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Engineering Change: The Appropriation of Computer Technology at Grupo ICA in Mexico (1965-1971)

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***Abstract*— In 1966 Mexican civil engineering firm ICA installed its first computer, an IBM 1130. A CDC 3300 followed in 1971. We document the development of its computing efforts, tracing the influence of personnel and practices transplanted from earlier computing efforts within the Mexican government, examining the development of technical and administrative applications, and exploring an unsuccessful attempt to turn the computer center into a service bureau as the foundation for a computer utility business. To explain this strategy we situate the story within the broader history of ICA, in particular the firm's organization as a network of smaller businesses.**

***Index Terms*— Computer centers, History, Data processing, Computer integrated engineering, Mexico**

Introduction

This article records the development of the evolution in the use of computer technology by the civil engineering firm 'Ingenieros Civiles Asociados S.A. de C.V.' (ICA), one of Mexico's most successful businesses. ICA installed an IBM 1130 in 1966. Driven by its internal market system, applications soon shifted from engineering to administration, particularly cost accounting and payroll. After winning a major external engineering contract in 1968 the firm ordered a larger CDC 3300 computer as the foundation for an ambitious computer services business. However the computer was unreliable and the fledgling business failed to win many internal or external customers. A push into the fashionable "computer utility" market failed to get off the ground. By 1972 a combination of reduced ambition and the installation of an IBM 360 yielded a stable but conservative subsidiary focused on a handful of applications.

The history of computing has been dominated by technological histories of key machines or systems and by business histories of major hardware companies. As Michael Mahoney observed, the field absorbed an implicitly "machine centered" master narrative.[1]But in recent years attention has turned toward the use of computers in particular social contexts. This reflects a broader turn toward examination of use and users

[1] M. S. Mahoney, "The Histories of Computing(s)" Interdisciplinary Science Review, vol. 30, no. 2 2005, pp. 119-135.

within both science studies and the history of technology.[2] However early computers were purchased, configured, and applied not by isolated individuals but by large organizations. Attention to use therefore requires us to combine several distinct perspectives. First, we must be willing to follow the suggestion of JoAnne Yates in studying organizations, rather than individuals, as users of computer technology.[3] Yates also makes a persuasive case for the need to consider entire industries, rather than isolated firms, as agents of computer adoptions and has documented to role of trade associations in creating a consensus on the nature and proper application of computers within an industry.[4] But we must not forget that organizations are made up of people, and that institutions exist within the minds of individuals and are reproduced and enacted through in their daily interactions. Hence it is also important to consider the role of different occupational groups and practices in the evolution of computer use, providing a middle ground between the tendency within science and technology studies to focus on individuals as users and adopters of technology and the tendency within business history to treat an entire organization as a single user.[5]

Business historians generally follow an approach of history from the "top down" in which all actions are the result of decisions made by the firm itself, as an institutional actor, or by its most senior managers. Labor historians, following the decades old orthodoxy of social history, seek to explain events with a "bottom up" perspective in which rank and file workers struggle to shape their own destiny. We adopt what might be called "history from the middle out" in which technical experts and junior managers located deep within the organization chart of a large, chaotic firm attempt to reshape its structure, culture and practices to their own advantage. The introduction of computer technology gave a powerful tool for the ascent of a new, technocratic class within ICA and within Mexican society more generally. This has resonance with a broad literature on the ability of elite groups to wield social authority on the basis claims to scientific or technical expertise.[6]

Shifting our focus to computer technology in use poses other kinds of challenge to the existing literature. A standard computer might be used in very different ways in different industries. As James W. Cortada has shown, it is possible to write the history of computer usage as a collection of dozens of loosely connected stories covering different industries.[7] Likewise, by the 1960s the international computer industry was

[2] A classic call for attention to users in the history of technology is R. S. Cowan, "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology" in The Social Construction of Technological Systems, W. E. Bijker, T. Pinch and T. P. Hughes, Ed., Cambridge, MA: MIT Press, 1987, pp. 261-280. A recent, a high influential, sampling of work in science studies on users was given in N. Oudshoorn and T. Pinch, Eds., How Users Matter: The Co-Construction of Users and Technology. Cambridge, MA: MIT Press, 2003.

[3] J. Yates, "How Business Enterprises Use Technology: Extending the Demand-Side Turn" Enterprise and Society, vol. 7, no. 3, September 2006, pp. 422-455

[4] J. Yates, Structuring the Information Age. Baltimore: Johns Hopkins University Press, 2005.

[5] The early establishment of identities, practices, and division of labor in administrative computing is explored in T. Haigh, "The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954-1958" IEEE Annals of the History of Computing, vol. 23, no. 4, October-December 2001, pp. 75-104.

[6] Expertise has been a central topic in science studies for many years. A broad and recent examination is H. Collins, and R. Evans. Rethinking Expertise. Chicago, IL: University of Chicago Press, 2007.

[7] J. W. Cortada, The Digital Hand: How Computers Changed the Work of American Manufacturing, Transportation, and Retail Industries. Oxford: Oxford University Press, 2003; J. W. Cortada, The Digital Hand, Volume 2: How Computers Changed the Work of American Financial, Telecommunications, Media, and Entertainment Industries. Oxford: Oxford University Press, 2006; J. W. Cortada, The Digital Hand, Volume 3: How Computers Changed the Work of American Public Sector Industries. Oxford: Oxford University Press, 2007.

dominated by a handful of firms, mostly American. But we should not assume that the adoption of American hardware by a non-American firm necessarily reflects the adoption of American values and practices, nor should we assume that the same machine would produce the same results or convey the same cultural meanings in another country. While Cortada has called for research on the international "diffusion" of computer technology, we prefer to follow a recent trend in characterizing the international transfer of high technology as a process of "appropriation."[8] Whereas diffusion is a passive and directionless process driven by random collisions, appropriation suggests an active process in which ownership of a new technology is deliberately and even forcefully established by its recipients.

As a case study of early computer use in a Mexican engineering firm, this paper contributes toward meeting Mahoney's daunting challenge to explore the "Histories of Computing(s)" in all their richness.[9] The few detailed studies of computer use in particular industries have thus far tended to focus on financial organizations.[10] Likewise almost nothing has been written about any aspect of the history of computing in Mexico, and Latin America as a whole has received little more attention.[11] As a case study of a 'grupo industrial' the paper demonstrates some of the challenges (and opportunities) of researching 'big business' in Latin America. As loose federation of industrial and family interests, the groupo is a popular organizational form in the region but under researched when compared to the multitude of business history studies on stock owned, publicly traded corporate bodies typical of the Anglo-Saxon mode of capitalism.

This article details the introduction and diffusion of computer technology within ICA: how purchases were made, benefits to the company, challenges to make the technology work, changes in the use of computers over time, relationships between computer use and organizational structure, and events that led to the creation of an independent computer services company. Our story relies on oral histories of participants involved in the setting up and running computer centers for ICA.[12] Following established practice in this area we interviewed people separately, obtained documents from their personal collections to verify details

[8] Discussion of the "appropriation" of technology emerged quite recently as an alternative to the idea of its use or consumption. It implies a more active and creative role for the recipient. Early use was often intended to grant historical agency to members of marginalized social groups – for example in much of the work in R. Eglash, J. Crossiant, G. D. Chiro and R. Fouché, Eds., Appropriating Technology: Vernacular Science and Social Power University of Minnesota Press, 2004. However it has also been used to describe international transfer of technology, for example M. Hård and A. Jamison, Eds., The Intellectual Appropriation of Technology: Discourses on Modernity, 1900-1939. Cambridge, MA: MIT Press, 1998. The concept recently gained currency within the history of computing as a way of conceptualizing the international transfer of computer technology from the US to Europe, an idea discussed in a recent special issue of Annals. G. Alberts, "Appropriating America: Americanization in the History of European Computing" IEEE Annals of the History of Computing, vol. 32, no. 2, April-June 2010, pp. 4-7.

[9] Mahoney, "The Histories of Computing(s)" .

[10] As well as Yates' work, this includes D. de Wit, The Shaping of Automation : A Historical Analysis of the Interaction between Technology and Organization, 1950-1985. Hilversum: Verloren, 1994. There has been an increasing interest in Europe for similar studies in banking as suggested by contributions in B. Batiz-Lazo et al, eds, Technological Innovation in Retail Finance: International Historical Perspectives (Routledge, 2011).

[11] On computing in Mexico, see Cantarell, A. and Gonzalez, M. (2000) *Historia de la computación en México* (three volumes), México DF: Hobbiton Ediciones SA and L. A. Lomnitz and L. Chárazo, "Basic, applied and technological research: computer science and applied mathematics at the National Autonomous University of Mexico" Social Studies of Science, vol. 29 1999, pp. 113-34. Developments in Chile during the 1970s are explored in E. Medina, "Designing Freedom, Regulating a Nation: Socialist Cybernetics in Allende's Chile" Journal of Latin American Studies, vol. 38, no. 3 2006, pp. 571-606; E. Medina, "Big Blue in the Bottomless Pit: The Early Years of IBM Chile" IEEE Annals of the History of Computing, vol. 30, no. 4, Oct-Dec 2008, pp. 26-41.

[12] Namely two UNAM civil engineering graduates: Antonio Dovalí Ramos (General Manager Aereofoto, 1965-1969) José Piña Garza (Manager of the computer centre, 1965-1971); and two graduates of a private university, Universidad Iberoamericana: Luis Enrique Maumejean (civil engineering; computer analyst, 1965-1973; Systems Manager, 1974-1984), and Bernardo Bátiz Echavarria (industrial relations; Operations Manager, 1964-1984).

and prompt other contributors, and conducted several rounds of interviews with key informants in which questioning grew increasingly detailed.[13] This process of "triangulation" between sources eventually yielded a stable and robust narrative. The draft was also crossed checked by these participants.

Careers and Contexts

In 1961, José Piña Garza, later to head ICA's computer center, joined the Ministry of Infrastructure's (then called 'Secretaría de Obras Públicas' or SOP) Structures Department ('Departamento de Estructuras'). Born in Mexico City in 1938, at the time he was still an undergraduate in civil engineering at UNAM (from where he graduated in 1962).

UNAM was a central institution of the emerging Mexican technocractic elite.[14] Since the 1920s Mexico's political system had been dominated by the Institutional Revolutionary Party ('Partido Revolucionario Institucional') or PRI. It ruled without interruption until 2000, shaping a distinctive political economy in which closely interlocked networks of well connected individuals shared political and economic power.[15] By the 1950s revolutionary leaders had been replaced with a civilian ruling class, and from the 1960s onward a technocratic elite eventually dominated by economists played an increasingly important role. In the process a new vision of the role of government developed, with state sponsored construction of large scale infrastructure 'the engine' for economic development and modernization. [16] Mexico's growth rate surged in the 1960s, and the country was hailed as a model for Latin America.[17]

Computerization was an integral part of this state led push for modernization. Many member of Mexico's pioneering generation of data processing experts received their first exposure to computing while working in the public sector, before transferring this expertise and enthusiasm to private sector organizations. Piña's career exemplifies this transfer of expertise and technological capabilities from public to private sector. After joining the Ministry of Infrastructure he was soon trained in assembly language programming for its

[13] L. Hoddeson, "Writing Recent Science: The Historiography of Contemporary Science, Technology, and Medicine" in The Conflict of Memories and Documents: Dilemmas and Pragmatics of Oral History, R. E. Doel and T. Söderqvist, Ed., New York: Routledge, 2006, pp. 187-200.

[14] Among others see Flavia de Rossi, *El empresario mexicano* (Mexico, D.F.: UNAM, 1977); Babb, Sarah L. *Managing Mexico: Economics from Nationalism to Neoliberalism*. Oxford: Princeton University Press, 2001

[15] Roderic Ai Camp *Mexico's Mandarins, Crafting a Power Elite for the 21st Century* (University of California Press, 2002). Camp, R. (2002) Informal and Formal Networking Among Elite Mexican Capitalists and Politicians. *Comparative Sociology*, 2

[16] Cárdenas, E. (2003) "El proceso de industrialización acelerada en México (1929-1982)" in *Industrialización y Estado en la América Latina: La leyenda negra de la posguerra*, E. Cárdenas *et al.*(eds), . México, D.F., El Trimestre Económico - Fondo de Cultura Económica.

[17] The earliest business history studies of Mexican enterprises date to the period substantial economic growth between 1950 and 1970 that some historians called 'the Mexican Miracle' ('El milagro mexicano') in the early 1960s. See further James P. Baughman, "Recent Trends in the Business History of Latin America," *Business History Review* 39, no. 4 (1965), Albert Lauterbach, "Management Aims and Development Needs in Latin America," *Business History Review* 39, no. 4 (1965), Miguel S. Wionczek, "The State and the Electricity-Power Industry in Mexico, 1895-1965," *Business History Review* 39, no. 4 (1965). Contributions since then have been few and far between, although some claim they are now flourishing including Marìa Eugenia Romero Ibarra, "Panorama General Del Desarrollo De La Historia Empresarial En México," *Historia Mexicana* 52, no. 3 (2003).; Javier Arzuaga Magnoni, *Racionalidad empresarial. Los megaempresarios mexicanos.* (Mèxico, D.F.: Ediciones Gernika, 2004); Mario Cerrutti and Carlos Marichal (eds) (2010) *Grandes empresas y grupos empresariales en México,* México,D.F.: Plaza y Valdéz. Rather than focusing on the interaction between local businesses and multinational enterprises other recent studies have been concerned with the interaction of local elites with political powers e.g. Alicia Ortìz Rivera, "El Consejo Mexicano de Hombres de Negocios: Òrgano de acciòn polìtica de la elite empresarial," *Revista Mexicana de Sociologìa* 64, no. 1 (2002), Marìa Luisa Aspe Armella, "Un caso de integralismo interruptus 1929-1958: La supuesta homogeneidad de la Acciòn Catòlica y su contradicciòn interna en relaciòn a la Polìtica." (Universidad Iberoamericana, 2004),.

soon to arrive IBM 1401.[18] There were two of these courses, each attended by between 15 and 20 participants.[19] Since the 1401 was overseen by the General Services Department ('Departmento de Servicios Generales') and it was aimed at administrative processes (i.e. general accounting and payroll) most of the attendees had an accounting or business background. Piña was the only participant from Proyects and Laboratories Bureau ('Dirección General de Proyectos y Laboratorios'), the area responsible for the design of highways, bridges and buildings; and two other young engineers worked at the Constructions Bureau ('Dirección General de Construcción').[20] Even the trainers hired by IBM to prepare SOP staff for their new work found the content totally new, preparing for their duties by reading manuals beforehand and learning by working through exercises themselves as the course progressed.[21]

SOP's new computer was part of a sizable wave of installations created within Mexican state institutions during the early 1960s. Universities led the way. The very first computer in Mexico was an IBM 650. Two of these were installed 1958, one in Mexico City at the National University ('Universidad Nacional Autónoma de México' or UNAM) and another in Monterrey at the University of Nuevo León.[22] Other state and private universities were not far behind. For instance, the National Polytechnic Institute ('Instituto Politécnico Nacional') installed an IBM-709 in 1961.[23] Early applications were in technical and scientific computing, though administrative work followed at UNAM in 1965 when an IBM 1440 hosted payroll and mechanize the accounting function.[24] Within the federal bureaucracy in Mexico City larger computers were also applied to administrative tasks. The pioneer was the Mexican Social Security Institute ('Instituto Mexicano del Seguro Social') which adopted an IBM 7070 around 1961.[25] . The first large application in private business took place in 1962, when Monterrey-based Grupo Vitro installed another 1401.[26] In 1963 the same equipment was deployed at the Finance Ministry ('Secretaría de Hacienda y Crédito Público') and local subsidiaries of US-multinationals Colgate Palmolive and Ford Motor Co.[27] Large banks in the Mexican capital soon followed.

The development of data processing applications was left to the customer. After a computer was installed IBM support took the form of 'service' and 'support' engineers who were often deployed full time to the

[18] J. Piña Garza, Interview, September 19, 2009.
[19] J. Piña Garza, personal communication, November 21, 2009.
[20] J. Piña Garza, Personal communication, December 2, 2009.
[21] J. Piña Garza, personal communication, November 21, 2009.
[22] Gónzales Sánchez, Mario; Cantarell Martínez, Aquiles; and Ortega Soto, Martha (2000) "Génesis de la industria de computo" in Cantarell, A. and Gonzalez, M. (2000) Historia de la computacion en Mexico (vol. I), Mexico DF: Hobbiton Ediciones SA, p. 76
[23] "History of Computing in Mexico," available: http://cocomc10.pereanet.com/html/coco_in_mexico.html (accessed 13 July 2010).
[24] "50 años de la computación en México," available: http://www.cs.cinvestav.mx/SemanaComputoCINVESTAV/Computo.html (accessed 13 July 2010); Gónzales Sánchez, Mario; Cantarell Martínez, Aquiles; and Ortega Soto, Martha (2000) "Génesis de la industria de computo" in Cantarell, A. and Gonzalez, M. (2000) Historia de la computacion en Mexico (vol. I), Mexico DF: Hobbiton Ediciones SA, p. 77
[25] Gónzales Sánchez, Mario; Cantarell Martínez, Aquiles; and Ortega Soto, Martha (2000) "Génesis de la industria de computo" in Cantarell, A. and Gonzalez, M. (2000) Historia de la computacion en Mexico (vol. I), Mexico DF: Hobbiton Ediciones SA, p. 77; http://agamenon.uniandes.edu.co/museo/ifotos19.htm (accessed 13 July 2010)
[26] Cantarell Martínez, Aquiles (2000) "Reynaldo Iruegas Vázquez" in Cantarell, A. and Gonzalez, M. (2000) Historia de la computacion en Mexico (vol. I), Mexico DF: Hobbiton Ediciones SA, p. 120

new site. However they only looked after the hardware and answered very specific queries. Assembler-based administrative applications soon saturated the capacity of the 1401 at SOP,[28] but there was an expectation within SOP's middle and top ranks that computer technology could also be used to develop engineering applications.[29]

Photogrammetry at SOP

Mexico's geography is dominated by two major mountain ranges, meeting in the interior of the country. Its population concentrated around a handful of urban centers leaving vast amounts of territory unpopulated and unknown. To meet the central government's goal of expanding the country's infrastructure SOP had to substantially increase in the capacity to design and plan for new highways, roads and bridges.[30] By the 1960s SOP had identified the production of high quality topographical maps as a vital prerequisite for its program of large scale infrastructure projects. Map coverage was so incomplete and dated that highway contracts could not even be awarded, as routes were chosen to hug terrain and minimize the construction of bridges and tunnels. But traditional ground based methods of surveying this terrain were too slow and expensive to be practical.

The answer was photogrammetry, the production of topographical maps from aerial photography. Since the mid-1930s 'Compañía Mexicana Aereofoto S.A.' had been Mexico's sole commercial provider of topographic maps produced via photogrammetry. Its pilots understood the special flying techniques needed to produce usable images, and its analysts produced new maps under commission to private and governmental clients. As SOP expanded its infrastructure projects it became more closely involved in the production of maps based on Aereofoto's aerial data. This was highly labor intensive, and so the Structure Department's first major computer project was to partially automate photogrammetry by storing topographic information on punched cards. The decision to go ahead was taken towards the end of 1962.[31] Similar techniques had already been proven in Germany, Sweden and Switzerland (which Piña and two others observed first hand during a two month tour of Europe).

Approval of the project required the lease an IBM 1620 to sit alongside its overloaded 1401.[32] The 1620 was selected as it was both of 'modest' size and highly reliable.[33] Piña was one of approximately ten engineers chosen to receive IBM training in FORTRAN, marking SOP's first adoption of a high level

[27] Gónzales Sánchez, Mario; Cantarell Martínez, Aquiles; and Ortega Soto, Martha (2000) "Génesis de la industria de computo" in Cantarell, A. and Gonzalez, M. (2000) Historia de la computacion en Mexico (vol. I), Mexico DF: Hobbiton Ediciones SA, p. 81.
[28] J. Piña Garza, Personal communication, November 24, 2009.
[29] Fernando Espinoza, the head of the Projects and Laboratories Bureau, was a driving force in the adoption of computer technology at SOP and was keen to see the success of the photogrammetry project.
[30] J. Piña Garza, Personal communication, December 2, 2009.
[31] J. Piña Garza, Personal communication, November 24, 2009.
[32] J. Piña Garza, Personal communication, December 2, 2009.
[33] J. Piña Garza, Personal communication, November 24, 2009.

programming language. Five of these engineers were selected as the Programming Unit[34]: three of them were promising recent graduates from UNAM (including Piña). The two others were more senior and experienced in the design of roads and highways.

The project team soon discovered that by changing a small number of punched cards a process initially thought of as one of labor substitution and mechanization became one of optimization: the combination of photogrammetric information together with electronic calculation improved the alignment of the highway. Piña claims that this resulted in savings in the order of 10 to 15 percent of the overall expected cost of the construction, which more than compensated the cost of the additional effort to input data in punched card form. [35]

ICA acquires Aereofoto

Aereofoto's business evolved during the 1960s, as it conducted more work for SOP and its subcontractors. But the company was decapitated by the untimely death of its founder Luis Struck and his two sons in two separate airplane accidents. This led his widow and sole owner to sell the company to the engineering firm ICA, one of its main clients and a major contractor for SOP.[36] Victor San Miguel, then general manager of SOLUM (ICA's soil mechanics business) suggested the purchase of Aereofoto. Aereofoto's revenues were modest but a key aim was to facilitate contacts with government officials, learn of their plans and future priorities and thus get a heads up to eventual civil engineering contracts.[37]

Political connections were crucial to success in Mexico under the PRI, particularly for a firm like ICA eager to increase its role in the state driven construction sector. ICA was led by Bernardo Quintana Arrijoa, a colorful and charismatic leader who was the company's president until his death in August 1984.[38] In July 1947 Quintana had assembled a group of 18 engineers, then aged between 23 and 28 years old, to establish the firm as a partnership. Like other engineering firms created by the growing cadres of Mexican civil engineers, ICA needed to establish credibility, capabilities, and government connections sufficient to bid competitively for large urban projects and other infrastructure contracts. From the late 1940s into the 1970s a wave of economic nationalism inspired governments throughout Latin America to encourage the development of local firms and reduce reliance on imports and foreign companies. ICA's success in delivering to the Mexican government, followed by the construction of the Alto Anchicayá dam in the Colombian Andes in the late 1960s and several highways in Central America during the 1970s, effectively

[34] J. Piña Garza, personal communication, November 21, 2009.
[35] J. Piña Garza, Interview, September 19, 2009.
[36] ICA used aerial mapping until the mid-1980s and satellite sources only after 1990. E. Buzio, "Resguarda ICA acervo aerofotográfico," *Grupo Reforma*, August 10, 2005, available: http://anuario.ajusco.upn.mx/site?accion=articulo&id_art=78154&tema=
[37] A. Dovalí Ramos, Interview, September 25, 2009.
[38] *ICA*, "Nuestra historia," available: http://www.ica.com.mx/home_ica.htm?idioma=sp; Dirección de Relaciónes Públicas del Grupo ICA, *El Grupo ICA a 1967*, México D.F.: Grupo ICA, 1967, p. 1.

positioned the firm as the first indigenous Mexican company with major international activities.

In 1965, when it purchased Aereofoto, growth through acquisition was a new strategy for ICA. Since the 1950s ICA had regularly been spinning of parts of its fast growing business as independent companies that sold their services externally to the market and internally to other companies within the group (at ostensive market prices). By 1967 there were 30 such companies, employing almost 20,000 persons and forming what was then called "Grupo ICA."[39] ICA aimed to maximize the reinvestment of after-tax profits and reduce tax payments by obscuring a contract's net profit inside its web of seemingly independent companies.[40] This resulted in the group being run by a number of 'divisional viceroys', hindered the development of standardized processes, procedures and practices, and gave no incentives to share common facilities (including computing equipment).[41] ICA retained its partnership structure well into the 1990s, sharing dividends from its different businesses among its partners. The creation of new companies was seen as a crucial step in advancement toward this exalted and lucrative position. ICA's partnership structure was unusual amongst capital intensive firms and large Mexican enterprise, but its legal structure as a collection of independent firms with common ownership was not uncommon. Similar "Grupos" existed in a variety of Mexican industries.[42]

The Arrival of the IBM 1130

Shortly after its acquisition by ICA, Aereofoto secured a hefty contract to draw topographic maps of large irrigation areas based on photogrammetry.[43] San Miguel oversaw the running of Aereofoto while a permanent general manager was appointed. He approached Piña regarding the possibility of deploying in Aereofoto a system similar to that at SOP.[44] Soon Antonio Dovalí Ramos, an up and coming young engineer, was appointed general manager of Aereofoto. Like San Miguel, he believed that manual processes for creating maps through the combination of aerial photographs and topographic information were tedious and prone to error.[45] For instance, correlating information required the four people involved in

[39] Ten of these were grouped into building and construction ('Empresas Constructoras'), four related to technical services ('Servicios Técnicos'), three into auxiliary services to construction ('Servicios Auxiliares a la Construcción'), one in real estate management ('Inmobiliarias') and eleven in heavy construction engineering ('Industria de Mécanica Pesada'). Dirección de Relaciónes Públicas del Grupo ICA, *El Grupo ICA a 1967*, México D.F.: Grupo ICA, 1967, pp. 1, 5.

[40] A. Dovalí Ramos, Interview, September 25, 2009 and J. Piña Garza, Personal communication, December 02, 2009.

[41] J. Piña Garza, Interview, September 19, 2009; L.E. Maumejean, Interview, September 15, 2009.

[42] e.g. Taeko Hoshino, "The Alfa Group: The Decline and Resurgence of a Large-Scale Indigenous Business Group in Mexico," *The Developing Economies* 31, no. 4 (1993), John Sargent, "Getting to Know the Neighbours: 'Grupos' in Mexico," *Business Horizons*, no. Nov-Dec (2001), Gustavo del Angel Mobarak, "The Corporate Governance of the Mexican Banking System. A Historical Perspective: 1940-2000". Centro de Investigaciòn y Docencia Econòmicas (CIDE) Nùm 373 (Mèxico, D.F.: 2002), Hugo Ceròn Anaya, "Identity of the Mexican Entrepreneurial Elite, 1970-1980" (University of Essex, 2003), Julio Labastida, *Grupos Económicos Y Organizaciones Empresariales En México* (México, D.F.: Alianza Editorial / UNAM, 1986). Garrido, C. (1994) Los grupos económicos en México. *Revista de la Cepal*, 54. Roett, R. (Ed.) (1998) *Mexico's Private Sector: Recent History, future Challenge*, London, Boulder. Admittedly, during this era other large firms were moving toward complex structures with multiple levels of professional management, though in most cases families rather than diverse partnerships remained the core owners of the business. Dávila and Miller have noted that one of the most intriguing issues, in terms of Latin American business history, is the lack of research on how the family business groups that dominate most countries in region incorporated professional management as they grew in the course of the last century [Rory Miller and Carlos Dávila, "Introduction," in *Business History in Latin America: The Experience of Seven Countries* ed. Rory Miller and Carlos Dávila (Liverpool: Liverpool University Press, 1999), 15.]

[43] B. Bátiz Echavarria, Interview, September 15, 2009.

[44] J. Piña Garza, Interview, September 19, 2009.

[45] A. Dovalí Ramos, Interview, September 25, 2009.

calculations at Aereofoto to work with 16 digit decimals in operations involving logarithms and trigonometric functions. Since the demand for large projects at Aereofoto was influenced by requests for up to date maps and cartography, workloads were unpredictable. This made staffing difficult.

Having decided to duplicate the computerized photogrammetry operation built by Piña at SOP, Aereofoto was in urgent need of two things: a computer and a computer center manager. In the months that followed his appointment as general manager, Dovalí had several meetings with Quintana in order to secure the computer. This was an uphill struggle. ICA's hierarchy in general, and Quintana in particular, tended to avoid capital investment and were not convinced of the benefits of computer technology. Dovalí won agreement by promising immediate savings from partially automating Aereofoto's labor intensive calculation process.[46]

Piña, acting as external consultant, oversaw the selection of the computer and programming team.[47] He was given free rein to choose staff and equipment. By the mid-1960s it was increasingly evident to those involved in Mexican computing that their second generation (transistor-based) machines such as the 1401 and 1620 would soon be replaced with new models.[48] At ICA the selection strongly favored IBM, thanks in part to its prevalence within the Mexican government[49] (ICA's main client). IBM faced only limited competition in Mexico and was seen as the most (if not the only) credible provider with infrastructure to service computer equipment in Mexico.[50] Moreover, ICA had an existing relationship with IBM, having leased its tabulators to help control the location and servicing of earth-moving equipment.[51] The only European competitor in Mexico was GE-Bull (servicing the National University and Banamex) while Burroughs and Honeywell were the only other US manufacturers with local servicing facilities.[52]

Piña chose the IBM 1130 over the smallest computers from the company's System 360 range, believing it more suited to engineering projects. Introduced in 1965, the 1130 'was IBM's least-expensive computer to date, and was aimed at price-sensitive, computing-intensive technical markets like education and engineering'.[53] The 1130 addressed many of the shortcomings of the 1620, used by Piña at SOP. For instance, the 1130's removable disk was seen as more versatile than the 1620 fixed storage device. At 64k the 1130's memory was substantially bigger than the 1620's 60,000 digit capacity storage.[54] ICA's order

[46] J. Piña Garza, Interview, September 19, 2009.
[47] J. Piña Garza, Personal communication, November 24, 2009.
[48] J. Piña Garza, Personal communication, November 24, 2009.
[49] Gónzales Sánchez, Mario; Cantarell Martínez, Aquiles; and Ortega Soto, Martha (2000) "Génesis de la industria de computo" in Cantarell, A. and Gonzalez, M. (2000) *Historia de la computación en México* (vol. I), Mexico DF: Hobbiton Ediciones SA, p. 77
[50] J. Piña Garza, Interview, September 19, 2009.
[51] J. Piña Garza, Personal communication, December 2, 2009.
[52] B. Bátiz Echavarria, Interview, September 15, 2009; J. Piña Garza, Interview, September 19, 2009. Sperry-Univac seems to have made inroads with some banks and Control Data with insurance companies while Olivetti arrived in the mid-1960s to service newspapers. See further Cantarell Martínez, Aquiles (2000) "Los convidados al mercado" in Cantarell, A. and Gonzalez, M. (2000) *Historia de la computación en México* (vol. I), México DF: Hobbiton Ediciones SA, pp. 83-6.
[53] "IBM 1130 Computing System," available: http://ibm1130.org.
[54] A. Dovalí Ramos, Interview, September 25, 2009 and J. Piña Garza, Personal communication, November 24, 2009.

for the 1130 was made a couple of weeks after it was announced in March of 1965 in the US. This was the second order for the machine anywhere and the first to be deployed outside the USA.[55] It arrived at Aereofoto in 1966.

Finding a manager for the new installation was easier. After the computer had been installed, Piña was hired full-time by Aereofoto and named Chief of the Electronic Computer Department ('Jefe del Departamento de Cómputo Electrónico'). In part this followed a pattern familiar in American companies since the early 1950s in which members of the committee established to do a "feasibility study" of computerization lead the new department once a decision to purchase is made. However this Mexican case has an interesting twist, since Piña had conducted the study while an employee of SOP, a state ministry. His departure thus represented a transfer of tacit knowledge from part of the government apparatus into a closely allied part of a private company.

The new department needed staff. Piña employed ten newly graduated engineers to be trained on the job as computer programmers and analysts (all male), most of whom were graduates from the National University's Faculty of Engineering and had FORTRAN experience.[56] The team also included four female punched card operators as well as Bernardo Bátiz Echavarria, who had firsthand knowledge of computer programming through recent doctoral courses in Operations Research at the Wharton School (thanks to ICA's scholarship program).[57] It was a fairly informal working environment. Computer programmers and machine operators in particular shared the workload and many became 'jacks of all trades'.[58] This was in sharp contrast to the strictly hierarchical organizational structure typical of Mexico in the 1960s.

[55] J. Piña Garza, Personal communication, November 24, 2009.

[56] One of this was Luis Enrique Maumejean, graduate in civil engineering from Universidad Iberoamericana where he had worked with an IBM 1620 (L.E. Maumejean, Interview, September 15, 2009). It is not clear when this private university installed its computer equipment but undergraduate courses in electrical engineering had 19 lecturers and 50 students in 1957. J.J. Ledesma, *Trayectoria Historico-Ideologica de la Universidad Iberoamericana*, vols. 1 & 2, México, D.F.: Universidad Iberoamericana, 1985, p. 434.

José Piña Garza and Bernardo Bátiz Echavarria, both were instrumental in the running of the IBM 1130 and the purchase of the CDC 3300. September 2009.

Even though the 1130 required an air-conditioned room, a dust free environment, and card punches and readers for input, it remained small and cheap compared to other computers of its day (and to much of the other equipment needed by a heavy engineering company).[59] The monthly rent was roughly equivalent to the monthly payroll of three senior engineers so its cost could easily be recouped if effective applications were found.[60]

The first IBM 1130 at Aereofoto, circa1966. Courtesy of Fundación ICA.

As is evident in the picture there were severe limitations in room that housed the first machine. Temperature was controlled through an air-conditioning unit mounted on a window while cables were initially exposed (later covered with makeshift cardboard covers).[61]

Establishment of an Internal Service Center

Computing practice was shaped profoundly by ICA's reliance on market mechanisms to coordinate its many subsidiaries. The newly created computer centre team at Aereofoto had a mandate to sell its services to other companies within the group by providing computerized support for engineering projects.[62] Some of these could benefit from standard 1130 applications such as those for project management and structure cost estimates.[63]

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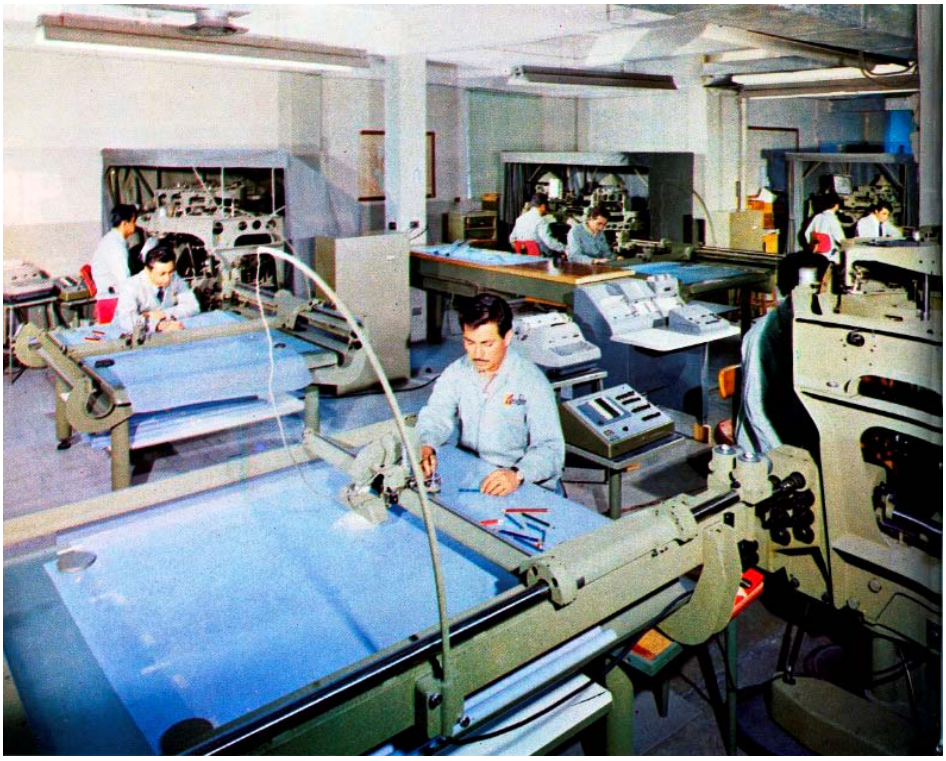
[57] J. Piña Garza, Interview, September 19, 2009.
[58] L.E. Maumejean, Interview, September 15, 2009.
[59] J. Piña Garza, Interview, September 19, 2009.; B. Bátiz Echavarria, Interview, September 15, 2009.
[60] J. Piña Garza, Personal communication, November 24, 2009.
[61] J. Piña Garza, Personal communication, November 29, 2009.
[62] B. Bátiz Echavarria, Interview, September 15, 2009.
[63] J. Piña Garza, Interview, September 19, 2009. See further Campbell-Kelly, Software, p.89.

Computerization of engineering applications went well.[64] But an uneven flow of work threatened to leave the computer idle for long periods of time. Dovalí therefore pushed for the development of administrative applications, even though the 1130 was not designed for them and the computer staff had expertise in engineering rather than business systems analysis. At the instance of Fernando Favela (vice president of the Heavy Engineering division, 'vicepresidente de la División de Ingeniería Pesada') the first of these was a program for the accounting control of construction equipment.[65] This involved keeping a tally of hourly use of earth moving equipment by different companies at different locations. These machines were owned by ICA and provided to subsidiaries at market prices. This application benefited from a pre-existing procedure based on punched-cards and electro-mechanic tabulators.[66] However, the computer program also estimated depreciation charges and kept a record of service and maintenance per machine.[67]



Mechanization of engineering projects at ICA. Photogrametry capabilities for highway design included a punched card machine (towards the back). Aereofoto circa 1967. Courtesy of Fundación ICA.

In parallel the team built a payroll system for Aereofoto. It automated manual processes by updating staff turnover files and daily attendance to generate paychecks as well as debits and credits to the general ledger. The payroll was run weekly and paid in cash. This application was attractive because it would consume

[64] A. Dovalí Ramos, Interview, September 25, 2009; J. Piña Garza, Interview, September 19, 2009.
[65] J. Piña Garza, Interview, September 19, 2009.; B. Bátiz Echavarria, Interview, September 15, 2009; J. Piña Garza, Personal communication, December 2, 2009.
[66] J. Piña Garza, Personal communication, December 2, 2009.
[67] L.E. Maumejean, Interview, September 15, 2009.

computer time on a predictable basis.[68] Programming the payroll application proved to be quite a challenge.[69] The 1130 then had no COBOL compiler and its FORTRAN used floating point arithmetic unsuited for accounting purposes. Adding and multiplying subroutines were needed to ensure that the accounting tally for pesos and cents was accurate.[70]

Why was such a generic application developed from scratch? IBM did offer some sort of payroll application for the 1130. But IBM's software was based on US laws, requirement and organizational practices. Many Mexican companies (within and outside ICA) had idiosyncratic practices and requirements that made localizing US software more expensive that programming from first principles.[71] And, even in the US, the market for generalized application software had not yet developed.[72]

Scaling up Computer Capabilities

Aereofoto soon needed more computer power. Quintana had convinced General Alfonso Corona del Rosal, the newly appointed Mexico City regent ('Jefe del Departamento del Distrito Federal', 1966-1970), to build a subway system ('Metro') in support of the Olympic games (1968) and Football World Cup (1970). ICA promised delivery in record time.[73] Aereofoto's programming team developed operations research simulation programs (most in FORTRAN but some using the General Purpose System Simulator or GPSS) to estimate its optimal passenger loads and train lengths. When the contract was granted ICA faced the challenge of managing a weekly payroll of up to 12,000 manual laborers hired within short periods of time by different companies within ICA.[74] A tax reform introduced in 1967[75] required that companies report consolidated annual income and tax withheld per worker to the Finance Ministry.

In response to the increased workload, a second IBM 1130 was leased. This installation had twice the memory of its sibling, two more removable disk units, an additional magnetic tape reader/writer (used mainly for back-ups), cables covered under 'proper' flooring , and 'more appropriate' air-conditioning.[76]

[68] L.E. Maumejean, Interview, September 15, 2009.

[69] To meet cash payments the main printout was a tally of how many bills and coins of each denomination had to be inserted in pay envelope. Dealing with actual cash was outsourced to a securities transport and armored truck company. Besides weekly and annual taxes, the system also had to calculate weekly and annual contributions by individuals to the national health service ('Seguro Social') as well as aggregate bimonthly reports to it. At the end of the calendar year, companies also had to make pro-rata payments of a fixed portion of after tax profits to all employees ('reparto de ultilidades'). Some of the companies being serviced also required 'ad hoc' reports by project or function so they could inform their cost and management accounting systems. *Source*: J. Piña Garza, Personal communication, December 2, 2009.

[70] J. Piña Garza, Interview, September 19, 2009.

[71] L.E. Maumejean, Interview, September 15, 2009.

[72] T. Haigh, "Software in the 1960s as Concept, Service, and Product" IEEE Annals of the History of Computing, vol. 24, no. 1, January-March 2002, pp. 5-13.

[73] B. Bátiz Echavarria, Interview, September 15, 2009.

[74] L.E. Maumejean, Interview, September 15, 2009; B. Bátiz Echavarria, Interview, September 15, 2009.

[75] The 'Ley del Impuesto sobre la Renta' introduced a 'Impuesto sobre Productos del Trabajo' or ISPT.

[76] J. Piña Garza,, Personal communication, November 29, 2009.

Second IBM 1130 at Aereofoto circa 1968. This time an effort was made to house it under more suitable conditions. Courtesy of Fundación ICA.

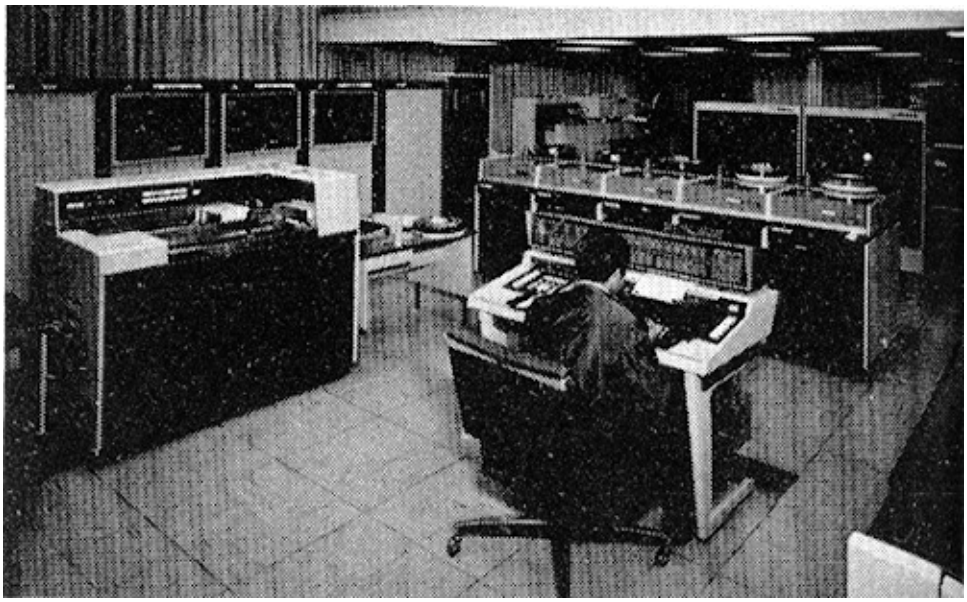
Aereofoto's leaders anticipated further outsourcing of payrolls, general accounting applications and project management from other firms within ICA. In January 1970 a new company was established within ICA called 'Procesos y Sistemas de Información, S.A.' (PSI). The idea was for the computer installations to grow into a general purpose company that 'offered all services currently available around electronic computing'.[77] All those in Aereofoto involved with computing were relocated to staff the new company, with Dovalí as general manager ('Gerente General'), Piña as second in command ('Subgerente General') and Bátiz Echavarria as chief operations manager ('Jefe de operaciones'), overseeing the day to day running of computer related projects, computer selection and details of the new computer centre.[78]

The IBM 1130s remained unsuited to administrative applications. These ambitious plans demanded a newer, larger computer. Quintana was again reluctant to release additional funds for the new machine. During their negotiations Dovalí suggested placing the computer in a glass plated room on the ground floor of the newly opened central office building (in the corner of Mineria No. 145 and Viaducto Miguel Alemán, Col. Escandon, Mexico City). This building embodied modernist architectural concepts such as open plan and floor to ceiling glass entrance. It would be placed right in the front entrance and across the hall from the elevator bank (leading to Quintana's office). Dovalí remembers telling Quintana: 'you are going to be able to show off all the little lights, because these machines have loads of them'.[79] Quintana finally warmed to the idea of a new computer as a symbol of modernity and agreed to the replacement.

[77] *Establecimiento de un servicio público de computo electrónico*, Compañía Mexicana Aereofoto, S.A., circa 1970, p. B.

Several manufacturers with local representatives were considered including IBM, RCA, Victor, and Honeywell.[80] Eventually the team chose Control Data Corporation, which offered a 3300 computer at the price of the smaller 3100.[81]

The new machine started working on February 1970.[82] This computer, and its staff of 130 people, were claimed to constitute one of the top ten computer centers in Mexico.[83] The ground floor at Mineria 145 catered to its special requirements for power, temperature, humidity and dust control. Cables were hidden from view behind false flooring and ceilings. CDC not only supervised but also advanced the cost of fitting the showpiece room for the computer.[84] Staff was initially housed in the mezzanine floor overlooking the glass plated computer area (but eventually re-located to the basement just below the computer).



The CDC 3300 at ICA's headquarters in Minería 145 (circa 1970). Punched card reader and magnetic tape units to the left, removable disk units towards the back. Curtains to front and back of the building were drawn to help with temperature control. Towards the top there is a glimpse of the mezzanine floor housing programmers. Courtesy of Fundación ICA.

The increase in staff numbers allowed for more rigorous specialization and formal organization within the computer team, with some focusing on the operating system, others on computer operation, managing data input, the payroll system, engineering applications, and so on.[85] But the combination of rapid growth, high

[78] B. Bátiz Echavarria, Personal communication, November 29, 2009.
[79] A. Dovalí Ramos, Interview, September 25, 2009.
[80] B. Bátiz Echavarria, Interview, September 15, 2009.
[81] B. Bátiz Echavarria, Interview, September 15, 2009.
[82] F.P. Guerrero, *Propuseta a Grupo ICA (1-1078)*, México, D.F., Arthur D. Little de México S.A., May 5, 1970, p. 1.
[83] 'PSI: apoyo técnico',*Boletín del Grupo (*circa 1970),México, D.F.: Departamento de Relaciones Públicas, p. 1.
[84] J. Piña Garza, Interview, September 19, 2009.
[85] L.E. Maumejean, Interview, September 15, 2009.

staff turnover and poor documentation soon resulted in administrative mayhem.[86] Moreover, new graduates within the 35 or so programming and computer operating staff were keen to learn new computer languages (such as IBM's APL) regardless of their suitability for the firm's actual needs.[87] Isolating computer staff and equipment behind physical as well as organizational walls was a bit of a shock for some, particularly to those who had more intimate contact with computer equipment at university.[88]

The CDC 3300 was plagued with problems.[89] In theory it would require only a couple of hours to run the same process that took a day on the old IBM 1130.[90] But failures were very frequent. Some were the results of poor management -- installing the wrong update or software package.[91] The new integrated circuit technology was unreliable, as the soldering of circuits onto boards was prone to loosen.[92] Power conversion was one of the most frequent (and frustrating) sources of operational failure.[93] The 3300 required 400 Hz electrical power and came with a converter from the 60 Hz used in the US. Mexico's 50 Hz standard required a further convertor.[94] Fortunately the CDC's high throughput meant that when it actually functioned properly for a few hours it could quickly clear the accumulated backlog of jobs.

CDC had promised to build up capabilities to deliver a highly reliable and swift engineering support for Mexican companies.[95] But its Mexican engineering support and servicing teams were not set up to deliver on its promises. Engineers and spare parts often had to be flown in from the US and this increased the time to provide a solution.[96] This was in sharp contrast to the service IBM had provided to Aereofoto, as IBM's service engineers were knowledgeable, available immediately at any time of day (or night) and prompt to secure spare parts.[97]

By mid-1970 the credibility of the PSI team was in freefall as quite often the machine failed to be ready to run weekly payroll (manual workers at Metro organized more than one revolt in response). To make matters worse, frustrated with the key punching, Dovalí had insisted that the 3300 should have an Optical Character Recognition (OCR) device.[98] OCR was intended to speed up and reduce error in data capture tasks. But even where volume was sufficient to use them continuously, the OCR devices of the late 1960s and 1970s were very expensive and could only capture half of the data on ICA's forms as much was hand

[86] L.E. Maumejean, Interview, September 15, 2009.
[87] L.E. Maumejean, Interview, September 15, 2009.
[88] L.E. Maumejean, Interview, September 15, 2009.
[89] A. Dovalí Ramos, Interview, September 25, 2009; J. Piña Garza, Interview, September 19, 2009.; L.E. Maumejean, Interview, September 15, 2009.
[90] L.E. Maumejean, Interview, September 15, 2009.
[91] L.E. Maumejean, Interview, September 15, 2009.
[92] J. Piña Garza, Interview, September 19, 2009.
[93] J. Piña Garza, Interview, September 19, 2009.
[94] J. Piña Garza, Interview, September 19, 2009.; B. Bátiz Echavarria, Interview, September 15, 2009.
[95] L.E. Maumejean, Interview, September 15, 2009.
[96] J. Piña Garza, Interview, September 19, 2009.
[97] J. Piña Garza, Personal communication, November 24, 2009
[98] A. Dovalí Ramos, Interview, September 25, 2009; J. Piña Garza, Interview, September 19, 2009.

written.[99]

Offering Computer Bureau Facilities through Joint Ventures

PSI struggled to increase its volume of internal 'client' companies as planned, even as the Metro construction project, and attendant stream of payroll processing income were beginning to wind down.[100] Maximizing the use of the CDC and finding new income streams was crucial. An external group of consultants based at Arthur D. Little de México S.A. submitted a proposal in May 1970 to identifying and prioritize areas for software development.[101] In 1970 Dovalí moved with some of the technical team from Aereofoto to set up a consulting and special projects company called ICATEC.[102] By then the PSI team had started to develop a large number of engineering and administrative applications around the 3300, but without much input from the managers of ICA's companies who were their prospective customers.[103] For these managers, adding transparency to their operations would mean losing opportunities to 'dress up' financial performance. Payroll processing and accounting work was not consolidated in the computer center and continued to be scattered across individual businesses. This killed PSI's hopes of becoming a leading local provider of computer and software-related consulting services.

The search for new income streams also inspired planning for a joint 'computer utility' venture. The idea originated with the success of Doval and Bátiz-Echavarria in deploying a machine maintenance application by installing a time-sharing terminal from University Computer Corporation (UCC) in the border town of Brownsville, Texas to support an engineering contract in the Mexican side of the border.[104] Thus was born the idea of a shared service to give other Mexican firms access to computer capacity. US-based computer services organizations could assist with software development and localizing software packages as well as offering time sharing and teleprocessing services inside and outside ICA.[105] However, negotiations with the Americans stalled chiefly because the Mexican government retained the monopoly in data transmission.[106]

Lack of progress led Piña in 1971 to explore the possibility of developing a joint computer centre with Banco del Atlántico, a mid-sized financial institution.[107] The idea was to develop applications for banking, engineering, and general purpose computing. To study the options another consulting firm was employed.

[99] A. Dovalí Ramos, Interview, September 25, 2009; J. Piña Garza, Interview, September 19, 2009.

[100] J. Piña Garza, Interview, September 19, 2009.

[101] The proposal considered a US$30,900fee and plus US$5,500 in expenses. The consulting team was made out of Arnoldo C. Hax, Joseph J. Leshick, Fernando Pérez Guerrero and José Sánchez Padilla. F.P. Guerrero, *Propuseta a Grupo ICA (1-1078)*, México, D.F., Arthur D. Little de México S.A., May 5, 1970, pp. 8, Appendix.

[102] B. Bátiz Echavarria, Interview, September 15, 2009.

[103] J. Piña Garza, Interview, September 19th 2009.; L.E. Maumejean, Interview, September 15, 2009.

[104] B. Bátiz-Echavarria, Personal communication, November 29, 2009.

[105] J. Piña Garza, Interview, September 19, 2009. Note that in 1972 Grupo ICA had 41 subsidiaries and took part in many joint ventures, plus holding minority shares in other enterprises ("Empresas ICA Sociedad Controladora, S.A. de C.V.," available: http://www.fundinguniverse.com/company-histories/Empresas-ICA-Sociedad_Controladora-SA-de-CV-Company-History.html. For details of a successful non-technology joint venture with a US partner in the 1980s and 1990s see G. Gordon and T. Williams, "How do you spell success in Mexico? CALICA," *Business Horizons*, Jan-Feb, 2001, pp. 11-18.

[107] C. Sama and J. Piña, *Consideraciones para la integración del centro de computo PSI-BANATLAN*, México, D.F., Ingeniería de Sistemas BANATLAN-Procesos y Sistemas de Información S.A., circa 1971.

Its report urged ICA to enter the market and acquire 'the necessary managerial expertise' either with UCC or alone.[108] It was read by ICA's top brass, rather selectively, to justify dropping all plans for commercial timesharing and service bureau operations and focusing PSI on servicing ICA's subsidiaries.[109] Piña's was removed from the management of PSI in 1971, moving over to its sister consulting firm ICATEC.

To salvage the situation the PSI team decided in 1972 to replace its temperamental CDC 3300. An IBM 360/40 arrived as a stopgap until a 370 was delivered in 1974.[110] Only the most profitable applications were retained, among them some engineering applications and payroll of construction workers (as a means of control rather than labor cost saving). This rationalization of scope and reduction of staff size left a profitable, albeit much smaller, operation. By the mid-1970s ICA had finally reached a stable, if conservative, model for the application of computer technology.

Conclusion

During this era computers were spreading beyond their initial beachhead in elite state institutions. According to one estimate, there were 250 computer centers in Mexico in 1967.[111] This grew to 1,200 by 1976, most of which were deployed in Monterrey and Mexico City. This story confirms the need to consider the histories of computer use within the broader contexts of nations and industries. ICA's rise during in 1960s and 1970s reflected its successful alliance with the state during Mexico's nationalistic drive for growth. By the 1990s this model had broken down. Mexican companies fortunate enough to survive the turmoil of the 1980s looked toward global markets as the source of new growth. At ICA financial standardization eventually took place in response to external pressure in preparation for ICA's flotation on the stock exchange in 1992. Reporting requirements and investor expectations drove consolidation of accounting controls, rationalization of subsidiaries, and elimination of the incentives to general managers had to tweak reporting of internal accounting figures.[112] ICA was adopting the US model of a decentralized multidivisional firm held together by rigorous financial controls.

During the 1960s and 1970s, however, ICA represented a distinct and alternative model for corporate organization with profound implications for the development of its computing operations. The computerization movement within ICA was led by a youthful cohort exposed to new technology within the public sector. Strategies and applications were pursued with gusto but without much discipline and without a firm understanding of potential internal and external markets. ICA's structure as a web of interlocking companies required its computer staff to seek a stable income stream from other ICA units and encouraged

[108] ibid, p. 1.
[109] J. Piña Garza, Interview, September 19, 2009.
[110] J. Piña Garza, Personal communication, November 29, 2009.
[111] J. Piña Garza, *La ingenieria de sistemas del Grupo ICA*, ICATEC S.A. Consultores: México, D.F., p. 1.
[112] J. Piña Garza, Interview, September 19, 2009.

them to seek out external customers. But it also starved them of the resources and support needed to effectively enter the nascent markets for computer services, facilities management, or online services. ICA's first computer, the IBM 1130, was intended for engineering applications but was soon switched to administrative data processing work. These ill-fated attempts to rush into unproven business areas were not simply a matter of bad marketing or poor discipline on the part of the computer staff. Ambitious managers felt pressure to grow their teams into profitable, independent companies. Dovalí, Piña and their colleagues pressed on time and again. Dovalí achieved partner status in the mid-1970s after being credited with the establishment of PSI and ICATEC while Piña, partly as a result of the PSI 'fiasco' and his failure to develop the computer utility service, remained a middle manager throughout his career at ICA.

The same distinctive culture and fragmented organizational structure that pushed Piña and his colleagues toward rapid growth and opportunistic pursuit of new business also ensured that they would be deprived of the most obvious source of revenue for most data processing operations: operation of a standardized corporate accounting system. Adoption of standardized accounting and administrative programs implied, and facilitated, the standardization of financial controls and procedures across the company. This promised a huge revenue and steady income stream for PSI, and would have had profound implications for the transparency of ICA's internal accounting systems. But business managers had considerable autonomy and the top ICA managers did little to enforce the rapid introduction of standardized norms and procedures across subsidiaries. Thus the evolution of data processing within ICA was shaped by the evolution of organizational form within Mexico, which must be understood within the distinctive political economy developed under decades of rule by the PRI.