The Centre National d'Etude des Télécommunications and the Competitiveness of French Telephone Industry, 1945–1980

Pascal Griset

Introduction

The control of telecommunications is a central stake that largely determines the balance of power among nations.[1] In 1950, France was completely dependent on foreign companies to equip its telephone network. French companies were mainly subsidiaries of ITT[2] and, through lack of funds, the network was old and inefficient. Thus, the problem of competitiveness was twofold. Firstly, the French telephone industry was not able to compete with foreign industries. The national market was therefore totally open to foreign technology, which for a strategic industry had tragic consequences from the point of view of independence and commercial balance. Secondly, the telephone network was not able to perform efficiently, which handicapped the economic development of the country. The solution to this last problem was not in fact really complex—all Postes, Télégraphes, Téléphone (PTT) needed was money to build new lines and provide service to its customers. ITT's subsidiaries were ready to supply new and efficient equipment. However, this solution would make the problem of dependence on foreign technology considerably worse as well as hurt the balance of payments.[3] In order to resolve the two problems simultaneously, France had first to create an independent telephone industry.[4] Competitiveness was the key to achieving this goal. Beyond the "symbolic significance" of this word, "the critical determinants of competitiveness are productivity, improvements, and technological innovation."[5] After the drama of World War II, and starting at a very low level, this multidimensional project constituted a real challenge. This quest for competitiveness has to be analyzed as a fundamental chapter of the history of French industry, but it also constitutes part of a wider ev-

olution included in the context presented by Stanley Hoffmann as ". . . the eternal drama of the relations between the French and their government."[6]

The Technological Bet

According to two leading economic historians, David Mowery and Nathan Rosenberg, "the process of technical innovation has to be conceived of as an ongoing search activity that is shaped and structured not only by economic forces that reflect cost considerations and resource endowments but also by the present state of technological knowledge, and by consumer demand for different categories of products and services." A study of French industrial policy demonstrates that there is another basic element: the pursuit of national independence.

The French Telephone Industry after World War II

A dramatic situation

Compare to other European countries or to the United States, the French telephone network was underdeveloped in 1945. During the first years of telephony, the government had been unable to develop an efficient network. After a brief period of private concession,[8] a completely state-owned monopoly was reestablished in 1889.[9] This nationalization did not result in an improvement in equipment, mostly because of political disinterest, the lack of dynamism on the part of PTT, and budget problems. In 1910 there were only 230,000 telephone sets in France compared with 650,000 in Great Britain, 1,060,000 in Germany, and 7,600,000 in the United States. All efforts to increase financing made during the early 1920s were ended by the Depression. As a result, in 1938, France had only 1.6 million telephone sets, Great Britain 3.4 million, Germany 4.2 million, and the United States 20.8 million. The war blocked any further development and destroyed many understructures.

In this context no strong national industry could emerge, so when the war ended in 1945, the industry was unable to meet the needs of an industrialized nation. At the same time, the French market was completely controlled by foreign technology: The Compagnie Générale de Construction Téléphonique (CGCT)[10] and Le Matériel Téléphonique (LMT)[11] were ITT subsidiaries;[12] the Société Française des Téléphones Ericsson (STE) was a subsidiary of the Swedish group LM Ericsson. These three companies controlled 65 percent of the market. The technology came from foreign laboratories, and even la Compagnie Industrielle des Téléphones (CIT), the only significant French manufacturer, had to produce switching equipment under license from the foreign-based companies.[13] Thus, in order to create an independent industry, France first needed to end its reliance on foreign technology.

Seeds of hope

Established in May 1944,[14] and confirmed by the Provisional Government,[15] the Centre National d'Etude des Télécommunications (CNET) was the end result of a process begun in the interwar period.[16] Its role was to develop research in order to

satisfy the needs of the administration. The text defining the mission of the new institution included a modern definition of the word "telecommunications." "CNET is entrusted with scientific research and general studies of national application in the domain of telecommunications (telephone, telegraph, broadcasting, teleconferencing, beacons, security systems, etc. . . ."[17] Its first responsibility was to the research groups scattered among several institutions: ". . . The essential idea was to create a kind of pool of state laboratories working in the sphere of telecommunications whose activities until then had been separated by watertight barriers."[18]

CNET also had to coordinate the development of the industry. This was a radically new responsibility for it. In a 1945 memorandum the director of CNET wrote: "The telecommunications industry and CNET will grow in parallel; the force of the one will develop the force of the others. Trust and understanding will necessarily be born from the work and the common effort." This optimistic point of view soon came face to face with administrative realities. Between 1945 and 1954, CNET's development depended on the decisions of a long series of succeeding governments—too many to allow harmonious collaboration. At last, in 1954 a reform initiated by the PTT allowed the Center to find a real homogeneity under the exclusive leadership of the telecommunication administration. Pierre Marzin, the head of this "CNET Mark II," decided to increase public research and tried to coordinate the development of private companies.

An Ambitious Research Policy

Organization and first explorations

In the early 1950s telephone switching was still accomplished electromechanically. Then, in 1957, three engineers returning from a symposium organized by AT&T told Pierre Marzin about the recent evolution of electronic telephone switching in the United States. Convinced that electronics was the way to go in developing the next generation of exchanges, Marzin created a new division in CNET, called Recherche sur les Machines Electroniques (RME). Its mission was to create an electronic switching system. Louis Joseph Libois was in charge of this new division. In creating this new division, Marzin went against the company's organization chart, according to which the "telephone switching division" should have been given the task of developing the new switching system. Instead, Marzin gave the responsibility of the program to new men assembled from different divisions.[19]

The RME team started with basic research in order to explore, without preconception, a wide variety of directions. Its first achievement was the building of two prototypes, ANTINEA (1958–1960) and ANTARES (1961–1963), which allowed the team to evaluate the problem in two main directions:

- The right use of electronic components
- The methods to conceive software

At the same time, the team studied the technologies developed in the English-speaking world. At the end of the 1950s, despite the development of transistors, the electronics industry still relied on tubes. In this context, the British decided to build

a fully electronic exchange using tubes. Their prototype, nicknamed the "gas plant," was extremely bulky, needed an air-cooling system, and functioned below expectations. As a result, its sad career ended in 1963. After this expensive failure, the British stayed out of the electronic switching field for the next twenty years.

The Americans were less ambitious, deciding to first explore "space division technology." Bell Labs succeeded and chose Morris, Illinois, as the location of the first central system of this type, which it completed in November 1960.[20] AT&T created components especially designed for use in this kind of system. This part of the project was one of the most expensive. But neither the American plan, which was too expensive, nor the British plan, which had failed, could be adopted by CNET. Thanks to these different experiences, the RME engineers decided to adopt what they felt was a more realistic process: "The policy adopted at this time was to try to use the components that were supposed to become very widely used in the future. That meant they had to follow, as closely as possible, the evolution of computer technology, taking into account that this market would quickly become the main outlet for electronic components."[21]

At the same time, a specific effort was made to develop new software. In this area, the researchers were surprised by the complexity of the problems they had to solve, and their evaluation took a long time. When they occurred, these delays were caused by an underestimation of the time it would take to write and test the software.[22]

The first successes

Since the number of people involved in the project increased continuously, the first results seemed to be encouraging. Even though time-division switching was the primary long-term objective, it was impossible to neglect space-division technology completely. Thus these two branches were worked on simultaneously during the 1960s, with the first results occurring in space-division technology. The results were in the form of two prototypes that allowed CNET scientists to explore different ways of development and test many different solutions.

ARISTOTE[23] was to be used in setting up a high-capacity system organized around one central processor and a number of peripheral secondary processors. ARISTOTE was purely electronic, the switching network consisting of matrices of transistors. Its central processor (RAMSES) had been developed from ANTINEA.[24]

SOCRATE[25] was much more traditional and was essentially based on crossbar components.[26] Its main purpose was to develop new software for the control system.[27] ARISTOTE and SOCRATE were both connected to the network in Lannion in the mid-1960s. The main decisions reached by CNET as a result of these experiences decisively influenced the development of electronic switching.[28]

Based on these results, a new period in CNET's research began in 1965, and two new prototypes were developed. The first one, PERICLES (space-division switching) was created in association with the manufacturers; the second one, PLATON[29] (fully electronic) was undertaken exclusively by CNET.

PERICLES led to the installation in 1970 of the first telephone exchange in Clamart.[30] This system formed the basis of the Metaconta developed later by LMT.

It was the prototype of a system that was intended to provide 30,000 subscriber lines. The design adopted was conventional, in line with the principles considered at that time most appropriate for space-division switching exchange.[31]

PLATON was completely different. Designed by Louis Joseph Libois, it was based on the principles of time-division digital switching. In order to create a system suitable for commercial manufacture, PLATON was conceived of as a low-capacity system, based on the simplest possible architecture, using a minimum of new types of equipment. Nevertheless, its architecture was revolutionary.

> The principles behind Platon's design may be seen by an expert eye to foreshadow two major trends that were to become increasingly important from the late 1970s onwards: decentralization of the control units and the use of microcomputers for that purpose. It will be noted that in the early 1970s when Platon was in the process of being developed, microprocessors were just beginning to appear and the very term "microprocessor" had yet to be coined.[32]

In January 1970 PLATON was connected to the networks at Perros-Guirec, where it initially serviced 700 subscribers. A few months later the system was enlarged to connect 2000 subscribers. This was a world premiere. Pierre Marzin liked to jokingly say that his butcher's complaints about the problems of connection informed him about the development problems a few days before his engineers' reports.[33]

From these two prototypes, CNET was able to develop both space-division and time-division technologies. Even though the first prototype was shared with the manufacturers (and specifically the ITT subsidiaries), the second was controlled exclusively by CNET. Nevertheless, CNET, which was part of the PTT, was not in a position to manufacture this new equipment. In order to equip the French network with the new technology many problems had yet to be solved, among them choosing and training the right manufacturers and finding the funding.

From Research to Industry

In order to allow France to take an international industrial lead, CNET decided to bypass the space-division step and to develop directly time-division technology. But, even if PLATON and time-division technology proved its feasibility, there was still the time gap between the prototype and production to be covered.[34]

A French Company for a French Technology

Transfer of technology

CNET decided to lead French industry to independence by the development of the time-division technology. To this end, the center asked CIT to produce the new system. The managers of this relatively small company were at first reluctant to take on the project, which involved a completely new field. But the offer was so nice,

it was impossible to refuse. As a subsidiary of the Compagnie Générale d'Electricité (CGE), CIT also had to consider Ambroise Roux's opinion. Roux, who was chairman of CGE, was very much in favor of the project, first because of the profits that would be generated, and second because the "gaullist" nature of the industrial ambition coincided with his political beliefs. A subsidiary of CIT, La Société Lanionnaise d'Electronique (SLE), created in Lannion at the end of the 1960s, was the perfect organization to assume the most difficult part of the plan: the transfer of the technology from a state laboratory to a private company. For one thing, none of the engineers working for CIT had the knowledge or skills necessary to work effectively with the new technology. Therefore, SLE, which was a small company, was able to act as an interface between CNET and CIT. During the period that PLATON was being developed, SLE's engineers were closely involved in CNET's work.

The industrialization

In the last phase of development, the CNET engineers in charge of the project, with the blessing of CNET's director, "deserted" and joined SLE. This last part of the project consisted of the adaptation of the technical specifications to market standards. The choice of new electronic components[35] and new developments in software led to the E10A system. A factory specifically designed to produce the system was set up in Lannion in 1972. By 1975 its annual production capacity had reached 200,000 lines.

The product was ready. All that remained was for PTT to buy it.

However, to go back in time a bit, during the 1960s and 1970s the developmental level of the French telephone network progressed from being a problem to being a scandal. The humorist Fernand Reynaud wrote a successful sketch titled "Le 22 à Asnières" that pointed up the unfortunate situation of the French subscribers. People used to say: "In France half of the population wait to get the telephone; the other half wait to get the tone." As a result, President Pompidou decided to put an end to the situation. The determination of Bernard Esambert, the president's adviser, and the action of Yves Guéna, minister of PTT, were instrumental in initiating a powerful plan. At the same time the promotion of Pierre Marzin from the direction of CNET (where he was replaced by Louis Joseph Libois) to the direction of the administration of telecommunication showed that the future of the national network would be based on French technology. According to the plan, the reorganization would be both structural and financial, but the financial effort was so huge that the budget was not able to support it. The government therefore had to take out a loan in order to continue the financing. The main decision was made in 1969, and four companies were created to arrange for these loans:

FINEXTEL (February 1970)
CODETEL (January 1971)
AGRITEL (June 1972)
CREDITEL (October 1972)

To give the plan a fair chance of success the old and conservative PTT administration also had to be overhauled. A separate presentation to the Parliament of the Post Office's and Telecommunications' budgets in 1970 and the suppression of the Secrétariat Général aux PTT in 1971 signaled the liberation of the telecommunications branch.

Development of the Network and Industrial Policy

A change of course

In 1974 everything necessary to accomplish the great project initiated in 1957 was ready: an independent French technology existed; a French company was prepared to use this technology to build operational telephone switching equipment; and the financial problems were resolved. The next step would be simple. PTT would call for time-division equipment, but only one company, CIT, which had a jump of several years to its competitors, would be able to answer. Unable to propose any system of this quality, ITT's subsidiaries would be "naturally" supplanted. With American imperialism neutralized, the victory would not only be total but elegant. Unfortunately, the death of President Pompidou destroyed these hopes.

After the election of Valery Giscard d'Estaing a completely different approach prevailed. National independence no longer had priority. The goal of the new administration was to quickly equip the country and to obtain lower prices from the manufacturers. On October 16, 1974, Gérard Théry was nominated to replace Louis Joseph Libois as head of the Direction Générale des Télécommunications. The entire policy of CNET for the past twenty years was criticized, and the center was accused of abuse of power. In essence the new executives said that CNET's role was to do research, not to decide industrial policy. A few months later a reform reduced the power of the center. "All of the organization which allowed CNET to manage the innovation process was called into question. This was pretty serious when you know the time necessary to constitute [a] high level research team."[36]

To make a complex history short, the new Administration decided to create a competitive market in France.[37] Time-division technology was abandoned by the new administration, because this technology, for so long nurtured to compete with ITT's subsidiaries, was suddenly considered to be too risky and too expensive. Instead, space-division technology was chosen because it was considered to be more cost-efficient. PTT therefore invited bids in order to equip the network with space-division switching, but CIT, prepared for many years to develop time-division switching equipment, was unable to respond. Instead, ITT's subsidiaries were able to offer space-division switching equipment that was based on American patents. "The public authorities made internationalization their key word. But isn't the better the enemy of the good? There are moments, especially in the latest technologies, when it is necessary to stop a policy and consider it. Competition is a good thing if it does not turn into anarchy." The planned defeat of ITT was transformed into a victory. . . .[38]

But this doctrinal liberalism proved to be intolerable in a political context. Therefore, putting liberalism aside for a while, Giscard's men decided to reorganize

the telephone industry in order to avoid a new era of American domination. Pressure applied to ITT convinced the American company to sell one of its subsidiaries to a French group. The plan was intended to reduce ITT's market share while creating competition between two French companies. The company entering the telephone market was Thomson. This initiative postponed the agreement signed in 1969 between CGE and Thomson.[39] According to this "Yalta de l'électronique," the telephone industry was reserved for CGE. Thomson's comeback was strongly supported by the new government, but for some commentators the liberal doctrine was not the only explanation: "In its principal activities, CGE has just lost in some cases its hopes, in some cases its leadership. Industrial setback or political cabal? . . . In this country where everything begins and everything ends by political tunes, there are those who sing in more than one key; the government, VGE leading, intends to eliminate whoever was the friend of Pompidou." (Ambroise. Roux)[40] The industrial consequences of these changes were catastrophic: "Some considerable investments were dedicated to the putting in the place of the products of intermediary technology . . . Some factories had been totally disrupted, training programs had been put in place for thousands of workers, laboratories had been entirely dedicated to the development of space-division technology."[41] As a matter of fact, two years later, the choice of space-division technology was criticized and time-division technology was finally adopted. Thus, a huge investment was lost: "On the very day that the new factory intended for these products was inaugurated, the administration of PTT announced that it would not order more of those materials and that its purchases henceforth would focus on the products of the new electronic generation."[41] This strategy was a major failure and delayed the international development of the French industry. This new change in technology meant that Thomson had to develop its own time-division system. Since this meant competing with Alcatel, which owned CNET's technology free of charge, Thomson was forced to give up for financial reasons, and in 1983, it sold its telephone department to Alcatel. Many years and billions of francs had been lost in this Franco–French competition.

A worldwide manufacturer and a modern network

Despite the incorrect analysis of the Giscard d'Estaing administration, the results of CNET's action seem to be positive. The double goals of equipping the country and developing an independent industry were accomplished.

The competitiveness of the French economy was enhanced by the most modern telephone network in the world. The first step in achieving this was the elimination of the antiquated system that handicapped the country, an effort that began vigorously in the mid-1970s. From the Côtes du Nord, modernization of the network progressed quickly until, in 1990, with 28 million main telephone lines, the density of the French network was one of the most impressive in the world. Seventy-five percent of the switching and 80 percent of the transmission were digital. This evolution allowed the opening of the first ISDN network in the world in 1987 in Britanny. Then in 1990 the entire national network was upgraded to its present quality. As a result, it became possible for any subscriber to be connected to this service, commercially called "Numeris." The E10B and E10MT equipment, manufactured by

Alcatel, enhanced the network to a high level of quality. On average, one line is in trouble once every seven years. During the same period, the price of intercity communications decreased from 3.80 francs in 1985 to 2.60 in 1990. With its new status, the telephone administration is currently much more independent. In 1990 its activities exceeded 100 billion francs.

At the same time the small, dependent industry of the 1960s was transformed into a world leader with a high level technology. After 1983 CIT-Alcatel became the only French manufacturer of telephone switching equipment. "It is that, with nearly ten years' delay, which the men of Georges Pompidou wished to do."[42] All the equipment in the country was based on nationally owned patents and exportation was increasing. In order to expand its activities to the international level, Alcatel had to find allies. Its first break came from its old enemy, ITT. In February 1986, ITT withdrew the 1240 system from the U.S. market, because the company had neglected to adapt the system, originally created in Europe, to American specifications.[43] In June 1986, ITT transferred about 70 percent of its vast array of telecommunication industries to Compagnie Générale d'Electricité. These interests amounted to a veritable empire that operated in almost 100 countries, with those engaged in switching equipment manufacture accounting for 10 percent of the world market. The agreement took effect on December 30, 1986, creating the world's second largest supplier in telecommunications after AT&T. Registered in Amsterdam as Alcatel NV, the group's activities are mainly based on the technology developed over many years by CIT-Alcatel. Thus, the 1957 goal had not only been achieved, but largely surpassed. However, in order to preserve competitiveness in the French market, Alcatel does not enjoy a monopoly. In 1987 CGCT, nationalized since 1982, was sold by the government. As a result of heavy competition from AT&T and Siemens, a third contender, LM Ericsson, was selected to join with the French company Matra.[44]

Conclusion

"The force of all advice yields to the times the opportunities and the methods roll along and change without cease."[45] The controlled experiment of the 1960s and 1970s does not constitute a "model" for today, nor is it a countermodel to be destroyed on the bonfire of liberalism. The action of the French telecommunication administration cause the competitiveness within the national telephone industry to increase dramatically, while at the same time, the country was able to build the telephone network that had been needed for many decades. Considering the weakness of the French industry at the beginning of the 1950s, an interventionist strategy was the only one possible. Certainly, its success is partial, but like an efficient medicine, interventionism has some side effects. The link between political evolution and industrial strategy is certainly the worst of them. When the industrial policy changes each time the political majority changes, it is impossible to succeed.

At the edge of the twenty-first century, with Japanese industry challenging European and American technology everywhere, the existence of a group like Alcatel is certainly a trump card for the future of French industry. Similarly, the development

of France Telecom proves that a state-owned monopoly is not condemned to failure. If France Telecom has to change in the near future, its base is strong.

From a technological point of view, time-division switching technology is a major event. As of now, computers and telecommunications are evolving separately, but they will converge sooner or later.

To compete means to have a will to succeed. Competitiveness is the main goal for a company or, more and more often, for a country. This convergence of national and private interest is not new and is not specifically French. The path followed by France to reach competitiveness in the telecommunication industry could be analyzed through the framework proposed by Kilmann, Shelleman, and Uzzi.[46] The second quadrant, where the role of technology and the influence of government are crucial, would surely parallel the French telephone switching experiment.

The convergent efforts of a state-owned laboratory, of an old administration deeply renewed, and of a private company seem to be a good example of the "holistic, integrated and collective approach not only desirable but also imperative . . . in the face of unprecedented global competition."[47]

In the case of countries facing a long delay, this will to succeed means that the challenger is entitled to adopt its own rules and to accept the challenge only when it is ready. To fight on the field and at the time chosen by the enemy is surely not the best way to compete. Neither interventionism nor liberalism is a pragmatic panacea. Adaptation of an industrial policy to a nation's needs and abilities, and adjustment to international context are certainly two elements leading to competitiveness.

Notes

1. P. Hall, *The Carrier Wave: New Information Technology and the Geography of Innovation, 1846–2003* (London: Unwin Hayman, 1988). Concerning telecommunications and geostrategy: D. Headrick, *The Invisible Weapon; Telecommunications and International Politics, 1851–1945*. (Oxford: Oxford Univ. Press, 1991). P. Griset, *Les révolutions de la communication, XIX°–XX° siècles* (Paris: Hachette, 1991). A. Smith, *The Geopolitics of Information* (London: 1980). T. MacPhail, *Electronic Colonialism* (Los Angeles: SAGE, 1987).
2. P. Griset, "Fondation et empire: l'hégémonie américaine dans les télécommunications internationales: 1919–1980," *Réseaux*, No. 49, Septembre–Octobre 1991, pp. 73–89.
3. Usually, the equipment sold to the French administration had to be built in France, but the royalties and profits collected by ITT's subsidiaries were not nationally controlled.
4. D. Mowery and N. Rosenberg, *Technology and the Pursuit of Economic Growth* (Cambridge, England: Cambridge Univ. Press, 1989).
5. L. D'andrea Tyson, "Competitiveness; An analysis of the problem and a perspective on future policy," in *Global Competitiveness: Getting the U.S. Back on Track*, ed. M. Starr (New York: Norton), pp. 95–121. See also: *The Competitive Edge: Research Priorities for U.S. Manufacturing: Report of the Committee on Analysis of Research Directions and Needs in U.S. Manufacturing*, Manufacturing Studies Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, 1991.
6. S. Hoffman, *Sur la France* (Paris: Seuil, 1976).

7. Mowery and Rosenberg, *Technology,* op. cit., p. 8.
8. The State monopoly on telecommunications was proclaimed in May 1837. The text was extremely clear: "Quiconque transmettra sans autorisation des signaux d'un lieu à un autre, soit à l'aide de machines télégraphiques, soit par tout autre moyen, sera puni d'un emprisonnement d'un mois à un an et d'une amende de 1000 à 10 000 francs . . . le tribunal ordonnera la destruction des postes, des machines et des moyens de transmission."
9. In 1879, two companies, La Compagnie des télélphones (Bell patents) and Berthon et Compagnie (Edison patents) were allowed to develop a privately owned and operated telephone network. They merged in December 1880 to form La Société Générale des Téléphones. In 1889 the slowly growing network was nationalized.
10. The CGCT mostly equipped small cities.
11. LMT mostly equipped large towns and very large cities.
12. R. Sobel, *ITT: The Management of Opportunity* (New York: 1982). ITT's "real politic" is still a subject of controversy. Concerning the "Pro-Nazi" tactic in Germany see: A. Sampson, *The Sovereign State of ITT* (New York: Stein & Day, 1973).
13. The ITT European research laboratories were based in Bruxelles. Ericsson's central laboratories in Midsommarkransen in Stockholm provided a very high level of technology.
14. *Loi,* No. 102, May 4, 1944.
15. Ordonnance de validation du 29 janvier 1945.
16. The main steps of this evolution, which created a centralized research structure in the field of telecommunications, correspond to the creation of different instituions: in 1916, the Service d'Etudes et de Recherches Techniques (SERT); in 1941, the Direction des Recherches et du Contrôle Technique (DRCT).
17. Article 2.
18. P. Tucoulat, Director of CNET, Note, September 1947.
19. Concerning this kind of problem in France, see P. Bernoux, *La sociologie des organisations* (Paris: Seuil, 1985) and M. Crozier, *Le phénomène bureaucratique* (Paris: Seuil, 1963).
20. About Bell Labs see M. Fagen, *A History of Science and Engineering in the Bell System* (Murray Hill, N.J.: Bell Laboratories, 1975 and 1978).
21. P. Lucas, "Les progrès de la commutation électronique dans le monde," *Commutation Electron.*, Vol. 44, January 1974.
22. The Morris, central's software, had already 50,000 lines.
23. Appareillage Réalisant Intégralement et Systématiquement Toute Opération de Téléphonie Electronique.
24. See P. Lucas, A. Profit, J. Pouliquen, and M. Rouzier, "Aristote electronic telephone exchange in Lannion," *Proceedings of the 1966 Paris International Switching Symposium,* pp. 1105–1145.
25. Systeme Original de Commutation Rapide Automatique à Traitement Electronique.
26. CP 400.
27. P. Lucas, J. Duquesne, J. Pouliquen, and J. P. Berger, "Semi-electronic switching system of Lannion (project Socrate)," Proceedings of the 1966 Paris International Switching Symposium, pp. 116–127.
28. That is (1) for the switching network, to abandon electronic crosspoints in favor of matrices of reed relays in a sealed tube; (2) to adopt the principle of load sharing between the processors of the control unit; to have the central processor handle all the functions of signal registration, signal translation, and call recording for billing subscribers.

29. Prototype Lanionnais d'Autocommutateur Téléphonique à Organisation Numérique. Lannion is a town in the north of Brittany. The politics of decentralization led to the transfer of part of the CNET staff from Issy les Moulineux (a suburb of Paris) to Lannion. This small city became the most important research center in the field of electronic switching. The fact that Lannion was the birthplace of the director of CNET had, of course, nothing to do with this choice of place.
30. Serving 800 subscribers.
31. See L. J. Libois, P. Lucas, J. Dondoux, and J. Duquesne, "Basic principles of the Pericles system," *Commutation Electron.* October 1967, pp. 5–21.
32. R. Chapuis and J. Amos, *Electronics, Computers and Telephone Switching* (Amsterdam/New York/Oxford: North-Holland, 1990), p. 223.
33. This jest underlined the decisive importance of in situ development. When it comes from the laboratory, the switching system is far from ready.
34. See C. Freeman, *The Economics of Industrial Innovation* (London: Frances Pinter, 1982); N. Rosenberg, *Inside the Black Box: Technology and Economics* (Cambridge, England: Cambridge Univ. Press, 1982); and F. Caron, *Le résistible déclin des sociétés industrielles* (Paris: Perrin, 1985).
35. The evolution of electronic components was decisive in order to prove the profitability of electronic switching; cf. E. Braun and S. Macdonald, *Revolution in Miniature: The History and Impact of Semiconductors Electronics* (Cambridge, England: Cambridge Univ. Press, 1982); A. Beltran and P. Griset, *Histoire des techniques XIX°–XX° siècles* (Paris: Colin, 1990).
36. M. Nouvion, *L'automatisation des télécommunications* (Lyon: PUL, 1982), p. 303.
37. For more details see P. Griset, "Le développement du téléphone en France depuis les années 1950. Politique de recherche et recherche d'une politique," *Vingtième siècle revue d'histoire,* October–December 1989, pp. 41–53.
38. J. M. Quatrepoint, *Le Monde,* July 30, 1976.
39. Thomson entered the telephone field in 1904 with the acquisition of Postel-Vinay. In 1927, Thomson left this company, renamed Compagnie des téléphones Thomson Houston, to ITT.
40. *Le Point,* May 17, 1976.
41. J. Darmon, *Le grande dérangement* (Paris: J. C. Lattès, 1985), p. 168.
42. *Le Matin,* September 9, 1983.
43. One hundred and fifty million dollars in research were lost.
44. This was a reintroduction of the AXE exchange, but in a digital version. Before the transaction, the administration guaranteed a 16 percent market share for the company.
45. M. Montaigne, *Essais,* Vol. 3 (Paris: Gallimard, 1965), p. 55.
46. R. Kilmann, J. Shellemann, and B. Uzzi. "Integrating different approaches for achieving competitiveness," in *Making Organizations Competitive,* ed. R. Kilmann (San Francisco: Bass, 1991), p. 110.
47. Ibid., p. 122.