@fcaglp.edu.ar

Albert H. J. Christensen
T-FCO
7836 Muirfield Court
Potomac, MD 20854-4077
USA
Tel. + 1 301 983 9004
E-mail: ahchris@erols.com.

The National Mapping Act and the Status of Cartography in the Argentine Republic

Ruben C. RODRIGUEZ and Dr. Claudio A. BRUNINI, Argentina and Albert H. J. CHRISTENSEN, USA

1. MAPPING IN ARGENTINA BEFORE THE ACT

The first recorded action as regards governmental cartography in Argentina was the establishment of the Topographic Department in June 26, 1826. That step, taken during the presidency of Bernardino Rivadavia, had as objective the delineation of the internal and international boundaries of the nation's territory. The Topographic Department still lives today, under the guise of Directorate of Geodesy, Ministry of Public Works and Services of the Buenos Aires Province.

The second significant event in the institutional history of Argentinean Cartography occurred on December 5, 1879, during Nicolás Avellaneda's presidency, with the creation of the Army Topographic Bureau (Oficina Topográfica Militar). The Bureau, tasked with the production of maps required by the Army, changed its name in 1904 to the current *Instituto Geográfico Militar* (Army Geographical Institute) or IGM.

Disjoined geodetic and mapping coverage was the rule before the passing of the Act. Several small areas were mapped by IGM along the country's borders, while a much larger area, encompassing the richest soils in the country, was the subject of a well organized mapping effort. The project, known as the Castelli System, covered parts of the Buenos Aires, Santa Fe, Corrientes and smaller areas of other adjoining provinces, with the datum located in Castelli, a town in Buenos Aires Province. The triangulation needed to cover those areas consisted of 779 first and second order stations and 2840 stations of third and fourth order. *Order* is a ranking of triangulations, depending loosely on the distances between stations but tightly on measurement standards. To wit:

1st: 25 to 30 km
2nd: 15 to 18 km
3rd: 7 to 1o km
4th: 4 to 6 km

The numbers of charts published by IGM during the pre-Act years were: 126 quads at 1:25,000, 400 at 1:50,000 and 200 at 1:100,000 scales.

A geodetic work of transcendence was the measurement of an arc of meridian, mandated by a 1936 federal law to a committee made up, inter alia, by the Astronomical Observatory of La Plata, IGM and the School of Exact, Physical and Natural Sciences of the University of Buenos Aires. This committee was chaired by Félix Aguilar, an eminent astronomer and geodesist, director of the Observatory, and with a prestigious work record at IGM and at that University. The largest span of the arc followed the 64W meridian. Today the arc consists of 248 stations, 17 bases, 756 elevation points, 1600 km of leveling in both directions, and 96 gravimetric stations. Of those numbers, about 40% were the actual work of the Committee.

The rest was measured by IGM. In time, the whole arc of meridian was integrated with the IGM network.

In the private sector it is necessary to mention the *Plano Catastral de la República Argentina* by Carlos de Chapeaurouge, (Figures 1 and 2) published in 1901 (2 vol. 105 pages in-folio). The maps, at 1:500,000 scale, in that notable work contain the planimetric information compiled independently by the author, and a fair idea of the hypsometry as well in the shape of 67 cross-sections of the country.

Figure 1: Title page of Carlos de Chapeaurouge's Cadastral Atlas of Argentina.

2. THE NATIONAL MAPPING ACT (*LEY DE LA CARTA*)

In 1925, Ladislao Fernández, who headed IGM during its longest and most fruitful period, initiated a study of a law for the mapping of the country. Sadly, that instrument was never passed and the country had to wait until 1941 to see the National Mapping Act, herewith called *the Act*, put into effect as Law 12696. The Act laid down the rules for the execution of a topographic map covering the country's 2,800,000 km^2. Most importantly, it clearly stated the resources to be allocated to the project as well as the term for its completion.

Significant objections were raised against the Act, mostly from the prestigious *Centro Argentino de Ingenieros* (Argentine Society of Engineers), both because of budgetary ambiguities and loose technical specifications. Other negative criticisms were voiced by Antonio Saralegui (1963, 1981), with the authority bestowed on him by his long dedication to the university and his witness credentials in the promulgation and execution of the Act.

The Act, supplemented by bylaws passed in 1953, stipulated the mapping of the county to consists of:

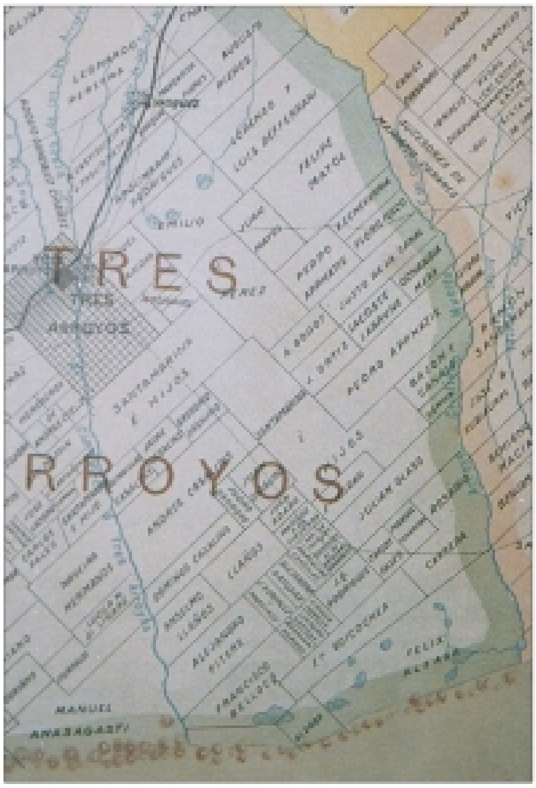

Figure 2. From Chapeaurouge's Cadastral Atlas, showing a small part of a folio (Buenos Aires Provincia).

- *Red Fundamental Argentina* or RFA (Fundamental Geodetic Network): horizontal measurements resulting in triangulation chains every two degrees of latitude and longitude, constructed with quadrilaterals with double diagonals, bases and first order astronomical stations (Figure 3);

- Gravimetric determinations;
- Leveling in approximately 500 km long polygons;
- Tidal measurements;
- Triangulations nets filling the interior of the RFA polygons (Figure 3);
- Incorporation into the effects of the Act of the work executed by the Committee for the Measurement of a Meridinal Arc;
- Topographic charts at 1:50,000, 1:100,000 and 1:500,000. Later modifications appended a 1:250,000 series;
- The sheets for Argentina of the 1:1,000,000 World Map.
- Wall maps;
- Yearbooks and technical publications with lists of spherical and plane coordinates, elevations, etc.

The purpose of the Act was to provide the Nation with the documents needed for the development of its territory, at scales that, while permitting the full coverage of its territory within the budgetary constrains of the time, would be technically adequate for future planning studies as well as bases for eventual larger scale surveys.

3 THE WORK ACCOMPLISHED BY THE ACT

According to published reports (IGM, 1979 and http://www.igm.gov.ar), the work accomplished since the passing of the ACT can be summarized as follows (rounded figures):

- RFA and its filling nets made up of 18,000 points expressed in the Campo Inchuspe reference frame;

- A GPS network of 130 points;
- Vertical control network consisting of 90,000 km of geometric leveling;
- Gravimetric network occupying 50 % of the benchmarks;
- Series at 1:500,000 and 1:250,000 that cover the whole country;
- In approximate quantities, 1830 charts were completed in the 1:50,000 series (Saralegui 1963, IGM 1979 and http://www.igm.gov.ar), of the 7200 needed for the full coverage ordained by the Act;
- 1140 quads of the 100;000 series, of 1840 planned;

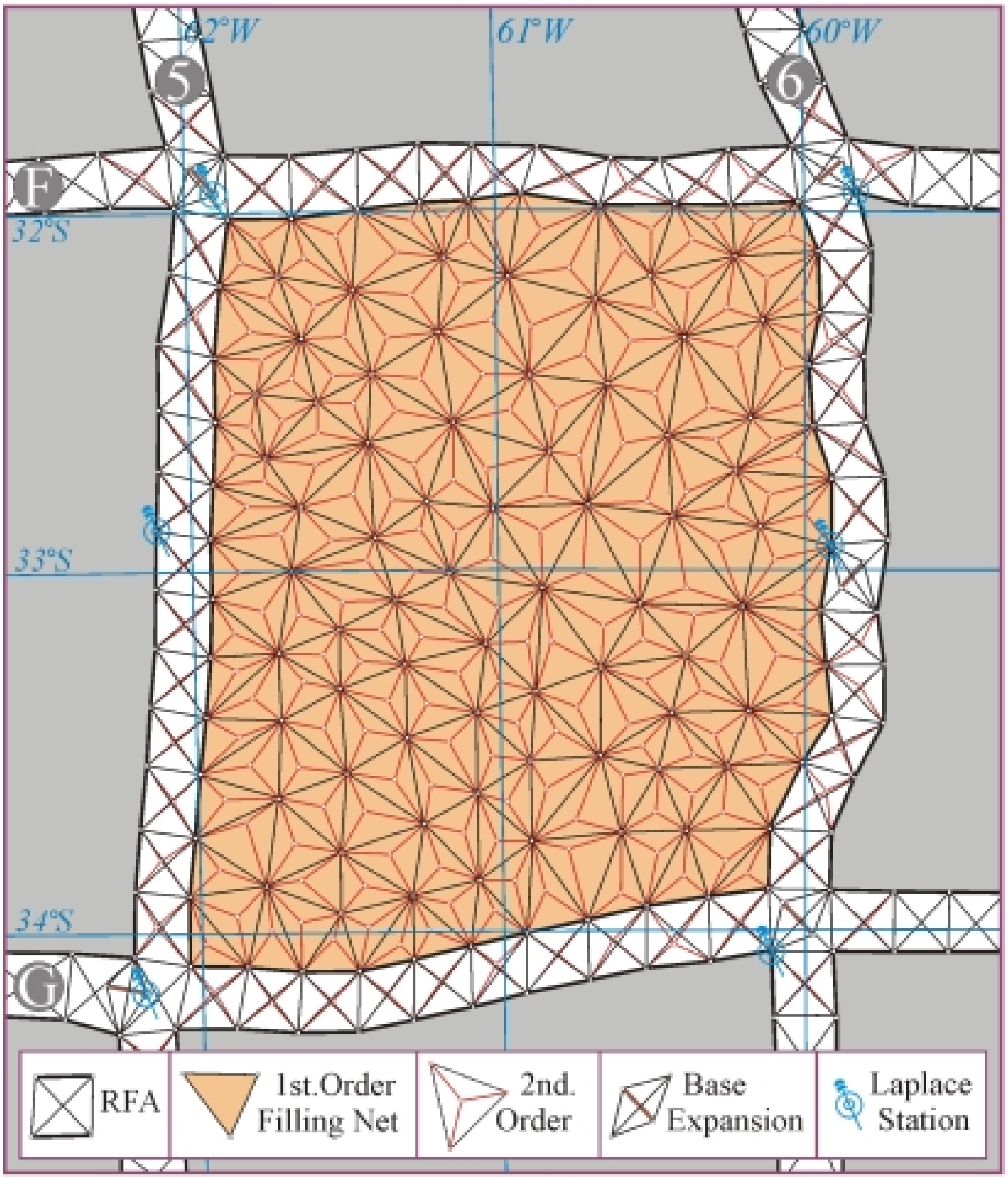

Figure 3 : Geodetic Unit 5F

- Wall maps at the scales 1:2,500,000, 1:5,000,000 and 1:10,000,000;
- Yearbooks, atlases, and technical publications.

Graphics showing the geodetic and cartographic coverage can be found in the IGM web page listed under *References*. The relationships between charts planned and charts published for the standards series is shown in Figure 4.
Of the work units listed above, the next two sections single out for remarks and observations those that carry more weight: the cartographic coverage and the horizontal networks.

3.1 The Cartographic Coverage.

With the number of published sheets of the 1:50.000 series in sight, – equivalent to 25% of the total planned by the Act one cannot fail to wonder about the reason for that shortcoming. Although the wondering cannot be satisfied with a simple and definitive answer, as usual in matters where economy tells, the main cause is in plain view: lack of budgetary resources. The shortfall was consequence, inter alia, of the economic and financial setbacks Argentine suffered since the end of WWII, which gradually reduced the allocation of constant pesos 1941 to the Act to the current 25% level. Other causes, surely secondary in their impacts, might be proposed, such as the relative loss of prestige suffered by the Civil Service that accompanied those economic upheavals. In regard to remedies, Antonio Saralegui proposed (in a personal communication to one of the authors) a minimal tax levied from properties as contribution to the Act. Yet another possibility, discussed at the time, was the outsourcing of the tasks stipulated by the Act. With fairness guaranteed by public solicitations, this procedure would have lowered the costs to levels the federal administration could never reach. With hindsight such a procedure seems very attractive today, especially considering the trend towards outsourcing observed today in Latin America. However, evident financial advantages notwithstanding, outsourcing presents dangers, as noted later in regard to the cadastral projects funded by international banks, when technical specifications are deficient or when the control of the projects is in venal or incompetent hands.

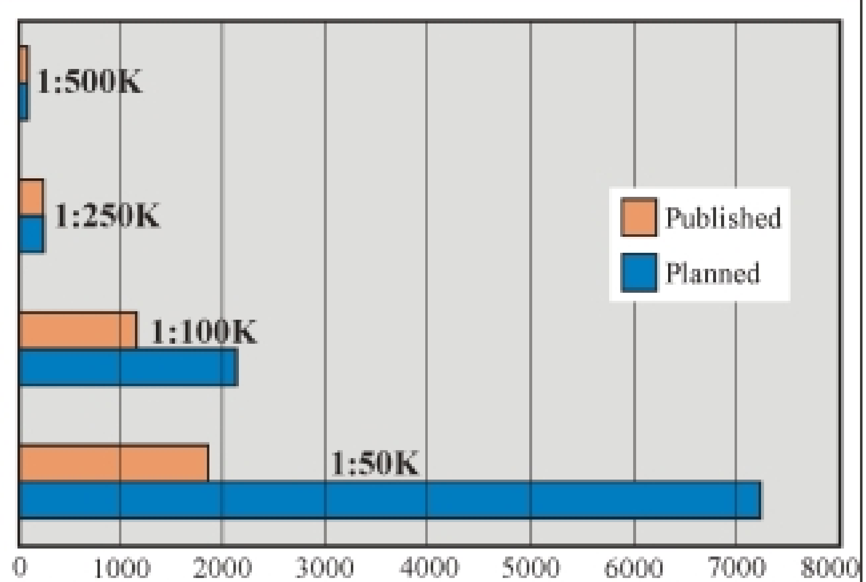

Figure 4 : Numbers of planned and published topographic sheets

Finally, to close this rather sad account, one should return to 1941, at the time the Act was promulgated. If that were possible, one should certainly ask oneself whether it was wise to devote time and money to map what was already mapped, instead of dedicating those resources to the areas totally devoid of cartography. Moreover, whether a quick updating of the Castelli maps would not permit the nation to wait until the rest of the territory was covered with the new maps, before redoing those Castelli maps. Back to today and with hindsight and the shortcomings of the Act on sight, today one could certainly wonder why that approach was not taken.

On the smaller scales, it must be noted that a full coverage of the country has been accomplished at the 1:250,000 scale. That completion in a scale that is only of limited technical use, must be set in contrast with the purpose of the Act, that was to provide support for initial projects and bases for more detailed studies.

3.2 Geodesy.

The geodetic networks approach much more closely the design contemplated by the Act than the actual cartographic coverage: a horizontal network of 18,000 stations was determined with great accuracy (considering the standards at the time). The vertical network consists of approximately 34.000 monumented high-order stations. Although a significant number of the monuments have been destroyed, enough of them remain to allow for an adequate determination of the geoid model (by comparing GPS and spirit level elevations).

Two events can be considered milestones in the Geodetic work executed under the Act. The first was the 1969 adjustment of the horizontal nets, a task that, for undone, was for many years a hindrance to the publication of geodetic data. The second was the establishment in 1993 of a GPS network of 127 stations.

In 1969 and observing the counsel offered to its members by the International Union of Geodesy and Geophysics in 1967, IGM recomputed and expressed the coordinates of the Campo Inchauspe datum in the Conventional International Origin, CIO. At that time, as the completed RFA had grown to nineteen completed polygons, it became peremptory to subject them to a free and simultaneous adjustment. The operation was carried out at the US agency then called Army Map Service, in Washington DC, with the assistance of Messrs. Albert H.J. Christensen and Alfredo V. Elias, that had been assigned by IGM to that project. The adjustment, which included 1,000 stations and 5,000 observations (directions, distances and astronomical azimuths), yielded an RMS equal to 0.42 arc seconds. In this enterprise as in many other IGM projects, the contribution and help of Stefano Horvat, formerly head of Zagreb University and at that time IGM scientific advisor, was of paramount importance. In addition, Mr. David D. Byars, Head, Americas Division, US Army Map Service, and colonels Carlos Quinteros and Luis María Martínez Vivot, IGM, were instrumental in the critical support and agreements thanks to which that project was completed (Rodríguez, 1992 and 1999). However, the primary assignment of Messrs. Christensen and Elias to the Army Map Service was something else: the preparation of a set of programs for the adjustment of horizontal nets. The programs, running, –by the standards of the time – in a small mainframe, solved the normal equations by the block elimination method supplemented by the ideas of Pranis-Pranievitch on the simultaneous elimination of unrelated blocks of unknowns (Christensen, 1973). Later, in Argentina, those programs were used to adjust several groups of new RFA polygons in forced agreement with the core of freely adjusted 19 polygons.

The second remarkable fact in the geodesy of the Act was the creation of the POSGAR 94 (*Posiciones Geodésicas Argentinas*) reference frame with a network of 127 GPS points. That network, with distances between stations averaging 200 km, represents the embodiment of WGS 84, which in 1997 became the official reference frame in Argentina. Later, POSGAR 94 was enhanced into a new frame, POSGAR 98, by a more precise computation of the observations and by its links to a continental system known as SIRGAS (*Sistema de Referencia Geocéntrico para las Américas* (SIRGAS) and to the International Terrestrial Reference Frame, ITRF) (Moirano, 1997). Most of the positions in POSGAR 98 coincide with those of POSGAR 94. Also deserving notice are 15 GPS stations that make up the *Red Argentina de Monitoreo Satélital Continuo*, RAMSAC (Argentinean Network of Permanent Tracking Stations).

4. A NEW AGE

Since the seventies the operational capacity of IGM has eroded further, decreasing steadily as the nation went from one financial crisis to the next. The dwindling competence of IGM went unnoticed because hardly anything was happening in the geomatics sector in Argentina during those years. The landscape changed abruptly in the early nineties. Argentine geomatics received the biggest financial boost ever in the form of World Bank loans for the modernization of provincial cadastral databases to support equitable real estate assessments. The provinces, through their Directorates of Cadastre, administer the loans, draft the contracts and control the execution of the cadastral projects. As a result, the elaboration of part of the cartography and the supporting geodetic infrastructure (new provincial geodetic control networks) was de facto decentralized and came under the authority of the Directorates of Cadastre in each province, thus reducing the IGM to the role of a spectator in the process of geodetic and cartographic modernization.

The privatization wave initiated by the Menem administration, also in the early nineties, succeeded in transferring large networks of services and product distribution to the private sector, thus intensifying the need for current land information. The *Proyecto de Asistencia Técnica al Sector Minero Argentino* (Technical Assistance to the Argentine Mining Sector; PASMA) is an illustrative example: It is also financed through international loans and aims at updating the national mining cadastre as well as securing title to mining property, with the ultimate goal of attracting more foreign investment in the mining sector. During the first phase of PASMA, dense geodetic control networks were established in six Argentine provinces; a second phase will extend this network to the entire national territory (Gillone 1998).

As a project aimed solely to the mining sector, the result of PASMA amounted to the staking out of 5400 mines and claims, probably one of the major contributions to the solution of the delimitations of mining claims.

The proliferation of fiscal and mining cadastre projects made the lack of geodetic leadership and coordination at the federal level painfully evident. Provincial project authorities, – the Directorates of Cadastre – produced ambiguous requests for proposals with unclear geodetic specifications, creating frequent conflicts between them and contractors. It was difficult for the contractors to implement ambiguous geodetic specifications and impossible for the project authorities to control the quality of the final product, i.e. the provincial geodetic network.

In 1993 the federal coordinator, – *Unidad Ejecutora Central* (UEC) – of the provincial cadastral projects took the initiative of creating a new national spatial reference system in Argentina to provide a national framework for the emerging networks established by the Directorates of Cadastre. The UEC entrusted the technical part of this task to the La Plata National University and to IGM. The result of the initiative was the so-called POSGAR 94 mentioned in the previous section.

In numbers of geodetic positions, the total of PASMA plus the cadastral projects yields an average of a station every 1200 km^2, or, in other words, a reach of 20 km per station. Although those figures could be considered a success, the same cannot be said of the characteristics of the networks, on account of the different standards under which they were measured. So much so that fitting them together will be a difficult, if not impossible, task.

To bring to a successful completion the fundamental task of the cadastral projects, was considerably more difficult than the establishment of the Geodetic control. The avowed purpose of the development loans was the cleansing of provincial administrations, to be accomplished by streamlining the real estate tax collection and by ensuring fairness in the tax assessments.

Argentina was not alien to good cadastral systems. Indeed there was a great deal of experience in establishing and maintaining cadastral systems in the major cities and in productive areas of the country. Foremost among them was the system that the Municipality of the City of Buenos Aires undertook in 1940. But that system, with its provincial brothers, suffered badly during the crisis years the country went through since the end of WWII. Gradually the real estate registers deteriorated, clandestine constructions multiplied and taxes were unfairly levied. As a remedy, the loans from the international development banks provided modern tools, – computers and software – with which to organize, establish or update the real estate records. Although the experience in traditional cadastral system was at hand, the projects ran into serious obstacles. One was consequence of the excessive reliance placed on the capabilities of modern software. In that respect GIS comes to mind because it was looked upon as a panacea as well as one essential component of the standard cadastral system. More fateful was the underestimation of the costs of the real estate census, the really fundamental task in all the projects.

The task of properly organizing a computer-based cadastre was compounded by the existence of separate administrations, each in charge of essential parts of the task. As Argentina is a federal republic, provincial authorities manage the cadastre proper. On the other hand, local municipalities (or heads of departments, as counties are known in all but one of the provinces), handle re-zoning, building permits and as-built certificates. It is clear, then, that an antecedent condition for a smooth and guaranteed maintenance of the cadastral registers is a well designed and fully automated interface between the central administration of a province and all its municipalities. A well-designed interface would ensure the incorporation of new constructions and improvements to the real estate registers and make irreversible the benefits of the international loans. However, this cornerstone for success was wanting in many if not all the requests for proposals issued by the provinces and endorsed by the technical inspectors of the lending institutions.

5. THE FUTURE

This final section deals with the impact of new technologies on IGM and on the private sector. As done earlier, Geodesy and Cartography are addressed one at the time. In addition this section makes short visits to Topography and Photogrammetry.

5.1 Geodesy

Once the execution of countrywide geodetic surveys by the private sector was almost unconceivable. Today, however, technology has made available to surveying firms the means necessary to position points on the Earth with the same accuracy as IGM, and the possibility of doing so with relatively modest capital investments. It is therefore advisable to redefine the role of IGM, with the double purpose of ensuring its presence and increasing its strength. The following five components are considered fundamental to that enterprise:

- A set of permanent tracking stations, more numerous than at present and harmonized in their operation with those that are still outside IGM's control.
- Database with IGM's own records as well as those from other organizations, private and governmental, with open access from the Internet.
- Establishment of protocols and rules under which Geodetic data could be incorporated into the database, regardless of the affiliation of the producer (Federal, provincial, local or private).
- Preservation of the Geodetic marks and monuments, by means of agreements between IGM and cadastral, highway, railroad, etc., administrations as well as with professional societies.
- Establishment of a plan of measurements by GPS methods on benchmarks, with the object of carrying through the regional model of the geoid up to the definition of a three-dimensional model.

5.2 Topography and Photogrammetry

New technologies made topographic surveys simpler and faster, if not less costlier. However, the execution of this type of survey by the provinces was always possible and in fact, a reality in the most developed of them. So, as regards Topography, not much can be said in the way of forecasts or recommendations for the future. As in the matter of cadastral survey, noted above, Argentina was not alien to quality photogrammetric surveys. In fact, the country was, in its own way, an innovator. Argentina saw in 1921 the building of its own terrestrial photogrammetric stereoplotter, the *Estereógrafo Mecánico* (Saralegui, 1979), and six years later its first private photogrammetric firm, IFTA. Its leaderships did not last more than a few years, though, due to the competition of governmental agencies. Recently, thanks to the trend towards private industry, Argentina again saw enterprising firms venturing into what until then had been the preserve of governmental institutions. Now, however, photogrammetric surveys have become more and more reliant on complex and costly systems, as on-board equipments are, with high-resolution analogue or digital cameras coupled to GPS receivers and inertial navigation devices, and even more so satelite-based sensors. Those new systems, with their high costs and operating complexities may make difficult for those firms to remain competitive as well as technologically advanced.

5.3 Cartography

As a complement to the five proposals made earlier under *Geodesy*, two new ones can be made concerning the cartographic work at IGM. The first is the establishment of an advisory committee on cartographic policy, modeled on the Subcommittee on Geodesy which has proved to be particularly successful. The definition of the country's reference frame, noted earlier, is one of its accomplishments.

The second proposal concerns the enhancement of the lines of communications between IGM and professional surveyors. At the time budgets are compiled and in order to be able to estimate the required funds and resources, professionals must count on the prompt support of the agency as regards active stations, networks, and general cartographic and geodetic documents.

As to the consequences of technological advances on Cartography, it is possible to establish a parallel with those recorded in Geodesy. Around 1978 IGM purchased a mini-computer based CAD system, especially geared for Cartographic work. At that time that system was practically off-limits to any surveying firm. Today the work executed in such CAD system could be done equally if not better in an ordinary PC, thus opening for small businesses the opportunity of executing the most demanding cartographic work. With more title it is then possible to say that, as far as the Cartographic aspect is concerned, today provincial administrations can very well take up the execution of their own map series.

Making a short incursion in Cartography education, today one should notice a shift of emphasis in the lengthy apprenticeship required for craftsmen in the field. The emphasis placed in purely manual skills since the dawn of Cartography must today be directed towards the knowledge and operation of a large and varied number of complex systems. That changeover would necessitate teachers and supervisors with a knowledge level that presupposes a tertiary education on basic sciences. As regards Geodesy, that was always so in Argentina. Now the turn for Cartography has arrived.

REFERENCES

Christensen, A. H. J., and Elias, Alfredo V. 1973. Programs for the Adjustment of the IGM Nets. Presented to the International Symposium on Computation Methods in Geometric Geodesy, IAG, Oxford University, UK. IGM, Argentina. 34 p.

Gillone, R. and Brunini, C. 1999. Setting boundaries. *GPS World*, 10, 2, 32-36.

IGM, 1979. *100 Años en el Quehacer Cartográfico del País (A Hundred Years of Cartographic Work in the Nation*. Instituto Geográfico Militar, Cabildo 381, C1426AAD Buenos Aires, Argentina.

Moirano, J., Brunini, C., Drewes, H. and Kaniuth, K., 1997. Realisation of a geocentric reference system in Argentina in connection with SIRGAS. In Advances in positioning and reference frames, *IAG Simposia Syrie*, Springer, Berlin. 118, 199-204..

Rodríguez, Rubén C., 1995. The Development of Geodesy and Cartography in Argentina. *Surveying and Land Information Systems*, 55, 2.

Rodríguez, Rubén C., 1999. La Evolución del Sistema de Referencia Argentino: de Campo Inchauspe a POSGAR 94. En: Contribuciones a la Geodesia en la Argentina de Fines del siglo XX. Homenaje a Oscar Parachú. Universidad Nacional de Rosario. 65–73.

Saralegui, Antonio M., 1963. Geodesia, Topografía, Fotogrametría y Cartografía en la República Argentina, *Evolución de los Recursos Naturales de la Argentina*, Consejo Federal de Inversiones, Buenos Aires. II, 3-102.

Saralegui, Antonio M. (1979) .Comentarios sobre el desarrollo de la fotogrametría en la Argentina. *Revista Cartográfica Nro. 36,* PanAmerican Institute of Geography and History, 125-137

Saralegui, Antonio M., 1981. La Carta General Topográfica de la República Argentina. Academia Nacional de Ciencias de Buenos Aires. Av. Alvear 1711, C1014AAE Buenos Aires.

BIOGRAPHICAL NOTES

Rubén C. Rodríguez.. BSc (Surveying), National University of Buenos Aires. Worked at Army Geographical Institute. Professor at the *Instituto de Enseñanza Superior del Ejército* and in the School of Astronomical and Physical Sciences, La Plata National University. Projects: POSGAR, SIRGAS, and networks in Santa Fe and Neuquén Provinces. Member IAG, AAGG, ACSM, *Colegio de Agrimensores de Buenos Aires*.

Claudio A. Brunini. PhD, (Astronomy), La Plata National University. Director of the computation of the Argentina National Frames POSGAR 94 and 98 and several regional densification networks for cadastral and mining purposes. GPS Tide Gauge Bench Mark Monitoring Pilot Project. Member, IAG, IAU, American Geophysical Union.

Albert H. J. Christensen. BSc (Surveying) National University of Buenos Aires. Worked at: Army Military Institute and Directorate of Military Manufactures, both in Buenos Aires; National Research Institute for Mathematical Sciences, Pretoria; Chicago Aerial Survey, Chicago, Illinois; GEONEX, St. Petersburg, Florida, and IBM, Kingston, NY, and Bethesda, Maryland. Member, ACSM, ASPRS.