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RISØ-R-2492

PROGRESS REPORT 1 January 1983 - 31 December 1984
COMPUTER INSTALLATION

Abstract. This report describes selected parts of the activities at the Computer Installation of Risø National Laboratory in 1983 and 1984. Information given may be preliminary.

INIS descriptors: BURROUGHS COMPUTERS; COMPUTER NETWORKS; DATA PROCESSING; RISØ NATIONAL LABORATORY

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PRODUCTION STATISTICS 1984	56

1. INTRODUCTION

This report describes selected activities at the Computer Installation of Risø National Laboratory in 1983 and 1984.

Following a short survey of the period this report describes the operational improvements through the installation of a local area network and optimizing of the operation of the B7800, followed by the development in the field of broadly used software, namely graphics, databases, linear programming, Fortran 77, and programming tools in general.

We go on to discuss assistance to specific users, primarily work with some mathematical models and programming assistance to various departments.

Finally, an appendix gives operational statistics and lists of staff and equipment.

2. THE COMPUTER INSTALLATION 1983-84

The period which is covered by this progress report has not brought changes as dramatic as the previous one. Yet there has been a rapid development, both from reasons internal to the Computer Installation and because of Risø Management's growing interest in data processing as a strategic element.

In early 1983 the capacity of the B7800, which was installed in June 82, was abundant. However, the terminal system, Cande, was felt as an annoying part by many users for three reasons: The editor part of Cande was line oriented; the normal transmission speed was only 300 bit/second and the maximum speed 1200 bit/second, because of the quality of the telephone connection and the price of modems; and the number of available ports into B7800 was becoming insufficient, and an extension was prohibited by the capacity of Risø's telephone exchange.

All three points have been remedied. In 1983 an independent datanet (exchange, multiplexers, and cables) was installed on Risø's premises. It provides a 9600 bit/second connection between a growing number of V.24 (RS232C) interfaces in all Risø's departments and an equally growing number of B7800 ports. In fact, the net will connect any interface to any other, and terminal users may choose from a number of computers. The datanet is described in a separate article in this report (section 3 page 7). Subsequent to the improvement of the transmission speed, a full screen editor was introduced.

The use of the computer has grown through the years. This applies in particular to the total connect time of Cande, which nearly doubled in the period. The growth surpassed the expectations and forced work on optimizing the operations (section 4 page 15). The scheduled availability of Cande has been extended until 8 p.m., but in reality B7800 and Cande are usually running around the clock, including weekends.

In order to increase the users' awareness of their consumption of expensive resources, it was decided to implement a scheme of internal payment for the use of B7800. This scheme started on 1 January 1985, but already in late 84 a positive effect was seen as our archive of files on magnetic tapes was reduced from app. 125,000 files to about 90,000.

The Computer Installation's software development has continued in specific as well as in general areas. Among the latter we emphasize Risø Interactive Graphics System (RIGS, section 5, page 20), database systems based upon Burroughs Data Management System (section 6, page 23), and communications software in connection with the datanet and the growing number of different terminals and protocols.

The B7800 configuration was augmented with a Benson 1333 digital plotter, another dual exchangeable disk drive, three 6250 bpi magnetic tape drives, and more data communication equipment. On the other hand, two 20-year-old Calcomp 507/565 digital plotters, an on-line cardpunch, and two manual card-punches were discarded.

The terminal equipment for the staff of the Computer Installation was augmented with five VDU terminals, one graphic terminal, and one graphic workstation with an advanced colour-display, a digitizing tablet and a table-top plotter.



Mounting a 6250 bpi magnetic tape.

The operation of the B7800 has by and large been smooth with a high level of reliability, yet there have been a few difficult periods. In spring 1983, some magnetic tapes took to stitching to the read/write heads. The tapes were destroyed in the process and one incident provoked a fire alarm due to smoke. The trouble was confined to one brand of tapes, which we have now discarded.

In November 83, our catalog system, which keeps track of all files on userpack and in the magnetic tape library, collapsed. After several days the reason was found to be a so-called open time-window, which permitted an update of the catalog while it was being copied, resulting in an inconsistent copy. When this error was recognised, it was easily circumvented.

For a period we had sudden malfunctions in the datanet and the plotters. They were tracked down to irregularities in the 220 V power supply, originating from the starts and stops of the nearby motors in the air-conditioning equipment. (B7800 itself has always had separate supplies and was not interfered with).

In early 84 some widely publicized claims of hacking - unauthorized intrusion into computer systems - occurred in Denmark. There is no evidence of attempts to enter Risø's B7800, but relevant security procedures for choosing, changing, and guarding passwords were enjoined on all users.

A considerable part of the work has the character of consulting, giving advice in the fields of numerical and other disciplines of mathematics, statistical methods, operations analysis, and computer science and engineering.

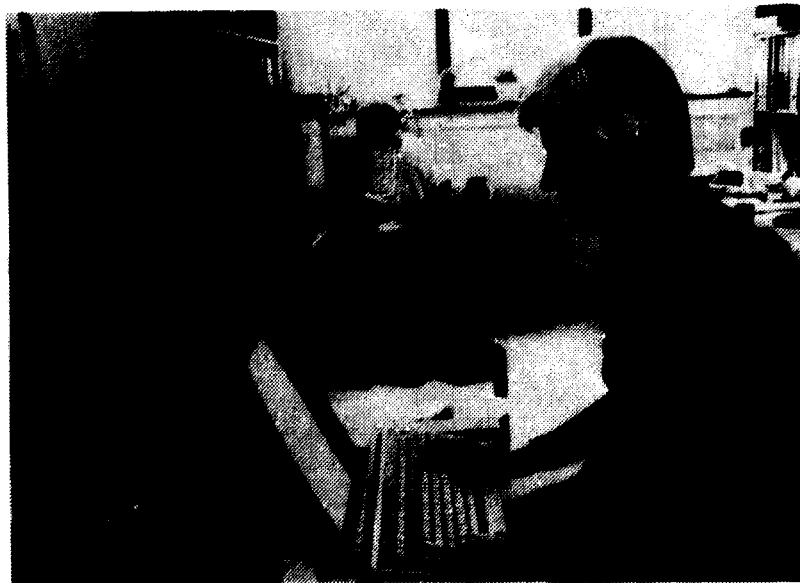
Our training activities have been continued at a high level (section 10, page 39) and we have received a number of visits from senior schools and other groups.

The Computer Installation contributes to Risø's commercial activities, primarily by supporting the activities of the scientific departments and to a lesser extent by providing computer time and programming expertise to external users. The RIGS-software has been sold to another Burroughs installation.

The Computer Installation takes care of Denmark's liaison with NEA Data Bank, an international organization which acts as a library for computer programs of interest to the nuclear community, and which is a part of the global four-centre network for nuclear data. We receive half a dozen programs from NEA every year, some of them mathematical packages. In the latest two years period, our representative was in charge of the Data Bank management committee.

Risø introduced a new archival and filing system in 1983. In connection with this the Computer Installation developed a couple of utilityprograms to form fileregister and subject index.

The secretary's office has installed a Lexitron word processing work station, which may exchange files with B7800. A certain pressure upon our floorspace has forced us to move some functions and furnish a previous print- and punch room as a meeting- and classroom.



The word processing work station in the secretary's office may exchange files with B7800.

In the spring 1983, an internal Risø committee with representatives from the Computer Installation drafted an edp-strategy for Risø, which later was adopted by the management. The strategy outlined a dozen goals, some of which in fact have been mentioned above while others have been pursued by the edp-committee. One of these has so far led to a study about supplementing the B7800 with a supermini in order to offer the staff a broader choice in computers and software. For economical reasons, this plan has not been implemented so far.

The edp-committee has also sponsored working-groups which have produced a series of notes with recommendations for different types of workstations such as word processors, terminals, graphic terminals, and personal computers. The Computer Installation has participated in most of these groups.

Finally, the head of the Computer Installation was a member of a group which studied Risø's potential for a programme of research and development in the field of informatics. This combines a long-standing interest in "advanced information processing" in one department with recent efforts to utilize Risø's knowledge in many fields in systems for "computer-aided engineering" and possibly "computer-integrated manufacturing".

3. LOCAL AREA NETWORK

3.1 The demands on a local area network

In January 1983 it was decided to invest in a local area network at Risø. The two main demands were more flexibility and better economy than the solution then, which was based on 300 baud telephone connections.

The specifications on the flexibility were:

1. Transmission speed (up to 9600 bit/sec)
2. Installation of new terminals
3. Distribution of connections to the entrances to B7800
4. Possibility for attaching other local computers to the network
5. Possibility for transmission to external computers (e.g. the regional centres at the Danish universities)
6. Transmission code. The system then used ASCII code with a TTY-compatible transmission protocol, but a possibility for use of other codes and protocols was desired.

The economy should already in a short view be substantially better than the solution then, and furthermore we attached great weight to the possibility to make the installation by easy stages, so that the costs could be spread over a number of financial years.

3.2 Offers from three firms

After a market survey three firms were invited to tender a local area network.

Trend Communications A/S offered a Micom MICRO600-data-PABC combined with multiplexing linedrivers, which provide connection to the terminals through permanent telephone circuits.

The function of MICRO600 is similar to that of a telephone exchange. Each multiplexing linedriver can transmit 4 or 8 data "conversations" through 4 wires (2 twisted pairs), and the MICRO600 may have 1500 asynchronous terminals in the 50 - 9600 bit/sec range. The connections are made through the general telephone cables, which generally speaking already are established all over Risø.

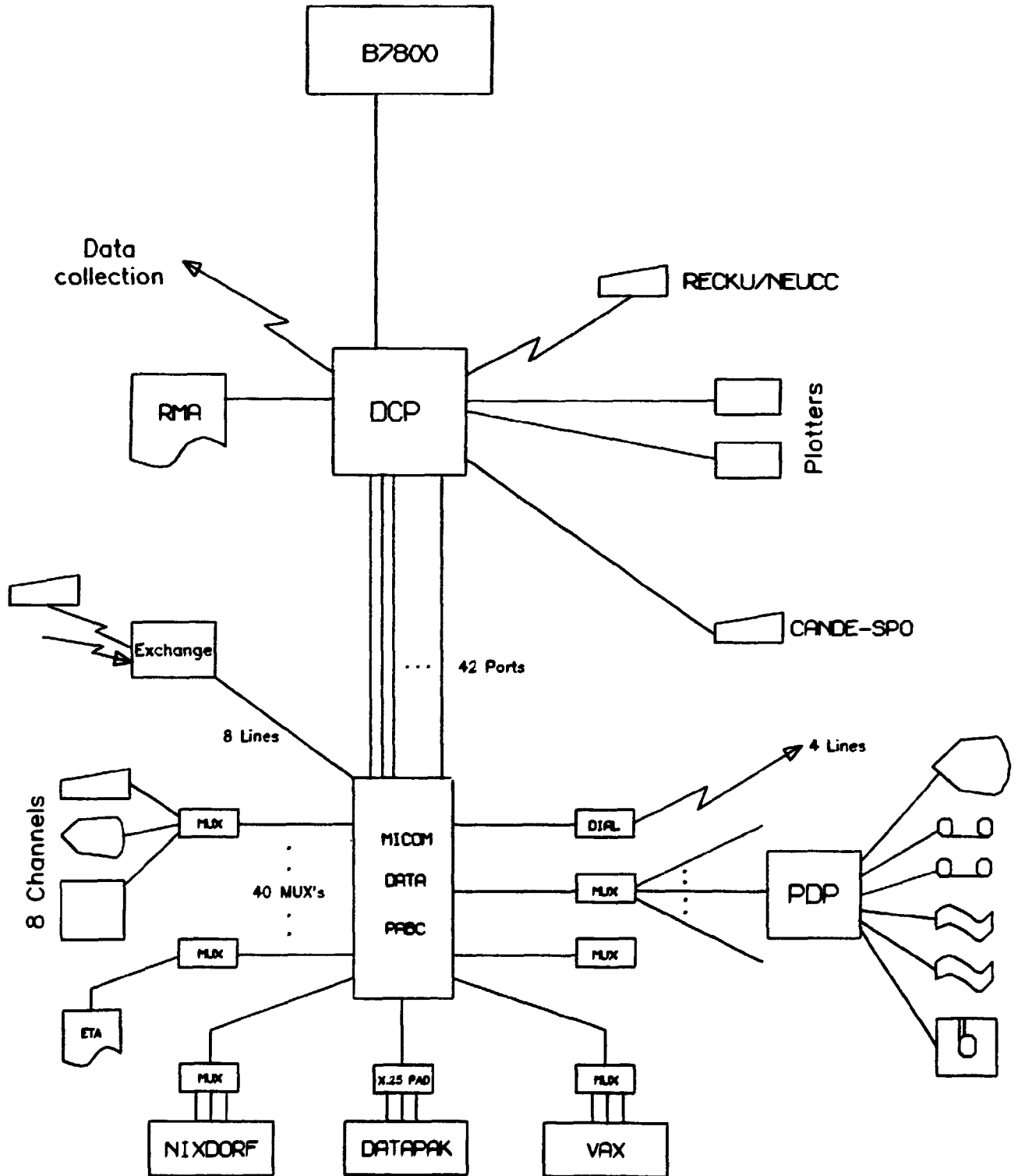
The offers from the two other firms were based on coaxial cables in a ring and a tree topology. They provided several facilities which would not be important to Risø in the foreseeable future, and they were much more expensive for the initial configuration as well as extensions. Therefore, the choice was quite easy.

3.3 The construction of the local area network

The installation of the local network started in early May 1983 and finished with an acceptance test in early August 1983. From the beginning the network was a success. It was the intention that the installation should have several phases, but following the users' wishes the first phase included nearly all terminals at Risø. Therefore, this phase became nearly twice as expensive as originally planned.

A diagram of the present connections to B7800, including the local area network is shown on the next page. All datacommunication on B7800 runs through a data communication processor (DCP) to which different units are connected, including a remote unit with an autodial facility for collection of data, a remote printer, two plotters, and a dial up line to the regional centres.

For the moment the Micom has 40 connections to the DCP. They can all transmit data with an optional speed of 50-9600 bit/sec. All the rest of the equipment, alphanumeric and graphic displays, minicomputers, microcomputers, wordprocessors, a remote printer a.s.o. are connected with the DCP through the Micom.

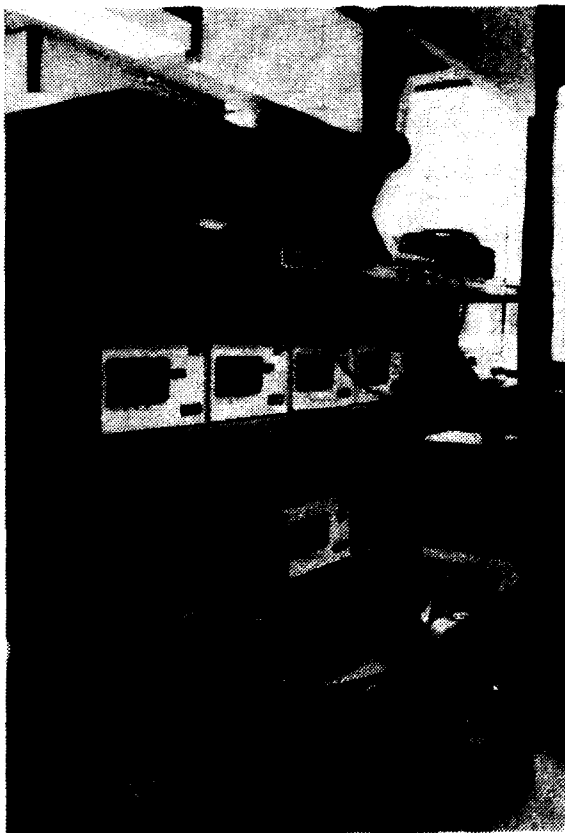


Local Area Network
at Risø.

Presently, the network has 264 terminal interfaces in Risø's departments and totally 150 terminals of different kinds are in use. Only few of the terminals are not connected to the network. For these and for users outside Risø, the telephone exchange has kept four 300 baud and four 1200 bit/sec connections to the network

Besides the Computer Installation's B7800, a Nixdorf computer, which runs the budget system of Risø, and a Vax, which is situated in the Electronics Department, are connected to the network as hosts with 3 gates each.

Furthermore, the network has 4 autodial gates, which permit transmissions to the computer centres outside Risø through modems.



Modems, autodial units, and test equipment for use with the datanet at Risø.

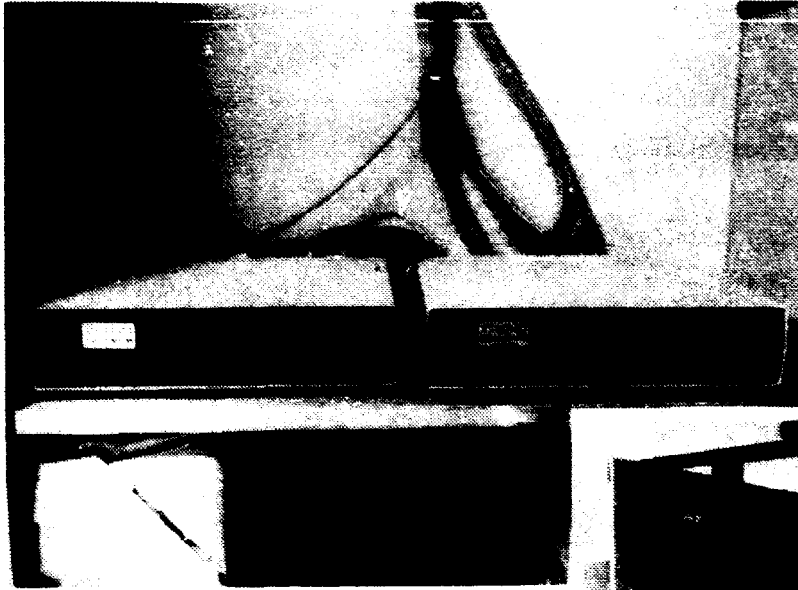
Finally, with a Micom MICRO 800/X.25 concentrator PAD a connection is established to the Danish Postal Datapak service. Datapak is a packet switched network, and the X.25 concentrator Packet Assembler Disassembler is a unit that concentrates up to 24 V.24 asynchronous terminal connections and adds relevant packings and addresses. Our PAD has at present 8 channels. It is configured with four channels which give access to the computers that are connected to Risø's local area network. Primarily, these channels are intended for use by the scientific libraries in the other Nordic countries, which input data to an energy database on B7800, but they are also usable by others outside Risø. The other four channels are configured in such a way that terminals from Risø's local area network can be connected to Datapak and from here to foreign packet switched networks. This is of great interest for Risø's Library.

The configuration of the system is an autobaud system which uses ASCII-code with a teletype protocol. That the system is an autobaud system means that all the channels will adjust their transmission speed to that of the terminal. During a terminal session there is a possibility to change transmission speed, this is important, e.g. for graphical terminals with sideplotters connected.

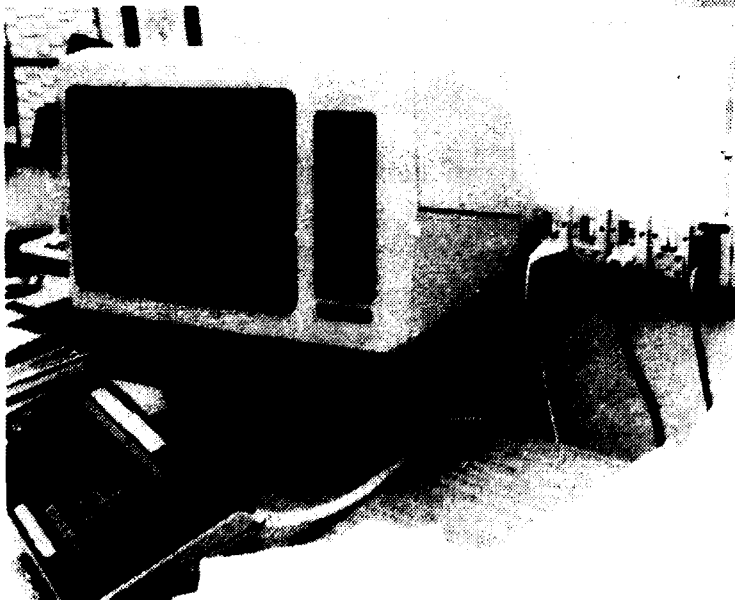
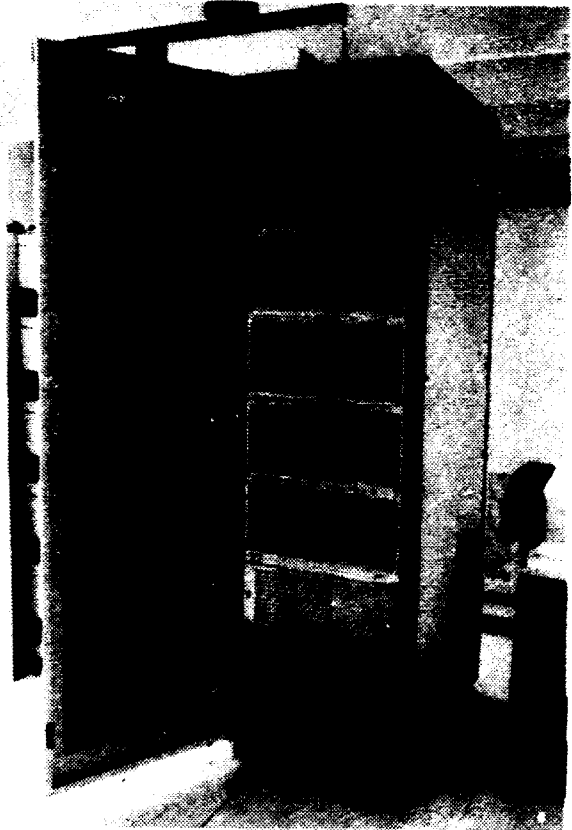
The network is physically realized by use of telephone cables between the Micom and the individual departments, which have multiplexing linedrivers in central places. The terminals are connected to the multiplexing linedrivers with cables of up to 50 m length. The maximum distance from the Micom to a multiplexing linedriver is about 1.5 km, which corresponds well with the geographical extension of Risø.

3.4 Practical experiences with installation and operation

KTAS (The Copenhagen Telephone Company Ltd.) has been responsible for the establishment of the necessary permanent connections and this work has passed on easily and faultlessly. Our only regret is that the time needed to establish a permanent



The Micom-PABC in the computer room is here shown between two multiplexors in a department and the network interface in an office



connection is two months at present, and on a whole, all the time is spent with administration, as we have noted that only one or two days pass from the time the technicians get their instructions to establish a connection until it is done.

As mentioned above the installation of the local area network began in early May 1983, and it was intended that taking over should take place on 1 July following an acceptance test of fourteen days. This taking over did not occur until 5 August as some deliveries were delayed, and as the acceptance test was delayed one week following restarting because of an error in the system. The very installation passed on remarkably painlessly. As mentioned above, it was RTAS which managed the establishment of the connections.

The Computer Installation has managed the central installation assisted by the vendor, and the Service and Electronics Departments have had the responsibility to connect the wires from the multiplexers to the terminals. We succeeded in running this work simultaneously in such a way that no further delays occurred apart from those mentioned.

The network has now worked for 1½ year, and it must be noted that the up-time has been one hundred per cent. Of course there have been some minor errors, but none of these have caused the breakdown of the total network for a longer period. The only real interrupts have taken place in connection with installation extensions to the network. The most annoying error was a problem with restarting the network such as what one would have to do after a power cut but there was no apparent reason for the problem. These errors meant that the users lost their connections to the computer and had to reestablish them.

After the start of the local area network the wishes for more connections have poured in, and in the beginning it was a problem that the vendor could not stand the promised time of deliveries. The delays were typically one or two months. This problem does not exist any more.

Shortly, it can be concluded that the establishment of a local area network on Risø has been a success.

3.5 Future

At present (March 1985) Risø's local area network is nearly finished. The number of multiplexers may be extended and the accesses to the outer world may be augmented with some connections to the Nordic Public Data Net.

Furthermore, it is planned to connect telex/teletex to the network in such a way that it is possible for the users to send telex/teletex messages themselves.

Finally, we may subscribe P & T's Databox service, which can be reached through the Datapak connection.

In the longer term you can imagine that activities as image processing, CAD/CAM etc. which demand more rapid data transmissions, will make it necessary to acquire a base- or broadband network. It will function side by side with the existing network, which will be used several years forward.



A growing number of terminals are placed in offices and laboratories.

4. OPTIMIZATION OF THE B7800 COMPUTER OPERATIONS

During the past ten years or more the use of edp at Rise has increased by 20-30% per year. This exponential growth obviously presents a problem. In order to meet this growing need, it has been necessary frequently to increase the computing capacity.

In the late 1970's the expansion capability of the Burroughs B6700 computer was nearly exhausted, and it was decided to find its successor.

In June 1982 the old central computer was replaced by a dual processor Burroughs B7800, which at that time was the most powerful computer in the series of Burroughs Large Systems.

During the years, when the B6700 was the central computer, it was necessary (in addition to extending it) to optimize its operations, frequently, in order to try to meet the growing load. The introduction of the B7800 meant an increase in computing power by a factor of 5-10, and the users experienced a considerable decrease in terminal response time.

With ample computer power available, there was no need to optimize the computer operation, and it was decided to postpone the optimization until necessary.

During the past 2 1/2 years the load on the computer has continued to grow with the previously known growth rate, which can be seen from Appendix C. Furthermore, the programs, run during normal work hours, tend to have a much larger core usage, and they have become more interactive in character.

The ability of a computer to handle the load has the characterization of a step function. When the load is lower than a certain threshold, there are no problems. When the threshold

is reached, the bottlenecks of the system start affecting the performance, which can decrease dramatically. In mid-1984 the situation became quite unsatisfactory, and the users experienced large terminal response times. It was obvious that the computer operations optimization, which was not needed 2 years earlier, had to be carried through.

Evidently this optimization of the computer operations will have only a temporary effect if the load keeps growing.

So far the only limit to growth has been the computer capacity. With a demand increasing exponentially, this will inevitably lead to the need for costly extensions.

In order to try to stop the growth, it has therefore been decided that computer power shall no longer be a free resource. This arrangement is effective 1 January 1985 for a trial period of 2 years.

Many different areas within the system may be objects for optimization, but we have concentrated on the hardware configuration and some installation and vendor provided system software.

4.1 Hardware configuration

The resources of major interest with respect to performance optimization are:

- a) 2 central processors (CPM)
- b) 1 input-output processor (IOM)
- c) Core store (768 kWords = 4.6 M byte)
- d) 4x200 MB permanent disk store connected to the core store with 2 disk channels through the IOM
- e) 6x87 MB mountable disk store connected with 2 disk channels through the IOM
- f) 1 datacommunication processor with approximately 45 terminals.

Performance measurements revealed that the system was unbalanced because one of the 200 MB disk store units carried a major part of the load and constituted a bottleneck. It was possible to redistribute files and thereby spread the disk traffic between the units, close to balance. This had a considerable positive effect on system performance.

Furthermore, it was found that the bottleneck of the system, after balancing, is the core store. An expansion of the core store will improve system performance twofold, namely by reducing the need for overlay, and thereby reducing the disk traffic.

4.2. Swapper

As mentioned the daytime load on the computer has become quite interactive. As part of the system optimization it was therefore tried to utilize the swapper system software provided by the vendor.

The B7800 computer has a virtual memory, which means that it simultaneously can handle a number of programs which between them demand more than the available physical core. In the non swapper mode of operation the core used by a program is divided into overlayable and save core. The save core holds the parts of a program that must be present all the time, such as buffers shared by the central processor and the I/O processor.

The overlayable core holds program code and data, and when need occurs segments of code or data are overlaid to disk, and of course have to be brought into core again when needed. On a heavily loaded core this strategy will lead to a large number of I/O operations, which can turn disk store and disk channels into bottlenecks.

When the swapper is active, a part of the core store is allocated to the interactive programs, and if necessary, these programs (code, data, buffers etc.) are swapped out of core as an entity (one large output operation), onto a special

swapdisk which is reserved for this purpose. Programs that are swapped out are not swapped in again until required by terminal activity. The use of the swapper is thus expected to reduce the number of I/O operations in an environment of interactive programs, by converting a large number of small I/O operations to a small number of large I/O operations.

Unfortunately, the use of the swapper had a very negative effect on system performance. The reason for this is not yet understood, but it is suspected that the swapper system software does not function properly on the B7800 system.

4.3. Catalog

The user files are stored on disk and tape. The active files, which total approximately 5000, are on disk. The inactive files (120,000 at the peak) are on tape. The management of these files is taken care of by the catalog system, which is a vendor-supplied product supplemented by some installation software.

The computer resources involved in maintaining the catalog, are not negligible. Because we suspect that there are certain inefficiencies in the catalog system software, this will be subject to an optimization process in the near future. The introduction of charging has reduced the number of files in the catalog by 30,000.

4.4. Data transmission

An increasing amount of data is transmitted from minicomputers - connected to experimental facilities - to the central installation. This has so far been done using a system utility program which simulates papertape-read.

When data enter the computer in this way, they go via the primary queue of the Cande-terminals system, which also handles input from all other terminal users' editing programs. The load from a minicomputer, transmitting data, is large compared with

input from terminal users. The primary queue can therefore become a bottleneck and users may experience an increase in response time, when transfer of data is taking place.

In order to take this load away from the Cande primary queue, a program to handle data transfer has been developed.



Part of Computer room.

5. RISØ INTERACTIVE GRAPHICS SYSTEM AND GRAPHICS FACILITIES

In December 1983 version 2.0 of Risø Interactive Graphics System (RIGS) was released with English documentation in the Risø report Risø-R-493.

This version includes full support to Algol-, Fortran 66-, and Fortran 77 programs together with an image editor with facilities for interactive image-manipulation.

Further, it contains an initial release of the so-called "business-graphics-module", providing menu-driven generation of piecharts, histograms, etc. However, since then this module has been segregated as a stand-alone program using RIGS. The new business graphics module has been extended to contain facilities for creation of curves and overheads. The images produced have been improved to conform with Risø's standards for publication in reports and periodicals.

RIGS has now been qualified for external sale and the first delivery took place medio 84.

Since the report was published, further development has taken place. The most important improvements of RIGS are:

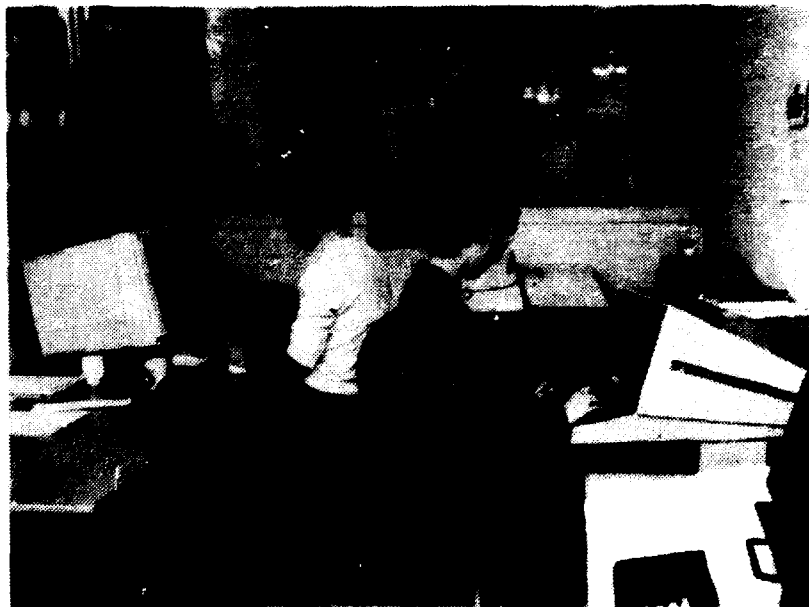
- Several new devices have been included in the program's description of the user's graphics station (graphic- and alphanumeric terminals, plotters, tablets, digitizers, etc.).
- Texts have been improved by use of the so-called "Hershey"-characterfonts providing more than 20 different character-styles (see page 22).
- Subimages within an image may now be manipulated using digitizers to select, position, delete, extract or insert the subimages, interactively.

At Risø more than 100 users have attended a training course in RIGS and the system is now used intensively for computer graphics in most departments.

In the Computer Installation a graphics work station consisting of an advanced large-screen colour terminal (SEIKO GR/2414) equipped with a large tablet used as a digitizer, has been installed. The graphics station is available to all users at Risø.

The siteplotters have been augmented by a high-quality drum plotter (Benson 1333) with 4 colours (pens) and options for 30 cm or 90 cm paperwidth. It also provides facilities for dashed and thickened lines. Drawings made on this plotter may be used in offset-reproduction directly.

RIGS has been a very great success and is believed to be among the most powerful computer graphics systems providing programmatic as well as interactive creation and manipulation of high-quality drawings.



Room with graphic equipment and other terminals.
Note digitizing table in background.

EBCDIC: ABCDEFGHI JKLMNopqrstuvwxy z (|)

EBCITA: *ABCDEFGHIJKLMNopqrstuvwxy z (|)*

DANISH: ABCDEFGHI JKLMNopqrstuvwxy z æ ø å

DANITA: *ABCDEFGHIJKLMNopqrstuvwxy z æ ø å*

SIMPLEX: ABCDEFGHI JKLMNopqrstuvwxy z { | }

SIMDAN: ABCDEFGHI JKLMNopqrstuvwxy z æ ø å

SIMSWE: ABCDEFGHI JKLMNopqrstuvwxy z ö ö ö

SIMSCRIPT: *ABCDEFGHIJKLMNopqrstuvwxy z { | }*

COMPLEX: ABCDEFGHI JKLMNopqrstuvwxy z { | }

COMDAN: ABCDEFGHI JKLMNopqrstuvwxy z æ ø å

COMSWE: ABCDEFGHI JKLMNopqrstuvwxy z ä ö å

COMSCRIPT: *ABCDEFGHIJKLMNopqrstuvwxy z { | }*

COMITA: *ABCDEFGHIJKLMNopqrstuvwxy z { | }*

COMITADAN: *ABCDEFGHIJKLMNopqrstuvwxy z æ ø å*

COMITASWE: *ABCDEFGHIJKLMNopqrstuvwxy z ä ö å*

DUPLEX: ABCDEFGHI JKLMNopqrstuvwxy z { | }

DUPDAN: ABCDEFGHI JKLMNopqrstuvwxy z æ ø å

DUPSWE: ABCDEFGHI JKLMNopqrstuvwxy z ö ö ö

TRIPLEX: ABCDEFGHI JKLMNopqrstuvwxy z { | }

TRIPDAN: ABCDEFGHI JKLMNopqrstuvwxy z æ ø å

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GOTHICGERM: *ABCDEFGHIJKLMNopqrstuvwxy z ä ö å*

GOTHICENG: *ABCDEFGHIJKLMNopqrstuvwxy z { | }*

SIMGREEK: ABHΔEΦΓXII KΛMNοπϑρστυωωξψζ { | }

COMGREEK: ABHΔEΦΓXII KΛMNοπϑρστυωωξψζ { | }

Sample of Hershey-fonts in RIGS

6. DATABASE ACTIVITIES

6.1. Background

In a scientific environment like that at Risø a database management system has always been considered a tool for implementing administrative applications. Further, the complexity of database management systems, the level of expertise necessary to support it, and expectations of considerable system resource requirements have postponed an actual evaluation of the use of a database management system at Risø.

Alternative methods, some of which are simpler, have been selected to handle even large volumes of experimental data. Usually data are processed sequentially, and data collection and preparation has been clearly separated from processing. There has been little or no inter-relation between different data sets, and structures are simple. Recovery from faults and restarts are performed by simple reprocessing.

In this environment the major concern is the selective retrieval of information, and in most cases the hierarchical file access structure has been sufficient to implement efficient selective retrieval of data sets. To a great extent these structures have functioned as Risø's "data management system".

Another simple tool for information storage and retrieval is a small set of procedures called the "GET/PUT"-system. These procedures store and retrieve arbitrary data sets by reference of user-specified identifiers. Major features are simplicity, "ease of use", and relieving application development of concern about file structuring. A weakness of the system is lack of recovery facilities. Still, this system has been used in developing a few online applications, and to store graphic images in the Risø Interactive Graphics System (RIGS).

But, even in a scientific environment, user requests for more online applications to handle new areas of information processing - with complex relationships between data sets and a need of sophisticated recovery facilities - are rising. This is true when manual procedures grow too big to handle, and old batch-systems are outdated.

To implement such online applications we needed the facilities available in a database management system.

6.2. Evaluation of database management system

The choice of a database management system was easy to make, as Burroughs offers a fully supported database software package (DMSII), with interfaces in the operating system and tailored to Burroughs architecture.

To our knowledge there is no alternative database management system available for Burroughs Large Systems, and Burroughs generously made the software available for an evaluation at Risø.

This meant that we could concentrate on the actual evaluation of system resource requirements and the features introduced by the DMSII software, without having to perform an analysis of other competitive software.

For the evaluation process we decided on a pilot project to implement a library administration system for Risø Library, which is open to the public and specializes in energy literature.

During spring and summer 1983 the design of the system was specified by a group of five persons - four from the Library and one from the Computer Installation. At this stage we had no experience at all in database management systems, and we wanted to keep it that way, until the design had been completed. This design was later used as an evaluation criterion that the software could actually fulfill the original design.

From August through autumn and winter 1983 the implementation of the system was carried out, including learning the DMSII software on a self-study basis. In February 1984 the system was presented, in a nearly completed state, to Risø Library and others with interest in the introduction of a database management system at Risø.

The conclusions of the evaluation were that the DMSII software was capable of fulfilling the system design, system resource requirements were reasonable for an application of that kind, the features of DMSII were more than sufficient, the efficiency was unusually high and programmer productivity could be greatly improved by mastering the DMSII database management system.

It may seem that the elapsed period of the pilot project is rather large, but it was performed as a part-time exercise, mainly involving only a single person with no prior experience in database management systems.

The library administration system was not fully completed and put in production. It was used by Risø Library to gain experience on the implications of changes in the daily work and on the level of demands and expectations of improved efficiency they could request for a future Integrated Library System, covering all functions in a modern library. A proposal for a 3-year plan and budget for implementing this fully integrated library system has now been accepted.

6.3. Actual database systems

In 1984 a new system had been implemented based on the pilot project. This system replaces an outdated batch implementation for administration of the circulation of magazines and other periodicals among Risø's employees and departments and external users of Risø Library (app. 1500 periodicals and 800 "customers").



In Risø Library, barcodes and lightpen are used to register despatch and receipt of periodicals.

Danish research institutions, including Risø, have for many years had a common administration of instruments and equipment. (It is known as FRIT, a Danish acronym for The Instrument Service of the Research Councils and Risø). This organization handles app. 10,000 instruments, using an outdated batch-system, which is run on Risø's B7800. Implementation of an on-line database system to replace this has been started.

The development of a uranium management system for the Hot Cell department is mentioned in section 14, page 47. At first the program was based upon the above-mentioned "GET/PUT"-system, and its main portions were ready when the DMSII software was acquired.

However, it was calculated that the time required to implement our own recovery facilities, would surpass that necessary to rewrite the program, using DMSII, which would give us the mechanisms for recovery without cost. Today, the uranium management system is running as a true database system.

7. LINEAR PROGRAMMING

Linear Programming (LP) is the mathematical discipline which is concerned with the minimisation of a linear function, called the objective function, under linear constraints. For well over a decade the Computer Installation has been involved in the development of different kinds of LP software. In the early period (1973-78) the emphasis was on the construction of small compact LP codes. They were intended to form building blocks in user programs. Not much published LP software existed at that time, because then as now most codes in this field were developed under commercial auspices. As there were a number of reasons speaking against Risø buying its LP software, we started a research on LP algorithms with the purpose of writing our own codes.

Almost all LP codes are based on various forms of the so-called Simplex method. In one step of Simplex we move from an extreme point of the constraint set to an adjacent one, seeking to improve the value of the objective function. This fundamental principle has been challenged from time to time by alternative methods claiming to be more efficient, at least theoretically. But in practice these methods are too complicated to be able to oust Simplex, which has undergone many refinements in the past and still does so, after more than forty years of use. The widespread use of linear programming is of course related to the explosive growth in digital computing capabilities. LP is an outstanding example of a mathematical field which is explored commercially. The large computer companies, notably IBM, started their own development of LP codes. A result of this was the stand-alone program system MPS, later followed by the extended version MPSX released about 1974. This powerful and reliable latter system is unfortunately accessible only on IBM-compatible computers.

It is not hard to write a Simplex for very small problems (such a code could be implemented on a micro). But when the problem size grows, so do the difficulties. Two foes must be fought: rounding errors and storage demand. Rounding errors in LP codes are particularly nasty, because they not only inflict a certain "noise" level on the results, but they may also cause Simplex to take wrong decisions and thereby invalidate the solution completely, e.g. the program may postulate an optimal solution which is not even feasible. Storage problems come from large LP matrices. Many thousands of constraints and variables are not unusual in commercial applications. Such huge problems can be dealt with only by sparse matrix technique. Fortunately practical LP matrices are very sparse, and sparser as the problem grows larger.

In our Progress Report for 1979-80 it was described how a specific need for an LP solver in a project in energy system analysis led to the construction of the Risø code Linprog. This is a general-purpose program but has fewer facilities than MPSX. The design principles for Linprog were Revised Simplex and sparse matrix technique. Revised Simplex means that the inverse of the current basis matrix is updated in each step (the basis matrix is formed by those columns that correspond to nonzero decision variables). Sparse matrix technique entails the use of files or lists to store the nonzero elements. During calculations these lists grow and must occasionally be compressed. The well-known re-inversion procedure is used for this purpose. It amounts to constructing the current basic solution from scratch by inversion under use of as little storage as possible. Re-inversion is very important in any LP program designed to solve more than the smallest problems.

What is actually the demand for LP software at Risø? Our experience tells that the demand is not very intensive, but rather sporadic and fluctuating. There are roughly three types of applications: In the first, the user programs need the incorporation of LP procedures for small-scale computations. In the second category, there is a need for LP software in user programs in what could be termed medium-scale applications.

Finally there is use of LP software as a non-integrated problem solving device. To meet the first demand, compact simplex subroutines without sparse-matrix facilities were developed about 1977. The second is fulfilled by a special subroutine collection which is essentially the computational core of Linprog. The third category relates to small or medium off-line problems, and here Linprog is the proper tool.

Linprog is designed to solve problems with a few thousand ranging up to some million matrix elements, most of which are supposed to be zero. The scope of Linprog is properly characterized as medium-scale problem solving, the most prominent examples of use being: energy system analysis, design of optimal schemes for fuel management in nuclear reactors, and optimal allocation of restricted economical resources. These applications are all quite straightforward in that they do not call for specialized LP extensions like parametric programming. There has been some interest though in integer programming modules and also in the possibilities of handling upper bounds.

The experiences from the above applications have influenced what direction the further development of the Linprog program should take. We believe that it is important to have an efficient LP solver which is flexible enough to allow incorporation in user programs as well as off-line use. Numerical stability is very important. Also important is efficiency, whereas the need for LP extensions is not so urgent, maybe apart from bounds and integer programming. The current version of Linprog is a good starting point to achieve these goals but the program must be improved in a number of ways. Below we describe the points in which Linprog is under improvement. The work is ongoing and was incomplete by the end of 1984:

First, the re-inversion technique in Linprog is based on the so-called PFI form (product form of the inverse). A more accurate and storage-saving form is the EFI (elimination form of the inverse). EFI, which is the most popular inversion scheme in commercial codes, is equivalent to a triangular (LU) decomposition of the basis matrix. It resembles Gaussian

elimination by Crout's method. LU inversion schemes are difficult to code because of the fill-in of nonzeros during the inversion itself and because the Simplex updating of an LU form of the inverse basis is a complicated matter. But the more elaborate coding is offset by a gain in speed, storage, and most of all numerical stability. Presently, we are implementing both LU inversion and LU updating schemes in Linprog. The inversion will proceed in two steps: The first is called the boolean part because here we are concerned only with the positions of nonzero matrix elements, whereas the second step takes hands on the numerical values. This is the PPP method (preassigned pivot procedure), meaning that pivots are found in advance in the boolean step. Inversion schemes of the PPPP type (partitioned PPP) with a block diagonalisation of the basis have also come in use, but we find that they are too complicated and only profitable for much larger problems than those we intend to solve. The LU updating procedure to be used in Linprog, for the Simplex step is similar to that used by Forrest and Tomlin; it avoids fill-in completely.

Linprog will also be simplified in the way it handles the Simplex phases. Instead of executing a special "Phase 0" for zero-slack elimination this process will be merged into Phase 1 where the feasibility is established.

A further design criterion for the next version of Linprog is portability. We write the code in standard Fortran 77 and anticipate none or very few changes if the program should run on a mainframe other than B7800. We suppose only that Linprog is used on computers with virtual store; this is essential in handling the long lists in the sparse-matrix procedures. Also, a certain minimum of high-speed store will be necessary, and Linprog is interesting only in connection with mainframe computers that are not too small. Portability is also enhanced by intrinsic setting or use of the many tolerance parameters which is necessary to make a large Simplex code work reliably. In the test phase we foresee some help from the VAX installation at the Electronics Department.

Linprog will be maintained as a complete stand-alone program with the same input/output communication format as in MPSX (this format is de facto standard in LP) and also in a "core" version as a subroutine collection for direct interaction with user programs. No attempt has been made to code a general matrix generator or report writer in connection with Linprog.

Plans for LP extensions to be incorporated in Linprog later on include restriction-free rows, accuracy monitoring and implementation of bounds. The IP (integer programming) and MIP (mixed IP) extensions will probably be outside the scope of Linprog, but they might be implemented as separate pieces of software. As a matter of fact we wrote some years ago an experimental code for the BMILP problem (binary mixed integer LP).

It is our policy to try to keep Linprog within a manageable size. A typical commercial LP system will probably in total be counted in tens or even hundreds of thousands of code lines. Until now Linprog is confined to about 2500 lines of Fortran code. With the planned improvements and extensions this size will probably go up to about 4000 lines.

All our LP software is generally available at Risø as part of the Risø Computer Library (RCL).

8. FORTRAN 77 ON B7800

8.1. General experience with the use of Fortran 77

It is our impression that Fortran 77 has really caught on and gone into intensive use at Risø in 1983, and since then it has taken over most of the new Fortran programming activity. The old Fortran 66 compiler, still in operation on B7800, is used mainly for old, complex, and static programs. With the advent of conversion aids within the Burroughs Fortran 77 compiler, it will hopefully be feasible some day in the near future to withdraw Fortran 66 completely. The two compilers are somewhat different in the style of their file-handling capabilities and extension of the standard instructions. A withdrawal of Fortran 66 will therefore rationalise our total Fortran support to the users.

The efficiency of Fortran 77, compile-time as well as run-time, is by now much better than in the earlier releases and must be characterised as quite acceptable.

All our training activities in Fortran are now based on Fortran 77. This pertained to both the Fortran course for beginners in 1983 and the advanced Fortran course held in 1984. Apart from these courses the Computer Installation gives advice and clears up many Fortran problems for users. Such consultation work is of increasing extent and puts a significant load on our staff. To some extent the advisory work has replaced the earlier compiler debugging efforts, reflecting both the better shape of the compiler and the increased interest in using it.

Late and inadequate Burroughs documentation has severely impeded the widespread use of Fortran 77 at Risø. A usable though certainly not perfect Reference Manual appeared as late as September 1984. In spite of this lack of Burroughs

documentation we did not abstain from introducing Fortran 77 on Risø. But we had to supply some documentation of our own: a memo describing the general character of the Fortran system on Risø's B7800 (RMA memo no. 41, in Danish), and a document file (INFO/FORTRAN77) with an updated list of known compiler errors and various practical advice to the users. Last but not least we promoted the procurement of a large number of copies of a good Fortran 77 textbook (Ekman/Eriksson: Programmering i Fortran 77, in Swedish.)

8.2. Error reportings to Burroughs

Also in 1983-84 the Computer Installation was heavily involved in locating and reporting software "bugs" in the Burroughs Fortran 77 compiler. Each error report contains typically a small demonstration program of about 10 lines; it is marked with a priority level (LOW, MEDIUM, or HIGH) according to the estimated severity level of the fault. From the time we received the first version of the compiler from Burroughs in mid-November 1981 until the end of 1982 the number of Fortran 77 reports were 48 (8 LOW, 17 MEDIUM, 23 HIGH). The corresponding figure from 1983-84 is 59 (18 LOW, 28 MEDIUM, 13 HIGH). This means that the average rate of disclosure of new compiler errors was 3.6 per month prior to 1983 and has dropped to 2.5 per month in 1983-84. In particular, there is a marked decrease in the errors with priority HIGH. The total of 107 reports in 1981-84 represents the debugging work of approximately one-half person-year.

The responsiveness on the part of Burroughs to Risø's Fortran 77 error reports has improved much since 1983. The reason is probably a combined effect of our personal contact to their compiler group in USA and a generally better coordination of problem solving within the company. They send us new releases of their compiler at irregular intervals, and each time we see some effect of consolidation. It is true that there are still quite a number of unsolved problems, and new faults are occasionally discovered. But when we try to assess the consolidation of such a piece of software we must also count on the more intensive testing of the compiler by a growing number of Risø users.

9. PROGRAMMING ENVIRONMENT

The use of Risø's B7800 is characterized by the developing and running by about 200 of the users themselves of their own programs. It is estimated that Risø spends about 100 person-years per year on this work. Because of this investment the availability of development facilities is of great importance for increasing the efficiency of Risø's operation.

The basic tools are of course the compilers and the interactive language, Cande, all of which are provided by Burroughs. The work with large programs with many procedures or subroutines is supported by several features in the system software. Among these, Library, Import, and Sepcomp are mentioned below.

The Computer Installation contributes to the programming environment, above all with the huge collection of routines in Risø Computer Library. Further, we have recently developed program generators, which assist users in designing a command language or a screen menu into their application programs.

9.1. Burroughs utilities

In our earlier progress report for 1981-82 it was mentioned that Burroughs had introduced a new software feature called Library. Library is a program which provides a set of subroutine entry points which can be reached by other programs. A call on a procedure in a Library is equivalent to a call on a procedure (or a subroutine) in the user's program.

A Library, either in Algol or in Fortran, contains precompiled procedures (subroutines) and is started when a user-program calls a precompiled routine. One of the ideas in the Library concept is that it is possible to call both Algol Libraries and Fortran Libraries both from a Fortran program and an Algol program with the restriction that a call of an Algol routine

from a Fortran program is possible only when the parameters in the Algol procedure have corresponding Fortran parameters.

But it was also told that the Fortran Library concept had some serious drawbacks. One was that it was impossible at that time to have subroutine or function parameters in the Fortran Library, another that it is necessary to have 'skeleton' declarations in the Fortran Library. (The use of a skeleton declaration in Algol Library is not felt inconvenient because Algol procedures always must be declared). In spite of these drawbacks we started to make a Fortran 66 Library and later also a Fortran 77 Library of the routines in Rise Computer Library when the Fortran 77 compiler was ready for use in B7800.

The first drawback is now removed since Burroughs recently has improved the Fortran Library concept to include also the use of subroutine/function parameters in the subroutines such that it is now possible for us to make a complete Fortran 77 Computer Library. The first version of our Fortran 77 Library of standard routines was operational in June 1983 and the full Fortran 77 Library (with subroutine and function parameters) in autumn 1984. The same improvement in Algol is scheduled for 1985, but its inclusion in Fortran 66 is uncertain.

The requirement of skeleton declarations for subroutines to be accessed in a Library has recently been relieved by the Import Statement, which may also, in addition to subroutines, import Common-areas and files. The import facility is presently available in Fortran 77 only.

The Sepcomp (Separate Compilation) software now provides facilities for incremental program development. This feature may reduce compilation time when recompiling large programs, where only a few of the subprograms are modified. For large programs the savings may be a factor of ten or more. Furthermore, the long Cande updatings are avoided.

9.2. Risø Computer Library - RCL

One of the greatest improvements of Risø Computer Library (RCL) has been the introduction of Fortran 77 Library such that all the standard Fortran subroutines are precompiled and are ready for direct use by the Fortran user programs. The RCL is still based on the use of skeleton declarations. However the user has only to write: \$ INCLUDE 'FORT/HEADS' in the beginning of the program to obtain access to the Fortran subroutines. This statement causes the inclusion of the file FORT/HEADS which contains all the skeleton declarations necessary for use of the standard routines, such that the user need not consider that in her/his programming. All the parameters in the call of the subroutines are transferred to the precompiled subroutines, also the subroutine and function parameters. But as mentioned above there is still the restriction that the main program must be in Fortran 77.



Risø Computer Library abstracts is available as a loose-leaf foil

Another improvement is the introduction of RCL2 which is: Risø Computer Library Service Class 2. RCL2 can be considered as an extension of that part of RCL (= Risø Computer Library Service Class 1) which is directly available and documented with abstracts in RCLA. RCL2 contains various collections of software for applied mathematics, mainly obtained from sources outside Risø and written for non-Burroughs computers. Service class 2 means that the Computer Installation takes no responsibility regarding the correct functioning of the programs. The major parts of RCL2 are in Fortran but some are in Algol. Our criteria for placing software in service class 2 rather than 1 are:

- Software too large, complex or difficult to manage and maintain.
- Software not fully tested or not tested at all.
- Software not adequately documented.
- Scope of software expected to be of limited interest.
- The methodology or coding standard not satisfactory.

Thus, service class 2 does not mean that the quality of the software needs to be inferior, and we feel that much of it might be valuable for Risø users. In particular the CACM collection mentioned below is a very powerful source of mathematical software.

At the present time, RCL2 includes the following packages or collections:

- General mathematical and numerical routines: CACM, ALGWPROC, HSL, and SSP. The two last mentioned are quite old versions.
- Routines to solve ordinary or partial differential equations: DIF, ODEPACK, ELLPACK.
- Routines to solve linear equations: LINPACK.
- Routines to solve unconstrained minimization and least squares problems: MINPACK.

9.3. FATGS (Finite Automaton Table Generator System)

A program generator used for implementing command controlled program execution has been developed and placed into operation. The syntax of the command language is formally defined with associated semantics, and from this definition a finite automaton table generator will generate syntax tables. At execution time an interpreter will analyze the input text according to the syntax and activate the appropriate semantics which must be provided in a well-structured semantics procedure. The system has been successfully used for the command language of RIGS (see section 5), the text editing system SETUP (see Progress Report 1981-82), the MENU system (see below), and several smaller applications.

9.4. MENU

The appearance of ASCII terminals with cursor control, reverse video, etc. has provided facilities for use of input/output menus, where the computer displays a number of fields with guiding texts, and the user may pick a field or fill values into one or more fields.

To support programming of such menus, a program generator has been constructed. The menus are defined using a concise notation. From this definition, the generator constructs a procedure to perform the actual conversation with the screen terminal. An associated semantics procedure provides well-structured semantics for each of the fields in the menu.

10. TRAINING ACTIVITIES

The Computer Installation has continued the extensive programme of courses and colloquia about data processing matters, which was described in the previous progress report.

The basic pattern has not been changed with two fundamental courses - "Introduction to the Computer Installation" and "Cande" - offered twice a year and the rest as need be.

In the period under review, two courses have had particular interest and have been repeated several times. "Risø Interactive Graphics System - RIGS" has been given five times after the manual was issued in early 1984, and "Introduction to Electronic Data and Text processing" was given six times.

The latter is designed to give a basic understanding of data processing and some of its immediate consequences. The target group is staff with no or little prior experience in these matters, primarily secretaries, and clerical assistants.

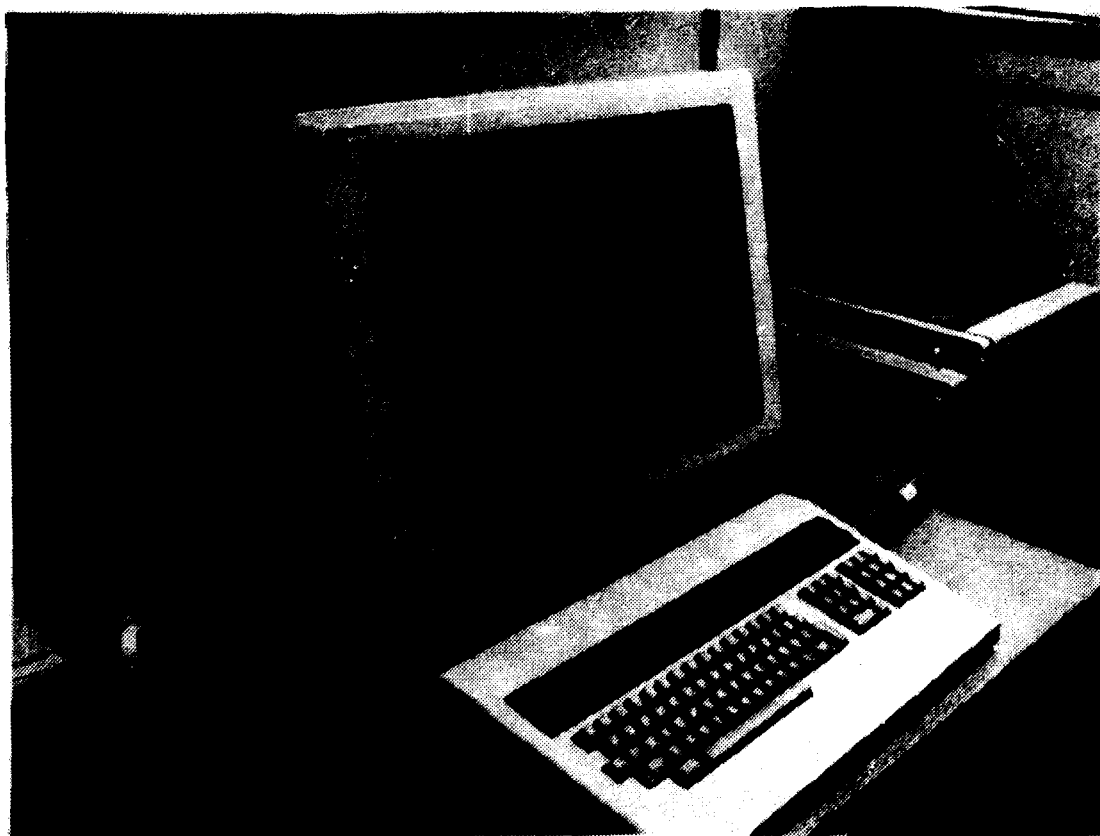
A new type of course has been developed, using video tape. A usual course is a combination of an oral explanation and a demonstration on a terminal. The video part of the tape shows the terminal while the audio part repeats the explanation.

Our first instance of this method was an English-speaking course on Cande, and it has become quite popular, in particular with foreign visitors, who can study the subject at the time and speed which suits them best. A combination of the video equipment and an on-line terminal, where new information can be tried at once while the tape is stopped, has proven very efficient.

A number of external teachers as well as staff from other departments have been invited or hired to present some of the courses and colloquia in order to bring a broader view of edp to Risø. Also, the staff of the Computer Installation has occasionally lectured outside Risø or for groups of quests. Complete lists may be found in our Danish annual reports.

A thorough programme of revision of manuals, course material, and user instructions written by the Computer Installation has been carried through.

In late 1984 we were compelled to abandon our previous meeting-room, which we used for classes. It gave us the opportunity to furnish another room for the specific purpose of giving courses.



Comparison of chemical processes, using RIGS.

11. PARTICIPATION IN SUPERSARA GAMMA-SCAN PROJECT

In 1983 the Computer Installation took part in an EEC contract project together with the Metallurgy Department. Our part of the work was the development and testing of a computer model, which simulates nondestructive gamma-scanning measurements on SuperSara test trains (fuel elements). Originally real measurements were planned at the ESR reactor in Ispra, but they were abandoned in connection with the close-down of SuperSara in 1983. Instead, the experimental work was confined to a test facility at Risø, using prototypes of the test trains. The computer program Gassco was written to simulate the gamma-scan measurements. The idea was to verify Gassco against PGE measurements and then use it for predicting sensitivity and feasibility analyses of nondestructive gamma scanning in general. This is much faster and cheaper than relying exclusively on experiments. The work is described in detail in the report: Gamma Attenuation Of SuperSara Test Trains, Final Report, by C.Bagger and P.Kirkegaard, Contract No. 1914-82-07 ED ISP DK). Gassco is able to compute the diametral variation of the gamma-ray transmission from internal activities as well as from perpendicular external sources. Output can be presented as histograms or tables. With such computations one hopes to assess what sort of deformations or destructions of the fuel pins one can expect to visualise by the gamma-scanning technique.

The fundamental principle we adopted in Gassco is a raster mapping of the components of the fuel element cross-section into a great number of small homogeneous square-shaped regions, the so-called pixels. By this process smear average data for the attenuation coefficient and the activity are allocated to each pixel. The program has also facilities to rotate the whole raster configuration through a fixed angle.

Once the smear data for all the pixels are known it is a relatively easy task to compute the gross attenuation rates by summing the pixel contributions using exponential attenuation formulas for each of them. The difficulty lies in the geometrical mapping itself. A typical fuel element is very complicated with many tubes, shrouds, supporting fixtures, coolant areas and fuel pins with cladding; some of these are possibly missing. All this may be characterised by a set of homogeneous material regions separated by interfaces made up by line segments and circular arcs. We needed a systematic treatment of such a structure, and devised for this purpose a graph-theoretical approach which proved to be very powerful: All the boundaries in the configuration are organised as nodes in a rooted tree where the root corresponds to the outermost boundary. The node j is a successor of node i if contour j is enclosed in contour i and the material between them is homogeneous. Thus all nested contours within some specific contour i can be viewed as subordinate to node i in the tree. Efficient and systematic tree-scanning routines exist and is used in Gassco to map the various geometrical elements on the raster, starting from the outside; the same tree scanning can also be used to control the drawing of a check plot of the configuration cross-section being studied. With this graph-theoretical representation a change in the topology can be made very conveniently. In particular deletion of regions corresponds to removals of nodes from the graph and is implemented as an option in Gassco.

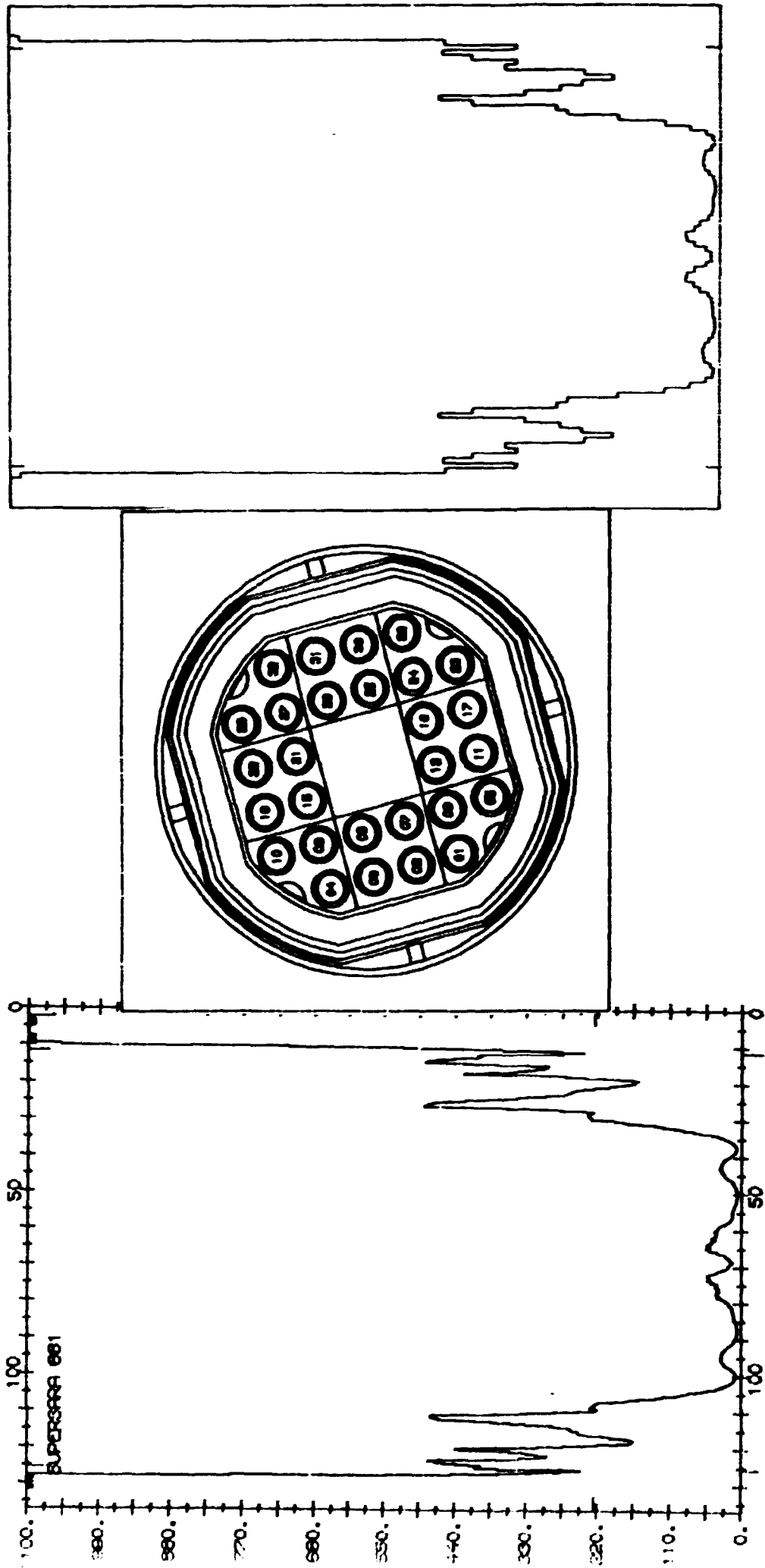
During the supervisory tree-scanning process Gassco calls a set of procedures for mapping basic geometry elements onto a square raster. The basic elements are circles, line transversals, circle segments, and rectangles. By combining these the more complicated boundaries can be treated. All the elementary mapping routines in Gassco have undergone thorough testings by which a very large number of random input configurations were generated, covering all imaginable positions in the raster.

When Gassco was finished and tested at Risø's B7800, the code was experimentally verified by comparisons with the prototype

measurements at the PGE. Output from these experiments were histogram profiles of the diametral distribution of the transmitted radiation (see next page). The histogram step was about 1.4 mm and matched the pixel width used in Gassco. The agreement with the Gassco predictions was very fine. Thus verified, Gassco was applied in a large series of production runs in which the sensitivity of the gamma-scan method to simulated failures in the fuel elements (e.g. bowing or disruption of fuel) was estimated. To get through these production runs in an easy and flexible way we developed an interactive menu-driven input editor program Gedit. By means of this program it was possible to make selective changes in the Gassco input and thereby facilitate the necessary parameter studies.

Both the programs Gassco and Gedit are written in standard Fortran 77. The size of Gassco is 2100 lines of code, and that of Gedit is 600 lines. Gassco contains a main program and 27 sub-routines. As a final part of the fulfilment of our contract we agreed with the Italian counterpart of the project group to install and test the programs at JRC Ispra's central computer facility Cetus, which is equipped with an Amdahl 470 computer. The installation of the software in Ispra took place in September 1983 and was successful, though some problems had to be surmounted. In the short installation time available (four-and-a-half days) it was necessary to get acquainted with the job control language, the Fortran compiler, the file handling, and the editors available on the Amdahl. This computer is compatible with IBM but is very different from B7800. Further, the graphical procedures used in the Risø version were replaced by the local graphical system used in Cetus which was based on the GINO-F system. After the installation the local staff was instructed in the use of the computer programs.

This last installation phase of the Gassco project was, like all the other phases of the gamma-scan contract work, subject to quite strict time schedules. Though the whole SuperSara project was stopped the same year it was anticipated that a substitute project would be able to benefit from Gassco, which is in fact a rather general research tool. The computer model would also be valuable in various investigations at Risø.



Measured (left) and calculated (right) diametral attenuation of an element with cross section as shown in between.

12. SIMULATION OF CHEMICAL REACTION SYSTEMS

In an earlier annual report (Annual Report 1978) we described a program for simulating chemical reaction systems. This program has undergone a large improvement since that time. Many new features have been included in the program, e.g. the use of RIGS (Risø Interactive Graphics System) and a new integration routine Episode (a modification of C.W.Gears original routine). The program is described in a Risø Report. In connection with this report a memo containing a series of standard input files for simulation of water radiolysis experiments performed at Risø is also published.

Since these publications a larger revision of the program has been made in order to simulate non-isothermic kinetics. Such simulations are important in the study of exothermic processes as, e.g. combustion.

We have also exchanged the integration routine Episode with Lsoda from Odepack.

The new version of the simulation program will probably be in operation in spring 1985.

13. AUTOMATIC ONE-DIMENSIONAL QUADRATURE

In an earlier annual report (Annual Report 1978) it was described that we have adopted an adaptive quadrature formula devised by A. Riesel, which we found has an overall good performance and robustness in comparison with other known adaptive integration methods.

The method is based on a 6th order 7 points quadrature formula with the property that all the nodes are reusable and all weights positive.

The success of this method has given us the idea that there could exist quadrature formulas of higher-order with the same properties. Attempts to find such formulas by paper and pen resulted in finding such formulas of order 8 with 9 nodes, 10 with 11 nodes etc. Then we implemented a method in B7800 Extended Algol for systematic search of higher-order quadrature formulas with these properties. The result was positive; we found quadrature formulas of order up to 128 before we stopped the search. We assume that there are more than the formulas found. For the present time it has not been possible to give a mathematical proof of the conjecture that there are infinitely many quadrature formulas which are imbedded in each other.

We have implemented an Algol procedure which uses the orders up to 20 and the experiences are promising. The overall performance with respect to number of function evaluations and robustness are better than the 7 points formula as was expected.

14. PROGRAMMING ASSISTANCE

The Computer Installation provides programming assistance to users to some extent. Some programming projects from the period of this report are mentioned here.

14.1. Hot Cell

July 1983, a request was received from the Hot Cell Department about the development of a program that could help them keep count of the radioactive fuel pins used for experiments and which are very carefully accounted for by hand on index cards.

Two persons from the Hot Cell department were selected to assist in defining, together with the programmer, the demands on the program. It was soon obvious that the program was to contain the following basic functions: input, delete, change, and information. Furthermore, it was decided to control the program by menus.

```
MAIN MENU
LEVEL:1

INPUT
  1) New project
  2) New batch
UPDATE
  3) Divide batch
  4) Divide sample
  5) Change batch
  6) Change sample
  7) Change storage
DELETE
  8) Batch
  9) Sample
VARIOUS
  10) Librarymenu
  11) Informationmenu
  12) Output on printer
  13) Notes
```

Select number or STOP: 2 (S for stop or R for refresh.)

The programming started without a detailed list of demands; instead there was a close contact between the programmer and the user. As soon as the program contained a function that

worked, the user was given a copy in order to have the function tested and to let the user decide if it responded properly to his demands. If not, new demands arose which would be implemented and returned to further testing, etc.

In this way, the program was developed menu by menu until the first version to run in production was finished in December 1984.

```
INFORMATION MENU.  
LEVEL:2  
  
OVERVIEW OF  
1) *****  
2) Projects and batches  
3) *****  
EXPERIMENT  
4) Identify  
5) Cutting table  
6) Isotopes total  
CRITICALITY  
7) C.F. for storage area  
8) C.F. for batch  
9) C.F. for sample  
10) C.F. for new item  
SAFEGUARD  
11) Updated inventory listing  
12) Inventory distribution  
13) Identify with all info
```

Select number or STOP 5 (STOP = MAINMENU or R for refresh.)

A conclusion on this approach says that the result should meet the users' requirements pretty well, but on the other hand, had there been more emphasis on discussion of the demands set forth by the user, time could have been saved.

14.2. Conversion of Fortran programs

In analogy with the offer of programming assistance to users, limited assistance has been offered for converting Fortran programs from other computers to B7800. Six large programs have been converted, partly in Fortran 66 and partly in Fortran 77.

In connection with such a conversion a great deal of problems may occur. These can be divided roughly into five groups:

1. Differences in file organization between B7800 and the computer, where the programs have been developed.

2. Some of the programs from outside are written in double precision, where we prefer single precision on the B7800; on B7800 single precision is sufficient for many purposes and the increase in processor time when changing from single to double precision on the B7800 is worse than on the computers in which the programs have been developed. Therefore, the conversion also demands a change of constants in the program.
3. B7800 Fortran demands a complete correspondance of types between formal parameters in a subroutine and actual parameters in the corresponding calls, while other computers may accept divergences, e.g. a simple variable instead of an array.
4. Programs from some computers as CDC6600 use an overlay structure, which may cause serious problems during the conversion.
5. Call for "Library-routines", e.g. random number generators, error handling routines, and time functions.

It must be stressed that a succesful conversion demands a full documentation together with a full set of test data and test output, which unfortunately not always are available.

Apart from one Fortran program, our experience with the conversions is pretty good, also seen from the users' point of view, as they can use the converted programs as satisfactorily as if they had instead used the computer on which the programs were developed.

One program, Forsim, a package for solving ordinary and partial differential equations has not been converted yet because of the problems mentioned above.

The conversion of Odepac, a package for solving systems of ordinary differential equations, and Mopac, a program for calculating molecular orbital movements used for the study

of chemical reactions, was facilitated by use of a VAX-11/780 in the Electronics Department. The Vax is compatible with an IBM computer, and the programs ran without difficulty on the VAX, whereas the output from B7800 was incorrect. The reasons for the differences was easily found by running the programs with the same test output statements on both computers.

14.3. Helium, a program accounting for delivery of liquid helium.

Risø has the only liquid helium production plant in Denmark. It produces liquid helium for Risø's own laboratories and supplies university laboratories and hospitals as well.

The yearly production amounts to approximately 26,000 liter liquid helium, distributed in 200 deliveries. Most of the helium gas is recovered and returned to Risø. The losses amount to 25-30%.

To account for the helium deliveries and the return of helium gas as well as the purchase of supplementary gas a menu-driven program has been developed.

The program, which can be run by a technician without edp-skills, has 5 screen displays for transaction reporting, and it can generate 6 status reports.

14.4. MET/AUTO, a program for automatic transfer of data

The National Air Pollution Laboratory has a number of meteorological stations located around the country. These stations automatically collect data about temperature, wind-speed and direction, etc. The stations are run automatically by micro-computers, which are able to store data from 7 days of measurements.

In order to collect data from these stations, a program has been developed. This program can contact the stations one by one via an autodial facility connected to a 1200 bit/sec

switched modem-telephone line. When a connection has been established to a station, the program can order the microcomputer to transmit its data. The data thus received are stored in a file for further processing.

The program has now been in operation for one year, serving four meteorological stations successfully at the moment.

14.5. Time sheet account system in the Metallurgy Department

The time sheet account of the Metallurgy Department was formerly recorded on punchcards. The punching used a lot of time and there was a high risk for errors.

In spring 1983 the Computer Installation was requested by the Metallurgy Department to make a menu program for the recording.

The results were:

- Quicker recording
- Fewer possibilities for errors.
- More flexibility. The Metallurgy Department has installed a terminal itself in the secretary's office. This terminal is connected to Risø's datanet and may communicate with B7800. The secretary can now do the recording at her convenience, where she formerly had to go to the punch room in the Computer Installation.

APPENDIX A

CONFIGURATION OF THE RISØ B7800 COMPUTER AS OF DECEMBER 1984

- 2 Central Processor Modules, 8 MHz
- 1 Input-Output Module with 28 Channels
- 768 K Storage, (4.5 MB)
- 1 Maintenance Processor (B800) with Console and Magnetic Tape Station
- 2 Dual Disk Drives (Fixed)/Dual Controller with a total of 800 MB
- 1 Dual Disk Drive (Exchangeable)/Dual Controller with a total of 6x87.2 MB
- 3 Magnetic Tape Drives, 9 track, 6250/1600 bpi, 780/200 KB/s
- 1 Magnetic Tape Drive, 9 track, 800/1600 bpi, 100/200 KB/s
- 1 Card Reader, 800 cards/minute
- 1 Line Printer, 132 printpositions, 64 characters, 1100 lines/minute
- 1 Benson 1333 Digital Plotter
- 1 Calcomp 1012 Digital Plotter
- 3 Operator Console Displays
- 1 Data Communication Processor, 8 K local storage
- 42 Line Adapters connected with data PABC with entrance for keyboard terminals, visual display units, graphic terminal and transmission of large numbers of data from experimental units.
- 1 Line adapter with direct connection of visual display unit
- 2 Line adapters with interfaces for digital plotters
- 2 Line Adapters with permanent connection to two Remote Printers
- 1 Line Adapter with Datel 2400 Modem for external computers
- 1 Line Adapter with 1200 bps for data collection from remote stations through an autodial unit
- 1 Micom data PABC with a present connection possible for 256 terminals to the local area network, 4 Datel 300, 4 Datel 1200 and 4 X.25 entrances, 2 Datel 300, 2 Datel 1200, and 4 X.25 exits

**TERMINAL EQUIPMENT AT THE COMPUTER INSTALLATION AS OF DECEMBER
1984**

4 Tec 610 Visual Display Units
3 Tandberg TDV 2220 Visual Display Units
3 Hazeltine Esprit III Visual Display Units
1 TeleVideo Model 970
1 Tektronix 4010-1 Graphical Terminal
1 Tektronix 4006-1 Graphical Terminal
1 D scan GR 2414 Graphical Terminal
1 D scan GR12 Tablet
1 Diablo 1620 KSR Printing Terminal
1 Diablo 1650 KSR Printing Terminal
1 Data Dynamic 303 KSR Printing Terminal
1 Centronics 6080 Line Printer
1 PDP-8 Minicomputer with two Floppy Disk Drives, VDU,
Paper Tape Reader, Paper Tape Punch, 3M Cartridge Station
(ECMA 46), and Philips Cassette Tape Drive (ECMA 34)
1 HP 7475A plotter

EDP-EQUIPMENT SUPPLEMENT

1 IBM 029 Card Puncher
1 RDS 202E Word Processing Unit

APPENDIX B

STAFF OF THE COMPUTER INSTALLATION 1 JANUARY 83 - 31 DECEMBER 84

Head: L. Hansson

Office staff: B. Andersen (from 1 April 1983)
L. Hansen (until 31 March 1983)
L. Lyng* (from 3 September 1984)

Scientific staff: E. Hansen
J. Houmann
P. Kirkegaard
O. Lang Rasmussen

Technical staff: S. Bechmann (until 15 September 1983)
C. Bergmann
J. Deutschbein
I. Elmholdt-Hansen
S. Frederiksen
H. Kiærulf Kristensen
K. Lou (from 15 September 1983 - 1 November 1984)
P. Lou
K. Visby Møller (from 27 November 1984)
S. Madsen
S. Rahbek
T. Seidmann** (2 July - 24 August 1984)
S. Ziavras ** (28 June - 24 August 1983)

*Temporary assistant

** IAESTE trainee

APPENDIX C

PRODUCTION STATISTICS 1983

	Production	On-Line	PM	UM	Processor
January	246.20	2795.48	20.00	0.56	132.53
February	238.30	2692.14	6.00		148.31
March	328.40	2919.54	14.00		181.06
April	321.20	2454.25	12.00	0.10	124.27
May	510.30	2864.37	6.00	1.00	142.05
June	524.00	3424.26	7.00	1.00	209.48
July	679.30	2573.17	5.00	6.00	286.01
August	481.15	3179.06	19.30	5.00	283.29
September	459.00	3135.50	12.00	4.00	296.09
October	551.50	3385.46	11.40		329.49
November	519.30	3462.51	12.10	4.25	447.21
December	512.00	3000.43	11.15		274.38

Production: Hours and minutes the computer has been on for production runs.

On-line: Sum of use of terminals, hours and minutes.

PM: Preventive Maintenance, hours and minutes.

UM: Unforeseen Maintenance including waiting time, hours and minutes.

Processor: Automatically logged use of central processor, hours and minutes.

PRODUCTION STATISTICS 1984

	Production	On-line	PM	UM	Processor
January	512.00	3000.43	23.00		274.38
February	541.00	4369.59	11.00		320.03
March	629.45	4401.03	13.15		375.54
April	486.40	2999.28	5.00		187.03
May	627.25	4059.20	12.30		274.59
June	656.30	4068.30	11.30		277.02
July	702.45	3435.32	11.00	1.15	263.34
August	604.45	4147.51	10.00		326.16
September	687.20	4231.36	9.30	1.50	332.20
October	718.00	4939.07	16.30		434.12
November	562.50	4642.22	12.30	5.10	338.46
December	704.00	3847.06	12.30		227.30

Production: Hours and minutes the computer has been on for production runs.

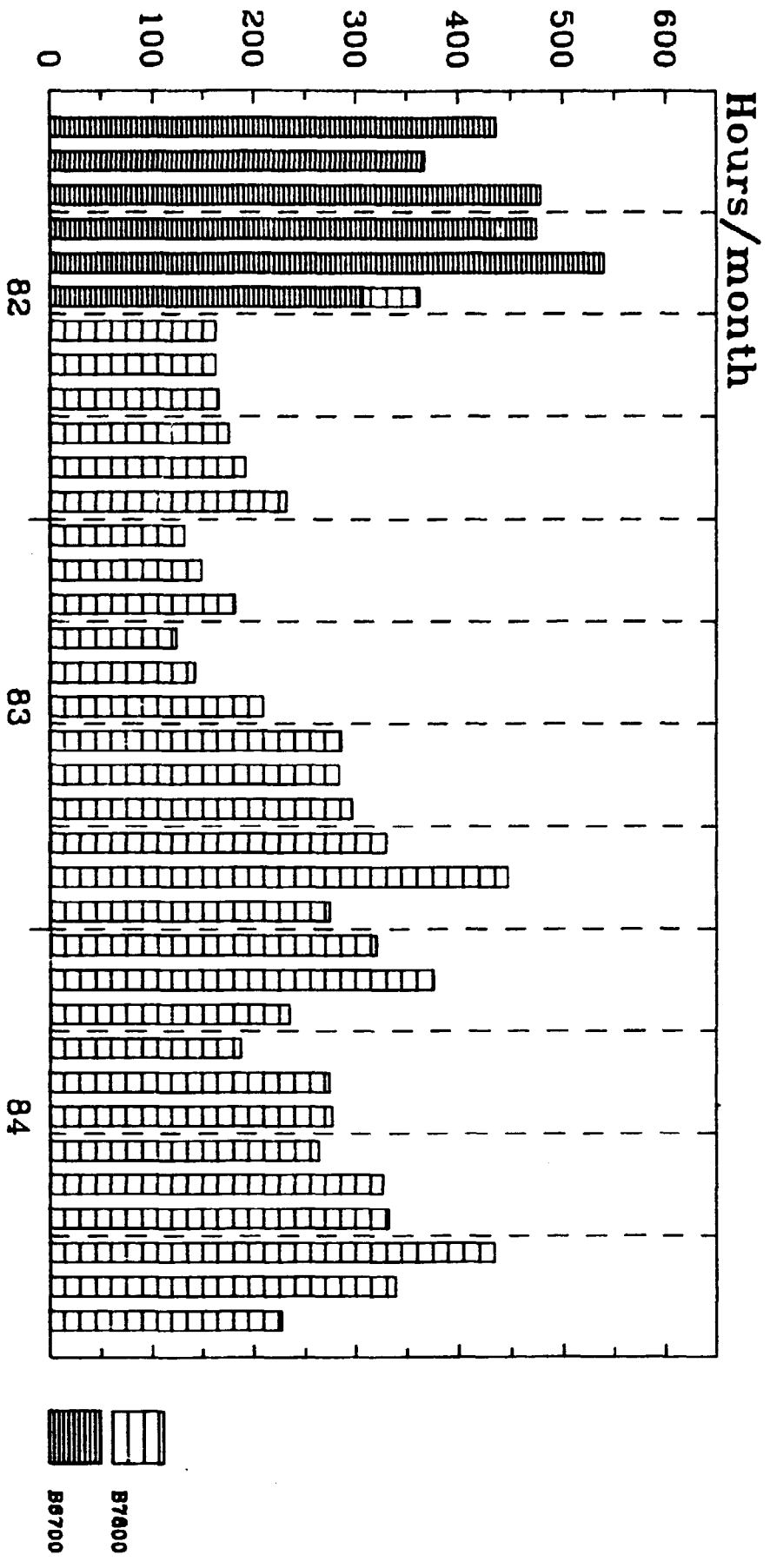
On-line: Sum of use of terminals, hours and minutes.

PM: Preventive Maintenance, hours and minutes.

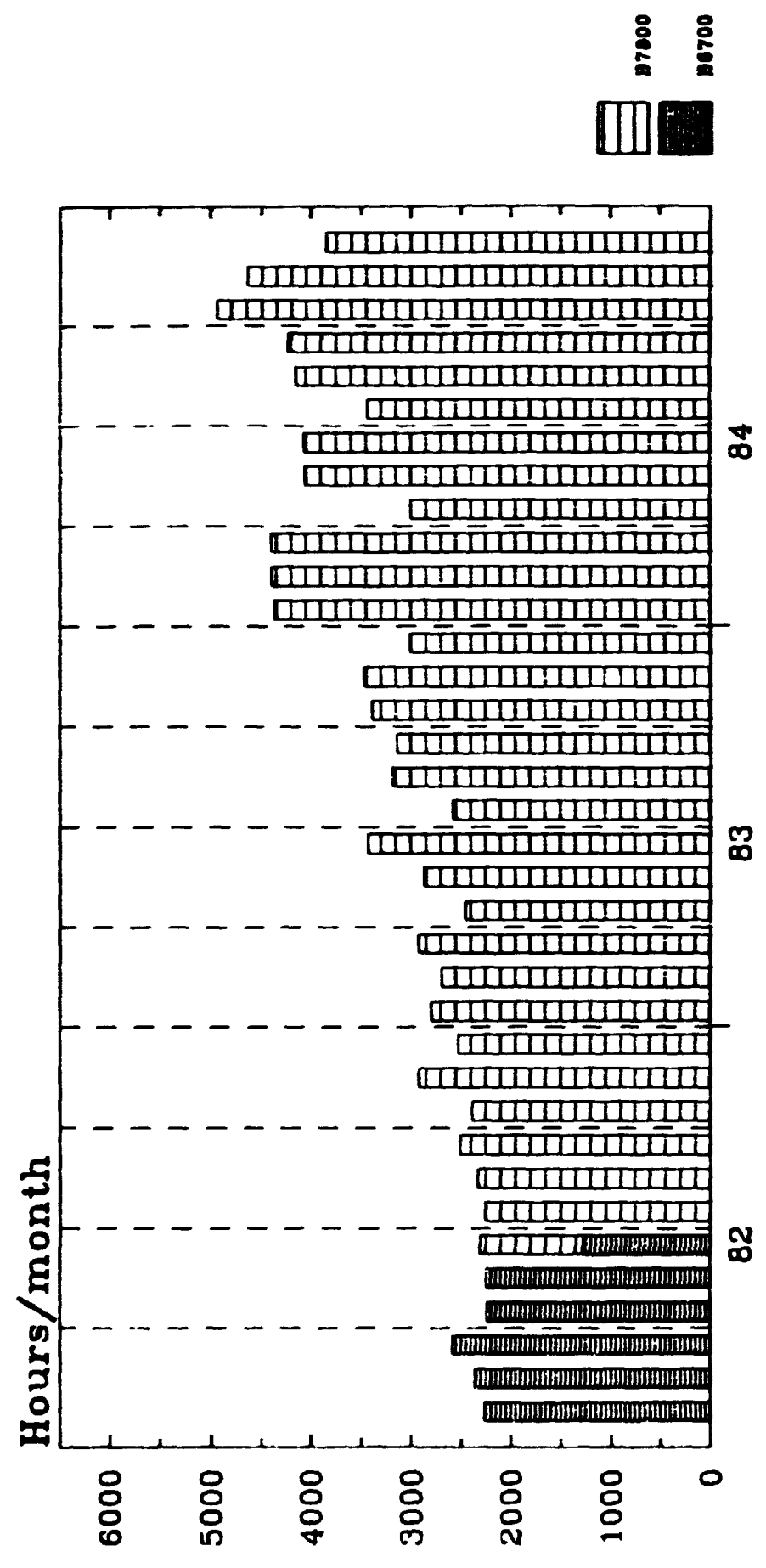
UM: Unforeseen Maintenance including waiting time, hours and minutes.

Processor: Automatically logged use of central processor, hours and minutes.

Statistics of the use of B6700-B7800 Processor time



Statistics of the use of B6700-B7800 Onlinetime



Risø - M - 2492

Title and author(s) Progress Report 1 January 1983 - 31 December 1984 Computer Installation	Date April 1985
	Department or group Computer Install.
	Group's own registration number(s) Memo nr. 63
58 pages + tables + illustrations	
Abstract <p>This report describes selected parts of the activities at the Computer Installation of Risø National Laboratory in 1983 and 1984. Information given may be preliminary.</p>	Copies to
<p>Available on request from Risø Library, Risø National Laboratory (Risø Bibliotek), Forsøgsanlæg Risø), DK-4000 Roskilde, Denmark Telephone: (03) 37 12 12, ext. 2262. Telex: 43116</p>	