From Research Institute to Computer Company: Regnecentralen 1946–1964

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Personal contacts between Danish and Swedish scientists played a major role in transferring computer technology to Denmark. The first Danish computer, DASK, was a result of that cooperation. In order to build and run DASK, and for doing research in the computer field, Regnecentralen was founded. Caught between the commercialization of the computer market and the national government's technocratic vision of a controlled development in the use of computers, Regnecentralen managed to survive, unlike most governmental agencies, playing a role in early computer development. This article tries to explain how and why this happened.

Introduction

From its start in 1955 and until the first part of the 1970s, Regnecentralen (RC, Computing Center) was the only Danish computer manufacturer. It had its offspring in Denmark's technical and scientific milieu, and the company had a profound impact on education and research in the computer field in Denmark. From the start, employees from RC participated actively in the development of Algol—for instance, RC's Peter Naur was the editor of *ALGOL-Bulletin* and edited the final definition of that language.[1] Members of the RC staff wrote the first textbooks on programming and *datamatik*, as computer science was called in the first years. They planned and arranged curricula at Denmark's Tekniske Højskole (Technical University—DTH) and the other Danish universities and were active in the international field, such as IFIP and the Scandinavian cooperative organization NordSAM.

The history of RC can be divided into four phases:

1) 1946–1955: The Academy of Technical Sciences (ATV) had a committee on computing machinery that monitored the developments in that field. The ATV, founded by P.O. Pedersen from DTH in 1937, was inspired by its Swedish counterpart, Ingeniörvetenskabsakademiet.[2] Its purpose was to promote and support cooperation between science and industry and consisted of various working groups, covering different technical areas, and several independent laboratory institutions in areas such as a welding center, a geotechnical institute, and a radio research laboratory.
2) 1955–1964: In 1955, the committee on computing machinery was transformed into a self-governing institution. Its first task was to build and run the first Danish computer, DASK. Under its dynamic director Niels Ivar Bech, RC was the central institution for the promotion of the use of computers in Denmark and was a research institute for the development of procedures and methods in that field. In that period, the first original Danish computer, GIER, was constructed.
3) 1964–1972: After its reconstruction as a private limited company, RC started to produce computers and peripherals. The RC 4000 was developed, and another product, the RC 2000, was the fastest punched tape reader in the world, and it turned into a commercial success. RC was very active in the educational field and expanded its commercial activities by founding subsidiaries in Sweden, Norway, Germany, Netherlands, and Austria. An important export market was Eastern Europe. Many RC staff members left the company at the end of this period, founding academic courses in *datalogi*—the Danish word for computer science.
4) 1972–1992: After RC's second collapse in 1972, Bech was forced to leave the company. In the next years, most of the original staff left the company, and most of the independent hardware development ceased. After another reconstruction in 1979, RC was owned by different foreign companies, finally to become part of ICL. In 1992, RC ceased to exist.

This article follows the development of RC in the first two phases, during which it transformed from being primarily an institution for research and development to being a manufacturer and a service bureau. Two aspects will be discussed. The first is the role of RC in the transfer of computer technology. The other is the attempts by the Danish state to form a policy for the computer field and the relations to the governmental center for data processing, Datacentralen (Data Center, DC), the latter being a key factor in the development of RC.

Phase 1—Mathematical Machines

The first step in the transfer of a new technology to a country is awareness of its existence. As Hans De Geer points out in his study of the political reactions to computer technology in Sweden,[3] the first information on a new technology often comes through personal relations and mostly within the technical and

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scientific milieus. That is certainly the case in Denmark, where the information came via Sweden.

Sweden had shown an early interest in the development of the new computing machinery. Shortly after World War II, Professor Stig Ekelöf went to the United States and, through work with the ENIAC, gathered information on other initiatives in this area. Returning to Sweden, he reported on his findings at a meeting with interested parties from industry, the military, and science in September 1946. Among the audience was Professor Richard Petersen from DTH, who was also a member of ATV and the Defence Research Council. Richard Petersen immediately wrote a letter to ATV, in which he suggested that a committee should be formed to monitor the international developments in the field of advanced computing machinery. In this letter, he emphasized the potential contributions to scientific research and pointed out that the new computing machines had contributed to the compilation of several valuable tables. At an ATV meeting, the academy decided:

- to invite Ekelöf to make a speech on his findings,
- to ask Norwegian colleagues about their experience, and
- finally, to ask engineer Lottrup Knudsen, who was staying in the United States, to look at the recent initiatives.[4]

In February 1947, Ekelöf made his speech, and shortly afterward, Douglas Hartree, known as one of Britain's leading experts in the area, was also invited to comment. This led to the creation of the Committee on the Preliminary Discussion of the Latest Calculating Machines, shortly thereafter renamed the Committee on Computing Machinery (Regnemaskinudvalget, RMU) in December 1946.[5] The members of this committee were the following professors from DTH and the University of Copenhagen:

- Prof. (dr phil) Richard Petersen (chairman),
- Prof. Robert Henriksen,
- Prof. (dr techn) M.O. Jørgensen,
- Prof. (dr phil) N.E. Nørlund,
- Prof. Jørgen Rybner,
- Prof. A.G. Schneider, and
- Prof. (dr phil) Bengt Strømgren.

At first, the main objective was simply to become informed on the international developments through studying publications and obtaining reports from Danish scientists staying in the United States and Britain. A major source of information was the close contacts with Swedish colleagues. Building an electronic digital computer in Denmark was out of the question at that time. Although Denmark had not suffered as much during World War II as most other nations in Europe, the economic conditions were still difficult. The problem was a lack of foreign financial reserves. To put it in a simplified manner, in the past, Denmark had financed its import of machines, raw materials, and energy by its export of agricultural products to Britain. After World War II, Britain was in a difficult economic situation. Furthermore, world trade was now dominated by U.S. dollars. The scarce supply of U.S. dollars had to be reserved for absolutely necessary imports.

At first, the RMU concentrated its efforts on analog differential analyzers. It is not known if Ekelöf and Hartree played a role in this decision, but both were experts in that technology. Ekelöf had recommended the procurement of differential analyzers in Sweden before the war, and Hartree's contribution in that area is probably familiar to most readers of *Annals*.

The Danish Technical Scientific Research Council (Danmarks Teknisk Videnskabelige Forskningsråd, DTVFR) decided in February 1948 to grant financial support to the construction of a differential analyzer similar to the machines constructed by Vannevar Bush[6] and simultaneously to support experiments in the use of electronic calculators in solving linear equations by Professor Rybner at DTH. However, any plan of obtaining a computer was still considered unrealistic. Suddenly, there was another way of getting access to the technological and scientific knowledge concerning computers.

International Computation Centre

In June 1946, the French delegation at a meeting at the Preparatory Commission of the United Nations Organization for Education, Science, and Culture (UNESCO) proposed the establishment of an international laboratory for computing. The argument was that small and economically weak countries would not have the possibility of getting access to the new automatic calculating machines being developed at that time. To ensure access for these countries, UNESCO should establish an international research laboratory equipped with these machines. In 1948, the General Secretary of UNESCO asked the U.S. delegation to form an expert committee to draw up a proposal. Originally, the laboratory was supposed to be located in China, thus giving the scientific community in East Asia a boost, but that plan was abandoned due to the Communist Party takeover of power there. Instead, the International Computation Centre (ICC) should be placed in one of the smaller countries in Europe that had the necessary scientific potential. The U.S. expert committee submitted its report to UNESCO on 27 July 1949, but a preliminary confidential report was received by some scientists beforehand, among them Danish mathematician Harald Bohr.

The RMU held a meeting on 14 June 1949[7] to discuss the report. On that special occasion, other prominent professors from the relevant areas were invited. Professor Brandt Rehberg introduced the meeting with a few general remarks on the report. The original plan had been to establish the center in Asia, but the plans had changed, and the scientific background of the staff was now emphasized. Because of this, the plans now called for a location in Europe, for instance in Denmark. An intense discussion followed, and it was decided to make an effort to bring the center to Denmark. Because the plans were rather general, a detailed proposal indicating the required buildings and staff would be premature, and Rehberg, Jakob Nielsen, and Strömgren were asked to write a proposal.[8]

At a meeting on 27 October 1949, Jakob Nielsen presented his proposal, which was accepted with some minor changes. The proposal outlined the activities in the field in Denmark, mainly the formation of the RMU and its activities concerning the construction of a differential analyzer and the electronic calculator for solving linear equations. It supported the idea of having the center placed in Europe with two arguments:

1) The first argument was that Europe and its scientific community had suffered badly due to the war. Every initiative that would contribute to the recovery of European science would be most welcome.
2) The second argument was that the center should not be limited to performing computational tasks.

On the contrary, its primary task should be to:

> foster and develop the mathematical theory behind modern computation, to adapt problems of pure and applied mathematics to the new and powerful tools of our days and to collect and publish the results gained in order to avoid the waste of overlapping work.[9]

Because of that, the center should be composed of the most qualified people internationally, which again supported a location in Europe.

UNESCO formed another expert commission in the summer of 1951. Among its members were Herman Goldstine, Richard Petersen, and Professor Nils Zeilon from Sweden. Ekelöf was attached as one of the consultants. However, at this time, Denmark had lost interest. The work on the differential analyzer was making good progress, and there was now a realistic possibility that Denmark could get its own computer. Involvement in the ICC could block this development instead of support it.

Operation and maintenance of a computer required a degree of knowledge about its construction that could be obtained only by active participation in the construction of the machine.

Phase 2—Establishment of RC

As mentioned before, there was a close cooperation between the ATV and its Swedish colleagues. In 1950, the Swedish Matematikmaskinnämnden (MMN) had started the construction of BESK, with the IAS computer and EDSAC as models. In the Danish Forsvarets Forskningsråd (Defense Research Council, FFR), the possibility of building a Danish computer in cooperation with the Swedes was discussed during 1951. In September 1952, a joint committee between FFR and RMU was formed, and a letter was sent to Sweden asking about the possibility of buying a copy of BESK. Only a month later, the committee received a positive answer from MMN in Sweden. MMN recommended the computer be constructed in Sweden, because the special equipment and the expertise were situated there, but it would also be possible to construct the computer in Denmark, in which case RMU should send two engineers to Sweden in order to obtain the necessary know-how.[10] MMN certainly would prefer the former option, since that would make it easier to maintain the qualified staff presently involved in the construction of BESK. The Danish copy would fill the gap between the completion of BESK and the work on a possible successor.

In the following month, an application was sent to the Defence Ministry, requesting 500,000 Danish kroner for a copy of BESK.[11] In the application, it was stated that until then, the purchase of a computer had not been economically realistic, but that the situation had now changed. Commercial computers were now offered on the market in Britain, the United States, and France. The Dutch had established a computation center in Amsterdam equipped with modern calculators. Also in Switzerland, there was an institution with a computer. Norway had a big differential analyzer and was about to get an electronic digital machine. In Sweden, there was the relay machine BARK, and two electronic computers were about to be completed (BESK and the copy in Lund, SMIL). In relation to BESK, an Institute for Numerical Analysis would be established. The finance application also stated that it would not be advisable to buy a commercial computer. Operation and maintenance of a computer required a degree of knowledge about its construction that could be obtained only by active participation in the construction of the machine. The Swedes had offered full support in the construction of the machine. Not only could Denmark benefit from the valuable experience gained by the Swedes, it would also be possible to start working together with Swedish engineers immediately, thus saving time and costs. In only 18 months, Danish science and industry would have an electronic digital computer and a differential analyzer at its disposal, thus keeping up with the developments in other countries.[12]

Actually, the first Danish engineers had already been sent to Sweden. The first was Bent Scharøe Petersen, who became interested in digital techniques during his trainee service period at DTH. He had also participated in a course on modern computers at the Nordic Summer University, where Naur had lectured. The young astronomer Naur had the chance to go to Cambridge University shortly after his final exam, and he had worked with the EDSAC in the years 1950–1951.[13]

Bent Scharøe Petersen had developed his interest in the new technology, and for his final exam, he tried to construct a delay line in glass, utilizing polarized light. In this process, he discussed the mathematical and technical problems with Richard Petersen, Rybner, and J. Oskar Nielsen, all members of the joint committee between RMU and FFR. Richard Petersen realized the potential of the young engineer, and using his influence and good contacts, Bent Scharøe Petersen became part of the construction team at BESK, while part of the time doing his military service. This seems strange today, bearing in mind that Denmark was part of the NATO alliance and Sweden was declared neutral, but it shows that the scientific communities in Sweden and Denmark would not let a minor thing like the cold war interfere with their traditional close connections.

There was another young Danish engineer who soon became involved in one of the Swedish projects. This was Tage Vejlø, who was employed at the construction of SMIL in Lund.[14]

In the meantime, progress in Denmark was slow. Although the Defence Ministry's attitude was positive, it had some reservations concerning the demand for a computer and feared that its capacity would far exceed the demands for computing power in Denmark. After lengthy discussions, it was decided that the ATV should build the computer for the Defence Ministry, but that it should also establish a self-governing institution to manage and operate it.[15] In 1955, after the Danish government granted 900,000 kroner from the Danish counterpart fund of the Marshall Plan, the Regnemaskineudvalg was dissolved and Regnecentralen—Dansk Institut for Matematikmaskiner, literally Danish Institute for Mathematical Machines (officially the name was Danish Institute for Computing Machinery)—was founded on 18 October 1955. The board was composed of two representatives each from DTH, the University of Copenhagen, the Board of Industry, and the military. Richard Petersen remained as chairman. In the articles of RC, it stated that the RC's purpose was to acquire, build, and run

"mathematical machines" for military and civilian research and computational tasks. RC should also carry out research in computers and the mathematical tools connected with them.

In the spring of 1956, the construction of the computer started under the leadership of Bent Scharøe Petersen.[16] It was soon called DASK. In the literature, this usually is considered to be an acronym for Dansk Aritmetisk Sekvens Kalkulator, but the minutes of the board meeting show that originally it just meant DAnsk version af BeSK (Danish BESK version).[17]

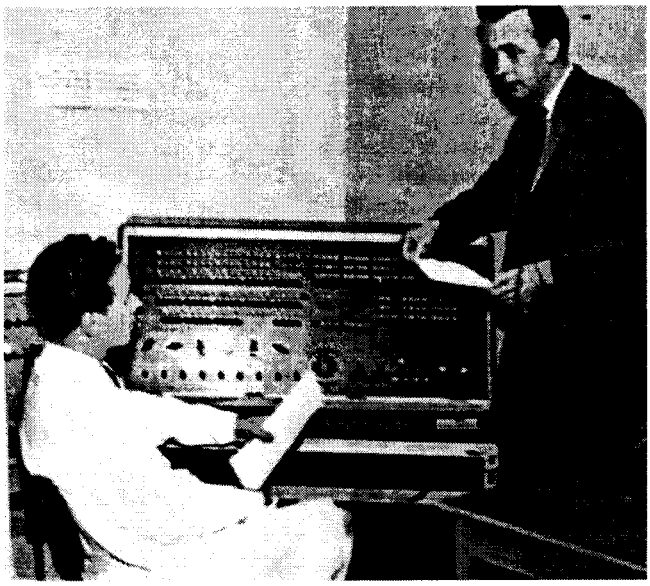

Fig. 1. Tage Vejlø and Niels Ivar Bech at control console for DASK.
(Photo from Tage Vejlø's private collection)

In order to foster an interest in industry for the use of computers, and thus preparing a market for DASK, the old RMU had undertaken some public relations work, publishing articles and giving lectures on the possible applications of computers. Courses on programming and coding were also held, initially for the Swedish machines, thereby giving Danish industry a chance to gain experience in the use of computers. As early as 1954, several Danes participated in courses in Stockholm. The first were Hans Brøns, Bent Scharøe Petersen, Aage Winther, and last, but not least, the future director of RC, Bech.[18] Later, Christian Andersen and Ole Møller also took a course.

The first courses in Denmark were given by Christian Andersen, Bech, and Møller—all being employed outside RC, but soon to be associated as consultants. The number of participants in these courses is not known, but a list from November 1955 has 82 names, primarily from laboratories and institutions associated with DTH and ATV, from the Air Force, from the naval yard, and from other parts of the military.[19] There were only a few participants from industry. Interest grew, partially because the completion of DASK was in sight, partially because RC had announced the terms and prices for its use, and partially because there was a growing awareness of the computer's possibilities.

At first, the participants in the courses were a motley crowd of computers (in its original sense of the word), academics, and others. In the beginning, many leaders took part, expecting they could do advanced computations themselves, but they soon realized that the courses were better suited to technically minded persons who had the necessary knowledge to understand the details of the computing processes.

The Construction of DASK

From the start, it was clear that DASK should not merely be a copy of BESK, but that the experiences from BESK should be incorporated. DASK was equipped with a core memory from the start. In a meeting with Bent Scharøe Petersen, Bech, and Naur, it was decided to incorporate features Naur and Bent Scharøe Petersen knew from their work with EDSAC. That meant using a modified order code and index registers. Richard Petersen was a little concerned about these modifications, because compatibility with BESK was considered important. The constructors, however, had their way. See Fig. 1.

The construction proceeded as planned, although the budget was tight. Most of the elements were manufactured by members of the construction team themselves, instead of buying them ready-made. One example was the core memory. The cores were imported (which caused some confusion at the customs office), and the wives of the staff members were employed to sew them to memories. Another example was the magnetic drums used for storage. The brass drums had their magnetic coating applied to the surface by a modified standard vacuum cleaner.[20]

The agreement with the Defence Department called for the completion of DASK in the beginning of 1958, but the first test program ran successfully on 29 September 1957. It was introduced to the public in October at the big Electricity and Atoms Fair at Forum in Copenhagen. In cooperation with Standard Electric, a data transmission line was hooked up, and visitors could have their taxes calculated in record time. This display attracted some attention, but was partly overshadowed by the launch of the Soviet *Sputnik*. Later that year, Bent Scharøe Petersen and Bech toured the country and demonstrated the abilities of DASK in the same way.

DASK was officially assigned to the Defence Ministry on 13 February 1958. The construction team of only five permanent staff members took some pride in that they not only had kept within schedule but also there was also 25,000 Danish kroner left in the budget.

At first, DASK was primarily used for technical and scientific computation for Danish industry, mainly shipyards, telephone companies, and machine works. Actuary computations for insurance companies were another application. Scientific computation, for example for the atomic research center at Risø, was initially an important proportion of work, but was soon to diminish in importance. Also, the jobs for the military took only a small proportion of the operation time. Mostly, they were ballistic calculations for the Artillery Training School, but decryption work for the Defence Central Radio was probably another task.

The big breakthrough in the public's awareness came during the general elections of November 1960, when Danish television asked RC to participate in the broadcasts that evening. Bech saw this as a big chance to promote computers, and despite Naur's opposition, who feared that it would delay the work on an Algol compiler, all resources were mobilized. In five weeks, the necessary programs were ready, and with some nervousness (a similar attempt in Sweden two months before had not been convincing), election night was eagerly awaited.[21] Fortunately, everything went

fine, despite some problems with the data transmission, which the viewers did not notice.

Niels Ivar Bech

Shortly after DASK was put into use, the board of RC decided to employ Bech as director. Bech was originally a teacher, but later worked as a "computer" at the actuary office of the Copenhagen Telephone Company. He had been part of the first group of Danes at the programming course for BESK, sent there by his boss Arne Jensen, who was familiar with EDSAC. Bech was a constant agitator for the use of computer technology and was convinced that it would be of great importance for every aspect of society in the future. In contrast to most of the board, who had technical or scientific backgrounds, Bech saw the potential of computers in office automation and administrative uses. His associates have described him as an inspirational leader, who managed to create a unique working climate, where people from many and varied backgrounds worked in an interdisciplinary environment. His main management principle was called "moleing," meaning that employees were encouraged to disregard formal structures and work across departmental boundaries.[22] His enthusiasm was inspiring, but this sometimes led him to be overoptimistic. As RC grew, he occasionally lost track of things. As a leader of a research institution, where one must take chances and where it is important to be encouraging and inspiring, Bech was brilliant, while his qualities as a businessman were not quite as convincing.

Fig. 2. Basic GIER system. GIER itself is placed in the background, looking like a wardrobe. This was Isaksson's idea. Punched paper tape was the data medium that RC preferred.
(Photo from Tage Vejlø's private collection)

Under his leadership, RC quickly expanded, with departments devoted to:

- engineering computations,
- operations analysis,
- office automation,
- mathematical analysis, and
- electronics engineering.

In order to be able to fulfill the new requirements, DASK was expanded with fast printers, punched card readers, and magnetic tape drives. DASK was a hybrid computer, the central part relying on tube technology, while the peripherals were transistor-based.

Also in this area, the ability to improvise was important. Although printed circuits could be bought, they were considered to be too expensive, and the delivery too slow. Vejlø then remembered a book on lithography (from 1872) he had inherited from his father. From that book, he developed a crude but effective technique for manufacturing printed circuits, which was used at RC in subsequent years.[23]

GIER

After the completion of DASK, there was some consideration as to whether RC should start work on a new computer in order to obtain know-how in transistor technology. First, a continuation of the successful cooperation with the Swedes seemed to be promising, but the developments in Sweden put the plans for a successor for BESK, the SuperBESK, into the distant future.[24] On the other hand, the board considered it too risky to start work on a Danish machine by itself. Luckily, the director of the Geodetic Institute, Ejnar Andersen, came to the rescue. The Geodetic Institute had a long tradition of using calculators for its computations—inspired by L.J. Comrie's work in England. From 1953 onward, Torben Krarup and Bjarner Svejgaard had started to use a modified IBM 602A punched card calculator for their work.[25] Ejnar Andersen suggested to the RC board that Krarup and Svejgaard should design and RC should produce a transistorized computer for the Geodetic Institute. The Defence Ministry, of which the institute was a part, was not thrilled by the idea, but with the help of creative budgeting, Ejnar Andersen managed to cover the development costs within his normal budget. In an early 1958 cooperative effort among Krarup, Svejgaard, and Bent Scharøe Petersen, the general design was quickly defined for what was to be called GIER (Geodætisk Instituts Elektroniske Regnemaskine, Geodetic Institutes Electronic Calculator), and construction began, primarily under the leadership of Henning Isaksson and H. Worsøe.[26] See Fig. 2.

Before GIER was completed, industrialist Haldor Topsøe made an inquiry to RC about the possibility of buying a copy of GIER. Topsøe owned and led one of the most technologically advanced industrial companies in Denmark, and GIER seemed well-suited for process control and calculations in chemical plants. In general, GIER must be characterized as a flexible and comparably cheap computer. Topsøe's inquiry was followed by others. Reluctantly, the board of RC decided that eight machines should be built, and Vejlø was asked to make the necessary arrangements. It was emphasized that only eight machines were to be built—the staff therefore knew from the start that employment was limited to only one year.[27]

Because development on the prototype and production happened in parallel, Vejlø had to improvise again. He would go to the development department in the evening and take photographs and notes on the circuits completed during the day. The next morning, these photographs would be projected onto a screen in the production department and copied. Since GIER was intentionally a one-of-a-kind machine, problems would later arise in the production models. For instance, the frame was too weak, causing damage during transportation.[28]

Inquiries for GIER kept coming in, and RC tried to find a company that would take over the production. For some time, there were negotiations with IBM, which received detailed information on architecture and components. Parallel negotiations took place with FACIT in Sweden and the Danish electronics company DISA. In May 1961, IBM finally told RC that it was not interested in GIER, and an agreement with DISA was made.[29]

The future development of RC should be seen in light of chronologically parallel developments on the political stage, which will be described below.

Local Government Data Processing

Parallel with the development in the technical scientific area, there was also a development in the use of data processing equipment in local and national government. Here, IBM was the driving force and dominating actor. In order to describe the background for the next events in the history of RC, it is necessary to give a short account of computer development in governmental areas.[30]

In local government, the first significant uses of punched card technology were initiated when IBM, in 1947, invited the municipalities of Copenhagen and Frederiksberg to discuss the use of punched card machines for tax calculation. In the following years, systems for local government tax calculation were developed. It was not IBM's intention to get more work for its service bureau, but to sell machines and punched cards to local government. The systems were primarily demonstration projects, the purpose being to show the system's viability. IBM succeeded. In 1951, IBM proposed to Købstadsforeningen (Association of Market Towns) that a joint punched-card-equipped service center for all local governments should be established. In 1952, Kommunernes Hulkortcentral (Local Government Punched Card Center) was established, covering 22 local authorities on the island of Zealand.

Similarly, various types of joint data processing centers were established in Jutland. In 1951, IBM opened a service bureau in the northern town of Aalborg, which soon undertook data processing tasks for Aalborg, Esbjerg, and Silkeborg. Later, Aalborg established its own center, which was joined by 17 other local authorities. The same thing happened in Aarhus, which opened its center in 1951, gradually expanding to other local authorities. In 1955, IBM again approached Købstadsforeningen, suggesting that a joint service bureau should be established in Jutland in the same way as had been done in Zealand. This happened in February 1956, when 30 local authorities joined JKH (Jyske Kommuners Hulkortcentral).

Finally, we have the third regional area in Denmark, the island of Funen. On the suggestion of Købstadsforeningen, the center in the biggest town, Odense, from 1956 onward gradually covered all local government authorities on Funen.

The general picture was that IBM took the initiative to contact leaders in local government and actively cooperated in introducing punched card machinery in data processing. Generally, the IBM service bureau initially took over the tasks, but this was primarily to develop the systems and show the viability of that approach to local government decision makers. The ultimate goal was to sell machines and cards to the local centers. In many ways, this development seems quite parallel to the computerization of local government administration in Norway a few years later.[31]

It was not that the other manufacturers of punched card machinery were entirely passive. Danish Punched Card System (Powers) had offered a data processing center to the city of Kolding and the surrounding areas in 1950, but using its 40-column cards proved to be troublesome. Instead, Kolding chose to cooperate with Bull, but in 1956, since no other local authorities joined them, Kolding decided to back JKH. Bull had another try with four local authorities in Jutland in 1953, but after two years, those local authorities decided also to join JKH.

By the second half of the 1950s, the structure of local government data processing consisted of two big centers and four smaller ones, owned by a single authority. Three of these also acted as service bureaus for other local authorities. This structure remained until the creation of Kommunedata in 1972.

To sum up, it was IBM that took the initiative and established a close cooperation with local government leaders on automated data processing. IBM urged them to establish their own centers, thus freeing IBM's service centers from the seasonal workloads, but primarily because IBM's goal was to sell machines and cards. In 1959, when the local government centers ordered IBM 1401 computers, the transition to computers started, with IBM having a virtual monopoly as supplier.

National Government Data Processing

After the end of World War II, punched card equipment was increasingly used in several governmental administrative areas—namely, the Varedirektoratet (Directorate for Import Licensing) and Statens Hulkortcentral (National Punched Card Center). Establishment of the various punched card installations was, however, not coordinated with an overall plan. Consequently, in 1956, Finance Minister Viggo Kampmann commissioned a technical report and an organizational report. The organizational report should primarily investigate how governmental data management could be effectively rationalized. The technical report was specifically to investigate the advantages of using EDP.[32]

Kampmann was one of the ideological driving forces within the Social Democratic Party in postwar Denmark. The Social Democrats had accepted that Denmark's postwar economy was vulnerable and could be stabilized only through significant industrialization, thereby liberating the country from its previous dependence on the agricultural sector. Export of manufactured industrial product was seen to be the future—a goal that naturally required a large proportion of the nation's resources to be funneled toward industrial investment.

It is here that PAYE (Pay-As-You-Earn tax) entered from stage left. It was scarcely possible to turn the tax screw any further within the existing legislation. If more taxes were to be generated and demanded while maintaining a socially just legislation, PAYE was a significant possibility.

As early as 1947/1948, Kampmann had advocated PAYE, but because of the existing Danish tax system, in which local governments administrated and collected the taxes, and because of the complicated system of tax deductions, there existed no responsible method of administration. Kampmann saw PAYE as a natural application for the new computer technology.[33]

It was Forvaltningsnævnet, the Finance Ministry's office for rationalization, that undertook the task. Forvaltningsnævnet's own secretariat was responsible for the organizational report. Eleven of the 12 national government punched card machine installations were examined—the only exception being the Defence Central Radio, presumably because it was involved in intelligence work.[34]

The report concluded that there was no coordination between installations, and as such, they were not being optimally utilized. About 90 percent of all machines originated from the same supplier, IBM. Furthermore, the purchase of machines had not been put out to public tender.

The report suggested that the largest installations should be combined, namely, those in use in the Statistical Department, Varedirektorat, and Statens Hulkortcentral.[35]

IBM consultant Willy Olsen was chosen to produce the technical report. There is no doubt that Olsen was competent; via IBM's virtual monopoly of the market, he had the necessary insight into public data processing. With the benefit of hindsight, it is nevertheless interesting that no one identified a possible conflict of interest by entrusting a major governmental report to a person so closely associated with a potential supplier.

With the benefit of hindsight, it is nevertheless interesting that no one identified a possible conflict of interest by entrusting a major governmental report to a person so closely associated with a potential supplier.

The report concluded that there was a basis for creating a centralized EDP center that could cooperate within the existing national and local government data processing centers. The option of two separate centers was also considered, thereby ensuring a backup in case of failure. However, there were doubts as to whether there was enough work to optimally utilize the two centers.

The result of the report was that, in March 1958, Kampmann established a Tilsynsråd for Statens Hulkort- og Automatiseringsvæsen (Supervisory Committee for the Governmental Punched Card and Automation Services), comprising representatives of RC, local government, Kommunernes Hulkortcentral, Forvaltningsnævnet, and the Tax Department. The committee's first task was to ensure the fusion of the biggest punched card installations, as previously suggested. This failed due to opposition from the Statistical Department.

The second task was to establish a working group that would investigate which national and local governmental functions could be carried out with EDP within the next two to three years. To establish a perspective for this question, the Tilsynsråd requested a further report. There was a great deal of consideration as to who should lead this report. The choice finally fell upon Olsen once again—the rationale being that IBM would supply Olsen to undertake the task without charge, since the government had indicated a willingness to buy a computer.[36] Olsen was, through his work with IBM and the preliminary technical report, familiar with the various ministries. The new report was, as such, relatively simple to generate. He identified 30 areas where EDP could be used to advantage within a short time frame. In reality, IBM concentrated on 13 areas that had already converted to punched cards.

On the basis of this report, Tilsynsrådet suggested that there should be established a common center for local and national government or, failing this, for national government alone.

Therefore, there were two questions that needed to be resolved. First, which organizational structure should the center have. Second, which firm should supply the machines. Earlier, RC had been asked that in its planning of a large-capacity computer for its own use, whether it would consider building a copy for the national government. As we have seen, this was not a realistic possibility, and the planning of GIER had begun instead. Bech recommended considering the immediate purchase of a large computer, since Olsen had documented the need. RC's board also put forward a letter dated 16 November 1958 that included a detailed suggestion that DASK be promptly utilized for data processing in some of the most obvious areas. RC would assist with the necessary planning and coding work and supply qualified personnel at a reasonable tariff. This meant that the necessary experience could be harvested, enabling the organizational and technical questions for the proposed center to be thoroughly grounded. Simultaneously, insufficient usage of the planned large computer installation would be avoided during the startup phase, plus it gave the possibility of training the necessary personnel for the extensive tasks ahead. The lack of qualified personnel was seen as the major bottleneck hindering the introduction of EDP—education and training were therefore of major importance.[37]

The suggestion was discussed at a meeting on 18 November 1953, but, especially, local government representative Kock Nielsen was skeptical. It was a puzzle to him that a research institution was, in this case, acting as a commercial company. In reality, RC did not receive government funding and wished only to cover its own expenses.

Bech responded by criticizing a local government report presented at the previous meeting. This report proposed the establishment of a local government EDP center based on IBM equipment that would be independent of the prospective national government center. Bech attacked the calculations that underpinned the IBM solution because the source of information was IBM's own sales brochure.

The discussion ended with the foundation of a working group including, among others, Bech. Although the working group's terms incorporated the initial use of an IBM 7070, it was emphasized that this constituted no commitment to a final choice of machine.

The report discussed five separate organizational models for the national government's EDP center:

1) National and local government should establish a combined center that would handle planning, programming, and machine operation.
2) There should be a purely national government center that would handle programming and machine operation.
3) RC should operate machines and handle programming.
4) National and local governments and RC should establish a center together.
5) The tasks should be licensed out to tender.[38]

To ensure local and national governments optimal influence over budgeting and work priorities, the working group decided to reject Options 3 and 5. Likewise, the purely national government option was rejected, as it would all too easily cause conflict with the proposed local government center. The working group concluded that a combined national and local government center with involvement of RC would be the best solution.

During the ensuing consideration of the working group's report, the suggestion of starting with a smaller machine or a model

with numerous smaller machines was immediately rejected, as the representative for Forvaltningsnævnet, E.A. Buchardt emphasized that the introduction of PAYE would demand a large capacity. Despite the fact that the Swedes had introduced a similar tax system without electronic aid and Norway had also done it with just an IBM 650, the Danish tax system precluded this option.

At the same meeting—in which Bech was unavoidably absent—Kock Nielsen argued for the use of an IBM machine. He stated that IBM's economic policy was undoubtedly strict, but the company offered excellent service.

In the following period, there was uncertainty as to what the relationship with local government should be. During the summer of 1959, Kampmann apparently resolved the situation by offering to ensure finance of the proposed data processing center. The local governments could hardly refuse this offer, and during the course of the following months, the arrangement was negotiated and finalized. These negotiations took place in the political sphere, and, as such, RC took no active part. Finally, DC was established in December 1959, and Olsen was employed as its director. Shortly afterward, a technical working group under the leadership of Buchardt decided to order an IBM 7070 machine to be delivered two years later.

The arrangement meant that DC would be run by a board with equal numbers of representatives from national and local governments. Local governments could use their own discretion as to whether or not they used DC. In addition to being a data processing center, it was also intended that DC should steer and guide the national governments' EDP development.

Paragraph 12 of the articles stipulated that none of the interested parties could operate or purchase electronic data processing machines without first obtaining permission to do so from DC. In practice, this did not hinder local governments from doing what suited them. The paragraph was largely ineffective, except in one situation that will become apparent.

The University Plan

As previously mentioned, one of the most important of RC's goals was the spreading of knowledge of methods and use of computers together with the support of research and education in that field. This involved holding courses for interested parties from the commercial world in both technical and administrative applications. Another area of significant interest was naturally the universities and other academic institutions. RC offered the first courses on coding and programming on BESK at DTH in 1953; later, other educational institutions were included. As time passed, plans were developed to create a more formal cooperation between RC and the academic world. Early in 1960, Bech discussed with Svend Bundgaard, the dean of Aarhus University's Natural Sciences Faculty, plans to move a part of RC's activity to Aarhus and enter into an ongoing cooperation. Similar consideration applied to DTH.

For Aarhus University, the plans were as follows:

1) The university would initially supply free of charge a building of 800 square meters and later 1,200 square meters for RC's disposition.
2) In return, RC would install a GIER together with employees and support staff. GIER would be available gratis to the university at least eight hours a day, of which one hour would be in normal office hours.
3) RC's other commercial activities would be no concern of the university. Furthermore, the university could purchase additional time at favorable tariffs (300 kroner per hour) as well as having access to the planned big computer in Copenhagen. RC would relocate research groups for electronics, numerical analysis, operational analysis, and econometrics, together with a part of the administration, to Aarhus.[39]

RC emphasized that it would also act as a communication conduit between the related faculty groups at the various institutions and thereby act as a catalyst for research in the area. For the university, the advantages were clear: direct access to an advanced computer together with considerable expertise in new scientific areas. This would have not only meaning for research but also an important effect, in that faculty would share access to some of the country's leading expertise. The commercial aspects of RC were considered advantageous for research and teaching, as both would be based on actual and practical problems. This relationship between the academic and the practical—of educating through realistic actual problems and work methods—was to characterize the structure and content of academic teaching in computer science in the years to come.[40]

Parallel negotiations continued with DTH that, at this time, was relocating to Lundtofte. Despite it being more problematic to reach agreement than in Aarhus, a similar model was used. Also here, several research groups and a GIER would be moved to DTH, and RC would site its large machine at DTH when it became a reality.

When, in June 1960, Copenhagen University sent an application for a GIER, the Finance Ministry decided to generate a more general overview and established a working group led by mathematics professor Hans Tornehave. The ministry wished:

> a response to the question whether the scientific/academic institutions expected that needs for electronic data processing machines should be met with appropriation of smaller electronic data processing equipment at the academic institutions or development of a large centralized data processing installation.[41]

The ministry had been informed that large computers worked more economically than smaller ones.[42]

The working group comprised representatives from educational institutions plus the omnipresent Buchardt, who was representing the central government administration. Buchardt was in enemy territory. Already at the opening meeting, the Finance Ministry and Buchardt were under concentrated attack, in that Ejnar Andersen, director for the Geodetic Institute and initiator of GIER, delivered an extensive tirade. He emphasized that the Finance Ministry had a completely incorrect understanding. GIER was an electronic computer, not a data processing machine. The most important feature was therefore computational speed and flexibility and, to a lesser degree, input and output speeds. Furthermore, he highlighted the necessity of direct access to computers in education and research. He compared GIER and the IBM 7070 in relation to computational speed and facilities, such as dynamic indexing, and, of course, price. He concluded that GIER was approximately 50 times cheaper to use than the 7070, in that it was up to five times faster with computations while costing only one-tenth as much per hour. He identified the lack of qualified personnel as the most serious hurdle to computerization in Denmark, and

it was, as such, even more important to establish education in the area. Finally, the authorities were attacked for not consulting with RC before purchasing the IBM 7070 for DC. RC represented at this time the best-qualified academic and scientific knowledge in the use of computers.[43]

It is clear that this tirade surprised Buchardt, who was forced on the defensive. His position is characterized by a bureaucratic logic—for him, the paramount consideration was that the machine should be used optimally from a capacity point of view.

The Tornehave committee's preliminary report was basically a long recommendation of GIER and the University Plan, despite the fact that GIER was not specifically named in the report. This was hardly a surprise, as all the other members of the committee were directly involved in these plans. It should, however, be pointed out that there was no consensus in the academic world. In a commentary to the Tornehave report by DTH's Ole I. Franksen, he criticized that the needs of engineers had not been met. For many applications, the large data processing machine was a necessity, and for tasks that involved optimization problems, analog machines had important functions.[44] Franksen emphasized his experience with MIT, where a central computer with external terminal and data transmission had worked effectively. Finally, the use of an IBM machine entailed access to a large program library via Share.

The academic wing pointed out that all experience showed that the need for computer power would increase dramatically in the ensuing years, and as such, DC's overcapacity problems were merely temporary.

In its final report, the Tornehave committee maintained its recommendation while also recommending analog machines and, in the long term, the purchase of a large machine for DTH. The Finance Ministry also asked for DTVFR's opinion, and a special committee that Topsøe chaired investigated the case. After minor adjustments to the agreement had been made, DTVFR recommended the University Plan. It also concluded in the same way as the Tornehave committee that education of qualified personnel was an absolute necessity for the development of computer usage in research and industry. The University Plan was the quickest and most economical way of dealing with these needs.

The University Plan had in the meantime become a part of the long-term plans for RC's development. The plan demanded considerable investment, and the increased need for calculations in industry demanded that RC expand its capacity by acquiring a new large machine to replace the old DASK. After first showing interest in the Telefunken TR4,[45] it became clear that this machine would be considerably delayed, therefore negotiations with CDC were initiated with the aim of purchasing a CDC 1604.

All this required finance; the expansion of activities together with the perspectives set out in the University Plan required finance of 17 million kroner to be guaranteed by the government. The loan would be repaid over a period of five years. The application for the required loan guarantee was presented, and RC was confident that it would glide easily through the parliamentary finance committee, as political support for the plan had been secured. Topsøe had unofficially contacted Kampmann, who in the meantime had become prime minister. Kampmann had expressed strong support for the ideas and had promised finance to RC of 25 million kroner to "jump start" the computer field. Seen against this background, RC's loan application was modest.[46]

Conflict Between RC and DC

The University Plan was to be approved at a meeting of the parliamentary finance committee on 19 February 1962. A few days before the meeting, DC's chairman, Svend Alstrup, saw the application and, with reference to paragraph 12, demanded that DC be consulted. Subsequently, on 6 July, DC answered in the negative. DC pointed out that in the building, 6.5 million kroner had been used. Furthermore, lease contracts with IBM of 3 million kroner per annum had been made, and employment of qualified personnel with a salary bill of 1.2 million kroner had been hired and trained. The center was as yet not operative, but would be by the new year. There had not, however, been secured enough tasks to ensure that capacity was fully utilized. On the other hand, it was emphasized that capacity could be easily expanded to handle scientific and technical computational tasks. DC was therefore opposed to any form of support to extension of outside capacity, as it would directly compete with DC. If this happened, the economic foundation for DC's existence would crumble.[47]

DC's answer clearly illustrated the dilemma and the weakness within its entire structure. As DC was initially planned to carry out large tasks, such as PAYE and central person registration, it had operated with a large capacity and was therefore committed to machines based on these criteria. As implementation of these tasks was delayed, DC was left with unused capacity—the very situation that central control of EDP procurement had hoped to avoid. This politic was from the start undermined by DC's very structure and construction. As the national government required the support of local government to carry out its extensive plans, the national government had resisted binding local government to using DC. Local governments had also, quite unimpeded, continued to equip their own centers. With this in mind, it is interesting to recall that RC had suggested a gradual development of DC.

DC's attitude came as a shock to RC and its partners. Already at the first presentation of the agreement with Aarhus University in 1961, RC had pointed out that the situation was urgent and, as such, could not understand why developments should be delayed further when all competent organs had recommended acceptance. There was a feeling that the Finance Ministry bureaucrats were attempting to hinder RC and that IBM and its allies were responsible.[48] If the University Plan failed, the long-term plans for RC and therefore its very existence would be threatened. First and foremost, RC and the academic world could not understand the resistance. It appeared to them completely irrational, as everyone inclusive of DC accepted the fact that the lack of qualified personnel was the biggest bottleneck hindering the further development and spread of computers. It seemed absurd not to make every effort in this all-important area.

The academic wing pointed out that all experience showed that the need for computer power would increase dramatically in the ensuing years, and as such, DC's overcapacity problems were merely temporary. Various large tasks in different tax areas were on the verge of being defined. As the resistance against the

agreement could not be explained rationally through academic logic, something else must be behind it. The only explanation appeared to be that IBM and allies in DC wished to sabotage RC.

For the bureaucrats in national government administration and DC, the situation appeared, naturally enough, different. For them, a data processing task was just that, a task. If researchers wanted to carry out calculations, why could they not use a central machine? They could merely use data transmission or send data and programs on punched cards or paper tape. The desire for their own computers was considered as narrow-minded self-interest in the same way as when each particular ministry and state institution wanted its own computer. It would merely lead to a waste of resources, an unnecessary expense, and it was precisely what they were employed to avoid. It was a case of a conflict between two entirely different frameworks of understanding.

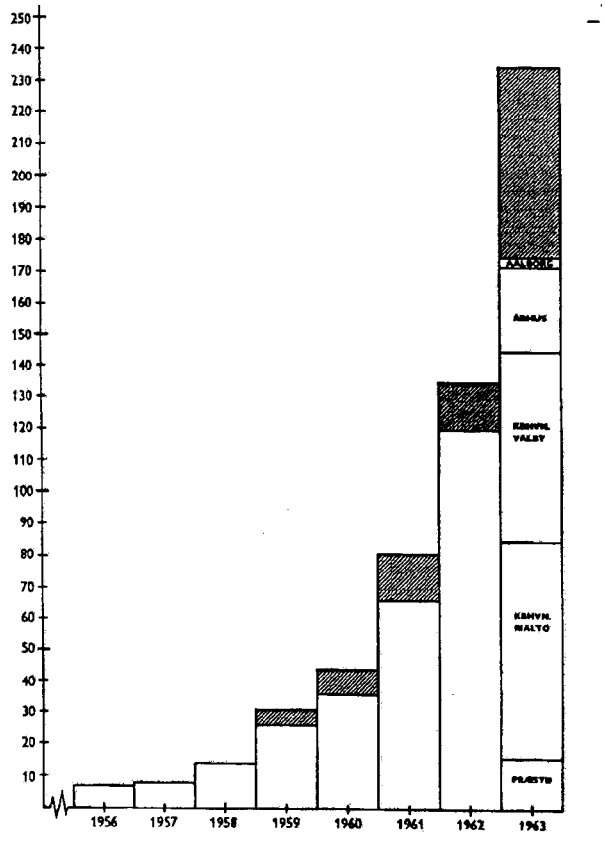

Fig. 3. Development in numbers of employees at RC. The hatched areas represent part-time employees. Præstø is the production facility, Rialto was primarily the service bureau, running GIER and CDC. Valby was primarily development and DASK.

(Photo from *ATV. Virksomheden indenfor ATV. 1962-1963.* Copenhagen, 1963, p. 69)

Unfortunately for RC, it did not enjoy the same political support, because Kampmann had in the meantime become seriously ill, and his position as prime minister had been taken over by Jens Otto Krag, who was by no means as technology-oriented as Kampmann. Worse was the fact that Krag could not be expected to honor the verbal financial commitment to financing. For Krag, it was politically paramount to nurture the relationship with local government. Any uncertainty would complicate the necessary fundamental changes in government.

To solve the problems, one of Denmark's most influential and powerful civil servants, Erik Ib Schmidt, was called in. Schmidt was known as one of the architects of the welfare state, and he was well-connected to other civil servants in government administration as well as the academic world as a member of ATV and as one of the driving forces behind DTVFR. Better still, he was known to support a strengthening of research and was considered an excellent troubleshooter.

Schmidt sought and received aid from Topsøe, who could take initiatives and act in areas where Schmidt could not. These two knew each other well from their previous work with DTVFR and the Atomic Energy Commission.

In the coming months, Schmidt convened a series of meetings with representatives of RC and DC.[49] It became quickly apparent that RC was flexible in a number of areas. The loan application was reduced to 9 million kroner. RC believed that it could cover any ensuing losses with a combination of economies and the sale of GIER computers. Furthermore, it was willing to give up all public administration tasks and concentrate on research and education and jobs for industry. Despite this, DC was still uncompromising. RC was to be limited to research and education and not be allowed to pursue or run commercial businesses. This demand was completely unrealistic, as the earnings from commercial activity was the basis of the research and education effort, especially considering that RC did not receive direct state support.

This was also acknowledged by Schmidt. In a memo to Prime Minister Krag, he wrote that RC had shown itself open to compromise, whereas DC was dominated by short-term economic interests. DC would rather see RC reduced, limited to a research and education center. This was not practical, as commercial activities were necessary to the funding of all RC activities. (For a graph of the number of employees at RC, see Fig. 3.) Furthermore, DTVFR had emphasized the importance of cooperation with educational institutions. Without RC's expenditure on this type of activity, the national government's expenditure on this area would undoubtedly increase. Finally, Schmidt mentioned the fundamental problems of DC's organizational structure discussed earlier.

On the political level, there was difficulty in achieving a compromise as the situation stalled. At a meeting on 7 December 1962, all relevant parties gathered to finally resolve the situation. Educational institutions again emphasized the importance of implementing the University Plan as soon as possible. Only then could research and academic aspects of the plan be realized. Alstrup, on the other hand, respected the well-known capacity problem, but in the same breath offered to increase capacity by upgrading to an IBM 7074 computer—a statement that provoked puzzled comments from representatives of academic institutions.

In a last attempt to reach a compromise, Topsøe, during a meeting in early 1963, had tried to win support for a structure in which RC and DC created a cooperative organ. It should have an executive authority and therefore insight into budgeting and planning. In practice, it would be a new superior decision-making body for the public-sector use of computers. However, this was exactly DC's foundation, and as such, it was not prepared to relinquish this position. Topsøe ended the meeting, since further negotiation and discussion were apparently pointless.

The constant delays resulted in an almost desperate situation at RC. Trusting that the University Plan would be approved, a department had already been established in Aarhus. In addition, the attempt to transfer the production of GIER to the electronic company DISA had not produced the required result. Computers were still a new phenomenon and demanded a special and extensive insight in the computer's possibilities, the practical areas of usage, and the extensive support required to sell them. Examining the purchasers of GIER, it is clear that the clients were firmly anchored in the same socioeconomic sphere that RC occupied. It was therefore no surprise that in the year DISA was responsible for production and sales of GIER, not a single machine was sold. In January 1963, RC decided to reclaim DISA's activities.[50] Another impulse to this decision was that the delay in RC's application created the demand for a new source of income: The sale of GIER computers was a possibility. Preliminary inquires from domestic and foreign research institutions had been received—they were attracted by GIER's Algol compiler combined with a reasonable price. The transfer of activity meant that the Vejlø group had to be maintained and a permanent production organized. After investigating several possibilities, RC accepted an offer from the town of Præstø to purchase a redundant school. Præstø was a small town 50 kilometers southeast of Copenhagen that had suffered a lengthy population and economic decline. The town was happy to welcome a new company, and employees of RC themselves wished to leave Copenhagen.[51]

These actions were an expression of an increasing commercialization, a necessity if RC was to continue. The service department was strengthened by the installation of a CDC 1604A and establishment of a service department in Aalborg. Commercialization was also a risky business, demanding sizable investment in material, service departments, and of course production in Præstø—all this at a time when RC suffered a chronic lack of capital. Only with creative financial transactions, such as financing of delivery contracts, combined with the goodwill of employees, suppliers, and banks did RC succeed in remaining intact. It was clear that a fundamental change of organizational structure was necessary, not least because increasing commercialization was incompatible with RC's status as an institute under the Academy of Technical Sciences.

RC worked frantically to reorganize, splitting RC into a commercial part and a research department under ATV. By December 1963, it was clear that RC could be saved only by immediate capital investment. The sale of GIER machines was not as fast as Bech's optimistic prognosis, and much of the available capital was tied into materials and production in Præstø. It was therefore academic that the University Plan was finally approved—much to DC's consternation—by the Finance Committee on 16 December 1963. With prompt and decisive action, RC succeeded, in a few hectic days over the New Year holiday period, to attract commitments from a number of Danish companies that would invest in a limited company that was subsequently established on 13 January 1963—A/S Regnecentralen.

Bech continued as director supplemented by an economic director, Poul Dahlgaard, and a completely different board composition, including representatives from commercial companies. Despite these changes, RC continued to be characterized by its innovative research even though commercial activities became more common. GIER was a moderate success, with 34 computers being produced. The development of the RC 4000 and its innovative operative system proved that creativity still existed.

Conclusion

In the early days of computers, most countries experienced the extensive role played by public research institutions in the development and spreading of this new technology, which also included construction of computers as an integral part. Examples are Matematikmaskinnämnden in Sweden, NPL in the United Kingdom, and the National Bureau of Standards in the United States. Generally, research organizations played a role only until the commercial actors stepped into the arena. That this was different for RC was caused by a peculiar political constellation. It can be said that it was a lack of cohesive government policy in this area that made commercialization of RC necessary. It was not the intention that RC enter into the commercial market with GIER. The construction of computers was a method of achieving a level of know-how within transistor technology and creating the expertise to give a better background to carry out technical assessments and thereby being able to act as advisor to both state and industry. That the national government did not exploit the expertise was caused by factors that become apparent only through historical analysis.

Subsequent analysis of RC's history and computer development in Denmark, especially analysis from the 1970s, is characterized by the opinion of the time, where actions were interpreted exclusively in the light of multinational capital—represented by IBM—against the innovative national initiator and supplier—represented by RC.[52] There can be no doubt that IBM quite naturally pursued its economic interests. Historic analysis shows that, in this instance, there is also a conflict not only of interests but also of interpretations of computers and their consequences. The bureaucratic and the technical/academic worlds' understanding of computing, its possibilities, and its future development was grounded in entirely different frames of reference and, as such, these worlds found it difficult to constructively agree.

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[35] *Rapport vedr. gennemgangen af hulkortvirksomheden indenfor statsadministrationen.* Forvaltningsnævnets sekretariat, Aug. 1957. *Tilksynsrådet vedrørende Statens Hulkort- og Automatiseringsvæsen 1958-60.* Box 37/1, Part 1. Rigsarkivet s. 28.

[36] Tilsynsrådet for statens Hulkort- og Automationsvæsen. Minutes from meeting, 19 Apr. 1958, op cit., Box 37/1, part 2.

[37] Letter from the Board of RC, 11 Nov. 1958, M*elbye-archive.*

[38] Tilsynsrådets arbejdsudvalg. Rapport, 28 Jan. 1959, op cit.

[39] This section is primarily based on the following archives: *ATV-archive* Box 216. The *Melbye-archive. Aarhus University Archive,* op cit. Box Regnecentralen. 325/60—NF 22. *Forvaltningsnævnets Sekretariat,* op cit, and *Tilsynsrådet,* op cit. A good account on the discussions on the university plan from Aarhus University's point of view can be found in S. Bundgaard, *Hvordan EDB kom til Aarhus Universitet.* Aarhus, Denmark: DAIMI, 1978. Minutes from meeting between RC og Aarhus University's committee on calculating machinery, 8 June 1961. *Aarhus University Archive.* Note on the establishment of a branch of RC at Aarhus University, 23 June 1961, op cit.

[40] On the Copenhagn tradition, see E. Sveinsdottir and E. Frøkjær, "Datalogy—The Copenhagen Tradition of Computer Science," *BIT,* no. 288, 1988, pp. 450-472.

[41] From the terms of reference to the committee, 28 Feb. 1961. Copy in *Melbye-archive.*

[42] This was the generally held view at this time, sometimes referred to as Grosch's law. H. Grosch, "The Digital Computer as a Research Tool," *J. Optical Soc. of Am.,* vol. 43, no. 4, pp. 306-310, Apr. 1953, especially p. 310.

[43] Expert opinion given at the first meeting at the Tornehave Committee, 15 Apr. 1961. Cited from *Melbye-archive.*

[44] I will not discuss the relationship between analogue and digital approaches here. See L. Owen, "Where Are We Going, Phil Morse? Changing Agendas and the Rhetoric of Obviousness in the Transformation of Computing at MIT, 1939-1957," *Annals of the History of Computing,* vol. 18, no. 4, 1996, pp. 34-41. A report from the Union of Young Scientists in AtV as late as 1963 concluded that both approaches have their advantages. *AtV-archive,* Box 192, op cit.

[45] Personal contacts may have played a role, since the designer of the TR4, Wolfgang Händler, had worked with the Swedish BESK several times between 1953 and 1956, where he probably met B.S. Petersen. See H. Petzold, *Rechnende Maschinen.* Düsseldorf, Germany: VDI, 1985, s. 472.

[46] S. Stigø, *Inspiration: Haldor Topsøe: Mod og meninger.* Bogan. Lynge, 1988, p. 48f. Interview with H. Topsøe, 19 June 1998.

[47] Letter from DC to the Ministry of Finance, 6 July 1962. University of Aarhus archive.

[48] Minutes from the meeting of the board, no. 23, 31 May 1961. *Melbye-archive.*

[49] Based on Aarhus University archive, op cit, *Melbye-archive,* and *Budgetdepartementet—Erik Ib Schmidts embedsarkiv,* Box 11.

[50] Minutes from the meeting of the board, 14 Jan. 1963. *Melbye-archive.*

[51] Interview with T. Vejlø, 25 Aug. 1998.

[52] Examples are M. Kyng, *EDB-rapporten—studier i datateknikkens indflydelse på det danske samfund.* Copenhagen: DSF, 1974, pp. 71ff, E. Andersen, 1976, op cit., C. Gram, 1976, op cit. There is the same general interpretation on the Swedish development in J. Annerstedt, *Datorer och politik, Studier i en ny tekniks politiska effekter på det svenska samhället.* Lund, Sweden: Zenit, 1970.

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