

HISTORY OF COMPUTING IN FRANCE: A BRIEF SKETCH

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French

The History of Computing in France can be roughly divided into three periods. In the first one, from the immediate after-war to the mid-1960s, digital electronics and symbolic programming emerged in information processing, and know-how was acquired from Britain and from the United States. The first stored-program computers were installed in 1955; and in 1961, about ten French companies were producing computers: France seemed to be catching up fairly well, with machines like the Bull Gammas and the SEA CAB series, and the first software companies (SEMA, CAP). From the start, these firms had to face IBM competition, and worked for an open market (Bull exported 1/3 of its products).

A brutal change happened in the mid-1960s, mainly due to the acceleration of US competition. In 1964, Bull became a subsidiary of General Electric. As a reaction, the Plan Calcul was launched by the government in 1966: Most smaller computer manufacturers created in the previous period were merged into a "national champion", the CII (Compagnie Internationale pour l'Informatique). Together with the Plan Calcul, other plans aimed at developing component and peripheral equipment industries. Meanwhile, a specialized institute, IRIA (Institut de Recherche en Informatique et en Automatique), was established outside the University. None of these efforts appeared convincingly successful. CII initially imported or manufactured American computers (SDS), then launched its home-made "IRIS" series. Yet the most innovative French computers of the time were made by new entrants, not planned in the Plan Calcul: Télémécanique (minis) and R2E-Micral (micro-computers, from 1973 on).

In the mid-1970s, a new series of changes occurred. The Giscard cabinet terminated the Plan Calcul in its initial form, by letting CII merge with Honeywell-Bull (Honeywell had bought General Electric's computer interests in 1970). This also put an end to the European enterprise Unidata, created in 1974 by CII, Siemens and Philips. Industrial concentration went on under Mitterrand, in the 1980s, when the Groupe Bull included nearly all French computer industry, then took control of Honeywell Computer Division. Simultaneously, the development of computerized telecommunications, of micro-computers and of the "smart card" opened new horizons to digital electronics, while software and services firms soared.

I Data Processing Industry And Market Until WW II

An early start is not enough to ensure technical and industrial leadership in the long term. In 1643, Blaise Pascal had invented his "Pascaline". Two centuries later, Thomas de Colmar designed the Arithmometer, a calculator whose reliability and ease of use made it the first real commercial success in the history of computing: More than 2 000 were sold between 1820 and the 1870s. At the same time, more than 10 000 units of the punch-card controlled Jacquard loom were produced, bringing automation into the textile industry. These successes might contribute to qualify the usual historical view, according to which France was considered lagging behind Britain in the industrial revolution.

Yet, from the last quarter of the XIXth century on, the situation changed deeply. While inventors continued to design novel calculators (Bollée, etc.), the French artisans who produced

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them lost their markets to the German-Swiss industry (Odhner, Coradi, Egli, etc.), and even more to the aggressive US exporters like National Cash Register (established in France in 1896). One reason for this was that the French market of office mechanization (calculators, typewriters, etc.) was far less receptive to these devices than was the German, for instance.

This part of the story is still poorly documented, but the situation of the French calculator industry under the IIIrd Republic seems to have been worse, and for a longer period, than other precision industries. Small businesses like Ateliers Vaucanson maintained some production of calculators. Around 1900, the director of the Statistique générale de la France (SGF), Lucien March, developed non punch-card tabulating machines, the “classi-compteurs-imprimeurs”, which were used for the census until WW II. This was not dangerous competition for IBM, which established offices in Paris between 1914 and 1920, under the name “Société internationale des machines commerciales”; a plant was created in Vincennes to supply the local market and overcome national custom barriers. Powers followed, creating in 1922 a French subsidiary of its British branch : Société anonyme des machines à statistiques (SAMAS), with a factory in Saint-Denis. In 1931 a third competitor, Egli-Bull, started building punch card machines based on the patents of a Norwegian engineer, Fr. R. Bull. A smaller venture, Logabax, was attempted by the Spanish banker and inventor Francisco Campos.

However, the French market was rather cold. On the commercial applications side, dominated by punch card technology and smaller accounting machines, this fact is attested for example by the size of the Statistique générale de la France in 1936: a hundred employees, of whom 15 “statisticians”, using “25 classi-compteurs and one Powers sorter”, to be compared with equivalent Polish institutions (350 staff, 200 machines) or German (2519 staff, 14 tabulators, 650 calculators)². SGF personnel was even reduced in 1934 as a result of Prime Minister Laval’s anti-inflation policy. In 1939 the French IBM subsidiary was fivefold smaller (540 staff) than Dehomag (2600 staff³). One main reason was the weak demand of economic statistics on behalf of the government, then dominated by lawyers and literary politicians; another was the taste for industrial secrecy among companies, often family-owned, who saw no reason to communicate data to the State administration.

The atmosphere changed from the late 1930s on, due to the successive *dirigistes* administrations, staffed with a new generation of technocrats who reacted against the *laissez-faire* policies which had proved inefficient against depression and unemployment. Toward 1938, the Front Populaire cabinet passed socialist decrees which implied the monitoring of wages, labor, industrial production and finance figures, and practically compelled the bureaus to acquire data processing machines. The threat of the approaching war led the Defense administration to set up ambitious reorganization and mobilization plans, including the use of several hundreds punch card machines (the Defense was Bull’s main client during the 1931-1940 decenny). A military manager, René Carmille, advocated “the use of machines in administrations⁴”. This movement was even amplified after the 1940 debacle. In order to face the severe economic restrictions, Vichy’s ministry of industrial production acquired punch cards systems to dispatch goods and raw materials between sectors and companies⁵. Besides, Carmille created a Service national des statistiques, acquiring considerable equipment⁶ and staffing it with 6000 ex-officers from the Army; under cover of population census, they prepared the

² Marietti P.-G. *La Statistique Générale en France* PUF, Paris 1948.

³ Bauer, G. *Datentechnik im Wandel*, Springer Verlag, Hambourg 1986. This difference in size is due to the vitality of the German market; in France, Bull’s and Samas-Powers’ competition was still marginal.

⁴ Carmille R. *La Mécanographie dans les administrations* Sirey, Paris 1936 and 1942.

⁵ Volle M. *Histoire de la statistique industrielle* Economica, Paris 1982, 303 p. Voir aussi Bédarida F., Bouvier J., Caron F. *et al.*, Actes du colloque *Pour une histoire de la statistique* INSEE, Paris 1976.

⁶ Bull and IBM equipment: 227 punches, 85 sorters, 34 tabulators... (Marietti *id.*)

re-mobilization of the French forces (Carmille was arrested by the Gestapo in 1942 and died in Dachau).

After the Liberation, this office mechanization movement continued. Throughout various political colours, the interventionist State ideology, already put into practice by the Front Populaire and Vichy, was now firmly rooted in the new generations of polytechnicians and later *énarques*⁷. The nationalization of railways and major airlines and aircraft manufacturers, then of power networks (Electricité de France), of major banks and insurance companies, of various industries (renault, coal mines, etc.) created large organizations, which had the resources and size to buy costly data processing equipment and to justify it, and were staffed with polytechnician engineer-managers whose education fit perfectly with the rationality embodied in *la mécanographie*. The same was true in some areas of the private sector, which carried on vast concentration operations; for example, the Groupe Drouot was created in 1948 by the merger of five insurance companies, with the explicit aim to rationalize their structures and afford a data processing service. American management techniques were a model for executives and businessmen, who visited the US (often with Marshall Plan “productivity missions”). This explains the rapid growth of office equipment manufacturers and the soaring of professional societies and journals⁸, during and after the reconstruction years.

II The State research and pioneer computers: A failure (1939-1959)

Things were quite different in the scientific field. Mathematics was a corner-stone of the French educational system (candidates to the leading engineering schools and to the Ecole Normale Supérieure were selected primarily on their mathematical aptitude, and this in turn oriented the secondary school system). But there was no teaching, at any level, of calculating methods, considered too technical for the elite educational system. In research and higher education, the hierarchy between pure and applied mathematics reminded strongly of the hierarchy between nobility and *Tiers-état* in the *Ancien Régime*. This was even strengthened by the growing influence of “Bourbaki” — a group created in the mid-1930s by young and bright university professors, who decided to clean up mathematics from triviality, and to establish the discipline on solid conceptual foundations. To the Bourbakistes, there was no such thing as “applied mathematics”: Mathematics was an autonomous discipline which studied its own, particular objects (series, numbers, functions...); “mathematicians” who worked on other disciplines’ objects (mechanical or physical forces, atoms, rockets...) were merely “appliers of mathematics” and could hardly be tolerated in maths departments or committees. The Bourbakistes conquered major power positions after 1940, and dominated the field until the 1970s.

The domination of pure mathematics is one of the reasons for the under-development of calculating equipment and practice in French science in the 1930-1955 period. Other explanations can be expressed in market terms (it is my hypothesis): There was a low demand for scientific computing. In other words, French researchers and engineers had very modest needs for numerical calculation. I suggest four interpretations, the first one resorting to R&D economics, the three others to history of Science and Technology. Firstly, French research suffered a “great misery” in the 1920s, as its financial support had remained constant since 1914 while inflation soared; the situation improved only slowly during the 1930s: Scientists were thus prevented from evolving toward “Big science” practice, particularly from undertaking to build

⁷ Polytechnicians: Graduates of the Ecole Polytechnique, the most prestigious engineering school in France, created in 1794 to educate military and civil engineers for the State. Enarques: Graduates of the Ecole Nationale d’Administration, created in 1945. Also see Kuisel R. F. (*Capitalism and State in France - Modernization and Dirigism in the XXth Century* Cambridge University Press, 1981).

⁸ *Revue de la Mécanographie*, created in 1948; *Informations Mécanographiques*, created in 1955.

calculators or to learn to use and manage computing laboratories. Secondly, French scientists had an excellent mathematical education, which allowed them to solve many problems with methods more “elegant” and less fastidious than numerical reckoning. Thirdly, the French electrical industry did relatively little research, since most companies depended on American or German licenses for most of their products; thus it needed less calculation than world leaders like Siemens, General Electric or Westinghouse; this point is important when we remember that the first differential analysers were developed in the early 1930s for electrical engineering research, in the United States. Contrary to most industrialized countries, France did not build any differential analyser before the mid-1950s. Fourthly, physics as it was practiced in France until the 1940s was essentially experimental physics, reluctant to adopt the theoretical models which were revolutionizing the conception of the universe, in Copenhagen, in Göttingen, in Cambridge, in Princeton at that time⁹.

At the very material level, calculating machines were a rare thing in scientific organizations. The inventory of the laboratories’ equipment, made in 1938 in the perspective of the “scientific mobilization”, shows their scarceness¹⁰. A few computing bureaus existed — almost exclusively in Paris —, equipped with small desk calculators; the only exception was the Paris Institut de Mécanique des Fluides, where Joseph Pérès and Lucien Malavard had developed water tanks, a novel analogue device for solving Laplace equations. Even in rich and well equipped provincial faculties, like Lille and Grenoble, it was hard to find one or two desk machines. It was even worse in engineering school, where almost no research was carried.

The war suddenly boosted the demand, as the military expressed urgent needs of calculations for ballistics, optics, aircraft structure and aerodynamics, etc. Computing capacities appeared to be a major bottleneck in the war effort, as shown in a report written by Louis Couffignal¹¹. The academic labs which had already a computing service increased their staff and equipment. After June 1940, however, this endeavour aborted as most of the machines were confiscated by the Germans. The larger French calculating facility, at Institut Poincaré, was disbanded. After WW II, most laboratories were satisfied to import desk machines from Germany (500 to 800 machines were imported between 1945 and 1950, mostly Baüerle “Peerless”). Yet this showed a desire to recuperate the 1939 equipment level (real or ideal), rather than to enter the Computer Age heralded by the ENIAC or even by the Bush differential analysers, which were well known to the French through learned journals.

This point about the weakness of calculating equipment and culture in French science is important if we observe the evolution process which took place in some places in other countries (Cambridge Mathematics Laboratory, etc.): demand of scientific calculations → development of a computing service → growth of demand → construction of a more powerful machine (mechanical or electrical, analogue or arithmetical → adoption of electronics around 1950 and development of a computer.

Because of the particular situation of applied mathematics and of computing in the academic spheres, France is the only large industrialized country where the State research system did not make any computer during the pioneer era, that is before 1960. Several calculator projects were launched between the late 1930s and the early 1950s, particularly at the Institut Henri-Poincaré, at the Centre National de la Recherche Scientifique, at the Institut d’Optique, at

⁹ Pestre D. *Physique et physiciens en France 1918-1940*, Editions des Archives contemporaines, Paris 1984.

¹⁰ CNRS(A) Laboratoires universitaires Paris, enquête 1938-1939, Chemise “Liste des appareils de la CNRS figurant dans les Laboratoires” (Arch. Nat. 80/0284/7), and other archives.

¹¹ CNRSA, Rapport général sur les problèmes scientifiques intéressant en priorité l’économie ou la Défense nationale, fascicule II (Industrie de transformation et activités diverses), chapitre “Mathématiques et calcul” (RA 1939 du HCCRS, adressé par J. Perrin au Ministère de la Défense nationale, SHAT 2 N 136/1).

the Centre National d'Etudes des Telecommunications, and at the Office de Recherches Aéronautiques. However, none was successfully completed, and the process which is described above aborted at one stage or at another. At the end of the 1950s, the industry supplied stored-program computers, and the role played by the academic research in their design and conception became secondary: A university which wanted to have a computer needed no longer to build one, but just to buy it.

Calculators in French State Research 1950s

Laboratory	Machine Name	Date	Fate
IHPoincaré	Fréchet's Machine	1939-40	Abandon
IHPoincaré	Couffignal's Machine	1939-40	Abandon
Pères-Malavard	No numerical machine project		
	Water tanks, then resistor network calculator industrialised by Labinal		
IBP	Couffignal's Machine	1947-52	Abandon
Institut d'Optique	Marechal's project	1948	Abandon
ONERA	Druet's computer project	1951-53	Abandon
	MOP	1953-59	Obsolete when completed
CNET	Mechanical calculator	1952	Obsolete Technology
	Analog calculators inspired by SEA company (1954)		

In the second half of the 1950s, laboratories acquired commercial computers: Bull Gamma ET, Elliott 402, IBM 650 and 704, etc.

1960s

Laboratory	Machine Name	Date	Fate
CNET	Antinea	1962	Bases for research on digital switching, renewed the telephone industry (Alcatel)
Toulouse University	CAT	1966	Teaching use (inspired by SEA CAB 500)
ISEN Lille	Cordonnier's computer	1966	Teaching use (inspired by IBM 1401)
Grenoble University	Perret's MAT 01	1966	Novel mini-computer, industrialised by Mors, then by Telemecanique — technical and commercial success.

III The Computer Industry: Companies' behaviour, strategies and the component Problem

As no computer know-how was available in the public research system, the first two French computer manufacturers, Société d'électronique et d'automatisme and Compagnie des machines Bull, adopted risky policies — either very innovative (SEA) or rather conservative (Bull). A third set of companies, the electrical equipment manufacturers, did not invest in computers until 1960, then chose to buy American licenses. In this chapter, I will particularly put

the stress on the relationship between the French computer manufacturers and the component industry, between 1952 and 1972.

At the beginning of the 1950s the computer manufacturers bought components from specialised producers and soldered these together to form the circuits that constituted the central unit, the "processor", of the machine. Twenty years later, advances in miniaturisation and integrated circuitry had made it possible to produce a complete processor as a single component, the microprocessor. Over this period, therefore, the two professions had experienced fundamental changes not only in the techniques they used but also in their very businesses: whilst in the 1950s the development of electronics for mass-market products (radio and TV) had been the driving force behind the transistor industry, in 1972 it was the computer industry which generated the main demand for semiconductors (39% of the total production of s.c.), especially for integrated circuits (58%); and to this we should add the demand for industrial control devices and telecommunications equipment, both making more and more use of digital electronics.

How then did the French computer industry conduct itself during this revolution? To what extent did the manufacturers offer a market that would stimulate the semiconductor producers? Was there any collaboration between the two in the design of new circuits? What effect did the Plan Calcul, launched in 1967, have on their relations?

We cannot avoid these questions if we want to understand the relative decline of the electronics industry in France during the period. Here we shall attempt some answers by studying the relevant attitudes of the main computer manufacturers: IBM France, SEA, Bull, CSF, CGE, Compagnie des Compteurs, CII.

a) Société d'Electronique et d'Automatisme (SEA)

Formed in Paris in 1948, SEA — Société d'Electronique et d'Automatisme — was both a research consultancy and a producer of specialised electronic calculating equipment¹². Its Director, F-H Raymond, an electrical engineer with a Doctorate in physics, had worked in the Navy's research laboratory and afterwards in various enterprises where he had become familiar with the then state-of-the art in electronics. SEA established its reputation and founded its business on its designs for analogue computers, various products for telecommunications and automation, and simulators for aeronautics. It installed the first digital computers in France in 1955, and seemed to be overflowing with inventiveness: it had patents in text processing, in virtual memory, in teleprocessing and in electronic telephone switching. Initially these were intended for the scientific world, with business applications considered later. Some of these projects failed because the quality of the components produced in France around 1954 was not up to the technical demands of SEA, and importing from America was made difficult by customs barriers. The situation was to improve within a few years. In 1960 SEA produced a small scientific computer", the CAB 500, which was to become its best-seller; at the same time it launched a series of transistorised business machines, the SEA 3900s. Its joining the Schneider group made possible the production and marketing of its machines on an industrial scale. In 1967, when it had a staff of 850 and its Director was participating in formulating the Plan Calcul, SEA was to all intents and purposes absorbed into CII, Compagnie Internationale pour l'Informatique.

¹² Despite the loss of most of its archives with the disappearance of CII, the history of SEA is beginning to become fairly well known, thanks to the participation of its former partners and senior staff in conferences on the history of computing, e.g. *Colloques sur l'Histoire de l'Informatique en France*.

Ferrite Cores

Raymond has written of the views he held at the beginning of the 1950s: "The primary question was, how to design memories? Various laboratory solutions had been experimented with, in France, in Great Britain and in America ... In my opinion at the time, none was suitable from an industrial point of view. When I was in the USA in 1946 I had met Jan Rajchmann, then deputy to Zworykin who was head of the RCA laboratories at Princeton, and luckily I was able to get him to give a lecture to the French "radioelectricians" on ferrite core memories (Rajchmann 1952: 479-491). His talk helped to plant the idea that these were a genuine possibility into the French engineers community. Cores had to be produced. Only Radiotechnique took up the idea, and we were able to make our first 'core planes' by buying wired and tested cores from Radiotechnique." (Raymond 1989). Fifteen years later RTC (Radiotechnique-Coprim) were producing 250 million cores annually. The collaboration with Philips's French subsidiary was to remain a consistent feature of SEA's innovation strategy.

The Physics & Chemistry Department: Betting on Hybrid Circuits

In 1955 SEA set up a department for research in physics and chemistry, in order to monitor the evolution of components and to master the basic technologies needed in the design and manufacture of computers. Ten years later this had a staff of 40, organised into five groups — hardware, devices/systems, electronics/ memories, circuits/ technology, workshop/ models.

Between 1961 and 1966 this Department made 17 studies under contracts with various military departments and with the DGRST (Délégation Générale à la Recherche Scientifique et Technique); these led to 83 patent applications in the field of computer components. One of the main production tools that were developed was a machine for cutting silicon wafers by means of a power-driven wire; licences were sold in America, Great Britain and Japan. "The computer today depends on the solid state" wrote Raymond in 1966. "Neglecting research brings the certain risk of being destroyed by the competition; handing the research to other companies, even if allies, risks being served badly and too late. Depending on licences or foreign patents means being always 2 to 5 years behind in getting a machine on to the market" (Raymond 1967: ch. 5 p. 1) Keeping up with the technology gives freedom to decide on what hardware to produce, without waiting for the competitors' product announcements; and this favours a policy of effective dialogue between the computer manufacturer and the components industry. SEA could consent to sub-contract production and even the marketing of its machines, but not research.

In early 1964 the chiefs of the Physics & Chemistry Department went to America to study the state-of-the-art in solid-state physics, visiting about ten industrial and university laboratories¹³. They were disappointed by what they saw of monolithic integrated circuits. "Whilst, technologically, the integrated circuit is in the line of semiconductors, it must be a compromise for the simple reason that it is made up of different devices in the same material. This compromise must be to the detriment of performance. Further, the fabrication technology is so complex that the yield [the number of "good", i.e. usable, circuits, as a percentage of the total number produced] is less than 3%. Thus with its poor performance and high cost the integrated circuit does not meet the needs of the computer industry."

This judgement, which seems astonishing to us now, was based on notes made on the spot by the two specialists. Originally, integrated circuits were indeed too expensive to be used in computers manufactured for the commercial market, and their use was limited to military,

¹³ The French team visited Philco (Lansdale and Blue Bell), IBM (Thomas J. Watson Research Center), RCA, Bell Labs, Johns Hopkins University, Stanford Research Institute, Caltech, Fairchild, Motorola and others.

space and nuclear applications. It was not until the end of the 1960s that the yield for TTL circuits reached about 30%, when the average price fell from \$ 50 to \$ 2.3.

On the other hand, the two Frenchmen found confirmation among their American hosts of the view taken by SEA five years previously, that the right fabrication technology was that of depositing thin layers on an insulating substrate. Passive elements — conductors, resistors, capacitors — could already be made in this way, the problem was how to add active elements.

In the mid-1960s SEA incorporated pilot hybrid circuits in pre-prototype computers for testing, and prepared for industrial production with Radiotechnique (the good collaboration of the two companies was partly based on the fact that Dreyfus-Alain, at SEA, and Brunet, head of s.c. development at RTC, were both alumni from the Paris Ecole de Physique-Chimie). This represented a change in the nature of the company from an assembler of components to a designer, a change stimulated by the evolution of semiconductors. In 1965 Raymond proposed to the Defence administration a computer project, "CAB 15000", intended to result in a compatible range comprising at least three processors, with the expectation of producing about a thousand units altogether (Raymond 1965). In the event, only one example was produced, using hybrid circuits operating at 20 MHz, developed by SEA in collaboration with Radiotechnique. Receiving no Government support, the project was soon cancelled.

This was followed by a project to design a family of monolithic integrated circuits: despite their initial scepticism, the authors of the 1964 report had concluded: "... However, this is not sufficient reason for us to dismiss all considerations of integrated circuits and their variants from our thoughts." By 1966 the yield of the fabrication process had passed 10% (Kilby 1966). SEA planned to use integrated circuits in the Axe 2 range of computers which would take over from the CAB 1500 about 1970. In 1965 Radiotechnique launched its DTL circuits for numerical applications, producing a million in 1967 and ceasing to lose money in this venture in 1969. However the Plan Calcul, launched in 1966, simply ditched SEA's projects.

b) Bull: A Client For the Semiconductor Industry

The Compagnie des machines Bull was incorporated in Paris at the beginning of the 1930s to exploit the patents for punched card machines taken out ten years previously by a Norwegian engineer, Frederik Rosing Bull. It was owned and managed by a group of industrialists, including in particular George Vieillard, a Polytechnician of the 1914 vintage who was Managing Director until 1962, and by members of the Calliès family, related to Michelin and owning the Aussedat paper mills that supplied the cards required for Bull's "accounting and statistical machines". Starting with a workforce of 50 in 1931, the company won for itself a respectable fraction of the French market against the competition from well-established multinationals like IBM and Remington-Rand. Since 1948, Bull had been engaged in an ambitious international expansion (Mounier-Kuhn 1989, 1990).

Also in 1948 the management decided to set up an electronics laboratory to give them the knowledge to beef up their machines and so make these better able to face the competition, in particular that from IBM's new products. The founder of this laboratory, Bruno Leclerc, left with his colleague Henri Feissel — both of whom had worked on radar projects at LMT, a French subsidiary of ITT — for a visit to the USA. On their return they designed and built the Gamma 3 calculator, marketed in 1952 (Leclerc 1990a, 1990b). In their initial forecasts the company had hoped for 70 sales at 920,000 F each; in fact, in 10 years they sold more than 1200. The success

of the Gamma 3 was one of the main factors in the spectacular expansion of Bull during the following decade¹⁴.

Gamma 3 was an excellent machine, superior to the equivalent IBM product (IBM 604) both in its logical design and in its technology — logic circuits based on germanium diodes, exhaustively tested and much more reliable than vacuum tubes. But like the 604, the Gamma 3 was an electronic *calculator*, not a computer; the program was not stored in the machine but was wired on a plug board similar to those in a manual telephone exchange — the standard way of "programming" punched card machines. It was not until 1956 that Bull added to the machine a magnetic drum, to give what was their first computer, the "Gamma Extension Tambour". The commercial success of the Gamma systems made Bull one of the major European users of germanium diodes.

Bull started to build transistorised machines in 1957. These included the Gamma 60, a powerful machine using 38,000 transistors, first delivered in 1960 (only 19 produced); Gamma 322, successor to Gamma 3, in 1961; Gamma 30, made under licence from RCA; and Gamma 10, a small commercial machine of which 1850 were sold. Up to 1970 all Bull and Bull-GE machines were built from discrete components, the technology of which made great progress in both performance and cost reduction during the decade, paralleling the microcircuit "revolution".

Until the end of the 1950s Bull did not produce electronic components, instead buying its vacuum tubes from CSF and RCA and its germanium diodes from Radiotechnique.

The components remained a competitive handicap to Bull, even the passive components. In 1956, the syndicate of the French electronics industry stressed that prices of professional equipment were 35% above the international rates. In 1961 Bull's President complained that the European manufacturers were penalised by components prices: for example, mica capacitors cost from 1 to 4 F, against 0.4 F. in the USA. No company would embark on automated production unless assured of very large orders, and Bull could not commit any orders unless the quality of the product was guaranteed. A high level engineer from the Ministry of Industry, Sueur, after a visit to Bull in 1963, recorded that automated production of components was "a factual impossibility [...], the industrialists will not risk making the investments needed [...] and the government is rather helpless¹⁵."

Development of new components became one of the main concerns of Bull's R&D during the 1960s; it absorbed between 10% and 20% of the R&D budget¹⁶. This was accompanied by a great increase in the company's interest in the academic science community, of which the "Bullists" had taken little notice up to then. The management began to court the DGRST and the minister responsible for research, with the aim of attracting Government support. However, Bull received little support for work concerning hardware development — partly, it seems, for

¹⁴ In 1960 Compagnie des Machines Bull was one of the world's leading manufacturers of data processing machinery. It had a base of over 4,000 installations, of which a third were exported; 14,000 employees in France, ten factories, and a global turnover of 201 MF, which had multiplied by 10 over the past ten years. Its profits began to fall in 1962 and in 1963 it showed a loss of 85 MF, with no hope of recovery in the short term. A series of political and industrial manoeuvres ended in 1964 with its takeover by General Electric.

¹⁵ Callies à Blancard, délégué ministériel pour l'Armée de l'Air, 23 février 1961 (AN 771521/52).

¹⁶ The *Rapport Schulze & Bigard* gives the following provisional research budget for 1964:

General advanced studies		6 MF	
Scientific and process-control calculators	7.6		
Business-machine development		14	
Enhancement and improvement of existing business-machine hardware		4.3	
Miscellaneous			2.1
Total			34 MF

political reasons: the Callies, owners of Bull, were outspoken antigaullists; moreover, this manufacturer of accounting machines had a mediocre technical reputation in the military milieu.

In the mid-1960s the semiconductors, still germanium, came mainly from Cosem-CSF and Radiotechnique, where Bull sponsored special production lines. Later General Electric, who controlled Bull, sought to persuade them to buy from SESCO, a joint subsidiary of Thomson and GE; but Bull's engineers expressed a preference for Texas and Fairchild, on grounds of both performance and price. From 1967 Bull-GE research teams designed exclusively machines based on integrated circuits, but the combination of their own shaky financial position and GE's scrimp and save policy prevented them from producing any such machines before the 1970s.

c) CSF and CGE: Adopting American Technologies

The CAE (Compagnie Européenne d'Automatisme Électronique) was formed on 1 July 1960 as a joint venture by CSF, Intertechnique and the Californian corporation Thompson-Ramo-Woolridge. Intertechnique had won in 1958 a contract with EDF for control of nuclear reactors by tendering the small RW-300 computer, which it would build under licence from Ramo-Woolridge (RW). TRW offered technology in the form of licences for RW machines.

The main partner, CSF, seemed to hold all the cards needed for success in informatics. It was one of the leading French companies in electronics with a staff of 15,000, including 1400 engineers, and a turnover of 600 MF; backed financially by Banque de Paris et des Pays-Bas, it had the resources to invest massively in a new technology.

Exceptionally for France at that time, CSF had a strong tradition of research; it was the only big company headed by a "Normalien"¹⁷, Maurice Ponte, who had a doctorate in physics. Its research facilities were divided between two centres: electronic and particle physics in the Warnecke and Simon laboratories at Corbeville, with 800 staff including about 100 engineers and research scientists, which alone made about 30 MF by selling its research in France and elsewhere; and physical chemistry at Puteaux, with 250 staff including 50 engineers, where one of the three departments worked on semiconductors under the direction of Claude Dugas, a former assistant of Yves Rocard's¹⁸. Applied research was done in most of the company's subsidiaries.

CSF produced electronic hardware for the professional market, mainly for the military; its industrial capability was well suited to producing the computers of the period, small series in runs of a few dozens. The group was also the biggest producer of components in France: Vacuum tubes, ferrite cores, diodes and transistors. In principle, this vertical integration ensured control of costs, control of quality of supplies and technical command in the designing of systems. From this point of view CAE represented the opening of a new outlet for CSF component.

With the RW-300, CAE imposed itself as the leading provider of control equipment for nuclear power stations, and added new RW machines to its catalogue. Later it developed a

¹⁷ An graduate of the pure science-oriented Ecole Normale Supérieure, in Paris.

¹⁸ "Visite au Centre de physique électronique et corpusculaire de la CSF", *L'Onde électrique* n° 400, July 1960. The Semiconductor department was working mainly on silicon power transistors, tunnel diodes, field-effect devices and photoelectric cells. Between 1963 and 1965 the laboratory obtained three contracts with DGRST, as part of a general programme for electronics R&D. 22 doctorate theses had emanated from this laboratory between 1933 and 1960, for research directed by professorial friends of Maurice Ponte (de Broglie, Grivet and Rocard). Ponte came close to sharing the Nobel Prize with G.P. Thomson in 1927: it was only a **delay/scarcely-explicable hold-up** in the transmission of his paper that prevented this.

machine based on the American technology but with an improved logic, the CAE 510; this proved a success as a real-time scientific computer. At the same time, to provide the missile guidance systems for France's nuclear weapons, it built under licence the RW-130 which had already been used in the USA for various military applications; from this it derived upgraded computers by adding silicon transistors to TRW's germanium components.

A Customer for Texas Instruments

CAE grew rapidly, its turnover increasing by a factor of ten between 1963 and 1966, partly as a result of its taking over the informatics activities of another company, CGE (now Alcatel). The association between CSF and CGE led CAE to take out a licence from another American company, SDS (Scientific Data Systems), whose products CGE had begun to import.

The new computers announced by CAE in 1964 were clones of the SDS 900 range. The SDS 910, which appeared in the USA in 1962, was the first civil computer to use silicon transistors. SDS followed this by a very early move to integrated circuits, with small- and medium-scale real-time scientific calculators, relatively low-priced for the period. In 1965, CAE, having made a commercial breakthrough into the market for scientific computation, appeared as the main manufacturer financed by French capital. Between 1960 and 1967 it produced between about 150 stored-program computers and 50 various measure and control devices.

CAE "frenchified" American calculators, meaning that it built these, partly with elements made in France: ferrite cores, magnetic reading heads and various other parts. Strangely, the active components — transistors, and integrated circuits especially — came mostly, not from Cosem, but from Texas Instruments, who in 1961 had opened its factory at Villeneuve-Loubet. According to the former technical director of CAE, Cosem's silicon transistors were too unreliable and the development took too long, doubtless because CSF had not acquired the same command of silicon technology as had its American competitors. "CSF's policy was to be a second source; they were not used to undertake any development unless requested and underwritten by the Administration¹⁹."

Five years later a government study implicitly condemned CSF's policy of simply following behind the leaders. "Lacking big enough military orders or broad enough markets developed early enough, the French industry, taken as a whole, was unable to establish a firm financial base, for it usually started to manufacture this or that family of products just when the selling price had fallen to a very low level. Consequently it can not meet from within its own resources the high cost of the micro-electronics studies on which its future depends. [...] Without the means, and perhaps also due to a lack of judgement, CSF-Cosem was late in developing the products [ICs] that should now be taking over from their predecessors [Ge discrete components]."

The short term view taken earlier by its management in favour of germanium saddled the company with a certain amount of technical backwardness. According to the then head of the CSF St.Egrève laboratory, the most difficult technological revolution the component manufacturers had to contend with was not the germanium transistor, which did not require a production organisation essentially different from the vacuum tubes', but silicon, an especially difficult material to handle. In addition, St.Egrève, in the Alps, was 600 km from the Paris CSF laboratories and communication between the two was slow and arduous; whilst the key to success in micro-electronics lies in improving the fabrication processes, and this requires close collaboration between research and production. Further, CSF was not accustomed to mass production. Its priorities were for custom products made in small numbers for the Army and for

¹⁹ Conversation (26-09-1992) with Robert Chambolle, former Technical Director of CAE.

nuclear research, which offered few possibilities of economy of scale — a tentative diversification into radio and TV for the mass market failed; as for discrete components, its publicity boasted "Cossem, the main European producer of diodes". It left the gate open for silicon components, through which the new American companies poured — Texas Instruments, Fairchild and Motorola: France was Motorola's main customer in Europe in 1966, with a turnover of \$ 2 M.

D) The Plan Calcul: National Ambitions and American Technology

The Plan Calcul, one of the most ambitious technological programmes of the Fifth Republic, aimed at establishing an informatics industry that would guarantee France independence from the American manufacturers.

The government's policy was to shape a "national champion", a company, preferably big (if necessary, formed by "inducing" several companies to merge) which the State would support through R&D grants and preferential purchases. The "Calcul" and "Composants" plans meant, primarily, concentrating the industry so as to reduce internal competition and generate a "critical mass" effect. The weakness of such a course is evident: the "national champion" is formed, not as the product of market pressures — which would have left a number of competing firms — but in response to criteria imposed by the State in the interests of its own needs, and to existing alliances between this or that branch of the government service and this or that firm²⁰. It will therefore orient its structure and its strategies to the demands of the State rather than to the needs of the market, and will find it very difficult to change its behaviour and ethos so as to remain competitive.

The main industrial protagonists in the Plan Calcul were CGE and Thomson-CSF. Their main objective was neither the closing of the gap in component production (Cossem's doctrine was "controlled delay" and CGE had sold its components subsidiary to Philips-Radiotechnique) nor the development of a computer industry (in an official report in 1966 they told the government that they feared this would provoke reprisals from IBM), but the control of government funding. As the government submitted the distribution of its funding to the condition that the industry "concentrated" its activities, CGE, CSF and Thomson began a series of mergers so as to regroup their specialised subsidiaries. The resultant companies were anointed "national champions". This enabled them to both drain off most of the public money and eliminate any rival firms who might try to compete for subventions. Thus in the computer field, SEA was absorbed; in components, Radiotechnique was marginalised; and the new entrants, Silec and later Efcis, were doomed.

The launching of the Plan Calcul was expressed by the creation of a "Délégation à l'informatique" at Government level, two research centres, IRIA and LETI and an industrial complex consisting of CII (computers), SPERAC (peripherals) and SESCOSEM (components). These creations were accompanied by large investments, 7,500 MF (about \$ 1,500 M) between 1967 and 1975.

CII (Compagnie internationale pour l'informatique) was formed in December 1966 by the merger of SEA and CAE, enforced in a very hostile climate. The two companies had been competitors, and on bad terms with one another for a long time. They approached the Plan Calcul with conflicting strategies: SEA wanted to strike out on a new line, investing mainly in research so as to "skip a generation" and have new, very competitive products to offer in the early 1970s, whereas the CAE team took a shorter-term view and proposed building SDS

²⁰ A service devoted to "managing" and encouraging mergers ("Bureau des fusions et regroupements d'entreprises") was created within the Ministère de l'Industrie by a 6 October 1967 decree !

computers under licence. Given the relative strengths of the industrial, and above all political, forces involved, the actual outcome of the creation of CII was that SEA, the more innovative company, was absorbed into CAE, who imposed their own strategy and products: thus the first products of the national champion were American computers built under licence. Only in 1969 did CII begin to manufacture its home-brewed computer range, "IRIS".

For components, the State agreed with the industry a "5-year Micro-electronics Convention"²¹. This, the first of a long series of plans concerning components, guaranteed the French producers a certain amount of government finance, officially to support research aimed at reducing the estimated 3-year technical lead of the Americans. All this was, in fact, inscribed in the context of the big industrial manoeuvres of the period: Thomson absorbed CSF and the semiconductor activities of the two groups were combined in the merging of SESCO and COSEM to form SESCOSEM²², which received 20 MF between 1969 and 1973 for support of its R&D. To what extent was the support for research diverted into cover for losses? An unsigned note in the DGRST papers, dated 13 February 1968, complains: "Nothing of this has been achieved. The Components Plan is simply a rescue operation, for saving Company X when its losses — due to bad management — have become catastrophic²³". The evolution of Cossem's turnover showed a peak of discrete Ge components in 1966, followed by a rapid decline; combined with weaknesses in the sales force and above all with technical backwardness in Si products, this resulted in a general fall in Cossem's production in 1967. Financial results fell to zero in 1966, to - 3 MF the next year. Cossem never became profitable again.

Yet CSF-COSEM did carry out research on integrated circuits. In 1964 it had produced an experimental TTL circuit under contract with the Air Force, and in 1968 a 16-bit MOS memory under contract with DGRST at the Corbeville laboratory. But the step from laboratory to industrial scale was always long and difficult. The DTL and TTL circuits were still in the development stage at COSEM in 1967, and it was not until 1968 that the first production was presented at the Paris component fair. The forecast then was that the output of TTL circuits would reach 100,000 per month in 1969; now, Texas had been producing the same "chips" — their Series 54 and 74, of which COSEM's were clones — at their plant at Villeneuve-Loubet since 1966. In 1969 the American company reduced the price of its MSI circuits by 25%, forcing its competitors either to follow suit or to throw in the towel. It did the same again in 1971, just when the recovery attempt at Sescosem was beginning to bear fruit; Sescosem then began to consider giving up production of TTL circuits.

Those in charge of the Plan Calcul regarded informatics as the driving force for innovation in the semiconductor industry: this indeed was one of the main reasons for launching it (Allègre 1969). Unfortunately, the informatics industry which they set up did not constitute, for Sescosem, a large enough outlet to justify a decisive reorientation towards computer components: the 246 systems installed by CII between 1967 and 1970, a high proportion of which were SDS "minis", were not enough to persuade the French electronics industrialists to

²¹ *Plan Composants* was announced by the Minister for Industry in April 1967, just at the moment when CSF published its deficit. It was to provide 100 MF over 5 years, mainly to support production of integrated circuits. This was followed by a second convention in 1972 which doubled the support to 200 MF over 5 years, equivalent to over 900 MF in 1991.

²² Thomson and CSF had reached agreement in the field of semiconductors in the summer of 1966. An Italian subsidiary, Mistral, which supplied the consumer market, was added to the combination resulting from their merger, which then had a turnover of 135 MF, with one third of the French semiconductor market and 10% of the European. Thus Thomson-CSF was for a time the second European producer, after Philips.

²³ Quoted by Zysman (1982: 173). SESCO and COSEM were both in deficit after the mid-1960s. Merging the two was far from forming the "critical mass" that was the official aim of the merger. In 1969 SESCOSEM's research department had a budget of 30 MF and employed 90 engineers, less than a quarter of the resources committed to component research by Texas in the USA, whom France sought to overtake.

make the massive investments that would be needed to put digital integrated circuits on what was a hyper-competitive market. Such circuits represented less than 0.2% by volume of Sescosem's production in 1969. In its forecasts for 1974-1975, SESCOSEM did not hope to sell more than 20 MF of ICs for computers (8% of its expected revenues), out of which CII accounted for one quarter. The CII engineers modified the SDS machines by replacing the original DTL circuits by TTL; these gave higher performance, but most had to be bought from the leader in this technology, Texas Instruments.

Since it is difficult to find any written information about the semiconductors purchased by computer companies, I opened a few CII machines and examined their components. Most of the integrated circuits came from Texas Instruments. For instance, I dived into the entrails of an IRIS 42 and an IRIS 50 (medium-sized business machines, built around 1970) and a Mitra 15 of 1973. In the IRIS, about 90% had the TI logo alongside the CII attribution mark; COSEM (CSF) produced the remaining 10%, and most of the discrete components (diodes and transistors). In the Mitra 15 minicomputer, the most important chips were again Texas. For good measure, we also looked inside a Micral (the first microcomputer, built in 1972, based on the Intel 8008) made by an independent small company, R2E : without exception, all its logic components were American, and of 200 circuits 119 were from Texas²⁴.

In a report dated 1974 the Délégation à l'informatique said: "At the same time as its notorious deficiencies in production and even development of Schottky TTL logic circuits, Sescosem has had good results in the field of bipolar memories and now has a good, though not perfect, command of several MOS technologies. The general outcome is, however favourable, since *the fraction of components used by CII that are of French origin, almost zero at the start of the Plan Calcul, is over 50%* [at the end of the second Plan Calcul]²⁵". This certainly shows progress, but seven years had gone by; given the cumulative nature of innovation in the semiconductor industry, for France to recover from its shortcomings had become a practical impossibility.

As emphasised by John Zysman, "Although learning-curve economies occur in all branches of industrial production, they are critical to an understanding of the component business because they have a peculiar impact on business strategy in the active component industry. The cost of producing semi-conductors appears to decline by 20-30% every time the total number of units produced doubles" (Zysman 1982). The refusal of the government to associate Bull with the Plan Calcul in 1966 made CII a company of sub-critical size (one-third the size of Bull), whether in terms of output or of negotiating power with the component producers (Mounier-Kuhn 1993). The hoped-for driving effect of informatics on the French semiconductor industry never materialised to any decisive extent.

Conclusion

At the start of the 1960s there were more than ten companies making computers in France. These were generally in very small runs, a few tens of units and in some cases only a few units — apart from IBM and Bull. Nevertheless, this group of firms constituted a respectable market for the component producers, of the order of a million transistors annually, and increasing rapidly.

²⁴ The British "national champion" acted in just the same way as CII: in order to remain competitive against the Americans, ICL used Texas Instruments circuits rather than those of its compatriot, Ferranti.

²⁵ (Our italics) The author of this report does not say whether the percentages quoted refer to *all* components or only to integrated circuits; it seems to mean the latter. The text does not give any percentages in terms of value. Quoted by P. Audoin (1988: 36). A much less optimistic estimation, in a 1975 pamphlet published by CII unions, stressed that Sescosem supplied only 5% of CII total consumption of s.c.

SEA, who had a good appreciation of the long-term evolution of informatics technologies, developed microcircuits in partnership with Radiotechnique-Philips, who seemed to have had the ability to react quickly to technology and market changes. But this symbiosis disappeared with the launching of the Plan Calcul.

Bull chose to investigate new types of magnetic memory and up to 1970 did no work on the development of semiconductors; at first a customer of CSF and Radiotechnique, it turned more and more to American suppliers. With an unstable financial situation that prevented it from developing integrated-circuit computers, Bull-GE did not at that time constitute a market that would attract the European producers to the most innovative components.

The major French electronics group, CSF, seems to have had no very coherent policy in this field. After refusing for a long time to invest in digital computing, it created CAE, with licences to build American machines: this was entirely contrary to its traditions of relying on its own R&D to create innovative products. With COSEM encountering difficulties that delayed the necessary moves first to silicon transistors and then to integrated circuits, CAE turned to Texas Instruments; consequently there was little synergy between computer design and component manufacture within the CSF group. This is a point of major importance, which should be looked into carefully in any future comparative study of the international scene: beyond the case of CSF, why did the Japanese electronic giants — NEC, Toshiba, Fujitsu — succeed in informatics, whereas the corresponding American and European (especially French) companies abandoned this, one after the other²⁶?

Was the failure of Bull, CGE and CSF to reach agreement in 1963 an historic opportunity missed? The three companies had sketched out an alliance, in an attempt to overcome Bull's crisis; but Bull, who found no concrete help from its French partners, preferred to join General Electric in 1964 — motivated in part by the hope of finding a competitive supplier of components. Would not a strong alliance of the three French companies, supported by the State, have created an above-critical mass which, whilst certainly less than IBM, would nevertheless have been large enough to persuade the French semiconductor industry, and especially COSEM, to turn its attention to the components with the greatest potential? This is wishful thinking, since neither CGE nor CSF were willing to attack the commercial computer market.

Without this agreement, French informatics had no consolidated front to present against the American component suppliers; the latter steadily increased their domination both by selling directly to the computer manufacturers and by licensing their processes to the French producers, who then became "second source" suppliers. The Plan Calcul and the Plan Composants had little effect; they were too late and lacked any serious strategy — they aspired to produce business computers, while excluding Bull. It could even be claimed that the two plans were mutually inconsistent, since the national champion (CII) they set up, starting with a heavy commercial

²⁶ The one exception was Siemens, who however have experienced many setbacks. The conclusions we have come to as a result of studying the French companies confirm what was said by Franco Malerba (1985), with a few qualifications concerning:

- the role of the State, which was more positive than one might have thought in the nascent French computer market; the public sector bought about 60 of the 120 machines installed between 1955 and 1959
- the role of IBM, whose French subsidiary bought its components mainly from European producers up to the end of the 1960s.
- the absence of "new entrants", enterprises going into semiconductor production and renewing the industrial fabric. Malerba reckons that the absence of companies like Motorola and Intel largely accounts for the decline of the European electronics industry. This is a persuasive argument, but seems to us over-simplified. There was indeed a French "new entrant", SILEC, formed in 1956 by a Thomson engineer, to make silicon components; this was a success story and is now a piece of forgotten history. Our impression is not that there was a lack of entrepreneur spirit in France, but that the State always tended to support existing companies and sectors, rather than the nascent ones.

handicap in front of IBM and Digital Equipment, had either to use American integrated circuits in its products or be completely uncompetitive²⁷.

Does this mean that planning is basically wrong, and that we should trust only the unregulated market to manage our industry and promote innovation ? No. The Plan Calcul failed mainly because its initial managers devoted more attention to politics and not enough to real industrial and technical strategy. In fact, the Plan Calcul was neither seriously planned nor calculated, if we consider the organization of research, production and sales. The government should not have picked up “national champions” among big, established companies with political connections - but among the smaller companies which were successfully developing and selling innovative minicomputers. It should have helped the innovators, the winners, instead of pouring the taxpayers’ money into mismanaged firms. It should have maintained competition between them and let the market decide who was to be the “national champion” - instead of decreeing this from a Ministry office. In other branches of computing activities, the governmental policy was more subtle, more modest, more appropriate: The French software industry has prospered in a context of free competition with contracts from State administrations; the French telecommunication industry, which was almost nonexistent 40 years ago, has become a pioneer in digital telecom and networks, based on long-term research done at the Centre National des Telecommunications; the smart card, patented in 1974 by a young inventor, soon supported by France Telecom, has become an industry and contributed to change our lives.

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