

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

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The Mexican civil engineering firm ICA installed its first computer, an IBM 1130, in 1966. By documenting the development of ICA's computing efforts over almost 15 years, the authors trace the influence of personnel and company practices, examine the development of technical and administrative applications, and explore the computer center's story within the broader history of ICA.

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This article records the evolution of the use of computer technology by the civil engineering firm *Ingenieros Civiles Asociados* (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 traditionally 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.<sup>1</sup> In recent years, attention has turned toward the use of computers in particular social contexts. This reflects a broader turn toward the examination of use

and users within both science studies and the history of technology.<sup>2</sup> However, early computers were purchased, configured, and applied not by isolated individuals but by large organizations. Attention to use therefore requires that we combine several distinct perspectives. First, we must be willing to follow the suggestion of JoAnne Yates in studying organizations, rather than individuals, as computer technology users.<sup>3</sup> Yates also makes a persuasive case for the need to consider entire industries, rather than isolated firms, as agents of computer adoption and has documented the role of trade associations in creating a consensus on the nature and proper application of computers within an industry.<sup>4</sup>

Nevertheless, we must remember that organizations are made up of people and that institutions exist within the minds of individuals and are reproduced and enacted through 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 technology users and adopters and the tendency within business history to treat an entire organization as a single user.<sup>5</sup>

Business historians generally follow a top-down approach to history in which all actions are the result of decisions made by a firm, 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. In contrast, 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 computer technology was 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 of claims to scientific or technical expertise.<sup>6</sup>

Shifting our focus to computer technology in use poses other challenges. A standard computer might be used in distinctive 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.<sup>7</sup> Likewise, by the 1960s the international computer industry was dominated by a handful of firms, mostly American. Still, 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. Cortada has called for research on the international “diffusion” of computer technology, but we prefer to follow a recent trend in characterizing the international transfer of high technology as a process of “appropriation.”<sup>8</sup> 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 article strives to meet Mahoney’s daunting challenge to explore the “histories of computing(s)” in all their richness.<sup>9</sup> The few detailed studies of computer use in particular industries have tended to focus on financial organizations.<sup>10</sup> 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.<sup>11</sup> As a case study of a *grupo industrial*, the article demonstrates some of the challenges (and opportunities) of researching big business in Latin America. As a loose federation of industrial and family interests, the *grupo* is a popular organizational form in the region, but it is under researched 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. Specifically, we look at how purchases were made, benefits afforded 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 setting up and running ICA computer centers.<sup>12</sup> Following established practice in this area, we interviewed people separately, obtained documents from their personal collections to verify details and prompt other contributors, and conducted several rounds of interviews with key informants in which questioning grew increasingly detailed.<sup>13</sup> This process of triangulation between sources eventually yielded a stable and robust narrative. Early drafts were also cross-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 the National University (*Universidad Nacional Autónoma de México*, or UNAM) in Mexico City (from which he graduated in 1962).

UNAM was a central institution of the emerging Mexican technocratic elite.<sup>14</sup> 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.<sup>15</sup>

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## Piña's career exemplifies the transfer of expertise and technological capabilities from the public to the private sector.

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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 becoming the engine for economic development and modernization.<sup>16</sup> Mexico's growth rate surged in the 1960s, and the country was hailed as a model for Latin America.<sup>17</sup>

Computerization was an integral part of this state-led push for modernization. Many members 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 the public to the private sector. After joining the Ministry of Infrastructure, he was soon trained in assembly language programming for its soon-to-arrive IBM 1401.<sup>18</sup> Between 15 and 20 participants attended two of these courses each.<sup>19</sup> Because the 1401 was overseen by the General Services Department (*Departamento de Servicios Generales*) and was aimed at administrative processes (general accounting and payroll), most attendees had an accounting or business background. Piña was the only participant from the Projects and Laboratories Bureau (*Dirección General de Proyectos y Laboratorios*), the area responsible for highway, bridge, and building design. Two other young engineers worked at the Constructions Bureau (*Dirección General de Construcción*).<sup>20</sup> Even the trainers hired by IBM to prepare SOP staff for their new work found the content new, preparing for their duties by

reading manuals beforehand and learning by working through exercises themselves as the course progressed.<sup>19</sup>

SOP's new computer was part of a sizable wave of installations within Mexican state institutions in the early 1960s. Universities led the way. The first computer in Mexico was an IBM 650, two of which were installed in 1958, one at UNAM and another at the University of Nuevo León in Monterrey.<sup>21</sup> Other state and private universities were not far behind. For instance, the National Polytechnic Institute (*Instituto Politécnico Nacional*) installed an IBM 709 in 1961.<sup>22</sup> Early applications were in technical and scientific computing, although administrative work followed at UNAM in 1965 when an IBM 1440 hosted payroll and mechanized the accounting function.<sup>23</sup>

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.<sup>24</sup> The first large application in private business took place in 1962, when Monterrey-based Grupo Vitro installed another 1401.<sup>25</sup> 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 the Ford Motor Company.<sup>26</sup> 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 new site. However, they only looked after the hardware and answered specific queries. Assembler-based administrative applications soon saturated the capacity of the 1401 at SOP,<sup>27</sup> but there was an expectation within SOP's middle and top ranks that computer technology could also be used to develop engineering applications.<sup>28</sup>

### Photogrammetry at SOP

Mexico's geography is dominated by two major mountain ranges, meeting in the interior of the country. Its population is 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 its capacity to design and plan for

new highways, roads, and bridges.<sup>20</sup> 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. Traditional ground-based methods of surveying this terrain were too slow and expensive to be practical.

The solution was *photogrammetry*, the production of topographical maps from aerial photography. Since the mid-1930s, *Compañía Mexicana Aereofoto* 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, so the Structure Department's first major computer project was to partially automate photogrammetry by storing topographic information on punched cards. The decision to move forward was made toward the end of 1962.<sup>27</sup> Similar techniques had already been proven in Germany, Sweden, and Switzerland (which Piña and two others observed firsthand during a two-month tour of Europe).

Approval of the project required leasing an IBM 1620 to sit alongside its overloaded 1401.<sup>20</sup> The 1620 was selected because it was both modest in size and highly reliable.<sup>27</sup> Piña was one of approximately 10 engineers chosen to receive IBM training in Fortran, marking SOP's first adoption of a high-level programming language. Five of these engineers were selected as the programming unit, and three of them were promising recent graduates from UNAM (including Piña).<sup>19</sup> The two others were more senior and experienced in road and highway design.

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 highway's alignment. Piña claimed that this resulted in approximately 10 to 15 percent savings

in the overall expected construction costs, which more than compensated for the cost of the additional effort to input data in punched-card form.<sup>18</sup>

### **ICA Acquires Aereofoto**

Aereofoto's business evolved during the 1960s as it did more work for SOP and its sub-contractors. However, the company was weakened 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 SOP contractor.<sup>29</sup> 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.<sup>30</sup>

Political connections were crucial to success in Mexico under the PRI, particularly for firms such as ICA eager to increase their 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.<sup>31</sup> 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 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 spun off 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 people and forming what was then called *Grupo ICA*.<sup>32</sup> 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.<sup>20,30</sup> 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).<sup>18,33</sup>

ICA retained its partnership structure well into the 1990s, sharing dividends from its various 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 among capital intensive firms and large Mexican enterprises, 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.<sup>34</sup>

### 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.<sup>35</sup> San Miguel oversaw 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.<sup>18</sup> Soon Antonio Dovalí Ramos, an up-and-coming young engineer, was appointed Aereofoto's general manager. 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.<sup>30</sup> For instance, correlating information required the four people involved in calculations at Aereofoto to work with 16-digit decimals in operations involving logarithms and trigonometric functions. Because 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.<sup>18</sup>

Acting as external consultant, Piña oversaw the selection of the computer and programming team.<sup>27</sup> 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.<sup>27</sup> At ICA, the selection strongly favored IBM, thanks in part to its prevalence within the Mexican government (ICA's main client).<sup>36</sup> 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.<sup>18</sup> Moreover, ICA had an existing relationship with IBM, having leased its tabulators to help control the location and servicing of earth-moving equipment.<sup>20</sup> 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.<sup>37</sup>

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."<sup>38</sup> The 1130 addressed many of the shortcomings of the 1620, which Piña had used at SOP. For instance, the 1130's removable disk was seen as more versatile than the 1620 fixed storage device. Equivalent to 64 Kbytes, the 1130's memory was substantially bigger than the 1620's 60,000-digit capacity storage.<sup>27,30</sup> ICA ordered the 1130 just a few weeks after it was announced in March 1965 in the US. This was the second order for the machine anywhere and the first to be deployed outside the US.<sup>27</sup> It arrived at Aereofoto in 1966.

Finding a manager for the new installation was easier. After the computer had been installed, Aereofoto hired Piña full time and named him 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 was made. However, this Mexican case has an interesting twist because Piña had conducted the study while an employee of SOP, a state ministry. His departure thus represented a transfer of tacit knowledge from the government apparatus into a closely allied part of a private company.

The new department needed staff. Piña employed 10 newly graduated engineers (all male) to be trained on the job as computer programmers and analysts. Most of these new engineers graduated from the National University’s Faculty of Engineering and had Fortran experience.<sup>39</sup> The team also included four female punched-card operators as well as Bernardo Bádiz-Echavarría (see Figure 1), who had firsthand knowledge of computer programming through recent doctoral courses in operations research at the Wharton School (thanks to ICA’s scholarship program).<sup>18</sup> It was a fairly informal working environment. Computer programmers and machine operators shared the workload and many became jacks of all trades.<sup>33</sup> This was in sharp contrast to the strictly hierarchical organizational structure typical of Mexico in the 1960s.

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).<sup>18,35</sup> 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.<sup>27</sup>

As Figure 2 shows, the room housing the first machine had severe limitations. Temperature was controlled with an air-conditioning unit mounted on a window while cables were initially exposed. They were later covered with makeshift cardboard covers.<sup>40</sup>

### 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 center team at Aereofoto had a mandate to sell its services to other



Figure 1. José Piña Garza and Bernardo Bádiz-Echavarría (September 2009). Both men were instrumental in the running of the IBM 1130 and the purchase of the CDC 3300.



Figure 2. The first IBM 1130 at Aereofoto, circa 1966. At this early installation, temperature was controlled with an air-conditioning unit mounted on a window while cables were initially exposed. (Courtesy of Fundación ICA.)

companies within the group by providing computerized support for engineering projects.<sup>35</sup> Some of these could benefit from standard 1130 applications such as those for project management and structure cost estimates (see Figure 3).<sup>18,41</sup>

Computerization of engineering applications went well,<sup>18,30</sup> but an uneven workflow 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 insistence of the Vice President of the Heavy Engineering Division Fernando Favela (*Vicepresidente*



Figure 3. Mechanization of engineering projects at ICA, Aereofoto circa 1967. Photogrammetry capabilities for highway design included a punched-card machine (toward the back). (Courtesy of Fundación ICA.)



Figure 4. Second IBM 1130 at Aereofoto, circa 1968. This time an effort was made to house it under more suitable conditions. (Courtesy of Fundación ICA.)

*de la División de Ingeniería Pesada*), the first of these was a program for the accounting control of construction equipment.<sup>18,20,35</sup> This involved tallying 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 preexisting procedure based on punched-cards and electromechanic tabulators.<sup>20</sup> The computer

program also estimated depreciation charges and kept a record of service and maintenance per machine.<sup>33</sup>

The team built a payroll system for Aereofoto at the same time. It automated manual processes by updating staff turnover files and daily attendance to generate paychecks as well as general ledger debits and credits. The payroll was run weekly, and employees were paid in cash. This application was attractive because it would consume computer time on a predictable basis.<sup>33</sup> However, programming the payroll application proved to be a challenge.<sup>42</sup> 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 an accurate accounting tally for pesos and cents.<sup>18</sup>

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, requirements, and organizational practices. Many Mexican companies (within and outside ICA) had idiosyncratic practices and requirements that made localizing US software more expensive than programming from first principles.<sup>33</sup> And even in the US, the market for generalized application software had not yet developed.<sup>43</sup>

### 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 1968 Olympic games and 1970 Football World Cup. ICA promised delivery in record time.<sup>35</sup> Aereofoto's programming team developed operations research simulation programs—most in Fortran but some using the General Purpose System Simulator (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.<sup>33,35</sup> A tax reform introduced in 1967 required that companies report consolidated annual income and tax withheld per worker to the Finance Ministry.<sup>44</sup>

In response to the increased workload, the company leased a second IBM 1130 (see Figure 4). 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.<sup>40</sup>

Aereofoto’s leaders anticipated further outsourcing of payroll, 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* (PSI). The idea was for the computer installations to grow into a general-purpose company that “offered all services currently available around electronic computing.”<sup>45</sup> 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-Echavarría 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 center.<sup>46</sup>

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 Mexico City. This building embodied modernist architectural concepts such as an open plan and a floor-to-ceiling glass entrance. The computer would be placed in the front entrance, across the hall from the elevator bank, leading to Quintana’s office. Dovalí remembered telling Quintana, “You are going to be able to show off all the little lights, because these machines have loads of them.”<sup>30</sup> Quintana finally warmed to the idea of a new computer as a symbol of modernity and agreed to the replacement.

Several manufacturers with local representatives were considered, including IBM, RCA, Victor, and Honeywell.<sup>35</sup> Eventually the team chose Control Data Corporation, which offered a 3300 computer (see Figure 5) at the price of the smaller 3100.<sup>35</sup>

The new machine started working on February 1970.<sup>47</sup> This computer, and its staff of 130 people, were claimed to constitute one of the top 10 computer centers in Mexico.<sup>48</sup> The ground floor at the central office building catered to its special requirements for power, temperature, humidity, and dust control. Cables were hidden from view behind



**Figure 5. The CDC 3300 at ICA’s headquarters (circa 1970). The punched-card reader and magnetic-tape units are to the left, with removable disk units toward the back. Curtains in the front and back of the building were drawn to help control the temperature. Toward the top there is a glimpse of the mezzanine floor housing programmers. (Courtesy of Fundación ICA.)**

false flooring and ceilings. CDC not only supervised but also advanced the cost of fitting the showpiece room for the computer.<sup>18</sup> 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 larger staff allowed for more rigorous specialization and formal organization within the computer team, with some staff focusing on the operating system and others on computer operation, managing data input, the payroll system, engineering applications, and so on.<sup>33</sup> But the combination of rapid growth, high staff turnover, and poor documentation soon resulted in administrative mayhem.<sup>33</sup> 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 (A Programming Language), regardless of their suitability for the firm’s actual needs.<sup>33</sup> 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.<sup>33</sup>

The CDC 3300 was plagued with problems.<sup>18,30,33</sup> In theory, it would require only a couple of hours to run the same process that took a day on the old IBM 1130,<sup>33</sup> but failures were very frequent. Some were the results of poor management—installing the wrong update or software package.<sup>33</sup> The new integrated circuit technology was unreliable because the soldering of circuits onto boards was prone to loosening.<sup>18</sup> Power conversion was one of the most frequent (and



frustrating) sources of operational failure.<sup>18</sup> The 3300 required 400 Hz of electrical power and came with a converter from the 60 Hz used in the US. Mexico's 50 Hz standard required a further convertor.<sup>18,35</sup> Fortunately, the CDC's high throughput meant that when it did function properly for a few hours it could quickly clear the accumulated backlog of jobs.

CDC had promised to build up capabilities to deliver highly reliable and swift engineering support for Mexican companies.<sup>33</sup> Its Mexican engineering support and servicing teams, however, were not set up to deliver on its promises. Engineers and spare parts often had to be flown in from the US, which delayed solutions.<sup>18</sup> This was in sharp contrast to the service IBM had provided to Aereofoto, as IBM's service engineers had been knowledgeable, available immediately at any time of day (or night), and prompt to secure spare parts.<sup>27</sup>

By mid-1970, the PSI team's credibility was in freefall because the machine was often not ready to run the 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.<sup>18,30</sup> OCR was intended to speed up and reduce error in data-capture tasks. Yet, even when volume was sufficient to use them continuously, the OCR devices of the late 1960s and 1970s were expensive and could only capture half of the data on ICA's forms because much was handwritten.<sup>18,30</sup>

### **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 winding down.<sup>18</sup> 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 submitted a proposal in May 1970 to identify and prioritize areas for software development.<sup>49</sup> In 1970, Dovalí moved with some of the technical team from Aereofoto to set up a consulting and special projects company called ICATEC.<sup>35</sup> 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.<sup>18,33</sup> 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 the University Computer Corporation (UCC) in the border town of Brownsville, Texas, to support an engineering contract in the Mexican side of the border.<sup>46</sup> Thus, the idea was born 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 of ICA.<sup>50</sup> However, negotiations with the Americans stalled chiefly because the Mexican government retained the monopoly in data transmission.

Lack of progress led Piña in 1971 to explore the possibility of developing a joint computer center with Banco del Atlántico, a mid-sized financial institution.<sup>51</sup> The idea was to develop applications for banking, engineering, and general-purpose computing. Another consulting firm was employed to study the options. Its report urged ICA to enter the market and acquire "the necessary managerial expertise" either with UCC or alone.<sup>52</sup> It was read by ICA's top brass, rather selectively, to justify dropping all plans for commercial time-sharing and service bureau operations and focusing PSI on servicing ICA's subsidiaries.<sup>18</sup> Piña 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 stop-gap until a 370 was delivered in 1974.<sup>40</sup> Only the most profitable applications were retained, among them some engineering applications and the construction worker payroll (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.<sup>53</sup> 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.

This model had broken down by the 1990s. 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 general managers' incentives to tweak internal accounting reports.<sup>18</sup> 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 them to seek out external customers. However, 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 develop 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. 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.

### References and Notes

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

4. J. Yates, *Structuring the Information Age*, Johns Hopkins Univ. Press, 2005.
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6. Expertise has been a central topic in science studies for many years. For a broad and recent examination, see H. Collins and R. Evans, *Rethinking Expertise*, Univ. of Chicago Press, 2007.
7. J.W. Cortada, *The Digital Hand: How Computers Changed the Work of American Manufacturing, Transportation, and Retail Industries*, Oxford Univ. Press, 2003; J.W. Cortada, *The Digital Hand, Volume 2: How Computers Changed the Work of American Financial, Telecommunications, Media, and Entertainment Industries*, Oxford Univ. Press, 2006; J.W. Cortada, *The Digital Hand, Volume 3: How Computers Changed the Work of American Public Sector Industries*, Oxford Univ. Press, 2007.
8. Discussion of the appropriation of technology emerged 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—as described, for example, in much of the work in R. Eglash et al., eds., *Appropriating Technology: Vernacular Science and Social Power*, Univ. of Minnesota Press, 2004. However, it has also been used to describe international transfer of technology, for example, see M. Hård and A. Jamison, eds., *The Intellectual Appropriation of Technology: Discourses on Modernity, 1900–1939*, 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 *IEEE Annals*: G. Alberts, "Appropriating America: Americanization in the History of European Computing" *IEEE Annals*, vol. 32, no. 2, 2010, pp. 4–7.
9. Mahoney, "The Histories of Computing(s)."
10. In addition to Yates' work, this includes D. de Wit, *The Shaping of Automation: A Historical Analysis of the Interaction between Technology and Organization, 1950–1985*, Verloren, 1994. There has been an increasing interest in Europe for similar studies in banking as suggested by contributions in B. Bátis-Lazo et al., eds., *Technological Innovation in Retail Finance: International Historical Perspectives*, Routledge, 2011.
11. On computing in Mexico, see A. Cantarell and M. González, *Historia de la computación en México* [History of Computing in Mexico], three vols., Hobbiton Ediciones, 2000, 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, no. 1, 1999, pp. 113–134. Developments in Chile during the 1970s are explored in E. Medina, "Designing Freedom, Regulating a Nation: Socialist Cybernetics in Allende's Chile," *J. Latin American Studies*, vol. 38, no. 3, 2006, pp. 571–606, and E. Medina, "Big Blue in the Bottomless Pit: The Early Years of IBM Chile," *IEEE Annals*, vol. 30, no. 4, 2008, pp. 26–41.
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13. L. Hoddeson, "Writing Recent Science: The Historiography of Contemporary Science, Technology, and Medicinem," *The Conflict of Memories and Documents: Dilemmas and Pragmatics of Oral History*, R.E. Doel and T. Söderqvist, eds., Routledge, 2006, pp. 187–200.
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  21. M. Gónzales Sánchez, A. Cantarell Martínez, and M. Ortega Soto, "Génesis de la industria de computo" [Genesis of the Computing Industry], *Historia de la computacion en Mexico* [History of Computing in Mexico], vol. 1, A. Cantarell and M. Gonzalez, eds., Hobbiton Ediciones, 2000, p. 76.
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  26. Gónzales Sánchez, Cantarell Martínez, and Ortega Soto, "Génesis de la industria de computo," p. 81.
  27. J. Piña Garza, personal comm. with B. Bátiz-Lazo, 24 Nov. 2009.
  28. 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.
  29. ICA used aerial mapping until the mid-1980s and satellite sources only after 1990. "La Fundación ICA resguarda 800 mil fotos aéreas del país" [The ICA Foundation Saves 800 thousand Aerial Photographs], Milenio Online, 25 Nov. 2011; <http://impreso.milenio.com/node/9068146>.
  30. A. Dovalí Ramos, interview with B. Bátiz-Lazo, 25 Sept. 2009.
  31. See [http://en.wikipedia.org/wiki/Bernardo\\_Quintana\\_Arriola](http://en.wikipedia.org/wiki/Bernardo_Quintana_Arriola); Dirección de Relaciones Públicas del Grupo ICA [Public Relations Division ICA Group], "El Grupo ICA a 1967" [The ICA Group: 1967], Grupo ICA, 1967, p. 1.
  32. 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 11 in heavy construction engineering (*Industria de Mecánica Pesada*). Dirección de Relaciones Públicas del Grupo ICA, "El Grupo ICA a 1967," pp. 1, 5.
  33. L.E. Maumejean, interview by B. Bátiz-Lazo, 15 Sept. 2009.
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35. B. Bátis-Echavarría, interview with B. Bátis-Lazo, 15 Sept. 2009.
  36. Gónzales Sánchez, Cantarell Martínez, and Ortega Soto, "Génesis de la industria de computo," p. 77.
  37. B. Bátis-Echavarría, interview with B. Bátis-Lazo, 15 Sept. 2009; J. Piña Garza, with B. Bátis-Lazo, 19 Sept. 2009. Sperry-Univac seems to have made inroads with some banks and CDC with insurance companies while Olivetti arrived in the mid-1960s to service newspapers. See further A. Cantarell Martínez, "Los convidados al mercado" [Invited to the Market], A. Cantarell and M. González, eds., *Historia de la computación en México*, vol. 1, Hobbiton Ediciones, 2000, pp. 83–86.
  38. "IBM 1130 Computing System," <http://ibm1130.org>.
  39. One was Luis Enrique Maumejean, graduate in civil engineering from Universidad Iberoamericana, where he had worked with an IBM 1620 (L.E. Maumejean, interview with B. Bátis-Lazo, 15 Sept. 2009). It is unclear 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* [Historical and Ideological Trajectory of the Universidad Iberoamericana], vols. 1–2, Universidad Iberoamericana, 1985, p. 434.
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  42. To meet cash payments, the main printout was a tally of how many bills and coins of each denomination had to be inserted in the pay envelope. The actual cash handling was outsourced to a securities transport and armored truck company. In addition to weekly and annual taxes, the system also had to calculate weekly and annual contributions by individuals to the national health service (*Instituto Mexicano del Seguro Social*) as well as aggregate bimonthly reports. 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 utilidades*). 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. J. Piña Garza, personal comm. with B. Bátis-Lazo, 2 Dec. 2009.
  43. T. Haigh, "Software in the 1960s as Concept, Service, and Product," *IEEE Annals*, vol. 24, no. 1, 2002, pp. 5–13.
  44. The *Ley del Impuesto sobre la Renta* [Income Tax Law] introduced a *Impuesto sobre Productos del Trabajo* (ISPT) [Labor Excise Tax].
  45. "Establecimiento de un servicio público de computo electrónico" [Establishing a Computer Service Bureau], *Compañía Mexicana Aereofoto*, circa 1970, p. B.
  46. B. Bátis-Echavarría, personal comm. with B. Bátis-Lazo, 29 Nov. 2009.
  47. F.P. Guerrero, "Propuesta a Grupo ICA (1-1078)," Arthur D. Little de México, 5 May 1970, p. 1.
  48. "PSI: apoyo técnico" [PSI: Technical Support], group bulletin, Departamento de Relaciones Públicas, circa 1970, p. 1.
  49. The proposal considered a US\$30,900 fee and plus US\$5,500 in expenses. The consulting team consisted of Arnoldo C. Hax, Joseph J. Leshick, Fernando Pérez Guerrero, and José Sánchez Padilla. F.P. Guerrero, "Propuesta a Grupo ICA (1-1078)," Arthur D. Little de México, 5 May 1970, pp. 8, appendix.
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52. C. Sama and J. Piña, "Consideraciones para la integración del centro de computo PSI-BANATLAN," p. 1.
53. J. Piña Garza, "La ingeniería de sistemas del Grupo ICA" [Systems Engineering at Grupo ICA], ICATEC S.A. Consultores, p. 1.



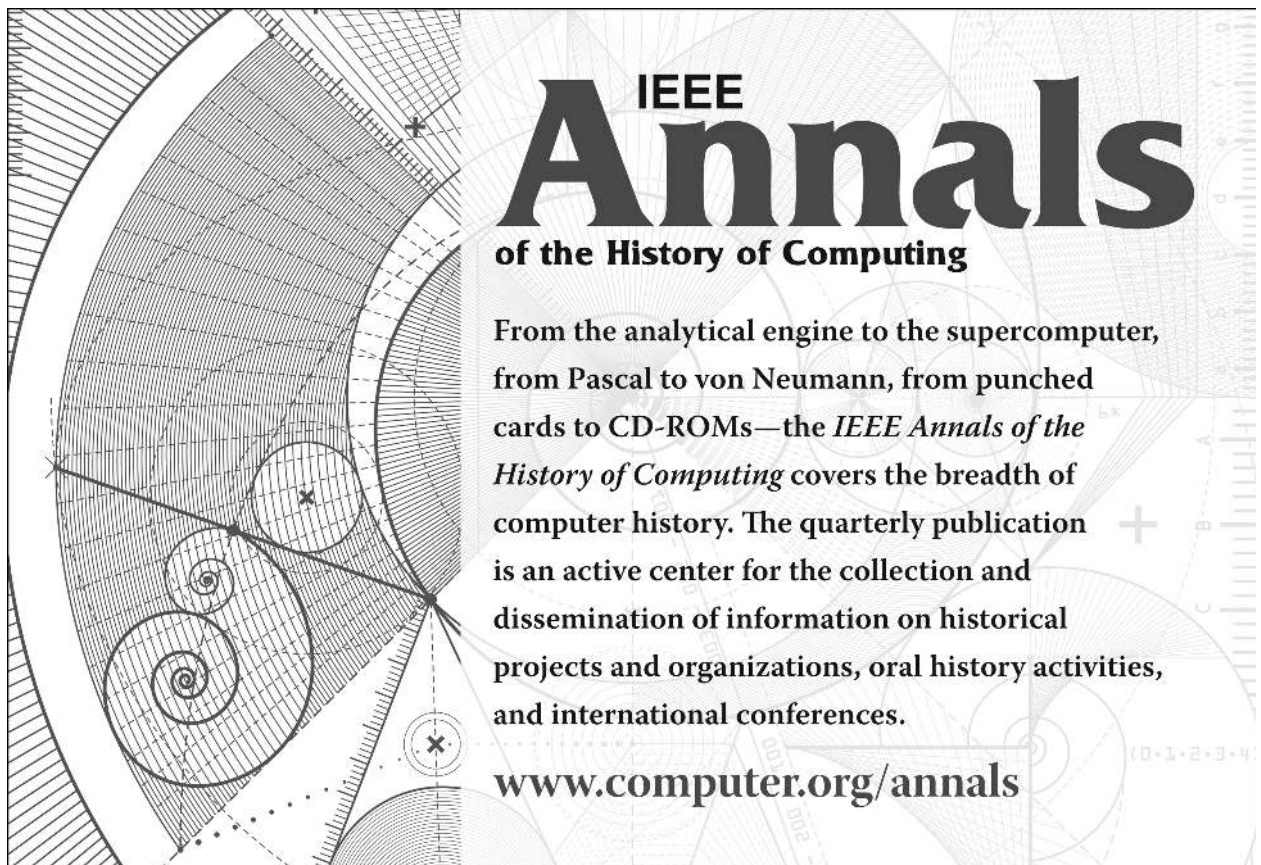
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