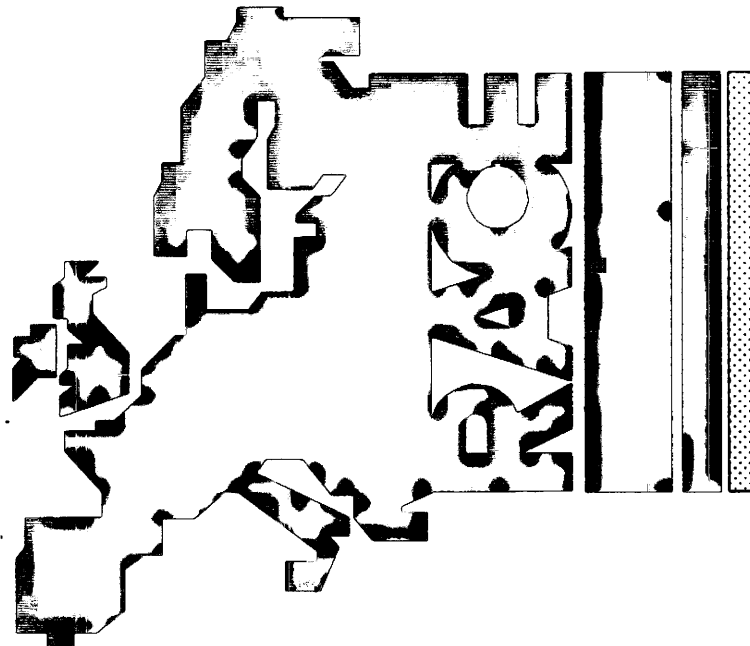


4412.1

# THE RACE PROGRAMME

Research and development in Advanced  
Communications technologies in Europe

## Executive Summary



1988

## THE RACE PROGRAMME

### EXECUTIVE SUMMARY

RACE (R&D in Advanced Communications-technologies in Europe) is a major European initiative in the field of telecommunications. It addresses advanced telecommunication infrastructures and technologies, with the aim of developing a strategy for introduction of advanced communications services in Europe.

It involves consultation with public and private telecommunications organisations, R&D by consortia of European companies and research organisations, and development of the consensus necessary for the introduction of an Integrated Broadband<sup>1</sup> Communications (IBC) network in Europe by 1995.

The programme will promote the competitiveness of the European Community's telecommunications industry, of its operators and of the service providers, and will ensure that customers for telecommunications services are provided with the services which will sustain the competitiveness of the European economy over the coming decades at minimum cost and with the minimum delay.

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<sup>1</sup> Broadband is the technical term for high-capacity communication systems for video and television signals with data transmission rates of greater than 2 Mbits/sec.

## **BACKGROUND TO THE RACE PROGRAMME.**

### **The political, social and economic background**

Telecommunications is a critical area for industrial and economic development: a telecommunication network is the nerve system of modern society. New telecommunications services will have profound effects on industrial activities, their geographical location, the efficiency and nature of services and on the level of employment.

Telecommunications also fulfills a basic human need to talk to each other. Easing the current technological and economic restrictions on communications in Europe will have a major social impact.

Structures and policies need review because of the convergence of telecommunications, computing and other applications of electronics; the growth in communications requirements; new forms of access to information and the establishment of a single European market in 1992. A basis for development of a common market for telecommunications services and equipment has recently been proposed by the European Commission in a Green Paper (COM(87)290).

Management and communication of information is already associated with an annual turnover of ECU 500 billion in the world: the market for telecommunications equipment is already ECU 90 billion; over ECU 18 billion in Europe. Revenue from services is ECU 300 billion worldwide and over ECU 60 billion in Europe. The telecommunications sector accounted for 2% of Community GDP in 1984 and is expected to account for 7% by 2000.

### **The Technological basis**

Technological developments will have a major influence upon the development of telecommunication and related infrastructures. The pace of development is fast and current developments will significantly affect the economics of present systems as well as the economic and technical viability of future developments.

The most fundamental development is the change from analogue to digital communication systems, made possible by very large scale integrated components, programmable elements and opto-electronic systems. Other developments, such as satellite broadcasting, advanced software and switching systems, efficient data transmission techniques such as Asynchronous Transfer Mode (ATM) data-packet transmission, and large flat-panel colour displays will form the technological foundation of high-speed digital communication systems capable of integrating telecommunication, information technology and broadcasting.

In the next few years these developments will allow widespread introduction of narrowband Integrated Services Digital Networks (ISDN), and in the 1990s they will provide the foundation for Integration of Broadband Communications.

### **The international situation**

Development initiatives similar to those of European countries are underway in the USA and Japan. The Information Network System (INS) was announced by NTT in Japan in 1983 and experimental transmissions are already made on an optical fibre link between Sapporo and Fukuoka. Development of Universal Information Services by AT&T in the USA began in 1985. International bodies are already studying standardisation requirements for Broadband Digital Communications systems.

## DEVELOPMENT OF THE RACE PROGRAMME

The Commission of the European Communities has been discussing Community telecommunications policy and a strategic programme of co-ordinated research and development with Member states since 1983.

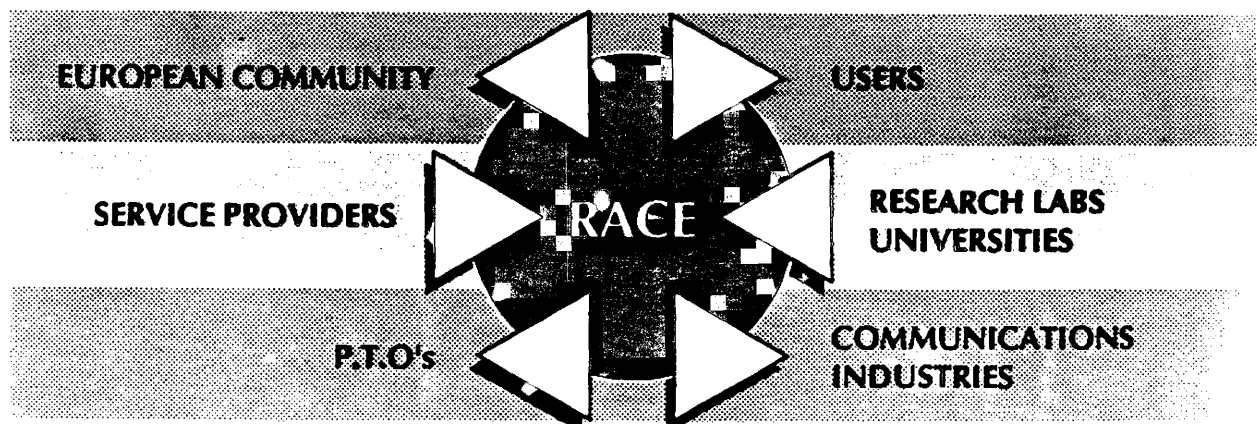
Following a Council decision in July 1985, a RACE Definition phase was established to plan a major programme of consultation, consensus formation and technology development. The Definition phase involved over 400 experts from industry, universities and national telecommunication organisations. A group of the European Conference of Post and Telecommunications Administrations (CEPT), representing 26 countries, worked on the development of IBC network specifications and a team of experts from a consortium of 30 major European electronic and communication companies worked on the definition of a terminal environment. Additionally, consortia of European companies and research organisations investigated the state-of-the-art of key technologies vital to the introduction of Integrated Broadband Services.

The Definition phase established that there was scope for a significant Community effort. It opened new avenues for cooperation between telecommunication system operators, industry, service providers and research centres and provided a framework in which all parties could collaborate. Significant progress was made in defining IBC scenarios, an IBC Reference Model, associated functional specifications, in assessing the economics of advanced telecommunications infrastructures and services and in identifying key areas where development was required and cooperation would be advantageous.

It was recognised that IBC development would require a common service definition, a common understanding of possible evolution strategies and coordination of national approaches towards world-wide IBC operation. This will require considerable effort from highly qualified and experienced personnel, but the definition phase demonstrated that collaboration could save time and money. The management approach which emerged proved effective and provides the basis on which to build further RACE activities.

The RACE programme was adopted by decision of the Council on December 14th 1987. Work started in early January 1988 and contracts have been placed for 46 projects involving over 180 European organisations.

## ORGANISATIONS INVOLVED



## **The RACE Programme objectives**

The overriding aim is to develop conditions for the market to provide Europeans with a greater variety of telecommunications services, of better quality and at lower cost, giving Europe the full benefit of a strong telecommunications sector, competitive in world markets.

The objectives are:

- to promote the Community's telecommunications industry;
- to enable European network operators to compete under the best possible conditions;
- to enable a critical number of Member States of the Community to introduce commercially viable IBC services by 1995.
- to offer opportunities to service providers to improve cost-performance and introduce new services;
- to make new services available at a cost and on a timetable at least as favourable as in other major western countries;
- to support the formation of a single European market for all IBC equipment and services;
- to contribute to regional development within the Community, by allowing less developed regions to benefit fully from telecommunications developments.

## The RACE Programme structure and timing

The RACE programme consists of three concurrent Parts, each involving a number of projects managed by international consortia of manufacturing companies, telecommunication system operators and universities:

### **PART I: IBC Development and implementation strategies;**

The main objectives are to reach a consensus on strategies for evolutionary IBC introduction, on functional specifications and on IBC system and sub-system definitions. A framework in which technology requirements can be identified will be generated. Tools for technical and economic evaluations will be produced and requirements for standardisation will be identified and assessed.

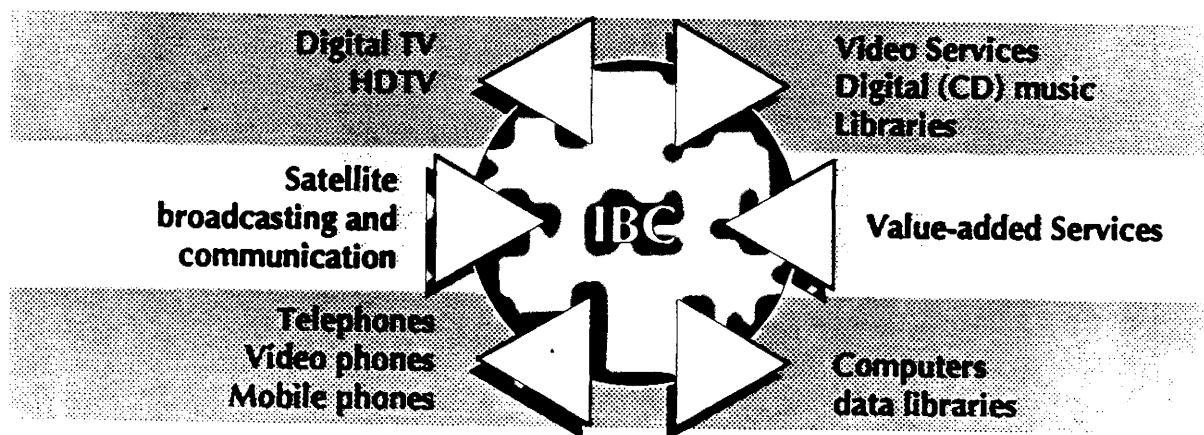
### **PART II: IBC Technology R&D;**

Co-operative pre-competitive R&D on key technologies for low-cost realisation of IBC equipment and services is essential. The main emphasis is on development of optical signal processing, switching and transmission. These technologies offer the capability to handle large volumes of information at great speed. Research also involves application of advanced technologies to system integration and management, development of the software that will control information flows (including ATM transmission), improving the usability of equipment, and development of evolutionary networks, systems and sub-systems.

### **PART III: Functional integration;**

Projects involve assessment of service functions and operational concepts, and development of pilot applications to investigate the characteristics of integrated Broadband systems and to demonstrate the potential for future use of an IBC network. The tools to test and verify integrated systems will be developed.

## TECHNOLOGY & SERVICE INTEGRATION



## **Programme Milestones**

A set of strategic milestones on the path to commercial IBC introduction in 1995 have been established. They are keyed to definition of an IBC system and a network architecture in 1990/1991.

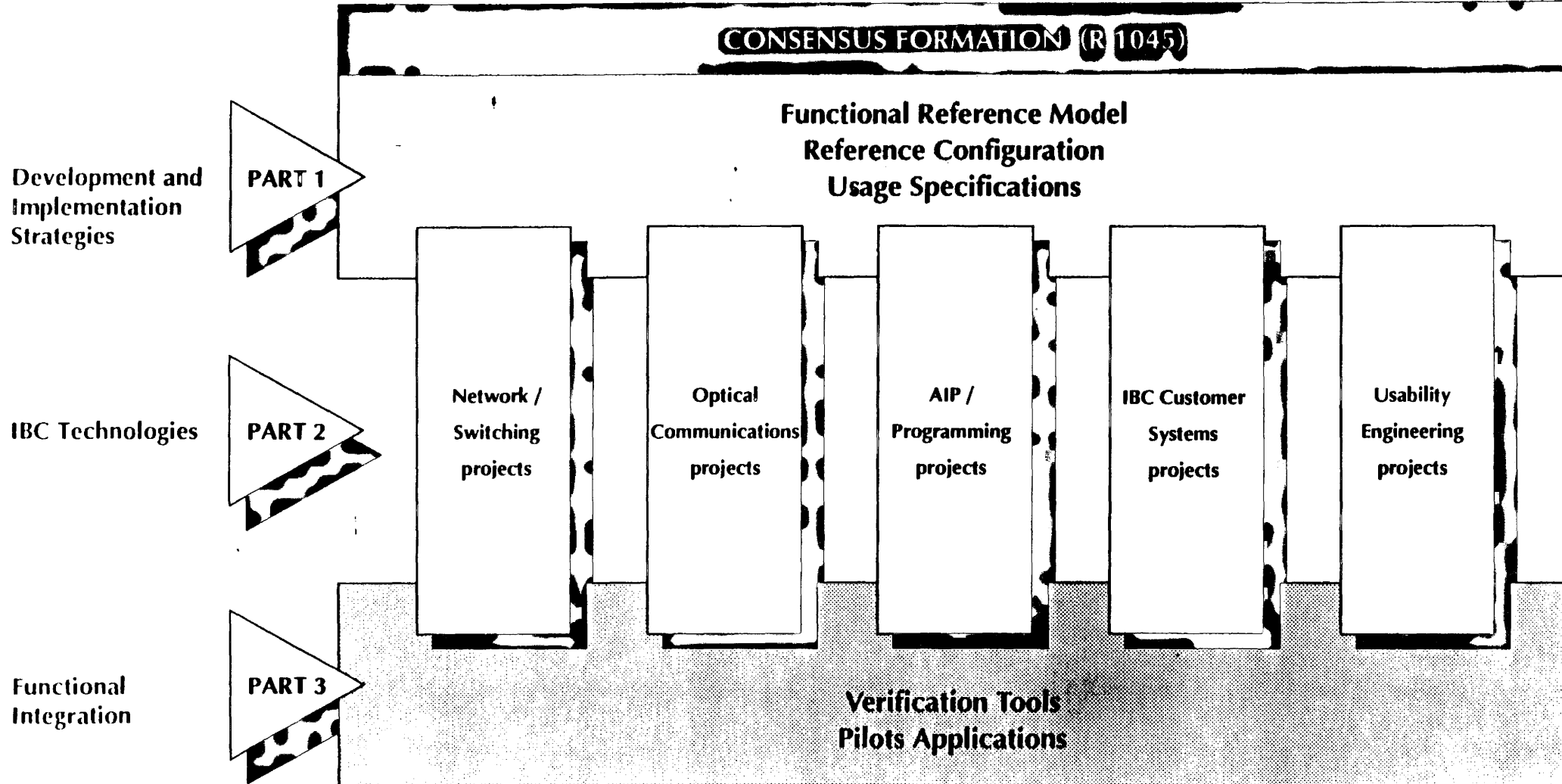
**mid-1988:** Establishment, within RACE, of a set of initial assumptions about the configuration and environment of an IBC system; The number of users, their distribution and calling rates etc.

**mid-1989:** Firm decisions on a first IBC network; its introduction strategy and its evolution strategy, drawing on the results of technology research and usage studies.

**mid-1990:** Definition of a set of system architecture proposals. These will be tested and validated in all Community countries.

**end-1991:** Agreement on an IBC system architecture: This key product of Part 1 of the RACE programme will be the basis of proposals for common functional specifications and common practices in international discussions and standards development.

# THE RACE PROGRAMME STRUCTURE





## THE RACE BUDGET AND CONTRACTS

The total investment in the RACE programme will be about ECU 1 billion, of which the Commission will contribute about half.

About 70% of the effort will be devoted to technological research and development (part II), about 10% will be devoted to strategic studies and consensus development (part I) and the remaining 20% of effort will be on functional integration, system verification and pilot applications.

### The current situation

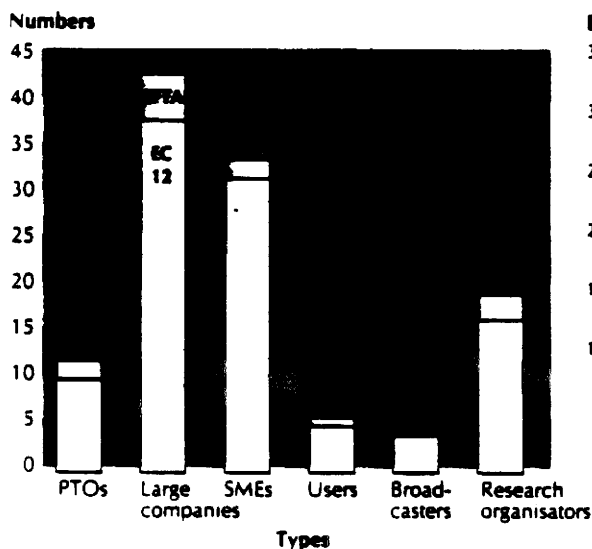
As a result of the first call for proposals, and the subsequent evaluation, 46 contracts for about 3500 man years of work have been signed, with a total Commission contribution of ECU 186 million over 3 years:

Within the EEC, 11 Telecommunications Administrations, 41 Universities and research establishments and over 110 companies (24 of them small companies) are involved in consortia. Organisations from 11 of the 12 EEC countries are represented, and major U.S. companies established in Europe, such as IBM and AT&T, are involved.

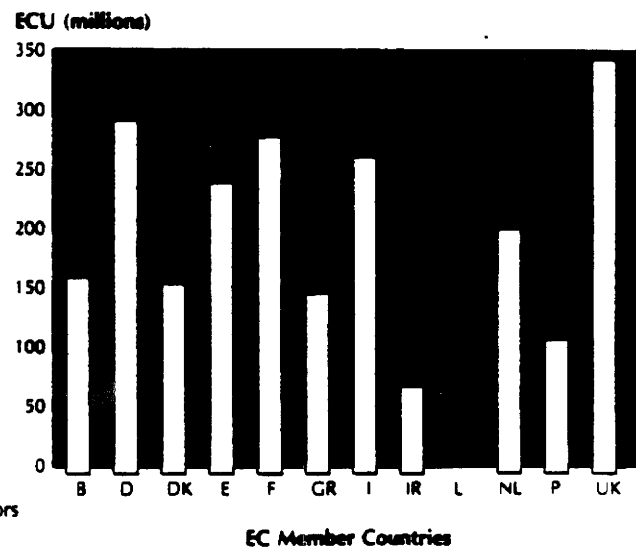
Organisations from other countries in the European Free Trade Association (EFTA) are also involved. Eighteen organisations from Austria, Finland, Norway, Sweden and Switzerland participate in 19 consortia and contribute about 13% of the effort.

It is intended to publish a second general call for proposals in 1988, and a third in 1991.

### PARTICIPATING ORGANISATIONS



### TOTAL VALUE OF PROJECTS IN WHICH EACH COUNTRY PARTICIPATES



## PROGRAMME MANAGEMENT

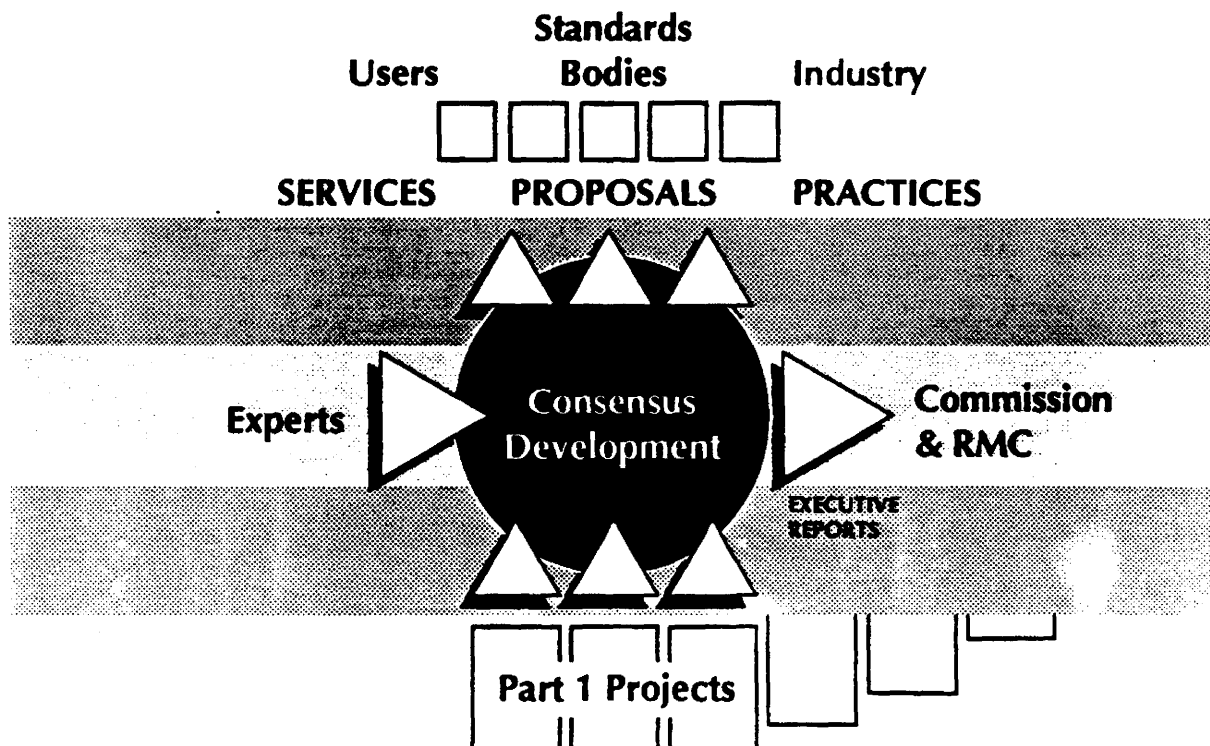
Responsibility for RACE programme management lies with Directorate F of DG XIII of the Commission of the European Communities, supported by the RACE Management Committee (RMC). This Committee consists of two nominees from each Member State of the Community. It is chaired by the Commission and its proceedings are confidential. It has a key role in the definition of the work to be undertaken, in the selection of proposals and in the evaluation of results. It formulates opinions by qualified majority.

Industry and National telecommunications organisations are closely associated with the planning of the programme. In addition, a consortium of 18 major European electronics companies, known as the RACE Industrial Consortium (RIC), together with network operators, is responsible for developing a consensus on the functional characteristics of a future IBC system. A special project has been set up, with a management team from industry and network operators in the RACE office in Brussels, to ensure that the results of other projects are taken into account in reaching agreements on common functional specifications and common practices. This project will also be responsible for dissemination of proposals for common specifications and practices to a wider international audience and to standard-setting organisations.

All tasks are carried out by consortia of companies, administrations and universities, each with its own project management, under contract to the Commission, but with costs shared equally between the consortium and the Commission. Each project and the programme will be evaluated each year.

An independent strategic audit of the situation in Europe with respect to needs and opportunities for integrated telecommunications services will also be commissioned each year. It will assess the prospects for development and implementation of an IBC network, taking account of other industrial developments, the economic and social climate, political constraints and opportunities.

A major review of the RACE programme is scheduled for mid-1990, 30 months after its start, and a comprehensive report on the programme and its results will be issued in 1993.



## **The value of RACE, its results and deliverables**

The development of an advanced European telecommunications infrastructure is vital for the competitiveness of European industry and commerce. New technological developments provide the opportunity to introduce advanced infrastructures with broadband digital capabilities. However, introduction in Europe depends on the collaboration of a large number of organisations and industries.

The RACE programme provides the essential focus for this collaboration and will ensure that key technologies are developed in a cost-effective way. It encourages cross-frontier collaboration and hence the best use of the Community's considerable intellectual, scientific and engineering potential. By emphasizing the need for Open Interconnection and flexible design, it encourages the establishment of a common market in telecommunications equipment of sufficient size to justify large-scale industry-funded research and innovation. By systematic exploration of future options for service providers, operators and industry, the RACE programme reduces uncertainties for all concerned and encourages investment. RACE funding also acts as a catalyst in key areas of technology development where leverage is high - that is, where limited R&D funding results in very much larger independent investments.

There will be a wide variety of specific results from the RACE programme. Each project is committed to deliver reports, specifications or prototypes, all of which are related to the goal of commercial introduction of IBC services by 1995. The feasibility of new technologies will be established, the capabilities of other new technologies will be improved, a consensus will be developed on common functional specifications and on reference configurations for IBC systems, and on common practices for IBC introduction.

To ensure that these results are fully exploited, all information and patents arising from work done under RACE contracts is owned by the contractors. However, other contractors involved in the same project will have royalty-free access to foreground information and royalty-free non-exclusive licences to new patents, where necessary for their work. Other organisations participating in RACE will have access to new information, and the option to take out non-exclusive licences on foreground information under reasonable conditions.

There will also be a major contribution to standard developments: Effective and integrated Broadband Communications will require development of, and international agreement on, a variety of world standards. RACE provides a forum for telecommunication operators and companies from all sectors of industry to discuss and agree on key issues; this accelerates the standardisation process, a notorious bottleneck in high-technology exploitation, and ensures the timely availability of commercially viable products. The technical proposals for Standards and Common Functional Specifications that emerge from collaboration in RACE stand a good chance of being accepted worldwide and will ensure a large external market for European Telecommunication Operators, service providers and industry.

# PROJECT DISTRIBUTION

IBC Development and Implementation

IBC Technologies

Functional Integration

PART 1

PART 2

PART 3

CONCENSUS FORMATION  
1045

FUNCTIONAL REFERENCE MODEL

1044/1  
1023  
1024  
1025

AIP / PROGRAMMING

Network management  
1006  
1003 1009  
1005  
Programming infrastructures  
1017  
1021  
1046

REFERENCE CONFIGURATIONS  
1044/2

1002  
1012  
1022 1014  
1026  
1028 1013

NETWORKS AND SWITCHING

CUSTOMER SYSTEMS

Networks  
1035 1011  
1015  
1043 (mobile)

SIGNAL PROCESSING

1041 1018 (HDTV)

TERMINALS

1001  
1004  
1007

SYSTEM VERIFICATION

1016  
1048

1044/2,3

OPTICAL COMMUNICATIONS

System design  
1010  
1012  
1030  
1036

Components

Active  
1027  
1029  
1031

Passive  
1008  
1032

Switching  
1019  
1020  
1033

USAGE SPECIFICATIONS

1037  
1050  
1044/1,2

USABILITY ENGINEERING

1034  
1038

PILOT APPLICATIONS

1039  
1042



## **RACE Projects underway in 1988**

### **Part II: IBC Technologies**

#### **Group 1; Networks and switching projects:**

- 1002 Satellite communications for IBC;
- 1012 Broadband local network technology;
- 1013 HDTV - switching;
- 1014 Atmospheric; ATM and STM hybrids;
- 1022 Technology for ATD;
- 1043 Mobile telecommunications;

#### **Group 2; Optical communications:**

##### **System projects;**

- 1010 Subscriber Coherent multichannel technology;
- 1012 Broadband local network technology;
- 1030 ACCESS - Advanced customer connection: an evolutionary strategy;
- 1036 WDTM Broadband customer premises network;
- 1051 Multi-Gigabit transmission in an IBC network subscriber loop

##### **Active opto-electronic components;**

- 1027 Integrated opto-electronics towards the coherent multichannel IBCN;
- 1029 Improved InP substrates for opto-electronic devices;
- 1031 Low-cost opto-electronic components;

##### **Passive opto-electronic components;**

- 1008 Silicon-based low-cost passive optical components;
- 1032 Development and testing of optical components for subscriber networks;

##### **Optical switching projects;**

- 1019 Polymeric optical switches;
- 1020 All-optical switching and bi-stable devices based on polymers;
- 1033 OSCAR - Optical switching systems, components and applications;

#### **Group 3: Advanced information processing (AIP) and software engineering:**

##### **Network management studies;**

- 1003 Guidelines - AIP and standards for Telecommunication management;
- 1005 NEMESYS - Traffic and Quality-of-service management for IBCN;
- 1006 AIM - AIP application to IBCN maintenance;
- 1009 ADVANCE - Network and customer administration systems;
- 1024 NETMAN - Functional specifications for IBC management;

**AIP for customer service functions; Subject of a new call for proposals:**

AIP for integrity mechanisms; authentication, proof of origin and receipt etc; Subject of a restricted call for proposals:

**Programming infrastructures;**

- 1017 IBC on-line environments;
- 1021 ARISE - A reusability infrastructure for software engineering (off-line)
- 1046 SPECS - Specification methods, programming languages, testing and reusability:

**Group 4: IBC customer systems:**

**Signal processing;**

- 1018 HIVITS - High-quality videophone and HDTV systems;

**Terminals;**

- 1001 Digital video-tape recording for HDTV;
- 1004 Electro-luminescent flat-panel display for terminal applications;
- 1007 ITIS - IBC terminal for interactive services;

**Customer-premises networks (CPN);**

- 1011 Business CPN;
- 1015 Domestic CPN;

**Group 5: Usability engineering:**

- 1034 Usability engineering requirements for IBC;
- 1038 Multi-media communication, processing and representation:

## **RACE Projects underway in 1988**

### **Part III: Functional integration**

#### **Group 1: Verification tools;**

- 1016 Test tools and equipment;
- 1048 RSVP - RACE strategy for verification;

#### **Group 2: Pilot applications;**

- 1039 DIMUN - Distributed manufacturing using existing and developing public networks;
- 1042 MULTIMED - Demonstration of functional service integration in support of professional user-groups;

A second call for proposals in Part III will be issued in 1988:

NB: Some projects appear in more the one part or group.



## Organisations involved in RACE (1988)

### Belgique - Belgie - Belgium

ACEC S.A (1018,1041)  
 ATEA (1044,1045)  
 BARCO Industries N.V (1044)  
 Bell Telephone Manufacturing Co. N.V (1002,1022\*,1044,1045,1046)  
 IMEC v.z.w., Gent (1010,1033)  
 Inter-Universitair Micro-Electronica Centrum v.z.w. (1019,1022)  
 Kone, Belgium S.A. (1039)  
 MBL N.V. (1022)  
 Philips S.A. (1022)  
 Régie des Télégraphes et des Téléphones (1022,1044)  
 Rijksuniversiteit - Gent (1004)  
 SPAG Services S.A. (1048\*)  
 Technical Centre of the EBU (1026\*)  
 Telindus N.V. (1044)

### Danmark - Denmark

Computer Resources International A/S (1009)  
 EMI Electromagnetics Institute (1014)  
 Elektronikcentralen (1016)  
 Fischer-Madsen & Lorenz Petersen Data Communications Consultants A/S (1005)  
 Jutland Telephone A/S (1022,1044)  
 Kjobenhavns Telefon A/S (1005,1022,1044)  
 NKT - Nordiske Kable & Traadfabriker A/S (1014,1030\*,1044,1045,1051)  
 Technical University of Denmark (1013,1027)  
 Teleteknisk Forskningslaboratorium (1046)

### Deutschland - Federal Republic of Germany

AEG A.G. (1018,1039,1043)  
 AEG Forschungsinstitut (1041)  
 AEG Kabel A.G. (1030,1044)  
 ANT Nachrichtentechnik GmbH (1002,1030,1031,1044,1051)  
 BIBA - Bremer Institut für Betriebstechnik und Angewandte Arbeitswissenschaft an der Universität Bremen (1039\*)  
 Danet GmbH (1006,1017)  
 Deutsche Thomson-Brandt GmbH (1001,1018)  
 Dornier System GmbH (1002)  
 Forschungsinstitut der Deutschen Bundespost beim Fernmeldetechnischen Zentralamt (1018,1022,1025\*,1032,1041,1044,1048,1051)  
 Fraunhofer Institut (1050)  
 Grundig EMV (1001)  
 Heinrich Hertz Institut für Nachrichtentechnik, Berlin, GmbH (1010)  
 Kabelmetal Electro GmbH (1032,1044)  
 Loewe Opta (1007\*)  
 Philips Kommunikations Industrie A.G (1015,1018,1022,1035,1041,1043,1044)  
 Robert Bosch GmbH (1044)  
 Siemens A.G. (1010,1012,1031,1044,1045)

Standard Elektrik Lorenz A.G.  
 (1003,1006\*,1013\*,1015,1016\*,1017\*,1022,1031,1032)  
 (1033,1034\*,1035,1038\*,1044,1045,1051\*)  
 Telenorma - Telefonbau und Normalzeit GmbH (1011,1035,1038,1044,1045)  
 Universität Stuttgart (1022)  
 Universität Dortmund (1033)

#### Ellas - Greece

Alpha S.A.I (1016)  
 Hellenic Aerospace Industry (1044)  
 Hellenic Telecommunications Organisation S.A. - OTE (1028,1043)  
 Intracom S.A. (1009,1021,1024)  
 National Technical University of Athens (1009,1014,1021,1022,1027,1051)  
 Research Center of Crete (1005)

#### Espana - Spain

Alcatel Standard Electrica S.A (1002,1006,1011,1017,1018,1035,1036,1043)  
 (1044,1046,1048)  
 AMPER S.A. (1044,1045)  
 Fundacion General de la Universidad Polytechnica de Madrid (1023)  
 Grupo de Empresas A.P.D (1042)  
 INTELSA - Industrias de Telecomunicacion S.A. (1023,1044,1048)  
 Institut Ildelfons CERDA (1037)  
 RTVE - Ente Publico Radiotelevision Espanola (1044)  
 SGS Microelectronica S.p.A (1014)  
 Sistemas Expertos (SIE) (1042)  
 Telefonica - Compania Telefonica Nacional de Espana S.A.  
 (1014,1018,1022,1024,1027,1028,1041,1044,1048)  
 Telefonica Sistemas S.A. (1009,1042\*,1051)  
 Telettra Espanola S.A. (1043,1044,1045)

#### France

Alcatel CIT S.A. (1013,1022,1031,1044,1045,1046)  
 Alcatel Espace S.A. (1002\*)  
 Alcatel Radiotelephone (1043)  
 APSIS (1042)  
 CAP Sogeti Innovation S.A.(1016,1017)  
 CNET - Centre National d'Etudes des Télécommunications (1015,1018,1022,1025)  
 (1027,1030,1031,1032,1035,1041,1044,1046,1048)  
 CCETT-Centre Commun d'Etudes de Télédiffusion et Télécommunications  
 (1018,1042)  
 CEA-Commissariat à l'Energie Atomique (1008)  
 CGE - Laboratoires de Marcoussis (1006,1019,1027,1046)  
 Clemessy S.A. (1016)  
 Companie IBM France (1005,1046)  
 DNAC-Ing, Université Pierre et Marie Curie (1009)  
 GSI-Tecsi (1046\*)  
 IDATE - Institute de l'Audiovisuel et des telecommunications en Europe (1050)  
 Instruments S.A. (1032,1036)  
 Jeumont-Schneider (1011)  
 MATRA Space S.A. (1014)

MATRA Communication S.A. (1004,1018,1041)  
 MET France (MATRA-Ericsson Telecommunications) (1014\*,1044)  
 Philips - LEP: Laboratoire d'Electronique et de Physique Appliquee  
 (1010,1018,1033\*)  
 Radiall Gie (1032)  
 RTC - Compelec (1031)  
 SAT - Société Anonyme de Télécommunications (1030,1044,1045)  
 SGS - Thomson Microelectronics S.A. (1004,1030,1036,1044)  
 Souriau et Cie (1030)  
 Synergie Informatique et Developpement (1009)  
 Tecsi Software (1005)  
 Telspace S.A. (1002)  
 Thomson S.A. (1044,1045)  
 Thomson - CSF S.A. (1015\*,1018\*,1029,1033,1035,1036)  
 Thomson - Hybrides et Microondes S.A. (1029,1030,1043)  
 Thomson - SINTRA S.A. (1033)  
 T.I.T.N. (1044)  
 TRT - Télécommunications Radioelectriques et Téléphoniques S.A. (1018,1022,1043)  
 Université de Sciences et Techniques du Languedoc (1029)

## Ireland

Broadcom Eireann Research Ltd (1003,1009\*,1021\*,1023,1024\*,1028)  
 National Software Centre Ltd (1046)  
 SUS Research Ltd (1028)  
 University College of Cork (1043)  
 University of Dublin, Trinity college (1009,1020\*)  
 Work Research Centre Ltd, Psycosomatic Unit (1034)

## Italy

AET - Applicazioni Elettotelefoniche SpA (1044)  
 COSI - Consorzio per L'OSI in Italia (1044)  
 CSATA - Centro Studi e Applicazioni in Technologie Avanzate (1028,1038)  
 CSELT - Centro Studi Laboratori Telecomunicazioni SpA  
 (1027,1018,1044,1046,1048)  
 Enichem SpA (1020)  
 FIAR - Fabbrica Italiana Apparecchiature Radioelettriche SpA (1009)  
 Fatme SpA, Fabbrica Apparecchiature Telefoniche e Materiale Elettrico "Brevei Ericsson"  
 (1011\*,1015,1035\*,1044,1045)  
 Fondazione Ugo Bordoni (1043)  
 Industrie Face Standard SpA, (1002,1006,1008,1017,1022,1038,1044,1045)  
 Istituto di Ricerca Sulle Onde Electromagnetische del Consiglio Nazionale delle Ricerca  
 (1020)  
 Intecs Sistemi SpA (1017,1021)  
 ITALTEL - Società Italiana Telecomunicazioni SpA (1012,1044\*,1045\*)  
 SGS Thomson Microelettronica SpA (1004,1030,1036,1044)  
 SIRTIS SpA (1032)  
 Telettra - Telefonica Elettronica e Radio SpA (1018,1027,1044)

## The Netherlands

AKZO International Research B.V. (1019\*)  
 AT&T en Philips Telecommunicatie Bedrijven B.V. (1022,1031,1033,1044,1051)

Dr Neher Laboratories of the Netherlands Postal and Telecommunications Services  
 (1015,1018,1019,1022,1033,1036,1041,1043) (1044,1046,1048)  
 Nederlands Philips Bedrijven B.V (1001\*,1010\*,1031)  
 Philips International (Elcoma Division) B.V (1022)  
 Philips Telecommunications en Data Systemen B.V. (1022,1045)

#### Portugal

Correios e Telecomunicacoes de Portugal (Centro de estudos de  
 telecomunicacoes) (1009,1021,1022,1023,1024,1028\*)  
 Instituto de Engenharia de Sistemas e Computadores (1011,1046)  
 Instituto Superior Tecnico (1051)

#### United Kingdom

Analysys Ltd (1028)  
 Barr and Stroud Ltd (1019)  
 BICC Cables Ltd (1032\*)  
 BBC - British Broadcasting Corporation (1018,1036\*,1043)  
 British Telecommunications plc  
 (1003\*,1006,1009,1018,1022,1023,1024,1025,1028,1033,1034,1037\*,1043) (1044,1048)  
 British Telecommunications (North of Scotland) plc (1028)  
 Case Group plc (1003,1005\*)  
 ERA Technology Ltd (1020)  
 GEC - General Electric Company plc  
 (1005,1009,1014,1018,1024,1033,1035,1036,1044,1045)  
 GEC Marconi Research Centre (1002)  
 GPT - GEC Plessey Telecommunications Ltd (1051)  
 Hewlett-Packard Ltd (1016)  
 Highlands and Islands Development Board (1028)  
 IBA - Independent Broadcasting Authority (1044)  
 ICI Wafer Technology Ltd (1029\*)  
 IFC (1050)  
 London University, Queen Mary College (1022)  
 London University, University College (1005)  
 Loughborough University of Technology (1042)  
 Marconi Communication Systems (1002)  
 Marconi Company Ltd (1043)  
 Marconi Space Systems (1002)  
 MARI Advanced Microelectronics Ltd (1007,1009,1021,1023\*)  
 National Computing Centre Ltd (1048)  
 Oxford Consultants (Europe) (1042)  
 Oxford Polytechnic (1042)  
 Philips Components Ltd (1043)  
 Philips Radio Communication Systems Ltd (1043\*)  
 Plessey Research (Roke manor) Ltd (1009,1011,1012\*,1015,1021,1035,1043)  
 Plessey UK Ltd (Caswell) (1010,1018,1033,1044,1045)  
 QMC Instruments Ltd (1006)  
 SERC Rutherford Appleton Laboratory (1042)  
 Software Sciences Ltd (1021)  
 STC plc (1008\*,1014,1022,1024,1027\*,1031\*,1036,1044,1045)  
 STC Technology Ltd (1036)  
 Thorn EMI, Central Research Laboratories (1015,1035,1043)  
 Unibit (Holdings) (1006)

University of Cambridge (1042)  
 University of Strathclyde (1043)  
 University of Surrey (1023)

**European Free Trade Association countries:**

**Austria**

Alcatel Elin Forschungszentrum GmbH (1017,1046)  
 Austrian Academy of sciences; Research Institute for Technology Assessment (1037)

**Finland**

Helsinki University of Technology (1039)  
 Lohja Corporation Electronic Industries (1004\*)  
 Nokia Corporation (1011,1022,1035,1043,1044)  
 Post and Telecommunications of Finland (1039,1044)  
 Technical Research Centre of Finland (1008)

**Norway (EFTA)**

EB Teknologi A.S. (1039,1043,1046)  
 Senter for Industriforskning (1039)  
 Standard Telefon og Kabelfabrik A/S (1022)  
 Televerket (Norwegian Telecommunications Administration Research Department)  
 (1022,1023,1044)

**Sweden**

Ericsson Radio Systems AB (1043)  
 Telefonaktiebolaget L.M.Ericsson (1014,1021,1033,1044)  
 Telelogic A.B (1021)  
 Televerket (Swedish Telecommunications Administration)  
 (1009,1014,1018,1021,1023,1033) (1041\*,1044)

**Switzerland**

Ascom Holding Ltd, Research and new Technologies Division  
 (1016,1033)  
 Konsortium Tricom (1022,1044)  
 Swiss Federal Institute of Technology, Zurich (1033)

