COMMISSION OF THE EUROPEAN COMMUNITIES

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COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

concerning

R&D in Advanced Communications technologies for Europe

(RACE)

- Progress Report 89 and 30-months Review -

(presented by the Commission pursuant to Articles 6/3 and 9 of the Council Decision 88/28/EEC on the Programme RACE)

ANNEXES

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1) The numbers in brackets refer to the corresponding section in the body of the text of the full Strategic Audit report.

2) For full details please refer to the Programme Management Audit

3) For further information please consult the Report "RACE 89"

Contents

1) Project numbers are given in brackets after each organisation title.

Executive Summary

In the approach to the year 2000, the service sector is emerging as one of the most important factors influencing both the world economy and the European economy.

The enormous range of market possibilities offered by the use of new communications technologies and integrating services are under intensive investigation by our US and Japanese competitors. The USA and Japan have taken a commanding lead in the Information Technology and Consumer Electronics markets, respectively. Although Europe is traditionally strong in telecommunications, it risks losing its market share as the telecommunications and information technology markets converge.

Europe has a clear lead in the conceptual development of advanced communications networks and services and it is in this context that telecommunications operators, the telematics industry and leading-edge users in most major application sectors have joined forces on the development of the advanced communications technologies required for low-cost and innovative services. A unique environment has been created in the RACE programme for concertation of efforts to develop advanced telecommunication services in Europe.

The RACE Programme (Research and development in Advanced Communications technologies in Europe) was decided by the Council on 14 December 1987, for an initial period of five years commencing 1 June 1987. RACE will "promote the competitiveness of the Community's telecommunications industry, operators and service providers in order to make available to final users the services which will sustain the competitiveness of the European economy and contribute to maintaining and creating employment in Europe".

The Decision proposed a annual communication to Council and Parliament as well as a review after 30 months. This communication addresses in one document both the annual report and the 30 months review.

The results of the RACE Programme will provide the European telecommunications and services actors with a strategic competitive advantage. It will create large scale awareness within the industry of the market opportunities which will accompany the implementation of the next generation of telecommunications and services systems in Europe. It will demonstrate the advantages of collaboration on a European scale in the pre-competitive R & D necessary to bring innovative system designs to the global marketplace.

The results described in this document are based on the outcome of several audits of the RACE Programme conducted by independent experts. A systematic overall verification of objectives, scope and progress of projects is conducted annually by the experts.

The results of these audits show that the RACE Programme has been successful in relation to its original objectives and suggest that the Programme will continue to achieve significant results in the future.

Proposals in relation to the expansion of the Programme in the future are based on the recommendations both of the Strategicv Audit as well as of the Requirements Board "Telecom 2000", which was convened in the framework of the investigation of future requirements and options in telecommunications.

1. Introduction

At present, telematic services generate a turnover of over 300 billion ECU per year. By the year 2000, as much as 30% of telecommunications revenues could be associated with value-added services.

World-wide, all spheres of life are being affected by the convergence of information technology, broadcasting and telecommunications. These sectors already account for a global annual turnover of over 500 billion ECU. The combination of data processing techniques with innovative ideas in telecommunications has led to service integration through the implementation of the Integrated Services Digital Network concept. The combination of service integration together with optical fibres offering cheap high-volume transmission provide the techno-economic basis for a fundamental restructuring of all of the sectors concerned with telematics through the development of the Integrated Broadband Communications (IBC) concept. This development of this concept is fundamental to the work of the RACE Programme.

The present report, which has been edited by the Commission's services, summarises and documents the results of the audits of the RACE Programme conducted to date in the context of the original objectives of the Council Decision.

The report addresses the context, organisation and results of the Programme in Section 2. The context, organisation and results of the audits of the Programme are described in Section 3. Conclusions regarding the future strategic direction are developed in the light of the results of the audits and the views of a panel of experts which considered the future development of the Programme in Section 4.

The RACE Programme audits have three distinct components:

- **A Strategic Audit**, which evaluates the performance of RACE as a whole with respect to the strategic and policy objectives of the Community in an international context,

- **A Technical Audit**, which evaluates the performance of the RACE projects with respect to the RACE objectives,

- **A Programme Management Audit**, which evaluates the performance of the Commission in its responsibility for the management of the Programme.

The detailed conclusions of the audits are described in the appendices to this document.

Further appendices summarise the work of the RACE Programme and list the participating organisations. A list of references, glossaries and an index are also provided.

2. The context and organisation of the RACE Programme

2.1 Meeting the challenge of telecommunications

The challenge of exploiting the development of the telecommunications market is being met on the Community level by the telecommunications policy of the EC. The RACE Programme forms an integral part of this policy. Linked to the standardisation policy and the information market policy, it builds on related work in the framework of ESPRIT. By addressing the cost-performance balance of the communication infrastructure in Europe, RACE is oriented towards meeting the requirements of the internal market, international competitiveness and the need to contribute to the socio-economic advancement of the Community.

2.2 The objectives of the Community's Telecommunications policy

The major goals of the telecommunications policy of the Community as set out in the Council Recommendation of 30.06.88 are summarised as follows:

- Creating or ensuring Community-wide network integrity, based on the principle of full interconnectivity between all public networks concerned,
- Progressively creating an open common market for telecommunications services,
- Promoting the creation of Europe-wide services according to market requirements and social needs,
- Further developing an open, Community-wide market for terminal equipment,
- Continuing Community measures regarding common standards in the telecommunications sector,
- Stimulating European co-operation at all levels, particularly in the field of research and development of telecommunications,
- Creating a social environment for the future development of telecommunications, and,
- Integrating the less-favoured areas of the Community fully into the emerging Community-wide market.

These objectives have to be the basic guidelines for the definition of future technology, services and application development options.

2.3. The objectives of RACE

The global objective of RACE is to contribute to the:

"Introduction of IBC taking into account the evolving IDSN and national introduction strategies, progressing to Community-wide services by 1995"

Review of the "General Objectives"stated in the Decision of the Council

General Objectives	Ways in which these objectives are addressed	Impact of the RACE work
Promote industry's internat. competitiveness	Reinforcement of the technology base Improved effectiveness of the use of human resources and technological assets Reduction of risks based on systematic exploration and comparison of the most promising options	Advances in communications technologies, incl. digital HDTV Concentration and worksharing on strategic priorities, eg ATM Rationalisation of the work on the main technology options Rationalisation of product lines and service options Closer collaboration of manufacturers, operators, service providers and users Improved awareness of requirements and options of world and European markets
Prepare operators for the challenge of new services	Development of common functional specifications by collaboration of all major sector actors Drawing-up the functional specifications and implementation options Simulation of IBC services	Assessment of opportunities and risks Defining options for implementation and transition strategies Convergence of planning of Telecom Admin. and reduct. of planning uncertainty Increased user access to network planning process Convergence of the views on the potential of advanced communications
Enable Member States to introduce IBC in 1996	Drawing -up the systems engineering specifications for implementation options based on concerted work of Telecommunications Administrations, industry and service providers taking into account regional aspects	Timely definition of requirements and specifications for the next generation Specification of differentiated evolution plans Identification of key techno-economic factors and their relations Articulation of European approach in the context of international developments
Open-up opportunities for service provider	Application Pilots and work on Usage involving leading-edge users and service providers	Identification of service characteristics and features Implementation concepts for enhanced services Provision of test bed for IBC experimentation and transfer of applications know-how
Make available internationally competitive services	Fostering interoperability as a perrequisite for economies of scale for equipment and services Orientation of European work on IBC towards the world market for services Addressing cost-reduction as an equal priority to performance improvements	Common functional specifications and common practices leading to cost-reduction Understanding of cost-structures in installation, operation and maintenance Development of low-cost components, sub-systems and exploitation of "economies of integration" Development of "reusability" and modular standardisation
Contribute to internal market and internat. standardisation	Development of techno-economically valid standardis. options for IBC equipment and services Reinforcement of the European standardisation bodies	Preparing the technical base for the introduction of enhanced telecom services Acceleration of pre-normative work on next generation systems and services Milestoneplan for functional specifications, common practices and standardisation
Contribute to regional development	Specific work on an intercept strategy	Identification of "intercept options" and their implications First orientations for the regional development in communications

In addition, the Council Decision states the "general objectives" of Community R&D in telecommunications as well as the "precise objectives" for each part of the Programme. How these objectives are addressed and what impact has been achieved to date is described in Table 1.

2.4 The scope and status of the work of the RACE Programme

In view of the rapid developments in telecommunications a phased approach to the implementation of the RACE Programme was adopted. The Programme began with a Pilot Phase (RACE Definition Phase[1]) which was followed by Phase I of the Main Phase of the Programme. Phase I began in June 1987 and is by now fully implemented. The 90 projects currently active address all the aspects foreseen under the initial workplan, with the participation of 306 companies including the major telecommunications actors.

The work Programme is divided into three parts (See Figure 1):

Part I - IBC Development and Implementation Strategies

Part I projects address the development of functional specifications, systems and operations research towards the definition of proposals for IBC standards, concepts and conventions conforming to an open systems approach, and the analytical work serving the objective of establishing interoperability for IBC equipment and services. The results of Part I projects are available in the public domain and are expected to make a major contribution to the work of the international standardisation bodies.

Part II - IBC Technologies

Part II projects address the technical challenges of implementing the new technology required for the low-cost realization of IBC equipment and services.

Part III - Prenormative Functional Integration

Part III projects relate to prenormative cooperation in the realization of an "open verification environment" designed to assess functions, operational concepts and experimental equipment and applications with respect to functional specifications and standardization proposals arising from the work of Part I projects.

Within two calls for tenders, all work defined by the Decision for Phase I of RACE has been taken up within the resources given to the Programme.

Projects in RACE Parts I and II began in January 1988. The RACE Part III projects and additional Part I and II projects started in January 1989.

The distribution of the financial resources of the Programme is summarised in Table 2.

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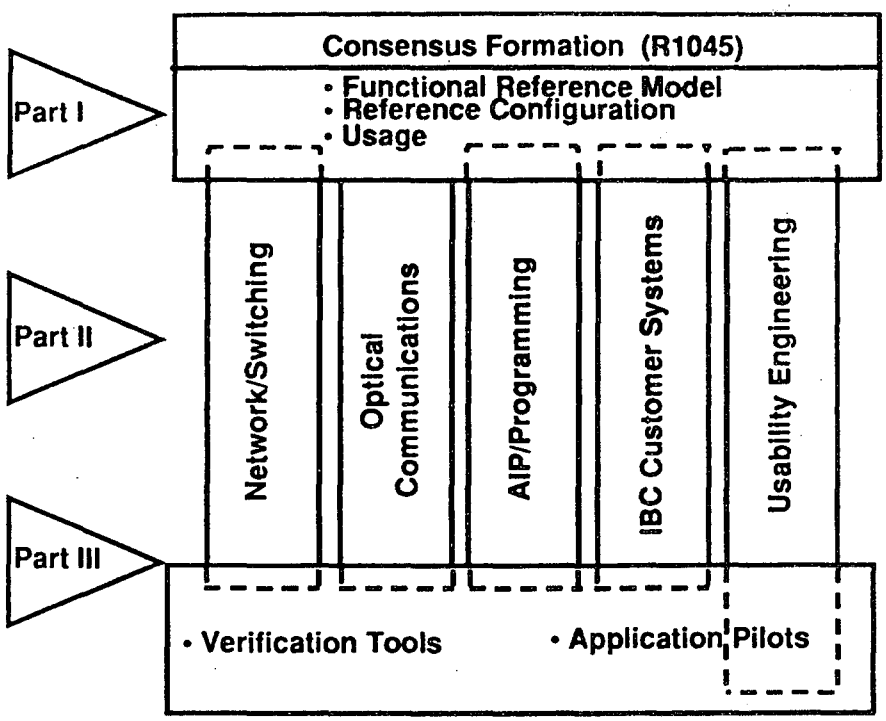
1) 85/372/EEC of July 25. 1985



Structure of the RACE Programme

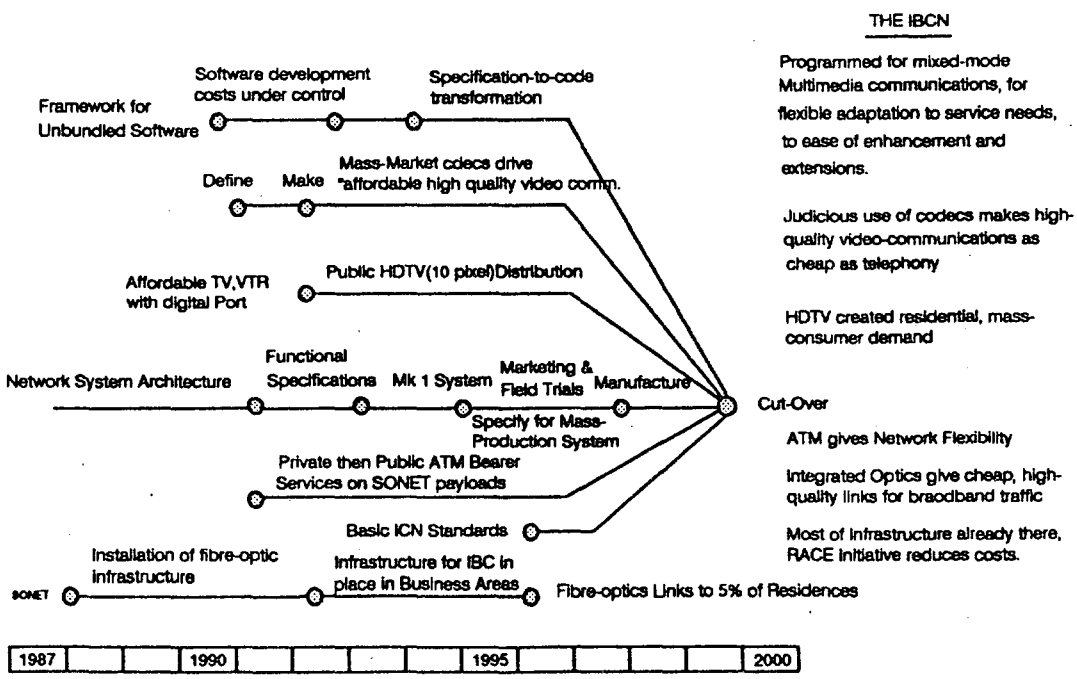


TABLE 2

SUMMARY OF USE OF FINANCIAL RESOURCES IN THE RACE PROGRAMME

PROGRAMME	DECISION (MECU)	(%)	ACTUAL (%)	SHIFT (%)
Part I	60	11.9	18.0	6.1
I.1 IBC Strategies	14	2.8		
I.2 IBC Realization	28	5.5		
I.3 IBC Usage	10	2.0		
I.4 Common operational environment	8	1.6		
Part II	332	65.7	55.0	-10.7
II.1 IBC Systems Functions	94	18.6	9.0	-9.6
IBC Programming Infrastructure	49	9.7	25.0	15.3
Usability Engineering	12	2.4	11.0	8.6
Network Evolution	117	35.0	10.0	-25.0
Part III	113	22.4	27.0	4.6
III.1 Verification tools	63	12.5	6.0	-6.5
III.2 IBC Application Pilots	50	9.9	21.0	11.1

The milestones leading to the evolution of the telecommunications networks towards IBC over the coming decade are summarised in Figure 2.

A summary the important features of the RACE Programme is provided in Table 3. A more detailed account of the Programme is presented in an Annex to this document.

The separate document entitled "RACE 89" provides a detailed description of the work undertaken by individual projects in relation to the precise objectives and the context of the work as described in the Decision of the Council.

2.5 The results of the RACE Programme

The RACE Programme will result in significant advances in the European telecommunications and services environment. In particular, it will lead to the development of:

- **Consensus** on a wide range of network planning and evolution issues and technology options for subsequent submission to standards bodies,

- **Technology** based on the outcome of the theoretical and experimental investigation of technical problems which must be solved to enable the implementation of the next generation of network systems,

- **User interaction** at an early stage in the planning of the next generation of systems in Europe.

These combined developments are leading to **awareness creation** on a European scale of the market opportunities which will accompany the development of an advanced telecommunications and services infrastructure in Europe.

Awareness of the opportunities facilitates the **early reaction** of the European actors to the dramatic changes which are taking place the global telecommunications environment.

In developing early awareness and reaction to change the RACE Programme is making a significant contribution to enabling the European telecommunications and services actors to obtain a **strategic competitive advantage** in the exploitation of the growing global market opportunities.

Summary of the main characteristics of the RACE Programme

General Description	Implementation of RACE
Decision	88/28/EEC of14.12.87 OJ L16/35-43 of 21.01.88
Title	R&D in Advanced Communications-technologies in Europe (RACE)
Duration	01.06.87 to 01.06.92
Community financial contribution	550 MECU representing less than 50% of the overall effort estimated at 1200 MECU
Financing of EFTA participants	The partners from EFTA countries do not receive funding from the Community but, inversely contribute to the management expenses. The EFTA national administrations make the corresponding contributions.
Number of technologists involved	An estimated 2000 persons collaborate in joint project teams
Overall objective	Introduction of Integrated Broadband Communication (IBC) taking into account the evolving Integrated Services Digital Network (ISDN) and national introduction strategies, progressing towards Community-wide services by 1995.
Scope	Part I: IBC Development and Implementation Strategies Part II: IBC Technology Part III: Prenormative Functional Integration
Nature of the cooperation	Pre-competitive and Prenormative R&D cooperation
Participation in RACE	**Is open to all organisations established in the Community**
Telecomunications Administrations	15 unique participations +INMARSAT and 160 participations overall
Telecommunication Equipment Manufacturers	127 unique participations and 395 participations overall
Small and Medium Sized Companies	130 unique participations and 183 participations overall
Universities and/or Research Establishments	84 unique partipipations and 106 participations overall
EFTA participation	27 unique participations and 72 participations overall from Austria, Finland, Norway, Sweden, Switzerland as full and equal partner
Other	59 other types of organisations
Number of consortia	90
Number of organisations involved	306
Number of participations in projects	797

RACE interworks with	Organisations active in related subjects
CEPT	Group Mixed RACE set up by CEPT
ETSI	Protocol which defines the interworking via the "Consensus Management Project" in RACE
EBU, CEN/CENELEC and SPAG	Periodic consultation meetings
EFTA national administrations	Periodic briefing and consultation sessions
EUREKA	Via Commission participation in the Ministerial Meetings and on the level of specific projects
ESA	Via the coordination group set up by the Commission to coordinate telecommunications policy matters
COST	Periodic concertation meetings and direct links between related projects
ESPRIT	Via Commission internal collaboration and via the respective Management Committees
RACE Integrates with	**Other policies at Community and national level**
Telecommunications Policy	Via the Senior Officials Group Telecommuniations (SOG-T) and collaboration with COM DG XIII/D
Standardisation Policy	Via COM DG XIII/E and SOG-ITS
RACE Management	**Follows industrial practice**
Programme Mangagement	Responsibility of the Commission supported by RACE Management Committee
	Advises the Commission on the implementation in general, adopts the yearly Workplan, assessment of proposed projects, level of Community finance, participation of EFTA organisations, exeptions from the general rules
Project Management	Responsibility of the Project Consortia
RACE Workplan	**Decribes in the context of the objectives all work which is to be carried out under the programme**
Defintion of the rationale and tasks	Developed with the sector actors concerned and formally adopted by Management Committee every year
Revision and update	The Workplan is revised every year in the light of the evolution of the objectives and the technology options
Impact Assessment and Forecasting	As a contribution to the yearly update of the Workplan and of the projects a systematic investigation of developments world-wide are undertaken. This is in addition to visits and contacts with related actions world-wide
International contacts	Contacts are maintained and by yearly visits reinforced.
Dissemination of RACE Results	**Is build into the programme**
Programme-level	This is carried out via yearly progress reports to Council and Parliament as well as yearly "Technical Reports"
Project-level	Projects are actively participating in conferences and seminars as well as publication of their results
	Each Project produces "Deliverables" which document results and/or transfer them to those who need them for their work.
Standardisation-related results	Via the "Consensus Management Project"
Within the Programme	Every six weeks all project leaders accompanied by some of their team members meet in "Concertation Meetings" to review the progress and dissiminate intermediary results
Within the Project Consortia	Project internal meetings assure transparency and dissemination of the results while the work is progressing.
Quality Control	For all systems engineering related work the "Consensus Management Project" is assuring the consistency of the results.
	For the deliverables in general Project Officers of the Commission assess the results.
	Once a year independent external experts carry out a Technical Audit of all projects

Tendering and Evaluation of Proposals	**Public call for tender followed by independent anonymous evaluation by experts**
Competitive tendering	After adoption of the Workplan the choice of proposals is made on the basis of a public tender
Conditions for participation	At least two independent industrial partners not all established in the same Member State, at least 50% contribution by contractors
Independent evaluation	Proposals submitted are anonymously assessed by independent experts
Contracting	A Model Contract is offered which has been developed with the sector actors for R&D cooperation in the field Consortia agreements are used to make specific arrangements as may be needed under certain conditions
Management Reports	Serves essentially the needs of Project Consortia to monitor progress of work. It also is used to signal problems.
"Red Flag" Procedure	If a project or a partner in a project encounters unforeseen serious problems he signals this to partners and the Commission by "raising a Red Flag" in the Monthly Management Report. If invited the Commission calls a meeting to resolve the problem, otherwise the issue is addressed within the consortium.
Yearly Project Progress Report	Each Project prepares once a year an Annual Report
Self-evaluation	As part of the yearly Annual Report each Project Team carries out a "self-evaluation" .
Annual adjustment of the Project	At least once a year the Technical Annex of the contracts are re-examined on the basis of a revised and refined Technical Annex for the next year.
Adjustment in the course of the year	The evolution of the work requires often a flexible adjustment of the plans. This is carried out in the light of the results of the "Concertation Meetings". Unless these are major changes they are agreed with the Project Officer without ammendment of the Contract
Deliverables	Major results which are either the basis for own exploitation or form an input for the work in other projects or the work of standardisation bodies, in particular ETSI. They are documented in a suitable form.
RACE Auditing	**Follows industrial practice conform to Community rules**
Strategic Audit (annual)	Examines the evolution of the political, economic and social objectives in the light of world-wide developments
Technical Audit (annual)	Examines the progress of all projects making up the RACE Programme
Management Audit	Examines the programme management performance in the context of the project management performance
Financial Audit	Is the verification of the correct use of public money. It includes both the Projects and the Commission Service in charge of the programme management function
Exploitation of RACE results	**Is part of the contractual commitment of the projects**
Industrial Property Rights	Rest with the partners in a project. Depending on the circumstances special provisions are agreed between the partners. The model contract foresees graduated provisions for access to the results of other projects and the conditions for exploitation
Documentation	**Technical work in the yearly Workplan and the yearly Technical Reports**
Results	In the Deliverables Reports and Annual Reports
Publication	Publications of the Projects in technological journals
Conferences	"1990 IBC Conference", and participation in IBC related conferences

3 The audits of the RACE Programme

3.1 Introduction

This section begins with an overview of the evaluation process employed by the Commission in relation to the RACE Programme. The results of the audits conducted are summarised and the general impact of the results on the Community is described. The section continues with a short report on a survey of the views of project participants on how they intended to exploit the results of the Programme. The section concludes with a revised set of milestones for the RACE Programme.

3.2 Evaluation as an on-going process

In view of the rapid developments both of technology as well as of user requirements, evaluation is a process which is pervasive in the preparation of the programme, its implementation and its execution.

The evaluation started with the collaboration of the telecommunications actors in the planning of the programme and the development of the Workplan. Following the initial definition of the Workplan, there has been a yearly up-date of the both the Programme Workplan and the workplans of all projects. In addition, there is throughout the year a continuous informal process of monitoring progress and adjusting the direction of projects and the Programme. The mechanisms used in this process are regular meetings between the consortia making up the programme (Concertation Meetings), a special team monitoring the consistency of the work (Consensus Management Project) and close relations with the standardisation bodies making use of the standardisation related results.

The Commission staff is contributing to the awareness of world-wide developments by their contributions to Impact Assessments and Forecasting. This activity provides the factual background for the yearly up-date of the work under the programme as well as minor adjustments during the course of the year. The Member States are involved in the Impact Assessment and Forecasting and participate in reviewing the evolution and assessing the needs for adjustment.

3.3 The RACE Programme Audits

The mid-term review of the Programme (30 months review) and the annual review of the progress of work, which are the subject of this document, are based on the outcome of several audits of the Programme by groups of independent experts.

Article 9 of the Council Decision states: "The programme shall be reviewed after 30 months on the basis of an evaluation of the results achieved in relation to the precise objectives set out in Annex II to this Decision. The Commission shall inform the Council and the European Parliament of the results of this review." By Article 6/4, third indent, the Commission is to refer the programme review to the Management Committee for opinion.

The work on Integrated Broadband Communication (IBC) in RACE needs to be periodically adjusted to respond to rapidly evolving techno-economic conditions and service opportunities. Therefore, within the programme, a yearly critical examination (Audit) is held of two aspects:

- **The strategic aspects**, evaluating the performance of RACE as a whole with respect to strategic and policy objectives of the Community in an international context

- **The technical aspects**, evaluating the performance of the RACE projects with respect to the RACE objectives

A third aspect, not covered by these yearly Strategic and Technical Audits, is that of

- **The programme management**, evaluating the performance of the Commission in its responsibility for the management of the programme.

These audits have been complemented with a forward looking investigation of future requirements and options in the framework of "Operation 1992[1]" in which leading strategy, policy and technical experts collaborated in the task of identifying requirements and options. A summary of the Requirements Board "Telecom 2000" are enclosed as an Annex to this document.

3.4 Summary of results to date

The main features of RACE and the programme management are summarised in the table. More detailed considerations are contained in the annexes.

The contributions of RACE Projects are to be seen in the context of work carried out in other frameworks, eg national programmes, independent work of industry and PTOs, EUREKA, COST and others.

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1) As part of the on-going exploration of requirements and options but in particular as part of the preparation of the revision of specific programmes and of the Framework Programme a Planning Exercise "Operation 1992" has investigated the domains of communications and the use of telematics services of major socio-economic interest.

Review Summary Table

Objectives	Ways in which RACE addresses these objectives	Impact of the RACE work
Objectives of Part I : IBC Development and Implementation Strategies		
Common understanding of the IBC evolution and its implications	Establishment of a collaboration between operators, industry and users aiming to arrive at common functional specifications for IBC and the transition. Strategic techno-economic investigations taking into account demand and technology options	Preparation of draft functional specifications System engineering approach to evolution planning Formation of a joint systems engineering team to assure consistency of quality of specifications developed in RACE and their consistency with objectives and requirements. Investigation of optimal conditions for IBC introduction Schedule of major technical issues, including a method of resolution and related international activities outside RACE. Establishment of close working relations with standards making process in Telecommunications.
Common definition of IBC systems and sub-systems	Development of a Reference Configuration [CCITT concept] to define the system structure of the Integrated Broadband Communication Network (IBCN), and the suitable implementation options and technologies.	An in-depth investigation of the proposals of CCITT Study Group XVIII (San Diego meeting) about the ATM. This contributed directly to agreement on a common European strategy in the domain.
Guideline for functional specification of IBC systems and integrated services	Development of a Functional Reference Model, FRM to create a logical structure of the IBC functions and interfaces, acting as a central agency for all functional requirements on implementation.	Development of "network integration" incorporating terrestrial and satellite options under a common network management Evaluation of medium and long-term options for optical access to the customer A consistent description of IBC in terms of functional specifications (Common Functional Specifications, CFS). The first CFS was put forward in June 1989.

Review Summary Table

Objectives	Ways in which RACE addresses these objectives	Impact of the RACE work
Identification of technology and RD&E requirements	Usage Reference Model to provide a conceptual framework to link user requirements and functional requirements. Systematic cooperative assessment of technological and operational options, including optical communications, mobile communication, satellites, CPN, new switching techniques, and HDTV is one of the major aims of RACE.	The first draft on the interface definition at the S_B reference point became available in June 1989. The T_B reference point and the mobile broadband interface components and system requirements have been established.
Tools of the evaluation of cost-effectiveness of alternative implementation routes	Preparation of common tools for techno-economic and operational assessments. Following the work done in the RACE Definition Phase two classes of tools were developed during the main programme : the first is related to economic analysis and the second to network planning and standards.	Common tools have been developed and made available for RACE participants. These tools provide the basis for transnational comparisons of options and strategies in relation to technical and economic characteristics as well as standardisation requirements.
Analysis of standardisation requirements	Regular meetings with the standardisation bodies, creation of a coordination group between the Consensus Management Project and the European Telecommunications Standards Institute (ETSI). Investigation of standard requirements deriving from user needs worldwide.	Technical contributions to different technical groups in ETSI have been made through the Consensus Management Project and directly from partners in the project. Orientation of the work in RACE projects to identify standards requirements in collaboration with ETSI and other standards bodies.

Review Summary Table

Objectives	Ways in which RACE addresses these objectives	Impact of the RACE work
Objectives of Part II : IBC Technologies		
Use of advanced technology for cost-effective implementation of IBC.	R&D in cost-critical optical components, subsystems and systems for both broadband transmission to the customer premises and switching, aiming at cost-efficient solutions for applications in all major domains. Investigations of Short term technologies (Eg. Direct Detection) in view of immediate cost reductions. Investigations of Medium/long term technologies (eg Coherent Detection) with potential for major cost savings and service enhancements. Development of ATM as a means to provide flexible and "future-proof" implementations. Investigations of a family of compatible video coding techniques for (HD)TV and video telephone ensuring cost-efficient use of bandwidth resources.	Specification and Development of systems, subsystems and components (connectors, lasers, switching elements, etc.) considering in particular cost aspects of different areas of applications (local network, CPN, etc.). Demonstration of those components and subsystems in terms of prototypes, and proposed low cost production procedures. Simulated realisation and comparison of different ATM options and requirement specifications for ATM switching systems. Simulated use of algorithms for bitrate compression techniques for high quality video services (TV & video-telephone) and start a new CODEC development.
Telecommunications software for complex integrated systems.	Development of an overall system architecture based on objects to allow for rapid introduction of new services. Investigation of the use of Advanced Information Processing Techniques (AI, Data Base, MMI, etc.) to implement IBC functions. Investigate new software technologies to specify, design, implement, verify and maintain telecom systems.	First version of object oriented abstract model for telecom systems. Architectures and prototypes for traffic management, maintenance, customer and network administration. Specification methods, development environment and on-line support for telecom systems. Initial model architecture for secure communication. Issue of a first "Call for Security Algorithms".

Review Summary Table

Objectives	Ways in which RACE addresses these objectives	Impact of the RACE work
Advance in ergonomic and cognitive facilities of IBC equipment.	Investigations of usability factors of dialogue, distribution, retrieval and integrated services, and of usability issues of domestic CPN.	A taxonomy for usability engineering.
		Identification of usability engineering requirements in advanced communications.
	Investigations into the usability issues for People with Special Needs (Eg. elderly and handicapped).	Early investigation of requirements for People with Special Needs in Advanced Communications.
	Improving consistency of design through the development of Usability Design Targets Database with easy access to usability knowledge and data.	Enhancement of interaction between usability researchers, users and equipment designers.
	Incorporation and evaluation of usability issues in Application Pilots.	Joint plan for capturing and analysing common usability issues in Application Pilot projects
Realisation of evolutionary subsystems and networks.	Definition and demonstration of generic architectures and appropriate techniques and technologies for IBC systems and subsystems,including video bit-rate reduction.	Operational and functional requirement specifications and design specifications for the various systems and subsystems (local network, CPN, terminals).
	Customer premises networks, aiming at the establishment of concepts which can act as a framework for satisfying domestic, business and other requirements across a range of applications and sizes.	Simulation and experimental studies for components and subsystems (Eg. transmission links), supporting the decision process for system designs and in particular the specification of ATM parameters.
	Various types of terminals (multi-service, multi-media, digital video tape recorder) integrating flat panel displays.	Detailed designs and implementations for components and subsystems (hard- and software) suitable for IBC applications.
	Adapting systems, enabling a smooth evolution from present systems to IBC.	Demonstration of an A4 size monochrome EL flat panel display integrated in terminals.
	Integrated systems comprising local networks, customer premises networks and terminals, interconnected via agreed interfaces at S and T reference points.	Identification of Interoperability requirements.
		Initial specifications for integrated systems and demonstrators.

Review Summary Table

Objectives	Ways in which RACE addresses these objectives	Impact of the RACE work
Objectives of Part III : Development of IBC Application Schemes		
Development of verification tools, verification of design concepts, functional groups or protocols	Development of Methods and tools for testing IBC Network Elements and subsystems. Verification of protocols at suitable IBC reference points. Recommendations for protocol conformance testing.	Identification and characterisation of the testing functions related to terminals, Customer Premises Network, Customer Access, Switching, on local and Trunk Exchange, Transmission systems. Development of testing procedures jointly between system engineers and testing tools designers. Identification of the test access points and protocols.
Refinement of functional specifications and/or verify standard proposals	Integration of pilot skeleton systems from subsystems for the purpose of refining the specifications of interworking protocols. Pre-normative verification of critical standardisation and specification items.	Specifications systems and subsystems to allow interworking available by the end of 1989. Provision of a mechanism for demonstrating interoperability features and compliance to standards and specification.
Development of experimental situations where service providers, network operators and users can test IBC experimental products so as to speed the understanding of the characteristics of IBC commercial exploitation	Definition of future service requirements in collaboration with leading edge users from all major business sectors. Implementation of a testbed structure by the European PTTs.	Realisation of Application Pilots in all major sectors.. The covered sectors are : Banking and Finance, Insurance, Media and Publishing, Manufacturing, Health Care, People with Special Needs, Transport and Distribution, HDTV Experimental Use. Participation of more than 100 leading edge users. Definition and agreement on the implementation by the network operators of EBIT (European Broadband Interconnection Trial - 2 Mb/s switched progressing to 140 Mb/s Europe-wide connections). Signature of a Memorandum of Understanding. Multi-national team assembled to give advisory support to the Application Pilots on their network and software requirements in order to assure interoperability of end systems through EBIT.

3.5 Review of the results of RACE by the Audit Panels

The main conclusions of the review can be summarized as follows:

- **Strategic orientation**

- The basic RACE objective remains generally valid: IBC[1] development is appropriate and necessary for Europe and the 1995 target date is consistent with requirements and with evolution worldwide.

- All in all, the current emphasis in RACE on the different areas covered is about right. Because of limited financial resources, priorities have had to be set. Roughly 18% of the effort is dedicated to systems engineering activities, 55% is devoted to developing key technologies, and about 27% to system verification and application pilots.

- The current emphasis in RACE on the different areas covered is about right; in a next phase, more effort should be given to customer-premises facilities, mobile applications, digital HDTV and verification and testing. ATM is to be considered as the key network technology. As a consequence, early LAN/MAN implementations in RACE have to be based on ATM. Optical customer access needs to be introduced as early as possible.

- An IBC system must provide the infrastructure and service functions for whatever mix of narrow-, medium- and broadband services exist, and for their functional integration. It will be necessary to develop a concept for flexible services integration which will allow adaptation to changing requirements. Standardization of Service Primitives is the right approach. High priority should continue to be given to pre-normative and system integration activities in RACE aiming at the definition of Service Primitives.

- In reviewing the balance of efforts, top priority is indicated for advanced application experiments and "additional measures" for network provision, while further cooperative pre-competitive research efforts continue to be needed for Europe to stay in the forefront of advanced telecommunication technologies; the visibility and credibility of the formation and management of technical consensus should be strongly reinforced.

- It is crucial for industry, users and telecommunications administrations to avoid continuing inconsistencies between basic IBC specifications and international market requirements.

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[1]) "I" "Integrated" not only means "integrated services" (at the user level and at the appropriate network levels), it also points to "integrity" of the whole network, and therefore to the proper interworking of all its essential constituent, including the existing and emerging ones: POTS; packet, ISDN, satellite, mobile ...

"B" "Broadband" not only means the "high-end" (in terms of bit-rate) portion of the services, it also designates the total mix of services to be considered, starting from the "upper end" of ISDN (e.g. certainly including 2 Mbit/s accesses, and possibly even 64 Kbit/s in specific application areas), up to what will be required by a realistic introduction of video (interactive and distributive) services (e.g. 140 Mbits/s).

"C" "Communication" not only means the "conventional" switching/transmission/CPN functions, it also includes the most advanced features to make service provision user-friendly, performant and economically sound.

■ **Projects - achievements and outlook**

- The work of RACE has been implemented under 2 Calls leading to projects taking up their work in January 88 and 89 respectively. The emphasis and tasks have evolved since adoption of the Programme. Already the 1988 Workplan placed increasing emphasis on Part I System Engineering and Part III Verification compared to IBC Technology in Part II. In a cummulative manner Part I increased from the estimated 11.9% to 18%, Part II decreased from 66% to 55% and Part III increased from 22.4 to 27% of the resources. This evolution occurred partly in the adaptation of the work of on-going projects and partly by changing emphasis in the 2nd Call. (See Annex for the review of the Projects and the summary description of the RACE Programme.)

- The Technical Audit and the continuous monitoring of the progress in regular meetings indicate that good progress is being made. Contribution to the international standardisation process has demonstrated that the results have international standing. One project has been terminated on the basis of mutual agreement. The work has been taken over by an new project.

- A special project team established by the 18 leading Telecommunications Manufacturers and Telecommunications Administrations (CEPT) is assuring system engineering quality control and technical consensus between the work of the RACE Projects and their consistency with international developments. This approach has proved to be of decisive importance for the cohesion of the Programme overall.

- Working relations to standardisation bodies, in particular ETSI have been established and assure the rapid exploitation of relevant results.

- Concertation Meetings bring the Project Leaders regularly together to review their progress and exchange information and assess the evolution of the international situation in telecommunications. This has proved to be a major factor in achieving rapid dissemination of results.

- A milestone plan for the work towards the introduction of IBC has been defined and forms the basis for the timing of the work.

- The results of RACE will serve product development (50% of projects indicate this), service development and introduction (30%) and corporate network planning and infrastructure planning support in general (20-25%). The work has led, or is leading to patents in 30% of cases.

- Analytical tools have been chosen and adapted for comparative techno-economic analysis throughout the Programme thereby assuring the balanced attention to cost and performance improvements.

■ **Programme management - Conclusions of Audit**

- The RACE Programme has largely adopted an industrial programme management approach. The conclusion of the Management Audit was that the main elements of this approach:
  - > workplan preparation in close cooperation with sector actors,
  - > importance given to system engineering aspects, and
  - > consensus making through information exchange

are on the whole appropriate and well-adapted to the typical objectives and general situation of the programme.

- The system engineering part is considered of prime importance to the extent that without it the whole action of the Community through these programmes would be severely restricted in its effectiveness.

- The negotiation process was on the whole seen as satisfactory but payment of the advance on contract signature needs to be done faster; the same goes for payment after approval of deliverables.

- The yearly Technical Audit has proved an effective approach.

- Cooperation among projects towards consensus on technical aspects is being promoted by regular Concertation Meetings, attended by representatives of all projects. In addition, specific ad-hoc groups have formed around at least seven areas: network management, ATM requirements, S and T interfaces, programming infrastructure, integrity, quality of service, and application trials. The cost-effectiveness of these Concertation Meetings could be improved by making them more attractive and more interesting and also less frequent.

- The concept of having special projects to take care of system engineering and consensus formation is considered to be vital. However, the functioning of these projects needs to be optimized.

Conclusion:

The Audit Team considers the management approach that DG XIII/F applies to RACE, DRIVE, DELTA and AIM to be both original and appropriate; it is highly successful in accomplishing the specific and general objectives set for the programmes; in several aspects it distinguishes itself favourably from what - in the experience of the Auditors - is normally found in comparable programmes and initiatives.

The overall impression is unequivocally good, even very good. Any remaining difficulties are of a minor nature. The Commission, in particular DG XIII/F, should definitely continue in its application of this approach, taking care to make the necessary improvements and adaptations as the programmes evolve.

■ **Relations with CEPT, and with ETSI/other standards organisations**

The coordination with the work in CEPT is assured by GMR (Group Mixed RACE established for this purpose in September 1987). CEPT has actively participated in the identification of candidates for the joint industry/PTT project assuring the technical Consensus Management (R1045).

The collaboration with CEPT has also resulted in 13 European Telecommunication Administrations signing a MoU to introduce a generalised testbed for IBC work (EBIT).

Regular meetings are also held with CEN/CENELEC, EBU and SPAG.

■ **Relation with other Community programmes/European activities**

RACE projects capitalize on the results of projects developing generic technologies, i.e. ESPRIT (microelectronics components, software tools, AIP for network management etc.); similarly, the telecommunications requirement of the application programmes DRIVE, DELTA and AIM draw heavily on the techniques addressed by the current RACE projects.

The collaboration with COST has been implemented by close links between related work and periodic meetings on the programme management level.

With the EUREKA Initiative, the strongest interaction has evolved in the field of audiovisual technologies. Part of the work related to the promotion of HDTV (EU 95) is under RACE contract; another EUREKA project (EU 256) is being incorporated in the RACE integration activities.

- **Relations with EFTA**

Organisations from Austria, Finland, Norway, Sweden and Switzerland are involved in RACE. From those countries, 27 organisations participate in 72 consortia.

3.6 General impact of the results on the Community

The opportunities presented by the new communications technologies will have a very important impact on future economic growth in the Community and the international division of labour world-wide. Three distinct but interlinked growth processes are at work:

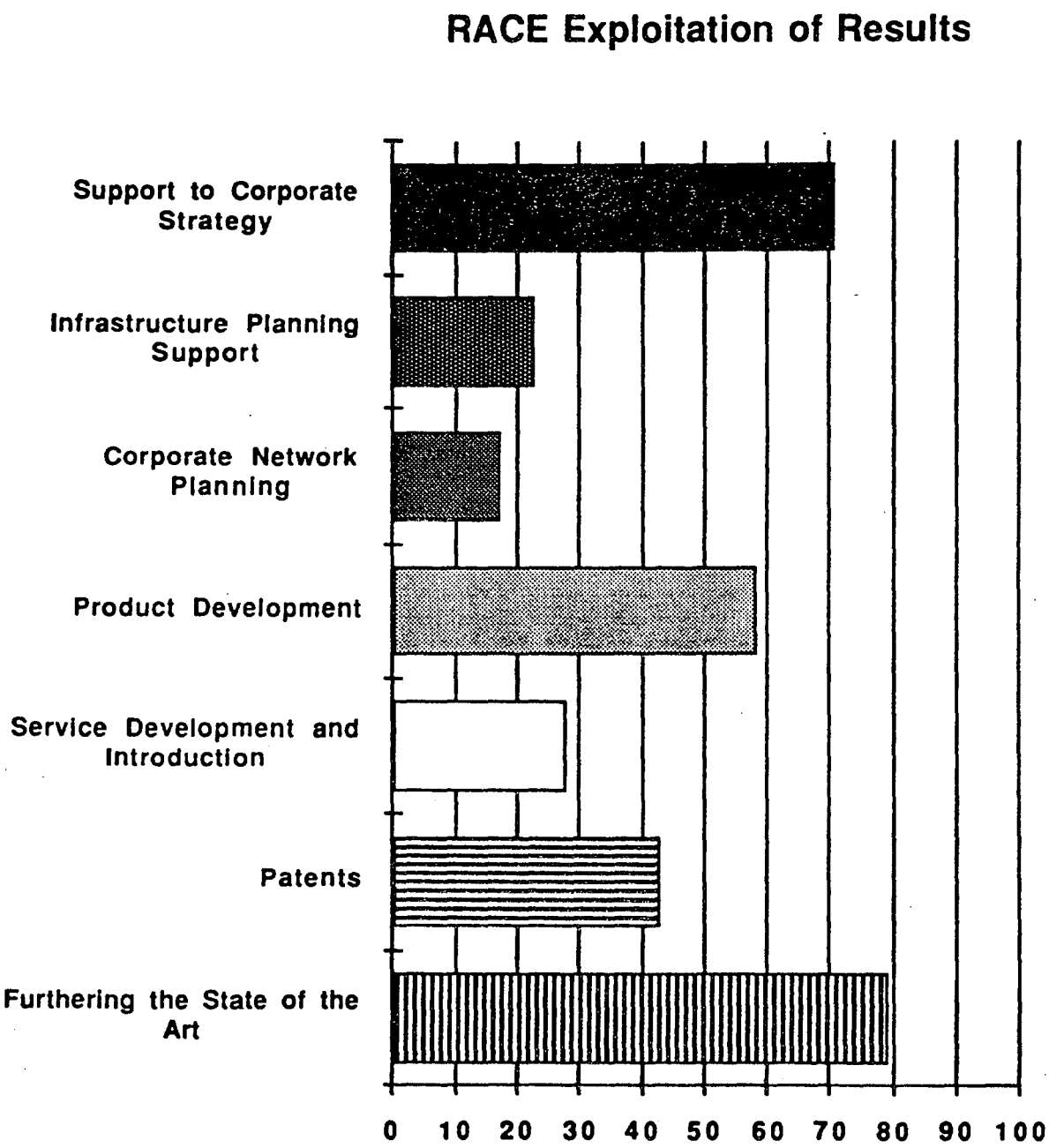
- Improved access to better information raises productivity throughout the economy,
- Improvements in communications raise the utility, and consequently the marketability, of both old and new services leading to their expansion,
- Transition to the new service-driven and information-based economy requires very large public and private investment in new infrastructures, both physical - cable, switches, terminals - and human, for the development of value-added telecommunications services.

Thus the quality - both technical and organisational - of communications will be crucial for future economic growth since it determines the capacity of the economy both to generate, and to use efficiently, the single most important factor of modern "production" : knowledge. The geographic organisation of infrastructures will strongly influence the social, economic and cultural space of tomorrow, just as railways did in the 19th century.

3.7 Exploiting the results of RACE

RACE is a programme with precise objectives which have to be implemented by work carried out in the projects. In order to assess the way the RACE results are to be exploited by the participants a specific action in the Programme has been introduced, the "RACE Exploitation Plan"(REP). It provides an integral view of the exploitation of the results by participants.

A statistical summary of the main use of the results is provided in the accompanying Figure.


RACE Exploitation of Results
Support to Corporate Strategy
Infrastructure Planning Support
Corporate Network Planning
Product Development
Service Development and Introduction
Patents
Furthering the State of the Art
0 10 20 30 40 50 60 70 80 90 100

3.8 Revised milestones for the RACE Programme

In a refinement of the original planning, the Requirements Board ("Operation 1992" GE0196) foresees for the period 1990-1994 (inclusive) the following major milestones can be tentatively identified:

1992/1993:

- Early (mostly business, professional) applications introduction,
- Application field trials (pilot) ready to test emerging new services, based on existing networks and (possibly) early prototype versions of IBC equipment,
- Procurement/investment decisions for future pan-European IBCN and full IBC services,
- Major standards finalisation,

1995:

- Initial IBC network implementation,
- Application field trials to test a full range of IBC services (incl. residential customers with 2-way video and digital HDTV) using completed versions of IBC equipment,

Several factors influencing the time schedule have been identified: they are the introduction of optical fibres for the long distance and distribution networks, the development of new information transfer techniques like ATM and of new architectures like MAN, and lastly the trend towards mobile networks and services.

4 Future requirements and options for work at European level

The possibility of sharing infrastructure and facilities for various classes of services, and of integrating services to form new value-added services, will not only lead to an increase in overall demand but also to a profound change in the relative share these service classes have in terms of added value and of investment in customer premises equipment. In order to ensure development of an integrated broadband communication system, regulatory intervention or coordination may be needed. The development and implementation of specific value-added services will be strongly dependent on the individual requirements of the users and the initiatives of the individual service providers. A network allowing the coexistence of all services would - by itself - develop very slowly and users would not have the full benefits of integration.

One is thus lead to the recognition that an IBC system must allow for the co-existence of all services, i.e. it must provide the infrastructure and service functions for whatever mix of narrow-, medium- and broadband services exists and for their functional integration (both static as well as dynamic, e.g. the ad-hoc integration of services). A common European approach will be required in order to provide the prerequisites in terms of concepts (flexible service integration), technologies and Standardization. The proper definition of Service Primitives becomes important. High priority should continue to be given to pre-normative and system integration activities in RACE aiming at the development of these Service Primitives.

Any further European R&D cooperation work would also need to address the balance of effort required between:

- Advanced telecommunications technologies (enhancing certain key technology areas, improving performance and/or reducing the cost of equipment),
- Ensure network and service integrity,
- Definition of future basic services and flexible integration of services,
- Network infrastructure planning, provision and evolution, starting with network IBC "islands" but evolving towards the generalised provision of broadband access in Europe,
- Advanced application experiments designed to realistically assess and test the "user needs" and to evaluate the new network configurations (e.g. ATM),
- Additional measures including formation and management of consensus, introduction and implementation strategies, definition of the regulatory environment etc.,

In qualitative terms, the new balance of efforts should indicate top priority for advanced communications experiments and "additional measures" for network provision; further cooperative pre-competitive research efforts are needed for Europe to stay in the forefront of advanced telecommunication technologies; the visibility and credibility of the formation and management of technical consensus should be strongly reinforced.

4.1 Priority subjects for consideration

The emerging Asynchronous Transfer Mode (ATM) technique, together with new architectures such as Metropolitan Area Network (MAN), will be sufficient to satisfy, in the short to medium term, operator and business needs leaving open, at the same time, the option of inclusion within the same structure of broader classes of users. The interconnection of LAN products and the provision of multi-terminal configurations made possible by this association seems particularly attractive. Thus these developments need to be given appropriate priority.

In mobile services, Europe has the opportunity of being in the forefront of development. The transition to digital technology, and the penetration of mobile service products in the consumer market offer vast chances to European industry, provided it can avail itself of the European market dimension. A variety of mobile service products needs to be developed: pan-European digital cellular radio, telepoint services, digital cordless telephones, pan-European paging, etc. Complementing the R&D developments in RACE, which may need to be intensified, there should of course be appropriate regulatory measures and reservation of the necessary bandwidth in the radio frequency spectrum.

On the technological side, it is found that in a next phase more emphasis should be given to customer-premises facilities, mobile applications, digital HDTV and verification and testing. ATM is to be considered as the key network technology. As a consequence, early LAN/MAN implementations in RACE have to be based on ATM. Optical customer access needs to be introduced as early as possible.

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ANNEXES

I. IBC Strategic Audit - Executive Summary and recommendations for Action

This first Strategic Audit[1] has concentrated on global objectives and priorities, taking into account political, social, economic, technical and industrial developments and the evolution of demand for advanced telecommunications.

The Strategic Audit has been carried out by six experienced advisors acting in a personal capacity

Mr John Alvey
Mr José Viana Baptista
Mr John Barrett
Mr Basilio Catania
Mr Joseph Cornu
Mr Jacques Dondoux
Mr Dietrich Elias

The Commission has been represented by Mr. M. Carpentier and Mr. R. Hüber, assisted by Mr. P. Johnston.

The report reflects the consensus and the findings that have emerged from the joint work.

A. Key issues

The Strategic Audit has resulted in the identification of a number of key issues. The main points are summarised below and are treated in more detail in the main text.

1. IBC implementation issues[2)]

It is appropriate and necessary for Europe to develop an advanced communications system (IBC) that will provide the essential base for the emergence of new economic activities, new employment opportunities and international competitiveness *(2.1)*.

The differences prevailing between Member States require a regionally differentiated approach to the realisation of the common objective of IBC and therefore early standardisation is essential. Joint Ventures, Memoranda of Understanding and Franchises may offer appropriate models for a consistent but regionally differentiated approach to the realisation of IBC-Services *(2.3)*.

The timely realisation of IBC services will be strongly dependent on appropriate regulatory developments *(3.1)*.

Europe should develop a leading-edge market of its own for advanced terminals and services, otherwise industry and service providers will need to rely on leading-edge markets in the USA *(3.7)*.

The strategy for IBC infrastructure investments needs to rely as much as possible on both business and domestic use of both communication and entertainment services. The strategy for IBC service introduction should, however, focus initially on meeting the needs of businesses *(3.9)*.

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1) For the full details please refer to the IBC Strategic Audit Report

2) The numbers in brackets refer to the corresponding section in the body of the text of the full Strategic Audit report.

The target date of 1995 for introduction of full IBC services is consistent with requirements and with the evolution of the situation worldwide *(3.12)*.

Preliminary IBC Services should be available for business users by 1992. At the same time, appropriate measures should be taken to ensure the compatible evolution of Cable Television networks by promotion of two-way video and HDTV services *(3.12)*.

An intensification of efforts is necessary in order to develop in Europe a coherent approach to, and time-table for establishing an IBC infrastructure and services *(4.1)*.

Future services, even more than in the past, depend on international and wide-spread user acceptance. For this reason, co-operation in large-scale application trials will be needed to explore the best ways of meeting present and future services demand, to limit investment risks and to accelerate the introduction of a broadband infrastructure in Europe *(4.2)*.

2. Towards integration of services

Greater emphasis should now be given to the encouragement, development and demonstration of innovative IBC services *(2.2)*.

Appropriate geographical areas should be chosen for pilot applications combining distributive, communication and new 2-way broadband services, not necessarily similar in each country: A variety of pilot applications will be needed to develop a good understanding of opportunities and requirements of future services *(3.2)*.

It will be necessary to develop a concept for flexible service integration which will allow adaptation to changing requirements. Standardisation of Service Primitives is the right approach to achieve this. High priority should continue to be given to pre-normative and system integration activities in RACE aiming at the development of Service Primitives *(3.10)*.

Future cooperative R&D should be extended to support Integrated Services Engineering[3] *(4.3)*.

3. Standardisation issues

There should be an initiative to encourage harmonisation in optical fibre installations to subscribers in Europe. The architecture and interface specifications of future optical fibre networks should be defined as soon as possible. ETSI should be encouraged to give priority to these specifications *(3.3)*.

The approach of complementing standardisation proposals with "Common Practice Recommendations", in RACE, is appropriate *(3.11)*.

ETSI should be the prime forum for generating European telecommunication network standards, CEN/CENELEC should address IBC terminal issues and EBU the broadcasting aspects of IBC, but effective coordination is essential and it will be necessary to collaborate directly with US and other standardisation bodies *(3.17)*.

The ETSI effort needs to be reinforced in order to meet a number of time-critical specification deadlines *(3.17)*.

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3) Integrated Service Engineering involves putting together basic service elements or Service Primitives for new applications of advanced communications.

Europe should organise its research and standardisation efforts in such a way that it has the equivalent to the support available to the US in the combination of ATT Bell Labs, Belcore and T1 (as well as from the EIA and the FCC). A basis for this could be an increased cooperation between national research organisations and a follow-up of RACE *(3.17)*.

CCITT continues to be the best forum for obtaining world-wide consensus on all telecommunications issues *(3.17)*.

4. The emphasis in RACE

The objective of RACE does not need to be adjusted. The relative emphasis in RACE on the different domains is about right. In a next phase, more effort should be given to customer-premises facilities, including software, mobile applications, digital HDTV and verification & testing *(3.13&3.14)*.

5. Related policy issues

A model tariff structure for IBC in line with the ONP concept should be developed on a European level *(3.5)*.

Radio frequencies should be assigned to mobile services where other services can use cable networks. New local and regional TV channels should be preferentially distributed on cable networks; satellite TV broadcasting should be used to promote European harmonisation *(3.6)*.

It is vital that Governments realise what social changes advanced communications services will bring, and plan for them. The necessity of studies and of a dialogue within all sectors of organisations is evident. This should take place in an appropriate framework *(3.15)*.

Trans-border traffic issues are very important and need to be addressed in the appropriate context *(3.16)*.

B. Recommendations for Action

The introduction of advanced "broadband" communications in Europe will provide potentially enormous benefits to Europe. However, the benefits can only be realised by innovative services relying on a new generation of terminal facilities and infrastructures. A major investment programme will be involved, with all the risks associated with large-scale deployment of new technologies and services.

The success of any introduction strategy will depend crucially on the compatibility of developments throughout Europe and on the active stimulation of markets for new services. Because some developments in advanced communications also involve highly political issues, a reduction in the uncertainty about the conditions for service-provision is a prerequisite for service providers, telecommunication & broadcasting administrations and industry to take up the challenge and to make the required investments. This calls for a firm and consistent political commitment in Europe resulting in the creation of conditions for cost-effective use of new infrastructures. Given that the appropriate conditions can be offered, market driven developments, competition in provision of value-added services and private investment will become possible.

The full benefit and added-value of integration of services to the user, as well as to telecommunication & broadcasting administrations, will only be realised by joint use of infrastructures and terminal facilities. The most significant addition to the infrastructure will be the introduction of optical fibre networks. For this, the investment resources of the major users and telecommunication, broadcasting and cable television administrations may be needed. Joint ventures by telecommunications, broadcasting and cable administrations and service providers should therefore be made feasible, with the possibility of using the same infrastructure for communication services and TV distribution.

The infrastructures and the availability of new services will evolve over several decades and will be different in different local areas. Whatever approach to infrastructure implementation is chosen, it needs to be pluralistic but consistent.

The normal development towards integrated broadband communications will involve investment in new networks, including local optical-fibre networks, by Telecommunication Administrations. However, if Telecommunication Administrations do not invest in such networks, an alternative way to reconcile the problems of long investment cycles (15-20 years) with the need for a regionally differentiated approach, would be to grant concessions to private investors to provide a local infrastructure and services. Local or regional arrangements should be open to commercial tender, subject to review at appropriate intervals.

While technological R&D and mechanisms for consensus formation has been successfully established in the framework of RACE, it is now timely to consider what further action is needed to exploit the results for the benefit of Europe's telecommunications users.

The following further actions should be considered[4]:

A) National Governments should collaborate to define by 1992 the conditions and regulatory provisions which should be applied to the introduction of pan-European advanced communications services;

B) Telecommunications, Broadcasting and Cable TV Administrations should propose, by mid-1989, a concerted approach to, and a timetable for, development and use of IBC infrastructures for both telecommunications and entertainment services including HDTV, taking full advantage of private sector investment initiatives when appropriate;

C) Telecommunications Administrations should prepare an initial Memorandum of Understanding by 1990 on closer collaboration in their intra-European long-distance links and operations;

D) Service Providers should specify, by the end of 1990, a first set of service requirements, commercial conditions and regulatory provisions which would favour an early and widespread use of IBC services;

E) Telecommunications, Broadcasting and Cable TV Administrations, Service Providers and the Telematics Industry should agree a Memorandum of Understanding by mid-1989 to complement the collaborative R&D in RACE by pilot implementation of some IBC Services on a European scale for a business-led introduction of IBC by 1992;

F) Collaborative R&D should be extended to include Integrated Service Engineering, fixed and mobile applications and techniques for verification & testing of communications equipment and service functions by the end of 1989;

G) European Standardisation Bodies should reinforce and co-ordinate their efforts towards international standardisation for IBC and advanced services. A standardisation schedule should be established by mid-1989, particularly for ATM;

H) Member States should address the problem of frequency allocation in Europe over the whole range of frequencies and applications. They should permit, by 1992, a rationalisation of frequency allocations reflecting evolving needs and priorities.

C. Investment implications of IBC implementation

The introduction of Integrated Broadband Communications in Europe will involve a major programme of investment. The investment will need to come about equally from Telecommunications Administrations, businesses and individuals:

4) Annex I includes a description of the scope of these recommendations.

- European Telecommunications Administrations have already made considerable progress in the installation of optical fibres for trunk links and in digital switching, but further major programmes of investment in fibre network installation to subscribers, for broadband switching equipment and for network management systems will be needed. The total infrastructure investment requirement is probably of the order of ECU 100 Billion over about 10 years for Europe. To justify such investments, it is particularly important to widen the range of services that could be carried on a Broadband network - to include distributive (HDTV) and interactive services as well as point-to-point communication services - and to widen the potential investment base to include Cable TV Administrations.

- A substantial investment will be needed in new Customer Premises systems and terminals. Business investment in Office Communication Networks already represents a significant proportion of expenditure on telecommunications equipment and, if IBC systems are developed, European business investment in Broadband Local Area Networks and Customer Premises equipment will probably total about ECU 100 Billion over 10 years. Such a figure is in line with current expenditures and trends.

- The domestic use of IBC, particularly if associated with HDTV and new interactive video services, could lead to an additional stimulus to private investment in multi-function terminals. A cumulative expenditure of the order of ECU 100 billion over about 10 Years could be envisaged, with a corresponding growth in the domestic electronics supply industries.

The development of advanced services using Broadband Communications will also require major investments in software for data management, accounting and billing, and in the creation of the intellectual content of new services. The annual revenue from European telecommunications services is expected to grow to over ECU 80 billion in 1992.Investments of the order of ECU 50 Billion in service development over about 10 years can be envisaged.

The total investment requirement over about 10 years could be of the order of ECU 500 billion.

II. Summary of the report of the Requirements Board "Telecom 2000" on future requirements and options

1. Introduction

1.1 Terms of Reference

The mission of the Requirements Board (RB) was to address, at a strategic level, future requirements and options in telecommunications infrastructure and services in the light of international developments and specific European conditions. The scope includes all industrial, service and technological aspects which are relevant to defining a consistent strategy for actions of sector actors including, where required, the development of governmentalal actions. The scope must be comprehensive and must take into account the convergence of IT, Telecom and Broadcasting, and both stationary as well as mobile usages.

1.2 Members of the Requirements Board "Telecom 2000"

V. Steiner, Deutsche Bundespost, Chairman
J. Ernest, Alcatel, Vice Chairman
C. Hamon, Bull SA
P. Conruyt, France Telecom
C. Massoto, SIP
K. Katzeff, Televerket
J. Van Egmond, Philips
N. Bininda, Siemens
J.A. Munoz, Telefonica
J.J. Don, MFA
J.A. Barrett, RIC
S.R. Temple, DTI
G.P. Oliver, British Telecom
G. Fabri, Italtel

For the Commission R. Hüber, Director DG XIII/F and Mr. S. Konidaris, Head of Division participated in the work.

2. Identification of major requirements and options

The Requirements Board "TELECOM 2000" fully supports the general conclusions from the analysis of the foreseeable economic, industrial and social development in the Community, which are set out in the Commission's "Green Paper on the development of the Common Market for Telecommunications services and equipment" and in the annex to the Strategic Audit Review Report.

3. Objectives and milestones for services and network development

The basic objective of the RACE programme which is the "Introduction of Integrated Broadband Communications (IBC[5]) taking into account the evolving ISDN and national introduction strategies, progressing to Community-wide services by 1995" remains generally valid and has to be remembered in the preparation of any programme revisions.

In the short and medium term emphasis should be given to facilitating the implementation of IBC as a result of phase 1 of the RACE programme:

- the preparation of the Europe-wide introduction of IBC infrastrucutre by 1995. This Intelligent Integrated Broadband Network, generated through an evolutionary process on the basis of existing network elements, should include new network management facilities needed by the operators and support with appropriate enhancements new services and high flexibility to respond to all user demands.

- the further improvement with respect to costs and further services of Integrated Broadband Communications for the second half of the 1990s.

- inclusion of mobile communications and flexible integration of new emerging services.

The strategy for IBC infrastructure investments needs to rely as much as possible on both business and domestic use of both communication and entertainment services including HDTV, but should focus initially on meeting the needs in the business field.
In the long term additional and very new efforts are required, integrated into or complementary to future RD&T activities at Community level:

- development of new system architectures and components for safeguarding network integrity and for the adaptation of different parts of the overall network

- a new approach to the definition of services in parallel and in line with the concept of OSI in order to provide long-term compatibility of services

- a new strong emphasis on standardization, taking into account world-wide and European requirements

- development of techniques to protect user privacy, proprietary rights and the exchange of data in general

- creation of a favourable environment for IBC by starting a dialogue on the social consequences

- extension of Community activities to the European level

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5) The meaning of Integrated Broadband Communications should be understood as:
"I" "Integrated" not only means "integrated services" (at the user level and at the appropriate network levels), it also points to "integrity" of the whole network, and therefore to the proper interworking of all its essential constituents,
"B" "Broadband" not only means the "high-end" (in terms of bitrate) portion of the services, it also designates the total mix of services to be considered,
"C" "Communication" not only means the "conventional" switching/transmission/CPN functions, it also includes the most advanced features to make service provision user-friendly, efficient and economically sound (e.g. it includes Intelligent Networks and Network Management facilities as well as advanced man-machine interface features as a necessity.

- early stimulation of markets outside Europe for IBC products.

4. Technical capabilities

Within the framework of the "call for ideas" and the Technical Work Panels set up by the Commission a large amount of material has been collected concerning the technical capabilities for future network and services development. Additional material has been submitted by the members of the RB .

The widespread scope of proposals clearly indicates the need to set up key priorities for common activities in the perspective of the requirements and the general strategy for the implementation of IBC.

5. Domains for cooperation on a European scale

Pre-competitive and pre-normative RD&T are very important for the creation of a climate of cooperation on a European scale. Future activities should be concentrated both on the basic technologies and components for future telecommunication systems as well as on some operational aspects, making the best use of all existing programmes like ESPRIT, RACE, COST, EUREKA etc.

In view of the growing interdependence of information technologies and telecommunications the coordination and cooperation between the important Community programmes ESPRIT and RACE should be reinforced, in order to attain increased mutual benefits, eg by inclusion of ESPRIT results in RACE Advanced Communications Experiments.

Activities for **standardization**, carried on in ETSI, are necessary and should be supported.

Co-ordinated network planning and co-ordinated implementation strategies are of particular importance. Related initiatives of the Council and "additional measures" on the Community's side could support the relevant actions of the Network providers in particular in planning electronic highways; actually carried out in the framework of CEPT/CAT.

A coherent market strategy is necessary for IBC products and services and first actions are required to stimulate the demand for IBC products and services outside Europe.

Development of prototype equipment for both the network infrastructure and the terminals should progressively be carried out in cooperative arrangements.

It is proposed to make increasing use of MoUs for the coordinated introduction of telecommunications networks and services. The CEPT is pursuing activities on the basis of MoUs in all relevant fields but political support for such MoUs from the Commission is required in order to complement the collaborating RD&T in RACE by a strong commitment of all parties involved.

Early application of the concept of ONP (Open Network Provision) to IBC would be an important step in the regulatory environment towards a harmonized early implementation of IBC in Europe.

6. Evolution scenario and balance of efforts

In line with the "economic, social and industrial progress scenarios" the RB has outlined a most reasonable, and at the same time, most desirable type of evolution scenario for the European telecommunication networks and services towards IBC, against which background recommendations for further activities in RACE have to be defined.

This "most reasonable/most desirable" type of scenario has the following characteristics:

- The evolution towards a pan-European integrated network, catering for as full a range of services as possible in the most economic way, should be as gradual as possible. That is, for each major step, care should be taken that the risks of further network fragmentation (both as regards the national situations and among the various types of networks/services) are minimized.

- This applies essentially to the physical as well as to the digital ONP infrastructures where the network operators play the major role.

- The evolution scenario also has to take full account of the existing wide diversity in the initial national situations, but at the same time, there is a recognized need to allow the early introduction of new services and new technologies.

- The evolution scenario should also has therefore take into account a large degree of flexibility and adaptability so that fast response can be given to those emerging needs, while providing the appropriate gateways and interworking between the various architectures implied (e.g. private networks, LANs-MANs, existing public networks i.e. ISDN and PDN's or others interworking with the "basic" infrastructures).

The further European RD&T cooperation programme calls for a proper balance of interaction between five major areas of activities:

- Advanced telecommunication technologies,

- Definition of future bearer services, flexible integration of emerging bearer services and teleservices to allow value-added services to be built on network infrastructure provision,

- Network infrastructure planning, provision and evolution,

- Advanced communications experiments,

- "Additional measures" including formation and management of consensus over: introduction and implementation strategies, definition of the regulatory environment (ONP), common functional specification and the preparation of standards, new financial instruments for network and services implementation, presentation of IBC outside the Community, development of common marketing strategies, development of the social consensus.

7. Recommendations for the revision of the Framework Programme and a future Framework Programme in the field of Community Telecommunications RD&T

A. Further cooperative pre-competitive research efforts should be maintained at present level and clearly **focussed** on a limited number of key strategic areas, with the basic generic purposes:
   - contributing to further cost/performance improvements in the most critical technologies for IBC deployment, e.g. "optical communication", "user-friendly terminal technologies", "signal coding for image communication", "ATM-switching", "complex systems specification methods and tools").
   - inclusion of new emerging areas of high relevance, such as: intelligent networks, mobile radio technology, communications management, distributive technologies viz. HDTV and information security.

B. Priority for any increase in Community RD&T should relate to **Advanced communications experiments**.
   - Advanced communications experiments should become central to the next step in the European cooperative RD&T programme.
   - The relevant planning efforts at Community level should be implemented within a consistent framework.
   - Telecommunications RD&T in the Community should continue to be managed in a way where all the component parts including in the future advanced communications experiments, can be coordinated properly. Further the flexible means should exist for the Community RD&T activity to be related to the relevant external actions in other fora and to the independent players.
   - Related network provision should be supported by appropriate "additional measures", so that a satisfactory distribution of the sites of advanced communications experiments can be achieved among the interested European Countries.

C. The EC RD&T role in advanced communications experiments needs careful definition. Within this definition experiments should:
   - stay within precompetitive, prenormative or preregulatory boundaries;
   - have reasonable expectation of viable commercial follow through within a reasonable time period;
   - require support to occur at Community level;
   - lead to results proportionate to resources envisaged;
   - having application to more than one Member State;
   - represent a significant advance on the state-of-the-art.

D. The visibility and credibility of the **Formation and Management of Consensus**, among the major actors, should be strongly reinforced. The "Consensus Management Organization" of RACE has therefore to give due emphasis in the direction of monitoring, identifying and carrying the key strategic issues into the appropriate external fora in a timely way eg ETSI..

E. There is a need for the European market in network and services to be strongly developed and to this end concerted action is necessary amongst all actors to reduce the risks and advance time-scales.

The RD&T actions should be concerted with the use of other Community policy instruments.

F. The development activities directly needed for the advanced communications experiments part of the programme, will require appropriate arrangements for safeguarding industrial property rights and specific management provisions.

G. As a substantial part of the development and investment, costs will be borne by the actors themselves (TA's, Industry), a careful mutual "pacing" of the objectives and commitments of the EC and the major actors is therefore essential.

H. The following major milestones are anticipated:

1992/93:

- early (mostly business, professional) applications introduction;
- advanced communications experiments ready to test emerging new services, based on existing networks and (possibly) early prototype versions of IBC equipment (e.g. ATM, CPN) as available;
- procurement/investment decisions for future pan-European IBCN (major decision steps: optical fibres in the loops and in the transeuropean trunks) and full IBC services.
- major standards finalization.

1995:

- initial IBC network implementation;
- field trials to test a full range of IBC services (incl. residential customers with 2 way video and digital HDTV) using completed versions of IBC equipment.

This time schedule is justified by the actual status of IBC technologies in Europe, as supported by the RACE programme, and by the additional advances expected from the further efforts recommended above. Furthermore, this schedule, particularly the 1992/93 major milestones, corresponds to an appropriate response to the world-wide competitive pressure in the area of IBC introduction to the market.

III - Technical Audit of the RACE Projects

A. The Audit Procedure

To be able to adapt the Programme to the development of technology and to changes in the perception of demand, the RACE Decision foresees that each year a workplan is established defining the detailed objectives, the type of projects and actions to be undertaken and the corresponding finance plans.

This implies that the progress of all the on-going projects must be annually reviewed with respect to the objectives and also be compared with the need for the future work to be addressed within RACE. The Technical Audit includes the following major elements:

(a) The partners in each project carry out a "self-evaluation" by reviewing the project in all its essential aspects and document the results of this evaluation in the Annual Review Report of the Project.

(b) The Annual Review Reports are evaluated by independent external experts (Auditors) identified with the help of RMC. Following the evaluation of the reports the projects are given a "hearing" under the chairmanship of the Commission. The Projects had the opportunity to highlight achievements and to outline future work, and after the Auditors, grouped in Panels according to their respective expertise, question the projects so as to complete the picture given by the Annual Report and the Presentation.

(c) The Panels consolidate their conclusions and recommendations to the RMC and to the Commission and document them in the Audit Panel Reports.

(d) The Audit Report of the external experts is complemented by an assessment of the contractual deliverables by the Project Officers of the Commission (in general the deliverables are considered confidential and are not disclosed to the Auditors). If the project is carrying on a prenormative work is complemented also by the endorsement activities of the Consensus Management Project.

B. Technical Audit Team of Audit '88

P.G. Anastassakos, Planet S.A.
R. Belton, British Telecom
P. Decaesteke, Matra Communications
V. Diaz Nunez, CET
J. Ekberg, Finland Research Centre
V. Ghergia, CSELT
S.R. Gomez, Com. Port. Radio Marconi
R. Goodfellow, Plessey Research Caswell
F. Hofman, Dr. Neher Laboratories
J.J. Jimenez Lidon, TID
H. Johansen, Norvegian Telecom
G.D. Khoe, Philips Research Lab.
P. Kostilainen, Finland PTT
J. Masure, Alcatel
J. McEwans, SEL
H. Melchior, Swiss Fed. Inst. of Techn.
E. Nicolaisen, Danish Technical University
D. Osborne, BBC
G. Perucca, CSELT
J. Petersen, University Saarlandes
G. Rolle, Siemens AG
J.M. Salles, Jutland Telephon
B. Scharoe Petersen, JYDSK Telephon
Schiffner, Ruhuruniversitat Bochum
J.P. Simon, CNET
B. Slamin, BBC
B. Slof, Philips International
J.H. Stewart, British Telecom
T.J.B. Swanenburg, Philips Research Lab.
G. Tardini, Telettra
G. Thwaites, System Designers
B. Walke, Fernuniversitat Hagen
H. Waeltring, DFVLR.

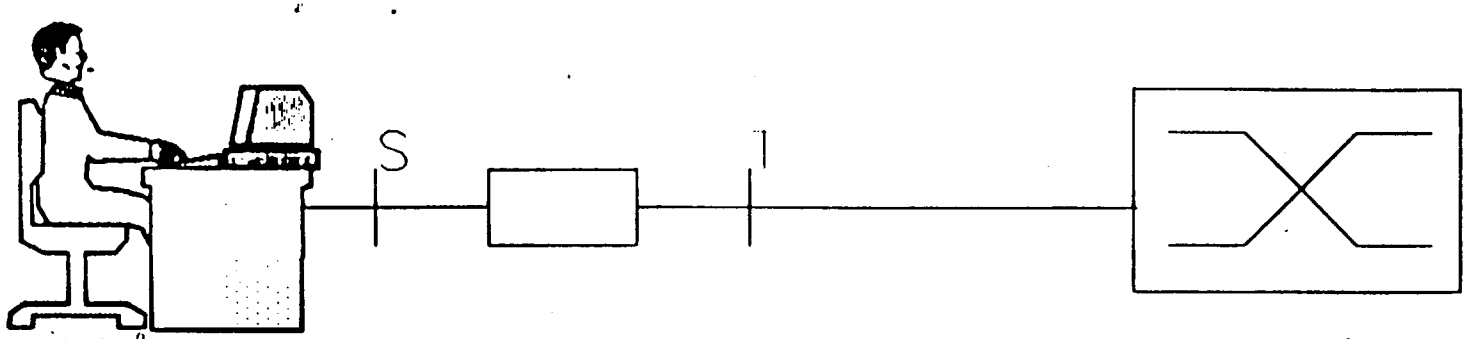
C. Results of Technical Audit '88

The first technical audit of RACE Projects was held by 33 internationally recognized experts during the first week of October 1988. The hearing has been recorded on video.

The official report of the 47 Projects audited says:

- 2 Projects have been completed and the results are consistent with the objectives;
- 1 Project will be completed during the next few months and is expected to reach its set objectives;
- 36 Projects have been recommended for continuation with some observations to be taken into account in the negotiation of the Year 2 adaptation of the Technical Annexes;
- 6 Projects have received support for continuation to compliance with substantial recommendations in the Year 2 adaptation of the Technical Annex and/or Project Management Procedures;
- 2 Projects have encountered serious reservations which has led to the recommendation to consider discontinuation.

The last 2 Projects passed a detailed Technical and Financial Audit ("Red Flag Procedure"), and 1 of them terminated the activities by the end of 1988. All the multiannual projects negotiated successfully the Year 2 activities.



Services & Users	Terminals	CPN	CAC	Network/Node	
R1037 User Criteria R1050 Appl. Analysis R1071 Appl. Analysis R1070 REMUS R1077 URM R1088 TUDOR	R1025 Security R1045 Consensus Management	R1023 BEST R1026 Security R1035 CPN R1044 UNI R1045	R1002 Satellite R1026 Eurovision R1028 Revolve R1043 Mobile R1045 R1048 RSVP R1053 Terrace	R1002 Satellite R1023 Best R1024 Netman R1025 Security R1028 Revolve R1043 Mobile R1044/R1045 R1048 RSVP/R1049 ATM Concept R1053 Terrace	PART I Requirements & Specifications
R1034 Usability Spec R1039 Dimun R1065 ISSUE R1066 IPSNI R1067 Guidance R1088 TUDOR	R1001 DVT R1004 EL-FPD R1007 ITIS R1018 Hivits R1038 MCPR R1040 RIPE R1041 Funcode R1047 Integrity	R1011 BCPN R1015 DCPN R1022 ATD R1036 WTDM-CPN R1040 RIPE R1052 SPOT	R1002 Satellite R1003 Guideline R1005 Nemesys R1006 AIM/R1009 Advance R1010 CMC/R1012 BLNT R1030 ACCESS R1043 Mobile R1051 Multi GBit/s	R1002 Satellite R1003 Guideline R1005 Nemesys/R1006 AIM R1009 Advance/R1012 BLNT R1013 HDTV Switch R1014 Atmospheric R1022 ATD/R1040 RIPE R1047 Integrity	PART II Systems
R1042 Multimed R1054 APPSN R1055 Merchand R1058 RESAM R1059 Dividend R1060 DIDAMES R1061 Dimpe/R1062 MARIN R1063 Mobile Apps R1070 Pay per View R1073 Geotel R1074 Echo/ R1074 Telepubl. R1078 Museum R1079 Car/R1080 HDTV R1086 Telemed		R1017 IOLE R1021 ARISE R1046 Specs	R1008 R1027 CMC R1029 Substrates R1031 Low Cost Comp. R1057 AQUA R1064 MIOCA R1069 EPLOT	R1008 R1017 IOLE R1019 Opt. Switching R1020 Opt. Switching R1021 ARISE R1033 OSCAR R1043 Mobile R1046 SPECS R1068 ROSA	PART II Technology
	R1016 Tools of EQU. R1022 ATD R1056 Biped R1081 BUNI R1083 Parasol R1087 Prove R1043 Mobile R1072 Itaca R1082 Qosmic R1084 MIME				PART III Verification & Integration

RACE Projects: An Overview

Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
D. Project Review Summary Statements		
1. IBC Development and Implementation Strategies		
1.1 Common u nderstanding of the IBC evolution and its implications		
R1044	IBC system and Network Specifications.	Development of the Functional Reference Model, the Customer Service Reference Configurations, the Evolution Prospect and Framework and the User Network Interface.
1.2 Common definition of IBC systems and sub-systems		
R1002 Sat. Nwk.	Specification of capabilities of Satellite systems in an IBC environment.	Options for a rapid, (with limited coverage), IBC user-connection accessibilities throughout Europe.
R1024 NETMAN	Functional Specifications for Network Management (NM).	Interoperability of NM systems in a multivendor and multi-service network. Contribution to NM standards.
R1025 Security	Functional specification of security services Primitives, interfaces, protocols.	Integration of security services into the overall IBC functionality.
R1026 International Radio & TV	Proposals for the integration of the Eurovision network in IBC.	Eurovision requirements to IBC for integration of Euro-wide TV-broadcasting.
R1035 CPN Part I	Specification of the interface at S reference point; scenarios of relevant equipment configurations.	Active participation and contribution to the international standardization process, in particular for the interface at S reference point.
R1037	Identify and asses user criteria for realising the successful introduction of IBC.	Assessment of end-user requirements.
R1049	Provisional specification of the ATM layer and ATM signalling protocol.	Contribution to the specification of UNI.
R1053 TERRACE	TMN Ref. Configurations Scenario for a Pan-European TMN.	Harmonisation of NM in Europe. Framework for the creation of a European market for NM systems.

Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
R1050/R1071 Application Analysis	Collection of data by analysis of published material case histories and discussions with service developers. Development of an expert system to codify the analysis of comm. needs.	Provision of data and recommendations for action to provide entry strategies and pilots for IBC..
R1076 REMUS	Database of agreed usability design targets.	Man/machine interfaces that are easy to use and consistent across a wide range of IBC applications.
R1077 URM	Terminological definitions, creation of a usage data structure and relationship with services and network entities.	Usage knowledge data mappings to service/function definitions and network design.
1.3 Guideline for functional specification of IBC systems and integrated services		
R1023 BEST	A methodological support to the definition of the IBC functional specifications (handbook and consultancy support in use).	More uniformity in methods across the projects contributing to the IBC functional specifications.
1.4 Identification of technology and RD & E requirements		
R1014 "Atmospheric"	Spec. of hybrid network elements (ATM/STM) and a demonstrator.	Network design for hybrid transfer modes, and proposals for standardisation.
R1041 FUNCODE	Studies of the techno-economic aspects of video codec location.	Information on the most appropriate locations of video codecs inIBCN.
1.5 Tools for the evaluation of cost-effectiveness of alternative implementation routes		
R1028 REVOLVE	A planning support for the introduction of IBC services in the less favoured regions (LFR's).	A set of tools for the strategic planning of telecommunication development in rural areas.

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Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
1.6 Analysis of standardisation requirements		
R1045 Consensus Formation	**Preparation of Common Functional Specifications (CFS's) Common Practices for the development and implementation of IBC and interpretation of user requirements.**	**A consensus making mechanism on different levels between sector actors, including users.** **Quality assurance of project results for contribution to standardisation organisations.** **Efficient interfacing and exploitation of RACE output in ETSI, EBU, etc..**

Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
2. IBC Technologies		
2.1 Use of advanced technology for cost-effective implementation of IBC		
R1008	Prototype components using planar technology and fibre registration techniques.	Short term low cost solutions to some of CAC component requirements.
R1010 CMC	Specifications and demonstration systems for coherent CAC links. Technological solutions transmitters, local oscillators and polarization diversity receivers.	Development of high performance systems for distributive services for longer term domestic requirements.
R1018 HIVITS	Digital video coding algorithms for videotelephony, TV and HDTV.	A family of draft standards and CODECS for digital video bit-rate reduction.
R1019 POLYMER SWITCHES	Demonstration of compact, elementary switch arrays.	Potentially low cost optical switching matrices.
R1020 NON-LINEAR POLYMERS	Non linear, and switching elements in polymer materials.	Possibilities for all optical switching.
R1027 HDWDM/CMC	Active and passive devices for high density wavelength division multiplex transmitter receiver modules. Lasers suitable for CMC applications.	Implementation of CAC systems and optiimisation of components, providing high bandwidth services at low cost.
R1029 SUSBST	High quality, large area substrates in indium phosphide material.	Higher yield for active components and integrated optical circuits.
R1030 ACCESS	Short term solutions to direct detection CAC systems and architectures. Demonstration of system and components. Report on possibilities for sub-carrier multi-plexing.	Development of techniques making possible early implementation of fibre to the home and business subscriber. Potential low cost components, systems and subsystems.
R1031 LOW COST ACTIVE COMPONENTS	Low cost lasers detectors and transceiver modules. Automation and packaging solutions.	The prospective supply of low cost active components for direct detection systems for use in CAC/CPN systems.
R1033 OSCAR	Switching elements and matrics in III/V materials. Switch architectures & systems applications.	Establishment of integrable switch elements and maximum useful exploitation of optical regime.
R1036 WTDM CPN	Demonstrator for a CPN concept suitable for broadband service providers and for a range of other corporate applications, requiring very high bitrates (2.5 Gbit/s)	The availability of very high-bit-rate technology for video transmission based on WTDM techniques suitable for special BCPN's

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Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
R1043 RACE Mobile	Defining an evolutionary path from current systems towards U.M.T.S.	Specification of Mobile broadband air interface and IBC-services to mobile terminals.
R1051 HIGH BITRATE	Prototype demonstrations for CAC systems operating at bit rates up to 10Gbit/s.	Demonstration of the potential for distribution and contribution of HDTV signals.
R1057 AQUA	Advanced multiquantum well laser technology aimed at the requirements of high bit rate systems.	Well controlled reliable systems operating in the Giga bit regime.
R1064 MIOCA	Basic building blocks for complex integrated optoelectronic circuits. Demonstration of compatible combinations of receivers, transmitters switches, wavelength multiplexers, etc.	Ultimately replacing discrete components lower cost, increased reliability and superior technical performance.
R1069 EPLOT	Advanced multi-quantum well lasers for coherent systems.	Narrow line-widths and better control of centre wavelenghts leading to more reliable and stable CMC systems.
R1089 PASSIVE COMPONENTS	Prototype connectors, automated connector assembly, cable jointing techniques.	Low cost precision connectors for single mode fibres, cable end preparation methods, multifibre jointing procedures.
2.2 Telecommunications software for complex integrated systems		
R1003 Guideline	NM related Database, TMN Architecture.	Framework for development of TMN systems. Contribution to AIP standards.
R1005 NEMESYS	AIP Prototypes for Traffic Management.	Selectiont and application of AIP techniques for supporting quality of service Management in a multiservice network. (e.g. Real time expert systems).
R1006 AIM	Generic Maintenance System (GMS) Prototype using AIP Techniques.	Support to the Maintenance of multivendor IBC systems.
R1009 ADVANCE	AIP Prototypes for Network and Customer Administration Systems (NCAS).	Selection and application of AIP techniques in network and customer administration. (KBS, DDBS, MMI).
R1017 IOLE	Model for an on-line environment (Operating Systems and Processor Architecture).	Efficient physical system architecture.
R1021 ARISE	Software tools environment for Telecommunications.	Rapid and cost effective software development.

Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
R1040 RIPE	Portofolio of verified security algorithms.	Cost efficient, secure services.
R1046 SPECS	Formal specifications for telecom systems.	Verifiable systems, faster development.
R1047 TIMI	Architectures and prototypes for secure systems and services.	Cost efficient, secure service.
R1068 ROSA	Model for an object based Telecommunication system architecture.	Concept for rapid introduction of new services meeting IBC open systems requirements.
2.3 Advance in ergonomy and cognitive facilities of IBC equipment		
R1034 Usability of Engineering Requirements for IBC	An overview of usability issues for IBC.	Contribution to definition of RACE requirements in the area of Usability Engineering.
R1038 MCPR	Concept, architecture and prototype for a multimedia, communication, processing and representation system for broadband applications.	Meeting the complexity requirement and importance of terminal functional specifications.
R1065 ISSUE	Report on main usability factors affecting acceptability and uptake of videocommunication and multimedia retrieval services, based on emulation and simulation experiments.	Design guidelines for services and systems with high usability.
R1066 IPSNI	Report on functional requirements for enabling visually and motor/speech handicapped people to use IBC terminals and services.	Incorporation of the requirments of persons with special needs
R1067 GUIDANCE	Report on experimentally verified concepts for human computer interaction in an environment of integrated dialogue and retrieval services.	Guidelines for the design of usable integrated IBC services.
R1088 TUDOR	- A sector analysis of handicapped and elderly people. Usability data for this sector. Tutorials for the RACE-community to increase the awareness of this sector.	Awareness of the user groups which make up the general population and how to deal with them in an appropriate way.

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Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
2.4 Realisation of evolutionary sub-systems, systems and networks		
R1001 DVTR.	Video coding algorithm and scanner assembly for 100 Mbit/s digital recorder.	Definition of Consumer digital video recording system parameters and implementing it
R1004 ELFPD	A4-size electro-luminescent flat panel display.	Flat-panel display for incorporation into integrated multi-service demonstrator.
R1007 ITIS	Multi-service IBC terminal demonstrator with flat panel display from R1004.	Functional design and architecture of integrated terminals.
R1011 B-CPN	B-CPN demonstrator, validating a concept which can act as a framework for business requirements across a range of applications and sizes.	Demonstration of the possibility of a gradual evolution, at reasonable costs, from currently available solutions in the customer premises to the future IBC.
R1012 BLNT	Technology for medium term direct detection CAC systems. Specifications for switches. Demonstration system.	Implementation of advanced CAC systems techniques with broadband switching based on ATM.
R1013 GBb/s Swh. HDTV	A 1 Gb/s switching element.	Economical provision of HDTV to the user.
R1015 D-CPN	D-CPN demonstrator, validating a concept which supports services and applications offered by pre-existing systems (e.g. EUREKA IHS) as well as new advanced services like switched high quality sound and video, using low cost technology.	Impact on the definition of services and on technical/technological developments intended to facilitate the introduction of IBC in the domestic environment.
R1022 Tech. ATD	Spec. of pure asynchronous (ATM) network elements and a demonstrator.	Generic components for asynchronous transfermodes (ATM) and proposals for standardisation.
R1052 SPOT	Demonstration of advanced concepts for optical and cordless end-to-end communication at low cost.	Provision of techniques enabling low cost solutions for cordless and fibre transmission links in CPNs.
R1081 BUNI	Demonstrator integrating a customer access network (including local exchange), CPNs, multi-service-terminals and providing a connection to the BIPED demonstrator.	Contribution to the adoption of an agreed T-interface specification in Europe and verification of IBC system design concepts.

Review Summary Table:Projects Contribution to RACE Objective

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Project	Main Deliverable(s)	Impact
3. Prenormative Functional Integration		
3.1 Verification tools		
R1072 "ITACA"	Protocol Conformance test specification and automation.	Protocol specification and testing methodologies.
R1082 "QOSMIC"	Quality of service Verification methods and tools.	Requirements for Telecomm. Management Network Tech, and quality of service.
R1084 "MIME"	Emulators/Simulators of CPN's, Satellite, ATM networks.	Provision of simulated IBC network elements for testing and verification tools.
R1087 "PROVE"	Overall maintenance and testing concept for IBC, testing tools for IBC Network.	Contributions to an efficient IBC test bed and pilot schemes.
R1056 BIPED	Business IBC demonstrator integrating a customer access network (including local exchange), a B-CPN, and multi-service-terminals.	Verification of system end-to-end performance in an evolutionary hybrid (ATM/STM) network environment.
R1083 "PARASOL"	Asynchronous Transfer Mode (ATM) traffic generator and analyser.	Tool support for ATM verification and testing of the IBC network.
3.2 Development of IBC application pilot schemes		
R1039 DIMUN Distribution manufacturing using public networks	Demonstration of the improvement of a distributed manufacturing process using existing and developing networks, by the integration of the design-manufacturing and sales process, including customers and technical support.	Acceleration of the development of telecommunications services for manufacturing applications. Other pilots in different industries are started, based on the DIMUN philosophy.
R1042 MULTIMED	Definition and development of a prototype multimedia environment in the health-care sector based on the ISDN Primary Rate.	Improvement of the accessibility of multimedia health-care information for professional not- IT-trained users.
R1054 APPSN	Pilot project for delivering videocommunication services to elderly, visually, auditory and motor disabled user groups, eg alarm services, lipreading and signlanguage for the deaf and instruction and reading services for the blind.	Understanding of how IBC services can help in delivering care to elderly or handicapped people.

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Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
R1055 MERCHANT Electronic Retail Cash Handling	Reports on the impact of IBC on ERP (Electronic Retail Payment) services, specification and validation of test beds.	Better knowledge of ERP services in order to contribute to the progress towards an advanced pan-European ERP system.
R1058 RESAM Remote Expert Support for Aircraft Maintenance	Identification of the user requirements, definition of the information system, evaluation of the usability of the system.	Improvement of the efficiency of the aircraft maintenance through the use of a broadband communication network.
R1059 DIVIDEND Dealer Interactive Video	Specification of requirements on interactive video services within the financial dealing sector (videophone in particular).	Demonstration of the benefits of broadband communications in financial dealing sector.
R1060 DIDAMES	Demonstration of the application of local and wide area broadband communications within a distributed industrial design and manufacturing system for electronic subassemblies.	Understanding the limitation of the existing wide area networks and the networking capabilities of the telecommunication systems of several member states. Experience with integration of voice and video-based teleconference systems to support distributed CAD-CAM processes.
R1061 DIMPE	Pilot of Distributed Multimedia Publishing Environment; at first between two major publishing sites.	Understanding of user requirements, review of relevant technology, design and implementation of interim services and standardisation.
R1062 MARINE ABC	Demonstration of IBC application in the maritime industry: non-routine maintenance and repair with assistance of shore-based expertise.	Reduction of damage due to accidents and disasters at sea.
R1063 Mobile Application Pilot Schemes	Establishment of four application pilot schemes for mobiles.	Demonstration of potential use of mobiles as well as its limitations in certain important applications.
R1070 Testing pay-per view	Pilots for pay-per view television in three separate existing CATV networks.	Requirements for the man-machine interface, development of specialised software for traffic modelling and evaluation tools, strategy for the transition to IBC.
R1073 GEOTEL	Application Pilot of library service for the petroleum and chemicals industry throughout Europe.	Understanding of user requirements and database software requirement for such services.
R1074 ECHO Electronic Case Handling	Installation of an electronic case handling system based on the IBC within insurance companies.	Increase of effectiveness of personnel by the use of distributed workstations and servers.

Review Summary Table:Projects Contribution to RACE Objective

Project	Main Deliverable(s)	Impact
R1075 TELEPUBLISHING	Pilots on: 1) Individualised electronical newspaper, 2) Designing, printing and publishing of catalogues and 3) Design, layout and publishing of schoolbooks.	Understanding of the functional requirements, development of advanced software, standardisation.
R1078 European Museums Network	Pilot on the "associated" networked retrieval and display of images of visual and rendition of sonic artefacts owned by a large number of European Musea.	Identification of requirements for workstations and man-machine interface.
R1079 CAR-CAD/CAM for the automotive industry in RACE	Identification of new opportunities given to the automotive industry in Europe by the use of the IBC in the domain of the CAD/CAM application.	Effective exploitation of a broadband distributed CAD/CAM system involving different European car manufacturers.
R1080 HDTV Experimental Usage	A complete chain of HDTV production and transmission equipment according to the European standard for evaluation by TV professionals from every member state.	Provision of operational experience in HDTV production as the foundation for new video services.
R1086 TELEMED	Demonstration of the potential of the IBC for medical record transmission, management and control.	Stimulation of the development of medical applications based on IBC and identification of the related requirements.

IV. Programme Management Audit / Executive Summary[1]

A. The Audit Procedure

It is important in any research and technology development programme that there is regular and effective evaluation.

The Council Decisions covering the Framework Programme and the specific actions under it (including RACE, DRIVE, DELTA and AIM, for which DG XIII/F is responsible) imply a systematic evaluation/review of the performance with respect to strategic and policy objectives, precise technical objectives and programme management.

To address the first two aspects, DG XIII/F organises Strategic and Technical Audits on a regular, yearly basis. The **Management Audit** that is the subject of this report **covers the third aspect; it needs to be done only once in the lifetime of each programme**, before the Mid-Term Review, and at a time when most projects are still in their early stages, so that results can be fed back into the operation.

Because of the uniform management approach of DG XIII/F it was possible to hold **one common Management Audit addressing all four programmes**. The Audit was performed in the period June-September 1989 by a **team of independent experts**, chosen for their direct experience in the essential programme management operations. It addressed the whole "life-cycle" from workplan preparation through to contract execution.

A set of questions was sent to all project partners and to a selection of representatives of rejected proposals; this written enquiry was supplemented by interviews with project managers and Commission project officers.

B. The Management Audit Team

Mr. A. Vyverman, ASCENT Consultancy (chairman)
Prof. C. Salema, JNICT (vice-chairman)
Mr. W. Collin, NCC
Prof. L. Donato, CNR
Prof. J.-L. Funck-Brentano, Hopital Necker
Mr. H. Giertz, Ericsson
Mr. J.J. Jimenez Lidon, Telefonica
Mr. A. Lauer, CETUR
Prof. W. Lenz, BAST
Mr. C. Ouannes, Min. Rech. et Technologie[2)]

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1) For full details please refer to the Programme Management Audit

2) Participated until 1 September 1989, and withdrew from Audit Team after that date, for personal reasons

C. Results of Programme Management Audit

As a general conclusion, the Audit Team considers the management approach that DG XIII/F applies to RACE, DRIVE, DELTA and AIM to be both original and appropriate; it is highly successful in accomplishing the specific and general objectives set for the programmes; in several aspects it distinguishes itself favourably from what - in the experience of the Auditors - is normally found in comparable programmes and initiatives.

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The overall impression is unequivocally good, even very good. Any remaining difficulties are of a minor nature. The Commission, in particular DG XIII/F, should definitely continue in its application of this approach, taking care to make the necessary improvements and adaptations as the programmes evolve.

In pronouncing itself on the general appropriateness of the management approach the Audit Team has taken into account not only the precise objectives of each programme, but also - and even mainly - the wider objectives of the Community Framework Programme and of the Communities as a whole, of which these objectives are a part.

The first conclusion was that **the main elements of this approach**:
- workplan preparation in close cooperation with sector actors
- importance given to system engineering aspects
- consensus making through information exchange

are on the whole well-adapted to the typical objectives and general situation of the programmes, and that any improvements to be made are of a minor nature.

The system engineering part is considered of prime importance to the extent that without it the whole action of the Community through these programmes would be severely restricted in its effectiveness.

As regards promoting awareness of the programmes with potential proposers, the physical and logistic effort spent by each of the Central Offices is at the limit of what can be done with current staffing levels.

Available data show that a wide and balanced participation in the programmes has been obtained. However, while this goal is certainly very important, the Audit Team is of the opinion that quality of participation should have precedence after all. The way the programmes are prepared and the way the technical evaluation is handled satisfy this requirement.

On the basis of the information available to it, the Audit Team notes that **the programmes are on the whole well-structured and well-managed.** Consequently, its **general recommendation is for DG XIII/F to continue to apply this approach to the management of RACE, DELTA, DRIVE, AIM** and any future programmes of similar nature.

At the same time, the Team has pointed out a number of detailed issues where improvements can be made, that will enable the programmes as a whole to perform even better in reaching their objectives.

These detailed issues include in particular[3]:

- efforts to promote and explain the programmes well-ahead of Calls for Proposals;
- reaffirmation of the evaluation procedures, so as to avoid misunderstandings and disappointment;
- payment of the advance on contract signature;
- cost-effectiveness of Concertation Meetings;
- functioning of the system engineering and consensus formation projects;
- optimum size of consortia
- efforts to disseminate information

On the other hand, it was noted that:

- the preparation of the workplan is successful in achieving a workplan which reflects the priorities of the sector
- the negotiation process was on the whole seen as satisfactory
- there are no major problems with monthly control reports and Technical Audit
- the role of the Project Officer is judged to be well-performed

Programme Management Audit: Main recommendations for improvement

The general recommendation is for DG XIII/F to continue to apply its approach to the management of RACE, DELTA, DRIVE, AIM and any future programmes of similar nature.

The efforts of the Central Offices to inform potential proposers and to promote awareness of the programmes are generally appreciated. There are indications of a positive correlation between proposal acceptance and awareness of the programme during the preparation stage. This suggests that especially in the earlier years of a programme, when the circle of those who are directly involved is necessarily small, more should be done to promote and explain the programme well-ahead of a Call for Proposals.

It is necessary to reaffirm the procedure for evaluations, so as to avoid any possibilities for misunderstanding and disappointment: the procedure as currently practiced should be rigorously maintained, and potential proposers should be made more aware of it.

The procedure of having advance payments is considered a good principle. However, in practice payment delays are a source of problems; the Commission is urged to take the necessary steps to correct this situation. In case the delay remains important the partners' additional cost of financing should be allowable under the contract.

The Concertation Meetings are a very good forum for information exchange and to promote contacts, and their function is an essential element in the execution of the programmes. Because the Concertation Meetings are very expensive (travel costs and time spent away from work), one should do everything to make them more attractive and more interesting. Better prepared Concertation Meetings could be organised less frequently.

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3) A summary of the main recommendations is given below

The concept of having special projects to take care of system engineering and consensus formation (as concretised in RACE and DRIVE already) is vital. However, the experience gained so far in RACE is that these projects do not perform optimally.

The topic of Information Dissemination is still addressed insufficiently.

One should be careful not to create projects with more partners than are needed to provide the resources required. In general 5 to 6 partners is the practical limit, except for pre-normative and coordination-type projects.

V. Summary description of the RACE Programme[1]

Development of new and innovative services is essential to the successful introduction of advanced communications in Europe in the 1990s. The rapid growth of telecommunication-based services already shows that there is an enormous unsatisfied demand and indicates that by the year 2000, value-added services may account for a substantial proportion of revenues from telecommunications use.

The advanced techniques and technologies being developed in the RACE programme will allow a new generation of cost-effective innovative services to be introduced as well as improving the quality and economics of traditional services. They therefore constitute an essential element in the development of a Community-wide market in telecommunications services and equipment as proposed in the Green Paper on telecommunications. These advanced techniques and technologies will enable much greater emphasis to be given to visual communications, bringing the capabilities of telecommunications more into line with basic human needs. They will also be able to satisfy the huge growth in demand for fast data communications between computers.

It is essential that new Integrated Broadband Communications (IBC) systems are developed and designed with the use of innovative services as a key focus. Meeting present needs more economically and responding to the need of users for new services are paramount objectives. The RACE Programme therefore includes a significant provision for the investigation of future usage through real IBC application pilots.

The RACE Programme has been implemented in two phases. The first phase started in January 1988 and addresses system engineering (Part I) and technological work (Part II)[2]. The second phase, which addresses the investigation of future services, system integration and verification (Part III), has been initiated with a Call for Proposals in July 1988. These projects started work in January 1989.

For the implementation of Part III and some complementary work in Parts I and II, a total of 83 proposals were received. A substantial number concern major applications of broadband communications in entertainment (TV and HDTV), manufacturing industry, banking, insurance, publishing, health care and for people with special needs. These applications will need a Europe-wide infrastructure, and a proposal to provide a preliminary broadband network on an experimental basis (EBIT) has also been submitted by the major European Telecommunications administrations. The success of the second call for proposals for RACE opens the way for vigorous development in Europe of both advanced services and infrastructures for Integrated Broadband Communications. The contracts now negotiated will be an essential complement to the technology and system engineering activities already underway in RACE. The synergy between these interrelated activities will further strengthen the RACE initiative.

With this, the scope of the work laid down under the Decision for RACE is largely covered. There are now limited resources for taking up additional work.

In addition to almost all telecommunications operators and the telematics industry, leading-edge users in most major application sectors are now directly involved in RACE in the development of innovative services. A unique environment has been created for concertation of efforts on advanced telecommunication services.

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1) For further information please consult the Report "RACE 89"

2) This was subject of the report COM(88) 240 final II "Working towards Telecom 2000 - Launching the Programme RACE -"

A. Review of the objectives

The objective of RACE IBC has been critically reviewed in a world-wide context as part of the IBC Strategic Audit[3]. The results were presented to the European Parliament in February 1989. It has confirmed the importance of the work for Europe and the usefulness of the collaborative work engaged in the framework of RACE.

B. Review of the performance of the projects

The quality of the work of the first phase has already been subject to an external Technical Audit by a group of 33 internationally recognised experts. The Audit has confirmed that the work taken up in January 1988 is progressing satisfactorily[4].

The commitment of Industrial Users, Telematics Industry and Telecommunication Operators to the collaboration in the framework of RACE supports the view that a reinforcement of the efforts may usefully be considered. The prospects for realisation of Integrated Broadband Communications in Europe, with all the economic and social advantages that it will bring, have considerably improved.

C. Structure and timing

In order to achieve the objectives described, the RACE programme is structured into the three main parts shown in Figure 3.1.1, with each project containing verifiable objectives to be met and reported on:

Part I : IBC DEVELOPMENT AND IMPLEMENTATION STRATEGIES

Relating to the development of functional specifications, the systems and operations research towards the definition of proposals for IBC standards, concepts and conventions conforming to an open systems approach, and the analytical work serving the objective of establishing interoperability for IBC equipment and services;

Part II: IBC TECHNOLOGIES

Covering the technological co-operation in precompetitive R&D addressing key requirements of new technology for the low-cost realisation of IBC equipment and services;

Part III: PRENORMATIVE FUNCTIONAL INTEGRATION

Relating to prenormative co-operation in the realisation of an "open verification environment" designed to assess functions, operational concepts and experimental equipment and applications with respect to functional specifications and standardisation proposals arising from the work in Part I.

The corresponding work areas, tasks and approaches are specified further in the Annex II to the Common Position and in detail in the RACE Workplan OTR 200.

1. Timing of RACE Work

As part of the 1987 Evaluation, an "ad-hoc" Panel was set up to identify the priorities in time and to define an overall Milestone Plan. In order to generate a coherent programme for RACE, the retained projects had to be capable of meeting the strategic objectives set out by an "ad-hoc" Panel in the Evaluation Report (OTR-111). These are illustrated by Figure 3.1.2 reproduced from that Report.

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3) The IBC Strategic Audit was undertaken by senior personalities of the telecommunications sector.

4) RACE Technical Audit Report 1988 OTR 205, October 1988

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In the shorter term, one important strategic milestone is the definition of the IBC system and network architecture, scheduled for 1990/91, and projects addressing the shorter term must be matched against this milestone.

It is clear that all the pre-competitive, pre-normative work must be completed within the present RACE 5-year programme, partly to enable development (outside RACE) to proceed but also to track the Japanese INS programme.

2. Milestone Plan for the RACE Programme

The main elements of the Strategic Milestone Plan of RACE are set out in Figure 3.1.3, which shows a high-level interactivity diagram for Part I.

Four major internal milestones are proposed:

a) Initial Assumptions

The first milestone, achieved in mid-1988, is the dissemination within RACE of initial assumptions regarding the IBC and its environment. It comprises the outcome of four activities, viz:

- Studies relating to system requirements;
- Studies of National Networks;
- Studies relating to probable IBC network and system shapes;
- Studies relating to IBC Usage.

These assumptions embrace the basic parameters used by design engineers in dimensioning a system and in choosing among options. For instance, it is probable that ATM techniques will be used for future conversational broadband services and this assumption has a significant impact upon the design of the main and customers premises networks. The number of users, their disposition, their calling rates, the distribution of generated traffic, etc., all contribute to traffic models that help determine partitioning strategies and replication philosophies.

A number of such assumptions were generated during the RACE Definition Phase, in part based upon the 'Satania' model, and will be examined for continuing relevance.

It is also necessary to carry out preliminary studies concerning the eventual output of RACE, its form and content.

b) IBC Decisions

By mid-1989 a clear understanding will be needed about the Mark 1 IBC network and system, covering such issues as transfer mode, introduction strategy and evolution strategy. This understanding will need to be illuminated by major in-feeds from Part II and from Usage, and will set the scene for the architecture debates during 1989 and 1990.

These decisions must be binding for the initial phase of RACE, and a major set of design decisions relate to the 'freezing' of options. Normally, design options are layered and design freezes affect one layer for a given period of time. The high-layer decisions affect many aspects of the design and must be enduring. Lower-layer decisions can be frozen later and for a shorter period, whilst some decisions need never be frozen individually at system-design time, but can be incorporated into the system-build-level parameters.

c) Initial Architecture Proposals;

These are required by mid-1990, by which time a very clear picture of the Mark 1 IBC should be available. These proposals will need to be examined for validity in all Community countries before the architectures are accepted early in 1991.

It is likely that IBC will be introduced as a thin overlay into certain advantageous regions characterised by high densities of white-collar workers and high-technology industries, plus a significant residential community of relative affluence. RACE depends upon the mass residential market to achieve production levels of key optoelectronic components and upon high-technology business users for small-scale high-value service trials. Different regions will impose different needs and probably different system mixes, and a variety of operational environments are needed to test the product.

In addition, it is necessary to test our ability to service and maintain systems, to train staff, to operate networks, to interact with customers and market new services.

d) Agreed Architectures

These will form the basis of the formal deliverables from Part 1 at the end of 1991, the proposed CFSs and proposed Common Practices.

3. Intermediate Outputs from RACE

PTOs and all associated Industries will need periodic in-feeds from RACE relating to basic architectures. A one-year cycle is defined, aiming at progressive refinement, clarification, and endorsement of assumptions and hypothesis. These outputs are omitted from the diagram of Figure for the sake of clarity, but their source is evident.

4. Interactions Between Part I and Part II and Part III

Figure 3.1.3 shows a major interchange from Part I to Part II in 1990, concerning the technology implications of the proposed architectures, so that technology experts can help validate the architectures. By contributing to the system definition and by knowing the implications of that definition, technologists will become intimately associated with the system design and hence committed to provide the requisite technology on time.

The diagram also shows short-term ad-hoc technology studies taking place in 1990/91 to resolve system issues, again bringing the technology studies into the system definition process. Information derived from analyses of applications case studies and application pilots will provide clarification in this time frame.

5. Implications for Part II projects

The technology work in RACE is intended to be selective, using Community funding to improve the cost/performance of key areas of telecommunications. The optical technology studies aim to improve the cost/performance of optical networks, the codec studies aim to improve the cost-performance of transmission, and network management studies aim at cost/performance improvements at the network level. The work on domestic terminals aims at increasing the user base, as do the usage studies and trials, so improving cost/performance at the total system/network level.

All the technology projects for which Contracts have been negotiated have been justified against this global target.

As indicated in the RACE Workplan OTR-200, RACE addresses both medium and long term strategies. It is clear that some projects, such as those on optical switching, will not come to fruition during the next five years. The potential rewards in such areas are very significant, however, and such studies will significantly affect the later development of the IBC. They are thus justified on longer-term grounds. The participation of the optical communication experts in the mid-89 debates will ensure that the IBC system and network architectures will accommodate evolution to the Integrated Optical Network.

6. Matching the Milestone Plan with Resources Available

The general problem is to match the pattern of available resources to the tactical requirements of the RACE programme.
Almost all Projects have to deliver a major contribution to the IBC definition by mid-89, which has put a premium on experience with similar initiatives. This has required a rapid start-up for all Projects in 1988, which has been achieved. Similar requirements have been placed on those Projects starting in 1989.

The essential pre-normative work for IBCN has to be completed by the end of the RACE programme. This necessitates a major system definition activity during the next 3 years, with major decisions being taken within the first 2 years. On this basis, the bulk of Part II projects will run initially for 2-3 years, with the objective and scope of all projects being reviewed in depth after 3 years.

7. Scenario for an Appropriately Balanced Implementation of RACE

In the light of this reasoning and with the requirements and constraints set out in the preceding Sections the "balanced implementation" for the case of RACE has been as follows:

a) 1st Call

Retention and contracting of projects for 230 MECU extending over the first three years. The "implied engagement" under these conditions is of the order of 348 MECU taking into account the fourth and fifth years of the Programme.

b) 2nd Call for 1989 Onwards

This call covered those areas not dealt with by work taken up under the first call as well as the replacement for attrition, i.e. 170 MECU plus amounts freed by attrition of other projects.

The possibility of Restricted Calls is foreseen, in between the General Calls in the Official Journal, addressing urgent adjustments as resulting from the yearly Programme Reviews.

D. Programme Management

1. Introduction

The character of the RACE Programme as a strategic action with a technical objective, as described in Section 2, puts particular requirements on its management. The management of RACE has been divided into the following aspects.

- Project Management is the responsibility of the prime contractor of each RACE Project. The project manager has to ensure that the project fulfills its objectives within the agreed budget and time frame.

- Programme Management is the responsibility of the European Commission, Directorate XIII/F, RACE Central Office (RCO). Its primary purpose is to ensure that the programme remains on target with regard to the overall objectives and that the funds are spent in the interest of the Community It is responsible for the interactions with the RACE Management Committee and other official bodies. For this purpose it uses the programme management tools described below.

- Consensus Management is the responsibility of RACE Project R1045. It ensures that the strategic results from RACE have undergone a consensus and consultation process. It is responsible for the preparation of Common Functional Specifications and Common Practices and for the consolidation of the RACE submissions to standardisation bodies.

2. Concertation Mechanism

All RACE projects are considered to contribute to the objective of RACE, i.e. the "introduction of IBC by 1995". Therefore, close collaboration among practically all projects is a prerequisite for success. The Concertation Mechanism provides the framework for such collaboration.

a) Concertation Meetings

A major constituent part of the Concertation Mechanism is the series of Concertation Meetings which take place at about six weekly intervals and are attended by all RACE projects. The projects are represented by their project manager and one or two key researchers. The meetings last normally two days and are split into plenary and group sessions of variable geometry. Projects report on their findings, and special themes are selected for each meeting in order to maximize synergy.

b) Specific Concertation Working Groups

In areas where cooperation between projects seems to be necessary on a bilateral or multilateral basis, working groups have been formed for this purpose, stimulated by the Commission or on the initiative of the projects themselves.
To date groups have been formed on the following specific aspects:

- The ATM Requirements Group (ARG)
- Interfaces at S and T
- Programme Infrastructure Coordination Board (SICB)
- RACE Integrity Circle
- Application Pilots Transfer Group (APT)

ARG was founded by three major systems projects R1014 ATMOSPHERIC, R1012 BLNT and R1022 Technology for ATD. The aim of this group is to discuss issues concerning ATM, to find consensus on ATM parameters and to contribute to the international standardisation bodies. Other projects, such as those from the Customer Premises Network domain, have been invited as appropriate.

The working group on the User Network Interface has been established between the projects R1035 CPN Part I and R1044/WP2.10 UNI, concerned with the specification of the Terminal/CPN interface and the user Network Interface respectively. This working group seeks to harmonise the parameters of the Terminal/CPN interface with those of the User Network Interface. This working group also accepts input from the ARG on ATM parameters.

The SICB was set up in 1987 in order to closely coordinate the projects involved in programming. It was judged necessary eary on to avoid excessive duplication of effort. The board consists of projects R1017 - IOLE, R1021 - ARISE, R1046 - SPECS and, more recently, R1068 - ROSA. An agreement among the projects ensures that common requirements are specified and deliverables are exchanged.

The RACE Integrity Circle is in the process of being set up. It will assemble the three RACE Projects concerned with Integrity, namely R1025 - Functional Specifications of Security and Privacy in IBC, R1047 - TIMI and R104 - RIPE.

The APT group provides, on the one hand, a mechanism for information flows to and from the Application Pilotd, and on the other hand a forum for the discussion of issues of common interest among them. These issues include infrastructure, results capture and consolidation, common experience and relationships with non-RACE projects having similar concerns.

3. Programme Management Tools

Described below are some of the tools used by the RACE Central Office (RCO), which are particular to the RACE programme.

a) Deliverables Management

Deliverables from RACE projects are "stepping stones" in the achievement of the RACE objective. Deliverables are therefore to be used as inputs to other projects (obviously observing the contractual provisions for confidentiality). A data base recording the planned inter-project flow of deliverables is maintained and published by the RCO.

b) Yearly Cycle and Technical Audit

RACE projects follow a synchronized yearly cycle. By October each year, a report is produced by all projects, including a self-assessment of the work performed so far in the year, a detailed plan for the following year and proposals for a revision of the overall project plan. This report is subjected to a Technical Audit, in which all projects are reviewed together in the presence of all auditors. The Audit reports serve as a basis for the RCO's negotiations concerning the detailed plan for the following year and any other adjustment to be made. The detailed plan for the following year is then appended to the existing contract as an addendum.

c) Red Flag Procedure

Difficulties encountered by projects, which cannot be resolved from within the project itself, are communicated to the RCO as part of the monthly report under the "red flag" procedure. The Commission takes then the necessary steps to resolve the problem and lowers the flag. The RCO can also invoke the red flag procedure when any part of the programme appears to be failing to honour its commitments. Red Flags are normally brought to the attention of the RACE Management Committee. In this case, as foreseen in the contract, the project concerned may be subject to detailed technical and/or financial audit.

E. Analytical Tools

Following a Workshop on Analytical Tools held in June 1988, different actions have been taken to provide efficient support to the various RACE Projects in their work on the Techno-Economic and Strategic assessment of IBC Development.
Two classes of tools have been presented and demonstrated:

- Techno-Economic-oriented Tools (T.E.T.).

- Network-planning-oriented tools;

1. STEM

STEM is the first T.E.T. It has been retained under a contract for 2 years with ANALYSYS Ltd. under the following specific conditions:

- up to 16 Licenses (installations of STEM software at RACE Project contractor site);

- up to 33 users to be trained in using STEM;

- first-year support to each RACE Project (Hotline support, documentation, maintenance, consultancy support in the building of models, development of scenarios, interpretation of results);

- STEM RACE Support (Workshop, Seminars, STEM Newsletters, Research Briefing, Confidential Monthly and Annual Reports for the RCO on STEM Applications & Results, Annual Reports for the RACE Community on STEM Application & Results).

2. Other Tools

Negotiations started in 1988 with BIBA Bremen to update and provide two T.E.Ts complementary to STEM, and with REFER Ltd to provide the STAX standards database to the RACE Community.

Two other computer tools are also used by the RCO to support the Programme Management activities:

- TRACK, a keyword-based description of all RACE projects, which enables information about them to be found rapidly, and:

- DELPHI, the database used for management of the Deliverables.

3. Further Actions

Beside the seminars and workshops which provide the opportunitity for exchanging common experience and data resources (input/output data from the runs of those tools) among participants from the RACE Community, additional efforts should be focussed on the following:

- exhaustive acceptance tests and systematic programming linkage between BIBA's Tools and the STEM Tool, in order to facilitate the use of these tools once they have been developed, tested and accepted (in July-September 89);

- creation of a Reference Models Database (or a Common Tool Set) of relevance to the individual modelling objectives, including at least the following items:

  - a 'Typical European Country' for reference evolution;

  - summaries of the 12 countries of the EEC;

  - particular network situations (e.g. local loops), and particular geography (e.g. Rural, Urban, etc.);

- getting the benefit from the STEM workshop and Seminars over time. Certain projects' Deliverables related to the use of the T.E.T. could be self-assessed on that occasion, and each RACE Project officer could take these opportunities to "pre-audit" his project(s) as soon as possible; some material should also be collected to help in the preparation of the RACE Summer School and of the "RACE 30 Months Evaluation";

- organising regular live demonstrations of the presented tools other than STEM and BIBA Tools, in order to enable the capabilities, the power and the special features of each of those tools to be examined in detail.

A Compendium of Analytical Tools was distributed to RACE Projects during the RACE Concertation Meeting in December 1988. Further requests for the use of other tools will be communicated to the RCO. Accordingly, possible additional work of selecting or negotiating with the owners of the Tools concerned should be foreseen.

VI. Glossary

Ad-hoc integration	The possibility of combining services at will when needed
Applications	Use of the telecommunications network and value-added services
AT&T	Americal Telephone and Telegraph Corporation
ATD	Asynchronous Time Division switching, a multiplexing technique
ATM	Asynchronous Transfer Mode
BB-ISDN	Broad-band ISDN, an evolutionary stage between ISDN and IBC
Bandwidth	The frequency spectrum occupied by a signal
Bandwidth Compression	Technique to reduce the requirements for transmission capacity
Bit-rate	Number of bits (units of information) transmitted per second
Broad-band	Having a bit-rate of more than 2 Mbit/s
Broadcasting	Emission of messages addressed to all suitable receivers
CCITT	International Telephone and Telegraph Consultative Committee (U.N. Agency)
CEN/CENELEC	European Industrial Standardisation Organisations
CEPT	European Conference of Post and Telecommunication Administrations
COM(83) 573	Lines of Action of the Community Telecommunication Policy
COM(84) 277	Progress report on the implementation of the Telecommunication Policy
COM(85) 113	Proposal for the RACE Definition Phase
COM(85) 145	Communication giving the background and Rationale for RACE
COM(85) 230	Arrangements for mutual recognition of type approvals
COM(85) 276	Status of the Community Telecommunications Policy
COM(86) 325	European Communications Policy
CPN	Customer Premises Network, preferred term for SPN
Concertation Meeting	Consensus-building technique introduced in the RACE Definition Phase
Cryptography	Coding to ensure privacy
Customers	Corporate and private users
DBS	Broadcasting by Satellite suitable for direct reception with individual antennas
Dialogue	Two-way communication
Distribution	Forwarding messages to a defined set of receivers
EBIT	Experimental Broadband Infrastructure Trial
EBU	European Broadcasting Union
ECTEL	European Conference of Telecommunications and Electronics Industries
EFTA	European Free Trade Association
ESA	European Space Agency
ESPRIT	Community R & D Programme in Information Technology
ETSI	European Telecommunications Standards Institution
EUREKA	Industrial Cooperation scheme in high technology
Economies of Integration	Economic advantages arising from multiple use and higher utility
Economies of scale	Advantages arising from scale of production or service
Economies of scope	Advantages arising from commonality and synergy between diffrent products or services
Exchange	Switching centre performing interconnections and routing
Functional Integration	Combining different telecommunication functions
Functional Specification	Definition of what a device/system is designed to do, but not how to do it
GAP	Groupe Analyses et Prévisions (Sub-group of SOG-T)
GDP	Gross Domestic Product
GSLB	Group Spécial Large Bande (CEPT Group on broad-band telecommmunications)
Gateway	Device performing the functions required for the interconnection of networks
HDTV	High-definition TV (i.e. about twice the horisontal and vertical resolution of broadcast TV)
IBC	Integrated Broadband Communications
Integrity	Protection against damage or unauthorised access to information
ISDN	Integrated Services Digital Network
ISO	International Standards Organisation
Intelsat	International Telecommunications Satellite Authority

Interface	Means of interconnection of equipment, having defined characteristics
LAN	Local Area Network
Life-cycle Support	Maintenance of software products
Lines of Action	Presentation of a complex activity as a set of (relatively) independent components
Local Network	Set of telecommunication links within a limited area
MAC standards	Time-division-multiplex technique for TV/HDTV transmission
Man-machine interface	Arrangements for interaction between the user and the communication terminal
Messaging	One-way communication involving some storage or recording device
Modularisation	Construction of equipment from sub-assemblies having suitably-defined interfaces
Multiplexing	Reversible technique for combining signals for convenience in transmission
NSC	Network Service Centre
Narrow-band	Data transmission at less than 2 Mbit/s
Network Operators	PTTs and Private Operating Agencies
OECD	Organisation for Economic Cooperation and Development
OSI	Open Systems Interconnection (ISO interface specifications)
OTR 100	Initial Workplan for the RACE Main Programme
OTR 200	Revised Workplan for the RACE Main Programme
OTR 300	Draft Workplan for RACE Extension
Open Access	Availability of unrestricted access to a telecommunications service
Operational Integration	Integration of several telecomunications media to operate as an ensemble
Optical fibre	Enclosed medium (glass or plastics) for transmission at optical wavelengths
PET	Planning Exercise in Telecommunications technologies (forerunner of RACE)
PN	Permanent Nucleus created by CEPT for the RACE Definition Phase
Privacy	Means of ensuring confidentiality of information
Processing	Electronic manipulation of data or other signals
Protocol	Procedure required to establish, operate or discontinue a telecommunication connection
R,D&E	Research, development and Engineering
RDP	RACE Development Phase - Council decision 85/372/EEC of 25/7/85
RMC	RACE Management Committee, created by Council decision
Redundancy Reduction	Technique to reduce the required transmission capacity
Retrieval	Searching for and accessing information stored in a data bank
RIC	RACE Industrial Consortium
SME	Small or Medium-sized Entreprise
SOG-T	Senior Officials Group for Telecomunications
SPN	Subscriber Premises Network (former synonym for CPN)
STAR Proposal	Proposed programme to sponsor advanced telecoms investment (COM(85) 836)
Service provider	Organisation providing value-added services
Signalling	Transmission of service data to control communication operations
Standard	Officially-recognised specification
Subscriber	Former synonym for customer
Switch	Device controlling the interconnection of circuits
TDM	Time-division multiplex(ing): sequential transmission of separate signals
Technology enhancement	The possibility of enhancing utility by selective introduction of new technology
TMN	Telecommunications Management Network
Transport	The function of transmission in telecomunications
Trunk Network	Ensemble of main telecommunications arteries
Type Approval standards	Official recognition that equipment of a particular design complies with the relevant
Video	(Baseband signal corresponding to) moving images

VII. References

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Technical Report "RACE '89", *OTR 202 of March 1989*

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Report on the **State of Science and Technology in Europe** *ref.: COM(88) 647*

3rd Report of the European Parliament on **Europe's response to the challenge of modern technology**, M. Poniatowski, Chairman of CERT, May 1989

IBC Impact Assessment and Forecast, DG XIII/F, September 1989

Management Audit of the programmes RACE, DRIVE, DELTA and AIM *ref.: GE0180, September 89*

Briefing Package for the submission of proposals, *refs.: RPP136A, RIPMC95B, RIPGI15C of June 88.*

Deliverables Management, *ref.: OTR 288 July 89.*

Exploitation Plan *ref.: (in preparation, available Nov. 89)*

Agreement with ETSI *ref.: RMC 12.09.89*

VIII. Listing of Projects

Projects Ordered by PROJECT Number

1001 DVT - Digital Video Tape Recording Terminal for HDTV
1002 Satellite Communications for IBCN
1003 GUIDELINE - AIP and Standards for TMN
1004 EL Flat Panel Display for Terminal Applications
1005 NEMESYS - Traffic and QOS Management for IBCN
1006 AIM -AIP Application to IBCN Maintenance
1007 ITIS - IBC Terminal for Interactive Services
1008 Silicon-Based Low-Cost Passive Optical Components
1009 ADVANCE - Network and Customer Administration Systems for IBCN
1010 Subscriber Coherent Multichannel System
1011 Business CPN
1012 BLNT - Broadband Local Network Technology
1013 HDTV - Switching
1014 ATMOSPHERIC
1015 Domestic Customer Premises Network
1016 Test Tools and Equipment
1017 IOLE - IBC On-Line Environment
1018 HIVITS - High Quality Video-Telephone and (High Definition Television System
1019 Polymeric Optical Switching
1020 All-Optical Switching and Bistable Devices based on Semi-conducting Polymers
1021 ARISE - A Reusable Infrastructure for Software Engineering
1022 Technology for ATD
1023 BEST - A Methodological Approach to IBC System Requirements Specifications
1024 NETMAN - Functional Specifications for IBC Telecommunications Network Management
1025 Functional Specification of Security & Privacy in IBC
1026 International Transmission of Digital Television and Radio
1027 Integrated Optoelectronics towards the Coherent Multi-Channel IBCN
1028 REVOLVE - Regional Evolutional Planning for IBC
1029 Development of Improved InP Substrate Material for Opto-Electronic Device Production
1030 ACCESS - Advanced Customer Connections, an Evolutionary Systems Strategy
1031 Low-Cost Optoelectronic Components
1032 Development & Testing of Optical Components for Subscriber Networks
1033 OSCAR - Optical Switching systems, Components and Architecture Research
1034 Usability Engineering Requirement for IBC
1035 Customer Premises Network (CPN)
1036 WDTM Broadband Customer Premises Network
1037 User Criteria for the Realisation of Opportunities afforded by IBC
1038 Multimedia Communication, Processing and Representation
1039 DIMUN - Distributed International Manufacturing using Existing and Developing Public Networks
1040 RIPE - RACE Integrity Primitives Evaluation
1041 FUNCODE - Functional Specification of Codecs
1042 MULTI-MED
1043 Mobile Technology
1044 IBCN Development and Implementation Strategies
1045 IBCN Development and Implementation Strategies (Management)
1046 SPECS - Specification and Programming Environment for Communications Software
1047 Techniques and Integrity Mechanisms in IBCN

1048 RSVP - RACE Strategy for Verification and a Plan
1049 ATM Concept
1050 IBC App. Analysis
1051 Multi-Gigabits Transmission IBCN Subscriber Loop
1052 SPOT - Signal Processing for Optical and Cordless Transmission
1053 TERRACE - TMN Evolution of Reference Configurations for RACE
1054 Application Pilot for People with Special Needs
1055 MERCHANT - Methods in Electronic Retail Cash Handling using Advanced Network Technologies
1056 BIPED
1057 AQUA - Advanced Quantum Well Lasers for Multi Gigabit Transmission Systems
1058 RESAM - Remote Expert Support for Aircraft Maintenance
1059 DIVIDEND - Dealer Interactive Video
1060 DIDAMES - RPA (Distributed Industrial Design and Manufacturing of Electronic Subassemblies - RACE Pilot Application)
1061 DIMPE - Distributed Integrated Multimedia Publishing Environment
1062 MARIN-ABC - Marine Industry Applications of Broadband Communication
1063 RACE Mobile Applications Pilot Scheme
1064 Monolithic Integrated Optics for Customer Access Applications (MIOCA)
1065 ISSUE - IBCN Systems and Services Usability Engineering
1066 Integration of People with Special Needs by IBC
1067 Usability Design Information Support for the Integration of IBC Services
1068 RACE Open Services Architecture (ROSA)
1069 EPLOT - Enhanced Performance Lasers for Optical Transmitters
1070 Testing Pay-per-View in Europe
1071 T.458 - Applications Analysis
1072 ITACA - IBCN Testing Architecture for Conformance Assessment
1073 GEOTEL
1074 Electronic Case Handling in Offices
1075 Telepublishing
1076 REMUS - Reference Models for Usability Specifications
1077 Usage Reference Model for IBC
1078 European Museum Network
1079 CAR - CAD/CAM for Automotive Industry in RACE
1080 Promotion Plan for High-Definition Television
1081 BUNI Demonstrator
1082 QOSMIC - QOS verification Methodology and tools for Integrated Communications
1083 PARASOL - ATM Specific Measurement Equipment
1084 MIME - Development of Emulators and Simulators
1086 TELEMED
1087 PROVE -Provision of Verification
1088 TUDOR - Usability Issues for People with Special Needs
1089 LOOP - Low Cost Optical Components
1091 ESP - EBIT Service Project

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IX. Organizations involved in RACE Projects[1]

Belgique - Belgie - Belgium

ACEC S.A (1018, 1022, 1041)
ATEA (1044)
BARCO Industries N.V (1044)
Bell Telephone Manufacturing Co. N.V (1002, 1022*, 1044, 1045, 1046, 1083)
BETELCOM (1045)
DHL Worldwide Express (1063)
IMEC v.z.w., 1010, 1019, 1032, 1033, 1069)
Katholieke Universiteit Leuven (1066)
Kone, Belgium S.A. (1039)
MBLE N.V. (1022)
Philips S.A. (1022)
Refer BVBA (1076, 1087)
Régie des Télégraphes et des Téléphones (1022, 1044, 1045)
Rijksuniversiteit - Gent (1004)
Scitex Europe S.A. (1061)
SPAG Services S.A. (1048*, 1087)
SWIFT (1055)
Technical Centre of the EBU (1026*)
Telindus N.V. (1044)

Danmark - Denmark

Computer Resources International A/S (1009)
EMI Electromagnetics Institute (1014)
Elektronikcentralen (1016, 1087, 1084)
Fischer-Madsen & Lorenz Petersen Data Communications Consultants A/S (1005)
Copenhagen Telephone Cie (1091)
Jutland Telephone A/S (1022, 1044, 1072, 1081)
Kjobenhavns Telefon A/S (1005, 1022, 1044, 1083, 1053, 1058, 1082, 1084)
NKT - Nordiske Kable & Traadfabriker A/S (1014, 1030*, 1044, 1045, 1051, 1056)
Technical University of Denmark (1013, 1027)
Thrane and Thrane (1062)
SAS Denmark (1058*)
Teleteknisk Forskningslaboratorium (1046, 1068)
University of Aarhus (1040)

Deutschland - Federal Republic of Germany

AEG A.G. (1018, 1039, 1043)
AEG Forschungsinstitut (1041)
AEG Kabel A.G. (1030, 1044, 1056)
AEG Olympia A.G. (1063)
Andus (1060)
Anitra Medienprojekte (1070*)
ANT Nachrichtentechnik GmbH (1002, 1030, 1031, 1044, 1047, 1051)
Belser Wissenschaftlicher Dienst (1078)
BIBA - Bremer Institut für Betriebstechnik und Angewandte Arbeitswissenschaft an der Universität Bremen (1039*, 1062)

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1) Project numbers are given in brackets after each organisation title.

Broadcast Television Systems GmbH (1080)
Comtat (ZMF) T.A.Troge (1078)
Condatec Projekt Software GmbH (1075)
Cornelsen Verlag (1075)
Danet GmbH (1006)
DETECON - Deutsche Telepost Consulting GmbH (1075*, 1086, 1091*)
Deutsche Bundespost (1045, 1051)
Deutsche Thomson-Brandt GmbH (1001, 1018)
Deutsches Herzzentrum (1086)
Dornier System GmbH (1002)
Dr. Ing. Rudolf Hell GmbH (1061)
Empirica GmbH (1054)
Forschungsinstitut der Deutschen Bundespost beim Fernmeldetechnischen Zentralamt (1018, 1022, 1025*, 1032, 1041)
Fraunhofer Gesellschaft 3SM (1075)
Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V. (1078*)
Fraunhofer Institut Fuer Systemtechnik (1050, 1071, 1077)
FTZ (1044, 1048, 1053, 1087)
Gesellschaft Fuer Mathematik & Datenverarbeitung MbH (1068, 1072, 1075)
Grundig EMV (1001)
Heinrich Hertz Institut für Nachrichtentechnik, Berlin, GmbH (1010)
Institute of Shipping Economics and Logistics (1062)
Kabelmetal Electro GmbH (1032, 1044,)
Kulturbehörde der Freien und Hansestadt Hamburg (1078)
Lloyd Werft Bremerhaven GmbH (1062*)
Loewe Opta (1007*)
Nassauisches Heim (1054)
Nixdorf Computer A.G. (1060*)
NTE - Neu Tech, Neue Technologie Entwicklungs Gesellschaft MbH (1075)
Offset Repro Technik (O.R.T.) (1075)
Otto Versand (1075)
Philips Kommunikations Industrie A.G
(1015, 1018, 1022, 1035, 1041, 1043, 1044, 1046, 1083, 1058, 1074, 1078)
Philips Universität (1057)
PK Berlin - Projektgesellschaft für Kabelkommunikation GmbH (1078)
Robert Bosch GmbH (1044, 1054)
Siemens A.G. (1010, 1012, 1031, 1044, 1045, 1047, 1049, 1053, 1064*, 1069, 1081, 1083)
Standard Elektrik Lorenz A.G. (1003, 1006*, 1013*, 1015, 1016*, 1017*, 1022, 1031, 1032, 1033, 1034*, 1035, 1038*, 1044, 1045, 1051*, 1053, 1054*, 1057*, 1060, 1067*, 1077, 1086, 1083, 1081, 1087, 1088)
Sietec - Siemens-systemtechnik und Portfolio GmbH (1075)
Sloman Neptun Schiffahrts A.G. (1062)
Stollmann GmbH (1060)
Telenorma - Telefonbau und Normalzeit GmbH (1011, 1035, 1038, 1043, 1044, 1045, 1056)
Technische Universitaet Berlin (1075)
Teles GmbH (1060)
Universität Bremen (1062)
Universität Heidelberg (1086)
Universität Stuttgart (1022, 1057)
Universität Dortmund (1033)
Wandel & Goltermann GmbH & Co (1083)
ZMF (1078)

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Ellas - Greece

Alpha S.A.I (1016, (1084)
Elsyp S.A. (1075)
ELSYS S.A. Hellenic Information Systems (1091)
ESTTO S.A. (1061)
Foundation of Research & Technology (1005, 1066)
Hellenic Aerospace Industry (1044)
Hellenic Telecommunications Organisation S.A. - OTE (1028, 1043)
Intracom S.A. (1009, 1021, 1024, 1053, 1060, 1061)
Intrasoft (1009, 1021)
L CUBE Information Systems S.A. (1061)
Metatype S.A. (1061)
National Technical University of Athens (1009, 1014, 1021, 1022, 1027, 1051, 1062)
Planet S.A. (1061, 1073)
STAT S.A. (1075)

Espana - Spain

Alcatel Standard Electrica S.A (1002, 1006, 1011, 1017, 1018, 1035, 1036, 1038, 1043, 1044, 1046, 1048, 1056)
AMPER S.A. (1044, 1045, 1081)
Astilleros Espanoles S.A. (1062)
Centro de Textos Electonico S.A. (1061)
Elbasa S.A. (1060)
Fundacion General de la Universidad Polytecnica de Madrid (1023, 1072)
Grupo de Empresas A.P.D (1042)
INTELSA - Industrias de Telecommunicacion S.A. (1023, 1044, 1048)
Institut Ildefons CERDA (1037)
Labein (1072)
Navicon S.A. (1062)
Prensa Espagnola (1075)
SGS Microelletronica S.p.A (1014)
SIBS (1055)
Sistemas Expertos (SIE) (1042, 1068)
Telefonica - Compania Telefonica Nacional de Espana S.A. (1009, 1014, 1018, 1022, 1024, 1027, 1028, 1030, 1041, 1042, 1044, 1048, 1051, 1065, 1068, 1053, 1072, 1078, 1086)
Telefonica Sistemas S.A. (1009, 1042*, 1051, 1078, 1086, 1091)
Telettra Espanola S.A. (1044, 1045, 1081)

France

Alcatel CIT S.A. (1022, 1031, 1044, 1045, 1046)
Alcatel Espace S.A. (1002*, 1086)
Alcatel/ISR (1063, 1053*, 1055, 1060)
Alcatel Radiotelephone (1043)
APSIS (1042)
Bureau Int. D'Ing. Informatique (1083)
Banque Nationale de Paris (1059)
Cap Sesa Regiono (1087)
CAP Sogeti Innovation S.A.(1016, 1017, 1087)
CNET - Centre National d'Etudes des Télécommunications (1015, 1018, 1022, 1025,)
(1027, 1030, 1031, 1032, 1035, 1041, 1044, 1046, 1048, 1057, 1068, 1087)
CCETT-Centre Commun d'Etudes de Télédiffusion et Télécommunications (1018, 1042)
CEA-Commissariat à l'Energie Atomique (1008)

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CGE - Laboratoires de Marcoussis (1006, 1019, 1027, 1046, 1057)
Clemessy Electronique S.A. (1016, 1087, 1082)
CNUSC (1086)
Companie IBM France (1005, 1046, 1053, 1068, 1079, (1082, 1084)
Compagnie Technicon (1042)
DNAC-Ing, Université Pierre et Marie Curie (1009)
France Cables Radio (5309, 1091)
Geostock (1073)
GSI-Tecsi (1005, 1046*, 1059, 1082, 1084)
IDATE - Institute de l'Audiovisuel et des telecommunications en Europe (1050, 1086, 1071, 1077)
Institut Montpellierain (1086)
Instruments S.A. (1032, 1036)
International Council of Museums (1078)
Jeumont-Schneider (1011)
MATRA Space S.A. (1014)
MATRA Communication S.A. (1004, 1007, 1018, 1041, 1081)
MET France (MATRA-Ericsson Telecommunications) (1014*, 1044, 1083, 1056)
Peugeot S.A. (1079)
Philips - LEP: Laboratoire d'Electronique et de Physique Appliquee (1018, 1033*)
Radiall GIE (1032)
RTC - Compelec (1031)
SAGEM (1047)
SARDE S.A. (1073)
SAT - Société Anonyme de Télécommunications (1011, 1030, 1044, 1045, 1056)
SGS - Thomson Microelectronics S.A. (1030, 1036)
Sligos (1055*)
Sofrecom (1070)
Sogitec Industries (1075)
Sopha Medical (1042)
Souriau et Cie (1030)
Synergie Informatique et Developpement (1009, 1068)
Telesytemes (1061, 1065, 1073, 1074, 1077, 1086)
Telspace S.A. (1002)
Thomson S.A. (1044, 1045)
Thomson - CSF S.A. (1015*, 1018*, 1029, 1033, 1035, 1036, 1047, 1057, 1080)
Thomson Consumer Electronics (1080)
Thomson - Hybrides et Microondes S.A. (1029, 1030, 1043)
Thomson - SINTRA S.A. (1033)
Thomson Video Equipment (1080)
T.I.T.N. (1044, 1061)
TRT - Télécommunications Radioelectriques et Téléphoniques S.A. (1018, 1022, 1043, 1063)
Université de Sciences et Techniques du Languedoc (1029)
VITEC (1079)

Ireland

Allied Irish Bank plc (1059)
Baltimore Technologies (1021)
Broadcom Eireann Research Ltd (1003, 1009*, 1021*, 1023, 1024*, 1028, 1053, 1091)
Central Remedial Clinic (1088)
EOLAS (Irish Science & Technol. Agency) (1087)
Ericsson Ireland (1009)
Irish Medical Systems (1086)
National Institute for Higher Education (1046)
National Microelectronics Research Centre (1020, 1043)

National Software Centre Ltd (1046)
Norcontel (Ireland) Ltd (1059)
SUS Research Ltd (1028)
Telecom Eireann NSDD (1020, 1059)
University of Dublin, Trinity college (1009, 1020*)
Work Research Centre Ltd, Psycosomatic Unit (1034, 1077)

Italy

AET - Applicazioni Elettotelefoniche SpA (1044)
Algotech Sistemi (1076*)
CNUSCE/CNR (1091)
Consiglio Nazionale Delle Ricerche (1066*)
COSI - Consorzio per L'OSI in Italia (1044, 1072*)
CSATA - Centro Studi e Applicazioni in Technologie Avantzate (1028, 1038)
CSELT - Centro Studi Laboratori Telecomunicazioni SpA (1027, 1018, 1044, 1046, 1048, 1053, 1054, 1057, 1081)
DIPI S.R.L. (1073)
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, 1056, 1072, 1081)
Fondazione Ugo Bordoni (1043, 1065*, 1068, 1072)
Industrie Face Standard SpA , (1002, 1006, 1008, 1013, 1017, 1022, 1038, 1044, 1045, 1066)
Instituto di Ricerca Sulle Onde Electromagnetishe del Consiglio Nazionale delle Ricerca (1020)
Intecs Sistemi SpA (1017, 1021)
ITALTEL - Societa Italiana Telecomunicazioni SpA (1012, 1044*, 1045*, 1068, 1069, 1081)
Marconi Italiana (1044)
SARIN (1065)
SGS Thomson Microelettronica SpA (1004, 1044)
SIETTE (1086)
SIP (1053, 1091)
SIRTI Spa (1032)
Sixcom (Olivetti Group) (1055)
Telettra - Telefonica Elettronica e Radio SpA (1027, 1044)
Universita Di Firenze (1086)

The Netherlands

AKZO International Research B.V. (1019*)
AT&T en Philips Telecommunicatie Bedrijven B.V.
ATT Network Systems International (1022, 1031, 1033, 1044, 1045, 1051, 1077, 1083, 1081)
Delta Lloyd Verzekeringsgroep N.V. (1074)
Dr Neher Laboratories of the Netherlands Postal and Telecommunications Services (1015, 1018, 1019, 1022, 1033, 1035, 1036, 1040, 1041, 1043, 1044, 1046, 1048, 1054, 1065, 1068, 1081)
Fokker Aircraft B.V. (1058)
Institute for Rehabilitation Research (1066)
INTERCAI (1070)
Nederlands Philips Bedrijven B.V (1001*, 1010*, 1011, 1031, 1064, 1069, 1081)
Philips International (Elcoma Division) B.V (1022, 1074*, 1080)
Philips Telecommunications en Data Systemen B.V. (1022, 1045)
Philips USFA (1040, 1047)
PTT (1088, 1091)
Regio Kabel Limbourg (1070)
Stidrturg Matematish Centrum CWI (1040)

Portugal

Correios e Telecommunicacoes de Portugal (Centro de estudo de telecommunicaceos) (1009, 1021, 1022, 1023, 1024, 1028*, 1054, 1068,1091)
Instituto de Engenharia de Sistemas e Computadores (1011, 1046)
Instituto Superior Tecnico (1051)
Instituto Superior De Educacao Fisica (1054)
Sociedade Interbacularia de servicos (1055)
TLP - Telefones de Lisboa e Porto (1053, 1078)
University of Aveiro (1052)

United Kingdom

Analysys Ltd (1028)
Barr and Stroud Ltd (1019)
BICC Cables Ltd (1032*, 1060)
BBC - British Broadcasting Corporation (1018, 1036*, 1043, 1063, 1077, 1081)
British Telecommunications plc (1003*, 1006, 1009, 1018, 1022, 1023, 1024, 1025, 1028, 1030, 1032, 1033, 1034, 1037*, 1041, 1043, 1044, 1045, 1048, 1055, 1059, 1067, 1068*, 1077, 1079, 1081*, 1087, 1091)
British Telecommunications (North of Scotland) plc (1028)
Case Group plc (1003, 1005*, 1053, 1082, 1084)
Cimio Consultants Limited (1079)
CIRU Computer Industry Research Unit (1055, 1059)
Commercial Union Assurance Company (1074)
Contel IPC (UK) Limited (1059)
Crosfield Electronics (1061)
Electricity Council (1063)
ERA Technology Ltd (1020)
Ford (UK) Ltd (1079)
GEC - General Electric Company plc (1005, 1009, 1011, 1014, 1018, 1024, 1030, 1033, 1035, 1036, 1043, 1044, 1045, 1046)
GEC Marconi Research Centre (1002)
GPT - GEC Plessey Telecommunications Ltd (1051, 1056, 1081)
Hewlett-Packard Ltd (1016)(1083)

Highlands and Islands Development Board (1028)
HUSAT (1063, 1065, 1076, 1079)
IBA - Independent Broadcasting Authority (1044)
ICI Wafer Technology Ltd (1029*)
IFC Research Ltd (1050, 1071*, 1077)
International Automotive Design (IAD) (1079)
INMARSAT - International Maritime Satellite Organisation (1062)
I-NET Limited (1053)
London University, Queen Mary College (1022, 1083)
London University (1005, 1054, 1067, 1079, 1086)
Loughborough University of Technology (1042)
Marconi Communication Systems (1002)
Marconi Company Ltd (1002)
Marconi Space Systems (1002)
MARI Advanced Microelectronics Ltd (1007, 1009, 1021, 1023*, 1081)
Maxwell Communication Corporation PLC (1061*)
Midland Montagu (1059)
Monotype Corporation PLC (1061)
Mullard (1043)
National Computing Centre Ltd (1048)
Networking Centre Limited (1083)
Oxford Consultants (Europe) (1042)
Oxford Polytechnic (1042)
Philips Components Ltd (1043)
Philips Microwave (1063)
Philips Radio Communication Systems Ltd (1043*, 1063)
Plessey Research (Roke manor) Ltd (1009, 1011, 1012*, 1015, 1021, 1035, 1049)
Plessey UK Ltd (Caswell) (1010, 1018, 1033, 1064, 1067, 1068, 1069*)
QMC Instruments Ltd (1006)
Reading ITEC (Information Technology) (1066)
SERC Rutherford Appleton Laboratory (1042)
Software Sciences Ltd (1021)
Spectrum Energy & Information Technology (1073)
STC plc (1008*, 1014, 1022, 1024, 1027*, 1031*, 1036, 1044, 1045, 1053, 1056, 1057, 1059*, 1068, 1086, 1083)
STC Technology Ltd (1036)
Tarquin Shipping Co S.A. (1062)
Thorn EMI, Central Research Laboratories (1015, 1035, 1043)
Unibit (Holdings) (1006)
University of Cambridge (1042)
University of Dundee (1066)
University of Strathclyde (1043)
University of Surrey (1023)
University of Manchester (1021)
University of Wales (1088)

European Free Trade Association countries:

Austria

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

Finland

Helsinki University of Technology (1039)
Lohja Corporation Electronic Industries (1004*, 1081)
Nokia Corporation (1011, 1022, 1035, 1043, 1044)
Post and Telecommunications of Finland (1039, 1044) Technical Research Centre of Finland (1008, 1054, 1065, 1042, 1066, 1091)
Waertsilae Diesel (1062)

Norway

Alcatel (1086)
EB Teknologi A.S. (1039, 1043, 1046)
Det Norske Veritas Classification A/S (1062)
Olaf Petersen's Rederi A.S. (1062)
Senter for Industriforskning (1039, 1062)
Standard Telefon og Kabelfabrik A/S (1022, 1038)
Televerket (Norwegian Telecommunications Administration Research Department) (1022, 1023, 1044, 1083, 1053, 1086, 1091)

Sweden

Ericsson Radio Systems AB (1043)
Ericsson Telecom (1068, 1056*, 1081)
Swedish Institute for the Handicapped (1088)
S-E-BANKEN, SEB DATA (1059)
Telefonaktiebolaget L.M.Ericsson (1014, 1021, 1030, 1033, 1044)
Telelogic A.B (1021)
Televerket (Swedish Telecommunications Administration (1009, 1011, 1014, 1018, 1021, 1023, 1024, 1025, 1030, 1033, 1035, 1041*, 1043, 1044, 1045, 1083, 1053, 1056, 1059, 1067, 1087, 1086, 1091)

Switzerland

Hasler Holding Ltd, Research and new Technologies Division (1016, 1033)
Ascom Technology A.G. (1083, 1053, 1087)
Direction Generale PTT Suisse (1045, 1086)
Ecole Polytechnique Féderale (1057)
Konsortium Tricom (1022, 1044)
Swiss Federal Institute of Technology, Zurich (1033)

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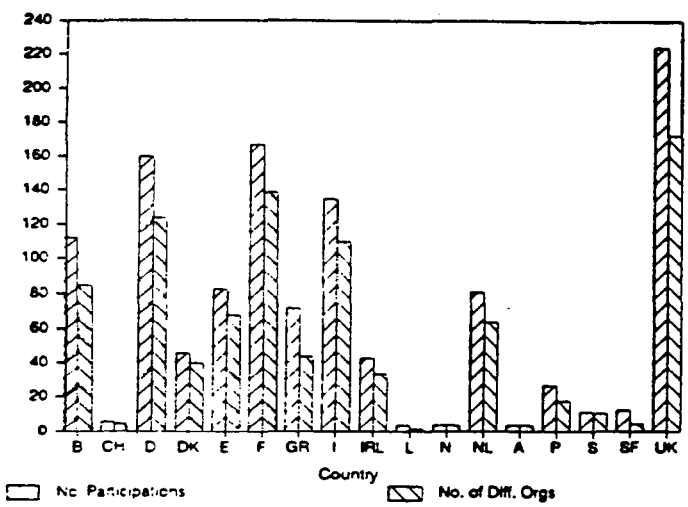
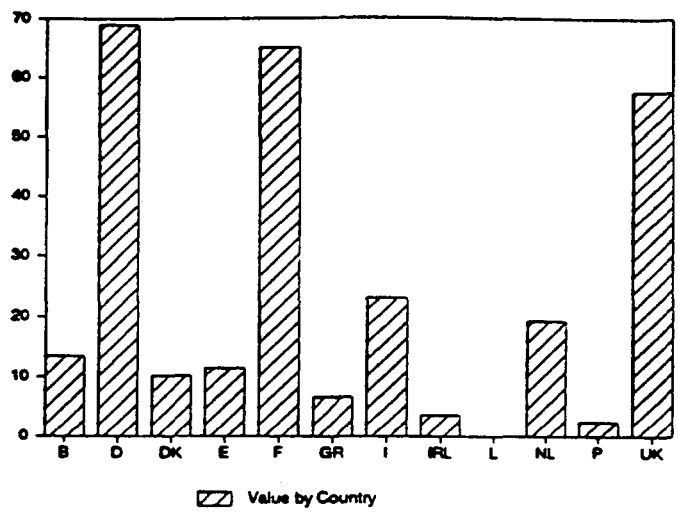
X. RACE Statistics

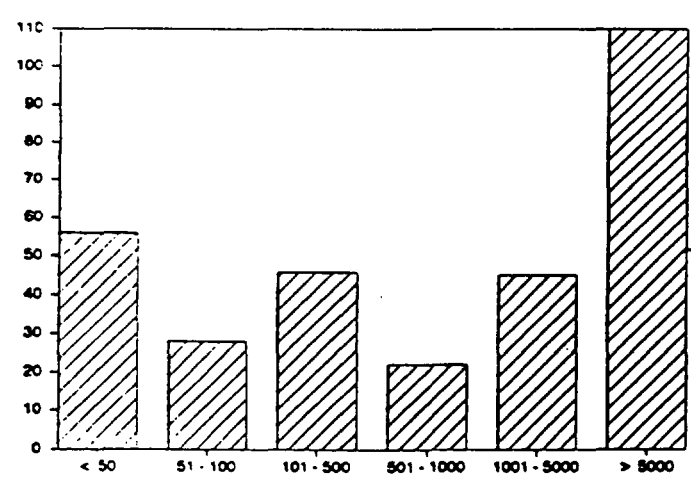
Country Distribution of Organisations



Financial Participation (MECU)



Sizes of organisations



Types of Organisations