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Working towards Telecom 2000

- Launching the Programme RACE -

Summary

Advanced Telecommunications is the subject of vigorous and intensifying development throughout the world, not only because of the direct economic importance, but also because of the enormous impact on the future wealth-generating capabilities of countries and the well-being of their inhabitants. By the year 2000, the telecommunications sector is expected to account for 7% of the Community GDP and 60 million jobs will depend on it. Constraints in transmission capacity will disappear and new infrastructures and equipment will allow the flexible integration of voice, data and image communications at low costs. Future infrastructures, equipment and services are all addressed by the Programme RACE[1].

In this time of rapid change, the Community has created, in the Programme RACE, a focus for Europe's[2] intellectual and industrial effort in advanced telecommunications technologies and services.

Collaboration has already allowed requirements to be identified, and the launching of RACE is the visible expression of the wish - and need - for industry and operators to work together in exploiting new technologies to meet demands for more powerful, more economic and, in particular, compatible equipment and services.

The work undertaken in the framework of RACE is focused on the definition of an Integrated Broadband Communication (IBC) system and network architecture by 1990/1991 and development of technology for Europe-wide introduction of economically viable IBC Services in 1995.

After a Definition Phase, the RACE Programme was adopted by the Council in December 1987 and work started in January 1988. Within its framework, about 1000 leading experts are collaborating in 46 projects. Practically all Telecommunications Operators (10% of the effort), all major European Telecommunications and Information Technology Manufacturers (38% of the effort), most major Research Establishments (14%), many Small and Medium Sized Enterprises (22%) and numerous Universities (13%) are collaborating in joint teams, sharing work, experiences and results. Organisations from EFTA countries are participating in about 13% of the work. Close collaboration with related work in the frameworks of COST, ESPRIT and with standardisation bodies, in particular CEPT/ETSI, CEN/CENELEC and EBU is ensured.

The success of telecommunications services, more than others, depends on wide-spread acceptance and uptake. The implemention of RACE therefore goes beyond developing the purely technological basis for telecommunications infrastructures and services. Concertation and consensus formation is as important an objective, and collaboration of technologists, telecom system operators, service providers and users is ensured in RACE at the grass-root level by creating opportunities for joint work at an early stage and on a European scale. RACE can be expected to make a vital contribution to a common European understanding of needs and capabilities and to the early commercial introduction of advanced telecommunications services.

This document highlights the issues addressed by RACE and the scope of the work started in January 1988.

(1) RACE: R&D in Advanced Communications technologies in Europe

(2) In the framework of RACE organisations cooperate which are either established in the Community or in one of the non member states with which a Framework Agreement has been concluded. At present this includes the EFTA countries.

Com-240 II

2

1. Telcom 2000 - concerting Europe's efforts

Progress in telecommunications is influenced by several interrelated factors, the most important being the need for widespread acceptance. Progress therefore depends critically on Telecom Operators, equipment manufacturers, the Consumer Products industry, Broadcasters, Information Technology Manufacturers and others agreeing on a consistent development strategy; all play important distinct parts in the new environment of enhanced telematic services. To avoid conflicting and thereby wasteful developments, concertation and collaboration between all parties is essential and it is vital that this takes place at an early stage of development, ie at the stage R&D.

Telecommunications is driven by rapid technological innovation and rising user expectations. However, because of the shear size of systems, the return on investment in telecommunications is slow and change has therefore been gradual. Fortunately, new programmable equipment will facilitate adjustment to new demands and the reduction in cost of electonic equipment will permit earlier replacement of equipment. These, and other technological developments are radically changing telecommunications and therfore historical trends may no longer be appropriate for forecasting future developments.

Information technology underlies the convergence of computing, telecommunications, broadcasting, consumer electronics and telematic services. This convergence has great potential to meet user demands for flexible and powerful services. However, this potential has not yet been realised. One reason is that the programmability of modern information technology is both a escape and a trap. For example, two microprocessors running even slightly different programmes can be incompatible as far as the user is concerned. Information Technology can encourages incompatibility by its very flexibility.

Although there is an increasing wish by all concerned for compatibility, it is unlikely to develop unless there is a concerted and systematic effort towards this common goal at the technological level as a basis for adoption of sound internationally agreed standards, and their adoption in private and public procurement.

Consensus at the technical level is important but is not in itself sufficient. The changing needs of users must also be taken into account.

The RACE programme provides a common framework and goal for collaboration in developing technology and services to meet user demands for the 21st century.

1.1 The value-added of RACE

RACE has many facets: it encourages cross-frontier collaboration and hence the best use of the Community's considerable intellectual, scientific and engineering potential. By emphasizing the need for Open Interconnection and flexible design, it encourages the establishment of a common market in telecommunications equipment of sufficient size to justify large-scale industry-funded research and innovation. By minimizing the risk of abortive development it encourages investment, and RACE funds act as a catalyst in key areas of technology development where leverage is high - that is, where limited Research and Development funding results in very much larger independent investments.

It provides a forum for telecommunication operators and companies from all sectors of industry to discuss and agree on key issues; this accelerates the standardisation process, a notorious bottleneck in high-technology exploitation, and ensures the timely availability of cost-effective products. The technical proposals for Standards and Common Functional Specifications that emerge from collaboration in RACE stand a good chance of being accepted worldwide and will ensure a large external market for European Telecommunication Operators, service providers and industry.

By systematic exploration of future options for service providers, operators and industry, it reduces uncertainties and investment risks for all concerned. This is of decisive importance for the timely emergence of Value-Added Services and their acceptance by users.

Finally, the IBC to which the work of RACE is oriented will provide an essential infrastructure for European service and other industries engaged in the Information-based sector that will dominate business activity in the twenty-first century.

1.2 RACE Programme

1.2.1 Objective

The main objective for RACE is to prepare for the "Introduction of Integrated Broadband Communication (IBC), taking into account the evolving ISDN and national introduction strategies, progressing to Community-wide services by 1995".

The general objectives of RACE are

- to promote the Community's telecommunications industry;

- to enable European network operators to compete under the best possible conditions;

- to enable a critical number of Member States of the community to introduce commercially viable IBC services by 1995.

- to offer opportunities to service providers to improve cost-performance and introduce new services;

- to make new services available to final users at a cost and on a timetable at least as favourable as in other major western countries;
- to support the formation of a single European market for all IBC equipment and services;
- to contribute to regional development within the Community, by allowing less developed regions to benefit fully from telecommunications developments.

1.2.2 Scope

RACE covers a very broad spectrum of interest. It covers all aspects of mobile telecommunications, satellites and terrestrial networks. It includes consideration of narrowband networks, distribution networks of all kinds, as well as specific broadband networks.

RACE is also concerned with services; their definition and their exploitation by end-users; pilot applications and trials; development of verification tools and assessment of macro-economics impacts on telecommunications development.

RACE lies between 'pure' un-directed research and development-for-manufacture. It leaves ample scope for innovation both in development and manufacture while taking into account the realities of telecommunication system operations, manufacturing industries and the market-place; it will make the best possible use of the Community's intellectual resources in defining and satisfying user requirements. Those working in RACE need a balance between vision and reality, enthusiasm and pragmatism, compromise and initiative and perhaps the most difficult, speed and timeliness.

1.2.3 Structure and Timing

The RACE programme consists of three concurrent Parts, each involving a number of projects executed by international consortia most of them including manufacturers, telecommunications operators and universities:

Part 1: IBC Development and Implementation Strategies

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

Part 2: IBC Technology Research and Development

Co-operative Research and Development on key technologies for low-cost realization of IBC equipment and services is essential. The main emphasis is on development of optical signal processing, switching and transmission. These technologies offer the capability to handle large volumes of information at great speed. Research also involves application of advanced technologies to system integration and management, improving the usability of equipment, and development of evolutionary networks, systems and sub-systems.

Part 3: Functional Integration

Projects involve assessment of service functions and operational concepts, and development of pilot applications to investigate the characteristics of IBC networks and services. These include the Research and Development into testing and verification of all key features of IBC.

1.2.4 Programme Milestones

A set of strategic milestones were defined during the RACE Definition Phase. They are keyed to definition of an IBC system and a network architecture in 1990/1991.

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

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

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

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

1.2.5 The Current Situation

As a result of the first call for proposals, and the subsequent evaluation, 46 contracts for about 3500 Man Years of effort have been signed so far with a total Commission contribution of 186 MECU over 3years:

Within the European Community, 10 Telecommunications Administrations, 33 Universities and research establishments and 70 companies (24 of them small companies) are involved in consortia. Organisations from 11 of the 12 European Community countries are represented.

Organisations from other countries in the European Free Trade Association (EFTA) are also involved. Fifteen organisations from Austria, Finland, Norway, Sweden and Switzerland participate in 19 consortia.

1.3 Outlook

The Programme RACE was adopted in December 1987 and work started in January 1988. This rapid take-up was only possible because all concerned were already cooperating and convinced that the work was urgent and corresponded well with common needs. With the 2nd Call in July 1988 (concentrating on Part III) for work in 1989, all three Parts of RACE will be implemented.

The Council Decision foresees that after 30 months, in December 1989, the Programme will be reviewed. The results will be evaluated in relation to the objectives set out in Annex II of the Decision.

2. Technological Scope and Thrust of RACE

2.1 Main Hardware and Software Thrusts

The changes from telephony via digital networks to 64 kbit-based ISDN, from paired-cable to fibre-optic transmission, from analogue to digital switching, and from channel-associated to common-channel signalling, already set the foundations for IBC, but much remains to be done. Cinema-quality television requires very much higher data transmission rates(bitrates) than those at present available. The tailoring of communications capabilities to individual user needs requires complex processing in both terminal and network, and the use of one universal network for a variety of purposes requires advanced network management and totally secure operation. Research into components for high-speed digital communications dominates the hardware technology studies within RACE, and the magnitude of the software problems necessitates a global approach to IBC software and system design, based on rigorous functional concepts.

Clear functional statements about 'What IBC must do' derive in part from formal user requirements setting out 'How the IBC network is used'. They, in turn, provide the foundation for the work on Reference Configurations describing 'How IBC is implemented'.

The users, those specifying functions, the system implementers and network planners all have complimentary views which must be taken into account in definitions: the structure of the RACE workplan reflects this need.

2.2 New System Concepts

Among various important systems and technologies addressed by RACE, three deserve particular mention.

2.2.1 Asynchronous Transfer Modes (ATM)

This efficient data transmission technique combines the advantages of circuit- and packet-switched networks and shows great promise for transmission of all kinds of signals. In combination with fibre-optic transmission, the Asynchronous Transfer Mode could remove the major barriers of fixed channels and limited bandwidth. A network that incorporated these advances would be able quickly and effectively to provide new services without significant modification. The ability, within RACE, to develop in parallel main and customers premises networks will ensure compatibility at the all-important terminal/network interfaces.

Asynchronous Transfer Mode development was started in the RACE Definition Phase, concentrating on a simple short-fixed-packet variant called ATD (Asynchronous Time Division). The main RACE programme has major projects centered around this and similar approaches.

2.2.2 Signal Processing

In the signal-processing area, the main emphasis is on bitrate-reduction techniques and, particularly in the subscribers premises equipment, on adaptation to an IBC environment. The former recognizes the role played by advanced CODECS (Coders and Decoders) in reduing the cost of data transmission at the network level, especially for TV signals, whilst the latter reflects the need to move from a broadcast-only environment using analogue techniques to a mixed cabled/broadcast environment using a mix of analogue and digital systems. Enhancement of existing ISDN subscriber-access signalling is a vital step in the evolution to an IBC system and is a major study topic within RACE.

2.2.3 Multichannel Coherent Optical Communications

Several different partly- and wholly-optical network structures are being studied within RACE. One of the most interesting concerns the further development of ideas for distribution networks using frequency-division multiplexing. These concepts are now being vigorously investigated all over the world.

2.3 Technology Availability and Priorities

Many of the essential telecommunications and processing technologies exist: they are expensive, but their costs will be reduced by technological advance; costs are furthermore higly volume-dependent, and the mass market for entertainment-related and associated services will generate the requisite volume.

RACE is thus concerned with mass-produced high-quality high-technology components and subsystems. It is particularly concerned with Consumer Products that will terminate the IBC network in homes and with the individual subscriber line and associated equipment that connects the user to the network. Low-cost components for these two areas are crucial to success of IBC, and there is general agreement that a viable fibre-optic subscriber connection should cost not more than 1500 ECU, including all civil engineering costs. This is a challenging but achievable target.

RACE is not concerned with technology-in-a-vacuum, but is at all times concerned with the delivery of the right component, at the right time, at the right price.

There are also emerging technologies that, whilst not essential to IBC, could considerably improve cost-effectiveness, flexibility and service quality. Single-frequency laser diodes will play a major role in fibre-optic transmission systems using space-, frequency- and time-division to put many channels onto one cable. The work in this area also embraces optical frequency multiplexing, local oscillators, channel selectors, amplifiers, direct detection devices and receivers.

Optical systems are still likely to evolve through several generations: All-optical devices for amplification and regeneration are needed for all-optical transmission systems and networks, whilst optical switching, although showing great potential, is still in its infancy.

RACE therefore includes some longer-term studies, although the main effort is on potentially cheap devices, both active and passive, based upon GaAs and InP substrates and compounds such as InGaAsP. Packaging is recognized as a major area of study, as are fibre joining systems and test equipment.

2.4 Interworking with Existing Plant

There is an large investment in existing plant and production capability but massive programmes are in hand throughout the world to replace out-of-date plant with electronic digital equipment. These programmes are driven by considerations such as cost-of-ownership and are justified for telephony alone. Already, around 70% of the Community transmission network, and 55% of the trunk switching, is digital. Fibre optic systems have penetrated the trunk and junctions networks and are now increasingly used in the subscriber loop area, also justified on telephony usage alone.

9

RACE includes investigations into the optimal usage of this new equipment and smooth progress from digital telephony-based networks to an IBC network and system. The need to interwork with existing systems is well-recognized and again, the modern narrowband systems now coming into service will help. The digital networks all conform to CCITT Recommendations and hence form a stable base from which to grow, as well as providing interworking gateways. The main-network digital No 7 signalling system is capable of enhancement to handle IBC traffic.

2.4.1 IBC and ISDN

The ISDN concept is built around integrated access to the circuit-switched digitized telephone network, to public packet-switched networks and to channel-switched leased-line networks. It is designed as a basic universal capability using paired-cable subscriber networks and telephone switching equipment operating at 64 kbit/sec., but allows for individual National implementations. Individual Administrations decide how and when they implement ISDN and considerable divergences exist within the Community, although measures to harmonize ISDN exploitation are now in place.

Although originally envisaged for non-voice exploitation, ISDN has become a vehicle for harmonizing business communications via circuit- and packet-switched channels and is being treated pragmatically in the U.S.A. Standardisation of the 'U' interface at 160 kbit/sec. and proposals for a '2B + Big D' interface for high-speed Local Area Network interconnection reflect regional priorities that may impinge on International ISDN standards in the future.

IBC depends upon integrated access to a broadband digital main network (the IBCN) that supersedes the different specialized networks mentioned above. It will be designed as a universal capability using fibre-optic transmission and high-speed digital switching enabling a thirty-thousand-fold increase in channel bitrate. Harmonization studies, included within the RACE programme, will minimize National variants and ensure a phased introduction of IBC facilities across the Community at the earliest possible moment.

The major technical advantages of IBC derive from the high bitrate capacity; the main economic advantages derive from having a single multi-function network that can handle telecommunications services, broadcast services (such as multi-channel high-definition television) and enhanced data communication facilities such as high-speed colour facsimile. IBC will make person-to-person videotelephony calls as cheap as present-day telephony, and will bring simple but powerful information-retrieval and entertainment capabilities into every home. RACE does not rely on new broadband services to justify its cost but it is of course investigating new IBC applications.

2.5 New Applications

These will certainly arise. Telecommunications is already perceived as a bottleneck, throttling initiative by restrictions on bandwidth, flexibility and quality of communication, and by high prices. User expectations are raised by evidence of technological capabilities in other fields, such as the aerospace and military domains, and users are frustrated by what they see as the inertia of the service providers. The IBC network and system will provide a quantum leap in fundamental communicative capability that will absorb innovative Research and Development on terminals for many years: these innovations will in turn fuel commercial and industrial progress. The effect of IBC will be to make distance irrelevant.

No-one can predict the long-term applications, but IBC applications studies, directed towards the near-term and hence foreseeable future, form a major area of work within RACE. The industrial and commercial strength of the Community could well depend in the future upon the timely availability of broadband communications to leading-edge users. By 1993, over one-half of the 'telecommunications' market could be related to integrated business information systems.

2.6 Contribution to Standardisation

The importance of the standardisation and functional specification process in telecommunications is universally recognized and it is clear that RACE must interact very closely with the relevent European Standardisation Organisations.

In fact, the major outputs from RACE are expected to influence standards directly and an executive team has been appointed to oversee the translation of RACE outputs into draft standards proposals.

Areas of particular importance are Asynchronous Transfer Modes and Integrated Optical Networks, both demanding a great deal of standardisation effort and coming closely on the heels of the ISDN standardisation process that has occupied Telecommunication experts for several years.

RACE work is expected contribute to the work of SG XVIII in CCITT and NA5 in CEPT. The European Telecommunications Standards Institute, now being set up, will help ensure the exploitation of RACE results in telecommunication standardisation.

RACE results are also expected to contribute to the standardisation work of CEN/CENELEC. Beyond this there are also important inputs to the work of EBU.

3. Annexes

3.1 Listing of Projects

Part I: IBC Development and implementation strategies

1045 Concensus management.

Cluster 1; Development of a functional reference model

1044 Functional Reference Model and customer service functions;
1023 BEST - A methodological approach to IBC system requirements and specifications;
1024 NETMAN - Functional specification for IBC management;
1025 Functional specification of security and privacy in IBC;

Cluster 2; Development of reference configurations and evolution planning:

1044 Reference configurations;
1002 Satellite communications for IBCN;
1022 Technology for ATD; Hybrid systems;
1026 International transmission of digital television and radio (Eurovision);
1028 Regional evolution planning for IBC (REVOLVE)
1035 Customer premises network (CPN);
1041 FUNCODE - Coding, service and interoperability for high-quality videotelephone and high-definition television (HDTV);
1043 Mobile telecommunications;

Cluster 4; Usage reference model development;

Application analysis and opportunities for IBC: Subject of the second call for proposals in 1988.

Part II: IBC Technologies:

Group 1; Networks and switching projects:

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

Group 2; Optical communications:
System projects;

1010 Subscriber Coherent multichannel technology;
1012 Broadband local network technology;
1030 ACCESS - Advanced customer connection: an evolutionary strategy;
1036 WDTM Broadband customer premises network;

Active opto-electronic components;

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

Passive opto-electronic components;

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

Optical switching projects;

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

Group 3: Advanced information processing (AIP) and software engineering:
Network management studies;

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

AIP for customer service functions;

Subject of a new call for proposals:

AIP for integrity mechanisms;

authentication, proof of origin and reciept etc; Subject of a restricted call for proposals:

Programming infrastructures;

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

Group 4: IBC customer systems:
Signal processing;

1018 HIVITS - High-quality video'phone and HDTV systems;

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

Customer-premises networks (CPN);
1011 Business CPN;
1015 Domestic CPN;

Group 5: Usability engineering:

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

Part III: Functional integration:

Group 1: Verification tools;

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

Group 2: Pilot applications;

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

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

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

3.2 Acronyms Used

CCITT	International Telephone and Telegraph Consultative Committee
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CEPT	European Conference of Post and Telecommunications
EBU	European Broadcasting Union
EFTA	European Free Trade Association
ETSI	European Telecommunications Standards Institute
GDP	Gross Domestic Product
GHz	Giga Hertz
IBC	Integrated Broadband Communications
IBCN	Integrated Broadband Communications Network
ISDN	Integrated Services Digital Network
MECU	Million European Currency Unit
NA5	Network Aspects group 5 of CEPT, SG on Broadband
RACE	Research and development in Advanced Communications-technologies in Europe
SG XVIII	Study Group 18 of CCITT, SG on Broadband