HISTORY OF THE FIRST 50 YEARS OF THE CPS

Computer Program Service of the OECD/NEA Data Bank

1964

1981

1991

2001

2014

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SUMMARY

First the events that have led to the creation of an international computer program service in the field of nuclear applications are described followed by the actual setting up in 1964 of the OECD – Nuclear Energy Agency (NEA) Computer Program Library. The activities carried out had to undergo a number of evolutions in order to meet the changing requirements and requests of member countries. The revolution of the computing technology was another important factor driving the activities and changing the way work had to be done. The premises from where the service was provided, has changed three times and the scope of work was enlarged to cover all scientific issues related to nuclear applications. The co-operation with other organisations outside its member states (e.g. IAEA, NESC, RSICC, RIST) had an important impact on the overall collection of scientific-technical material made available to the users, namely by ensuring high quality of content and comprehensiveness of scope. The internal working methods are described as well as the co-operation with other committees and divisions of the NEA. Statistics about the overall activities covering 50 years of history are provided in graphical form and appendices provide the names of the persons that in a way or another were involved and have contributed to the success of this service. Over the fifty years more than 100,000 computer program packages were distributed to about 800 institutions in about 90 countries.

[1] Author: Enrico Sartori, former staff member of the OECD/NEA Data Bank, prepared upon request by NEA © OECD
All stories told contain a bias, that of the author. This one is no exception.

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INTRODUCTION

In order to understand the present and the path that led to it from the past, we look backwards for key events that determined the direction the different developments have taken. When we carry out such a "time reversal" exercise we find the exact path that led to the present and our perception is that it has happened in a deterministic way. However, when we put ourselves into some distant past we remember that we had some ideas about how things might develop, but everything seemed embedded in a cloud of uncertainty. We had then a rather contingent-stochastic view of the future and we could not imagine the present situation.

Understanding history is somehow rolling back the time, going from the chicken to the egg. This procedure is used also in solving equations in science, in particular in nuclear related matters. The looking back into the past involves the solution of the adjoint equation or finding the importance function. This procedure provides the information as to what key events determined that we reached the present status. History books however tell the story in the forward direction after the historian has taken the inverse path to understand it. Here the same procedure will be used. So we shall start from where all this seems to have begun, not from Adam and Eve, but some hints to the more distant past are unavoidable.

Fifty years have passed since the Computer Program Service (CPS), (then Computer Program Library – CPL) of the Nuclear Energy Agency (NEA, formerly European Nuclear Energy Agency – ENEA) has commenced to operate. It is useful to look back and see how it was established, by first telling the pre-history, the different development phases and the evolution imposed by the changing technology and increasing use made of computer simulations, the priorities for the member countries for maintaining the service effective, the reorganisations and reorientations to be in line with evolving needs and the challenges to staff. The operation of the service has moved during these years across national borders: from Ispra (Italy) to Saclay (France) and later from Saclay to Issy les Moulineaux (France), in the suburbs of Paris and across technological developments. At each move specific innovative actions had to be undertaken involving also somehow disruption of habits and the personal life of staff.

One meets often hesitation towards change, because it introduces increased uncertainties, but overall, as concerns an organisation and institution, change is good, change is life and helps the survival of institutions. This is certainly the case for this service. Looking back, today it would make little sense to have kept this service within the joint research centre of Ispra. For staff, these changes were not easy, for some it increased difficulties considerably. But that's life.

Let's say, that from the nuclear application point of view, everything started with the discovery of the nucleus by Ernest Rutherford in 1911, followed by the discovery of the neutron by James Chadwick, also at Cambridge (UK) in 1932, followed by the discovery of fission by Otto Hahn, Fritz Straßmann, and Lise Meintner in 1938/9. The energy potential of fission was quickly recognised in a critical historical time, which led to the first critical nuclear pile in Chicago by Enrico Fermi on 2 December 1942 [1,2,3] and followed by the explosions of the first nuclear devices at the end of the Second World War in 1945.

The "Atoms for Peace" speech by US President Dwight D. Eisenhower, in December 1953 brought new hopes and many new promises. It was even thought then that electricity would become too cheap to meter"[2]. New organisations, agencies, companies emerged to work on this new big promise.

[2] This was before the advent of the "Nuclear Safety Culture". The U.S. Nuclear Regulatory Commission (NRC) defines nuclear safety culture as "the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment".

Chronological Table of Major Events

Date		Event
		PREHISTORY
1948	April 16	Organisation of European Economic Co-operation (OEEC) is established
1953	December 8	"Atoms for Peace" speech by US President Dwight D. Eisenhower to the United Nations General Assembly
	December 14	Secretary-General submits report to OEEC Council on energy supply difficulties
1955	May 24	Report by Louis Armand citing the potential of nuclear energy and need for European co-operation
	June 10	Working Party on Nuclear Energy set up
	September	First Atoms for Peace Conference, Geneva
	December 15	Working Party on Nuclear Energy submits its report
1956	February 29	OEEC Council establishes Special Committee on Nuclear Energy; four working parties develop proposals
	July 18	OEEC Council responds to working parties' proposals with a series of actions, including the establishment of a Steering Committee for Nuclear Energy
	Summer	Lew Kowarski's lecture on "CERN and what can be learned from similar enterprises" at the Sorbonne
1957	March 25	European Atomic Energy Community (Euratom) established
	July 29	International Atomic Energy Agency (IAEA) established
	December 20	European Nuclear Energy Agency (ENEA) established by the OEEC Council – precursor to the NEA
1958	February 1	ENEA Statute enters into force, Pierre Huet (1958-1964) Director General (DG)
	September	Second Geneva Conference on Atoms for Peace
1960	December 14	OEEC becomes the Organisation for Economic Co-operation and Development (OECD)
1962	September 17	Seminar on "New Trends in the Use of Digital Computers in Atomic Energy Research and Development", Argonne National laboratory
	December 10	Seminar at CERN of the Study Group on Digital Techniques
1963	November 27	The Steering Committee for Nuclear Energy approved the establishment of an ENEA Computer Programme Library (CPL); once created, the Library should be accommodated at the Ispra (Italy). Establishment of the Euratom Joint Research Centre
		HISTORY
1964	-	Einar Saeland (1964-1977) Director General of ENEA
	January 28	The OECD Council approved the creation of the ENEA Computer Programme Library
	Spring	Johnny A. G. Rosén (1964-1969), first Head of CPL
	May 15	First meeting of the CPL Management Committee
	June 17	The agreement with Euratom to host the CPL at the CETIS facility in Ispra was signed by Einar Saeland and Jules Guéron
	July 1	Final approval of setting up the CPL by the Steering Committee for Nuclear Energy
1965	February 23	Japan joins ENEA as an associate member.
	Spring	Meeting at ANL on "Application of Computing Methods to Reactor Problems". Paper by W. J. *Worlton* and E. A. *Voorhees* on "Recent Developments in

Date	Event
	Computers and their Applications" for discussing future actions by CPL.
Spring	Co-operative arrangement between USAEC and the OECD/NEA for the Exchange of Nuclear Data and connected Information and Computer Program Packages pertinent to Nuclear Science and Technology was signed
1968 March 18	Agreement between the OECD/NEA and the International Atomic Energy Agency to extend the computer program service to members of IAEA not members of OECD/NEA.
1969 -	Reginald Prescott (1969-1970) acting Head of CPL
1970 December 1-3	Workshop on Modular Coding for Reactor Physics Calculations
1971 -	Victor Bell (1971-1972) Head of CPS. On 19 February 1972 he was killed by an avalanche in the Italian Alps[3]
June 30- July 1	Workshop on Finite Elements Computer Programs for Stress Analysis
1972 -	Luis Garcia de Viedma (1972-1978) Head of CPL
April 20	Japan becomes a member ENEA becomes the OECD Nuclear Energy Agency (NEA) with membership expanded beyond Europe
October 17-18	Workshop on Shielding Computer Programs
Autumn	Start of a "Service on Experience on Code Utilisation (SECU)" in co-operation with the EACRP
1973 December 5-7	Workshop on Nuclear Data File Processing Codes
October 1	Australia becomes a member of NEA
1974 -	Workshop on Computer Programs for the Analysis of Problems in Thermal Reactor Safety
1975 April 1	Canada becomes a member of NEA
1976 January 1	Finland becomes a member of NEA
June	Discussion at SC meeting on "Considerations on possible changes in the budgetary arrangements of the CPL and the CCDN"
July 7-8	The Committees of the CPL and CCDN reached at a combined meeting the conclusions that amalgamation would bring important technical advantages and allow greater efficiency
October 1	The United States become a member of NEA
1977	Ian Williams (1977-1982) DG of NEA
1977 December 7	The SC approved the setting up of an NEA Data Bank with the terms of reference, initial programme, organisation, transitional arrangements and the 1978 programme of work
1978 January 1	Johnny A. G. Rosén (1978-1992) Head of Data Bank
January 1	Luis Garcia de Viedma (1978-1987) Head of CPS
March	First Data Bank Committee meeting, Paris
May 22	The CPL moved from Ispra to Saclay and was merged with the CCDN into the Data Bank

[3] The weekend on 19-20 February 1972 Vic Bell and 3 other friends had decided to spend it on the slopes of the skiing resort of Courmayeur. They left Ispra with two cars, but one car had a problem and so they reached the hotel with one car only. They went back to the car with the problem, but on their way there, a powder avalanche descended and created a pressure wave that made the car deviate from its direction. The car hit frontally a tree and all 4 were killed on the spot. Vic was survived by his wife and 3 children.

Date		Event
1979	January 1	Italy joined the Data Bank.
1980	January	The Incident Reporting System (IRS) is established by NEA/CSNI
1981	August 1	Establishment of NEDAC (later RIST) in Japan
1982	-	Howard Shapar (1982-1988) DG of NEA
	Spring	Start of Joint Evaluated File (JEF) Project
1985	-	Release of the first JEF file (JEF-1)
1986	May	Discussion on projections for the medium-term future of the Data Bank at the annual management committee meeting
1987	June	meeting of the so called "wise men group" on proposal for future programme of the Data Bank chaired by Heinz Küsters
1988	-	Kunihiko Uematsu (1988-1995) DG of NEA
	Spring	Enrico Sartori (1988-2009) Head of CPS
1989	-	Working Group Meeting on the Long Term Orientations of the NEA Data Bank's Scientific Services
	October	New Terms of Reference for the Data Bank
	Autumn	Setting up of a joint NEACRP/NEANDC Working Group charged with the task of co-ordinating a closer co-operation between ENDF, JEF and JENDL.
1990	-	Document on the development of the Data Bank's Services in 1991 and beyond followed by a Think Tank meeting on the future of the NEA-DB, -NDC, -CRP
1991	May	The Data Bank was moved from Saclay to the new NEA Headquarters at Issy-les-Moulineaux together with the other divisions previously located in boulevard Suchet and avenue Ingres, Paris.
	October	The extended role of the Data Bank was defined and the NEACRP and NEANDC were merged into the Nuclear Science Committee (NSC)
1992	March	Fuel Incident Notification and Analysis System (FINAS) created.
	Spring	Computer program service to non-OECD area suspended
	Summer	The Data Bank moves to Issy les-Moulineaux, where the NEA Headquarters were established
	Autumn	Nigel Tubbs (1992-1998) Head of Data Bank
1993	-	Renewal of co-operative arrangement on computer codes and nuclear data between NEA and US DoE
	May 24	Korea R.o. becomes a member of NEA
	September	“Strategic View on Nuclear Data Needs" was issued
	Autumn	Computer program service to non-OECD area temporarily resumed
1994	May	Korea R.o. becomes member of the Data Bank
	May	Mexico becomes a member of NEA
	Summer	Merging of JEF and European Fusion File (EFF) projects into Joint Evaluated Fission Fusion File (JEFF)
	Autumn	Setting up of the SINBAD shielding experiments database
1995	-	Samuel Thompson (1995-1997) Acting DG of NEA
	Spring	Combining the JEF and EFF (fusion) files into the JEFF Project
1996	-	Starting dispatch of programs on CD-ROM
	Summer	Reduction of staff by a A2/3 post
1997	May	Co-operative arrangement between NEA and USDOE concerning exchange of

Date		Event
		computer codes and nuclear data was renewed
	Spring	Luis Echávarri (1997-2014) becomes DG of NEA
	June 27	Czech Republic and Hungary become members of NEA
1998	-	40th Anniversary of NEA
	Spring	NEA Strategic Plan 1999-2003 approved and issued
	Summer	Philippe Savelli (1998-2002)) Head of the Data Bank
1999	-	Y2K issues addressed at NEA and NDB
2002	-	Thierry Dujardin (2002-2006) Head of the Data Bank
	June 13	Slovak Republic becomes a member of NEA and Data Bank
	November	New phase of TDB launched
2003	Autumn	Full computer program documentation in electronic form, full restructuring of CPS Master File system
2004	May	40th anniversary of the CPS – 67,000 packages distributed
	Spring	Approval of NEA Strategic Plan for 2005-2009
2005	May	Enhanced co-operation between CSNI, NSC and Data Bank in the frame of the Strategic Plan.
2006	-	Akira Hasegawa (2006-2009) Head of the Data Bank
	April 10	After a suspension of several years the Arrangement between the United States Department of Energy and the OECD Nuclear Energy Agency for Co-operation in the Field of Nuclear Data and Computer Programs was renewed
	September 22	NEA becomes Secretariat for the Multinational Design Evaluation Program (MDEP)
2007	June 13	Discussion on "The NEA Data Bank of the Future."
2008	February 1	50th Anniversary of NEA
	Spring	40th anniversary of computer program service to IAEA-non-OECD countries
2009	June	Juan Galán (2009 -) Head of CPS
2010	Spring	NEA Strategic Plan for 2011-2016 issued
2011	-	Kiyoshi Matsumoto (2011 -) Head of the Data Bank
	May 11	Slovenia becomes member of NEA and its Data Bank
2012	March	100,000th program package distributed by the Computer Program Service
2013	January 1	The Russian Federation becomes member of NEA and its Data Bank
	November	Establishment of the Collaborative International Evaluated Library Organisation (CIELO)
2014	March 13	First meeting of the Task Force reviewing the current activities and future development of the Data Bank
	May	50th anniversary of the CPS

PREHISTORY

Shortly after the "Atoms for Peace" speech by US President Dwight D. Eisenhower, in December 1953, René Sergent, the Secretary General of OEEC (Later OECD), submitted to its Council a report on energy supply difficulties in Europe. In the following year the potential of nuclear energy and a need for European co-operation was debated. This led to the setting up of a Special Committee on Nuclear Energy related with the Electricity Committee. Motivated by concerns over nuclear weapons proliferation, the USA had proposed at the end of 1953 the setting up of International Atomic Energy Agency (IAEA), an Agency of the United Nations. A year later the UN general assembly decided to organise a conference on non-defence uses of nuclear energy, held then in September 1955 in Geneva known as the "International Conference on the Peaceful Uses of Atomic Energy". During its first meeting (27-28 March 1956), the OEEC Special Committee on Nuclear Energy decided to set up a Working Party to study financial and technical problems that Member countries would face in the setting up of joint undertakings, such as plants for separating uranium isotopes, for the chemical processing of irradiated fuel, for the production of heavy water, and prototype and testing reactors, a Working Party on security control intended to prevent diversion of fissile materials and the international trade of such materials, a Working Party on the harmonization of national legislation, co-operation as regards training using existing facilities, on products to be standardized, and finally the setting up of a Steering Committee for Nuclear Energy. At that time the establishment of Euratom was being discussed also as it was felt that the time for establishing an international structure for nuclear energy was getting urgent. ENEA a European Nuclear Energy Agency was established in late 1957 including a wider number of countries compared with the six of Euratom. Responsible for this sector at OEEC was Pierre Huet[4], a "brilliant French lawyer specializing in international affairs". He became the first Director General of the new Agency.

Around that time, Lew Kowarski[5], a French scientist then working for CERN was very interested in the role computers would play in future in science and technology. He was well known for his research in the team of Joliot Curie at CEA, for his involvement in designing the first reactor in Canada (ZEEP), and the first two in France (Zoé, EL2[6]). In the summer of 1956, he had been invited to giving a lecture at the Sorbonne, on "CERN and what can be learned from it for similar enterprises". Articles about the lecture appeared in four Paris newspapers. "A young man of 24, a Swiss by name of Roland Perret[6] that had recently been hired by OEEC as a young engineering graduate, read one of the articles". "Perret became one of the striking personalities of the international scene in atomic energy, for several years" [4]. R. Perret was impressed by the account of Kowarski's lecture in the Paris press and sought advice from him in a first meeting in Geneva, followed later by a visit of P. Huet. Thus L. Kowarski became a high-level scientific adviser of P. Huet and was immediately involved in a study group for experimental reactors called REX, **R**eactor **Ex**perimental. The first chairman of which was Sigvard Eklund[7], the Swedish reactor specialist later Director General of the IAEA[8].

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[4] Pierre Huet (1920 – 2016)

[5] Lew Kowarski (1907 – 1979) [5]

[6] Roland Perret (1932 – 1969). "The first glance of him confirmed the impression, the fairly eccentric impression -- luxuriant black beards in those days were less common than they are now, especially on men of 24. His way of dressing was somewhat ornate, and -- however, at the very first beginning of the conversation, I immediately noted that here was a man with a very sharp mind, a man who seemed to understand my own eccentricities, and who asked me very pertinent questions about my lecture, which he had not attended" [4].

[7] Sigvard Eklund (1911 – 2000)

[8] Further background to prehistory can be found in the first chapters of references [21, 22].

Figure 1: Pierre Huet, Lew Kowarski, Roland Perret, 1959 (Source: Archive OECD)

"The general method of OEEC was to set up projects which would no longer be part of OEEC. They would be separate, by special governmental agreement, and OEEC just a kind of matrix out of which they came". "OEEC never was in any way a super-national organization. It was always an organization conducted as a consultation place for national delegates and their experts and their other representatives, who could agree among themselves to set up an autonomous international project." "Nobody had any super-national capacity. In fact, I think it's only in this way that the joint undertakings did come to be set up"[9]. [4]. A new type, the high-temperature gas-cooled reactor, which was known as Dragon, was then proposed.

So the ENEA was set up through the action of the French State Counsellor, Pierre Huet together with the British lawyer Jerry Weinstein. The technical aspects were taken care of by Roland Perret[10] and the high level scientific Advisor Lew Kowarski[11].

With the setting up of the ENEA also an "ENEA Scientific Office in Geneva" was set up, run by Lew Kowarski and his secretary. It operated for two years. The Second Geneva Conference on Atoms for Peace was held in September 1958 and P. Huet used that conference to discuss and negotiate new start-ups. The Dragon venture [21] was consolidated. It was realized though at that time with the sudden advent of the space age, when the first human made satellites were circling above the atmosphere, that

[9] These statements by Lew Kowarski [4] are cited here, as they express so well how OEEC and later [E] NEA operated.

[10] A first ENEA 'computer' had been copyrighted by R. Perret as early as 1960. It was a special, cardboard slide rule for computing all kinds of physics quantities required for reactor studies (see Annex I)

[11] See first French comprehensive chart of nuclides by L. Kowarski (1950) in Annex II.

the success of these projects was a question of survival for ENEA. First works then started on the European-American Nuclear Data Committee (EANDC[12]) and the European American Committee on Reactor Physics (EACRP). Other ventures concerned the nuclear chemical reprocessing plant called Eurochemic [22].

Figure 2: Pierre Huet, DG, Einar Saeland. DDG, Jerry Weinstein at ENEA meeting, 1963, (Source: OECD Archive)

From late 1960 the domain of action at CERN of Lew Kowarski concerned mainly computers and scientific information. It began to be formally known as the Data Handling Division. He built up the CERN computational capacity in those times and developed computerised data processing. During the Sixties Lew Kowarski worked 20-30% of his time as the scientific adviser of the just established ENEA.

It was in 1961, 3 years after [E]NEA was established, that for the first time the idea of a Computer Program Library (CPL) has appeared in an OEEC/[E]NEA document [SEN(61)27] with the following tasks in mind:

a) identification and then acquisition of computer programme documentation and the coded form stored on paper and magnetic tapes,
b) testing of these computer programmes, updating and documenting modifications,
c) upon request distribution of the programmes together with their complete documentation.

From the 17th to 21st September 1962 a seminar took place at the Argonne National Laboratory (ANL) under the aegis of ENEA, moderated by Lew Kowarski and William F. Miller, Director of the ANL Applied Mathematics Division on **New Trends in the Use of Digital Computers in Atomic Energy Research and Development.** Discussions concerned numerical computations in reactor physics and in the design of reactors and other atomic equipment, computers as tools of experimentation, computers

[12] The European-American Nuclear Data Committee (EANDC) was set up in 1959 to co-ordinate the measurement of nuclear data in the countries of the OECD.

incorporated in reactor installations, the problems of organisation and personnel related to central libraries of codes and programmes, the standardisation and adaptation of codes, and training of programmers specialising in atomic research, the development of equipment, the problems of research in computer methods, finally the scope for international action.The conclusions of this Seminar were discussed by the Study Group on Digital Techniques held at CERN Geneva on 10 and 11 December 1962 chaired by Lew Kowarski representing ENEA.

At the host organisation of the afore mentioned seminar a first centre with similar tasks had been set up already in 1960, named Argonne Code Center (ACC), later called US Code Center (USCC), and when the US AEC (Atomic Energy Commission) was reorganised establishing ERDA (Energy Research and Development Agency) with a wider scope than just nuclear it became the NESC (National Energy Software Center). ACC was serving as a template for setting up the corresponding European centre. The idea of a European CPL was welcomed by the AEC and first discussions took place to establish a co-operative arrangement once the European CPL was established.

During this discussion it was agreed that the work of the Study Group would begin by studying the concrete proposal of setting up a library of nuclear programmes; a mainly clerical service to be at the disposal of the users. The experts recognized however, that the international co-operation which might be set up in the field of digital techniques would be really useful only if on one hand, it tended to establish a closer alliance between nuclear physicists, reactor physicists and electronic computer specialists, and if, on the other hand, new research was initiated by this co-operation.

A first difficulty encountered was about terminology as to what a computer code or program(me) really meant[13]. At the meeting it was agreed to use the following terminology: program(me)[14] will cover both the outcome of a physical and mathematical study of a nuclear problem, and the means by which this is translated on a digital computer. If necessary, the first part will be called physical programme and the second part machine programme.

The first aim of the library would be to make available comprehensive information on the existing nuclear programs, namely a collection of abstracts and their dissemination, close contact with the similar libraries established by the American Nuclear Society at Argonne. Finally, it was strongly recommended that the collection of abstracts should cover not only the European programs but also the American ones, and if possible, those prepared in countries which were not members of the OECD.

Three candidate sites had been identified for hosting the CPL in 1963:

1. the computing centre of CNEN (Comitato Nazionale per l'Energia Nucleare), Bologna, Italy
2. the Euratom centre for the treatment of scientific information - Centre de l'Euratom de Traitement de l'Information Scientifique - CETIS) at Ispra, Italy
3. the Centre of Nuclear Studies in Saclay (Centre d'Études Nucléaires de Saclay, France)

A report comparing the facilities and infrastructures available was prepared to facilitate the final choice.

The OECD Steering Committee for Nuclear Energy during its meeting of 17 November 1963 after discussion with the national delegates during which France and Italy had renounced to host it in Saclay

[13] "According to Continental Europe a code is the outcome of a physical and mathematical study of a nuclear problem, which by means of a programme can be evaluated on any digital computer. A programme is prepared from the code for use with a specific computer. The definitions in the U.S.A. are exactly the contrary of these. Further there is a UK definition: the outcome of a physical and mathematic study of a nuclear problem is called a system. The programme has the same definition as in Continental Europe. A code corresponds to what is called in Continental Europe and U.S.A. the machine language."

[14] The English versus American spelling difference came to an end when it was agreed that programme was the generic term in English, however the technical term 'computer program' would be adopted in both spellings. CPL became thus the "Computer Program Library". This convention is used here also except in citations. The term computer program and computer code is used here throughout with the same meaning.

and Bologna and opted for Ispra decided to negotiate a final agreement and the corresponding conditions with Euratom.

Setting the Objectives

A note, dated Paris, 27th December 1963 [C(63)172], prepared by the OEEC Secretariat was submitted to its Council with the following statement:

"At its meeting on 27th November 1963, the Steering Committee for Nuclear Energy approved the establishment of an ENEA Computer Programme Library. The primary objective of the Library is the improvement of communication between the originators of nuclear computing programmes and the user scientists and engineers so as to ensure the most efficient and economic use in the field of atomic energy of the large and expensive computers available in Europe.

The Library will collect, standardize, edit and circulate abstracts and descriptions of atomic energy computing programmes from European and United States laboratories and centres. It will also collect, test, edit and distribute complete programmes and will advise laboratories regarding specific problems such as the suitability of certain programmes for particular applications. Lastly, the Library will promote and organize specialist seminars for discussion of nuclear computing questions."

The study group on Digital Techniques prepared also a report on the "Possibilities of setting up a nuclear programme library at CCR Ispra. This document reviewed the tasks of such a library, its organisation, equipment, and specific activities and staff requirements.

During the same period the Study Group wrote also a report on "The Compilation of Nuclear Data for Reactor Calculations" expressing the concern of the "*European-American Nuclear Data Committee (EANDC) at the inadequate way the experimental data which nuclear physicists produce is presented for reactor physics calculations*". "*The very expensive and large programmes of measurement which are new in operation throughout North America and, Europe produce vast quantities of basic data which must be efficiently handled, stored, and communicated to be fully utilised. Present methods of handling are laborious and their full worth is not being realised*". In conclusion it was found that there was a considerable scope for the co-ordination and co-operative action by computational methods in the field of acquisition, compilation, presentation, and use of nuclear data. Thus, the setting up of a centre holding the data libraries was suggested that would also assist in the development and evolution of the standard format, that would write data checking and handling programmes and apply them for the proper upkeep of the library. Under the auspices of a common code centre, such programs should fully be interchanged with others[15]. The Director General informed then the Committee that the

[15] "There is considerable scope for co-ordinated and co-operative action by computational methods in the field of acquisition, compilation, and use of nuclear data. The summary of the findings of the EANDC working group that met in 1962 is as follows:

i. Greater exchange of information on the use of computers through special analysis programmes should be made in the analysis of experimental results
ii. Co-operation should be encouraged in the writing and comparing of nuclear theory programmes, preferably at a common computing centre
iii. Exchange of data compilations and working methods is a first step towards the setting up of a central data library based upon an agreed standard format. The library would be centralised, store its information on punched cards, punched tape or magnetic tape, and would fulfil requests from information users.
iv. The centre holding the data library would probably assist in the development and evolution of the standard format, write data, checking and handling programmes and apply them for proper upkeep of the library
v. Experimentalists should be encouraged to record their experimental findings in machine language on cards or tape for later repeat analysis by data compilers
vi. The setting up of a central literature reference unit is considered desirable and may involve the use of digital techniques in its operation.
vii. A full interchange of processing programmes should be encouraged, preferable under the auspices of a common code centre."

Agreement with the French Commissariat à l'Énergie Atomique on the setting up of this centre in Saclay had been signed on 22 June 1964.

The main tasks for the CPL were described in the C(64)172 note of 27 December 1963 to the Steering Committee:

> *"The primary objective of the Library is the improvement of communication between the originators of nuclear computing programmes and the user scientists and engineers so as to ensure the most efficient and economic use in the field of atomic energy of the large and expensive computers available in Europe. The library will collect, standardise, edit, and circulate abstracts and descriptions of atomic energy computing programmes from European and United States laboratories and centres. It will also collect, test, edit and distribute complete programmes and will advise laboratories regarding specific problems such as the suitability of certain programmes for particular applications. Lastly, the library will promote and organise specialist seminars for discussion of nuclear computing questions."*

The agreement with Euratom to host the CPL at CETIS facility was signed in Brussels on 17 June 1964 by Einar Saeland on behalf of OECD/ENEA and by Jules Guéron on behalf of Euratom.

At the 25th Session of the OECD Steering Committee for Nuclear Energy, held in Paris on 1st July 1964 the Director General informed the Committee that the Agreement with the Euratom Commission on the setting up of this library at Ispra had been signed. The setting up of the ENEA Computer Programme Library at Ispra received its final approval.

THE YEARS OF THE CPL AT ISPRA ITALY

First terms of reference

The terms of reference set out for the CPL can be summarised as follows:

The primary objective of the Library is to improve the communication between the originators of computer programmes and the using of scientists and engineers so that the most efficient and economic use in the field, of atomic energy may be made of the numerous large and expensive[16] computers that are available in Europe. To meet this objective, the Library shall undertake the following activities:

- Collection and Circulation of [computer programme] Abstracts
- Collection and Distribution of Programme Descriptions
- Testing, editing and Distribution of Program Packages
- Advisory Activities
- Meetings
- Library Committee
- Liaison Group

The CPL was to be governed by a committee of representatives of the participating countries. A technical Liaison Group of users was then established, the officers of which had assigned tasks and duties, such as to ensure efficient contact between the laboratories, institutions and centres participating in the work of the CPL services. These officers were to transmit to the CPL the abstracts,

[16] Reading this sentence today gives some insight into how much computing technology has evolved in 50 years. The fact that "software" was something far more difficult and in the long run more costly than the "hardware" wasn't understood at all. Computers are today so widespread, so powerful and relatively economical that the cost concentrates now in networking and in software development, its verification and validation.

descriptions and packages of those programs evolved at their establishment. 'Liaison officers' would receive the CPL publications and were responsible for their dissemination to all interested parties in their establishment. They were also responsible to forward to the CPL all requests from their establishment for additional information, descriptions, or computer program packages. Contacts between the CPL and individual establishments were normally to be effected through the liaison officers, thus program packages were sent exclusively to 'liaison officers'.

The first Head of the CPL was Johnny A. G. Rosén[17].

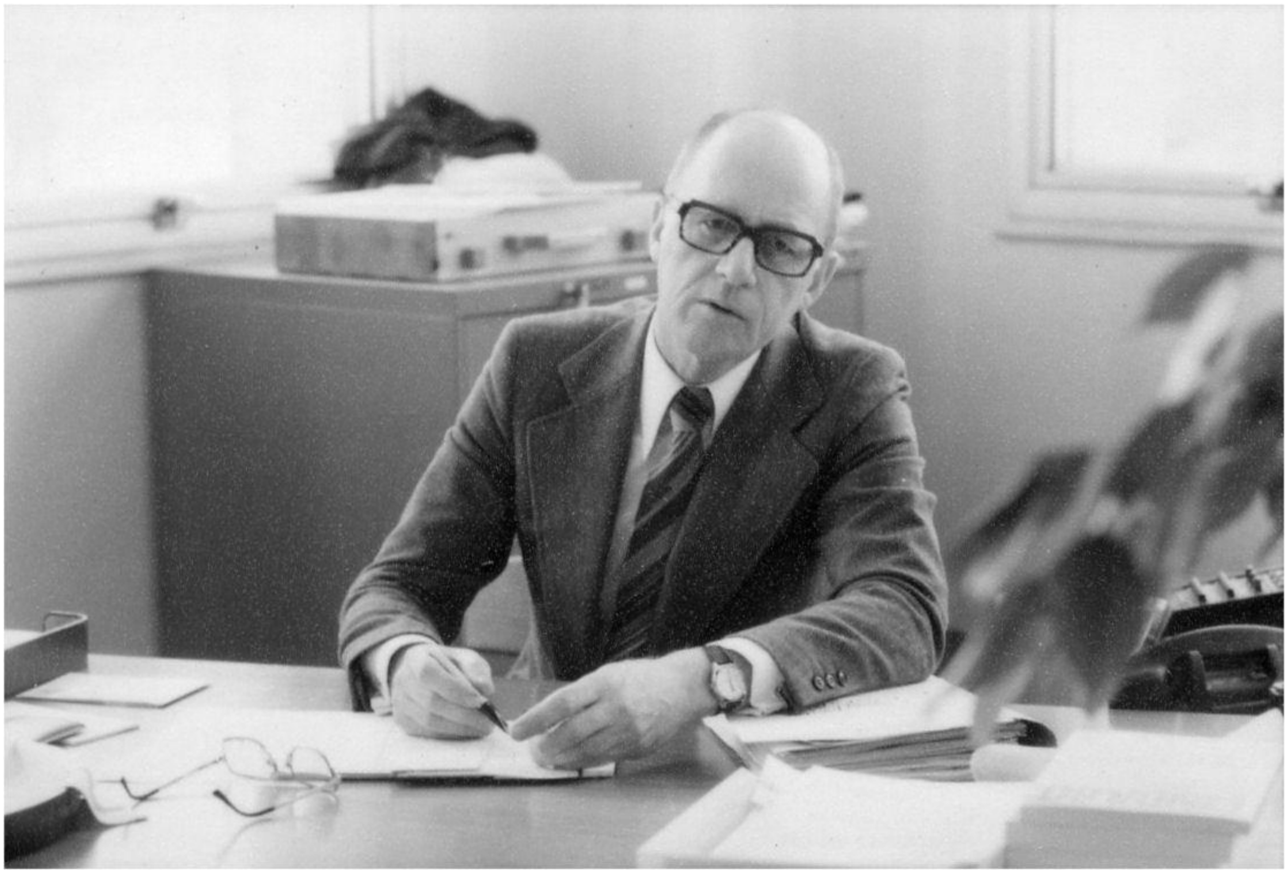

Figure 3: Johnny A.G. Rosén, first Head of the CPL

The first meeting of the CPL Committee was held on 15 May 1964 at Ispra, opened by the Director General of OECD/ENEA Einar Saeland. The first Chair and Vice-chair were respectively Ezio Clementel and Les Underhill. (The list of Chairs of the CPL and later of the Data Bank is shown in Table V). The Head presented the agreement that was going to be signed shortly with the Euratom

[17] Johnny Rosén (1927-2003), was known for cracking jokes.
One of the anecdotes he would tell was that when they were selecting the first head of CPL they interviewed several persons who had to prove their skills in "debugging" the programs. He was given a program that would give wrong results, and the local experts had been unable to find the error. He, one of the candidates, looked at the cards and exchanged the position of two, which obviously were out of order because the card deck had been dropped. He presented the "revised" version and proved that the problem had been fixed. "They were so impressed that they hired me immediately".
In his office one of the cupboards contained just one book. When discussing statutes, staff regulations and other OECD rules he answered that they were not needed, all was written in that single book: "il principe" by Niccolò Machiavelli.
Around a circular wooden table in his office did most discussions take place. One day the table was upside down. He explained that the geometrical configuration as to how the legs were held together was a most elegant demonstration of the theorem of Pythagoras. He concluded that the carpenter - designer was an experienced mathematician.

authorities, the statute and tasks of the CPL and the details of the budget, as well as the immediate activities. The nomination of participating establishments and 'liaison officers' followed next.

Table I. Officials at OECD/[E]NEA with responsibilities over Computer Program Service Activities

Responsible for Service	Period	Origin	@ Science Department (E)NEA	Period	Origin
Prehistory					
			Lew Kowarski (adviser)	1956-1964	France
			Roland P. Perret	1955-1964	Switzerland
Computer Program Library (CPL)					
Johnny Rosén	1964-1969	Sweden	Lew Kowarski (adviser)	1964-1968	France
Reginald Prescott (acting)	1969-1970	UK	Roland P. Perret	1964-1969	Switzerland
Victor Bell	1971-1972	UK	Johnny Rosén	1969-1970	Sweden
Luis Garcia de Viedma	1972-1978	Spain	Leslie Boxer	1970-1972	UK
			Johnny Rosén	1973-1977	Sweden
NDB Computer Program Service (CPS)					
Luis Garcia de Viedma	1978-1987	Spain	Johnny Rosén	1978-1992	Sweden
Enrico Sartori	1988-2009	Italy	Philippe Savelli	1993-2000	France
Juan Manuel Galán	2009-	Spain	Thierry Dujardin	2001-2014	France

Figure 4:First six staff members of CPL, Ispra, 1964

Logo of CPL

The CPL started with few staff members (6) to get the operation moving. Interest in this service increased rapidly. Originally the staff requirements were estimated as follows: 1 Head of the Library, 8 mathematicians (physicists), 9 programmers, 1 administrative officer, 1 assistant, 3 secretaries, 1 shorthand-typist, 7 operators (punching included), 1 book-keeper, 3 messengers. In all 35 staff with a ratio of graduates to non-graduates of 2.5 were proposed. This was later revised to the following, based on budget availability and revision of workload: 4 mathematicians, 7 programmers, 1 secretary, 1 operator, 2 messengers: a total of a staff of 15 and the graduate to non-graduate ratio was of 1 to 2. Table II and III show time snapshots of the evolution of staff and budgets over the full period of the operation for CPL activities, CCDN and later Data Bank.

The budget allocated for the initial three years was of 0.75MF (Million French Francs) per year. The computer facilities and premises were made available by CETIS Euratom at the conditions stipulated in the agreement.

Table II. Evolution over Time of Professional Staff (A[18] grade) Allocation for the Different Activities[19]

Activity	**1966[20]**	**1971**	**1981**	**1991**	**2003**	**2013**
Data Bank (or CCDN + CPL)						
Number of member countries	15	15	17	17	22	24
Management functions	*36*	*24*	*14*	*17*	*17*	*17*
Total Nuclear data services	*72*	*84*	*63*	*30*	*41*	*40*
Program testing and customer service	*60*	*36*	*44*	*48*	*47*	*49*
benchmarks and intercomparison studies			*18*	*8*	*4*	
Databases of integral experiments					*6*	*22*
Expertise to other parts of NEA						
Projects of interest to other NEA divisions			*6*	*34*	*32*	*33*
System programming	*12*	*12*	*15*	*12*		
Total	**180**	**166**	**166**	**149**	**149**	**161**

Table III. Budget - Staff Evolution (CCDN+CPL or Data Bank)[21]

Year	**Staff (A)**	**Staff (B+C)**	**Total staff**	**Staff cost[22]**	**Operation**	**Total cost**	**Support NEA (%)**	**Member countries**
1966	15	16	31	1.5MF	1MF	2.5MF	0	15
1971	14	16	30	2MF	2MF	4MF	0	15
1981	14	12	26	6MF	4MF	10MF	0	17
1991	14	12	26	16MF	9MF	25MF	21	17
2001	11	10	21	12MF	9MF	21MF	23	22
2011	10	11	21	2.3M€ (16MF)	1.6M€ (10MF)	3.9M€ (26MF)	20	23

The first activities consisted in collecting program abstracts, the programs themselves and their documentation and publicising it to the first user community. Programs were distributed only after they had been tested on the IBM 7090 available for the purpose or others made available and tested by other co-operating centres; this was in fact necessary to ensure the quality of the 'packages' distributed. This was also a period of gaining experience and learning from the feedback received from users. In 1965, some 450 computer programs had been made available or offered to the CPL for testing and distribution.

[18] Streamlining, innovation and automatisation of a number of tasks led to decreasing the support staff (B and C grades) to about half over the 50 years.

[19] in units of man-months

[20] In 1965 the estimation for staff requirements was much higher; it was later adjusted based on actual need and budgetary constraints

[21] the figures have been rounded and are not inflation adjusted

[22] MF: million French francs; M€: million Euros)

A 'Master File' system was designed to facilitate an automatised program distribution. This system would compress files to reduce the expensive for those times or otherwise voluminous storage space required, a first method, later universally known as file zipping had been invented.

The number of visitors to the CPL increased noticeably contributing additional experience and encouraging the release of programs.

Table IV. Countries who have participated as Member of the CPL or later of the Data Bank[23]

Australia (1975 - 1978)	Mexico (1994 -)
Austria (1964 -)	Netherlands (1964 -)
Belgium (1964 -)	Norway (1964 -)
Czech Republic (1996 -)	Portugal (1972 -)
Denmark (1964 -)	Republic of Korea (1993 -)
Finland (1976 -)	Russian Federation (2013 -)
France (1964 -)	Slovak Republic (2002 -)
Germany (1964 -)	Slovenia (2011 -)
Greece (1964 -)	Spain (1964 -)
Hungary (1996 -)	Sweden (1964 -)
Ireland (1989-1990)	Switzerland (1964 -)
Italy (1964 -)	Turkey (1964 -)
Japan (1965[24] -)	United Kingdom (1964 -)

From the start, 14 countries participated in the service provided by the CPL. Table IV shows the evolution of their participation over the full period of operation. Euratom, as the host of the CPL, had acquired the right of a regular member. As non-OECD countries started to show interest in this service the IAEA was invited as an observer to the meetings in order to find solutions and work out practical details to a possible extension of the service to these other countries.

Originally the Library had been established for a period of three years. Before the end of that period its activity would be reviewed and its future decided. The review was carried out in 1966 by the Head of the CPL together with Lew Kowarski as high level consultant. They revised the definition of the tasks and the estimate of staff necessary for each kind of task, the additional equipment needed, estimated the capital expenditure and operating costs, a comparison between the present and the possible future was analysed as well as legal aspects of the operation were identified and submitted to the Steering Committee.

[23] Australia and Ireland were Members only for a short period

[24] As associated member in 1965, in 1972 as full member

Table V. Chairmen and Vice-chairmen of the CPL Management Committee (1964-1977)

#	period	Chairmen	Vice-Chairmen
1.	1964-1965	Ezio Clementel(I)	Les Underhill(UK)
2.	1966-1966	Leslie Underhill(UK)	Peter Struch (NL)
3.	1967-1968	Theodor Auerbach, (CH)	Jürgen Merkwitz (D)
4.	1969-1971	Ramón Ortiz-Fornaguera(E)	E.M. Bousseyrol(F)
5.	1972-1973	Jürgen Merkwitz (D)	Peter Struch(NL)
6.	1974-1975	Leif Hansson (DK)	H. Ishikawa(J)
7.	1976-1977	Peter Struch (NL)	Heinrich Bruneder (A)

The discussion about the future was driven by presentations at a meeting held in 1965 at Argonne on "Application of Computing Methods to Reactor Problems". A paper by W. J. Worlton and E.A. Voorhees on "Recent Developments in Computers and their Applications" discussing the implications of the arrival of the third generation of computers attracted much attention [18].

The projected activity during the first three years proved to be underestimated, thus a request of staff and budget increase was made to cope with the workload and to work down the backlog. The users of the service were increasingly more requesting advice or provided feedback on the use of the computer programs. In order to make the service more widely known a series of publications were conceived and then distributed to member establishments. The publications underwent several evolutions in time in order to better meet the user requirements. These were the following:

Table VI. List of regularly issued publications

-	KWIC Index to Nuclear Program Abstracts (Key Words In Context, later KWOC i.e. Out of Context)
-	Nuclear Program Abstracts
-	Computing Facilities (of nominated, collaborating establishments)[25]
-	Newsletter (topical presentation of developments)
-	Proceedings from Topical Seminars / Workshops
-	News from CPL (announcements of new computer programs, corrections, seminars, workshops, training courses, relevant conferences)

The personnel were consequently increased from 6 to 8 members.

A proposal that the CPL provide a service carrying out computations on behalf of the member establishments was rejected.

The coupon system

Because the activity had augmented considerably during the first three years a proposal for an increase in staff and budget was made. E.g. the number of computer programs submitted to the CPL and their requests from member establishments grew very strongly so that the staff could not cope with the increasing workload. The SC however wanted to explore a method of charging fees for the service as a possible income for covering the budget increase in particular as concerned requests from industrial organisations. In a special meeting members discussed this issue and concluded that they were not envisaging increasing the Library's tasks beyond those which had been proposed already, however there was a need to deal with the increased volume of approved tasks. One possible way of limiting the demand was to solicit payment for each request satisfied. This system, if generalized to every request would have been in direct conflict with the spirit of the CPL. An alternative system consisting of

[25] With an increasing number of member establishments and of computers available it was felt that there was no longer need to publish existing computing facilities, thus the issuing of this publication was discontinued.

allocating to each participating country a certain number of requests which would be satisfied free of charge seemed preferable. Each country was thus allocated a number of coupons for a trial period of one year, and then extended by another year. The national delegates were responsible for distributing coupons in their own country. The CPL would not interfere with this distribution, but would answer requests only if a coupon was attached. This system was introduced for an experimental period lasting up to the end of 1967. Some members expressed though criticism to this method as they considered it to be inefficient. The coupon system was abandoned as of end 1969 it was found unnecessary and not useful.

In 1967 the CPL Committee agreed that dispatches on request should be made only of such programs that had been tested and assembled on the master file format. However, if a non-tested program was requested, the CPL could meet this request, provided that a senior programmer be sent to the CPL by the requestor for a period appropriate for the testing of a program, or in special cases the requestors assuming responsibility for testing the program in their own establishment without financial charge and communicating to the CPL the tested package of the program.

Co-operative Arrangement with the IAEA

Before establishing the CPL unofficial discussions with members of the Secretariat of the International Atomic Energy Agency (IAEA) took place about where such a computer program service should be established, one proposal was to include it among the services provided by the IAEA. At that time the Soviet Union was hesitant though. The IAEA not having activities in the field of computer program exchange, it had appeared that it would be possible and desirable for co-operation to be established between the IAEA and the ENEA in regard to the exchange of programs between ENEA countries and the other countries of the world. Lew Kowarski suggested that the Committee discuss this question with an IAEA observer at a future meeting. In the course of the ensuing discussion the members of the Committee agreed that such co-operation would, in principle, be interesting provided it did not burden too much additionally the work of the CPL. In the meantime, an IAEA representative was invited to participate as observer to the coming meetings.

At its April 1967 Committee meeting it was announced that the ENEA and IAEA were finalizing an arrangements for extending the CPL services to non-OECD countries and that as compensation a scientist would be seconded by the IAEA to work for the CPL and for taking care of the requests from these other countries for an experimental period of 5 years. This scientist would be integrated into the CPL staff and be responsible to the Head of the CPL. The person in charge would deal more particularly with the requests of programs from non-OECD countries. The Committee decided to examine in detail the results of this experimental period of co-operation at the following meeting. The arrangement was approved by the SC and a circular letter was sent out by the DG of the IAEA to the permanent missions of member countries announcing the service. The senior programmer sent by the IAEA started officially at the beginning of 1968. The names of the staffs sent as liaison person between the two organizations since then are provided in Table VI.

Requests by non-OECD countries for access to this service had to be addressed to the DG of the IAEA through the permanent Missions of these countries responsible for the final approval. This arrangement provided an equivalent service to non-OECD countries and establishments as for the Data Bank countries, except that computer programs originated in North America were excluded as USA and Canada were not members of the Data Bank. It was understood that the expected fraction of this service to non-OECD would amount to about 10-15% of the total.

The Management Committee was informed that the ENEA Steering Committee for Nuclear Energy at its meeting on 30th April 1970 had taken note of the new situation which had arisen from the coming into operation of the International Nuclear Information System (INIS), set up by lAEA. It had agreed on the creation of an ad hoc expert working party whose tasks would be to review in the light of this situation, the functions of ENEA in the field of scientific information. ENEA had been invited to participate in this information exchange system and share with INIS experience gained so far in information processing and handling. The staff member seconded to the CPL from the IAEA belonged to the INIS Section of the Division of Scientific Information within the Nuclear Energy Department. Zhan Turkov, Head of INIS, announced that computer program descriptions contained in the INIS Atomindex could be retrieved very easily; they would be forwarded routinely to CPL, as part of an internal IAEA Selected Dissemination of Information (SDI) service. The keywords in the INIS thesaurus were especially tuned so that the searches for computer programs would provide real hits with a minimum amount of noise. The service has been provided for many years until INIS was accessible on-line and has allowed the CPL and later the Data Bank to identify new computer codes that were being or had been developed.

INIS gave to the ENEA in addition access to their bibliographic databases of "grey" literature containing computer program documentation. In fact, such documents were specifically flagged to facilitate finding such information. This helped on the one hand the acquisition of the latest codes and the identification of publications that reported validation and benchmarking of codes the Data Bank had already acquired. The Data Bank then agreed to enter into the Atomindex all its open publications so that they could be easily found or retrieved from there. The Data Bank was given access to using IAEA's computers during the Eighties as additional compensation for the excess computer program service provided compared to the amount agreed originally.

The services provided by the CPL and later CPS included "receiving visitors" from non-OECD establishments and advising them on the use of computer programs. The text of the arrangement was neither specific about the duration of such visits, nor the number of visitors the CPL would accept receiving at any one time. At the end of the Seventies a request from Iraq for training two nuclear engineers arrived, disrupting the arrangement as it was felt to be a burden rather than a help. As the CPL had at that time just been merged into the Data Bank there was a need for overhauling the arrangement and adjusting it to reflect the change of premises from which the service would be provided and to make a few adjustments in the operational details. A revised arrangement was endorsed by the Data Bank Management Committee, by the IAEA and was approved by the SC in 1981[26]. This arrangement has been in place for 45 years and is among the oldest having survived. It proved also to be one of real mutual benefit for the two parties. Also, non-OECD establishments, in particular the IAEA itself, contributed substantially to the computer program collection of the Data Bank.

Figures 24 and 25 depict how the existing co-operative arrangements, including the one with the IAEA cover the different organisations and countries involved.

Among the personnel at the IAEA that had an influential role in establishing this service at the beginning there were Sigvard Eklund, the DG and David Fischer Director of external relations. The continuous support came, once the service was established, in particular from M.V. Ivanov, Ivan Zheludev, Zhan Turkov, Edward Brunenkant, Harold Pryor, Ivano Marchesi, Vassil Gadjokov, Arkady Romaneko, Claudio Todeschini, Thomas Hughes, Alexander Sorokin, and Taghrid Atieh.

Table VII. IAEA Liaison Officers

Name	Period
Werner Schuler	(1968-1972)
Enrico Sartori	(1973-1987)

[26] The final wording for visitors was as follows: A limited number of visits by experts from interested countries to the Data Bank can be accommodated. Short visits will allow discussions and explanations of programs and other facilities made available to them. Longer term visits can be accepted only where they would result in demonstrable and significant benefits to the Data Bank and its participating countries.

Ivo Kodeli	(1988-1989)
Vincenzo Tonelli	(1989-1993)
Juan Manuel Galán	(1993-2001)
Ivo Kodeli	(2001-2008)
Luigino Petrizzi	(2010-2013)

Co-operation with ACC (USCC) and RSIC(C)

When setting-up the Computer Program Library, Margaret Butler, then Head of the Argonne Code Center (ACC), and her husband Jim Butler contributed their experience and know-how acquired in the setting up the Argonne Code Center. As early as 1965 a "Co-operation arrangement between USAEC and the OECD/[E]NEA for the Exchange of Nuclear Data and connected Information and Computer Program Packages Pertinent to Nuclear Science and Technology" was agreed on encompassing nuclear cross-sections bibliographic references, microscopic nuclear cross-section data, evaluated sets of nuclear cross-section data, computer program packages pertinent to nuclear science and technology (in particular reactor codes and radiation shielding codes), and publications. The way third parties should be treated in this context were also part of the agreement including visits and exchange of personnel, common seminars, service areas and the different centres involved. It was signed for a duration of three years, with the possibility of further extension.

The head of the Argonne Code Center (ACC) participated in the CPL meetings occasionally, starting from 1966. The exchange with the US equivalent centres started to intensify and mutual visits were paid on a regular basis according to the signed arrangement with the USAEC (later ERDA, then USDoE). The USAEC decided to centralize the distribution of the programs developed under AEC contracts, and entrusted the ACC, from then on called the USCC, with this service. This co-operation lasted from 1963, during the setting-up of the CPL until 1991, when the Argonne Code Center, later called National Energy Software Center (NESC) with extended scope, ceased its operation as it was transferred to the DOE Office of Scientific and Technical Information in Oak Ridge, and renamed ESTSC (Energy Science and Technology Software Center).

The other Center, created in 1963, with whom the CPL established very close contacts was the Radiation Shielding Information Center (RSIC) in Oak Ridge, later renamed Radiation Safety Information Computational Center (RSICC). The first visits to the CPL were paid by Dave Trubey and Betty Maskewitz, both Directors of RSIC during different periods, who were advising the CPL on radiation shielding codes.

The CPL had adopted the same standards for packaging computer code information as defined by the USCC and RSIC, thus facilitating the exchange of information. The continuous interaction with the Centers in the USA enhanced the usefulness of the CPL for its users. Much of the success of the CPL was due to this close co-operation.

This agreement was reviewed and renewed at regular intervals of about 5 years. The last one was signed in 2006 and this time no limit has been placed on its duration.

While the flow of information was predominantly from the US partners in the Agreement to the CPL (and Data Bank), this trend was reversed in the Nineties and now the flow from the Data Bank to these partners is dominant. Overall, over the period of 50 years the exchange has been balanced and to the benefit of the different partners in the agreement.

Figure 5: Margaret K. Butler (ACC) and Betty F. Maskewitz (RSICC)

Table VIII: Heads of US Code Centers

RSIC(C)		ACC-NESC		ESTSC	
Name	**Period**	**Name**	**Period**	**Name**	**Period**
S. Keith Penny	1963-1966	Margaret Butler (ACC)	1960-1972		
Dave Trubey	1967-1970	Margaret Butler (NESC)	1972-1991		
Betty Maskewitz	1970-1983			Walt Kelly	1992-1995
Robert Roussin	1983-1996			Delores Brabson	1995-1998
Bernadette Kirk	1997-2000			Kim Buckner	1999-2011
Hamilton-Hunter	2001-2004			Susie Foust	2011-
Bernadette Kirk	2005-2011			Edwin Kidd, Berta Perez, Judy Wilson, Connie Lamb support staff	
Tim Valentine	2012-				

Arrival of the Third Generation Computers

One of the challenges for the CPL was to provide programs that would run on different makes and generations of computers. This involved also translation, e.g. from FORTRAN-II to FORTRAN-IV, to the benefit of other users that would move their computing equipment to the newer generation. To avoid duplication of effort in the translation of programs from FORTRAN-II into FORTRAN IV for IBM 360 and other makes of computers, the possibility that the CPL carry out this task on behalf of the member establishments was recommended. An inquiry was made about the view participating establishments had in this respect. This investigation was initiated in anticipation of the announced replacement at CETIS of the IBM 7090 computer by a more powerful IBM 360/65. It was also felt that this investigation would give some idea of the problems likely the Library would confront in the near future. From the replies received, it appeared that this problem had not yet been generally felt. However, one dozen centres have indicated their willingness to submit specified translated programs to the CPL. This would require new adjustments in the working methods and procedures, the use of new hardware and storage media, and the programming language.

Outside use of computers for program verification and testing

The issue of testing at different computer installation operating different computer makes were discussed. The CNEN centre in Bologna offered access to their IBM 7090 during the transition period. Also, an experimental teleprocessing link was established between the CPL and other computer facilities. The CPL tested computer programs outside CETIS on other makes and models of computers such as : IBM360/91 at KFK, Karlsruhe, CDC 6600 at University of Stuttgart and CYBER-76 at University of Hanover, (Germany), IBM 360/75 at Harwell, and KDF/9 and ICL 4/72 at UKAEA Risley and Winfrith, (UK), the CDC 3600 and IBM 360/75 at USCC Argonne, (USA), the CDC 6500 at ETH Zurich via EIR at Würenlingen, (Switzerland), UNIVAC 1108 at the Junta de Energia Nucléar in Madrid (Spain), UNIVAC 1140 at Fiat Turin, the IBM360/65 at the University of Bari and IBM 7090/7044 at CNEN Bologna (Italy). In August 1972 CETIS changed its computing installation from an IBM 360/65 to an IBM 370/165.

Figure 6: CPL staff, Ispra June 1968. From left to right: Luis Garcia de Viedma, Werner Schuler, Rodolfo Dicola, Reginald Prescott, Margherita Donzelli, Johnny Rosén, Makoto Akanuma, Helga Cocchi-Schuler, Klaus Hey, Renée Giustina, Sheila Greenstreet, visitor, Piero Tomba

The computer programs acquired by the CPL had been written for an increasing number of different computers, many of which had some special programming language features. This reduced the portability between computers and required sometimes rewriting parts of the program using only standard language features[27]. Annex XII lists some 50 programming languages or versions of the

[27] An interesting example was French FORTRAN, which was nothing more than the English instructions translated into French. In order to compile it, it had to be processed through a pre-compiler, translating the French back to English. This version of FORTRAN survived only a short time.

programs acquired by the CPL over 50 years. Annex XIV lists some 200 types of computers for which these computer programs have been written.

Respective roles of CCDN and CPL on nuclear data and their processing

As mentioned previously, in parallel with the CPS the Neutron Data Compilation Centre (Centre de Compilation des Données Nucléaires - CCDN) was operated at Saclay.

"*The principal objective of the Neutron Data Compilation Centre (CCDN) is to improve the collection and dissemination of experimental neutron data produced in Europe and elsewhere in order that the results of the very large effort being devoted in each country to the measurement of neutron cross-sections may be made more accessible to all interested users.*

To meet this objective the Centre will undertake the following initial activities:

- *the operation of a bibliographical reference index*
- *the collection and filing of experimental data from Europe and elsewhere*
- *the dissemination of these data and, at later stage, periodically*"

When the NEA was in the process of extending its co-operative arrangement with the USAEC a draft arrangement had been proposed by the AEC according to which the NEA Neutron Data Compilation Centre (CCDN) was called upon to play an active role in comparing, developing, and modifying computer codes for translation and handling of evaluated data files. This proposal had been submitted to the CCDN Committee at its meeting on 17th and 18th May, 1973; the Committee had agreed that work on codes should be left with the CPL, and had asked the NEA Secretariat to refer the matter to the CPL Committee, with a proposition that CCDN would be willing to act in an advisory capacity in that matter. The Committee was indeed of the opinion that the CPL should be in charge of such programs; it welcomed CCDN's offer of collaboration, and asked the Secretariat to clarify the situation with the USAEC.

The Committees of the respective centres clearly stated that evaluated nuclear data libraries would be distributed by the CCDN in Saclay. It was agreed also that the CPL should collect and hold the multi-group or processed cross-section libraries and distribute those data sets which members were prepared to make available for distribution. A number of the RSIC data sets were being made available through the CPL. It was agreed that keeping multi-group nuclear data libraries up to date for use with various programs must receive more attention. A number of new data processing codes had become or were about to become available for the purpose.

Co-operation with JRC Ispra

The Department of Reactor Theory and Computation (Teoria e Calcolo dei Reattori - TCR) of the JRC Ispra established a close and mutually beneficial co-operation with the CPL from the start. Two of the relevant groups were the European Shielding Information Service (ESIS) and the Integral Nuclear Data Centre (INDAC). Over the years the TCR has given the CPL advice on the physics aspects of a number of reactor calculation programs and in particular the CPL has co-operated with both the Shielding Group (ESIS) that had been involved with evaluating shielding programs for some time and the Nuclear Data group on the implementation of the programs. The EACRP had entrusted the JRC with an investigation on "clean" integral experiments. The necessary activity to achieve this consisted in collecting documentation on information used for the development of data files (experimental values deduced from differential and integral measurements and physical models used to interpolate or parametrise point values). Thus, the documentation of integral measurements made throughout the world was required as well as the filing of such experiments. The purpose of this work was to determine the integral experiments which could be used to test nuclear data as opposed to those which have been elaborated directly to test mock-up experiments.

Another activity concerned critical analysis of the confidence limits of various sets of few group cross-sections and their method of production as well as their adjustment by comparison between calculated values and the results of "clean" integral measurements.

The CPL activities received continuous support from CETIS through computer services, software system support, and technical co-operation with their Nuclear Codes and the Numerical Analysis Group.

Expansion of subject scope

In 1971/72 it was agreed to enlarge the subject scope of the CPL, formerly concentrating mainly on topics of reactor physics by including programs in the areas of nuclear structure physics and nuclear models, data analysis, in the nuclear fusion area and those related to the INIS (International Nuclear Information System of the IAEA) project for selective dissemination of information (SDI) as well as by including nuclear chemistry. Other computer programs areas at the outskirts of nuclear applications, such as archaeology, criminology, magneto-hydrodynamics were not retained.

A meeting of computer specialists using INIS Output Tapes was organised by the IAEA from 21-22 June 1973. The purpose of the meeting was to bring together programmers and systems analysts processing the INIS file by means of a computer, for an exchange of views on retrieval systems and selective dissemination of information (SDI) from files in machine readable form, input preparation techniques problems in machine-readable abstracts, etc. The CPL had been invited to participate in the meeting; information on the possibility and the advantage of including SDI programs in the Library were thus obtained.

Programs for the stress analysis of a variety of structures have generated considerable interest and have been widely requested and distributed. Over the years however, it turned out that this field belonging to mechanical engineering had produced a number of widely used codes applicable to a large set of engineering problems going well beyond nuclear applications. Many of these codes were proprietary or became available on a commercial basis.

Also, a seminar workshop on a number of newly developed shielding programs was held in the first half of 1972 in preparation of a more general shielding conference held under the aegis of the EACRP in 1972.

Program verification and testing

The program verification and testing consisted in the following steps:

Upon reception from the authors the material would undergo

- Verification that the following elements were present:
  - Reference manual and/or how to use
  - Computer program abstract
  - Source program(s)
  - Test problems in put and corresponding output
  - Data libraries (cross-section, material properties, etc.)
  - Scripts in job control languages for running the programs
  - If available reports describing program validation
- Installation on the same make of computer or a different one: compilation, debugging, documenting modifications, interaction with authors, preparing executables and running test problems successfully.
- Packaging all these elements according to the “Master File Format”

Relations with [N]EACRP and [N]EANDC

The Committee on Reactor Physics of ENEA (EACRP) and the CPL established closer contacts in order to improve the awareness of new computer programs being developed and identifying specific needs by the reactor physics community. The CPL started to submit an annual progress report to the EACRP in order to make the interaction mutually beneficial. Similarly, also input from the Nuclear Data Committee (EANDC) was received as to their needs in computer programs, in particular as concerned with experimental nuclear data processing, evaluated data verification and processing and nuclear model codes used for interpreting experimental data or to fill gaps where experimental cross-section data was lacking. Concerning computer programs in the area of nuclear models and nuclear structure, the CPL Committee expressed its appreciation of Professor Benzi's comprehensive list of computer programs for nuclear model calculations, an initiative started through the EANDC.

A pilot project with possible later extension on a "Service on Experience on Code Utilisation (SECU)" was set up in co-operation with the EACRP. An area of particular interest was to be selected, which should involve collection, correlation and analysis of user's experience and user/author confrontations in special seminars. As a first topic radiation shielding programs was selected in view of the International Radiation Shielding Conference ICRS-4 held in Paris in 1972.

[N]EACRP had a considerable interest in the SECU type activities. It felt that in the whole range of possible orientations for the CPL (from acting as a simple mailbox for code packages up to working on all aspects of programs including physical models built into them), that it was most useful at intermediate level of the following actions: testing codes with a sample problem on at least one computer, checking their completeness, distributing code packages, producing corrected versions, providing hints on the use of codes, securing feedback from users, etc. SECU had proved to be of value as it provided details of corrections to codes and identified up-dated versions thereof, gave access to a fuller list of references than that provided with the original code, it discussed difficulties, identified the need for supporting codes, discussed the choice of parameters, etc. A number of privileged codes would be so selected, for realistic test problems, for SECU type activities, and for follow up actions.

The committee decided to follow NEACRP's recommendations and invited the CPL to launch a SECU study of nuclear data processing codes in collaboration with the NEACRP.

However, this involved large amounts of effort by the CPL. It was clear that to fully develop this new activity more staff was required. The CPL requested two more posts of professional staff to cope with the increased workload due to the expansion of its scope of work.

Annex VII and VIII provide the list of the meetings held by these two committees and the respective Chairs and Scientific Secretaries.

Series of workshops

The series of CPL seminars and workshops at Ispra were as follows

1. Workshop on Modular Coding for Reactor Physics Calculations (1970)
2. Finite Elements Computer Programs for Stress Analysis (1971)
3. Shielding Computer Programs (1972)
4. Nuclear Data File Processing Codes (1973)
5. Computer Programs for the Analysis of certain Problems in Thermal Reactor Safety (1974)

These were very beneficial for the acquisition of newly developed, quality computer programs. Also they brought together specialists and gave high visibility to the work at the CPL.

Difficulties in acquiring new programs

One of the complaints by the participating establishments was that some were placing restrictions to the release of the programs they had developed. The cited reasons for restrictions were as follows:

- commercial;
- intellectual property
- limitations by a third party;

- administrative reasons;
- other reasons – e.g., one program was not released because “only experts can effectively use this program”

This led to discussing again the Tasks and Duties of Liaison Officers of participating establishments, as some would share their programs through the CPL, others would not, but would acquire those that were released generously. This discrepancy in complying with obligations could never be removed, as the National delegates in the CPL had no way to impose the release except to deny access to the CPL. This situation was quite different in the USA, as programs developed with governmental funds had to be released to the Code Centers. There were however good occasions such as workshops and conferences to shop for new programs, e.g., the conference on nuclear data held at Harwell in 1975. An important set of nuclear model computer codes covering particle interactions from thermal, to fast, and to intermediate energies were acquired and tested. Others recognized that the release of codes would provide advantages such as, the larger the user community the larger the testing on a large variety of applications. The feedback provided would contribute to the improvement and validation and requirements for new applications were the starting points for collaborations, contracts, and business. In brief, the commercial value was in providing a specific service on request once the program was working well and was widely known.

Renaming of Committees and Agency

In 1972 Japan became a full member of ENEA. Because of this major event ENEA changed its name to NEA – Nuclear Energy Agency and the two Committees EACRP and EANDC to NEACRP, and NEANDC respectively.

International Energy Agency (IEA)

On the 18th November 1974, the International Energy Agency (IEA) of the OECD was established. In a Ministerial Meeting in 1975 of the IEA it was agreed that the "IEA should initiate promptly an examination of the potential for expanded co-operation in the area of nuclear energy": a provocative statement towards NEA showing some ignorance of facts by the proponent but indicating possible phagocytosis of NEA by IEA. A long discussion has obviously taken place on this and the conclusion drawn was that NEA and IEA had evidently to work very closely together if they were to avoid wasteful duplication of effort and unproductive arguments.

This had some repercussions on the CPL and CCDN as well. E.g., the decision as to whether to widen the scope of the CPL to include computer programs in the field of nuclear fusion was continuously postponed. At that time one specific activity in fusion was set up at the CPC Program Library, Queen's University of Belfast and with the creation of the IEA this activity has moved under that aegis. Later, the neutronics aspects of fusion blankets, material activation and needs for nuclear data remained within the responsibility of what later became the NEA Data Bank.

Figure 7: CCDN Staff, Saclay, 1966, Douglas Colvin, Head, at the centre

Increasing complexity of computer programs

A workshop on Modular Codes for Reactors proposed by the [N]EACRP and organised by ENEA CPL was held at Ispra in 1970. The topics concerned the overall philosophies of such systems, the size of modules, their interfacing and their interchangeability with other modules, the system organisation, the experience with modular systems, finally the hardware and software requirements.

This workshop was a driver for the coming developments as it started to address the need to move away from programs that would carry out just one task at a time, even if a major one. Simulation required dealing with the multidisciplinary interaction in complex systems such as nuclear power plants. But the limited power of computers and their architecture at that time, the limitation of programming languages made such integration a real challenge. Three decades later, when such limitation had disappeared, the nomenclature had changed: one would speak of multi-scale / multi-physics approaches. In the Seventies computers were short of computer memory and such modular systems had to use memory overlay or program segmentation. The modules were loaded as they were needed, then removed and the next one loaded and executed. Such structures consisted sometimes of complex overlay trees. It was also in those days that the ideas of parallel computing started to develop, in which different modules would carry out the work on different processing units.

As a follow-up at the CPL specific work had concentrated on implementation and testing of large (modular) systems such as MC**2 and MINX (later NJOY) for evaluated data processing, the AMPX modular system for coupled neutron-gamma multi-group cross-sections preparation and handling. RSYST for reactor systems including all aspects from cross-section handling to neutronics to burnup and kinetics was installed with the help of one of the authors. Also, the ARC (Argonne Reactor Calculations) modular system and VENTURE Reactor Analysis System with Sensitivity and Burnup from Oak Ridge were implemented and tested.

Figure 8: CPL staff 1975, Ispra
Enrico Sartori, Derek McTear, Felice Lamantea, Renée Posca, Margherita Donzelli, Kjell Bendiksen, Maria-Teresa Garzola, Mme Petri, Luis Garcia de Viedma, Patricia Dutton, Rodolfo Dicola

Legacy computer programs from the DRAGON Project

In January 1973 collaboration between the Dragon Reactor Project and CPL had been endorsed by the Board of Management of that Project. Following the decision of the DRAGON Project Management to discontinue its activity in 1975[21], the Computer Program Library has been entrusted with custody of the archives of the DRAGON computer programs. Fourteen computer programs were released and tested at the CPL.

The foreseeable synergetic effect of combining CPL and CCDN

While located in Ispra and Saclay, there was almost no contact between the two groups. One would concentrate on verification of computer codes, ensuring that they were complete and portable to other makes of computers, the other mostly on compiling experimental neutron interaction bibliography and compilation of neutronic data into an agreed standard format. The evaluated nuclear data libraries were obtained from national centres and then simply distributed as is, never processed for applications. One part would handle aspects of the macroscopic phenomena of neutron interactions, the other the microscopic aspects. In practice, the two aspects needed to be combined for applications. The combining of the two groups was an opportunity to achieve also this necessary integration. There was considerable resistance at the beginning when the staff from Ispra moved to Saclay; it was understandable, the impression was that the invaders came to play unknown games. Mistrust disappeared after a period of relative tension and with the staff changeover also occurring around the time of the move things improved very quickly as everybody was interested in establishing cordial work relationships.

It was with the establishment of the Joint Evaluated File (JEF) project that a unique opportunity arrived. There was a requirement for benchmarking the JEF-1 data, especially for fast reactor applications. On the one hand there were the evaluated nuclear data processing codes and the radiation transport codes for carrying out benchmark studies, on the other hand there was the release of a new European Data Library. The European laboratories had joined their efforts to produce an improved library as compared to the previously available dispersed ones such as ENDF/B-IV, UKNDL, KEDAK, JENDL and other French and Italian evaluations. In fact, the US centres had decided not to release their newest version ENDF/B-V, although it contained many early evaluations of UK and German origin, because a kind of conflict emerged between the American and European fast reactor programmes. As only part of the countries was interested in the fast reactor programme, through the users of computer programs the encouragement came to extend the scope of the JEF file also to thermal and intermediate energy systems. The widened scope of JEF together with the wide scope covered by application computer programs made the integration possible. Also, this would benefit all the participating countries, whether or not they were embarked in nuclear power development or whether they were more concerned with industrial application of radiation.

Special efforts were then devoted to “debugging” codes required for the verification of the correctness of evaluated files, be it in the format, completeness, or physical consistency of the components, or be it the processability of the files to produce application nuclear data libraries. All the participating countries agreed to adopt the same standards for the format, the quality assurance (QA) procedures and the energy group structures to facilitate comparative analyses of the quality of the data. This created a full new dynamic that benefited the JEF project but also the user community. Later the ENDF/B-V library was released worldwide; this however did not halt the momentum built up by the JEF project and this co-operation has continued until today. A very strong co-operation on evaluation and processing of nuclear data emerged, new products such as improved application libraries were made available to the user community, supplemented by documents in which the validation work using experimental benchmarks were reported. This led to defining needs for more experimental data to improve parts of the library, especially to meet the needs of new generations of reactors.

Creation of the Data Bank

The document entitled "Considerations on possible changes in the budgetary arrangements of the CPL and the CCDN" at the SC June 1976 meeting was a first hint at forthcoming changes. In fact, the Deputy Director General recalled the proposal by the Steering Committee in autumn 1975 for a review of the budgetary arrangements of the Computer Program Library and the CCDN to see whether and how economies could be achieved after an increase of the budget had been requested. After consultations, the Secretariat had come to the conclusion that the evolution in the organisation of the two Centres was desirable and could be achieved by amalgamating them into one to be called NEA Data Bank. This would provide comprehensive facilities to the Member countries and would achieve more flexible and efficient use of specialised staff whose contribution was, in fact, substantially complementary. In addition, worthwhile economies could be expected. Consultations had shown that Saclay would be a suitable choice for the location of the proposed Data Bank, since one of the two centres was already on the site, which was also easily accessible from NEA Headquarters. It was pointed out that a decision of principle was needed so as to achieve this amalgamation in the context of the 1977 budget, and to submit the relevant proposals for programme and budget to the Committee in that autumn. The SC decided that programme and budget proposals for 1977 should be prepared, both on the basis of an amalgamation of the two centres and on the basis of continued separate activity; that a final decision should be taken at its October 1976 meeting as to which basis should be retained for the budgetary proposals for 1977.

At a combined meeting on 7th-8th July 1976, the Committees of the CPL and CCDN had reached the conclusions and recommendations confirming that, once the transitional problems had been overcome, amalgamation would bring important technical advantages and allow greater efficiency in the use of skilled resources and that there was also a prospect of annual economies of about 15%.

At its meeting of October 1976, the SC noted that no consensus could be reached at that meeting on the question of the future of the Computer Program Library (CPL) and the Neutron Data Compilation Centre (CCDN). The CCDN and CPL Committees met again after this and reaffirmed the position taken by the great majority of the CPL and CCDN countries in favour of amalgamation.

Two countries were opposed to the amalgamation, namely Australia and Italy. Australia later withdrew its opposition. The SC at its session of 28th April 1977 took note of the conclusions of the two Committees and decided, subject to a reserve by the Delegate from Italy, to proceed with preparing the amalgamation of the CCDN and CPL into a new Data Bank at Saclay.

At the special meeting of 7 December 1977, the SC approved the setting up of a NEA Data Bank with the terms of reference, initial programme, organisation, transitional arrangements and the 1978 programme of work as recommended by the special Working Party on 24th November 1977 charged with this task. This Working Party found that the principal justification for creation of the proposed NEA Data Bank in succession to the two existing Centres was that the complementarity of the professional resources needed to operate CPL and CCDN meant that their combination would create a service potential considerably greater than could be provided by continued separate operation of these two existing Centres. The Data Bank would be better able to respond to the changing needs of the future and in the longer term its potential should be realised by the provision and development not only of direct services to Member countries, but also of data and computing support in relation to the wider field of activities carried out within the NEA programme.

In synthesis the Terms of Reference proposed were as follows:
"*The NEA Data Bank should undertake the collection and dissemination of computer programs and scientific and technical data pertinent to the Agency's programme of work. It should maintain the computer resources and expertise necessary both to support its own programme and to contribute as appropriate to the needs in data and computing of other work undertaken by NEA*".

The SC also endorsed the recommendation that the close and effective collaboration between the Joint Research Centre of Euratom and the NEA Data Centres should be continued by the Data Bank without charge to Euratom.

A transition period of two years was defined. Italy declared that it would not participate in the Data Bank, but would reserve its position as to whether it would join it at a later stage. Also, Australia decided not to participate.

THE DATA BANK IN SACLAY, France

Logo of NDB

Move from Ispra to Saclay

With 1 January 1978 the Data Bank was officially established in Saclay, France. However, a number of actions specifically required to physically 'amalgamate' the two groups had to be carried out during the first half of that year. While the CCDN staff could continue working as before during this first transition period, the hard part was on the CPL staff. Some resigned from their position during that period, some others lost their job as the overall staff was reduced. Others had to look for new housings, for schools for their children, improving skills in the new local language and finally move their family and belongings to a new country and a new living environment. International civil servants are expected to accept this without frowning.

There was the removal of the office archives and other office material and storage equipment such as magnetic tapes, punched card decks, bulky computer program documentations and listings etc. from Ispra to Saclay. The building where the CCDN was located (bâtiment 445) had to be modified to host almost twice as much personnel as compared to the years before. Next, the adaptation of the working procedures to the new computing environment was addressed. The first period was thus devoted to get the 'system' moving again and to reassuring service users that delays in the response to their need would be reasonably short.

The first Data Bank Committee meeting was held in March 1978, when not all staff had moved from Ispra to Saclay; that happened on 22 May 1978

During the first meeting it was iterated by the DG of NEA that contribution of international co-operation in the nuclear field must be altogether a more integrated one in the sense that while the Data Bank would continue to foster its day-to-day links with specialists in the Member countries, it had also to develop its services in a sense complementary to the contribution of the NEA as a whole. This would imply extensions of the services provided when the Data Bank would be fully established. Closer ties with the other work of the NEA would be a benefit rather than a constraint on the work of the Data Bank. Obviously, the initial task was to establish the Data Bank and to achieve an orderly transition to the new mode of computer operation. This was expected to happen with the minimum of disturbance and that the transition would include also a modernisation as well as a consolidation of the technical effort. As the primary justification for the proposal to establish the Data Bank was the increased efficiency in the use of skilled resources, there was a need to ensure that this justification was correct. From such an improved foundation it should be possible to associate the Data Bank in the future more closely with other parts of the NEA programme, thus increasing the relevance of the Data Bank.

Priorities needed to stem from many different considerations and the Data Bank should be responsive to needs expressed. Work was expected in the field of breeder reactors, on high recycle fuel and the fate of the actinides, the plutonium recycle and management in thermal reactors. For this, improved quality and a larger coverage of nuclear data and computer programs would be required. The Data Bank would rapidly lose credibility if its collection of computer codes and nuclear data sets were progressively less relevant to the needs of the communities it serves. It was recognized that the scientific and technical services would grow considerably in importance if they were seen to be making a relevant contribution to the solution of the key problems in the nuclear field. The Data Bank was expected to offer an increased potential considerably beyond the sum of the CPL and CCDN contributions. The complementarity of the skilled manpower and experience of the two previous Centres provided a foundation for flexible future operation and increased productivity which could be invested in activities of the highest policy priority.

As the priority work went to installing the computer program operation to a new computing environment, very little time was left for the SECU activity which eventually was abandoned. Nevertheless, that activity was appreciated by users and was a driver for obtaining improved and newer versions of computer programs. It was maintained in another form, namely by requesting systematically from users and authors feedback on the use and development of the codes. Users of specific codes were informed when corrections became available or further information had been released. This further developed later when e-mail became available, which also allowed targeted dissemination of news.

The possibility was discussed of extending the role and activities of the liaison officers used to have in the computer program activities to cover also neutron data. It was found that such an arrangement would be less satisfactory for the neutron physics community because of its more dispersed pattern.

A first example of closer co-operation with the NEA Headquarters came from the Nuclear Development Division with the proposal of establishing a data base on “Uranium Resource Assessment” in support of the publication "Uranium Resources, Production and Demand”.

Attempts were made to render the DBMS (DataBase Management System) operational for the PDP 11/70, first for the needs of the nuclear data services. Based on this experience the systems would be adapted to manage the program requests and dispatches and for producing annual statistics of the use of the service.

The conversion work was much larger for computer programs than for nuclear data as the whole operation had to be transferred from Ispra to Saclay, involving a complete reorganization of the technical work in a very different environment. This conversion period was however beneficial in the sense that the procedures had to be modernised and adapted to newer computing technologies.

The first Head of the Data Bank was Johnny Rosén. The following table lists the Heads that followed him.

Table IX Heads of Data Bank:

Name	Period	Origin
Johnny Rosén	(1978-1992)	Sweden
Nigel Tubbs	(1992-1998)	UK
Philippe Savelli	(1998-2001)	France
Thierry Dujardin (acting)	(2002-2006)	France
Akira Hasegawa	(2006-2009)	Japan
Thierry Dujardin (acting)	(2009-2010)	France
Kiyoshi Matsumoto	(2011-)	Japan

The first Chairman of the Data Bank Management Committee was Josef Brunner from, Switzerland. The following table lists all the Chairs until 2014.

Table X: Chairmen of the Data Bank Management Committee (1978-2013)

#	Name	Organisation	Country	period
1	Josef Brunner	EIR Würenlingen	Switzerland	1978-1980
2	Bryan Patrick	AERE Harwell	United Kingdom	1981-1982
3	Leif Hansson	Risø National Laboratory	Denmark	1983-1984
4	Heinz Küsters	Kernforschungszentrum Karlsruhe	Germany	1985-1986
5	Sven Linde	Studsvik Energiteknik AB	Sweden	1987-1988
6	Claude Philis	Commissariat à l'Énergie Atomique BRC	France	1989-1990
7	Hugo Ceulemans	SCK•CEN Mol	Belgium	1990-1992
8	Leslie Underhill	AERE Risley	United Kingdom	1993-1994
9	Kjell Bendiksen	Institute for Energy Technology Kjeller	Norway	1995-1996
10	Harm Gruppelaar	NRG Petten	The Netherlands	1997-1999
11	Syed Qaim	Kernforschungsanlage Jülich	Germany	2000-2000
12	Pierre D'Hondt	SCK•CEN Mol	Belgium	2001-2014

Some difficulties

Although everything started with great optimism, staff had to address a number of technical problems to get the Data Bank operational. For some time, the IBM 370/125 of the former CCDN was used to handle the more administrative work of master-filing the program packages and to prepare dispatches following user requests. It turned out that the computer was under-dimensioned for the purpose. Attempts were made to transfer the operation to the IBM 360/91 of the CiSi, but also this was very problematic. When the DEC PDP 11/70[28] was installed at the Data Bank an attempt was made to use it for the purpose, but also in this case the computer was under-dimensioned. It was used though to submit remotely the jobs to the large IBM and CDC machines of CiSi and to receive outputs. But some of the bulky outputs received were excessive for the small machine. The expectation from introducing a DBMS (Data Base Management System) proved too optimistic as it was not dimensioned for the work at the Data Bank and specific software engineers had to be called to participate in the diagnostic test. The experience gained though was valuable for transferring the operation in an orderly fashion to the following generation of computers.

Another difficulty that the Data Bank faced was that the US Centers would not release the ENDF/B-V evaluated nuclear data even though the co-operative arrangement was in place. Evaluated data had so far been not subjected to restrictions, co-operation had been efficient and a number of data sets of ENDF/B-V were actually data produced by European research. But overall, it had also positive consequences because European research agreed to work closer together on this issue and in fact this triggered off the Joint Evaluated (or European) File – JEF project.

An additional issue raised concerned some imbalance in the exchange of computer codes between the US Centers and the Data Bank. As a concrete measure to resolve the problem the NEACRP had proposed to hold seminars in the US to give publicity to and promote codes of European and Japanese origin. Increased commercialisation of codes has made their release to the Data Bank less free than in the past, and personal intervention by Committee members was often necessary before codes could be exchanged. The Committee recognised the two problems of an imbalance between the US and Europe in the exchange of codes, and the increasing difficulties of availability of codes both in Europe and the U.S. The Data Bank was considered to be well placed to improve the exchange imbalance.

[28] One pretended justification for the change of computer make was that "IBM is an elephant with the brain of a mouse …". This was a clear prejudice. IBM is still alive while DEC has disappeared some time ago.

However, joint action of Committee members at a personal level and of the NEA Secretariat at governmental level was recommended to stop the trend towards greater restrictions on the availability of codes. The Committee recognized the difficulties in interference in the commercial processes of code exchange where the motivation of the originator is for a return on investment.

Figure 9: NEA Data Bank Computer room 1981, PDP 11/70,
Robert Guillou, Nigel Tubbs, Johnny Rosén, Bernard Armand, Luigi Pellegrino, Felice Lamantea,
Bernard Camboulas, maintenance expert from DEC

Differences in approaches and method

The issue "why was there was a need for the Data Bank" was occasionally raised. Could this not be left to the IAEA with a larger number of member countries and staff?

Among the reasons for maintaining the Data Bank two are mentioned here:
One of them was that some countries were reluctant to release computer codes and integral data without any control or restriction to all countries. The NEA had the possibility to accept restrictions imposed by the originators of the information to be distributed through generic limitations or through case-by-case handling. This option was not available to the IAEA: they had to make the information available to all Member countries, which practically covered the whole world. By managing the codes and data through the Data Bank, countries were willing to release much more information. Also, it was up to the national delegates in the committees to nominate which organisations had access to the services.

The other reason was that the programme of the IAEA technical departments was driven and eventually decided by the Secretariat. It often depended by the personality of the responsible officers whether projects and services would operate for long periods. The Technical Committee members have an advisory function and have no say on the budget to be allocated for projects and services. At the Data Bank and at NEA in general the programme is driven by the Committees and in the case of the Data

Bank members would make the recommendations relative to the budget as well. This ensured the survival in the long run of activities and services.

Future activities: 1978-1979 and extension of Data Bank's work.

The formation of the Data Bank in 1978, had aimed at integrating the work previously carried out by CCDN -and CPL in order to achieve improved synergy and to bring gains in working efficiency. The arguments in favour of it and the tasks themselves had been thoroughly reviewed during the discussions preceding its establishment. There was a need though to developing an explicit longer-term forecast of issues affecting its future in particular as concerned the technical tasks to be carried out.

Among the issues that were likely to affect the future the following were identified in 1979:

- Increased use of computer networks, and the spread of distributed data processing and distributed data files or data bases.
- Increasing pressure for sale of programs and data, either commercially or on a government-sponsored cost-recovery basis.
- The need for adequate validation of data and programs

Newer computer programs were growing in size and complexity. Whereas in the past a computer code was largely aimed at fulfilling one specific task, the new ones tended to be designed for a much broader field of application. This would affect the number of programs that would become available, the effort required to verify and test them and the possible tendency to commercialize them. In view of lower computer prices, it was also expected that the number of computer installations would increase und thus increase the number of users of computer codes.

An increased demand for "condensed" and processed nuclear data was expected, and a lesser one for differential experimental cross section data as an input to data evaluations. The interest for nuclear fusion data started to appear and thus data for energies higher than those for nuclear reactors needed to be acquired and processed.

It became clear that any new work would be carried out with manpower freed by increased productivity following the conversion or by supplementary manpower. The projections made then assumed no increase in manpower.

In the medium term, firstly extending and improving the Data Bank's range of services, and secondly new projects carried out in co-operation with the NEA Secretariat, were not considered to be in competition as they were likely to merge into each other.

The NEACRP Committee recommended that the future activities of the Data Bank had to be considered in the context of the agreements with other data centres in particular the developments discussed at the annual Four-Centers meetings of the Data Bank, the Nuclear Data Section of IAEA, the National Nuclear Data Centre, BNL, USA; and CJD Obninsk, USSR.

Possible future activities for the Data Bank were proposed with about six man-months allocated to new projects. Data files on uranium supply and demand, nuclide migration, and reactor incidents were to be studied during 1980 with advice from Data Bank staff, but without diluting the Data Bank's more traditional activities. The Committee supported this limited involvement particularly in the field of uranium resources and demand. The Committee supported the trend towards a research library role for the Data Bank - not only for nuclear data, but also eventually including information on storage, migration, and disposal of radioactive materials. New requirements for nuclear data for rare and highly radioactive isotopes produced in fusion reactors were likely to give greater importance to reliability of nuclear model calculations as a supplement to scarce experimental information. A role for the Data Bank was expected to develop in organising and participating in comparisons and benchmarks to assist users of codes with factual and neutral guidance.

International Standard Problem Exercises (ISP) and Benchmarks

Benchmark studies and Standard Problem Exercises on an international scale were already in the Eighties of high interest to many of the laboratories and other institutions served by the Data Bank. These studies concerned specific problems investigated by different NEA committees: CSNI in particular organised such exercises rather frequently, while others had been set up by the NEACRP. It was thought that the expertise in implementation and diagnostics of programs would allow the Data Bank to make a useful contribution to the numerical and computational aspects of this work in co-operation with other divisions of the NEA Secretariat. Such exercises were seen in fact as in-depth SECU studies carried to their logical conclusion. The question asked was "Should the Data Bank become a future Benchmark Centre? In this respect should it be a Centre of excellence "? Committee members thought that this would be a way to motivate personnel as they would be confronted with really interesting problems. This should then be a complementary activity with respect to the work in national centres, and also be appreciated by the national projects. The real advantage of the NDB was thought to be the fact that different nuclear data files with their processing codes, and the possibility of producing group constant sets for applications, were available together with a variety of nuclear codes from different sources. Research could be done by comparing the data files, establishing the influences of the different sets in reference cases, by comparing codes with each other and against a reference. Both numerical approaches could be validated by intercomparison (accuracy, limitations, computer time) and the underlying physical models could be discussed. As a very essential consequence, this activity would help to define standardized calculational methods based on approved codes and to introduce standard code interfaces.

The Data Bank would be a centre co-ordinating such exercises, with support of scientific committees, organise meetings where participants would meet, discuss the results of their calculations with each other, the methodologies used, sharing experience in interpreting the experiments used as the basis for these studies and above all transferring to each other know how, understanding the different approaches and their value. In other words, such an activity would add much value to work done in different research centres. This sharing of experience and transfer of knowledge would have a valuable overall impact in the way modelling was done.

This idea of a benchmark centre for the NDB was thought to be meaningful if the machinery was available and the personnel had experience in the selected benchmark fields. This latter aspect should receive support from experts outside NDB. This new activity would also provide an incentive for code originators to making their computer codes available, knowing that they will be participating in benchmark exercises.

The first benchmark exercises concerned nuclear model codes. These were used to interpret experimental cross-section data and to interpolate and fill gaps in cross-section evaluations where experimental data was scarce or inexistent. Different classes of comparisons were distinguished, from code-to-code comparisons, to model comparisons and from benchmarking against actual experimental data. This was a start for a deeper verification and validation methodology of synergetic value for the nuclear data and computer codes activities. It covered first optical models, then statistical models, then pre-equilibrium models and their combination. Exercises were carried out on cross-section resonance analysis and estimation of level densities. Later high energy models of use in particle accelerator applications were addressed. This led to a unique set of nuclear model codes, covering interactions of the different technological particles, and the energetic range from thermal to the GeV region.

This idea had started through interaction with the Committee on Reactor Physics (NEACRP) and on Nuclear Data (NEANDC). Later it was further enhanced when the Nuclear Science Committee (NSC) took over an extended scope of these two committees.

Indeed, a large number of benchmark exercises were initiated, first on code-to-code comparison for verification purposes and later for validation using experimental data. This was very similar to the actions taken by the CSNI with their International Standard Problem exercises (ISPs). The OECD benchmarks and exercises became a reference all around the world and are widely presented at international conferences, as articles in journals and are continuously revisited for the purpose of new code verification and validation (V&V) and benchmarking.

The Data Bank involvement with NEANDC and NEACRP required preparation of specialist meetings, and as far as was appropriate, active participation.

Possible Extensions of the Data Bank's Work 1980-1985

Since 1978 the Data Bank Committee had held regular reviews of its medium-term programme, first by discussing the possible extension of the Data Bank's work for the period of 1980-1985, followed by one started in 1983 for the period 1986-1990, then one starting in 1986 covering another 5-year period. In other words, there was a continuous adjustment to meet the requirements emerging from the changing priorities relative to nuclear energy in member countries, where accidents such as the one in Three Mile Island and seven years later in Chernobyl had a major impact, as expressed by the national representatives at the annual Management Committee meeting. Adjustments came also by the needs expressed by the Data Bank customers.

The possible effects of technical changes in computer use, most notably networking, the effect of increased commercial exchange in software (in contrast to free multilateral exchange through the Data Bank and NESC/RSIC.) were considered.

Projections and proposals for the medium-term future of the Data Bank (1987-1991 and beyond)

A meeting of a so called "wise men group" was held in June 1987 to discuss proposals for the future programme of the Data Bank, chaired by Heinz Küsters. In the aftermath of the Chernobyl accident, its effects started to be felt also at the Data Bank. The "wise men" agreed that the Data Bank should increase its level of effort in support of the nuclear safety and radioactive waste management areas of work. However, reservations were expressed by the NDB Committee about the balance of effort and schedule proposed between these new areas and the traditional areas of nuclear data and computer program collection and distribution.

The NDB Committee reaffirmed the pre-eminent value to the nuclear power community in Member countries of the ongoing activities of the Data Bank and considered that these would continue to require more effort after 1988 than proposed by the Secretariat. In particular the Committee noted:

a) Nuclear data and computer programs continue to be essential for the safety design of nuclear reactors and more generally to the further development of nuclear energy.
b) There is a need to continue safeguarding the past investment in nuclear data and to maintaining the momentum on data evaluation work.
c) That the Data Bank by making good quality and well tested programs widely available contributes greatly to the overall productivity, reliability, and safety of the nuclear power industry throughout the Member countries. Comprehensive testing of key selected programs by the Data Bank is an important activity in this field which should continue.
d) That a natural and important development of these traditional areas of work at the Data Bank has become an internationally recognised Repository of Quality Assured (QA) computer programs and data. Such a Repository, functioning in a way consistent with developments in computer technology is a major contribution to nuclear power safety.
e) The work in support of nuclear safety and waste management should form an important part of the Data Bank's programme.

In the 1989 discussion on possible developments in the Data Bank's traditional services, the following important points were made:

- The need to extend the collection of nuclear data and programs for fusion applications.
- The need for high energy neutron and charged-particle data.
- The need to extend the availability of software for nuclear applications able to use the vector processing capabilities (and thus the full power) of supercomputers.
- Interest in advanced reactor technology (HCLWR and actinide burning reactors) and spallation techniques for nuclear transmutation.
- The need by national authorities for certified programs and data for use in reactor evaluation.
- The need to conserve know-how in reactor technology, as represented in the Data Bank's collections.
- The value of the Data Bank as a source of objective information, including the emerging need for programs suitable to model transport of nuclear materials and atmospheric dispersion of fallout.

The SC discussed the proposals to develop the computer services of the Data Bank to support the priority areas of the NEA programme, with emphasis on nuclear safety and radioactive waste management. It supported the reorientation, which was considered necessary to meet then the NEA programme requirements, but requested that a smooth transition be secured in order not to impair the quality of the continuing traditional services of the Data Bank and suggested that the costs for the supporting services of the Data Bank should be reflected in the corresponding parts of the overall NEA budget, finally it emphasized that any limitation on the funding of the reorganisation of the Data Bank should not adversely affect the level of its traditional services.

With the arrival of the new director general Kunihiko Uematsu at NEA, all activities had to be rediscussed. At its first SC meeting as DG, he stressed when highlighting long-term issues *"that the uncertain future of nuclear energy programmes in many countries called for a more adapted strategy by the NEA to contribute to maintaining the potential of the nuclear industry until after the lean years were over. This would involve, inter alia, reinforcing the assistance to Member countries in regaining public confidence; diversifying nuclear development activities in an effort to help Member countries in preserving the nuclear industry's capability and know-how, including qualified manpower".*

In this context a document was prepared on ***Development of the Data Bank's Services in 1991 and beyond*** pointing out the Data Bank's strong points:

- The computer program collection covers the whole field of the Agency's work.
- It has a service experience, and a wide customer base.
- Latest hardware, software is available as well as expertise for data base construction.
- It has a proven ability to use this, and to build new data bases fast.
- Also proven ability to expand the program collection into new areas.
- Experience in benchmarking programs (co-ordination and analysis of work by Member countries) has been acquired.
- User training seminars and workshops for important programs are organised.
- It gives support services to organizing international conferences.
- It has longstanding contacts with NEA committees (especially NEACRP, NEANDC).
- It is part of the international Nuclear Reaction Data Centres network, with access to all data generated.
- Links to U.S. software centres have been officially established.
- It runs the IAEA computer program service in return for payment in kind (liaison officer plus computer time).

It was also found that the success of the Data Bank so far had been in doing a few things well, and that it would be prudent to stick to that principle. Also, new projects taken on should grow naturally from existing work and expertise.

Among the topics where the Data Bank's skills could be particularly useful, the following were listed:

- Advanced Reactor Technology
- Extension of Existing Plant Life
- Decommissioning
- New Accelerators
- Fuel Cycle
- Transport of Nuclear Material
- Data Banks with Integral Benchmark Data
- Quality Assurance
- Knowledge Based Systems

At its October 1989 meeting, the Steering Committee approved the new Terms of Reference for the Data Bank. The minutes of that meeting add in addition the following clarification:

"The Data Bank Management Committee exercises its competence at more than one level: on the one hand, over the scientific programme of the Data Bank of interest to all Members and, on the other, over the support services given to different parts of the NEA programme. In the latter case, the Management Committee included representatives from the sectors of activity concerned. Under the authority of the Steering Committee, the Management Committee had to ensure that all activities remained profitable."

The use of the CiSi Computers

At Saclay, after the "amalgamation" of the CCDN and the CPL, at least the CPL group had to change all their working habits and procedures and to adapt them to the new environment of the CEA and CiSi.

The in-house computer, IBM-370/125, later PDP-11 was completely inadequate to verify and test among the largest computer codes of those times. Consequently, the IBM 370 series of CiSi had to be accessed. Computer Networks were then not yet developed, so that the so called punched "card decks" with the instructions for the computer and input data and data libraries on large magnetic tapes had to be carried to the computer centre about 1 km away. Later a teletype terminal was installed at the NDB to allow submission of computer jobs remotely, also disk space was made available to users, and file editing programs were provided with the IBM T(ime)S(haring)O(perating) system. The results in the form of "output listings" were delivered twice a day to the Data Bank. In order to shorten the turn-around times, programmers had to pick them up at the CiSi computing centre.

Program packages for dispatching were initially prepared through the CiSi computers. This required a large number of input/output operations. Now, the charging algorithm at CiSi was designed more for intensive computing rather than intensive input/output and therefore economically unfavourable for the NDB. Also, the system default parameters for using of peripherals were all set to penalize input/output. Consequently, a study was carried out on how to reduce the cost by optimizing the system parameters for the NDB applications. This led to the rewriting of the standard job control instructions and procedures and reducing the cost of the work by over a factor of 5.

Later, with the introduction of the VAX computers, the in-house capabilities were enhanced and part of the operation was transferred to the leased VAX installation. Computer costs were thus further reduced for the NDB operation and higher flexibility was introduced.

Figure 10: Data Bank staff, Saclay, 1985,
Pedro Muñoz Diaz, Olivier Arnac, Paul Moallic, Carol Morris, Helmut Jacobs, Renée Posca,
Ignacio Olabarria, Yukichi Yamaguchi, Rodolfo Dicola, Luigi Pellegrino, Enrico Sartori, Adrian Thompson,
Sheila Greenstreet, Johnny Rosén, Felice Lamantea, Nigel Tubbs, Eliane Foltran, Bernd Neumann,
Hideki Takano, Isabelle Forest, Luis Garcia de Viedma, Pierre Nagel, Nevine Cheta

Figures 11 and 12 show the computer configurations the Data Bank staff had access to carry out the different tasks of the programme of work in the mid Eighties.

Table XI: Example CiSi Tariffs in 1989

Computer/System	Batch Jobs	Time Sharing	
	Computer Use		Connect Hour
	Price per Unit(F*)		Price per Hour(F)
CRAY/COS	4.0	-	-
IBM/MVS	0.6	1.1	15
IBM/VM	0.4	0.6	15
CDC-CYBER/NOS	2.2	2.2	15

*F = French Franc

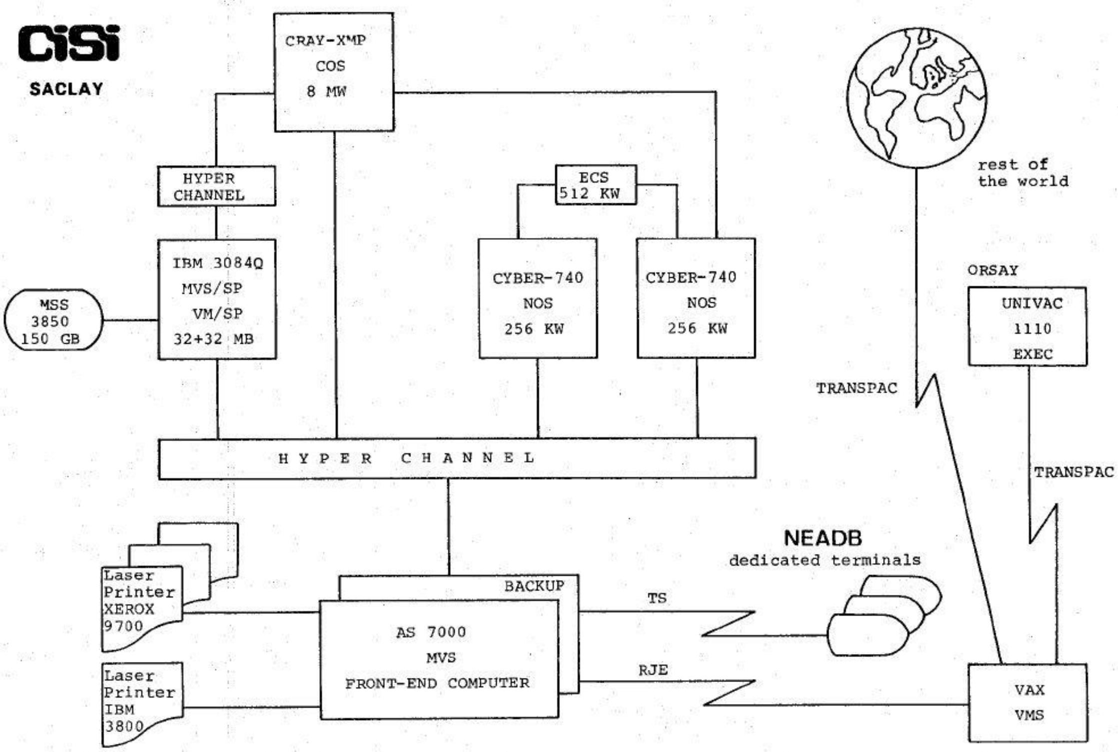

Figure 11: Access to outside computing facilities (1985)

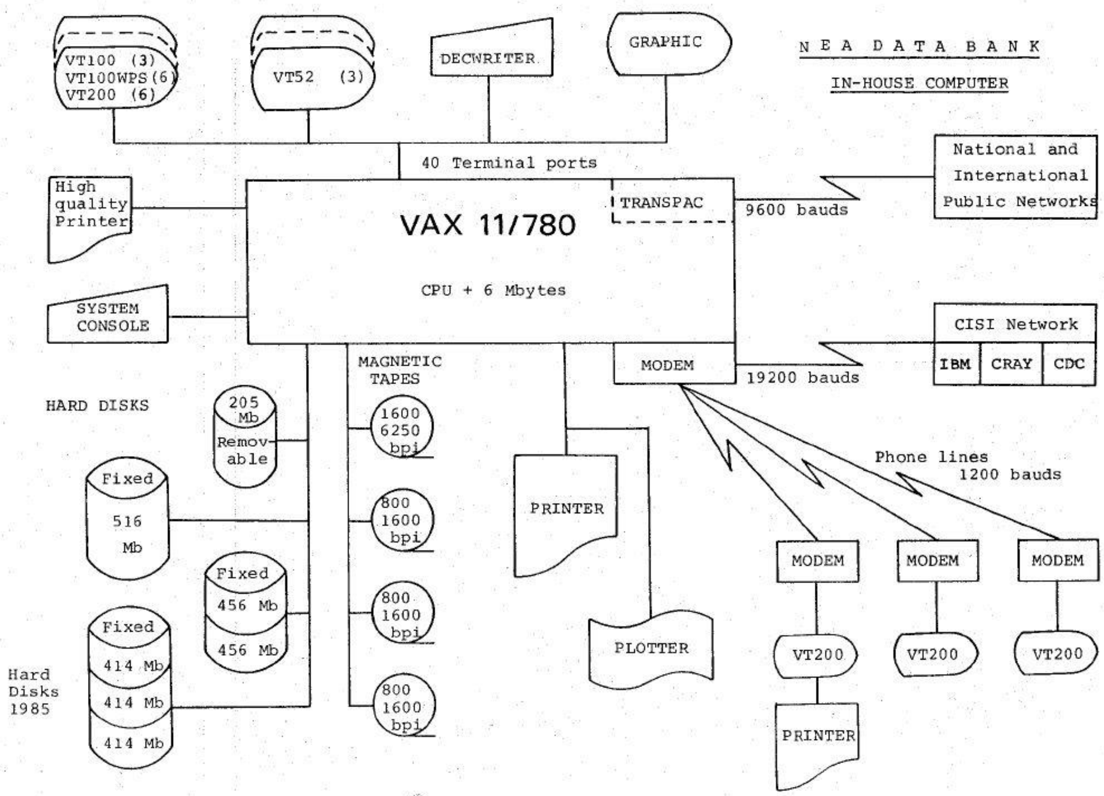

Figure 12: Configuration of Data Bank in-house computer (1985)

Development of database concepts and their installation

Already before the amalgamation of CPL and CCDN took place, issues related to best ways for storing structured numerical data that could be easily maintained, updated, and retrieved, were debated. In those times not many reliable computerized systems existed. Different database models were proposed, determining the logical structure of the data. Among these were the

- Hierarchical databases organized in tree-like structures with a single parent for each item
- Network models, an expansion of the hierarchical one allowing a many to many relationship between items
- Relational models based on tables, where information about a particular item is represented in rows and columns

Relational database systems were not yet matured when the Data Bank was set up so network models were implemented at the computer in Saclay. The advantage of the network database over the relational one was that access time to data during searches and retrievals was very fast and the PDP and the first VAX computers were not dimensioned for accepting simultaneous access from a large community if relational databases were used. The disadvantage of network databases was that they were inflexible: a modification to or expansion of the structure meant reloading the full database, which could take several days and would make the database not accessible during reloading. The relational databases on the other hand were very flexible and no reloading was necessary. As computers became increasingly faster, relational databases became more attractive and that model was then implemented and is still in use.

The first database that was converted to the new system was CINDA (Computer Index of Neutron Data), followed by EXFOR(Experimental data in EXchange FORmat). Next came all the data used for customer service that was stored in structured data bases. Most persons realised the great advantage of the new system. Data and information were stored only once and whoever corrected or amended it would share it immediately with all users. This decreased duplication, inconsistencies, and above all achieved a smaller error rate.

Visits to the Data Bank

The first Head of the Data Bank, Johnny A. G. Rosén, kept the contacts with the NEA Headquarters at Boulevard Suchet, and OECD Headquarters where he had an office. He understood quickly, that a vital way of giving visibility to the NDB operation was to invite visitors from national delegations, ambassadors, and the Secretary Generals of the OECD. For such visits he distributed the roles to be played by each staff member, and one can say that this was indeed done successfully. E.g., at that time the new term “word processing” was coined including somehow the automatic treatment and filing of correspondence. During his visit, the US Ambassador at large Richard T. Kennedy showed particular interest on how the Data Bank was handling the computerized correspondence and how letters could be searched and retrieved from the system.

The Secretary General Jean-Claude Paye was so impressed by the computerized operation of the NDB that before departing he said: “I want the OECD to become like the Data Bank”. This was indeed a flattering statement for the Data Bank, but the consequences of this were not only positive. In fact, the Data Bank was ahead of others because it had developed her own tools to handle the administrative tasks. In the meantime, commercial systems with similar functions became available and the term “office automation” was coined and used worldwide. NEA Headquarters introduced computers based on a Wang system, which was incompatible with VAX and the then installed Borroughs computer at OECD was equally incompatible. Each group felt to have made the better choice and wanted to impose its way. The OECD started to want the integration of the NDB computing into their system, although the Burroughs was completely inadequate for the NDB operations. To have an appropriate computer environment became for the Data Bank a continuous struggle, as Administration needed continuous reminders that the work at the Data Bank was different from the one carried out in the rest of the OECD.

Publicity / Publication

Program abstracts were distributed first on paper with an index (KWOC) to facilitate searching. It was later transformed into an electronic form distributed on diskettes. In a further development it was made available on CD_ROM with specific search facilities. Finally with the success of Internet they were posted on the Web to provide users with continuous updated information on new codes.

In order to keep requesters up to date with information on new acquired codes, integral experiments, of application data libraries, about publications issued, workshops, training courses and conferences of interest a bi-monthly electronic bulletin was sent out to liaison officers and subscribers. Liaison officers had welcomed the issue of an electronic newsletter in a poll carried out in 2000. The first edition was issued in December 2000.

Internet Listservers, fora for exchanging relevant information on experience with the codes, reporting and documenting problems encountered, and proposing corrections or announcing articles published had proven to be particularly effective. The first application concerned NJOY (nuclear data processing computer code system) and was extended to other widely used computer codes and for integral experiments databases with the aim of collecting user feedback.

Data Base construction for the NEA Main Secretariat

Collaboration had been established since early 1983 with the Radiation Protection and Waste Management Division of NEA in order to develop two small databases for information used in modelling the migration of radio-elements in the geo-sphere. The International Sorption Information Retrieval System (ISIRS) contained distribution coefficient data (K_d) and other information related to sorption while the complementary Thermochemical Data Base (TDB) contained standard chemical thermodynamic formation constants for solid phases and aqueous species of interest in migration modelling.

Radionuclide sorption processes are of importance in safety assessments of geological disposal of radioactive materials. The term ‘sorption’ is applied to a number of chemical mechanisms that cause particular elements to stick on solids rather than being carried in solution by flowing ground water. The practical effect is that although the movement of radionuclides is not stopped, it is delayed by sorption effects.

The International Sorption Information Retrieval System (**ISIRS**) was set up within NEA to develop a computer-based data storage system for the results of radionuclide sorption experiments. The project started in 1981 and was initially based at the Battelle Pacific Northwest Laboratory (PNL). The installation at the Data Bank of the data together with its software was approved in 1982. The Data Bank’ s role was to maintain the software system operational, while the division of Radiation Protection and Waste Management was involved in the updating and use of the data it contained.

The software system was quite sophisticated and had a large number of options for displaying the data, comparing it, extracting it following criteria set by the user. The weak point was that there was little experimental data available; the sorption parameter could not be derived through modelling to fill in gaps in the required parameter space for application, as it represented a macroscopic quantity often for diverse rocks or other geological materials. In the end it looked like a large beautiful castle with only a few inhabitants. For the specific purpose the system turned out to be too complex, too slow to operate and was later abandoned. Much simpler software became later available commercially, that was much easier to use.

One lesson was learned from this and other data bases: what matters for the long term is not so much the software designed for entering, verifying, storing retrieving, displaying the data, what matters after all is the comprehensiveness and the quality of the data, whether they were measured, interpreted, and evaluated according to standards, and had been subjected to QA procedures. Such data are of value also many decades later: the software around it will have changed many times in the meantime. Thus, an essential task and role of a group like the Data Bank is to contribute to the quality of the data. The database software is the interface for facilitating the access to it. (Additional information is presented in the chapter on “**Data Bank support to NEA divisions and committees”** where activities are presented by topic).

Cost Benefit Considerations of Direct Charges to Data Bank Users

During a session in 1983, following the examination of a document entitled "The Data Bank: present role and predictions for the medium-term future”, the Steering Committee for Nuclear Energy expressed satisfaction with the quality and efficiency of Data Bank services and invited the Committee to keep under review the question of charging for certain services.

The Data Bank Committee in turn discussed this recommendation in May 1984. After a detailed analysis of factors affecting any decision about direct cost recovery from users, the Committee concluded that introducing such a system of charges would lead to severe difficulties, and recommended that the Data Bank avoid doing so. But it was then agreed that the Data Bank Secretariat should in addition make a cost-benefit study of charging for these services. The question of charging had been reviewed on earlier occasions also when it was concluded that it was not desirable to introduce a system of charges for services to users. It was concluded that budget savings should rather be sought from increased productivity, and these savings were in fact achieved with the formation of the Data Bank in 1978, and had been improved on since then.

Obsolete programs?

The question as to whether it makes sense or not to keep codes in the CPL or CPS that had been developed in earlier days was raised. Codes were declared obsolete, once a new, improved, or corrected version of the same code became available. The obsolete codes were however removed or sometimes kept in the archive for the case where some tests had to be repeated for comparative purposes with the revised ones. As the number of codes increased over time and disk space became scarce, another criterion would be used: a code older than 10 years was declared obsolete and removed from the active ones. This turned out to be a wrong decision, because some codes that had been developed for innovative concepts, had been lying dormant in periods when the topic was not of interest, but when renewed interest was shown, the knowledge accumulated in them could not be retrieved. Consequently, codes solving special types of problems were kept alive because of their uniqueness. As computers became faster, codes grew larger and more integrated in the sense that they would couple features often run as separate codes in sequence. Also because of the fantastic increase in speed of computers (Moore's law, Fig. 28-29), increasingly brute force approaches were adopted and the codes were used often as experimentation tools. This was possible because turn-around times to obtain a solution to a test became trivially short. The codes of previous generations however had been developed to use minimum computer memory, to use smart methods to reduce computing time and simplifying models removing unnecessary complexity for the objective considered. Such codes are still today a mine full of good ideas and bright methods of solutions and should thus be maintained at least in an archive as documentation of past development, as basis for QA as they describe the origin and ideas of certain developments. Some of these ideas are certainly of good use today. So, what was old was not necessarily bad, on the contrary, it was a source of inspiration for solving problems.

Caution in declaring material obsolete was of particular relevance for application-oriented interaction cross section libraries. These data had been derived from evaluated data in specific group structures or in continuous energy form, some of them adjusted using integral data, thus often used as reference for certain applications. As revised or improved evaluated nuclear data libraries became available, new such libraries were derived. The previous data libraries were not declared obsolete, because these were an essential piece required for tracing results obtained previously and for comparative purposes. This was particularly important to industry. Without traceability it would have been difficult for industry to adopt the new libraries as the complete new validation process would have had a very high cost.

Principles relative to restrictions to be applied for distribution of information

As the information stored and handled at the Data Bank started to be accessible via network[29] in the early Nineties a discussion took place at the Top Management Level, as to what data and codes would be generally available and which ones had to be subjected to a controlled distribution. The discussion was completed with the involvement of the NDB management committee members. The following was agreed:

(a) Basic scientific information and data was considered like a heritage of humanity that can be shared without restrictions and therefore would be freely available to anyone who needed it. This was considered to be the best use of funds spent for its development as it would enhance new developments and foster new ideas. This meant that all basic nuclear data for particles, as well as chemical thermodynamics data would be accessible on-line.

(b) Information, data, computer codes that could be used for direct technological developments and applications would be subjected to restrictions, in the sense that only authorized users would be able to obtain them. These users would be designated by national representatives for their country. The distribution of such information would be recorded together with the declared purpose of its use, whenever required. This applied to computer codes (with the exception of codes for fundamental research, such as nuclear models), application oriented nuclear data libraries, both in multi-group or continuous energy form.

Hands-on training courses on major computer programs

Training courses started to be held as part of the knowledge preservation and transfer activities of the NEA. They should ensure that competent use is made of computer codes distributed by the Data Bank, and expert lecturers would transfer their knowledge to participants.

While the programs normally offered to the Data Bank have been tested to a high standard and in many cases validated in program comparison exercises (benchmarks), there remains a clear need for user training. Starting 1986 the Data Bank has organised seminars and workshops on well-known programs, followed by hands-on training courses, which have been attended by a large number of participants. In fact, over 2000 participations in 112 courses were registered. Most were held at NEA Headquarters, but the others in 20 different towns in 10 European countries: Belgium, Czech Republic, France, Germany, Hungary, Italy, Netherlands, Portugal, Spain, and the UK. Other courses linked to these were held also in Japan and Korea and many (MCNP, SCALE) in North America. These have been organised in collaboration with universities and research centres.

It is well known that the best computer code can produce wrong results if used by inexperienced users. When computer codes were small, used by experts only, no specific training was

[29] The first attempts to dispatch computer programs over a network were carried out in the early Eighties. The protocol then available was rather primitive as the transaction records, unlike for the TELEX would not confirm the delivery. It was therefore necessary to send either a fax of confirmation or make a telephone call in addition.

required. With the increased use of computer codes for modelling practically every aspect of science and engineering, a larger number of users need to be trained to ensure a correct and effective use of them. It is with this in mind that the Data Bank has organised courses and seminars on essential nuclear codes for many years.

Figure 13: First hands-on training course at the NDB, Saclay on geochemical modelling, 1986

These courses were financially self-supporting. The topics covered in the training courses, sorted by frequency or demand are shown in the following table.

Table XII: Hands on Training Courses at the Data Bank

Nr.	Code / Hands-on Training Courses
44	MCNP Monte Carlo Particle Transport
20	SCALE Modular System for Criticality, Shielding, Source Term, Inventories, Reactor Physics
17	PENELOPE Electron-Photon Transport by Monte Carlo
7	NJOY Evaluated Nuclear Data Processing Workshops / Users Group meetings
7	Analytical benchmarks - Neutron Transport Theory
5	TRIPOLI Monte Carlo Particle Transport
2	Geochemical Modelling with EQ3/6 and PHREEQE
2	FLUKA Monte Carlo general purpose tool for calculations of particle transport and interactions
2	SAMMY Multilevel R-Matrix to Neutron and Charged-Particle Cross-Section Data
1	REFIT Multilevel Resonance Parameter Neutron Transmission, Capture, Fission & Self Indication
1	AMPX Evaluated Nuclear Data Processing
1	EASY European Neutron Activation System
1	Electron and Photon Transport Code EGS4
1	PHITS Particle and Heavy Ion Transport Code System
1	WIMSD5 Reactor Lattice Calculation for Thermal and Fast Reactors
112	Total

Figure 14: Monte Carlo MCNP Training Course, Issy les Moulineaux, 2003

The institutions hosting the courses, besides the Data Bank at Issy-les-Moulineaux, were the University of Stuttgart, GRS in Garching (Germany), CEN-SCK in Mol and IRMM in Geel (Belgium), ENEA Bologna and University of Pisa (Italy), NRG Petten, (The Netherlands), Imperial College London and AEAT in Winfrith (UK), ITN in Lisbon (Portugal), CEA at Aix-en-Provence, Avignon, Paris and Saclay, FIRAM at Montpellier (France), University of Catalunya in Barcelona and University of Baeza (Spain), KFKI in Budapest (Hungary), NRI in Rez, Prague (Czech Republic). This ensured that the training would be easily accessible to many member countries.

In conclusion, there was a general understanding that good results from simulations with computer codes would be obtained only under two conditions: 1) the code was verified and validated; 2) the user was qualified, competent, and trained to use it.

The "best" computer codes

At annual meetings occasionally the proposal was made, that the CPS issue the list of the best codes for each subject category. This would help users / customers to make a valid choice among the panoply of the ones available. The criteria for defining what "best" means not having been specified, this sounded like one of those impossible tasks. First of all, such a definition would cause a possible conflict with the authors, who generously made their work available at no cost to others. The task of carrying out a comparative study on tests covering a wide range of parameters would have been very expensive with the need of calling in expertise from outside[30]. The CPS finally chose to inform, if requested, which were the codes more widely used and which ones seemed to be successful in applications. In order to support the validity of the codes, reports on code verification, validation and benchmarking were gathered and added to the packages thus enriching the documentation or bibliographic references were added to the abstracts as an aid to users. This was done in particular if the benchmark study was carried out within the activities of the reactor physics or nuclear data committees. The CPS also requested regularly feedback from users which was part of the release condition, in particular errors of coding users had found. This proved not to be very successful: only few users

[30] In one case, someone with good will, but a bit naïve, had proposed that he himself would compare each code against the other among the 50 nuclear model codes the Data Bank was distributing then, in order to find out which one was the best. This cyclopean work would have involved over 1000 comparison just for one problem case.

provided feedback. As explained elsewhere, the “best” computer code can give wrong results if it is not used by a competent and qualified user.

Adopted quality assurance procedure of computer programs at the Data Bank

A proposal for verification to a high standard of a small number of very important programs was discussed at length in 1989. Verification, which could be carried out by the Data Bank in co-operation with interested centres in Member countries would result in a fixed and well-defined production version quite distinct from any development versions. After sufficient practical validations in Member countries, such a production version could be certified for use in reactor licensing procedures. The Data Bank's role would be to co-ordinate the testing, and to prepare and distribute "loadable" copies of these packages ready for execution on a particular computer, together with all relevant documentation and data sets. The necessary copies of source code and data sets for licensed programs should be held by the Data Bank for reference over a long period. The high cost of such verification would make special financing or co-operative working arrangements necessary, to spread the cost between interested parties. Alternatively, or in addition, a substantial charge would be made for the verified package. Formal arrangements should be carefully worked out so as not to upset the present free-of-charge distribution arrangements for software. During the discussion, it was stressed that the legal responsibility for choosing and validating such a package would remain with the end user. Cautionary notes were sounded on several points: the large amount of man- power needed for the project, and possible problems in the exchange agreements with the U.S. The concept of program portability would be sacrificed, since only the "object code" would be certified. There would be a continuing and serious commitment to maintenance, and to verifying updated versions of the programs distributed. This idea was finally abandoned as it would have become a source of conflict especially with the increasing number of computer code vendors and because the manpower available was largely insufficient.

Revisiting Computer Program Testing

A subset of the Data Bank Executive Group met on the 24th May 1994, to discuss a proposal from the Secretariat concerning computer program testing criteria. The proposed four different levels of program testing were: screening, full or standard testing, program validation or benchmarking, and full quality assurance testing. The general testing criteria were approved by the group. A minimum number of programs would be fully tested per year in order to have a sound renewal of the program collection. Better feedback from code users would have to be sought, especially from those who had received only screening and the not fully tested programs. The benchmark validation of codes was found to be important and should be closely linked to the activities of the NSC. A maximum of one code per year should be considered for full quality assurance testing. The Executive Group stressed the importance of continued program testing and dissemination and left it to the Data Bank to select the criteria and to allocate the resources necessary to fulfil this task. High priority was given to the need for a quick response to user requests.

An endemic **backlog** had resulted towards the end of the 1980s and beginning of the 1990s due essentially to the reduced staff allocated for testing. The afore mentioned Task Group defined the criteria to be used in setting priorities in program testing, as well as on the minimum effort that should be devoted to the different levels of testing.

- "Screening only" should be used to speed up dispatch of programs to users agreeing not to require testing and on condition that they would provide feedback on their performance. In general, screening does not reduce the overall workload; it only delays it. For many cases, in the end screening leads to an increase of the workload.
- Program testing is essential and should continue to ensure that the information distributed is of adequate quality. The criteria defined for testing are well-structured and valid. They are:

- Frequency of request (market driven)
- Importance and relevance to the NSC projects
- Importance and relevance to other NEA projects and activities
- Conformity with the co-operative arrangements between NEA and US DoE as well as IAEA.

In order to ensure a renewal of the stock of programs and to keep a certain dynamism in the service, a minimum of programs would have to be tested each year.

- Validation and benchmarking are an activity of great value and should continue under the supervision of NSC.
- The "quality assurance" procedure defined by WPAC (see also section on ***Concepts used at the NDB for code Verification and Validation (V&V)***) should be limited to about one program a year. The selection would be made either by the NSC or on the basis of the bestseller list.

Among the possible means for reducing work pressure on the Data Bank were mentioned:

- Insisting that authors provide well-tested programs;
- The Data Bank should improve the feedback mechanism from users.

Sufficient manpower had to be allocated to program testing at the Data Bank to carry out meaningful work.

November 1990 Think Tank on future of NEA-DB, -NDC, and -CRP

There came the period of the “think tanks”, a group of senior scientists or experts[31], often already retired, called to express their point of view about future developments and perspectives. External and independent views have always played an important role in exploring new ideas and possibilities for developing the activities of the group. When it came to find a consensus, it was clear that it had to be the consensus of peers, not just any consensus in order to be one of quality.

A difficult period for staff was when it was decided that the Agency, who originally was dispersed over 4 different premises (Suchet, Ingres, Saclay, Ispra), later 3 (Suchet, Ingres, Saclay), had to move to a single one, with the aim that the different divisions worked closer together, and would profit from improved synergy. This was the period of the lean years for nuclear energy and when the Agency was under budgetary attack, with continuous requests for cost reduction. Nuclear energy development was at a stall or “rock bottom” as some would say as a consequence of the Three-Mile Island (1979) and Chernobyl (1986) accidents. The strategy of K. Uematsu, DG, was to deeply restructure and thus strengthen the Agency during this period, in view of a restart of nuclear energy development. A large part of the staff was against this moving together. They saw their personal disadvantages and a growing uncertainty for their future, and not that such a strategy was sound for the survival of the Agency as a whole. Some errors occurred in addition, beyond the control of the DG: the space requirements were wrongly calculated, the building chosen was inapt to allow the installation of the photocopying machines as well as the computer equipment from Saclay. Staff had to accept a strong reduction of the working space. Finally, the structure of the building was not apt for communication among staff[32]. This move was particularly difficult for some of the Saclay staff, as they had to commute every day for hours in heavy traffic.

But humans are flexible and adapt to new constraints and again looking back, the strategy of the DG shows a good foresight and an anticipation of changing times: he did what was expected from him as a director[33].

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[31] A joking statement says, “never ask more experts, ask only one, because they have all different opinions”. Some critics pronounced “think tank” the German way, i.e. sink tank.

[32] In order to reach the office of the DG most staff members would have had to cross 8 doors. Comments went like this “he is beyond the 7th heaven”.

[33] Some said: “he left no stone unturned, he changed everything”.

Proposal for a new committee – the Nuclear Science Committee (NSC)

The new DG K. Uematsu found that there was a general lack of understanding of the activities and internal relations between the Scientific Committees NEACRP and NEANDC and the Data Bank Committee. He proposed to improve this situation by introducing better horizontal information exchange between all NEA Standing Committees. With the aim of a simplification in organisational arrangements and a broadening of the scope of co-operation it was proposed to create a new committee to be known as the NEA Nuclear Science Committee (NSC) covering the whole area of pure and applied science related to nuclear energy.

This Committee should concentrate on policy issues and on developing the science programme which would ensure the necessary scientific base for the Agency's activities. The new programme should build on the work in progress under the existing committees keeping in mind the need for closer integration of their fields of expertise. Change would be evolutionary rather than revolutionary so that the right balance would be maintained between modernizing ongoing and valued projects (in particular Data Bank services to Member countries) and introducing new projects. The results of the work under the Nuclear Science Committee should be communicated efficiently to other NEA committees and to the scientific community in Member countries.

It was repeatedly stressed that the scientific and technical capabilities of the Agency should not be reduced and that the traditional services of the Data Bank should be maintained. Delegates underlined the importance of maintaining the unity of the Data Bank, which was felt to be essential to its effectiveness.

In this context of change also the logo of NEA was modernised.

Restrictions on the distribution of computer codes to the non-OECD area

In accord with the co-operative arrangement made with the IAEA (see section on “co-operative arrangement with the IAEA) on the service to the non-OECD establishments, computer codes originated in the NEA Data Bank member countries were distributed without restrictions since 1968. On a temporary basis countries subjected to sanctions from UN resolutions, after confirmation from the DG of IAEA, would be excluded from the distribution.

The arrangements’ first set up to provide computer program services to IAEA members had been revised in 1981. It did not though specify any eligibility criteria for potential non-OECD users, and in view of the OECD’s increased emphasis on relations with non-Member economies and the heightened concern about nuclear non-proliferation, the DG of NEA suspended the service as of May 1992 in order to allow the Steering Committee to review the programme. In 1992 the background of the arrangement for exchanging computer programs in the nuclear energy field between NEA and the IAEA, covering more specifically service to non-OECD economies, was outlined in a NEA Steering Committee (SC) document entitled "Review of the Arrangement for Provision of a Computer Program Service to non-OECD countries by the NEA Data Bank". It provided also the rationale behind the decision to suspend temporarily the services, namely the need to review and clarify the general distribution policy.

The service was reviewed at the Data Bank Management Committee meetings in June 1992, then at the following Steering Committee meeting and again at the NSC meeting in November. The DG sent out a letter to the permanent delegations to the OECD to verify whether the status of non-restriction on computer codes distribution to members of the IAEA but not members of OECD still applied, and if not, to provide specifically such restriction. Countries responded with different instructions. Some confirmed that no restriction applied, others specified that a case-by-case rule would be applied and, in each case, an official authorisation was required, others applied restrictions only to some categories of computer codes. This made the dispatch of the programs more complicated and could thus not be automatised. Each dispatch had to have an associated record specifying what rule was applied in authorising the distribution. This information was stored in the dispatch database and both statistics about the use of rules and the authorisation letters could be retrieved on-line.

Reviewing the experience with regard to this programme since 1968, Mr. Jacques Bouchard, the Chairman of the Nuclear Science Committee, underlined the benefits enjoyed by the NEA Data Bank and its member countries as a result of the significant contribution made by a number of non-OECD countries to the service, as well as the advantage that it provided in avoiding duplication within the scientific community. He added that the computer programs in question were mainly applicable to civil applications and did not contain sensitive material, although some of them could conceivably be used for other purposes. He noted, however, that precautions were normally taken in such cases by the contributing countries who could specify restrictions on the distribution of any particular program. Even though they recognized the non-proliferation concerns that may be related to this issue, the delegates expressed support for continuation of the program service to non-Member countries. The majority of speakers shared the view that there was little likelihood for any sensitive material to be involved, and that it would not be desirable to impose control measures that were out of proportion to the actual risk.

Figure 15: Data Bank staff and families at a birthday party in 1989

The DG agreed that the computer program service provided by the NEA Data Bank to non-OECD countries should be continued, subject to limitations specified by contributing countries with respect to distribution of their codes; and agreed, therefore, that contributing countries should be asked to specify any such limitations; it agreed that the practical modalities of application of guidance by contributing countries should be worked out as necessary by the NEA and the IAEA secretariats; and that the NEA and the IAEA should, in any case, regularly consult about the matter of possible limitations on the distribution of codes. Most Member countries have provided guidance to the Agency as to which programs are subject to a restricted distribution.

REMOVAL to ISSY-LES-MOULINEAUX

The most important event in 1992 for the Data Bank was the move from Saclay to Issy-les-Moulineaux. This implied several changes, e.g., the existing in-house computer was replaced by a VAX 6000-510 partly because of the need for more computing power, partly because of the easier and less costly maintenance and also because the previous computer was overweight and could not be installed on the top floor of the building. Personnel also was decreased: the main factor determining this was that through the moving to the same premises some of the administrative tasks were to be shared with NEA. No extra funds were made available for the restructuring of the Agency, and a large part of the funds required for establishing the new headquarters were taken from the Data Bank budget, thus no funds were available for travel to meetings outside Headquarters to the Data Bank staff that year.

In 1993 the agreement between the United States and the NEA on computer program and nuclear data exchange was renewed.

Disappearance of name "Data Bank"?

In 1999 a memorandum of understanding was signed between the International Atomic Energy Agency and the Nuclear Energy Agency. In this text the Data Bank is nowhere explicitly mentioned, although a co-operative arrangement had been signed in 1968 and renewed at different times later. The name Data Bank had disappeared! Also, in the titles of official documents the term "Data Bank" was not any longer in use and the term "Executive Group" was coined. This somehow diminished the visibility of the Data Bank, harmed indirectly her reputation and was a source of confusion.

Different approaches in setting up projects

Points of view and proposed approaches within the Data Bank differed concerning how to set up new projects and further develop them. Some wanted to design a complete, all comprehensive scheme and structure to be filled with actions and results, others preferred to identify a well-defined project with clear objectives and deliverables, to test it through pilot activities, to build it up on feedback acquired in this process, then little by little make it grow using a kind of **snowball effect**. The second approach proved to be the winning one, because what counted for the members of the committee was the proof that it can be done, that success was assured and that it was acquiring credibility. The all-comprehensive scheme was too dispersive, there were difficulties in seeing progress and was often abandoned.

The year 2000 "bug" (Y2K)

The kind of general panic around the Y2K bug also influenced the activities at the NEA somehow, in particular the sector dealing with nuclear safety and regulation. It concerned the potential problems that might have been experienced by computers and related systems and equipment when the date changed from December 31, 1999, to January 1, 2000, which computers might have read to be the year 1900. The NEA Data Bank, distributing over 2000 different computer codes for different makes of computers, had to analyse each program in that respect. As expected, no problem with the Y2K bug could be identified. First of all, no safety critical software was being distributed that would be used in real-time on-line. Most computer codes were not using date and time internally, and those who did, would call a system routine, outside the code itself for the purpose, or had a specific routine in machine language (Assembler). Into these latter code packages, a statement was included advising users to replace the routine with the corresponding designed for their system not having the problem. The disappointment was, as we know now[34], that during the first seconds of the year 2000 nothing happened, but software companies dealing with this had made a fortune, followed by a general market flop during the following years.

WORKING METHODS AND METHODOLOGIES ESTABLISHED WITHIN THE CPS

On structuring integral experiments databases

At the Data Bank the databases for integral experiments were structured essentially in two ways

1. Databases that require continuous updating and maintenance
2. Databases that require rare updates or none

For the first type a database management system such as ORACLE, OPEN-SQL, ACCESS are used. For the second a hierarchical tree structure of files consisting of an index, a structured abstract or synthesis, and finally the data files and corresponding documentation were most appropriate.

The first one requires software maintenance, upgrades, and user interface management, which can imply a certain amount of continuous effort as information technology evolves. The second case is 'lighter' in that it requires little maintenance, such as taking care / integrating feedback from users and ensuring its integrity over time and that the information is transferred across the evolving technology of storage media. Of the latter one each has an index describing with one line the item e.g., overall experiment / or the title of it. This title is linked to the structured abstract, which describes in more detail the experiment of the data gathered together with a description of the files and documentation available. This part of the structure consists of meta-information and is retrievable on line. The data and reports themselves are not on the Web as they are subject to controlled / authorized distribution. The full set or a subset or a single experiment is distributed, depending on the specific request made.

The full databases or subsets thereof are distributed on CD-ROM or DVD bearing the name of the recipient or organization together with a unique identifier. Users prefer this form as it represents the proof of having an authorised copy of the original. The Data Bank keeps track in the DBAIS database (see next section) of the transactions with the purpose of gathering feedback and for informing recipients of changes / updates. The CD-ROM/DVD obviously contains the full information: index, abstract, data files and documentation.

The files consist normally of tables with headers in ASCII, WORD, or EXCEL format; the reports are either in PDF, WORD, or ASCII file format. Feedback or reports describing the use made for validation of models and computer codes are added as they become available and recipients of those data are regularly informed of the updates.

Data Bank Administration and Information System (DBAIS)

A simple computerised system existed from the start of the computer program service but a more modern database was essential to register all transactions of items received and distributed as set out in the Term of References. A full traceability was requested for computer programs by the national delegates first of the CPL and later of the NDB Management Committee (Executive Group).

All operations of the program service were registered and monitored in DBAIS, a central on-line database. Originally DBAIS has been developed around the Data Base Management System DBMS-11,

[34] A FORTRAN programmer was so scared of what could happen with the arrival of the year 2000 that he decided to get himself hibernated. When he woke up, he did not recognize the persons around him and said: "So, I have survived the year 2000. What day is it today?" "31 December 2999". "Why did you not wake me up earlier?" "Well you are the only programmer still knowing FORTRAN and we need you to fix the year 3000 bug".

licensed from Digital Equipment Corporation, later on an ORACLE and ACCESS relational database system.

A main entry point for accessing the database is the Identification Number. It identifies the individual computer program or data package. The data type item contains a detailed description of the material relating to computer program or data sets that belong to the “package”: file descriptions, report references, etc. Time histories of all actions taken on them, e.g., time of arrival, integrity checks performed, etc., can also be found there.

The abstract text, which is subdivided into the different subject items can be accessed and updated. The individual data requests are registered and are linked to the User Profile i.e., information on name and address of the requester, required dispatch format, etc.

In the full schema of DBAIS, many data types are broken down into subunits to allow for a host of special queries to be formulated and retrieved easily. A number of update and query programs have been developed around DBAIS. Most of them are used internally by the Data Bank for its day-to-day work. A neural network system has been introduced to automatise the identification and classification of more than a million data files.

Inquiry about use of computer codes

The range of topics covered by the full set of computer program available from the NDB is very vast as shown in Fig. 17

Some NDB committee members argued that the scope might be too wide and wondered whether or not it should rather concentrate on nuclear power applications. The use made depends obviously on the application of interest to the program users, whose establishments were nominated by the National delegates in the NDB Management Committee. Consequently, an inquiry was made as to the use made of the service provided. Fig. 16 shows that non-power applications are predominant in universities, while in research, industry, and engineering companies, nuclear power is predominant. The distribution by countries showed as expected a predominance of non-power applications in those countries not embarked in nuclear power. In order to satisfy the needs of all participating countries it was agreed that the subject scope should not be reduced.

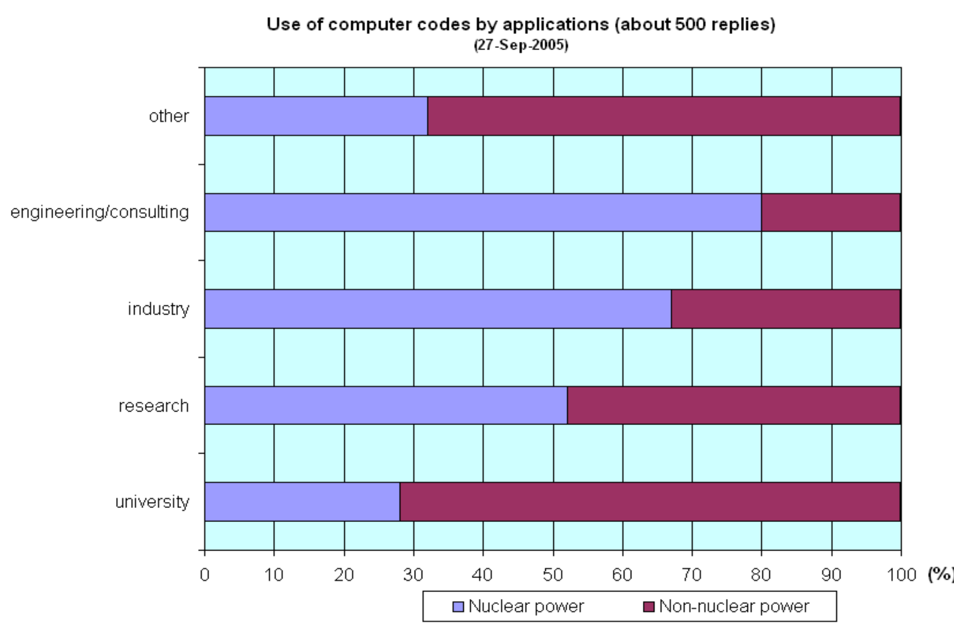


Figure 16: Use of computer codes by applications (2005)

Out of the about 6000 different computer codes or versions acquired over the years, about 2000 are still in the active status. Some have been retained, even though aged, because they contain original developments from the past.

Fig. 17 shows the subject categories and their percentage of the about 2000 computer codes that are still in active state at the Data Bank. Statistics about annual preferences by subject have been investigated to find trends. Annual fluctuations are strongly correlated with the topics of the new programs released or special topics of workshops and conferences. Overall trends can be seen by grouping the data in time slices of 5 years. It could be observed that emphasis started mainly on the original reactor physics codes, but with time it has moved to safety computer codes especially in periods after nuclear reactor accidents.

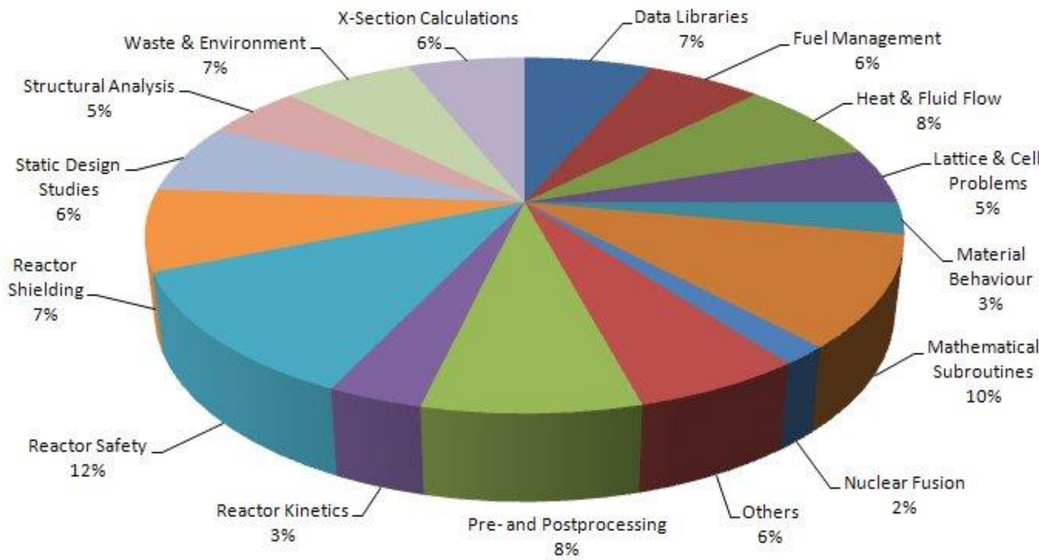


Figure 17: Profile of the full-set of computer codes available (about 2000)

Access to NEA Web Services

In order to streamline the service and the searching for increased efficiency with the use of new technologies a poll was carried out inquiring as to which topics on the NEA Web users were most interested in and their level of satisfaction. The satisfaction with the on-line services and Web information of the Data Bank was high, and a few suggestions made for improving access to information were implemented. This on-line method has thus been retained for further developments. Fig. 18 shows the frequency of access and interest at the time of the inquiry.

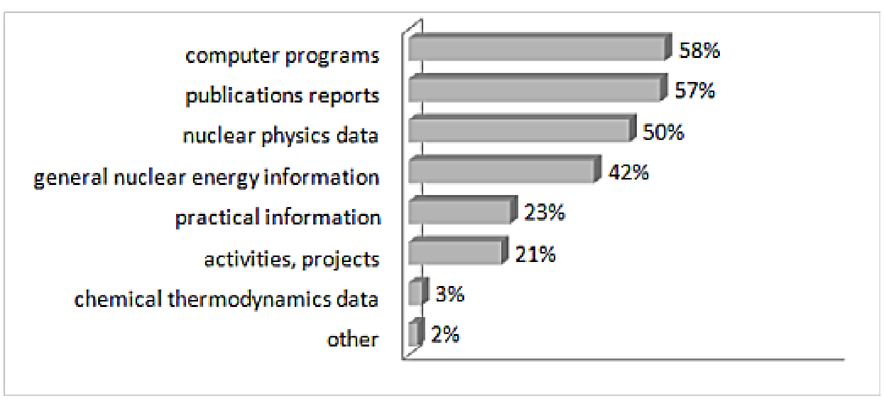


Figure 18: Access to NEA Web services

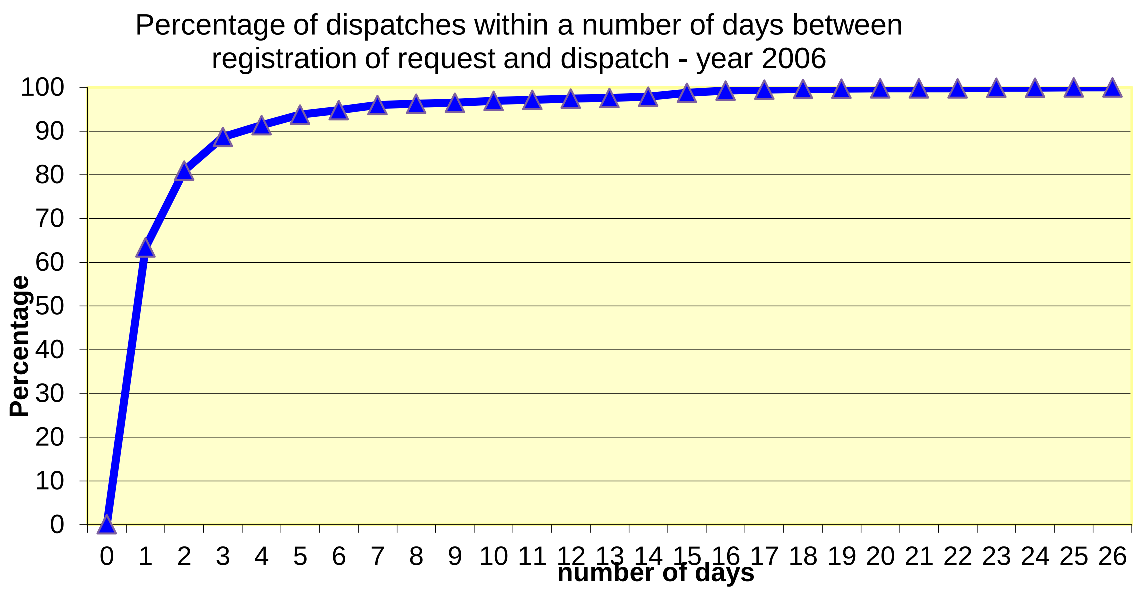


Figure 19: Percentage of dispatches within a number of days -2006

Delays in responding to customer requests were measured regularly. Fig. 19 shows that 2/3 were dispatched within 1 day of the time of registration and the time they were sent off, and 9/10 within 4 days. This was considered satisfactory by the users. Some of these internal delays were considerably longer, as some codes had to be tested by CPL first.

Interactions between Author / Data Bank/ User in the Programs and Data Exchange

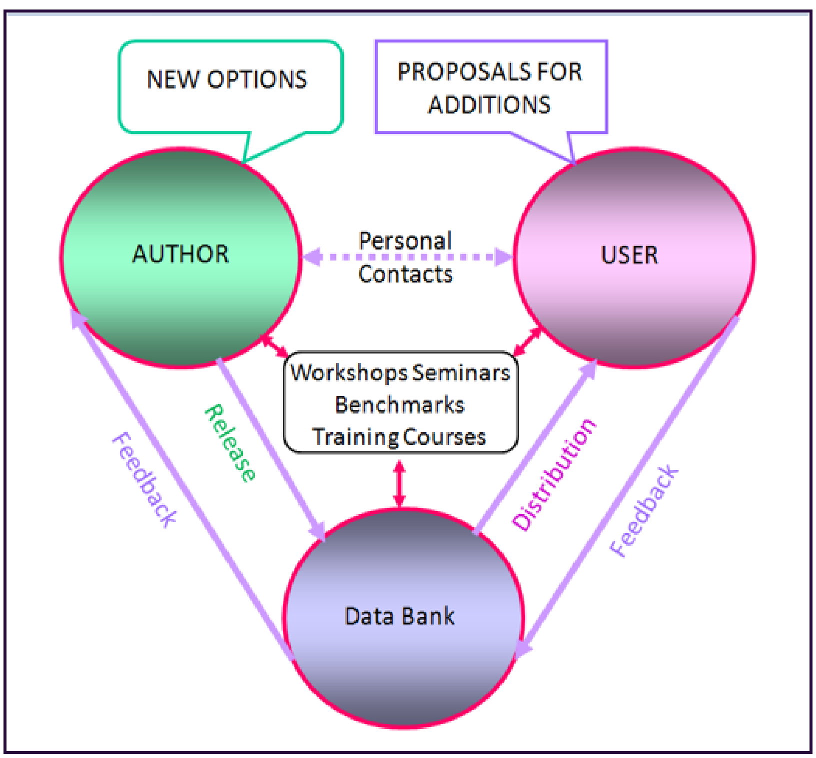


Figure 20: Interactions between Author / Data Bank/ User in the Programs and Data Exchange

In order to remove the burden to the author of a day-by-day interaction with users, administrative and some technical issues such as reporting errors or proposing some amendments are centralised and taken care of by the CPS at the Data Bank. Authors and users meet at Workshops, Seminars, Training Courses, and Benchmark Studies with the purpose of enriching the exchange of experience and to discuss difficulties encountered or desired improvements. This feedback mechanism has proven to be particularly effective and beneficial for all parties and for code authors to ensure that a large Verification and Validation base is thus established, because users' applications cover a wide field going beyond the authors' experience.

Concepts used at the NDB for code Verification and Validation (V&V)

The NDB is an institution for the collection, verification, validation, dissemination and enrichment through user experience and feedback of the basic tools used today for nuclear energy system design and the simulation of their functioning under different operating conditions. These tools comprise standardised databases with microscopic basic nuclear and chemical-thermodynamic data, computer programs for a wide range of applications, and integral experiments on fissile material systems, reactor or radiation shielding mock ups and on in-core fuel behaviour. Part of the work is carried out in co-ordination with NEA Nuclear Science Committee (NSC) in particular as concerns the establishment of international integral experiments databases. A major international activity involves validation of current and new calculational schemes comprising computer codes and nuclear data libraries, for assessing uncertainties, confidence bounds and safety margins, and to record measurement methods and techniques. The following paragraphs describe some of the principles and methods developed. Fig. 21 explains the meaning and relation between the different activities.

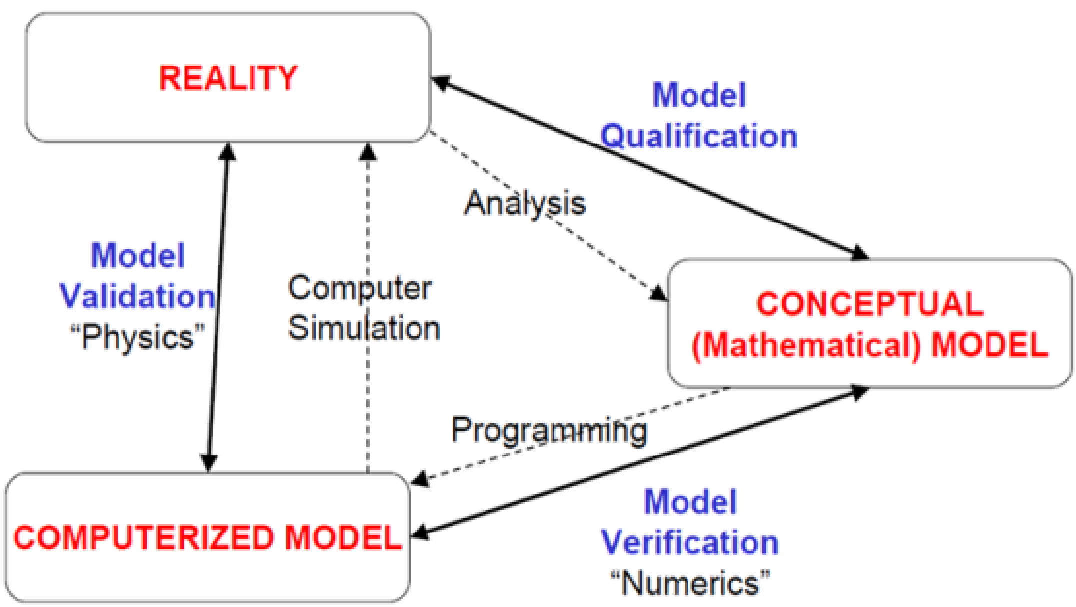


Figure 21: Model Verification, Validation, Qualification (Source: D.G. Cacuci)

The Data Bank had closely followed the work of the NSC Working Party on Advanced Computing (WPAC), and especially the drafting of a report on guidelines to help developers, users and regulators achieve and demonstrate the quality of scientific and engineering analysis software used in the nuclear industry. The topic "Software Standards, Validation and Exchange" was addressed, to be devoted to wider discussions on Quality Assurance and software for supercomputers, and the remainder to program validation and service work. A report describing existing standards was prepared, but the attempt to harmonise them with each other failed. Instead, a Task Force on Supercomputing in Nuclear Applications was established, which was active for many years. The spin-off was the establishing of the International Conferences in Supercomputing in Nuclear Applications (SNA)[35].

Another point discussed concerned common rules for verification and validation. A neologism emerged called “quality assurance (QA)”, like a decade or so before “informatics”[36] and increasing demands for providing QA reports were made.

When studying applications in nuclear technology we need to understand and be able to predict the behaviour of systems manufactured by human enterprise. First, the underlying basic physical and chemical phenomena need to be understood. We have then to predict the results from the interplay of the large number of the different basic events: i.e., the macroscopic effects. In order to be able to build confidence in our modelling capability, we need then to compare these results against measurements carried out on such systems. The different levels of modelling require the solution of different types of equations (see Annex XVII) using different type of parameters. The elements required for carrying out a complete validated analysis are:

- The basic nuclear or chemical data
- The computer codes, and
- The integral experiments.

The way these different components are linked to each other and the role they play are shown in Fig. 22

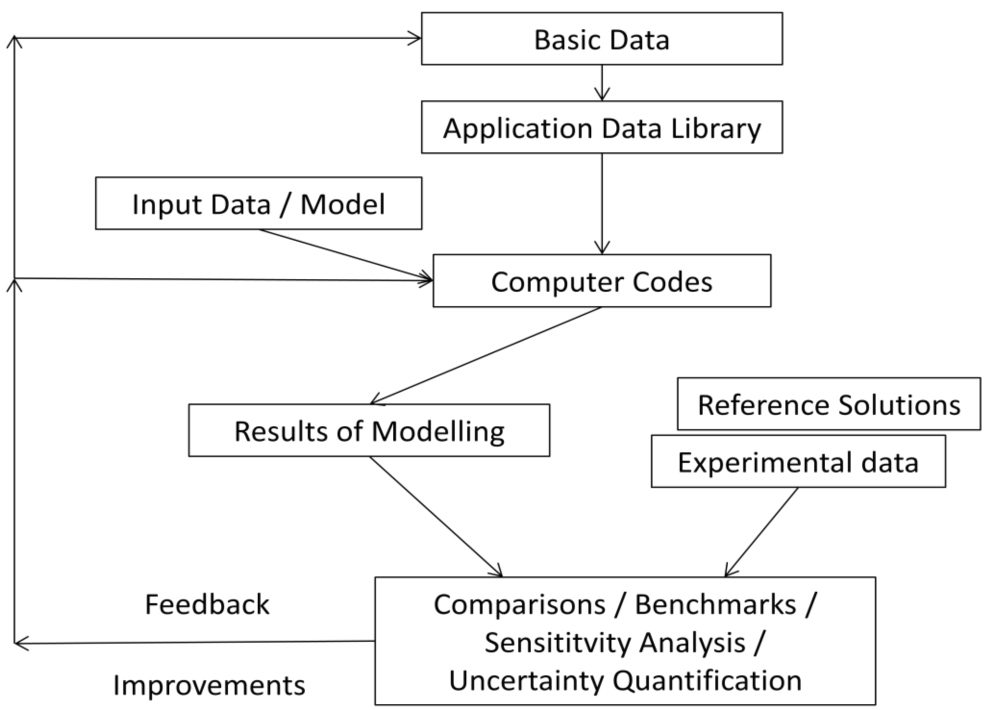


Figure 22: interaction of modeling and validation

[35] For more detailed information see section: ***Supercomputing / high performance computing***

[36] terms that were not well understood when they first appeared

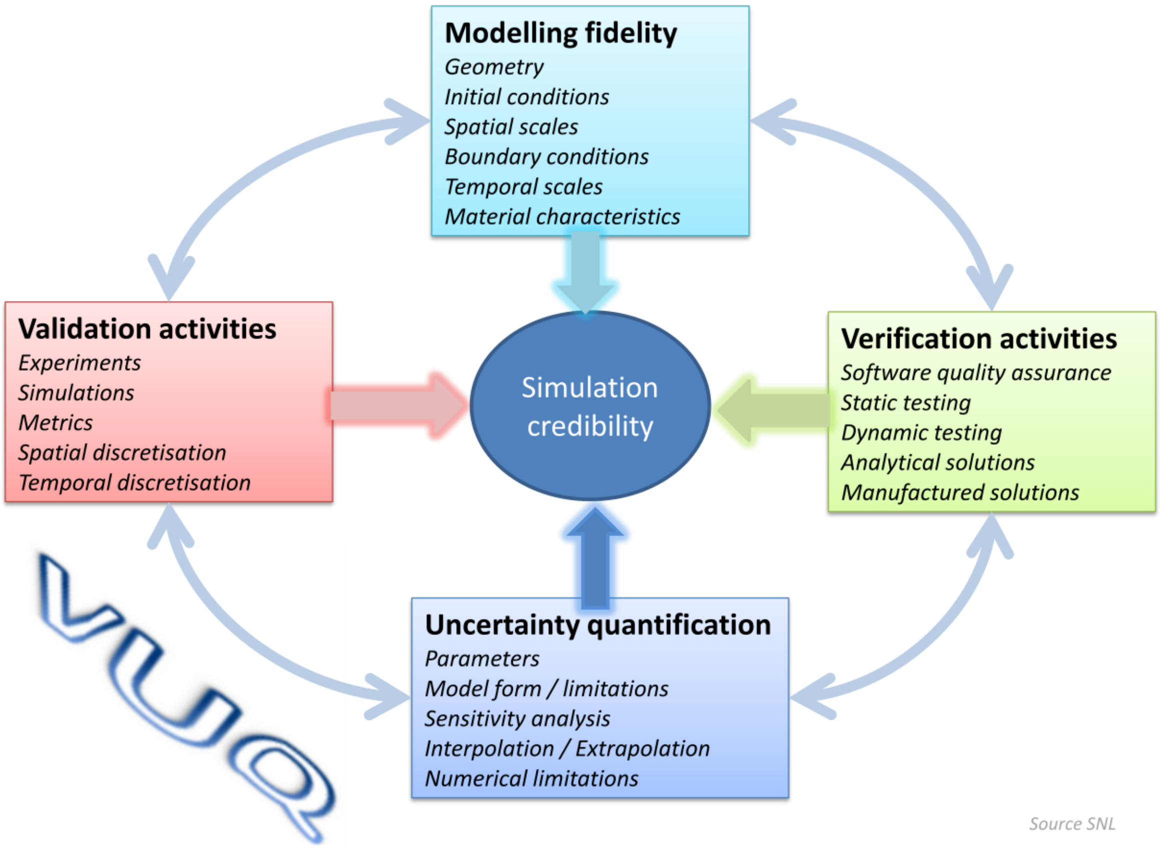


Figure 23: Simulation credibility

Slightly different formulations for Verification and Validation are used, but essentially each of these can be formulated as questions as well:

"**Code verification**": "Are we solving the mathematical model correctly?"

The Advanced Simulation and Computing (ASC) uses the following definition: "Verification is the process of confirming that a computer code correctly implements the algorithms that were intended". The definition used by the American Institute of Aeronautics and Astronautics (AIAA) is: "Verification is the process of determining that a model implementation accurately represents the developer's conceptual description of the model and the solution to the model".

Verification implies several activities such as:

- Benchmarking elementary operators and sets of elementary operators
- Comparison against analytical solutions for simplified physics
- Time and space convergence tests
- Software Quality Assurance procedures

"**Code validation**": "How well does the model represent reality?"

The ASC definition is: "Validation is the process of confirming that the predictions of a computer code adequately represent measured physical phenomena". The AIAA definition: "Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model".

Validation implies several activities such as:

- Benchmarking against "analytical" experiments
- Benchmarking against reference codes
- Benchmarking against "integral" experiments

The effort must obviously be adapted to the size and the importance of the codes and a difference must be made between mature codes and codes under development.

Agreements and Arrangements with Third Parties

The existing co-operative arrangements are often not well understood and the following graphs attempt to clarify the relationships.

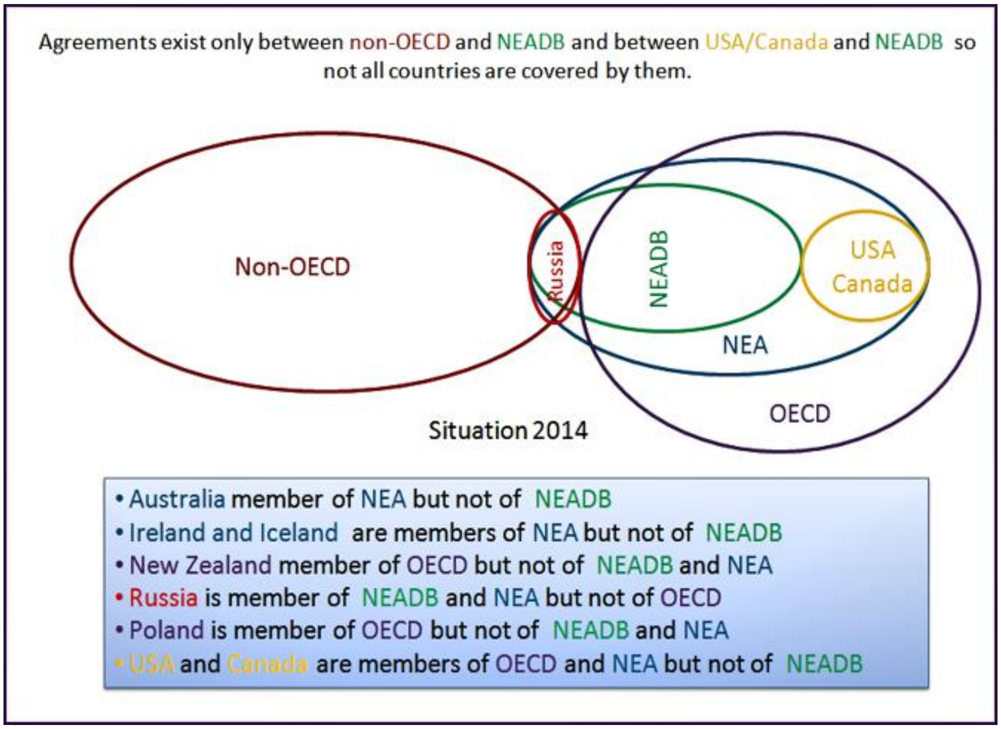


Figure 24: Agreements and Arrangements with Third Parties 2014

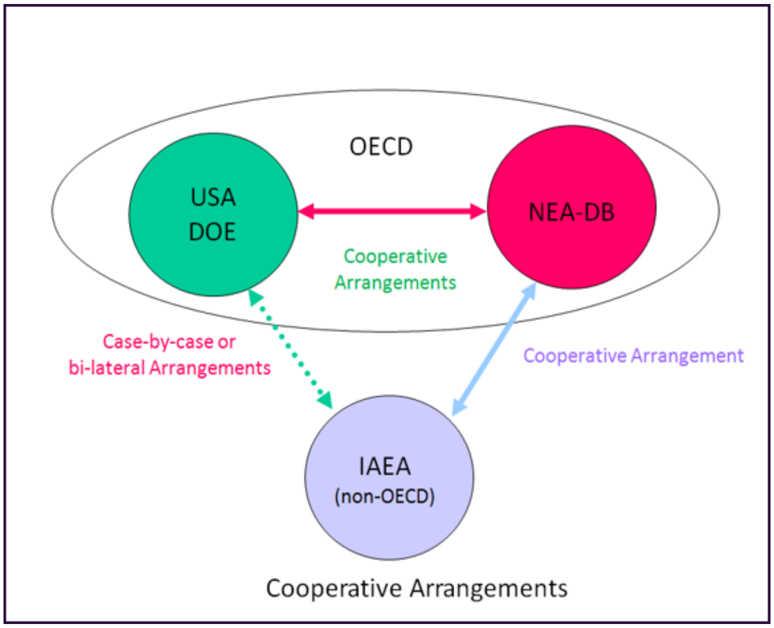


Figure 25: Co-operative arrangements

Figure 24 shows the different parties and their relations as far as the Data Bank, NEA, and OECD are concerned. This situation has evolved over the last 50 years. At the beginning only 15 countries were members of the CCDN and CPL (later Data Bank), in 2014 there were 24 member countries. Two countries were members for short periods but are not participating now: Australia and Ireland. Figure 25 shows the agreements between the different main players in this respect.

Approved Restrictions and Rules applying to the service and Role of Management Committee

At the June session of 2006 the rules and role of the Data Bank Management Committee also called the Executive Group were reviewed. The rules in place at that date were as follows:

Rules, Restrictions and Safeguarding

- A network of 'liaison officers', nominated by national representatives in the Data Bank Management Committee keeps the contact between the CPS of the Data Bank and the different establishments, companies, institutions. This ensures that the users have an official authorisation to make use of the Data Bank services.
- The distribution is exclusively done to these authorised persons; each copy (CD-ROM) carries the name of the recipient and a unique identification; authorised persons must provide the Data Bank with a signed statement of compliance to the rules established by the Executive Group
- Computer code files and documentation are not stored on the Web; only information ('abstracts' & indices) about the codes are on-line for facilitating searches and advertising.
- National authorities subject distribution of codes and associated data to their national rules; restrictions are normally waived for nominated organisations in member countries.
- Each request is screened for an authorisation rule or specific written authorisation before it is honoured; precise logging and tracing of distributions are carried out and recorded in a database.
- Restrictions to users include: no outside distribution, no commercialisation, obligation to acknowledge in publications their use and to provide feedback on shortcomings, errors, or suggested improvements

Tasks and duties of liaison officers

Their tasks consist of co-ordinating the contacts between the Computer Program Service and the users within their respective establishments concerning

- requests,
- distribution of material and information received, and
- also ensure the release of codes for distribution by the Data Bank.

Restrictions on the use

At the beginning of the Eighties, an increasing number of software companies and consultancy groups emerged in different countries with the intent of providing technical services to computer code users, in particular in the field of nuclear applications. It became thus necessary to establish the rules and restrictions that had to be applied to protect the intellectual properties of the authors.

Consequently, at the May 1981 Meeting of the NEA Data Bank Management Committee it was agreed that the authors and their establishments must be consulted if an organisation receiving certain programs intends to use them to provide commercial service to outside users. Users would receive a copy of the rules that applied and they had to sign a paper as commitment to respect them. These rules were as follows:

- Programs are provided on the understanding that the agreement of the originating establishment shall be obtained before a service is offered involving sale or use on a fee-paying basis of any program distributed by the Data Bank. This restriction applies also to modified versions derived from program copies obtained from the NEA Data Bank.

- Transfer of a program to a user in a given establishment confers only the right to use the program within that organization. In particular, copies of programs should not be distributed to persons outside their own establishment; users in other centres should contact their own liaison officer or the NEA Data Bank directly in order to obtain program copies.
- Computer Programs are provided on the understanding that whenever the use of programs obtained through the NEA Data Bank, or of locally modified versions of them, results in a publication (in a journal, conference proceedings, laboratory report, book, etc.), the program and its author or laboratory of origin shall be acknowledged in the publication.
- Where a modified version of a program is produced, to extend its functions or to run on a different computer, a copy should be offered to the Data Bank.
- users are not allowed to set up the code on a shared computer and have other users pay a royalty for its use,
- however, there is no objection that expert users, within a contract or project with a third-party model a problem, interpret results and recover the cost of their work and expertise by using a code received from the Data Bank.
- The ownership of codes stays with the originators

Restrictions on computer codes originated in the USA

With export control, introduced after September 11, 2001 for computer codes originated in the USA, each request had to be handled on a case-by-case basis requiring filling in of questionnaires requesting detailed information about the user and the intended use and the issuing of a single user software license. The transaction database had thus to be generalised and expanded to handle this additional information, and tables about actions as well as about intended use for computer programs could then be prepared for dispatch to the export control officer in charge in the USA. Some users protested, but to no avail.

The requirements for this additional bureaucracy made the automatisation of procedures ineffective. Manual interventions were required for verification of authorisations and the recording of all forms users had to provide before receiving a computer program.

Other items

- A disclaimer as to the responsibility of the use made is added to every package distributed
- Feedback from users is requested through an electronic form
- The enforcement of rules at the Data Bank end are ensured through the DBAIS management system

The Members of the Data Bank Management Committee (Executive Group)

- check annually the list of nominated establishments in their country and indicate any modifications needed, and refrain from renewing access to heavy users not providing any input and contribution for years
- review the rules for the computer program services and propose amendments if needed,
- endorse the agreed rules for the computer program services

These rules and restrictions to be applied by the Computer Program Service were endorsed by the Data Bank Management Committee.

Added Value / Benefits for authors and users

Authors of computer codes have occasionally wondered, what benefit they would gain from sharing the results of their work, in particular computer codes with others. The benefits identified by the CPS are the following:

- Independent verification of codes
- Sharing of development effort
- User feedback to authors for improvements / corrections
- Wider advertising and use, leading to business interaction with developers
- International validation embedded in the wide range of NEA activities (in particular NSC) (e.g., benchmarks, standard problems), access to validation against experimental data, publication of validation in NEA reports
- Hands on training courses using the codes, workshops, seminars organised by NEA
  good code + competent user = good results
- back-up of information to ensure its survival / long-term preservation
- Contribution to information and knowledge preservation / management

Figure 26: Data Bank Staff 1998 Issy les Moulineaux
Nigel Tubbs, Bernard Armand, Enrico Sartori, Werner Schuler, Marek Konieczny, Cristina Lebunetelle, Christian Penon, Pedro Vaz, Pierre Nagel, Amanda Costa, Robert Rulko, Juan Manuel Galán

Nuclear Model Code Comparisons

Among the first series of benchmark studies nuclear model codes had been chosen. The basis for selecting such codes was the list prepared by Prof. Valerio Benzi. A large number of codes was collected, classified by model type or application. These benchmarks aimed at comparing the predictive power of the nuclear model codes in support of nuclear data evaluations. Code to code and code to experiment comparisons were carried out in the studies. The list of international code and model comparisons carried out by the NEA Data Bank were as follows, covering the period of 1982-1998

- Average resonance parameters
- Coupled Channel Model Study
- Spherical Optical and Statistical Model Study
- Spherical Optical Model for Charged Particles
- Pre-equilibrium Effects.
- Blind Intercomparison for Pre-equilibrium Effects for n+^{184}W
- Decay Heat Calculation, an International Nuclear Code Comparison
- Hauser-Feshbach Calculations
- Fission Cross section Calculations
- Blind Intercomparison of Nuclear Models for Predicting Charged Particle Emission
- Thick Target intermediate Energy Nuclear Reactions
- Intermediate Energy Nuclear Reactions, Code Comparison
- International Codes and Model Intercomparison for Intermediate Energy Activation Yields,

The results of these benchmark studies are all available on the Web.

What has changed in the computer codes acquired over time and lessons learned

[1] At the beginning, codes were small in size (one or two boxes of punched cards i.e., 2000-4000 lines of code), the languages used were mostly FORTRAN-II or some in machine language such as FLOCO, FAP, or other Assembler languages. This was dictated by the fact that computer memory was very scarce and so was the disk (or drum) space available and the Central Processor Units (CPUs) were very slow compared to today's performance. The tasks carried out by each code were thus of very limited scope.

[2] As the power of computers grew (see Moore's law, Fig. 28-29), including memory, disk space, system complexity, the programs became larger and larger. The era of modular systems commenced that would allow carrying out several linked or integrated tasks in one run. This required however increased user competence to cover the full scope of the possibilities provided. The size in punched cards became unmanageable and the information was stored on magnetic tape or on magnetic disk. At the first workshop on the SCALE system, held in Paris, it was pointed out, that if the source code and data library were punched out on cards, their height would reach that of the Eiffel Tower(~300m)

[3] The codes acquired later and today are often integrated systems that cover a wide scope and can solve a vast range of problems. They solve multi-scale / multi-physics problems, coupling neutronics with thermal-hydraulics and thermo-mechanics, and they allow the use of refined models where required, they integrate sensitivity analysis and uncertainty quantification. Programming languages have evolved and object-oriented languages have emerged, an extension of older techniques such as structured programming and abstract data types. Some standard codes have been rewritten in more recent programming languages.

The Computer Program Service has dealt over these 50 years with programs or versions of programs of the order of 6000. The staff by working with them could observe how the computer program structures have evolved in time. The early programs were written in a style called 'spaghetti', programming followed by 'structured' programming (GOTO less programming), finally using 'object oriented' programming as mentioned above. Unlike product manufacturing such as computers that consist of many repetitive elements, the production of code for computers is non repetitive, thus complex. For that reason, testing was particularly difficult and cumbersome. The time required to produce a computer program is divided about as follows: 10-20 % of time for writing the code; 90-80% time for V&V and benchmarking. Experienced programmers claimed that the average productivity is of the order of 8 lines per day of programming including the time of testing. In the last two decades powerful debugging tools have become available thus facilitating the testing. The Computer Program Service acquired in the Eighties a software called RXVP, a FORTRAN automated verification system. The use of the RXVP-80 software tool system was introduced systematically for scanning incoming computer programs in order to identify missing material and very basic coding errors before starting the proper testing was launched. This facilitated interaction with authors without delay.

A set of standard procedures (PTS = Program Testing System) to increase the overall efficiency and cost effectiveness of testing operations was also elaborated in the mid Eighties. This aimed also at reducing the learning time required by new staff members and scientific visitors.

Portability - Impact of Language and Platform Evolution

Certain programs would compile only with specific compilers on which they were run by the developer, other compilers would translate it into different code and thus also different results would be obtained. Some programmers even used techniques to fool compilers knowing how compilers translated some sequences of statements into machine code. Needless to say, these 'vicious' programming methods, by some considered as smart, would result in non-portability across evolving compiler techniques. Tests were carried out on portability of full standard Fortran-IV programs to Fortran-77 programs. These would run on the Fortran-77 compilers without problems. This was even true for standard FORTRAN-II programs after simple adaptation of the input-output instructions.

During the year 2001 one more look was given at the possible problem the evolution of computer platforms, systems, programming languages and compilers might have on the survival of the stock of computer codes at the Data Bank, 98% of which were written in Fortran-77 or a subset thereof. It was considered important to preserve the valuable solvers and algorithms developed specifically for nuclear applications as they contain a wealth of knowledge and know-how accumulated during the last few decades. For that purpose, the problems that may arise from expected evolution and innovation needed to be categorised, measures for solving them found and the effort estimated for maintaining the codes operational. A pilot study was then carried out in 2001 and the results and lessons learned were reported at the following Data Bank meeting. In fact, the study was carried out to determine the difficulties encountered and the effort required to export codes written in **Fortran-IV, Fortran-77**, and platform specific implementation thereof to a Fortran-95 compiler environment was carried out. The objective was to determine the survivability of older software across language and system evolution. One conclusion drawn from this is that programs that complied largely with standards of the programming languages at the time of their development had a high survival rate and could be used further without or with only slight changes. 'Tricky' programming style programs required considerable effort to be maintained also in the future.

Computer Program Acquisition Methods:

One of the important tasks was identifying new, more advanced computer codes, to discuss with the author organisation and negotiate their release. This would make sure that the set of programs would continue to be of high relevance to the users.

The computer program acquisition activity was determined by following some main driving forces:

1. Requests by users for programs not yet acquired, which has triggered off the renewal of the stock of active programs in a consistent way over the years. It concerned about two-thirds of the renewals and offered a built-in guarantee of the continuing relevance of the program collection to the needs of users in all fields of nuclear energy.
2. Encouraging the release of new improved and expanded versions of existing codes by organising training courses to improve the interaction between authors and users, to train competent users (or licensed users), and widely publicise the quality of the codes so that also authors benefit from it. Contacting "Liaison Officers" so that they would offer codes from their establishment as a payment in kind of the service they have received.
3. Anticipation of new requirements in subject fields covering new trends in nuclear application activities. This was an important complementary force which has enabled the Data Bank to cover areas where interest is initially limited to a small number of specialist users, such as radioactive waste management and environmental impact studies of nuclear activities, in a rather short time. These programs are identified during specialist meetings, seminars, workshops, or conferences where codes and their performance are presented. By scanning the literature on new computer codes (SDI from INIS: searching INIS with a profile for finding new computer codes) on specific topics or in the recent literature.

Later this was complemented by acquisition of integral data in different domains needed for Validation and Benchmarking of codes, methods, and data.

Advertising service to users

One of the methods used to render the services well known to the users was through a bimonthly or quarterly "Computer Program Service (CPS) e-Newsletter". It would announce new computer programs available with pointers to the abstract, information on integral experiments made available, about training courses using computer codes, workshops, seminars and conferences of interest in the nuclear application field. The other method was a selective distribution of information based on the user profile. The profiles were established based on topics relative to seminars and workshops in which users had participated, categories of codes they had requested. Users received announcements of new versions of codes or new integral data directly within a short time. This latter method has proven to be particularly effective, as users did not receive information containing a large fraction of noise but just what they were genuinely interested in. The principle was that of "activating" the users on new information rather than waiting that they find something through search engines in a more "passive" way.

In this type of service what counts above all for customers is reliability of source, like with newspapers: the information will arrive regularly with no exception. Quality of information is next: quality is important but it comes with no actual proof of it; the user must do some homework to verify it.

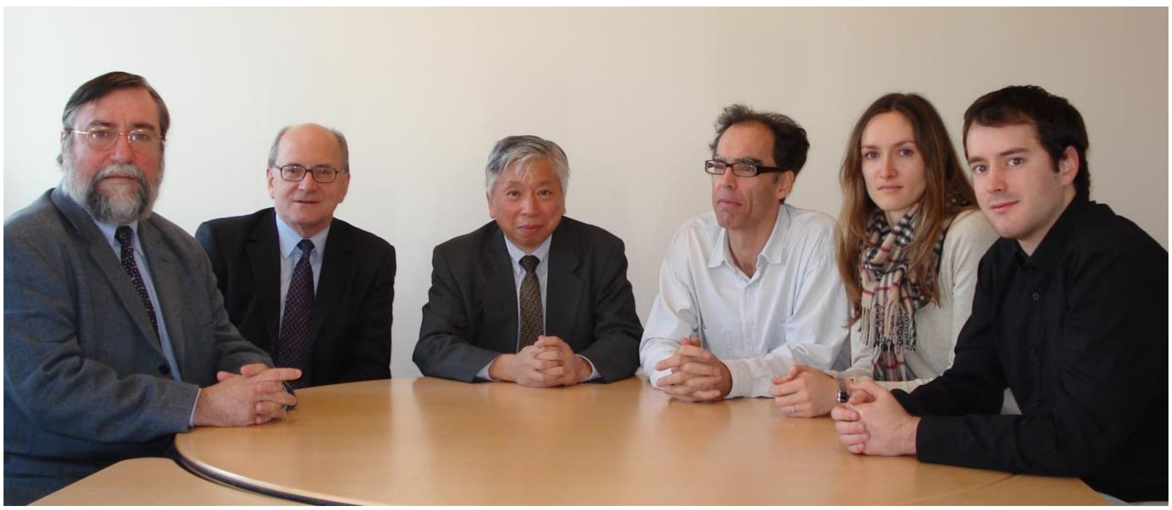


Figure 27: Staff of the Computer Program Service 2008
Juan Galán, Enrico Sartori, Akira Hasegawa, Ivo Kodeli, Catherine Rocher-Thromas, Jean-François Lerustre

Computer Program Service Users

Table XIII: Number of establishments and countries taking part in the CPS

	Establishments			Countries		
Year	NEADB	non-NEADB[37]	Total	NEADB	non-NEADB	Total
2001	491	87	578	22	41	63
2006	678	85	763	22	38	60
2014	720	76	796	24	36	60

Over the full period of its existence the CPS has distributed computer codes to 98 countries, economies, or international organisations.

[37] The decrease in non-OECD establishments is the result of the fact that some non-OECD countries have joined NEA and the Data Bank in the meantime.

Evolution of in-house Computing

As concerns computing, the evolution led to networks of distributed PCs and workstation. Each user, including secretarial staff had access to powerful equipment in the frame of office automation (OA), like in all offices around the world. Centrally a Network Attached Storage (NAS) stored the files and databases shared by staff. There has been an attempt to better exploit the computing power by introducing parallel computing over the network by using software such as the parallel Virtual Machine (PVM) and later Message Passing Interface (MPI), but that was not successful. The idea was to run overnight Monte Carlo simulations for reactor physics, radiation shielding or criticality safety benchmarks, when computers were idle.

One important aspect became security and protection of files and databases. For the purpose "Firewalls"[38] were installed and later upgraded, enhanced protection from spams (unsolicited commercial e-mail) and computer viruses was necessary and the files and databases were daily backed-up, and the back-ups stored remotely for safety reasons. In view of the increased number of accesses and downloads by the Data Bank users the network capacity was expanded. Providers were Renater (Réseau National de télécommunications pour la Technologie l'Enseignement et la Recherche) and KVM (Kernel based Virtual Machine). Oracle was chosen as the database management system which has proven to be reliable over the many years of its use.

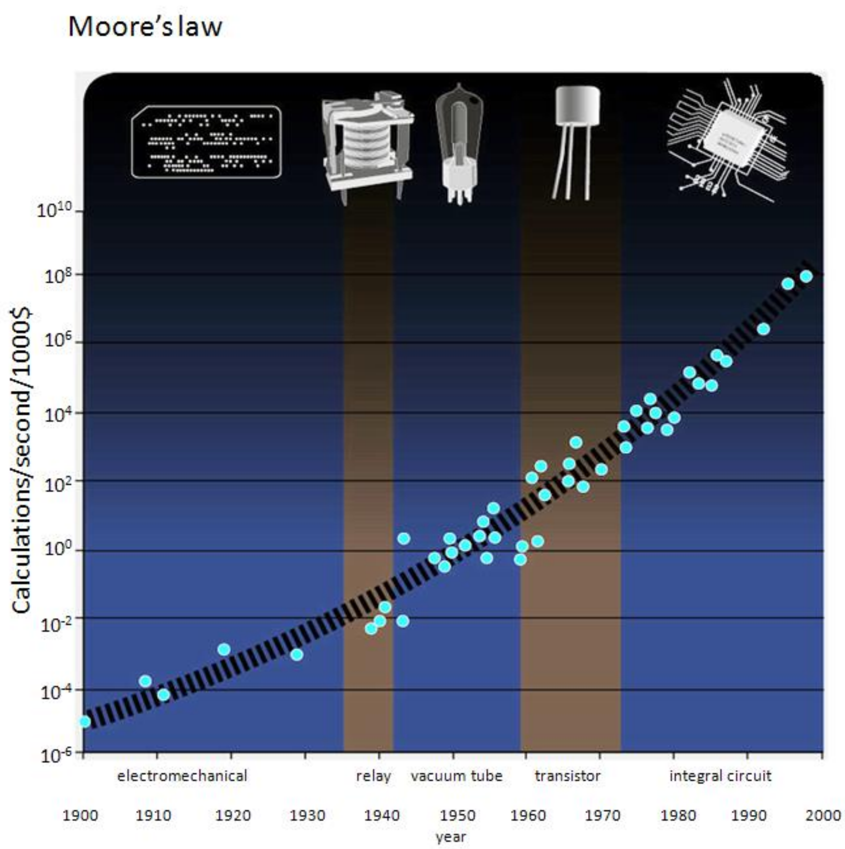
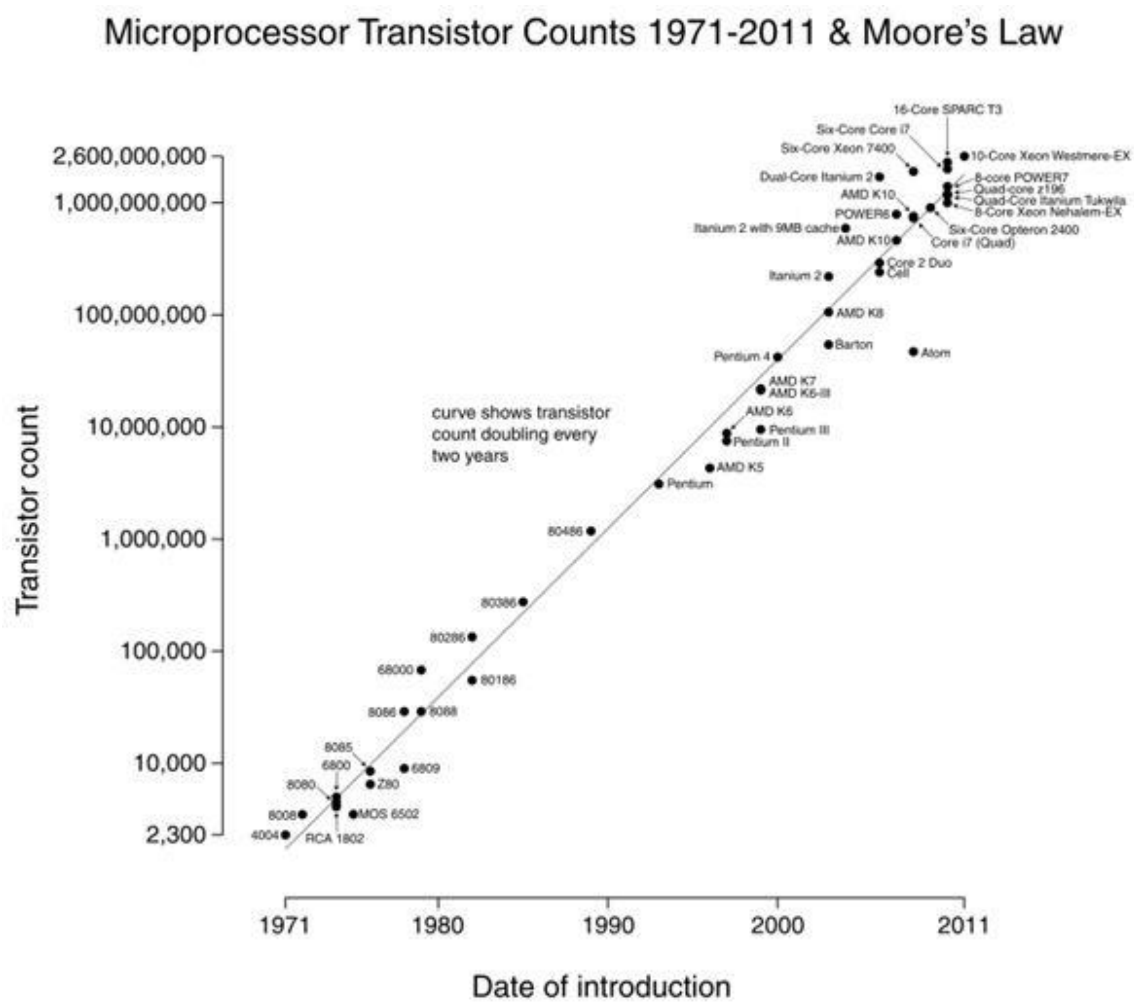


Figure 28: Fifth paradigm to forecast accelerating price-performance ratios for computing

[38] The way initially the system was protected proved to be vulnerable and led to one major incident. The weak point resulted to be the use of system privilege when carrying out operations that would not need one. This led to the counter reaction of excessive protection such as the introduction of 3 firewalls, making work difficult. This excess was later corrected.



Source: Wikipedia

Figure 29: Microprocessor Transistor Counts 1971-2011 & Moore's law

Integral experiments databases

– IFPE (fuel behaviour) compiled data about 1452 rods / samples

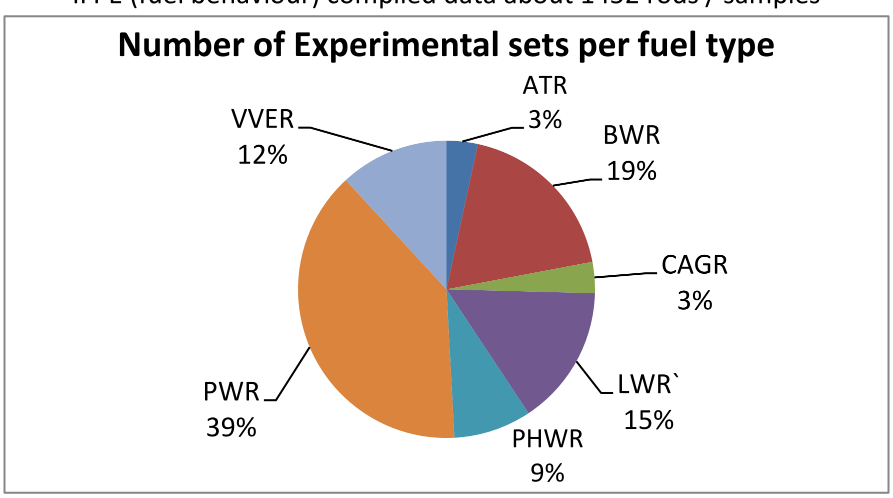


Figure 30: IFPE number of experimental sets per fuel type

- IRPhE Handbook Third Edition (136 experimental series from 48 reactor facilities)
- SINBAD (100 shielding & dosimetry experiments) 46 reactor shielding, 31 fusion blanket neutronics, 23 accelerator shielding experiments

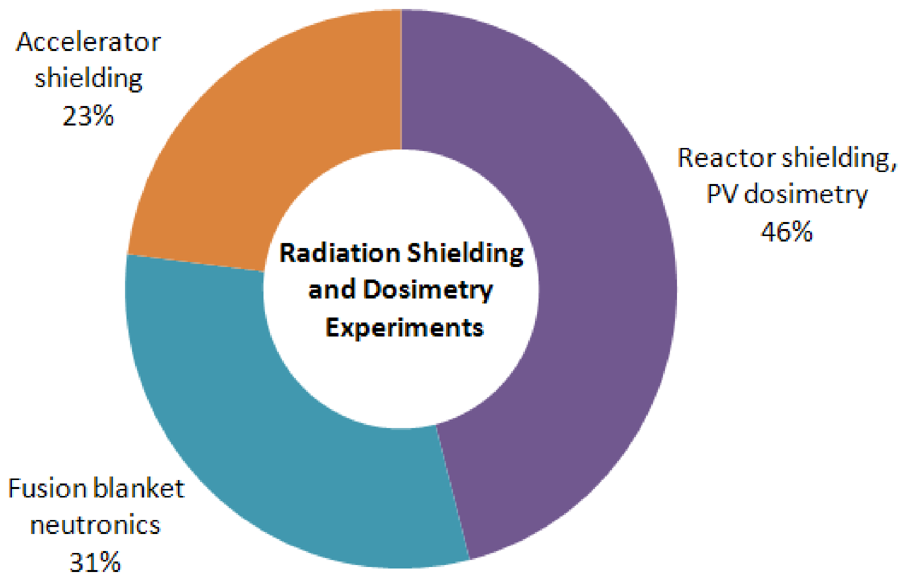


Figure 31: Radiation Shielding and Dosimetry experiments

- ICSBEP (criticality safety experiments) 558 evaluations representing 4798 cases

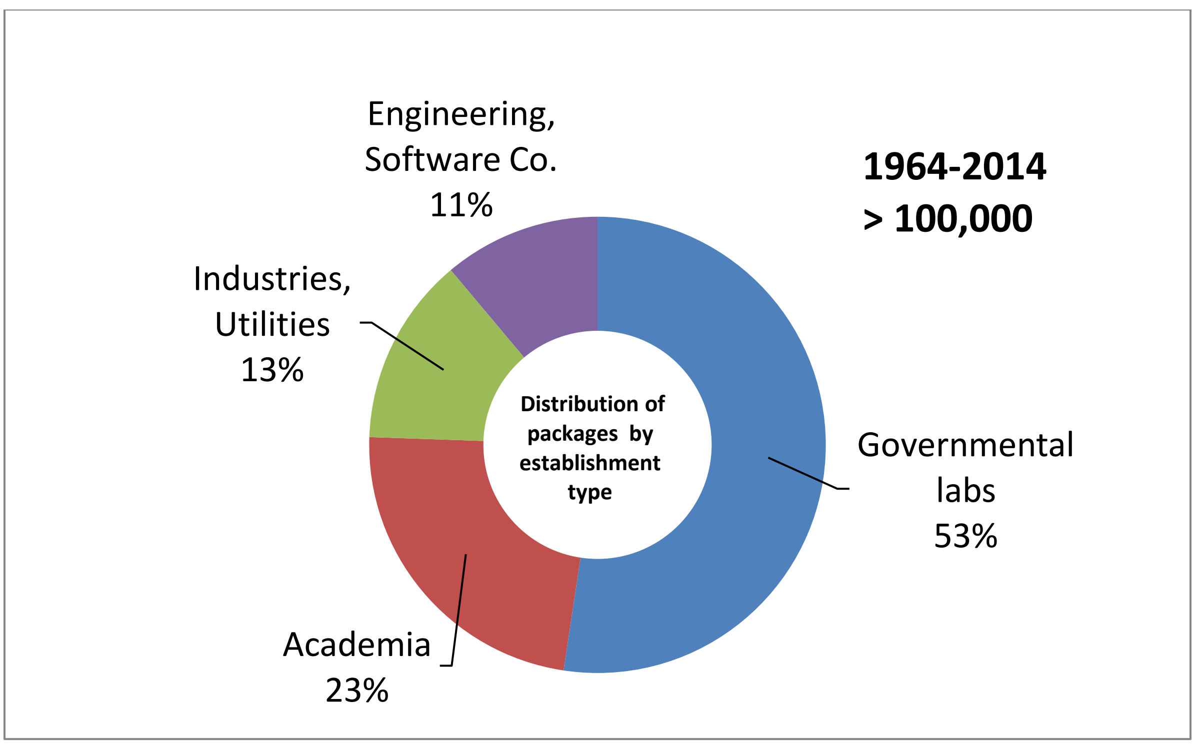


Figure 32: Distribution of packages by establishment type

Acquisition- Distribution Statistics

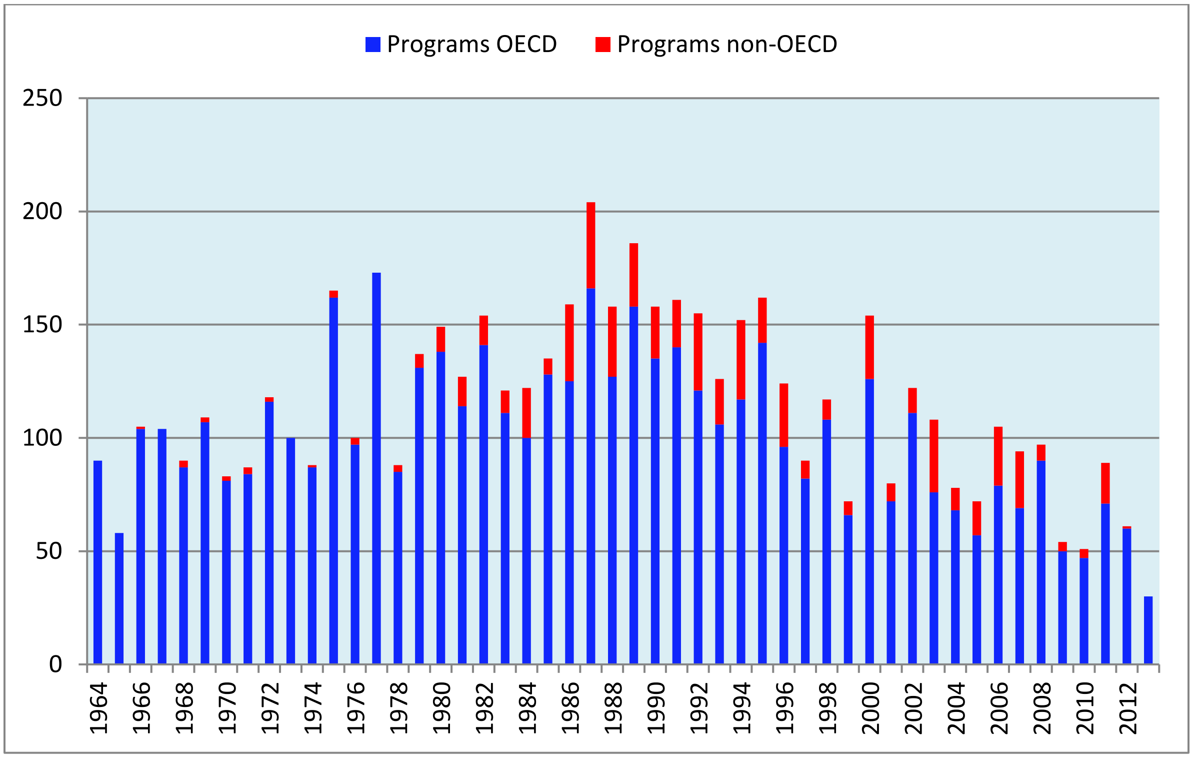


Figure 33: Acquisition of Packages over 50 Years by Origin

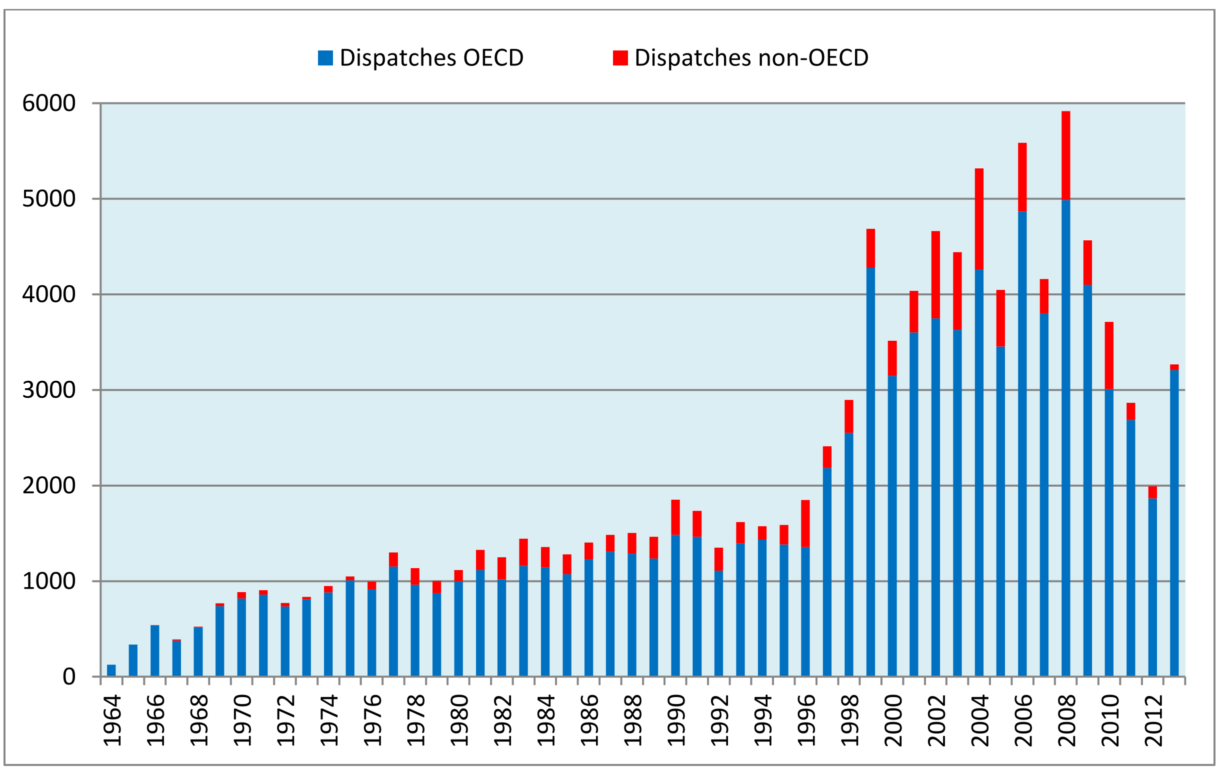


Figure 34: Dispatches of Packages over 50 Years by Destination

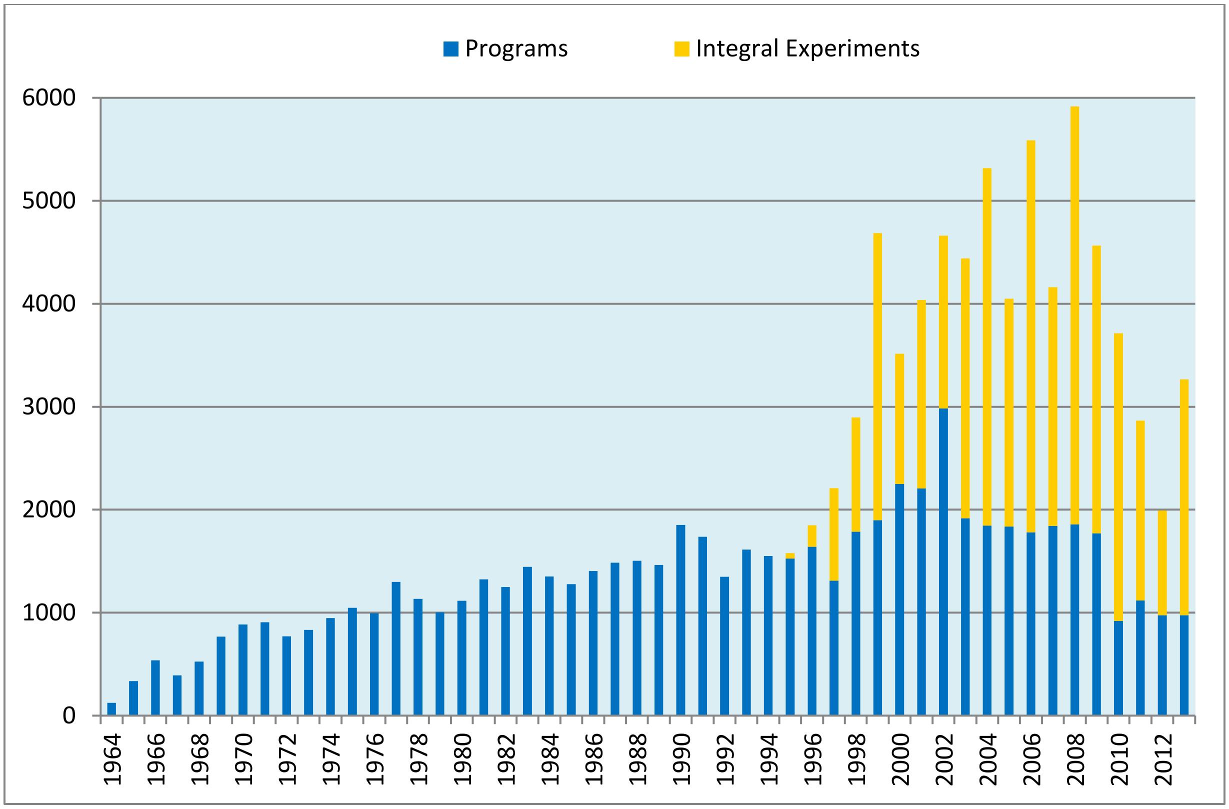


Figure 35: Dispatches of Packages over 50 Years by Type

Figure 33 through 35 show the evolution over the years of the relative importance of the service to NEA Data Bank and non-OECD countries.

Over 50 years more than 100,000 packages were distributed to about 800 establishments in 90 countries. 13 % of the service went to the non-OECD area.

About 6000 different computer codes or versions were acquired in the 50 years. 11% were contributed from the non-OECD area

The integral experiments data packages amount approximately to one third of the requests received over the 50 years. However, this fraction is about half if one considers the last 20 years and close to two thirds during the last 10 years. Reasons for this are: today computer codes are larger, integrate several simulation tasks, thus smaller overall number of requests for codes will be placed, but an increase of validation of codes results because of the increased complexity and because experimental data are specific and do normally not cover a wide range of scope like the codes.

Figures 36-38 provide statistics on the type of information and their origin acquired during the 50 years of existence of the CPS.

More than 6000 structured computer program abstracts describing in summary form the problems they solve using which method, their limitations, documentation, and actual program files available, etc. Several of them have been removed as they became obsolete; today about 2500 are still in active status.

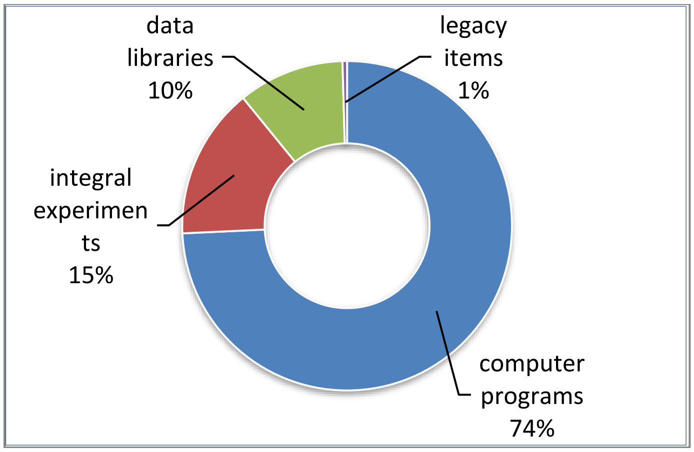
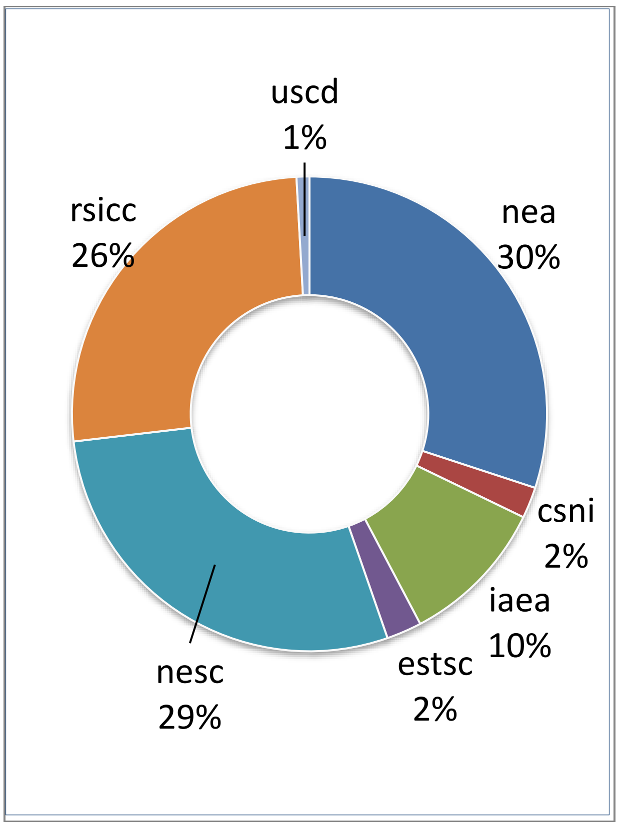


Fig 36 Packages/ abstracts by item type



nea : Data Bank member countries

csni : CSNI projects

iaea : non-OECD origin via Data Bank

estsc : OSTI/ESTSC Oak Ridge

nesc : ACC / NESC ANL

rsicc : RSICC Oak Ridge

Figure 37: Computer programs by area of origin

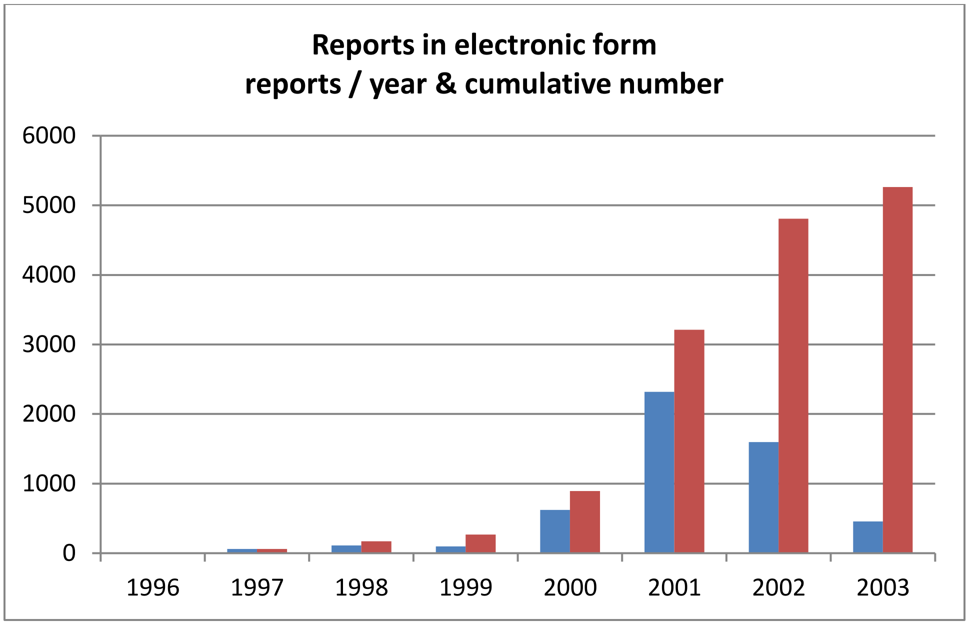


Figure38: evolution in time of electronic version of documentation,
(scanning activity in blue, cumulative results in red)

Agreement with NEDAC (later RIST)

A Nuclear Energy Data Center (NEDAC), a non-profit organization sponsored by the Japanese government, was established on 1 August 1981 at Tokai-mura, Japan, to encourage nuclear energy development through computer program development and services. It aimed at co-operating closely with JAERI (later JAEA) in terms of technical capability and personnel. The major activities of NEDAC were:

1. To collect and test computer programs in the field of nuclear energy and distribute them upon request. The library of computer code packages maintained by JAERI had been transferred to NEDAC, which now serves as the focal point in Japan for exchange with the OECD NEA Data Bank in France.
2. To develop computer programs in the field of nuclear energy under contract with pertinent government agencies, nuclear organizations, and industries, and to provide utilization services using selected computer programs.
3. To provide technical personnel to assist clients who want to develop sophisticated computer software.
4. To develop a data base management system for safety evaluation and analyses in the field of nuclear reactor systems, nuclear fuel cycle facilities, waste management, and radiation protection.
5. To operate and maintain the JAERI computer facilities.

A close collaboration between NEDAC and the Data Bank Computer Program Service was established. The first Director was Junichi Miida, who had been formerly Director at NEA of Development, Science and Computing, which included also the Data Bank. NEDAC was renamed in 1995 to RIST - Research Organization for Information Science and Technology.

This agreement has turned out to be very fruitful and a large number of exchanges has taken place.

NEA/RSIC[C] Personnel Exchange

The co-operative arrangement between US-DoE and NEA concerning the exchange of technical software and data foresees also an exchange of personnel, with the aim of a closer collaboration, to compare methodologies, and to agree on common standards. In 1994 E. Sartori of the Data Bank spent two months at RSIC. Since the two Centers have similar missions and programmes, the visit offered an opportunity to co-ordinate shared procedures. The objectives of this exchange were:

(1) to improve implementation of the co-operative arrangement through discussion, identification, and implementation of common standards in the computer program exchange and;

(2) to work with Engineering Physics and Mathematics Division personnel on the Radiation Shielding Experiment Data Base, a programme to co-ordinate the collection and preservation of essential and comprehensive data sets from experiments carried out on radiation shielding facilities. The data was to be stored in a computerized data base for easy retrieval by the radiation shielding community for validating shield design and analysis tools.

The SINBAD database was established during this visit as a common project between the Data Bank and RSIC. The visit was also an opportunity to participate with members of the Computing Applications Division in studies of the NEA Criticality Safety Working Group.

The following year John E. White of the Radiation Shielding Information Center spent two months at the Data Bank. The objectives of this exchange were:

(1) to fulfil the co-operative arrangement through discussion, identification, and implementation of common standards in computer program and data library exchange;

(2) to carry out Working Party on International Evaluation Co-operation (WPIEC) activities and

(3) to work on the Radiation Shielding Experiment Data Base, to include additional experiments in SINBAD,

This exchange agreement continued with e.g., the stay of Jennie Manneschmidt from RSICC at the Data Bank and of Cristina Lebunetelle from the Data Bank at RSICC.

Interruption of co-operative arrangement with USDoE (2004-2006)

The negotiations between the NEA Data Bank and the US Department of Energy regarding the renewal of the exchange arrangement in the field of nuclear data and computer programs were pursued in 2004. During the negotiation period, there has been no exchange of computer programs. This has affected the number of acquisition and consequently the amount of computer programs distributed on request. Following several years delay, the Arrangement was signed on 10 April 2006 in Washington DC, USA, by Luis Echávarri and the new US Assistant Secretary for Nuclear Energy, Dennis Spurgeon. This delay has had a significant effect on the Data Bank services, especially the one on computer programs. Overall, an interruption of roughly four years occurred because once the arrangement was signed further negotiations were required to define the export control procedures, imposed from the US Department of Commerce after 9/11. The exchange actually resumed in 2007 with a heavy overhead to handle export control procedures.

Technological changes in program dispatches

In the early days, computer codes, as they were mostly small in size, were distributed as decks of punched (perforated) cards, together with the manual, which was a copy of the original manual provided by the author/organization. Larger programs were distributed on magnetic tapes or reels, at the beginning written in 7 tracks, later in 9 tracks[39]. Tapes had the advantage that the programming

[39] Exceptionally, also larger programs were sent as card decks, sometimes up to 6 boxes, each of 2000 cards, when tape readers were not available at the users' establishment. It once happened that one of six boxes (number 4) did not reach destination and was returned to sender. The CPL received a thank you letter for the good service; they had not noted that a box was missing.

instructions were provided in the right order: card decks, if they happened to be dropped, risked to become shuffled. Tapes were also very expensive and therefore had to be returned to the CPL or replaced by a new one[40]. The tapes had to go through X-ray checks at airports and through customs. It was found out that early X-ray devices would obliterate partially the content. Therefore, special packaging was required and early dispatches were done in "Faraday" cages (see pictures in Annex XV). The wrapping of the tapes and reports of the "package" evolved over time and was simplified. Soon floppy disks and diskettes were placed on the market and the dispatches became less voluminous and cheaper. But as their capacity was relatively small, tapes continued to be used for the larger programs. Magnetic cartridges replaced the tapes in the Nineties and all information stored on tapes was transferred to this new storage technology. This was achieved by the end of 1999. Cartridges became quickly an obsolete technology, replaced by *CD-RW* (Compact Disc-ReWritable) or *CD-ROM* (Compact Disc-Read Only Memory). The advantage of the CD-ROMs was that the CPS could guarantee that an exact copy of the original package was delivered as the content could not be changed and had a larger storage capacity. This was a most promising technology, advertised of lasting "eternally"[41], which was of course a false promise. Next came the DVD's (digital versatile disc) with increased capacity (depending on technology and layers from 5-17G bytes capacity) compared to CD-ROMs(0.7Gbytes), followed by USBs (Universal Serial Bus) (at present capacity of devices ranging from 1 to 128 Gbytes). But today, one of the most popular ways is distribution via network. However, for QA reasons a certified copy of the original on a hard device was for many preferable; also, if the user modified the code, there was a possibility of going back to the original.

Obviously, as a distributing centre the Data Bank had to be flexible to satisfy the requirements of users. Not all would change storage technology introducing the latest and greatest. Therefore, the Data Bank kept the capability of providing information on media also on previous technology rather than just on the latest and checked with users through inquiries, how technology was evolving within the customer population. Some resistance to change from some was felt, and the right pace was not to run too fast with innovation. The latest had to go through a testing period and adaptation of system, a continuous process.

The new media became so cheap that the NDB renounced to request a replacement device for the medium sent to the user.

Another lesson was learned about storage media over these years: in order to preserve the bulk of information member countries and their laboratories had "donated" to the NDB it was necessary to transfer all the information to the new media that technology would make available[42]. Also, for safety reasons back-up copies were made continuously and the archival back-ups stored one locally, another

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[40] One day a very fancy car driven by a chauffeur in livery stopped at the Data Bank. A tape was being returned through the official diplomatic channels.

[41] Year 2050: A young boy, playing in the barn finds in a dusty cupboard a wrapped up package on which is written: for my grand-grandson. He runs and shows it to his father: "Dad, what's this?" "Well open it". He opens it; there is a round shiny disk inside and a handwritten note: *I have stored herein the map where I have hidden a treasure for you*. "Dad what is this shiny thing here?" "Well, I think they called them CD-ROMs". "Can we read it?"" Well, go to that antique shop down there, they might be able to". At the antique shop he asks "Sir, do you have a reader for this?" "Oh yes it is there in that corner, but very dusty". They introduce the CD-ROM, nothing happens. "Oh, we do not have the software anymore for reading it". So the only useful piece of information was written on paper …

[42] Disk space was very convenient as it facilitated fast access to data but at that time was very expensive. The CDRW technology became suddenly available increasing storage capacity and making storage much cheaper. It was thus decided to move to this new technology immediately. However, these systems had not yet matured enough and the companies having provided the different components would blame each other's software when problems arose. Consequently no support for solving such problems was available from competing vendors. It was a hard lesson, as two month of work of the technical staff was lost because of this. Conclusion: from then on, only mature technologies were installed in the computer system.

remotely. These procedures ensured that the legacy information stored in the Data Bank would be preserved for long times.

Nuclear Data Activities[43]

The Data Bank maintains, in close co-operation with other nuclear data centres of the Nuclear Reaction Data Centre (NRDC) network, large databases containing bibliographic, experimental (EXFOR) and evaluated nuclear data.

The input data produced by each centre are transmitted to the other centres in a common format; also included in this exchange is bibliographic information, which is periodically published formerly in book form as the CINDA Computer Index to Neutron Data. These experimental data are subject to a comparison and correction process leading ultimately to the generation of so-called "Evaluated Data Files", which constitute the current best estimate for the, values and accuracy of the data they cover, and are used throughout the world as a basis for power reactor calculations. It is these evaluated files which provide the ultimate economic justification for the neutron data work carried out by regional data centres. Evaluated and experimental data are supplied by the Data Bank on request to institutions and individuals in participating countries.

In order to inform nuclear data users about the work carried out or about developments in nuclear data or theory a semestral NEA Neutron Nuclear Data Evaluation Newsletter (NNDEN) was issued. It started to be sent out in 1970 and was stopped in 1995 thus producing in all 48 issues. The arrival of the Internet and Web based information changed the form in which this information was distributed.

1981- JEF

Proposal for a Joint Neutron Data Evaluation Program in association with the NEA Data Bank was made in 1981 (SEN/DATA(81)3). The proposal was to establish a joint European / Japanese file of evaluated neutron data. This collaborative project resulted from an initiative taken at the September 1980 meeting of NEACRP by an ad-hoc working group consisting of members of NEACRP, NEANDC, the Chairman of the Data Bank Committee, and some individual evaluators, discussing the need for such a file, and the desired form and content of the collaborative project to be proposed.

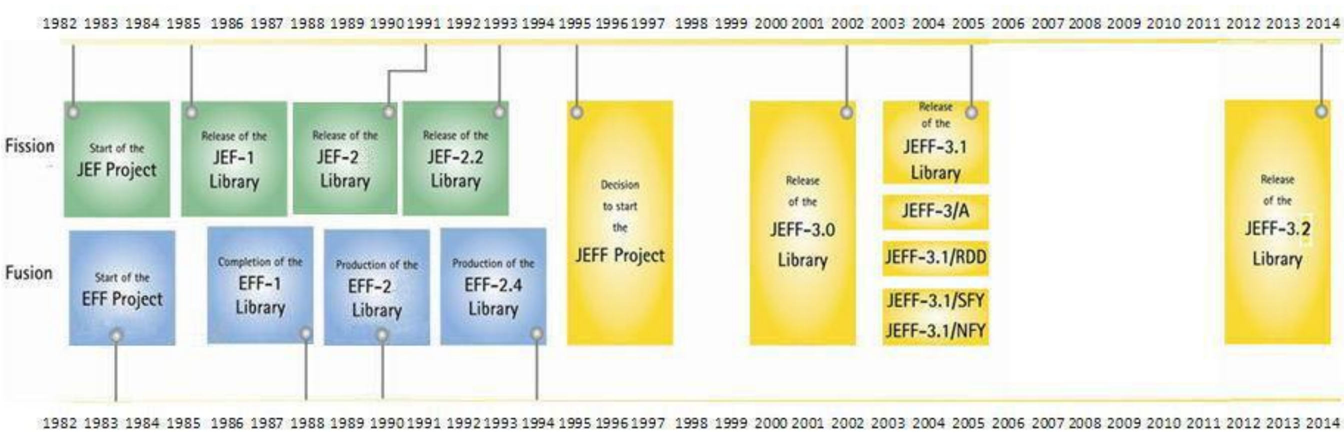

Figure 39: JEF project history of new data releases

[43] In this report details on the nuclear data work at NEA are omitted and are presented mostly to show the interaction and links that existed with the computer program service

The project aimed at producing a composite file of the best evaluations available to the participating countries, in ENDF-5 format, and serving as a common reference file. The file was assembled by the Data Bank, and was made available to all countries participating in the Data Bank. A programme of work was presented in two phases: establishment of the "starting file at the Data Bank using evaluations selected from those then available in participating countries, followed by the refinement and benchmark testing of this composite file in a second phase. The role of the Data Bank would be that of administering the joint activity and providing technical support, and they would not be directly involved in data evaluation as this would be performed by the participating members as a natural part of their national evaluation programmes.

Of particular relevance for the Data Bank and its member countries was the Joint Evaluated File (JEF) project that later merged with the European Fusion File (EFF) to be renamed JEFF. Figure 39 shows the evolution of the project as concerns the steps of releasing new libraries.

The Four Nuclear Data Centres

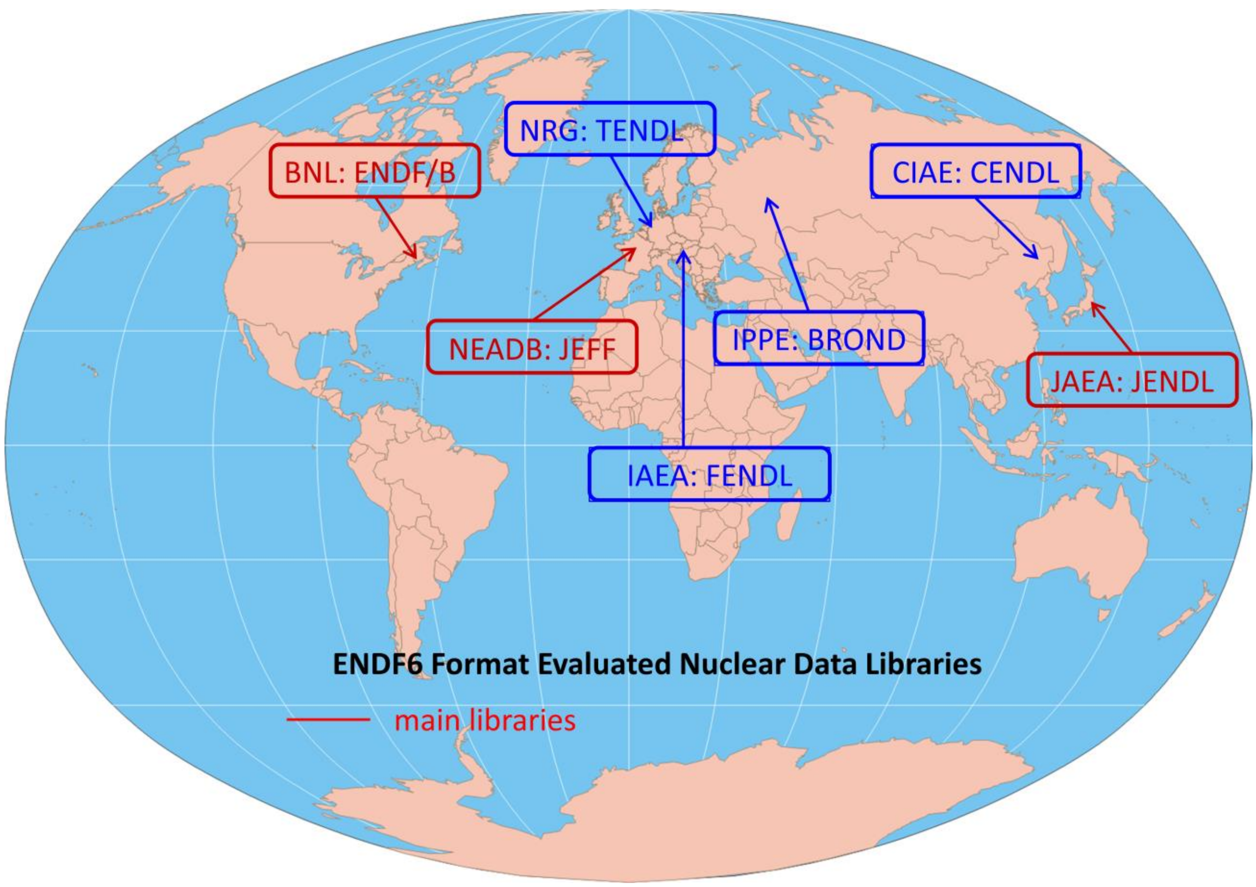

Figure 40: Evaluated nuclear data library projects 2013

The four neutron data centres, were set up in the Sixties; these are the National Nuclear Data Center (NNDC) in Brookhaven, CCDN Saclay, the Nuclear Data Section (NDS) of the IAEA in Vienna and the Centre for Nuclear Data (CJD) at Obninsk each one with the responsibility of taking care of a defined geographical area. The common tasks to be accomplished were defined and covered then essentially CINDA, EXFOR and exchange of Evaluated Neutron Data files. In the 1980s there has been a sharp fall in neutron data to be compiled since the peak of measurement activity in the 1960s and 1970s. In the discussions of those days suggestions emerged that not all these centres would be necessary in the 1990s. This forecast was wrong. Although nuclear safety research had absorbed a large part of the funds after the TMI and Chernobyl accidents, from the discussion on future generations of nuclear power plants with increased inherent safety it emerged that an improvement of the knowledge of the basic underlying nuclear interaction phenomena was required. Little by little funds for the experimental work were made available and the costs were shared at a more international level e.g., in Europe. A strong effort was devoted to improving the Evaluated Nuclear Data Libraries, leading to several new releases, covering a wider scope of possible applications, and including increasingly more, in addition to the cross-section data also their uncertainties, thus contributing to the estimations of confidence bounds in the results from calculations. The number of centres co-operating increased in time and Figure 40 shows the situation concerning evaluated nuclear data activities in 2013.

Supercomputing / high performance computing

In 1983 discussions were promoted at the Data Bank on Supercomputers: The Next Generation. It was noted then that over the 40 years of their development the speed of computers had increased by something like seven orders of magnitude; or to put it another way, a calculation which would have taken a year to run in 1940, or a full day in 1950, could be done in one second. And already then there was a strong push to produce even faster machines. Mr. Jack Worlton of the Los Alamos National Laboratory had been invited to give lectures to provide a perspective view of what was expected to come next. The issue concerned compressing the times required for solving complex problems from two months to say overnight, i.e., an increase in speed by a factor of 200. The suggestion was that a future generation of supercomputers would achieve only part of their increased speed by improved electronics, and designers would be forced into radical architectural changes, such as the introduction of parallel processing, to make up the difference. This would allow applications of artificial intelligence concepts to improve human communication with these extremely complex machines. At that time in France the “club du calcul parallel” was very active and Data Bank staff participated in the weekly meetings to understand what changes might be required in the work programme in this respect. IBM started with multiple processors, but a real change was the introduction of vector processors by Cray. These had a considerable success and thus the Data Bank started to collect programs for vector processors.

In 1990, upon an initiative of the Government of Japan in co-operation with NEA a series of international conferences was started, and repeated in the average every three years. These were held in Mito (Japan) in 1990, in Karlsruhe (Germany) in 1993, at Saratoga Springs (USA)in 1997, in Tokyo (Japan)in 2000, in Paris (France) in 2003, in Monterey CA (+M&C)(USA)in 2007, in Tokyo (+MC) (Japan)in 2010, in Paris (France) in 2013. The next one will be held in combination with the Monte Carlo Conference and the Mathematics and Computation ANS Topical in Nashville (TN) (USA) in 2015.

A Task Force was set up in 1996 on Adapting Computer Codes in Nuclear Applications to Parallel Architectures to study the growth area in supercomputing and its applicability to the nuclear community's computer codes. The result has been four years of investigation for the Task Force in different subject fields - deterministic and Monte Carlo radiation transport, computational mechanics and fluid dynamics, nuclear safety, atmospheric models, and waste management. A State-of-the-Art Report was the result of the investigation. The different chapters covered the following topics: introduction to high-performance computers and computing, the basic equations and parallel computing – an assessment of status and needs (stochastic and deterministic radiation transport), computational mechanics and fluid dynamics, status of advanced computing in nuclear safety, atmospheric models and HPC, finally grand challenge problems.

It continued its investigation of the need for high-performance computing in nuclear applications, the impact of new computer architectures on the performance of existing software, and the need to develop new algorithms for more efficient computation using massively parallel computers. E.g., in a demonstration exercise carried out during 1996, the group adapted a complex existing program for determining the atmospheric dispersion of radioactivity from a fixed source under specified weather conditions and succeeded in reducing computing time from about one hour to a few minutes. The Data Bank regularly tested and distributed programmes for CRAY computers to which it had access in external computing centres, and has assisted in the co-ordination of a study on adapting existing nuclear energy codes for use on massively parallel computers. Also, the plan was to take advantage of high-performance computing in-house, especially to test parallelized computer code systems and to run time consuming Monte Carlo benchmark calculations. The Parallel Virtual Machine (PVM) software was the system of choice then as it allowed running in parallel a heterogeneous network of computers. It was not installed during 1996 because the system operating the workstations was not ready for this and there were indications that it would be an advantage to install a vendor supplied Message Passing Interface (MPI) system instead. For the purpose of testing high performance computers at the University of Stuttgart, Germany and at the CRC in Japan were used taking advantage of new fast international dedicated networks. The MPI system was finally never installed, mainly because of lack of interest by computing support staff and management.

NEA Data Bank Computer Program Service Scope

In summary the computer program service proper scope can be summarised as follows:
it encompasses the full range of modelling needs in nuclear power and radiation physics applications:

- Codes required for evaluated data production, processing, verification (nuclear models, resonance energy range, generation of continuous energy and multi-group cross section libraries, physics and formats checks of data libraries, covariance data and processing etc.)
- Sets of application oriented cross section libraries in code specific format
- Reactor cell, lattice, spectrum, and static core calculations
- Isotope inventories, depletion, transmutation, fuel cycle
- Reactor dynamics, transients, coupling neutronics / thermal-hydraulics
- Reactor safety & hazard analysis
- Radiation shielding and dosimetry
- Heat transfer and fluid flow
- Radioactive waste repository simulation, geo-sphere, biosphere atmosphere, environmental impact of radioactive material
- Fuel performance, material behaviour
- Acquisition of basic nuclear data, computer codes and experimental system data needed over a wide range of nuclear and radiation applications
- Acquisition, verification, review and maintenance and dissemination of information and data from integral experiments in archive or database form for use in computer program validation
- Acquisition and dissemination of legacy books to students and researchers
- Independent verification and validation of these data using quality assurance methods, adding value through international benchmark exercises, workshops, and meetings and by issuing relevant reports with conclusions and recommendations
- Dissemination of the different products to authorised establishments in member countries and integrating user feedback
- Hand-on training courses to ensure computer codes are used by competent and qualified persons

DATA BANK SUPPORT TO NEA DIVISIONS AND COMMITTEES

With the formation of the Data Bank, it was decided that one part of the activities would be devoted to supporting the different NEA Divisions, such as Nuclear Development, Radioactive Waste Management and Radiological Protection, Nuclear Safety, and Nuclear Science. The work consisted in archiving, maintaining, and distributing results from different studies and experimental programmes under the guidance of the different divisions. The Data Bank would provide man-power for installing databases required by the divisions or maintaining computer programs required for specific studies as well as support for collecting data from international comparison studies using computer program simulations. Finally, it would provide support in activities requiring informatics (in-house computing) expertise available at the Data Bank.

The following sections describe the different activities carried out by the Data Bank in support of the different NEA Standing Committees depicted in the Figure 41 representing the situation before the reorientation of the work of the Data Bank. The scope is very wide and covers practically all technical / scientific aspects requiring modelling or simulation.

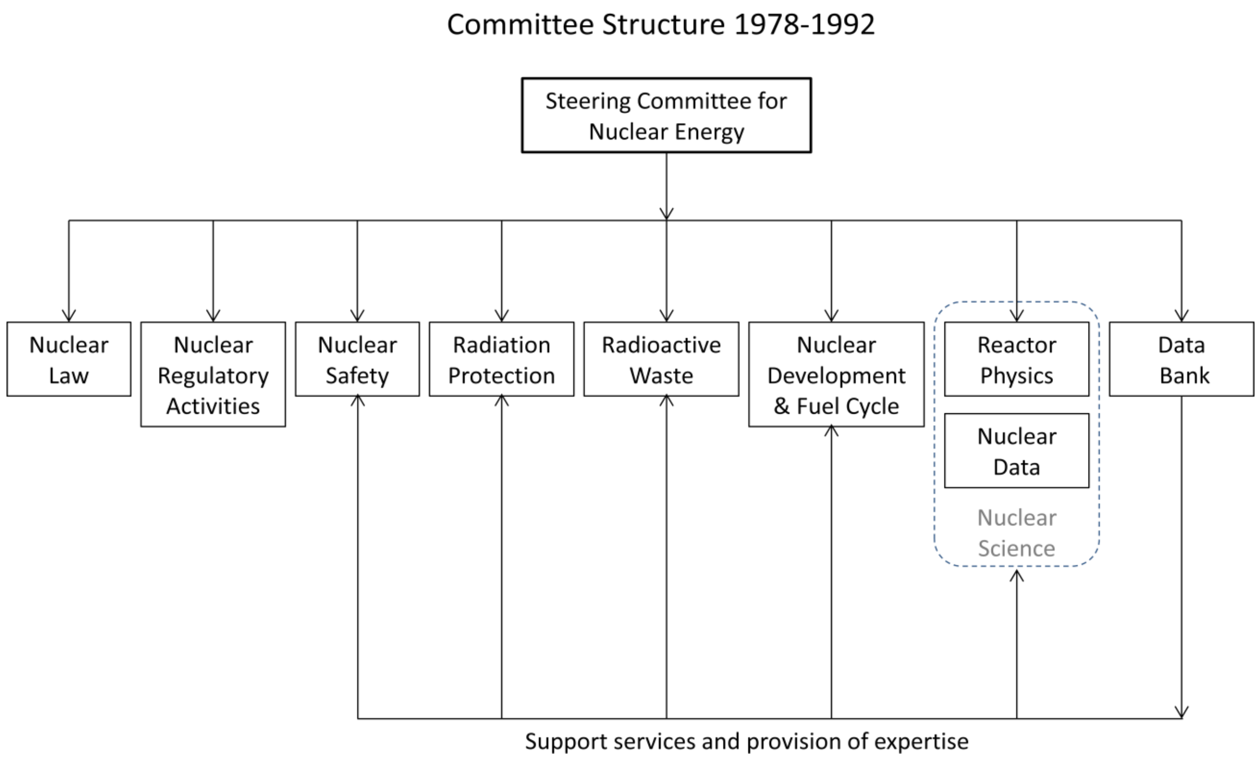

Figure 41: NEA Committee Structure 1978-1992

Support to the nuclear science area

In the Science area the two Committees on Nuclear Data and on Reactor Physics received support already when CPL and CCDN were separated, but increasingly more when the latter were amalgamated into the Data Bank. The interaction was mutually beneficial as it provided means for enhancing validation of nuclear data and computer programs and to exchange advice as to which areas needed additional attention or effort. Support was given by staff of the Data Bank also to the organisation of international conferences by providing the informatics infrastructure for collecting the abstracts submitted, to help in the review process and the issue of the final programme.

Assistance in the conduct and analysis of international benchmark exercises related to reactor physics including stability and transients, to the physics and chemistry of the fuel cycle, to criticality safety and to material science represented the major part of the support provided. This was also facilitated by the fact that it was actually NDB personnel that was in charge of most of the NSC activities.

Table XIV: Chairmen of the Nuclear Science Committee

Period	**Name**	**Country**
1991-1994	Jacques Bouchard	France
1995-1995	Renato Martinelli	Italy
1996-1996	Shojiro Matsuura	Japan
1997-2000	Massimo Salvatores	France
2001-2006	Tomas Lefvert	Sweden
2007-	John Herczeg	United States of America

The contributions to quality assurance of nuclear energy codes by the Data Bank concentrated on organizing benchmark tests and to comparing codes on different specific topics. These concerned fast reactor benchmarks, comparison of nuclear data processing codes, calculations on reactor cells and assemblies, e.g. of ***high conversion light water reactors*** (HCLWR), criticality during dissolution of fuels, modular codes, radiation shielding calculations, standard group structures for nuclear data libraries, interfaces for data sharing among modules, 3D radiation transport methods and benchmarking, reactor kinetics, dynamics, coupling neutronics with thermal-hydraulics, sensitivity/uncertainty analysis, finally multi-physics / multi-scale modelling.

A specific pilot project called ***SINBAD*** on ***Shielding Benchmark*** data was one of the first ones agreed by NEACRP and the Data Bank Committee. The aid of external consultants was used with the aim of structuring and preparing for archiving data from different shielding benchmark experiments sets. On the basis of this work carried out in 1989, specifications for a general storage structure for benchmark data were developed and discussed with other interested organisations for maintaining compatibility between benchmark databases at the Data Bank and in other organisations. The latest version contains experimental data for 100 experiments covering reactor shielding and dosimetry, fusion blankets and accelerator shielding for 27 materials and additional mixtures. It is maintained and distributed by the Data Bank and RSICC.

Around 1986 several NEACRP benchmark studies on ***transport casks*** for spent reactor fuel were performed including radiation protection assessment of transportation packages, heat transfer codes used in the assessment of transport packages and a TN12 shipping cask benchmarks using experimental data. Also, a reactor noise benchmark using experimental data was studied. Most computer codes were in the public domain and available from the Data Bank.

Shielding of accelerators, targets, and irradiation facilities (***SATIF***) was introduced as a new topic on a proposal by Japan. The first workshop was held in connection with the 8th International Radiation Shielding Conference, held in Arlington, Texas in April 1994. A large number of accelerators of different power existed or were being constructed for research, material irradiation and medical applications. Especially for higher energies there was a need to develop methods and codes, validate them by using data from experiments. Important experimental data were released to the SINBAD data base, benchmark studies were carried out on existing or newly developed codes, which were then distributed by the Data Bank. This series of workshops continued to be held every 2 years and in April 2014, 20 years later, the 12th workshop was held at the Fermilab, Batavia, Illinois.

Other topics under consideration, following NEACRP suggestions, were thermal lattice benchmarks, ***criticality*** of fresh fuel and spent fuel storage facilities and criticality of fuel undergoing dissolution. This became necessary also because different participants used discrepant sources of experimental information and in benchmark exercises much time was wasted to find out the source of these discrepancies. Establishing well defined, peer reviewed benchmark specifications was then considered as a necessary investment up front to be shared with other interested institutions. These two examples, radiation shielding and criticality carried out within specific expert groups spawned the organisation of workshops in which authors and users could meet and discuss the different issues and ensure interaction between code developers and users. These codes were distributed through the CPS who gave it large publicity. The feedback received ensured to authors a wide validation basis of their codes. Examples were deterministic and Monte Carlo codes for ***radiation transport*** applied to complex shields or to characterise the radiation environment in different application in irradiation facilities. This effort turned out to be beneficial also for nuclear data testing e.g. In JEF[F] and JENDL projects because the same sources of benchmark information would be used thus avoiding contradicting conclusions and advice to data evaluators.

One area of co-operation and co-ordination among different working groups concerned ***criticality*** safety involving the CSNI, NEACRP and the Data Bank. A Criticality Working Group (CWG) was set up, previously linked to the NEACRP and later to NSC, following a request by the CSNI Working Group on Fuel Cycle Safety (WGFCS). This Group recognized that it did not have the right expertise in resolving large discrepancies found when comparing result from criticality benchmarks concerned with away from reactor configurations, thus it charged the NEACRP to resolve them on their behalf. In the framework of this activity a large number of benchmarks were run and published covering Standard Problem Exercises on Criticality Codes for Large Arrays of Packages of Fissile Materials (9), on Criticality Codes for Spent LWR Fuel Transport Containers (12), on Criticality Codes for Dissolving Fissile Oxides in Acids (20). The models and methodologies to be used in these different cases were documented to the benefit of code users and criticality safety analysts. A new expert Group concerned with ***burn-up credit*** (BUC) benchmark for UOx fuel in PWR and BWRs was set up covering cases of practical interest such as: effects of major actinides and major fission products, comparing computed nuclide concentrations for depletion to actual measurements at different burn-ups, the effect of axially distributed burn-up in an array of pins, the effects of moderator void distribution in addition to burn-up profile, and the burn-up credit for mixed oxide (MOX) spent fuel. The results have given indications on specific needs of data for away from reactor situations and useful input to nuclear data evaluators leading to improvement of JEF[F], JENDL and ENDF/B files. The spin-off of this activity was the creation of the ***SFCOMPO*** Spent Fuel Isotopic Composition Database, developed at the JAERI and operated by the NEA Data Bank.

One additional study carried out within the WPNCS benefitting the Monte Carlo and deterministic radiation transport codes concerned ***source convergence*** for criticality safety analyses.

One of the most successful projects concerned the criticality safety experiments benchmarks (***ICSBEP***) started in 1992 at INL and then internationalized in the frame of the CWG. The leader in this was J. Blair Briggs from the INL. The first edition of the corresponding Handbook was issued in 1995. This project served as a template for the ones developed later and besides the CWG, that later became the WPNCS (Working Party on Nuclear Criticality Safety of NSC), the Data Bank was involved with it in particular with its dissemination and the development of the DICE database. The 2014 version contains about 400 experiments representing about 5000 configurations. This database is used worldwide for nuclear data validation and validation of criticality calculations.

In support of evaluated nuclear data verification and processing special emphasis was devoted to the codes for verification of format and mutual consistency of physical values stored in the data libraries as well as codes for editing and plotting of the files for a better readability and comprehension of the data. Continuous effort was dedicated to code systems for ***evaluated nuclear data processing***. Among these the best known were the set of pre-processing codes by D. Cullen, AMPX, and NJOY. The latter became the preferred computer code for JEF[F] data processing: user group meetings and workshops were held regularly, a computerised archive was set up with all sets of corrections provided by authors and users, experience on the use and performance, etc. This was transformed into an NJOY listserver later with the purpose of exchanging information between code developers and users, in order to ensure that the best use is made of experience gained on both sides.

The area of numerical methods for solving radiation transport problems was of common interest to NEACRP and the Data Bank, in particular the area of ***Monte Carlo*** codes received increased attention as computers started to increase considerably their performance. 3D radiation transport benchmarks were initiated by NEACRP starting with control rod worth calculations for small reactors with strong transport effects (Takeda), followed by estimating precision of calculations in simple geometries with void regions (Kobayashi), ***3-dimensional transport methods*** over a range in parameter space (Azmy) and a 3D deterministic transport calculations without spatial homogenisation of a MOX fuel assembly (Lewis). These benchmarks represent now an asset; they are used by transport code developers for testing the correctness of the algorithms used or their implementation, leading to improved codes released to the Data Bank. The specification and results have been packaged and are distributed by the Data Bank.

One area of major collaboration between the Data Bank and NSC Working Parties concerned the ***physics of plutonium recycling*** and reactor-based weapons-grade plutonium disposition. Many computer programs were designed for uranium fuelled thermal reactors and this was an opportunity to verify which ones were suitable for plutonium breeding or burning systems including whether the cross-section libraries distributed were adequate. This provided also feedback to the JEF[F] project. A series of international benchmarks were carried out and studies were published, a sample of which is shown in the following table:

Table XV: Example of publications linked to plutonium recycling

Volume I	Plutonium Recycling - Issues and Perspectives (1995)
Volume II	Plutonium Recycling in Pressurised Water Reactors (1995)
Volume III	Void Reactivity Effect in Pressurised Water Reactors (1995)
Volume IV	Fast Plutonium Burner Reactors: Beginning of Life (1995)
Volume V	Plutonium Recycling in Fast Reactors (1996)
Volume VI	Multiple Recycle of Plutonium in Conventional and Highly Moderated Pressurised Water Reactors (2002)
Volume VII	BWR MOX Benchmark Specification and Results (2003)
Volume VIII	Results of a Benchmark Considering a High-temperature Reactor (HTR) Fuelled with Reactor-grade Plutonium (2007)
Volume IX	Benchmark on Kinetic Parameters in the CROCUS Reactor (2007)
	Plutonium Management in the Medium Term (2003)
	Benchmarks on VENUS-2 MOX core measurements (2-D in 2000, 3-D in 2004)
	Computational benchmark on VVER-1000 LEU and MOX Assembly (2002)
VENUS-1:	With fresh UO_2 fuel (1983-1986)
VENUS-2:	With MOX fuel (1986-1987)
VENUS-3:	With partial length fuel (1988)
	KRITZ-2 Benchmark (including sensitivity analysis on nuclear data)
	PWR MOX/UO_2Core Transient Benchmark
VENUS MOX	Recycle configurations 07, 09, and 17
	Depletion Calculation Benchmark on Fuel Cycle Issues- Phase 1 on UOx Fuels
	Depletion Calculation Benchmark on Fuel Cycle Issues- Phase 2 MOx Fuel Cycles
	VVER-1000 MOX fuelled Whole Core Benchmark / in-core self-powered neutron detector benchmark
	MOX or UOX fuelled VVER Pressure Vessel Neutron Fluence Benchmark (based on Venus-2, and Balakovo-3)

As the benchmarking work on plutonium recycling progressed and experimental data was needed in support of the different studies and it became evident that the wish expressed already in the past, namely to create a database with peer reviewed reactor physics experiment benchmarks had to be realised. In the year 2000 the decision was taken to start the Preservation of Experimental Integral Reactor Physics data in the form of a pilot project that was to define scope, procedures, standards and to produce an inventory list of potential sources of experimental data. This group, until the definite set up was established, was chaired by János Gadó, KFKI, Hungary. As a template for the new database then called International Reactor Physics benchmark Experiments (***IRPhE***) served ICSBEP because of the accumulated experience and success it had received since its establishment. Since the inception of the IRPhE Project, the primary documentation of important reactor physics experiments was collected and has been transformed into electronic form to facilitate data retrieval and dissemination. An archive of those documents has been established. The activity in producing a benchmark evaluation would consist of describing the experiment, evaluate it, deriving benchmark specifications, and providing results from sample calculations. Finally, code and other data information, including typical input listings, would be provided in Appendices. The types of measurements include: fundamental mode lattice experiments, heterogeneous core configurations, power reactor start-up data, and specific applications experiments. For the purpose a detailed IRPhEP Evaluation Guide has been published, complemented by "Anatomy of a Benchmark Experiment Evaluation" by Virginia Dean, an expert consultant. The lead of the project was taken by J. Blair Briggs from INL, who had proved his capacities with the ICSBEP.

The first version of the IRPhE handbook was issued in 2006. Since then, a yearly new edition was issued with new benchmark evaluation and it has now reached 136 experiments carried out in 48 reactor facilities.

The benchmarks produced by the IRPhEP, ICSBEP and SINBAD greatly expand the collection of available integral benchmarks for reactor physics, criticality safety and radiation shielding/dosimetry modelling validation efforts and nuclear data testing.

Starting 1989 other areas of interaction concerned ***partitioning and transmutation*** of minor actinides and fission products. This process would help to improve radioactive waste management by cutting down the amount of long-lived radionuclides to be buried in waste repositories**.** To be able to model this, especially in the case of transmutation by accelerators, new nuclear data and calculation methods are required. Available computer codes distributed by the Data Bank had to be tested to verify their predictive capability in this case and to extend modeling capabilities where necessary. The ensuing studies covered e.g., “Calculation of Different Transmutation Concepts (1996-1999)”, “Benchmark Calculations for an Accelerator-Driven Minor Actinide Burner (1999-2002)” or “Theoretical and experiment-based benchmarks on a minor actinide burner systems (MUSE-4)”.

Particular attention received the issue of data ***uncertainty***. It was in the field of radiation dosimetry, later extended to radiation shielding where the need for providing ***confidence bounds*** to computed doses was felt strongly. In order to progress in this field, the Data Bank was charged to collect, analyse, and review group averaged cross section covariance data for shielding applications. This was carried out with advice from ORNL, CNEN(ENEA) and CEA. The first seeds were planted to what later became a major topic: ***sensitivity analysis*** and ***uncertainty quantification***. Specialists’ meetings and workshops on covariance methods and practices including their evaluation and processing were held in the late Eighties and Nineties under the guidance of the Nuclear Science Committee.

A Task Force was set up by the NSC in late 1993 with the objective of identifying areas of high priority which would benefit from co-ordination and co-operation on studies of the ***basic underlying phenomena of fuel behaviour*** under normal operating conditions and to advise on developments needed regarding data, models and experiments to meet the requirements for better understanding of fuel behaviour and for improved predictive models. The Task force has identified the most important scientific issues on the subject and concluded that the following aspects should be treated with the highest priority:

- thermal conductivity,
- fission gas release,
- fission product swelling and uranium oxide creep,
- thermomechanical behaviour
- high burnup fuel in transient conditions.

With the support of the Data Bank the development of an international data base with fuel behaviour experiments was decided. Also, fuel behaviour modelling computer codes were to be acquired and validated through benchmark studies.

The starting point was a review of nuclear fuel experimental data on which the database was to be constructed in co-operation with the IAEA, to be called **OECD/NEA - IAEA *International Fuel Performance Experiments (IFPE) database***.

The IFPE Structure was to contain the following components: instrumented tests providing on-line data on fuel behaviour, post irradiation examination data, steady state, long-term operation, power ramps, test reactor data and data after irradiations in commercial reactors.

The database is restricted to thermal reactor fuel performance, principally with standard product Zircaloy clad UO_2 fuel, with the addition of data from advanced products with fuel and clad variants.

To date datasets about 1452 rods/samples from various sources encompassing BWR, CAGR, PHWR, PWR, and VVER reactor systems have been included.

Another area of close collaboration between NSC and the Data Bank was and still is that of ***reactor stability, LWR transients, coupled neutronics/thermal-hydraulics, and coupled core/plant 3D benchmarks***. Several Expert Groups dealt with different reactor systems such as PWR, BWR, VVER, and PBMR. As this is of high relevance also for safety aspects of nuclear power operation, a strong collaboration was established with the Nuclear Safety Division of NEA and with sponsorship of the US Nuclear Regulatory Commission.

The objectives in this field are to advance scientific knowledge needed for the development of advanced modelling techniques for new nuclear technologies and concepts, as well as for current nuclear applications. This includes:

- driving of recent development of coupled 3-D neutronics / T-H codes;
- validation and benchmarking of their performance through comparison with experiments;
- verifying the correctness of methods and computer codes, building confidence in areas where research is very expensive or lacking;
- determination of model uncertainties;
- promotion of their use in production runs and safety analysis.

The transients considered include

- Rod Ejection (PWR);
- Uncontrolled Withdrawal of Control Rods (PWR);
- Main Steam-line Breaks (PWR TMI);
- BWR Stability, time series and frequency analysis (Forsmark 1 & 2, Oskarshamn-2);
- Cold water injection and core pressurisation (BWR);
- Turbine Trips (BWR Peach Bottom-2) benchmark;
- Critical Issues in Nuclear Reactor Technology (CRISSUE-S)
- VVER-1000 Coolant Transient Benchmark (V1000-CT, Kozloduy-6, Kalinin-3);
- BWR Full-size Fine-mesh Bundle Test (BFBT NUPEC);
- PWR Sub-Channel Bundle Tests Benchmark (PSBT - NUPEC)
- PWR MOX/UO_2 Core Transient Benchmark

- PBMR-400: PBMR Coupled Neutronics/Thermal Hydraulics Transient Benchmark
- Uncertainty Analysis in Modelling (UAM) - Coupled Multi-physics and Multi-scale LWR analysis

This latter expert group received a high level of support from the Data Bank in relation with the cross-section covariance data set required for its phase I (Neutronics phase), with fuel performance and fuel bundle thermal-hydraulics data for its phase II (Core phase) and reactor operation, transients and plant data for phase III (System phase) activities.

These activities have had a large impact on and made use of tools available from the computer program and nuclear data activities. In particular the Data Bank maintains and distributes the benchmark data and the results of these studies in a packaged form to the interested parties in member countries.

Support to the radioactive waste management area

Deep geologic disposal for the long-term isolation of high-level nuclear waste is one of the preferred options considered and has received much attention and many investigations were carried out during the last decades. As the geologic barrier is contributing most to the long-term isolation capability of the disposal system and the mobilisation and transportation of radionuclides by water is an essential element for release of radioactivity from a repository, the understanding of these processes and the capability of predicting their effect through modelling are therefore essential for assessing the performance of the geologic barrier.

One of the parameters used in modelling is the distribution coefficient to model retardation also called sorption coefficient which is determined empirically through laboratory experiments with different geological materials. In 1980, the NEA Radioactive Waste Management Committee recognised the usefulness of having a centralised international database of distribution coefficients for a variety of radio-elements, geological materials, and physico-chemical conditions. For this purpose, the NEA established the ***International Sorption Information Retrieval System (ISIRS)*** project in 1981.

A specialised database management system for handling sorption coefficients data and the associated experimental parameters was developed at Battelle Pacific Northwest Laboratories (PNL) in the US. During the second two-year period, the system and its prototype database were transferred to the NEA Data Bank and it was evaluated and optimised by NDB and PNL staff. Later, with the increased power of personal computers, it was possible to transfer the data to more widely used commercial software and thus the maintenance of a specific system became unnecessary. The NEA Sorption Project, now in its third phase, aims at demonstrating the potential of thermodynamic sorption models (TSMs) for improving confidence in the representation of radionuclide sorption in the context of radioactive waste disposal. The NEA Data Bank has given support to this project in its first phase.

In order to provide a broader variety of geochemical data to users the NEA Radioactive Waste Management Committee established in 1983 the *NEA* ***Thermochemical Data Base (TDB)*** including a critical review activity as a complement to ISIRS. While ISIRS contains more site-specific data this database contains fundamental chemical thermodynamic data from which the universal database for speciation and reaction-path tracking codes can be established. The objective of this activity is to compile, critically review and publish recommended values of these fundamental constants for elements important to high-level waste disposal and other nuclear technologies. Eventually it would become a comprehensive, internally consistent, and internationally recognised thermodynamic database for the inorganic, aqueous and solid chemistry of elements relevant for nuclear waste management. Over the 30 years of its existence 13 volumes and associated databases have been published through management and co-ordination by the Data Bank: uranium (1992), americium (1995), technetium (1999), neptunium and plutonium (2001), updates to U, Am, Tc, Np, Pu (2003), nickel (2005), selenium (2005), zirconium (2005), compounds and complexes of U, Am, Tc, Np, Pu, Ni, Se, Zr with selected organic ligands (2005), solid solution of nuclear radioactive waste (2007), thorium (2009), tin (2012), iron (2013). Also, a compilation of chemical thermodynamic data for minerals associated with Granite, using the data base at the Data Bank was produced in 1986.

In support of this activity several Training Courses on the use of chemical thermodynamics speciation codes in connection with TDB were held. Participants learned how to best use TDB data for predicting the chemical species formed in the geologic barrier surrounding a nuclear waste repository.

The driving force behind establishing TDB was Anthony B Muller, staff of the Radioactive Waste Management division, spending half time at the Data Bank. Staff that followed in his path was Hans Wanner, Isabelle Forest, Isabelle Poirot, Pierre Nagel, Ignasi Puigdomenech, Erik Osthöls, Amaia Sandino, Federico Mompean, Mireille Defranceschi, Jane Perrone.

The TDB project receives today funding that is separate from the main Data Bank budget.

The Probabilistic System Assessment Group [PSAG, formerly PSAC(odes)] was established by the Radioactive Waste Management Committee in January 1985 to help co-ordinating the development in OECD member countries of probabilistic safety assessment computer codes to be used in performance assessment of radioactive waste disposal facilities. The PSAG met approximately twice per year between its founding and its final meeting in June 1994. A key part of the Group's activities was the conduct of code intercomparison exercises aimed at building confidence in the correct operation of probabilistic assessment codes being prepared for applications in national programmes. Such exercises stimulated the thinking process and helped pave the way for basic developments, improvements, and advancements in the application of probabilistic methods to assessment of waste disposal systems. In addition, the PSAG discussed many topical issues of relevance to PSA code development and to the whole question of the treatment of uncertainty in performance assessment. The PSAG reported to, and had its work reviewed by the NEA Performance Assessment Advisory Group (PAAG). The PSAG has been assisted by the NEA Data Bank in collecting, analysing, and summarising results obtained from participants in benchmark exercises and contributing to the preparation of the final reports of these studies. In all, five publications were issued covering different levels of complexity. The five benchmarks concerned: verification and QA of modelling codes, deterministic and stochastic results comparison, realistic system models, biosphere modelling, sensitivity analysis. The results from these exercises contributed to quality assure the software used for licensing purposes and to demonstrate the use of PSA methods to underpin the regulatory evaluation of such safety cases.

The Data Bank has acquired, tested, maintained, and distributed computer codes released within the PSAG**.** Waste management modelling involves multi-physics and multi-scales: it implicates diverse disciplines such as rock mechanics, fluid flow in the aquifer, heat transfer, source term characterisation, chemical thermodynamics, nuclear and radiation physics, nuclear heat and decay, dosimetry, pathway-to-man modelling including surface transportation as well as atmospheric transportation affecting the biosphere. Some 150 computer codes are available from the computer program service of the Data Bank covering all these different aspects.

Figure 42: Support to PSA Group, team for data analysis, evaluation and writing of report (1987)
Enrico Sartori. Terry Andres, Bruce Godwin, Stephan Carlyle, Andrea Saltelli, Data Bank Saclay

Support Services to Nuclear Safety

At the end of 1978, the NEA took the initiative to establish an international system for exchanging information on safety related events occurring in operating nuclear power plants. In March 1979, the accident at Three Mile Island (TMI) provided further impetus to the development of an effective international operational experience feedback process. A real involvement began in 1980 when the NEA Committee on the Safety of Nuclear Installations (CSNI) introduced the ***Incident Reporting System (IRS)***. IRS would provide feedback from safety related operating experience for nuclear power plants structured around the report of the event, the identification of safety significance, and the analysis of lessons learned. These experiences would assist in reducing or eliminating recurrence of events at other plants.

This was the first project set up in co-operation with the NEA Data Bank and involved one and a half man-years of effort. The work consisted in analysing and transforming information provided by national co-ordinators into an agreed computerised format, storing it in a database and distributing the results to the national representatives in the project. In 1983 the IAEA extended the system by adding input from the other countries not members of NEA.

The accident at Chernobyl in April 1986 resulted in further recognition by regulatory bodies and agencies of various nations around the world of the importance of an effective event reporting and operating experience exchange system.

The Incident Reporting System (IRS) was transferred to Oak Ridge on 1st December 1989, following a decision by the NEA Steering Committee. The Data Bank had during 1989 continued to input data into the database and had developed a retrieval system for the PC version of the database. From ORNL it then moved to the IAEA. Since that time the IRS has been jointly operated by the IAEA and the

NEA. However, with the creation of the first comprehensive database on the IRS, Advanced Incident Reporting System (AIRS), in 1995, the responsibility of treating events (including quality checking) was transferred to the IAEA. The work at the Data Bank stopped with the transfer of IRS to ORNL.

The CSNI Principal Working Group on Coolant System Behaviour (PWG2) started in 1988 a pilot study to collect selected data sets from reactor transient simulation tests and to store them in a central location. These tests are arranged in a ***Code Validation Matrix (CCVM)**,* which represents a minimum set of experiments to be used for the assessment of large thermal-hydraulic computer codes.

It was agreed that the NEA Data Bank, in view of its broad experience in the handling of large volumes of computer data, would be an appropriate place to store and eventually re-distribute CCVM data.

As a result of surveys performed earlier with the members of PWG2, a list of data sets was established that could be made available for this exercise. The task force also discussed procedures to be followed for the acquisition, the storage, and the redistribution of the data. A major task was to acquire the missing data sets, identified as being important for the thermal-hydraulic code validation. In order to make efficient use of procedures already existing at the Data Bank, the CCVM data were integrated into the system used to operate the computer program service. Abstracts describing these newly acquired experimental data sets were compiled and entered into a database designed for the purpose (DBAIS). The data sets were formally checked and distributed to requesters following agreed procedures. Also, a special Web page was dedicated to the CCVM; the data is presented in two parts. The first concerns integral experiments (ITD) designed to follow the behaviour of a reactor system in various off-normal or accident conditions. The ITD matrix data is suitable for the validation of best estimate thermal-hydraulic computer codes: it consists of phenomenologically well-founded experiments, for which comparison of the measured and calculated parameters forms a basis for establishing the accuracy of the test predictions. These LOCA integral test data are from the following 18 facilities: BETHSY, DOEL2, FIST, FIX-II, LEIBSTADT, LOBI, LOFT, MARVIKEN, OTIS, PACTEL, PIPER, PKL, ROSA-III, ROSA-IV, SEMISCALE, SPES, TBL, TLTA. The second concerns the separate effects tests data (SET) matrix of experiments, suitable for the developmental assessment of thermal-hydraulics transient system computer codes by selecting individual tests from selected facilities, relevant to each phenomenon. This part contains experimental data from the following 17 facilities: ACHILLES, CORA, FALCON, FARO, G2, ERSEC, IVO, MARVIKEN, NEPTUN, PATRICIA, PDHT, PHEBUS, REBEKA, REWET, SMD, THETIS, and UPTF.

In September 1990, the OECD/NEA Committee on the Safety of Nuclear Installations (CSNI) Working Group on Fuel Cycle Safety (WGFCS) proposed instituting a Fuel Cycle Incident Reporting System, similar to the Incident Reporting System (IRS) used for nuclear power plants. The importance and effectiveness of having a database system to share operating experience between experts in member countries was stressed by the WGFCS. Consequently, a guideline document was developed and the ***Fuel Incident Notification and Analysis System (FINAS)*** was initiated in 1992 and a report of the FINAS guidance criteria was issued in 1995. This database includes incidents of the following type of facilities and activities: uranium and thorium mining and milling, refining, conversion, enrichment, fuel fabrication, radioisotope production, waste treatment and conditioning, fuel handling and intermediate storage, reprocessing, fuel cycle facilities research and development laboratories. The objective of FINAS is to contribute to improving the safety of fuel cycle facilities, which are operated worldwide by providing timely and detailed information on both technical and human factors related to events of safety significance, which occur at these facilities.

FINAS activities include the collection, evaluation, and dissemination of event reports. All reports are stored electronically in a database, in textual, numeric, and graphic format (including drawings and photos). For preparing the data computerised coding sheets are used.

The Data Bank has given support to the WGFCS in computerizing the system and providing the database system and software for acquiring the information.

Since 2001 it is jointly operated by the IAEA & OECD/NEA in a similar fashion as the IRS. New FINAS guidelines were published in 2006.

Another database called ***STEX*** in support of the work in reactor safety is a compilation of the experimental work conducted to investigate the phenomenon of "***STeam EXplosion***", an extensively studied problem. A steam explosion is a class of fuel-coolant interactions in which the timescale for heat transfer between the liquids is smaller than the timescale for pressure wave propagation and expansion in a local region of the fuel-coolant mixture.

Steam explosion experiments can be categorized in different ways depending on the scale or the conditions of the experiment: (1) in-pile vs. out-of-pile experiments, (2) small, intermediate, or large-scale experiments, (3) pouring, injection, or stratified contact mode. STEX began to be set up in 2006 with the help of an expert consultant from the University of Wisconsin. It contains data from 13 facilities: FARO, KROTOS, TROI, WFCI, ZREX, FITS, EXO-FITS, SNL, ANL R-22, UKAEA V(MFTF), MIXA, QUEOS and ALPHA facilities. This work was completed in 2009 and is distributed by the Data Bank.

Co-operation and co-ordination of activities between the Nuclear Safety Division and the Data Bank has been agreed on for many years relative to many other experimental data and corresponding primary to reports and experimental data released from the different separately funded projects under the aegis of the Committee on Safety of Nuclear Installations (CSNI). Organisation, storage maintenance and dissemination were assured by the Data Bank.

In 2005 an enhanced co-operation and co-ordination of activities between the CSNI, and the NSC and the Data Bank was agreed on. This was a follow up action to the approval of the Strategic Plan of NEA for 2005-2010 which afterwards had been approved by the SC. The corresponding document set out as one of the objectives that *"The Standing Technical Committees will optimise co-ordination among themselves and treat cross-cutting issues efficiently by:*

- *co-operating by means of joint studies or joint groups, and carrying out common analyses as appropriate;*
- *taking appropriate procedural measures to manage the cross-cutting issues in which the standing technical committees are involved;*
- *ensuring that the existing expertise in the other NEA committees is properly taken into account and not duplicated."*

Topics the three committees shared in their activities and for which they had common interest included reactor core transients, coupled neutronics/fluid-dynamics, core-plant interaction, and fuel performance. Co-operation in archiving, maintenance and distribution of final reports and associated data in electronic form from joint research projects related to nuclear safety through the Data Bank are other areas where co-operation has shown significant benefits. The main objective was to further develop the sharing of resources, enhance the sharing of information and consistently apply the results. The parties agreed that the common goal of further enhancing co-operation among them, should not compromise the independence of each committee, and should not impact on the timely resolution of matters addressed under the responsibility of each committee. More precisely the parties agreed that areas of common interests were as follows:

A. Computer codes (benchmarking, ISPs, verification & validation)
   A.1 Fluid-dynamics codes
   A.2 Coupled neutronics and thermal-hydraulic codes
B. Fuel behaviour
   B.1 in normal operation
   B.2 in accident conditions

C. High burn-up fuel
D. Pressure Vessel Dosimetry
E. Fuel Cycle Safety
F. NEA databases
  F.1 Code Validation Matrices
  F.2 Preserving Data from OECD research projects
  F.3 Acquisition, testing and distribution of computer codes
G. Joint Workshops in all previous areas where appropriate

The result of this co-operation proved to be very useful and successful. By 2014 the database activities related to joint research projects handled nineteen of them comprising topics such as: behaviour of iodine, bubbler condenser, CABRI water loop project: high burn-up fuel behaviour in RIA conditions, LOFT project, material scaling: in-vessel phenomena during severe accidents, melt coolability and concrete interaction, pressurised water reactor safety issues, fire propagation in elementary, multi-room scenarios, experiments for transient analysis of VVER-1000 reactors, physical and thermal behaviour of the corium in large-scale tests, lower head failure project, thermal-hydraulics experiments relevant for accidents management, cladding integrity , thermal-hydraulics, hydrogen, aerosols, iodine , TMI vessel investigation, and Paks fuel .

Support to Nuclear Development

Since 1985 several activities were carried out by the ***nuclear development division (NDD)*** in co-operation or with technical support from the Data Bank, in particular what concerns ***fuel cycle scenario modelling*** and collecting, analysing the bulk of data provided by the Member countries on electricity generation, electrical and nuclear capacities, fuel cycle capacity and demand and costs, on uranium resources, etc,. The results of the analysis were then published in the so called "Brown Book"[44].

The SCENARIOS code system was implemented, maintained, and developed on the Data Bank computer for the simulation model of the material flows through the various process steps in the nuclear fuel cycle. As input, it used data describing the deployment programmes for the various reactor types under consideration and the operational characteristics for each reactor type. These reactor programme data are used together with fuel cycle strategy data describing the deployment of spent fuel reprocessing facilities, descriptive data on away-from-reactor spent fuel storage facilities and data for lead times, delay times and material recovery efficiencies for each fuel cycle operation. The original version had been developed at the IAEA in Vienna. This system was used by the NDD to produce the "Yellow Book"[45].

A new edition of the so called "Red Book"[46], with data on uranium resources, demand, and supply, including forecasts for decades, was produced every 2 years since the mid Sixties. It is a government-sponsored publication tracking world trends and developments in uranium resources, production, and demand, and was later produced jointly with the IAEA Vienna. In 2014 the 25th edition was published. Also, for the database used to produce this publication the Data Bank has provided technical support.

In the framework of the study on "Advanced Fuel Cycles and Waste Management", which was performed during 2003-2005 by an expert group, the staff of the nuclear development division contributed to the Data Bank the code SMAFS, for steady-state analysis for advanced fuel cycle schemes, which is now distributed worldwide..

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[44] Nuclear Energy Data, OECD, Paris, 2008 - ISBN 978-92-64-04796-9

[45] OECD/NEA, IAEA, EC, A Proposed Standardised List of Items for Costing Purposes in the Decommissioning of Nuclear Installations, Interim Technical Document , OECD/NEA, Paris (1999) – "Yellow Book"

[46] OECD, IAEA: Uranium 2014 - Resources, Production and Demand, NEA No. 7209, - "Red Book"

Whenever a database had to be set up the help of the Data Bank was requested. Sometimes the amount of effort was small like when a small database was set-up for their new study on qualified manpower.

Environmental Applications

In the aftermath of the Chernobyl accident in 1986 the need to predict atmospheric dispersion of radioactive materials became evident. Upon an initiative coming from Japan this subject was introduced among those the Data Bank should deal with, in particular concerning computer codes used for modelling dispersion. The ones available were alas simple Gaussian models that some experts called "the dogs to be kicked". Thus, a specialists meeting on "Advanced modelling and computer codes for Local-scale and Meso-scale ***atmospheric dispersion*** of radionuclides" was held that showed the existence of considerable interest in specialised modelling codes. These programs would be used to provide a first test of the new approach, and to acquire the most advanced codes in this category, together with experimental data needed for their validation. Besides acquiring new, specialised computer codes for this topic the Data Bank started to collect, store, and distribute experimental data from atmospheric dispersion tracer experiments performed in the member countries. These data were needed for validating high-resolution supercomputer codes predicting dispersion within 50 km of the source of pollution and in the vicinity of the source and taking into account typical NPP site topographies. The schema for the data base and its management procedures were outlined and distributed. Examples of tracer experiments data collected are GUARDO-90; SIESTA-86, and ORESUND-85. As to the computer codes, examples of activities concerned parallel computing with a module called NOABL for the wind field modelling, using terrain following co-ordinates for atmospheric dispersion. Another module predicting the dispersion within that wind field (PAS) was also parallelised. These modules were part of the MESYST code system for the diagnosis of dispersion of radioactive materials around nuclear power stations. In 2001 the development and testing of the enhanced MC scheme for tracer atmospheric dispersion simulation MCDSIM, written in C++ and operating under PVM (Parallel Virtual Machine) was completed. Results were reported at the Conference on Supercomputing in Nuclear Applications 2000 in Tokyo. These code systems are distributed by the NEA Data Bank.

In the mid Nineties the OECD Environment Directorate had set up a ***toxicology data base***, which was then integrated in a more general UN data base (IRPTC). The NEA Data Bank has collected and then provided relevant toxicological information on radioactive substances in the form of a database (***TOXDB***)containing radio-chemicals which were missing from previous toxicology databases such as uranium, thorium, radon, plutonium, beryllium, cobalt, and iodine. TOXDB was contributed to the IAEA DECADES project (a data base for use in environmental impact studies). The specific work at the Data Bank was to compile critically reviewed toxicology data from an initial list of elements proposed by national contact persons.

Support to other parts – Databases, Conferences

With the help of the Data Bank, ***ISOE*** the ***Information System on Occupational Exposure*** has been installed and maintained on an ORACLE relational database on behalf of the Radiation Protection and Public Health (CRPPH) Division of NEA. In this context also data entry Web applications have been developed.

A continuous support is provided by the Data Bank to the ***Central Secretariat*** concerning computing and informatics services, e.g., it has developed and structured the NEA Web pages for many years until a Web master was put in charge of managing its content. The Data Bank has also operated the ***computer installation*** for the full agency.

The following Table XVI shows the list of databases that were either developed by the Data Bank or with their help and support:

Table XVI: Databases in Support of the Different Activities

Data Bank	
CINDA	Bibliographical Index to Nuclear Data
DBAIS	Computer Program Service Administration
EVA	Evaluated nuclear data (Including JEFF)
EXFOR	Experimental nuclear data
IFPE	International Fuel Performance Experiments (WPRS)
IDAT	Database and Analysis Tool for IRPhE (WPRS)
IRPhE	Evaluated Reactor Physics Experiments (WPRS)
JANIS	CD/DVD nuclear data viewer
MasterFile	Database with 2500 program and data packages (1 M files)
RTFDB	Research and Test Facilities
SINBAD	Radiation Shielding and Dosimetry Experiments (WPRS)
TDB	Chemical Thermodynamic Data (RPWM)
Nuclear Science Support	
DICE	Database for Evaluated Criticality Safety Experiments
ICSBEP	Evaluated Criticality Safety Experiments (WPNCS)
HPRL	High Priority Request List for Nuclear Data (WPEC)
SFCOMPO	Database of Spent Fuel Composition (WPNCS)
Generation IV International Forum	
GIF	Content Management System for collaborative work
Radiation Protection support	
ISOE	Information System on Occupational Exposure
Nuclear Safety support	
CCVM (ITD)	CSNI Code Validation Matrix Integral Tests
CCVM (STD)	CSNI Code Validation Matrix Separate Tests
FIRE	OECD Fire Incidents Records Exchange
OPDE	OECD Piping Failure Data Exchange
Safety Projects	19 Safety Joint Research Project Databases
SCAP	Stress Corrosion Cracking (SCC) and Cable Aging
STEX	Steam Explosion Experiments
Nuclear Development Support	
BBO	Nuclear Electricity Production (Brown Book)
RBO	Uranium Resources and Requirements (Red Book)
NEA as a whole	
Addresses	Contacts
Conferences	Organising Conferences
Correspondence	Archives of mail
Documents	Official NEA Documents
Missions	Mission reports
Publications	NEA Publications

Over the 50 years the NEA and the Data Bank and NSC were increasingly more involved in co-organising and actively participating in ***international conferences***. This provided a high visibility to the work of the Data Bank and NSC, in particular the "OECD benchmarks" were cited and revisited in many conference papers and this term became an international reference of quality in this domain. Also review papers on specific topics studied or summaries of state-of-the-art reports by the NSC had considerable success.

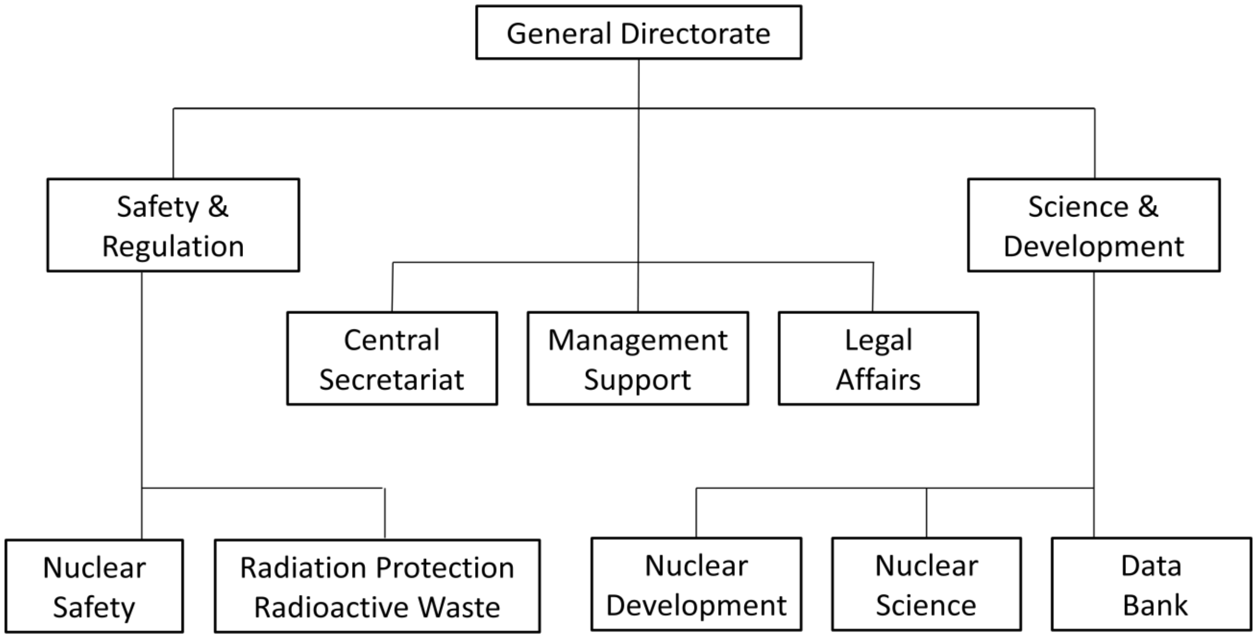
A large number of specialists meetings, seminars and workshops covering each part of the largo scope of the Data Bank were held, both at the premises of the Data Bank, OECD Headquarters or at different institutions collaborating with OECD/NEA.

Table XVII lists the series of conferences the Data Bank was actively involved with, also in providing a conference management database to facilitate the paper review and to shaping the technical programme of the conferences. It also helped to prepare the proceedings of several conferences.

Table XVII: List of conference series involving staff of the CPL or Data Bank

Acronym	**Description of Conference, Topical, Year and Venue**
SMORN	Specialists Meeting / Symposium on Reactor Noise. 1974 in Casaccia (Italy), 1977 in Gatlinburg (USA), 1981 in Tokyo (Japan), 1984 in Dijon (France), 1987 in Munich (Germany), 1991 in Gatlinburg (USA), 1995 in Avignon (France) and 2002 in Göteborg (Sweden)
M&C	International Conference on Mathematics and Computational Methods applied to Nuclear Science and Engineering, occasionally combined with SNA and/or MC , 1965 Argonne IL (USA), 1967 Mexico city (Mexico), 1969 Knoxville TN (USA), 1971 Ann Arbor MI (USA), 1973 Idaho Falls ID (USA), 1975 Charleston SC (USA) , South Carolina, 1977 Tucson AZ (USA), 1979 Williamsburg VA (USA), 1981 Munich (Germany), 1983 Salt Lake City UT (USA), 1985 Knoxville TN (USA), 1987 Paris (France), 1989 Santa Fe NM (USA), 1991 Pittsburgh PA (USA), 1993 Karlsruhe (+SNA) (Germany), 1995 Portland OR (USA), 1997 Saratoga Springs NY (USA), 1999 Madrid (Spain), 2001 Salt Lake City UT (USA), 2003 Gatlinburg TN (USA), 2005 Avignon (France), 2007 Monterey CA (+SNA), 2009 Saratoga Springs NY, 2011 Rio de Janeiro (Brazil), 2013 Sun Valley ID (USA)
MC	International Conference "Monte Carlo 2005" – Advanced Monte Carlo for Radiation Physics, Particle Transport Simulation and Applications, 2000 Lisbon (Portugal), Oak Ridge 2005, 2010 Tokyo (+SNA) (Japan), 2013 Paris (+SNA)
ICRS	International Conference on Radiation (or Reactor) Shielding, 1967 Harwell (UK), 1972 Paris (France), 1977 Knoxville TN (USA), 1983 Tokyo (Japan), 1988 Bournemouth (UK), 1994 Arlington TX (USA), 1999 Tsukuba (Japan), 2004 Funchal-Madeira (Portugal), 2008 Callaway Gardens GA (USA), 2012 Nara (Japan)
ICNC	International Conference on Nuclear Criticality, 1981 Los Alamos NM (USA), 1983 Dijon (France), 1987 Tokyo (Japan), 1991 Oxford (UK), 1995 Albuquerque NM (USA), 1999 Versailles (France), 2003 Tokai-mura (Japan), 2007 Saint Petersburg (RF), 2011 Edinburgh (UK)
PHYSOR	International Conference / Topical on PHYSics Of Reactors, 1988 Jackson Hole WY (USA), 1990 Marseille (France), 1992 Charleston SC (USA), 1994 Tel Aviv (Israel), 1996 Mito (Japan), 1998 Long Island NY (USA), 2000 Pittsburgh VA (USA), 2002 Seoul (Korea R.o.), 2004 Chicago IL (USA), 2006 Vancouver (Canada), 2008 Interlaken (CH), 2010 Pittsburgh VA (USA), 2012 Knoxville TN (USA)
GLOBAL	Congress on Advances Fuel Cycles and Systems, Nuclear Energy Systems for Future Generation and Global Sustainability, 1993 Seattle WA (USA), 1995 Versailles (France), 1997 Yokohama (Japan), 1999 Jackson Hole WY (USA), 2001 Paris (France), 2003 New Orleans LA (USA), 2005 Tsukuba (Japan), 2007 Boise ID (USA), 2009 Paris (France), 2011 Chiba (Japan), 2013 Salt Lake City UT (USA)
SNA	International Conference on Supercomputing in Nuclear Applications, 1990 Mito (Japan), 1993 Karlsruhe (Germany), 1997 Saratoga Springs (USA), 2000 Tokyo (Japan), 2003 Paris (France), 2007 Monterey CA (+M&C) (USA), 2010 Tokyo (+MC) (Japan), 2013 Paris (+MC) (France)
ND	International Conference on Nuclear Data for Science and Technology, 1978 Harwell (UK), 1982 Antwerp (Belgium), 1985 Santa Fe NM(USA), 1988 Mito (Japan), 1991 Jülich (Germany), 1994 Gatlinburg TN (USA), 1997 Trieste (Italy), 2001 Tsukuba, (Japan), and Jeju Island, South Korea (2010). 2004 Santa Fe NM, 2007 Nice (France), 2010 Jeju (South Korea), 2013 Brookhaven NY (USA)

The structure of the NEA in 2014 is as follows



STRUCTURE OF NEA 2014

Figure 43: Structure of the different Working Units of the Nuclear Energy Agency - 2014

OTHER GENERAL OBSERVATIONS

Were all developments positive?

One major impact on the restructuring of the committees was, while in the previous set-up in each committee and at each meeting specific specialists were present thus many technical questions were discussed and practical decisions of achieving progress were taken, in the new set-up the committee dealt increasingly more with administrative aspects and the technical part became rather diluted, to the disappointment of some and to the satisfaction of others. During the discussion at the SC meeting several delegates thought that there was a danger that the new committee would only introduce another layer of bureaucracy and that there would be a proliferation of subgroups with exactly the opposite effect of what was aimed at when combining the Committees. Several country representatives in the NDB management committee felt that the change in structure was rather radical and risked limiting existing technical work which was very highly valued in their countries.

The delegates with specific competencies in computing issues, one of the key strengths of the CPS, practically disappeared over time giving a decreased weight to those activities; the same happened with the new higher level management staff; they had a reduced understanding and interest for the more traditional activities covered by the former CPL and CCDN and were more interested in generic policy making.

While it definitively had a beneficial and synergetic impact on closer collaboration between the different players, this new set-up created also a kind of confusion as to who was pro-eminent in the decision making: was it the NSC who dictated the programme to the Data Bank? What role had the user community in the member countries receiving the services? Who would be players in defining and proposing the budgets? What was the exact role of the other Standing Committees in defining the NDB programme? Some countries were members of the NSC only, some of both NSC and NDB, who would receive what kind of service? How would this impact existing agreements and arrangements between USDoE, Data Bank and the IAEA? So, it looked like navigating through this fog towards an uncertain horizon.

Clearly the scope of the NSC grew in size and importance and with it the number of working parties, expert groups and task forces and the results were well recognised internationally, especially those involving benchmark studies, cited as OECD benchmarks at conferences, in journals and publications. The role of the NDB itself in turn was placed more at the margin, that of an appendix to the NSC in contrast with the concerns expressed by the delegates when the restructuring took place. The annual meeting was shortened to half a day. Only a subset of the national representatives would attend that half day meeting. The topics discussed were simply of administrative nature, thus not appealing to a number of delegates. They would hear anyway the results during a ten minutes summary presented at the NSC proper meeting. At the Bureau meeting held between two main NSC meetings the Data Bank issues were hardly discussed. Staff for the traditional services was continuously decreased in favour of support services to the whole agency, be it office automation or administration as a contribution in kind and in particular in support of NSC. When budgetary cuts were demanded by the SC it was the Data Bank who had to pay the highest share compared to other divisions. While in the past the Chairs of the Committees were changed every two or three years, all of a sudden, starting about a decade ago they became static, chairmen would rarely change, certainly doing a good job but breaking an unwritten rule, thus contributing to a diminished dynamic of all this. Finally, the DG did not think high about scientific issues; all that mattered was SAFETY, forgetting that without sound science as a basis you cannot operate safely NPPs. Also the accidents that happened: TMI, Chernobyl, Fukushima and those of criticality, like the last one at Tokai-mura, each one amplified the importance of the groups talking "safety". In fact, they were due to human errors, to management mistakes and to sloppy engineering decisions. None of them was due to lack of scientific knowledge. The humans, not science operate reactors, but they need sound scientific technical information to run them properly!

The co-operative arrangements did not cover fully the different cases that arose, not allowing to take clear decisions as to which arrangement applied: e.g. Australia, member of NEA but not member of the Data Bank had no access to the services according to the statute, but had theoretically access through the arrangement with the IAEA or could receive a service from the US centers. This applied also to many other countries (Canada, Chile, Estonia, Iceland, Ireland, Israel, Luxembourg, New Zealand, Poland). This would allow a free ride for countries not covered. This lack of completeness in the arrangements was mainly due to a lack of sensitivity at higher level of management.

Looking into the future

At the June 2007 Data Bank Management Committee meeting, for the first time since the reorientation of former committees, the Data Bank annual meeting was extended to include topical presentations and discussions on *new generation of computer codes in nuclear engineering* with the aim of finding future perspectives. Three presentations were made: Paul Turinsky (NCSU), "A Random Walk Toward Advanced Modeling and Simulation Capability in Nuclear Engineering", Christian Chauliac (CEA), "NURESIM: A European Platform for Simulation of Nuclear Reactors", Kenji Yokoyama (JAEA): "Current Status of Neutronics Code System in Japan" followed by a discussion on multi-physics simulations, the integration of stand-alone computer codes into systems that facilitate modelling and analysis.

In preparation of the NEA Strategic Plan of 2011-2016 for the same meeting a paper was prepared by the staff under the guidance of the Head of the Data Bank, Akira Hasegawa: "*The NEA Data Bank of the Future: What kind of Data Bank do we need to meet future challenges? Where are we going from here? The Data Bank as a centre of excellence for information / knowledge acquisition, preservation, and dissemination*" [16]. It contained a thorough analysis of the status of activities and what is expected to be required for the future in order to play the full role assigned to it by the Terms and References. It was mapped out into the following sections

- Scope and Role of the Data Bank
- Future Data Bank activities in the field of nuclear data
- Computer codes and related fields (computer codes, benchmarking, validation, user interfaces)
- Beyond "Chemical data" at the NEA Data Bank in the years to come: Data for Nuclear Materials
- Integral data and co-operation with other standing committees
- Other data bases to be considered for the future
- NEA Information Technology Future
- General questions for the NEA/DB Executive Group members

It was presented during a special session: "Discussions of the Future of the Data Bank". The result was that a questionnaire was prepared and sent out in order to gather views and opinions of all members. Each question was introduced with an explanation as to what was at stake. It contained a table "Importance of Data Bank Work Areas in the future" in which members were asked to rank the importance of each activity for the future. Half of the Members provided answers. The detailed analysis of the questionnaires showed that in general countries were satisfied with the service they received. The NEA/DB should act as an international technical knowledge pool and preserve data/knowledge bases and maintain them. The view was expressed that the Data Bank should be more autonomous from NSC but keep close contacts and the participants might be different from those of NSC with appropriate competencies proper to Data Bank matters. More interaction with industry and closer co-operation with the European Commission and the ITER project were requested. For the rest the overall reaction of both the Committee as well as the attitude of higher management was lukewarm. That was somehow surprising as it was a timely if not an urgent opportunity to safeguard and further develop the assets so far acquired. Another attitude seems to have been: "If it ain't broke don't fix it", spelling out a kind of reluctance towards changes. But staff was convinced that it was time "to fix it". Data Bank staff wished not to be reduced simply to Post Office staff for computer codes and data distribution. The overall result was that in the Strategic Plan for 2011-2016 the Data Bank role is described in half a page out of 40 and contains nothing notably different compared to the previous two strategic plans covering 1998-2010.

Upon the initiative of the Japanese Delegation and as a contribution to the next Strategic Plan of the NEA (2017-2022) a Task Force was set up at the Data Bank meeting in 2013 to discuss the programme, the strategy, and future activities for the Data Bank, as well as the relationship between the Data Bank and the rest of the NEA. "*The function of the NEA/DB and its services are expected to respond to the evolving needs of future nuclear programmes. It is therefore important that the framework of the NEA/DB is kept under review to help ensure that its objectives and programmes of work are developed in ways that will help sustain safe, reliable, and economic operation of current nuclear systems and to help develop next-generation technologies. In particular it is appropriate to review current activities, such as computer program services, nuclear data services and database services as well as other knowledge preservation / management functions, and to discuss the development of the NEA/DB activities in the context of future needs*". The Task Force would recommend the possible adaptation of systems and structures in the NEA/DB in a way that would help to initiate and sustain such enhancements/additions to its products and services. In March and in June 2014 the first and second meeting of the Task Force was held.

In this context the issue of a new emerging generation of computer codes in nuclear engineering was discussed: what role the Data Bank should play, how it should adapt to these new trends and evolutions in nuclear engineering simulations and what initiatives should be taken to best respond to needs of its user community. It was proposed that the Data Bank should provide support to the development of the next generation code systems and general environment for nuclear analysis and design. The code development style and the user community of codes have drastically changed during the last decade, though many of the legacy codes are still in use. The risk is that the investment made in past developments will be lost or not well understood by the young generation of engineers. One way to kick off an activity in this direction would be the organisation of an international workshop gathering experts and managers in charge of developing computer based platforms for simulation in nuclear reactor engineering and fuel-cycle modelling, with the aim of comparing the advanced methodologies used and introduced, discussing common approaches for facilitating exchange of modules, to define code / data interfaces, and present examples on effective / successful graphical user interfaces . It should also seek possible co-operation to develop such systems. Overall, it should benefit today's effort in "***Advanced Modelling and Simulation***".

THE MORE HUMAN ASPECTS OF THE HISTORY

Staff interaction and working atmosphere, and the positive effect of change

Over the 50 years under review, the many technological changes have had considerable effects not only on the way work was carried out, but also on the work relationships among colleagues.

In the early days, interaction among colleagues was much more intense. Computer input was prepared with punched cards and sometimes with perforated paper tape. Staff would meet to discuss then in the "punching" room or at the photocopying machine, once this marvel became available. The punched card boxes with the programs and input data had to be deposited at a computer room counter, where these were read-in by an operator. There was normally a queue there, thus questions and ideas about work could be exchanged. The turn-around times to obtain the output from the computer runs could be one or more hours: this was an opportunity also to visit the general or mathematical journal library to read the most recent articles and to discuss programming techniques with other programmers. Once a day there were coffee or tea time breaks. These were most enriching moments for exchanging ideas in problem solving, but also to get better acquainted with each other, thus building up trust in the relationship, all the contrary to wasted time. Next appeared teletype terminals, which allowed direct editing of the programs and their input data on disk files and to submit the "jobs" remotely. These were not located in the room of a programmer, but in a shared room assigned for the purpose. Also, there were opportunities to talk to each other and to exchange experience on file editors and procedures. Next, screen terminals became available, another major improvement, as they allowed not only to edit files, submit jobs, but also to inspect and visualise the results, once time sharing operating (TSO) systems were installed in the mainframe computers. Turn-around times for work on computers had shortened tremendously. Also, these screens were located in shared rooms and the exchange between staff continued to be lively. Next, the personal terminals that were placed in the office of each person emerged, later replaced by personal computers. Now staff would spend practically most of the working time in their office with reduced interaction with others. Computer networking began to become available and with-it electronic mail could be sent and received. This replaced Telex, telephone calls, and the direct verbal exchange. Some disliked this new situation, others loved it. But it had cooled down the working atmosphere considerably and sometimes, when you asked a question, the answer that came back was "I have sent you the answer via e-mail". Thus, staff was confined increasingly more into "splendid" isolation. It is useless to dwell on nostalgia from the good old times; changes have often very positive effects as they are a source for innovation. Office automation was the neologism that emerged, typewriters and carbon copies disappeared, word-processors removed the need for white fluid (e.g.," Snopake" or "Tipp-Ex") for the corrections. Instead of all CAPITAL letters in the computer communication, the standard upper-lower case presentation of messages and results became the new standard.

Another change came relative to handling in-coming and out-going mail, documenting the work of the staff and the interaction with the users of the service. Mails were circulating in folders from desk to desk. Staff had thus a way to get a detailed picture of what was going on. As the correspondence became more voluminous, someone in the management stated: "too much information, kills information" and from that day on only a trickle of mostly insignificant correspondence circulated among the staff. With the advent of e-mail, the correspondence was hidden in the computer disks of staff, was not recorded normally and staffs started to build little personal empires of information that was not shared, thus decreasing interaction. Because of the large number of users / customers it became necessary though to set up a computerized mail recording system, both for incoming and outgoing mail. In fact, all transactions with distributed computer codes and data along with the correspondence itself had to leave a trace, in particular for use when staff was absent or took up a different job or left the organization. The system ($COR) for correspondence was linked with the newly designed computer-based contact-address system ($ADD) in which names were linked to the correspondence and to the topics of their interest (topics of seminars, participation in meetings, categories of computer codes, benchmarking activities). Thus, each name of a person had assigned a profile of interest that was useful for targeted advertising messages on new information available in their field of interest. With time this system was used less and less by other groups except by the CPS with its thousands of users. Still today all computer program historical records from the past can be traced therein and the correspondence can be inspected on-line on the screen. The system allows also carrying out specific searches on past correspondence and interaction with customers and program authors.

As to the benefit change can lead to, the following is an example. Staff reductions had to be achieved in line with budget reductions and this affected in particular the support staff rather than the professional one. One summer two positions were suppressed that carried out work of operating the main computer and for preparing the photocopies of materials to be dispatched. Because of this, suddenly part of the operation ceased to function properly. The solution to this was the introduction of innovative methods based on new technologies. Thus, the half million pages of computer program documentation had to be scanned electronically, the computer code reports became then simply computerized files to be added to the source code, to the test problems and outputs from the test. The full "Masterfile" system had to be upgraded and restructured, the retrieval system modified and an automatic dispatching system had to be designed.

A neural network was then introduced into the system with the aim of recognizing, classifying, and verifying the types of files and be an aid to the automatisation. The introduction of CD-ROM or DVD writing robots then completed the automatised system.

The man-months

The budget discussions concerned also the man-months allocation. It is well known that the total man-power is the sum of the working staff multiplied by the number of months each one has worked. But the request was to provide the fine structure concerning the different tasks carried out. It is well known also that this exercise gives rather unreliable results unless each staff member works in parallel with the others, independently and only on one project at a time. Staff members were charged however with several tasks, which were not carried out in parallel, but in part sequentially, and tasks had inherent latencies in their execution. It was like identifying each piece and component of a hamburger: thus, it turned out that some worked 18 man-months a year, others 12. Was it overtime work because of understaffing or the effect described in the book *The Mythical Man-Month* [14]? Nonetheless, in the official documents the numbers were normalized to fit the correct total.

The human environment

The staff was composed of many nationalities, with a predominance of "natives" many of which were hired for the support work. For many this was a new experience, having components of charm and difficulty. The difficulty in communicating was not negligible; first of all, many would not express themselves in their mother tongue, thus the vocabulary and idiomatic expressions for every day's life activities were poor in the local language, though developed in expressing work matters. In fact, when hiring staff, the requirement was that they have "excellent knowledge of one of the two official languages (English and French) and ability to draft in that language. Good knowledge of the other one"[47]. The conversation was mostly short of jokes, unless they were very simple, because they would lead to misunderstandings and embarrassment. Explanations required occasionally repetition, for cultural reasons, and for the thin layer of common denominators different staff members would share. There were different interpretations of "yes" or "no" answers. Staff discovered that in some cultures "yes" means "no" if it confirms a "negation". The environment was dominated by Western attitudes, styles, and points of views and thus the communication with staff members from the Far East was more complex. Also, the relation to the hierarchical structures was not felt the same way: a suggestion in the western sense might have been an order in the eastern one. The staff learned also that it was important to pronounce correctly the names and surnames of participants in meetings whose mother tongue was

[47] Internal meetings were held in the language chosen by the person chairing it. Some, in order to prove that they knew both languages and were respecting that both were official, would start in one language, continue with the other and finish with the first one. Others would impose simply their mother tongue if it was one of the official languages. Some staff members from the Far East would speak French, but mostly they were rather fluent in English. It happened that the French person chairing the internal meeting would not react to the protest from the Far East: "English please" except saying, "Non, ce sera en Français, comme ça vous allez l'apprendre"

very different from the official OECD languages[48].But what a charm in all this after all; learning that there were other ways of looking at things, other traditions, not anyone superior to the other, other images in expressing ideas and the rich sound of other cultures!

This opened the mind of staff and when they returned to their countries, they would transmit this experience to others. At least, this was so when the communication systems and media were much less developed than today. There was occasionally a difference in predominance of official working languages versus local language. E.g., in Ispra the dominant language was Italian, the local language, in Saclay at the beginning was mostly English, for some time Italian and later French. The "natives" had a clear advantage, which OECD compensated for non-"natives" with an expatriation allowance. In order to facilitate communication and build a "group feeling", staff would organize luncheons, dinners, parties, and pick-nicks. Most famous were the "spaghettatas". All this was the right lubricant to have the work gears running smoothly[49].

Staff was recruited with the help of the Division of Personnel (later renamed Human Resources) following defined procedures. As in other international organizations and elsewhere not always the "best" candidate is necessarily chosen; sometimes unwritten selection criteria dominate giving more weight to one candidate than another, such as recommendations, relations, balancing different nationalities, pressure from national delegations. Some were dismissed because they were too "bright" or too "qualified" and the justification used was that they did not exactly match the profile sought after; there was hardly the risk that hired staff would cast a shadow onto the supervisor. In most selections, well qualified staff was hired, some were very dynamic and proactive in the field of their responsibilities, others though were waiting something to happen or were paralyzed when a decision had to be taken even though the decision was obvious as described in well-known pieces of literature[50].

Staff was subjected to continuously evolving performance appraisal procedures. The early evaluations were containing also explanations / justifications based on very personal situations and problems; later this was not allowed. Supervisors were rating the staff and, in the end, it was up to the DG to adjust the ratings. It so happened that overall ratings had to follow a "normal" or "Gaussian" distribution. Ratings were thus adjusted somehow to these curves proving the complete ignorance of what "statistics" is all about and that statistics cannot be applied to individuals. But fake scientific reasoning sometimes led to surprising results, e.g., the performance of the last year in office was rated rather low so that that fraction in the "normal" curve could be used for others and anyway as it was the last one it would not affect the career of the staff member concerned. The procedure required that the supervisor and the staff member would discuss work and performance at least once per year. For many this was a daily or weekly interaction, for some it was exactly once per year. Some supervisors would analyse performance in contexts similar to those outlined in "Games People Play"[51].

The paradigm of working together adopted by some of the leaders was that of an orchestra. The full complement of staff of the NEA was then 80 persons, as many as a big orchestra. It is well known that the Director of the orchestra does not teach the first violin how to play the violin, but he tells what

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[48] At one workshop a German chairman, with a bit of a hard pronunciation, gave the floor to the delegate from Japan by calling him "Mr. Wakabayashi", which he pronounced "Bakabayashi". The face of the delegate from Japan turned deep red and he shouted; "Why is he calling me Bakabayashi?" The German chairman had no clue, what was going on. What was wrong? It so happens that while "waka" means young in Japanese language, baka means fool, idiot. So by the wrong pronunciation of the surname, what was a beautiful nice smelling young forest in the spring time became the "stupid bush".

[49] For those who want to know more about the active life of international civil servants, the following book is highly recommended: Pierre Strohl "La paix rêvée"[20].

[50] Dino Buzzati: "Il deserto dei Tartari", Rizzoli, Milano, 1940
James Joyce: "Dubliners", Grant Richards Ltd., London, 1914

[51] Eric Berne: "Games People Play", Ballantine Books. ISBN 0-345-41003-3, 1964

to get out of the violin. Similarly at work, a leader does not tell the staff how to carry out the work, but what are the objectives, what results are expected in the end. The Director of orchestra uses the baton with great sensitivity and sensibility achieving as an overall result a symphony – a harmonious playing together. If instead the baton is used like a whip, the result is a cacophony. Over the 50 years staff has experienced a bit of both.

Acknowledgments

This report is dedicated to the staff that has worked at the CPL and NDB and to the members of the respective Committees who through their enthusiasm, hard work, and inventiveness have developed a service to Member countries that after 50 years is in good health and doing well. Particular thanks go to those who have contributed by sharing memories, documents, photographs that have been included here: thank you Ann, Carol, Catherine, Cristina, Margherita, Renée, Sheila, Felice, and Rodolfo. Particular thanks deserve Kiyoshi Matsumoto and Juan Galán for the support given.

Figure 44: CPS Staff of the NEA Data Bank, Summer 2014
Elena Poplavskaia, Cristina Lebunetelle, Kiyoshi Matsumoto (Head of Data Bank), Juan Manuel Galán, Catherine Rocher-Thromas

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(in parentheses years or periods of issue)

a. SEN/DIG(62)-(63)
b. C(63)
c. NE(63)-(64)
d. SEN(64)
e. SEN/PROG(64)-(77)
f. SEN/COMP(66)-(77)
g. SEN/DATA(77)-(91)
h. SEN/NSC/EG(93)-(13)

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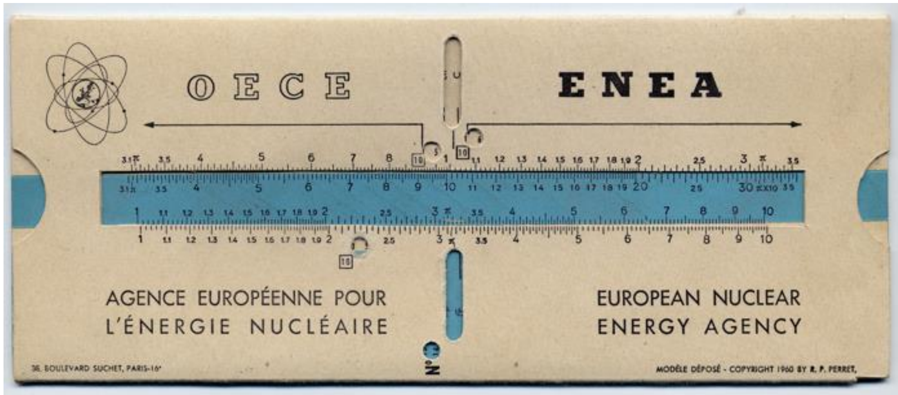
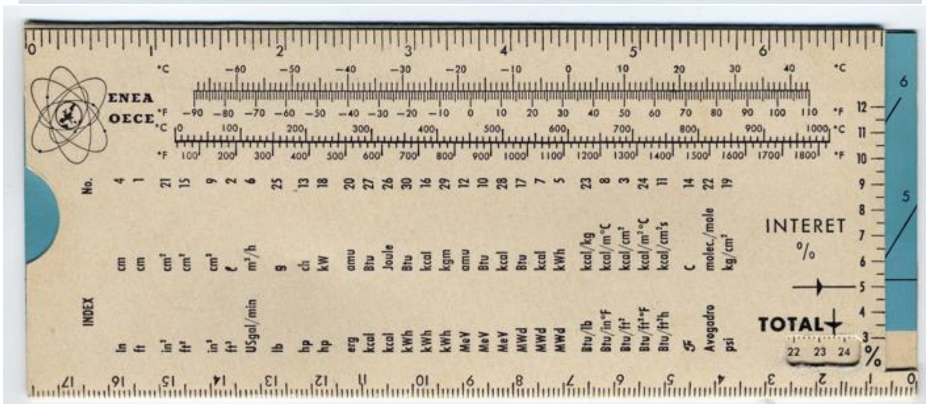
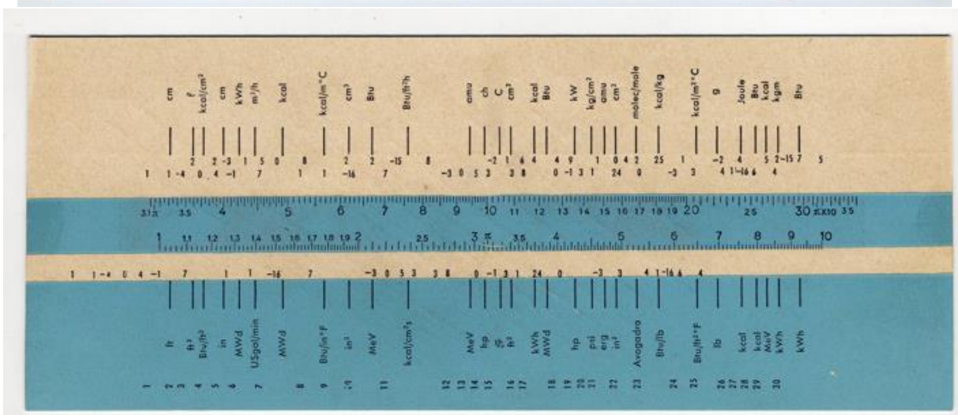
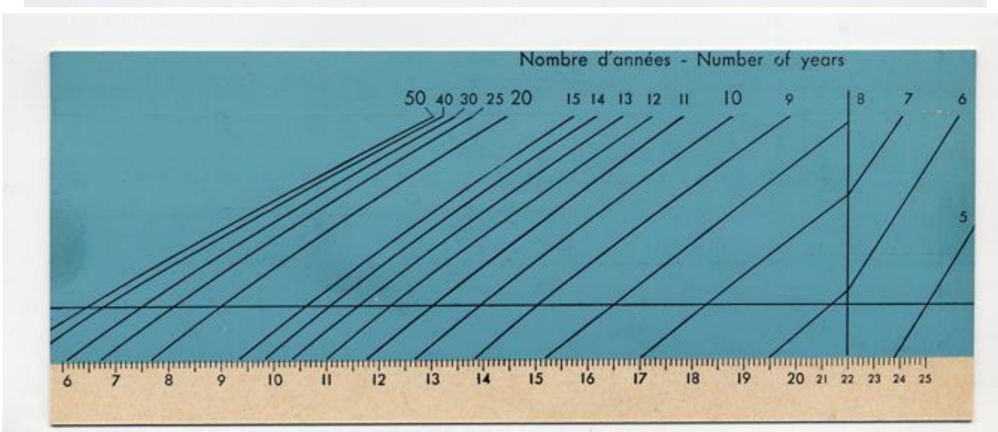
ANNEX I: The First [E]NEA "Computer" by Roland Perret (1960)



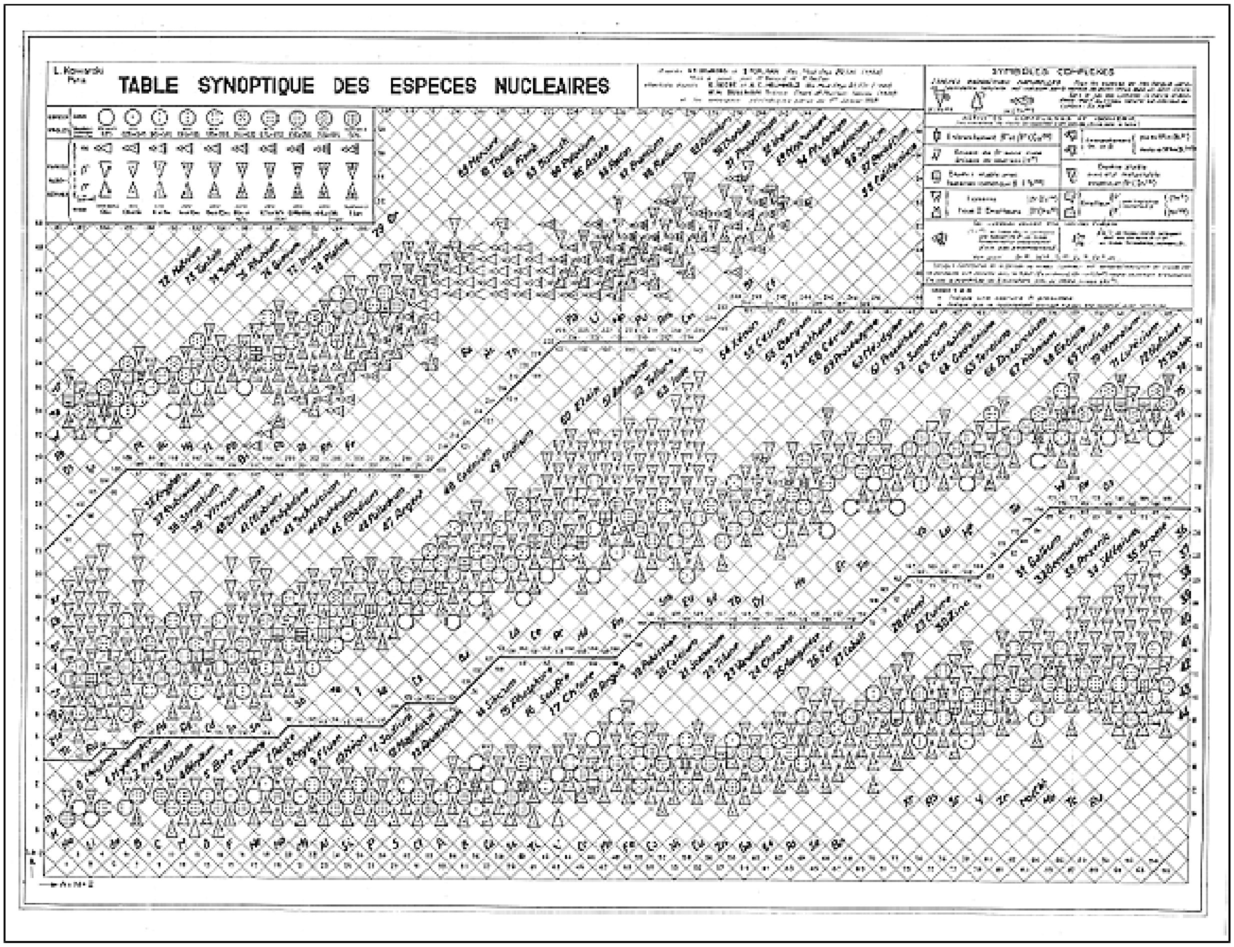






ANNEX II: Comprehensive Chart of Nuclides - Table synoptique des espèces nucléaires

(L. Kowarski, 1950)



ANNEX III Table: Members of Management Committee and delegates having participated in meetings related to the CPL and NDB activities

By country

Name	Country/org.	years
GARRAN, A.	Australia	1988-1989
SMITH, R.	Australia	1977
BRUNEDER, Heinrich	Austria	1968-1970, 1972-1978, 1980-1991
GRAFF, M.	Austria	1966
IZBICKI, H.	Austria	1966-1967
LANG, F.	Austria	1964-1966
LEEB, Helmut	Austria	2005, 2007
SCHNABL, G.	Austria	1988
CEULEMANS, Hugo	Belgium	1977-1978, 1980-1981, 1983-1988, 1989-1990, 1991-1993, 1994
de MEERSMAN, R.	Belgium	1966-1967
D'HONDT, Pierre	Belgium	1996-1998, 1999, 2000, 2001-2014
MINSART, Georges	Belgium	1974, 1976
Van der PARREN, J.	Belgium	1963
Van ROOSBROECK, G.	Belgium	1966, 1968-1970, 1972, 1975, 1977, 1979
KOZIER, Ken	Canada	2008
BECK, A.	Denmark	1977
HANSSON, Leif	Denmark	1964-1973, 1974-1975, 1976-1982, 1983-1984, 1985-1989
HØJERUP, C.Frank	Denmark	1977-1978, 1981, 1983, 1986, 1992-1995, 1996, 1998
NONBØL, Erik	Denmark	2000, 2004, 2006
THOMSEN, K.L.	Denmark	1991
ANTTILA, Markku	Finland	1988-1998, 2001-2010
DAAVITTILA, Antti	Finland	2011-2013
RUSO, I.	Finland	1977
SILVENNOINEN, Pekka	Finland	1976-1982
SOINI, Kristiina	Finland	1985-1987
TANSKANEN, Aapo	Finland	2000
AMOUYAL, Albert	France	1963, 1966
BAYARD, Jean Paul	France	1967
BOUSSEYROL, Elie .M.	France	1968, 1969-1971, 1972-1973
BUSSAC, Jean	France	1964-1966
CHAULIAC, Christian	France	2008
de CHOCQUESES, F.	France	1963
FINCK, Phillip J.	France	1996-1997
JACQMIN, Robert	France	2004, 2011
JOLY, René	France	1977-1982
KOWARSKI, Lew	France	1966
LAFORE, Pierre	France	1974-1975, 1977-1983
MADIC, Charles	France	2007
NIMAL, Jean-Claude	France	1984, 1986-1988, 1990-1991
PHILIS, Claude A.	France	1977-1979,1981-1986, 1987-1988, 1989-1990, 1991-1994
SAVELLI, Philippe	France	1992
SOULÉ, Jean-Louis	France	1966
ZAETTA, Alain	France	1998, 2002-2005, 2006, 2007-2014
BEHRENS, Heinrich	Germany	1986-1987
CACUCI, Dan Gabriel	Germany	2000
FINNEMANN, Herbert	Germany	1996, 1998

Name	Country/org.	years
HÖBEL, Willi	Germany	1973-1979,1981, 1983-1990, 1991-1992
KÜSTERS, Heinz	Germany	1977, 1979-1980, 1982, 1984, 1985, 1987-1988, 1990, 1992-1995
MERKWITZ, Jürgen	Germany	1963, 1964-1966, 1967-1968, 1969-71, 1972-1973
NETTERSHEIM, M.	Germany	1966
QAIM, Syed	Germany	2000, 2001-2005, 2008
SCHREITERER, M.	Germany	1977
TROMM, Walter	Germany	2005-2006, 2008, 2010-2012
ARGYROPOULOS, George	Greece	1976
INGLESSIS, Ms.	Greece	1978
KAVARIAS, K.	Greece	1988-1989
KONTOS, P.	Greece	1980
MARINOS, Emmanuel	Greece	2002
NIKOGLU, Andreas	Greece	2008
SIMOPOULOS, Simos E.	Greece	1994-1997
SYNETOS, S.	Greece	1989
YADIGAROGLU, G.	Greece	1980
KERESZTÚRI, Andras	Hungary	2011-2012
NOWLAN, Noel	Ireland	1989
BENZI, Valerio	Italy	1984-1986, 1988, 1990
CASADEI, G.	Italy	1968-1970
CAVALCHINI, L.	Italy	1977
CHIARINI, Arnaldo	Italy	1964-1970, 1972, 1974, 1977, 1980-1983, 1987-1988, 1990-1991
CLEMENTEL, Ezio	Italy	1963, 1964-1965, 1966
FARINELLI, Ugo	Italy	1974-1975
GLINATIS, Georgios	Italy	2012
LABANTI, L.	Italy	1973
MANZANO, Jorge	Italy	2013
MARTINELLI, Renato	Italy	1992-1995
MENAPACE, Enzo	Italy	1997-2005
PIERANTONI, F.	Italy	1963
REFFO, Gianni	Italy	1990-1991, 1996-1997
SABBADINI, Sergio	Italy	1989
TINTI, Renato	Italy	2007-2008, 2010
VOUKELATOU, Nadia	Italy	2008
AKIMOTO, Masayuki	Japan	1991-1997
ASAI, Kiyoshi	Japan	1987, 1989
ASAOKA, Takumi	Japan	1978, 1981
BITO, Takashi	Japan	1977
FUJINO, Hiroki	Japan	2013
FUKAHORI, Tokio	Japan	2013
FUKETA, T.	Japan	1977, 1978-1979,
HASEGAWA, Akira	Japan	1998-1999, 2001, 2003-2006
IGARASI, Sin-iti	Japan	1984, 1986, 1988-1989
IMAMURA, T.	Japan	1984
ISHIHARA, Yuji	Japan	1998
ISHIKAWA, H.	Japan	1966, 1968, 1970-1972, 1973-1974
IWAMOTO, H.	Japan	1966
KAMADA, Toshihiko	Japan	2012
KAMAI, Hiroyuki	Japan	2013
KATAOKA, Hiroshi	Japan	2000-2001
KATSUNO, M.	Japan	1977
KATSURAGI, Satoru	Japan	1967, 1969, 1975

Name	Country/org.	years
KIKUCHI, Yasuyuki	Japan	1990-1991
KOHSAKA, Atsuo	Japan	1983, 1985-1986
MAEZAWA, Y.	Japan	1989-1991
MATSUMOTO, Kiyoshi	Japan	2009-2010
MATSUURA, Shojiro	Japan	1996
MORI, Takamasa	Japan	2003-2012
NAKAGAWA, Masayuki	Japan	1997, 1998, 1999, 2000
NIITA, Akira	Japan	1999
OGAWA, Tsuyoshi	Japan	1997-1999
OGURA, S.	Japan	1987
OHTA, Shizuko	Japan	1996
OI, Michihiro	Japan	2000
OKAJIMA, Shigeaki	Japan	2013
OSUGI, Toshitaka	Japan	2000-2002
OTA, Shizuko	Japan	1997
OTANI, Takayuki	Japan	2012-2013
SEGAWA, Keiko	Japan	1994
SUYAMA, Kenya	Japan	2013
SUZUKI, Takashi	Japan	1994, 1996
TANAKA, Shunichi	Japan	1980
UEDA, Akihiko	Japan	1994
YOKOYAMA, Kenji	Japan	2008
YOSHIMURA, S.	Japan	1980-1981
GIL, Choong-Sup	Korea	2000
HUH, Young-Hwan	Korea	1994
KIM, Bong-soo	Korea	2009
KIM, Young-Jin	Korea	2003-2004
LEE, Kye-hong	Korea	2010
LEE, Soo Li	Korea	2002
LIM, Chae-Young	Korea	2011-2013
CASTILLO TRIGUEROS, Maria	Mexico	2012
BUSTRAAN M.	Netherlands	1977-1978, 1981-1985,
GRUPPELAAR, Harm	Netherlands	1986-1990, 1995-1996, 1997-1998
KONING, Arjan	Netherlands	2001-2009, 2013
STRUCH, Peter	Netherlands	1964-1966, 1967-1971, 1972-1973,1974-1975, 1976, 1977, 1978
BENDIKSEN, Kjell H.	Norway	1992-1994, 1995-1996
BERG, Jon	Norway	1977
DÖDERLEIN, Jan M.	Norway	1966
HÅVIE, Tore	Norway	1963, 1964-1967
HOLTE, Oddleiv	Norway	1968-1975, 1977
MOEN, Helge	Norway	1979, 1981, 1983
NITTEBERG, J.	Norway	1985-1986, 1988-1989, 1991
VITANZA, Carlo	Norway	1999
BRANDÃO, Maria A-	Portugal	1976-1978
CARLOS, C. Ramalho	Portugal	1983-1996
CARVALHO SOARES, José	Portugal	1997
da COSTA OLIVEIRA, J.F.	Portugal	1972, 1974
TEIXEIRA GOMES, F.	Portugal	1980- 1982, 1988
VAZ, Pedro	Portugal	2001, 2004-2005
ANDREEVA, Liudmila	Russia	2013
KAGRAMANYAN, Vladimir	Russia	2013
PATARAKIN. Oleg	Russia	2013

Name	Country/org.	years
KODELI, Ivo	Slovenia	2012
TRKOV, Andrej	Slovenia	2009
ARAGONES José	Spain	1998, 2005, 2008-2009
CARO, Rafael	Spain	1983-1985
GARCIA DE VIEDMA, Luis	Spain	1990-1998, 2000-2001
GUASP, José	Spain	1977
IGLESIAS, T.	Spain	1975-1978, 1980,
MANERO, F.	Spain	1979,1981
ORTIZ-FORNAGUERA, Ramón	Spain	1963, 1966-1968, 1969-1971, 1972-1974
PEÑA, Jorge	Spain	2002-2006, 2008-2010
PERLADO, Manuel	Spain	1982
RAMON CAMARMA, Javier	Spain	2011
BLOMGREN, Jan	Sweden	2006-2009, 2011-2012
GRÄGG, Clas	Sweden	1966, 1994-1999
HENRIKSSON, Hans	Sweden	2010
HOLTE, Gunnar	Sweden	1977
LEFVERT, Tomas	Sweden	2000
LINDE, Sven	Sweden	1963, 1964-1973, 1975-1985, 1986, 1987-1988, 1989-1991
NASLUND, Göran	Sweden	1966
OLSSON, Nils	Sweden	2001-2002
TOLLANDER, B.	Sweden	1969-1970
AUERBACH, Theodor	Switzerland	1965-1966, 1967-1968, 1971-1973-1975, 1977
BRUNNER, Josef	Switzerland	1966, 1969, 1977, 1978-1980, 1981-1983
CHAWLA, Rakesh	Switzerland	2001, 2008-2009
PATRY, Jean	Switzerland	1963, 1964, 1970, 1972
STEPANEK, Jiři	Switzerland	1984-1989
WYDLER, Peter	Switzerland	1991-1998, 2000
ALPAR, S.	Turkey	1977
BAYRAKTAR, B.	Turkey	1989-1990
BIRSEN, N.	Turkey	1977
ERGÜVEN, Y.	Turkey	1980
ÖZDEMIR, Adlan	Turkey	1986
SEBEN, Taner	Turkey	1994
BERRY, Dennis	UK	1998
EDENS, Derek	UK	1999-2001
FORREST, Robin	UK	1990-1992
HAWKES, Nigel	UK	2009
HESKETH, Kevin	UK	1998, 2002-2003, 2010, 2012
KNIPE, Alan D.	UK	1994-1996
McMAHON, Desmont	UK	2005
PATRICK, Bryan	UK	1977-1980, 1981-1982, 1983-1988, 1990
PEARCE, Andy	UK	2006-2008
PRICHARD, William A.	UK	1963, 1964-1966, 1968
SEGAR, C.	UK	1988
SIMISTER, David	UK	2004
UNDERHILL, Les	UK	1963, 1964-1965, 1966, 1969-1976, 1977, 1978-1988
BERRY, Dennis	USA	1998
BRIGGS, Blair	USA	2007
BUTLER, Margaret	USA	1966, 1973
de OLIVEIRA, Cassiano	USA	2005-2006
FRIEDMAN, A.S.	USA	1964
GOLDNER, Frank	USA	1988-1990

Name	Country/org.	years
HERCZEG, John	USA	2007-2013
MASKEWITZ, Betty F	USA	1969, 1978
MULLER, Anthony	USA	1992
NOWAK, David	USA	2008
ROSEN, S.	USA	1978
TURINSKY, Paul	USA	2008
BASTIAN, C.	CEC	1988-1991
COADOU, Jean	CEC	2006
DERUYTTER, A.J.	CEC	1992, 1994, 1997
HELMS, Hans	CEC	1975-1978, 1980-1981, 1983
KIND, Adolf	CEC	1970-1971, 1973
LISKIEN, Horst	CEC	1978-1985, 1987
MONDELAERS, Wim	CEC	2012
MONGINI-TAMAGNINI, Carla	CEC	1966-1967, 1970-1971, 1973-1974
PIRE, Jean	CEC	1977
POZZI, Giuliana	CEC	1963, 1964-1971, 1973-1974
RAIEVSKI, Victor	CEC	1966
RIEF, Herbert W.	CEC	1984-1992, 1994-1995
RIOTTE, A.	CEC	1968
RULLHUSEN, Peter	CEC	2001-2009
WEIGMANN, Hermann	CEC	1995
AMENTA, Joyce	IAEA	1992
BLANTON, Janice	IAEA	1997
COVEYOU, Robert R.	IAEA	1969
CIJNS, Martin	IAEA	1992
FILIPPOV, Alexander	IAEA	1984
GANGULY, C.	IAEA	2005
HUGHES, Thomas	IAEA	1982-1983, 1985
IVANOV, M.V.	IAEA	1966-1968
JUHN, Poong Eil	IAEA	1999
KELLETT, Marc	IAEA	2005
KONSHIN, Valentin	IAEA	1992
MANDRYKA, P.	IAEA	1988
McDERMOTT,	IAEA	1991
MUIR, Douglas	IAEA	1998, 2000
OBLOZINSKY, P.	IAEA	1996
POZNUKHOV, Gennady	IAEA	1984
PRONYAEV, Valery	IAEA	2001
RAMAMOORTHY, N.	IAEA	2004, 2008
ROMANENKO, Arkady	IAEA	1981
SCOTT, T.	IAEA	1966
SOROKIN, Alexander	IAEA	1986, 1994
TURKOV, Zhan	IAEA	1970-1975
WOOLSTON, John	IAEA	1970

In red: chairmen and years of chairmanship In blue: years of vice-chairmanship In green: observer status
Yellow : prehistory

ANNEX IV Table: Directors General and Deputy Directors involved with CPL and NDB matters

Director General	Deputy Director
HUET Pierre (1958-1964)[52]	PERRET Roland
SAELAND Einar (1964-1977)[53]	HANNUM William
WILLIAMS Ian G.K. (1977-1982)[54]	MIIDA Jun-Ichi
SHAPAR Howard (1982-1988)[55]	STROHL Pierre[56]
UEMATSU Kunihiko (1988-1995)[57]	SAVELLI Philippe
THOMPSON Samuel (acting) (1995-1997)	DUJARDIN Thierry
ECHÁVARRI Luis (1997-2014)	

ANNEX V Table: Staff in charge of Administration for

Section/ Department / Agency	Names	(period)
Computer Program Library	Klaus Hey Wilfried Bauer	(1964-1972) (1973-1978)
Data Bank	Wilfried Bauer Bernard Camboulas Renée Posca Rosa Philippe	(1978-1981) (1981-1984) (1984-2001) (2002-)
[E]NEA	Elie Silvera, Peter Sanderson, John Hembury Ricardo Lopez	(1966-1980) (1981-1993) (1993- 2009) (2010-)

[52] Pierre Huet (1920- 2016)
[53] Einar Saeland (1915-2008)
[54] Ian Williams (1921-2000)
[55] Howard Shapar (1924-2009)
[56] Pierre Strohl (1926-2022)
[57] Kunihiko Uematsu (1932-2009)

ANNEX VI Table: NEACRP [16]

Reactor Physics Committee Officials

	Month	Year	Place	Chairman	Vice-chairman	Secretary
--- **E A C R P** ---						
0	February	1962	Winfrith	T.Fry (UK)	none	none
1	June	1962	Saclay	B.Spinrad (USA)	none	R.Meier (CH)
2	February	1963	Zürich	B.Spinrad (USA)	none	R.Meier (CH)
3	October	1963	Idaho Falls	B.Spinrad (USA)	none	R.Meier (CH)
4	June	1964	Hankoe	P.Mummery (UK)	none	E.Critoph (CDN)
5	January	1965	Madesimo	B.Spinrad (USA)	none	E.Critoph (CDN)
6	October	1965	Montreal	P.Mummery (UK)	none	E.Critoph (CDN)
7	June	1966	Madrid	V.Raievski (JRC)	none	H.Kouts (USA)
8	February	1967	Roma	V.Raievski (JRC)	none	H.Kouts (USA)
9	October	1967	Tokyo	V.Raievski (JRC)	none	H.Kouts (USA)
10	June	1968	New York	E.Critoph (CDN)	none	U.Farinelli (I)
11	February	1969	London	E.Critoph (CDN)	none	U.Farinelli (I)
12	November	1969	Berlin	E.Critoph (CDN)	none	U.Farinelli (I)
13	July	1970	Richland	G.Campbell (UK)	none	E.Hellstrand (S)
14	June	1971	Stockholm	G.Campbell (UK)	J.Tyror (UK)	E.Hellstrand (S)
15	July	1972	Zürich	G.Campbell (UK)	J.Tyror (UK)	E.Hellstrand (S)
16	June	1973	Chicago	W.Hannum (USA)	M.Duret (CDN)	E.Hellstrand (S)
--- **N E A C R P** ---						
17	March	1974	Cadarache	M.Duret (CDN)	none	E.Hellstrand (S)
18	June	1975	Bologna	H.Küsters (D)	U.Farinelli (I)	R.Richmond (CH)
19	June	1976	Chalk River	H.Küsters (D)	U.Farinelli (I)	R.Richmond (CH)
20	June	1977	Petten	J.Barré (F)	U.Farinelli (I)	R.Richmond (CH)
21	November	1978	Tokai-mura	J.Barré (F)	U.Farinelli (I)	R.Richmond (CH)
22	October	1979	Paris	C.Till (USA)	M.Duret (CDN)	P.Silvennoinen (SF)
23	September	1980	Idaho Falls	C.Till (USA)	M.Duret (CDN)	P.Silvennoinen (SF)
24	September	1981	Winfrith	J.Askew (UK)	J.Bouchard (F)	P.Wydler (CH)
25	September	1982	Karlsruhe	J.Askew (UK)	J.Bouchard (F)	P.Wydler (CH)
26	October	1983	Oak Ridge	J.Askew (UK)	M.Salvatores (F)	P.Garvey (CDN)
27	October	1984	Aix/Provence	M.Salvatores (F)	L.LeSage (USA)	P.Garvey (CDN)
28	November	1985	Madrid	M.Salvatores (F)	L.LeSage (USA)	P.Garvey (CDN)
29	September	1986	Chalk River	L.LeSage (USA)	P.Garvey (CDN)	J.Stevenson (UK)
30	September	1987	Helsinki	L.LeSage (USA)	K.Shirakata (J)	J.Stevenson (UK)
31	October	1988	O-arai	K.Shirakata (J)	P.Wydler (CH)	F.McDonnell (CDN)
32	October	1989	Chicago	K.Shirakata (J)	P.Wydler (CH)	F.McDonnell (CDN)
33	October	1990	Paris	P.Wydler (CH)	F.McDonnell (CDN)	R.Martinelli (I)
34	September	1991	Würenlingen	P.Wydler (CH)	F.McDonnell (CDN)	R.Martinelli (I)

ANNEX VII: NEANDC[58]

Nuclear Data Committee Officials

	Month	Year	Place	Chairman	Scientific secretary
			---------- **E A N D C** ----------		
1	4 - 8 March	1960	Stockholm, Sweden	R.F. Taschek, USA	C.H. Westcott, Canada
2	15 - 18 November	1960	Oak Ridge, USA	R.F. Taschek, USA	C.H. Westcott, Canada
3	18 - 21 July	1961	Harwell, UK	R.F. Taschek, USA	C.H. Westcott, Canada
4	5 - 10 April	1962	Casaccia and Ispra, Italy	J. Spaepen, Euratom	R. Batchelor, UK
5	4 - 8 February	1963	Chalk River, Canada	J. Spaepen, Euratom	R. Batchelor, UK
6	11 - 15 November	1963	Athens, Greece	J. Spaepen, Euratom	R. Batchelor, UK
7	20 - 24 July	1964	Karlsruhe, Germany	E. Bretscher, UK	R. Batchelor, UK
8	17 - 21 May	1965	Los Alamos, USA	E. Bretscher, UK	R. Batchelor, UK
9	18 - 20 April	1966	Ascot, UK	G.C. Hanna, Canada	W.W. Havens Jr, USA
10	20 - 24 February	1967	Istanbul, Turkey	G.C. Hanna, Canada	W.W. Havens Jr, USA
11	11 - 14 Mars	1968	Montreal, Canada	P. Weinzierl, Austria	M. Neve de Mevergnies, Belgium
12	20 - 24 January	1969	Brussels, Belgium	P. Weinzierl, Austria	M. Neve de Mevergnies, Belgium
13	6 - 10 October	1969	Bournemouth, UK	P. Weinzierl, Austria	M. Neve de Mevergnies, Belgium
14	26 - 29 October	1970	Argonne, USA	W.W. Havens Jr, USA	G.C. Hanna, Canada
15	11 - 15 October	1971	Lisbon, Portugal	W.W. Havens Jr, USA	W.G. Cross, Canada
16	27 Nov. - 1 Dec.	1972	Paris, France	J. Story, UK	H. Condé, Sweden
17	24 - 29 Mars	1973	Tokyo, Japan	J. Story, UK	H. Condé, Sweden
			---------- **N E A N D C** ----------		
18	7 - 11 Mars	1975	Harwell, UK	S. Cierjacks, Germany	M.G. Sowerby, UK
19	20 - 24 September	1976	Stockholm, Sweden	S. Cierjacks, Germany	M.G. Sowerby, UK
20	3 - 7 April	1978	Oak Ridge, USA	R.E. Chrien, USA	C. Coceva, Italy
21	24 - 28 September	1979	Geel, Belgium	R.E. Chrien, USA	C. Coceva, Italy
22	5 - 10 April	1981	Aix-en-Provence, France	K.H. Böckhoff, Euratom	S.M. Qaim, Germany
23	27 Sep. - 1 Oct.	1982	Chalk River, Canada	K.H. Böckhoff, Euratom	S.M. Qaim, Germany
24	12 - 16 Mars	1984	Tokai-Mura, Japan	A. Michaudon, France	W.G. Cross, Canada
25	18 - 22 November	1985	Paris/Grenoble, France	A. Michaudon, France	W.G. Cross, Canada
26	18 - 22 May	1987	Rome, Italy	A.B. Smith, USA	P.G. Young, USA
27	26 - 30 September	1988	Los Alamos, USA	A.B. Smith, USA	P.G. Young, USA
28	26 - 30 Mars	1990	Harwell, UK	S.M. Qaim, Germany	H. Vonach, Austria
29	21 - 25 October	1991	Karlsruhe, Germany	S.M. Qaim, Germany	H. Vonach, Austria

[58] The European-American Nuclear Data Committee (EANDC) was set up in 1959 to co-ordinate the measurement of nuclear data in the countries of OECE(OECD). Its main purpose was advisory in nature. but equipment, personnel and material exchanges have been made possible by its existence

ANNEX VIII: Program Testing

Staff and consultants having contributed to Computer Program Verification and Validation (Testing)

Name	Type/section	Institute
Akanuma Makoto	computer programs	
Bargellini Maria Laura	computer programs	
Bell Victor	computer programs	
Bendiksen Kjell	computer programs	
Birgersson Göran	computer programs	
Briones Florentino	computer programs	
De Ridder Philippe	computer programs	
Diaz Muñoz Pedro	computer programs	
Dicola Rodolfo	computer programs	
Donzelli Margherita	Computer programs	
Galan Juan Manuel	computer programs	iaea
Garcia de Viedma Luis	computer programs	
Horikami Kunihiko	computer programs	
Kodeli Ivo	computer programs	iaea
Kohsaka Atsuo	computer programs	
Lamantea Felice	computer programs	
McTear Derek	computer programs	
Olabarria Ingnacio	computer programs	
Pellegrino Luigi	computer programs	
Petrizzi Luigino	computer programs	iaea
Prescott Reginald	computer programs	
Sartori Enrico	computer programs	iaea
Schuler Werner	computer programs	iaea
Shibuya Susumu	computer programs	
Suzuki Tadakazu	computer programs	
Tonelli Vincenzo	computer programs	iaea
Vanne Jussi	computer programs	
Vaz Pedro	computer programs	
Webster Simon	computer programs	
Yamaguchi Yukichi	computer programs	
Ahnert Carolina	consultant	jen
Aragonés José	consultant	jen
Arroyo Ricardo	consultant	etsii
Borchard Michael	consultant	expert
Borgwaldt Horst	consultant	kfk
Brestrich Ingo	consultant	ike
Bruneder Heinrich	consultant	dragon
Cabellos Oscar	consultant	etsii
Canamero Blanca	consultant	csn
Cantera Juan	consultant	etsii
Carlsson Bengt	consultant	lasl
Champeau M.	consultant	cea-saclay
Civita P.	consultant	enel
Cordan Erica	consultant	cisi
Cramer Noel	consultant	ornl
Crespo Antonio	consultant	etsii
De Almeida Miranda	consultant	itn
Eleta Ramon	consultant	enusa
Ellison John	consultant	nesc
Enderby John	consultant	risley
Engle Ward	consultant	ornl
Engstrom G.	consultant	foafyra
Eyberger Larry	consultant	nesc
Frillici Franco	consultant	enea
Gadjokov Vassil	consultant	iaea
Gago R.	consultant	etsii
Gallego J.	consultant	jen
Garcia Santiago	consultant	ciemat
Garralon Julio	consultant	csn
Gasbarro L.	consultant	enea
Giorcelli T.	consultant	cise
Goj Camillo	consultant	cisi
Gomez Alonso M.	consultant	jen
Grandotto Marc	consultant	cea
Guertin Chantal	consultant	edf
Gulden Werner	consultant	kfk
Higgs C. E.	consultant	eir
Honrubia Javier	consultant	etsii
Hval Sverre	consultant	scandpower
Isoda K.	consultant	jaeri
Jacobs Günter	consultant	kfk
Kavenoky Alain	consultant	cea
Laudiero Carolina	consultant	enea
Lazzeri D.	consultant	fiat

Name	Type/section	Institute
Legan Marianne	consultants	Acc/nesc
Löchte Martin	consultant	ubraun
Lopez Alfredo	consultant	jen
Luqui Ricardo	consultant	jen
Mattes Margarete	consultant	ike
Mazon Luis	consultant	iberduero
Merino F.	consultant	etsii
Miyahara Kaname	consultant	pnc
Nevyjel Alexander	consultant	ösa
Norton D.	consultant	ukaea
Orsi Roberto	consultant	enea
Özdemir Adlan	consultant	tk
Panini Giancarlo	consultant	enea
Peña Jorge	consultant	jen
Santolaya J.M.	consultant	etsii
Scheuermann Walter	consultant	ike
Suzuki Tomo-o	consultant	jaeri
Turnbull Antony James	consultant	expert
van Roosbroeck G.	consultant	moldonk
Vittone Ettore	consultant	task

Name	Type/section	Institute
White Rodney	consultant	expert
Yamazaki Y.	consultant	jaeri
Camboulas Bernard	databank	
Hasegawa Akira	nuclear data	
Nagel Pierre	nuclear data	
Neumann Bernd	nuclear data	
Nordborg Claes	nuclear data	
Shibata Keiichi	nuclear data	
Soppera Nicolas	nuclear data	
Takano Hideki	nuclear data	
Tsuchihashi Keichiro	nuclear data	
Gauvain Jean	nuclear safety	
Holmstöm Heikki	nuclear safety	
Ishack Georges	nuclear safety	
Iwabuchi H.	nuclear safety	
Vitanza Carlo	nuclear safety	
Suyama Kenya	nuclear science	
Wanner Hans	waste management	
Yui Mikazu	waste management	pnc

ANNEX IX: Staff having participated in the works of the CPL and Data Bank (1964-2014)

Names Surnames		
Agostinho Erica	Digne Daniel	Ko-oshima Sasha
Akanuma Makoto	Donzelli Margherita	Kortman Henricus
Ansell Barbara	Dupont Emmeric	Lacroix Eric
Armand Bernard	Dutton Patricia	Lamantea Felice
Arnac Olivier	Edvardson Lars	Lambletin Jean-Pierre
Bargellini Maria Laura	Ergun Tuncay	Latrois Olivier
Barnet Anna	Foltran Eliane	Laurent Mickaël
Bauer Wilfried	Forest Isabelle	Laviec Judy
Belanger Louise	Furuang Linda	Legall Jean-François
Bell Victor	Galán Juan Manuel	Legroux Monique
Bendiksen Kjell	Gandher Laetitia	Lesrustre Jean-François
Biasoli Anna	Garcia de Viedma Luis	Little Aileen
Birgersson Göran	Garzola Maria Teresa	Lotteau Cecile
Boffa Katjusha	Gilhooly Jan	Massara Simone
Borchart Michael	Girod Severine	Matsumoto Kiyoshi
Bossant Manuel	Greenstreet Sheila	Matthews Amy
Boxer Leslie W.	Griffin-Chahid Andrea	McGrath Joanna
Briones Florentino	Gryntakis Emmanuel	McTear Derek
Brunstermann Birgit	Guerard Carlos	Meflah Soraya
Camboulas Bernard	Guillou Robert	Michel-Sendis Franco
Camps Danielle	Gulliford N. Jim	Milne Barbara
Cardona Maria	Hasegawa Akira	Miyahara Kaname
Caron-Charles Marylise	Henriksson Hans	Moallic Paul
Chauhan Roopa	Hey Klaus	Mompean Federico
Cherki Georges	Hill Ian	Morris Carol
Cheta Nevine	Hofer Helmut	Muller Anthony
Choi Yoon-Jong	Holmes-Michel Deborah	Na Byung Chan
Cinque Mr.	Horikami Kunihiko	Nagel Pierre
Clare Paul	Iglesias-Lebunetelle Cristina	Nakagawa Tsuneo
Cocchi-Schuler Helga	Itakura Shuichiro	Nakajima Yutaka
Cocks Hannah	Jacobsen Birgitte	Nemoto Yoshiyuki
Coddens Gerrit	Jewkes Patricia	Neumann Bernd
Cornet Stephanie	Jimeson Christopher	Nordborg Claes
Costa (McWorther) Amanda	Johnson David	Nouri Ali
Coy Jérôme	Johnston Peter	Olabarria Ingnacio
Cramer Nathalie	Joyeux Frédérique	Osterhage Wolfgang
Danet Gérard	Kellett Mark	Östhols Erik
De Ridder Philippe	Kim Sook-Hyeong	Peckham Elizabeth
Defranceschi Mireille	Kim Sang-Ji	Pellegrino Luigi
Derrien Hervé	Klinken B.	Penon Christian
Déry Hélène	Kodeli Ivo	Perrone Jane
Diaz Muñoz Pedro	Kohsaka Atsuo	Petrizzi Luigino
Dicola Rodolfo	Konieczny Marek	Phalip Marie-France

Phelippeau Sheila
Philippe Rosa
Plessy Olivier
Poirot-Muller Isabelle
Poplavskaia Elena
Posca Giustina Renée
Potet Benjamin
Potter Gillie
Prescott Reginald
Puigdomenech Ignasi
Ragoussi Maria Eleni
Ries Daniel
Rocher-Thromas Catherine
Rodens Jaqueline
Rosén Johnny A.G.
Rousset Paul
Rugama Yolanda
Rulko Robert

Sakurai Satoshi
Sandino Amaia
Sartori Enrico
Schett Alois
Schofield Anton
Schuler Werner
Shibata Keiichi
Shibuya Susumu
Soppera Nicolas
Suyama Kenya
Suzuki Tadakazu
Takano Makoto
Takano Hideki
Tarsi Reka
Testori Pierino
Thompson Adrian
Thring Ann
Tobin Steven

Tomba Piero
Tonelli Vincenzo
Truran Lynette
Tsuchihashi Keichiro
Tubbs Nigel
Ueda Akihiko
Valente Saverio
Vanne Jussi
Vaz Pedro
Ventura Andrea
Wanner Hans
Webster Simon
Wise Colin
Yamagishi Isao
Yamaguchi Yukichi
Yamaji Akifumi
Yui Mikazu
Ziegler Brigitte

ANNEX X: CCDN

Heads of the CCDN and Chairmen of the Management Committee

Heads of CCDN	Period	Chairmen of the Management Committee	Period
COLVIN Douglas	1964-1968	SCHMIDT Josef J.	1964-1965
BELL Victor	1969-1970	JOLY René	1966-1968
LISKIEN Horst	1971-1972	SANCHEZ DEL RIO Carlos	1969 -1970
FRÖHNER Fritz	1973-1974	PENDLEBURY E.D.	1971-1973
LESCA Luigi	1975-1976	BRUNNER Josef	1974-1977
DERRIEN Hervé	1977-1978		

CCDN Staff*

Name	Surname
ARMAND	Bernard
BELL	Victor
BOURDARIAS	Francoise
BRINKMEIJER	J.
CAMPS	Danielle
COLVIN	Douglas
COURTIAU	M.J.
EDVARDSSON	Lars
DERRIEN	Hervé
ELMENHURST	Mme
FOLTRAN	Eliane
FÖTSCH	Mr
FRÖHNER	Fritz
GUILLOU	Robert
ISOART	Danielle
JOHNSTON	Peter
KESPARS	P.
KORTMAN	Henricus
LEGRAND	Mme
LESCA	Luigi
LISKIEN	Horst
OGET	Mme
OKAMOTO	Koichi
PARIS	Françoise
PÖTSCH	J.
POTTERS	Mr
RADET	M.
RAISSIS	M.J.
RICKERBY	Claes
ROBERTS	Catherine
SCHETT	Alois
SCHOFIELD	Anton
SCHWARZ	S.
TRURAN	Lynette
TSUCHIHASHI	Keichiro
TUBBS	Nigel
VALENTE	Saverio
WILLARS	H.
WINIWARTER	P.

*This list is incomplete

ANNEX XI: Chairs of the [E]NEA Steering Committee

Years	Chair	Nationality
1956-1961	Leander Nicolaidis	Greece
1961-1964	Jose Maria Otero y de Navascues	Spain
1964-1967	Urs W. Hochstrasser	Switzerland
1967-1969	Hans Henrik Koch	Denmark
1969-1973	Carlo Salvetti	Italy
1973-1976	Reinhardt Loosch	Germany
1976-1979	Bo Aler	Sweden
1979-1982	Hiroshi Murata	Japan
1982-1985	Ivor Manley	United Kingdom
1985-1991	Richard Kennedy	United States
1991-1994	Robert Morrison	Canada
1994-1996	Jörg Hermann Gösele	Germany
1996-1998	Christian Prettre	France
1998-2003	Lars Högberg	Sweden
2003-2005	William Magwood	United States
2005-2006	Jussi Manninen	Finland
2006-2014	Richard Stratford	United States

Secretaries of the Nuclear Science Committee (NSC)

years	Secretary
1992-2010	Claes Nordborg
2011-	Nigel J. Gulliford

ANNEX XII: Programming languages of codes distributed

Access Microsoft programming	LLNL-Fortran (LRLTRAN)
ADA Programming Language	French FORTRAN
Advanced programming language (APL)	JAVA language
Algorithmic language (Algol)	LabVIEW language
Assembler IBM	List processing language (LISP)
Basic, QuickBASIC languages, VISUAL Basic	Lotus-1-2-3-macro language
Block-Structured Recursive (BCPL)	MATLAB (Matrix Laboratory)
Bourne Shell command interpreter (BS)	Michigan Algorithm Decoder (MAD)
C-Language, C++, TURBO C	Modular multi-programming language (MODULA)
Common business oriented language (Cobol)	MVISUAL language
Comprehensive assembler (COMPASS -CDC)	PASCAL (object oriented) language
Continuous system simulation language (CSSL)	Practical Extraction and Reporting Language (PERL)
Control Data Assembly Program (CODAP)	PRAXIS language
DBASE-III, DBASE-IV	Programming Language One (PL/I)
Delphi, Delphi-V4 language	Python language
Disk Operating System (DOS)	Rational FORTRAN (RATFOR)
Excel spreadsheet	Runtime Revolution language (RunRev)
Floating point coding language (FLOCO)	Systems, Applications and Products language (SAP)
Fortran Assembly Program (FAP [IBM-7090])	VAX-11 Macro (DECMACRO)
Fortran-II, -63, -66, -IV, -V(Univac), -77, -90, -95, -2003	Visual FOXPRO 6 language (VFP)
EGTRAN Fortran	XBASE object-oriented programming language

Over 50 programming languages or versions

ANNEX XIII: Different Computer Makes for which Computer Codes were Acquired

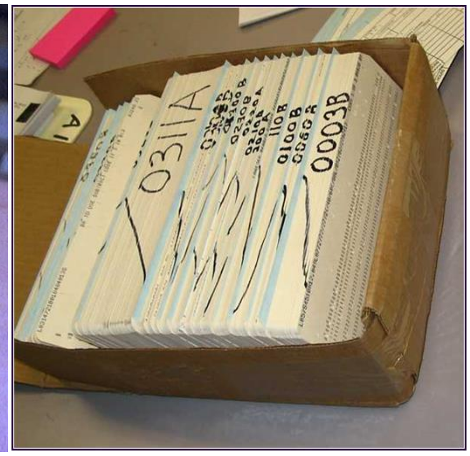
AMDAHL-470/V8, -5868, -5870
Apple I, Apple II, McIntosh, Power Mac
APOLLO DN3000
BURROUGHS-6700, -7800
CONVEX C120, C3
DATA GENERAL MV, ECLIPSE S/140
Digital Equipment Corporation (DEC)
ALPHA, ALPHA/AXP,
PDP-10, -11/34, -11/70
VAX-11/730, -11/750, -11/780, -4300, -5000
VAX-6000, -6220, -8200, -8350, -8500
VAX--8600, -8650, 8700, -8810, Micro-VAX
Intenational Business Machines (IBM)
IBM-704, -7040, -7044, -7090, -7094
IBM-3033, -3081, -3083, -3084(Q), -3090(VF), -360/65
IBM--360/75, -360/91, 370/91, -370/155, -
IBM-370/165, -370/168, -370/175, 4331, -4341
IBM, -9377, RISC-6000
IBM PC
80286, 80386, 80486, 80586
Pentium-75, -100, -166, -200, II-300, II-400, II-450
Pentium III-500, III 1 GHz, 2 GHz,
International Computers Limited (ICL)
ICL-1905, -2976, -2980, -4/40, -4/70, -4/72, KDF9
CRAY Computers
Cray-1, -2, -EL98, -XMP, -YMP
Control Data Corporation (CDC)
CDC-1604, -2300, -3400, -3600, -3800, -6400, -6500, -7600
CYBER-72, -73, -74, -76, -170, -172, -173, -174, -175
CYBER-176, -180, -720, -730, -740, 825, -830, -835, 855

Soviet Computers
BESM-6 (Большая Электронно-Счётная Машина)
MINSK M20, M220
ES-1040, -1055 (Единая система)
Japan Computers
FACOM-M-150F, M-160, M-190, -M200, -230/28, -230/60, -230/75
FACOM-M340S, M-380, M-780
FACOM VP-100, VP-2600
FUJITSU-FMV, -GS8400
HITACHI 280, 5020, M-150H, M-200H, M-280H, NAS AS 9000, NAS 8090
GENERAL ELECTRIC G400, G625, G635
GIER
GOULD-SEL 32/55
HARRIS 7
HEWLETT Packard HP-1000/F, -3000/III, -9000, -9825A
HONEYWELL 11600, 6600, DPS-8
ITEL AS/3-5
NEC ACOS 1000
NOSK DATA 500, 560, 570
PHILCO 2000
PR1ME
RANK XEROX SIGMA 7
SGI WS
SIEMENS 4004, 7541, 7580, 7875, 7880, 7890
SIRIUS1
SUN SPARK, WS
SUN WS
TELEFUNKEN TR4
TRS-80
UNIVAC 1100/44, 1100/60, 1106, 1107, 1108, 1110
XEROX 1100

Over 200 different types of computers

ANNEX XIV: Storage media used for archiving and dispatch (1964-2014)

Punched tape



Punched card Deck

Tape reels

cartridges

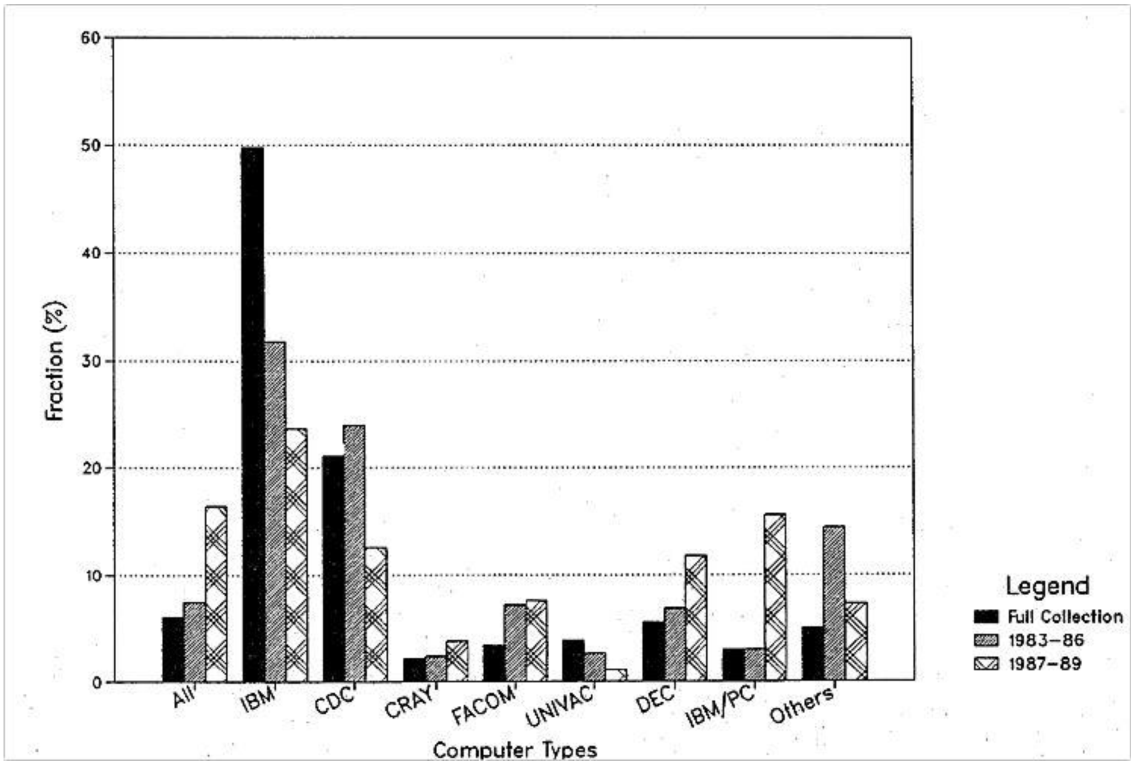
Dikette

CD-ROM/DVD

ANNEX XV: Shipping precious magnetic tapes across national borders, and Listings from computer codes runs

ANNEX XVI: Evolution of computer programs by computer make and in size

Distribution by age



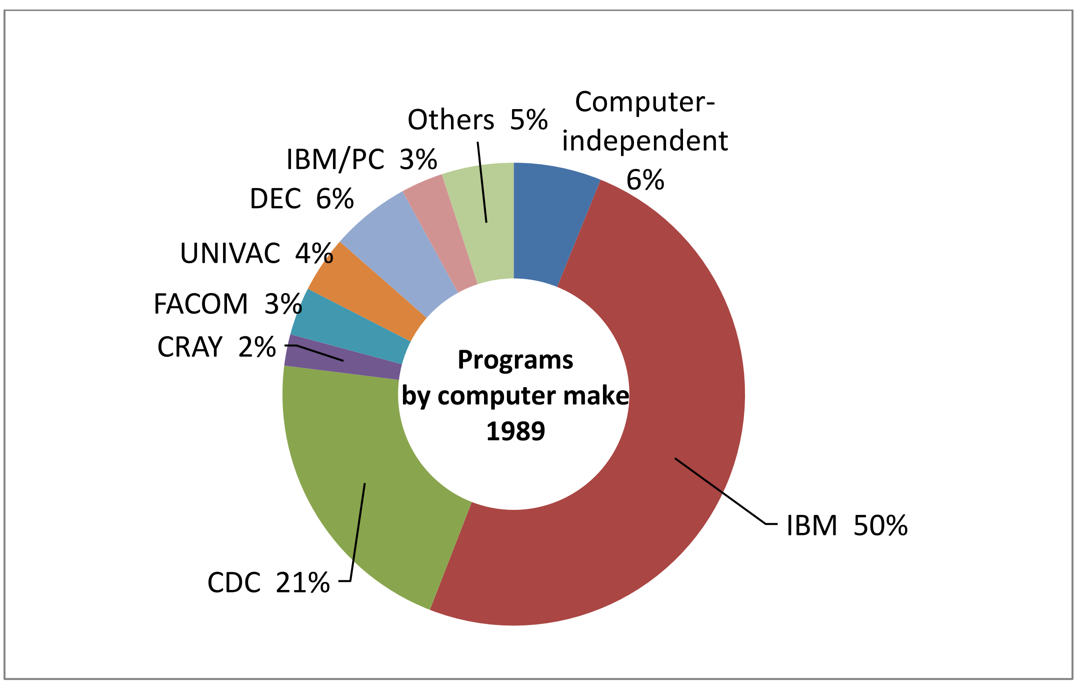


Figure XVI.1 Evolution of computer codes by computer make

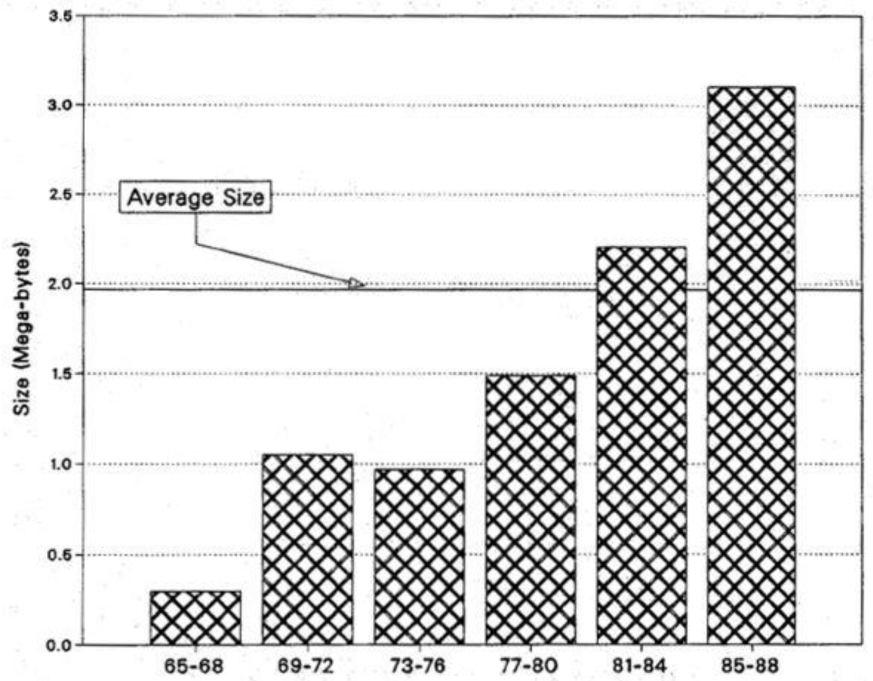


Figure XVI.2 Evolution of computer program size

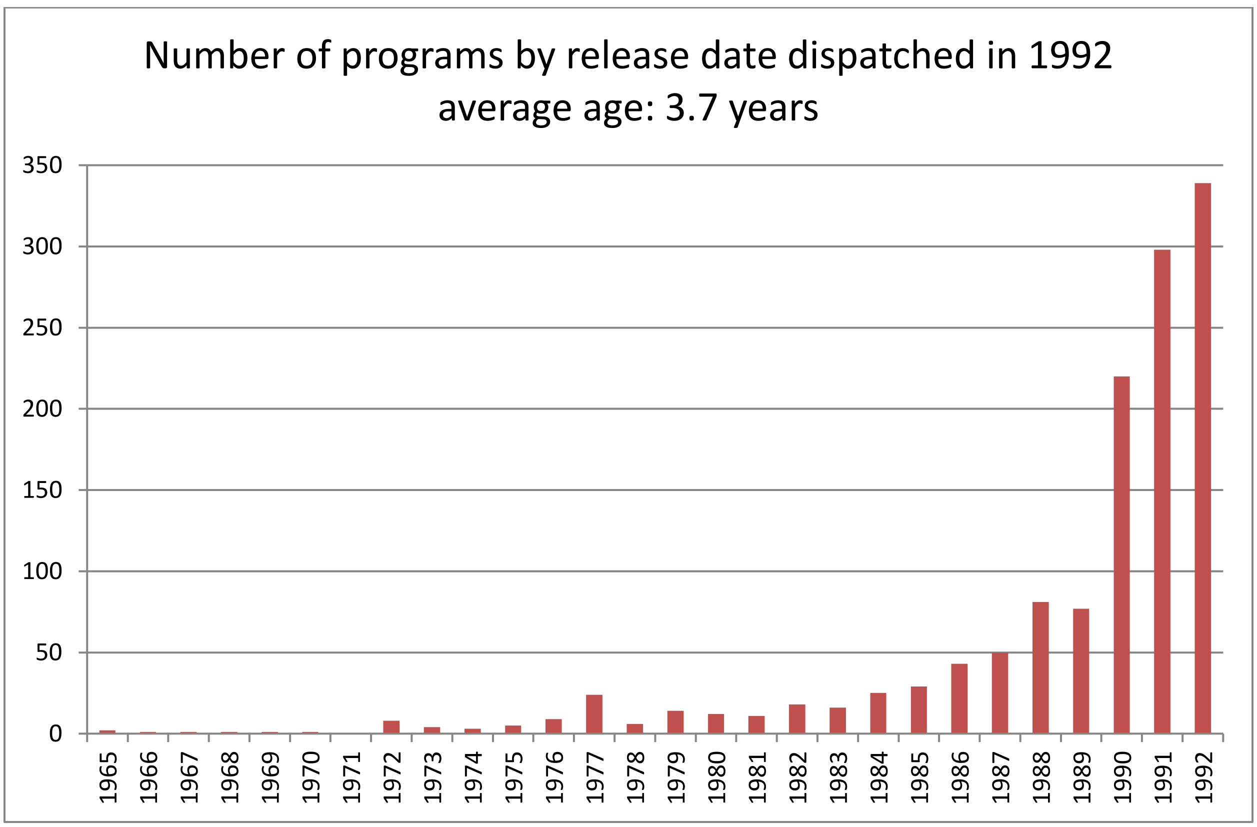


Figure XVI.3 Age of computer program distributed (1992)

ANNEX XVII: Equations used in the computer codes for nuclear power and non-power applications

$$\left(\beta mc^2 + \sum_{k=1}^{3} \alpha_k p_k \, c\right) \psi(\mathbf{x},t) = i\hbar \frac{\partial \psi(\mathbf{x},t)}{\partial t}$$

$$i\hbar \frac{\partial}{\partial t} \Psi(\mathbf{r},\, t) = -\frac{\hbar^2}{2m} \nabla^2 \Psi(\mathbf{r},\, t) + V(\mathbf{r}) \Psi(\mathbf{r},\, t)$$

$$\left[\frac{\partial^2}{\partial \kappa^2} + \frac{2}{\kappa}\frac{\partial}{\partial \kappa} - \frac{\partial^2}{\partial \chi^2} + \frac{2}{\chi}\frac{\partial}{\partial \chi}\right] V(\kappa, \chi) = 0$$

$$\frac{\partial u}{\partial t} = k \nabla^2 u$$

$$\oint_{\partial S} \mathbf{E} \cdot \mathrm{d}\mathbf{l} = -\frac{\partial \Phi_{B,S}}{\partial t} \qquad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\frac{\partial N(\vec{r}, \vec{\Omega}, E, t)}{\partial t} = -v\,\vec{\Omega}.\vec{\nabla} N(\vec{r}, \vec{\Omega}, E, t) - \Sigma_t(\vec{r}, E) v N(\vec{r}, \vec{\Omega}, E, t) + Q(\vec{r}, \vec{\Omega}, E, t) + \int_{4\pi} d\Omega' \int_0^{\infty} dE' \Sigma_s(\vec{r}, \vec{\Omega}' \rightarrow \vec{\Omega}, E' \rightarrow E) v' N(\vec{r}, \vec{\Omega}', E', t) \ldots$$

$$\frac{dQ_i}{dt} = S_i + k_{Q_{i-1},Q_i} \cdot Q_{i-1} - k_{Q_i} \cdot Q_i$$

$$\rho \left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v}\right) = -\nabla p + \nabla \cdot \mathbb{T} + \mathbf{f},$$

Dirac, Schrödinger, nuclear matter, heat conduction, Maxwell, Boltzmann, Bateman and Navier-Stokes equations used in computer programs

Abbreviations used:

Acronym	meaning
4C	Four Centers on nuclear data
ACC	Argonne Code Center
ANL	Argonne national Laboratory, Illinois, USA
CCDN or NDCC	Centre de Compilation de Données Nucléaires or Nuclear Data Compilation Centre, Saclay, France
CERN	Conseil Européen pour la Recherche Nucléaire, Geneva, Switzerland
CiSi	Compagnie Internationale des Services en Informatique, France
CPL	Computer Program Library, Ispra Italy
CPS	Computer Program Service of NDB
CSNI	NEA Committee on the Safety of Nuclear Installations
DG, DDG	Director General, Deputy Director General
EFF	European Fusion File
ENEA	European Nuclear Energy Agency, Paris, France, later NEA as of 1982 Energia Nucleare ed Energie Alternative, Rome, Italy
ESTSC	Energy Science and technology Software Center, Oak Ridge, TN, USA
Euratom	European Atomic Energy Community
HCLWR	High Conversion Light Water Reactor
IAEA	International Atomic Energy Agency, Vienna, Austria
INIS	International Nuclear Information System, IAEA
JEF	Joint Evaluated File
JEFF	Joint Evaluated Fission and Fusion File
NDB	NEA Data Bank, Saclay, later Issy les Moulineaux, France
NDS	Nuclear Data Services of NDB
NEA	Nuclear Energy Agency, boulevard Suchet, Paris, later Issy les Moulineaux, France
NEACRP	Committee on Reactor Physics of NEA (formerly- EACRP, European-American CRP)
NEANDC	Nuclear Data Committee of NEA (formerly- EANDC, European-American NDC)
NEDAC	Nuclear Energy Data Center, Tokai-mura, Japan (1981-1995) later RIST
NESC	National Energy Software Center, Argonne, Illinois, USA
NSC	Nuclear Science Committee of NEA
OECD	Organisation for Economic Co-operation and Development, Paris, France
OEEC	Organisation for European Economic Co-operation, Paris, France
ORNL	Oak Ridge National Laboratory, Tennessee, USA
OSTI	Office of Scientific and technical Information, Oak Ridge, TN, USA
RIST	Research Organization for Information Science and Technology, Tokai-mura, Japan
RSIC	Radiation Shielding Information Center, Oak Ridge, TN, USA, later RSICC
RSICC	Radiation Safety Information Computational Center, Oak Ridge, TN, USA
SG	Secretary General
SC	OECD Steering Committee for Nuclear Energy
USAEC	US Atomic Energy Commission
USCC	US Code Center, ANL, Argonne, Illinois
US-DoE	US Department of Energy, Washington, DC

INDEX of Keywords and Terms

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NEA
DATA BANK

AEN
NEA

AEN
NEA

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