Box 1989

SEPSU

Policy Study No. 3

EUROPEAN COLLABORATION IN SCIENCE AND TECHNOLOGY:

II. Pointers to the future for policy makers

SCIENCE AND ENGINEERING POLICY STUDIES UNIT

THE ROYAL SOCIETY   THE FELLOWSHIP OF ENGINEERING

The Science and Engineering Policy Studies Unit (SEPSU) is run jointly by the Royal Society and the Fellowship of Engineering. Its staff, based at the Royal Society, assist the Society and the Fellowship in their contributions to policy formulation in science and engineering and, more generally, provide expertise in policy analysis. Much of the Unit's effort is devoted to objective, data-driven studies of policy issues, either of its own choosing or in response to external commissions. The Unit also provides a service to other sections of the Society and Fellowship, and maintains an extensive database of relevant information.

Funding for the Unit is provided privately by the Royal Society and the Fellowship of Engineering, by industrial and commercial donors and by contract work. Support from the following donors is gratefully acknowledged:

BICC plc
British Gas plc
Central Electricity Generating Board
Coutts Charitable Trust
Imperial Chemical Industries PLC
Lucas Industries plc
Northern Engineering Industries plc
Prudential Corporation plc
THORN EMI plc
Wellcome Foundation Ltd

For further information, please write to:

Dr P.M.D. Collins
Head, The Science and Engineering Policy Studies Unit
6 Carlton House Terrace
London SW1Y 5AG

Tel: 01-839 5561

EUROPEAN COLLABORATION IN SCIENCE AND TECHNOLOGY:

II. Pointers to the future for policy makers

SEPSU Policy Study No. 3
February 1989
ISBN 0 85403 376 9

SCIENCE AND ENGINEERING POLICY STUDIES UNIT

THE ROYAL SOCIETY THE FELLOWSHIP OF ENGINEERING

FOREWORD

Overseas activities in research, development and the market are having an increasing influence on British science and technology. Knowledge of best practice and pointers for the future are prerequisites for success. Recognizing this, SEPSU is undertaking a research programme on international science and engineering policy. In December 1987, as part of this programme, we published a guide to schemes promoting European collaboration in science and technology for the UK scientist and engineer.

For the current report we have consulted a large number of people with recent first-hand experience of West European collaboration. We are most grateful indeed for all their help. The value of this study has been greatly enhanced by their vigour and candour, and their illuminating evidence underlines the necessity for and benefits from international cooperation. Their experience has provided clear pointers for future initiatives by policy makers in Government, industry, universities, research councils and other research bodies.

We have not sought here to bring forward specific recommendations, but we hope that readers will be able to apply the findings of this report to their own enterprises.

This report has been endorsed by the Councils of the Royal Society and the Fellowship of Engineering.

Sir Roger Elliott, Sec. R.S.
Chairman, SEPSU Steering Group

Professor B. Crossland, F.Eng, F.R.S.
Vice-Chairman, SEPSU Steering Group

October 1988

ACKNOWLEDGEMENTS

The SEPSU Steering Group wishes to thank the Chairman and Members of the Task Group for their ideas, enthusiasm and hard work in guiding the study.

Dr I.D. Nussey, F.Eng (Chairman)	IBM United Kingdom Ltd
Dr H.H. Atkinson	Science and Engineering Research Council
Dr M.J. Crumpton, F.R.S.	Imperial Cancer Research Fund
Mr J.R. Fryer	Lucas Industries plc
Dr A.W.C. Keddie	Department of Trade and Industry
Professor A. Ledwith	Pilkington plc

We also gratefully acknowledge the invaluable and stimulating help of staff in the following organizations who so willingly participated in the interviews or contributed in other ways to the case studies. In many organizations we interviewed several departments.

Alvey Directorate
British Aerospace
British Telecom
Cambridge University
Commission of the European Communities
Department of Trade and Industry
GEC
Harwell Laboratory
Heriot-Watt University
IBM
ICI
ICL
Imperial Cancer Research Fund
Imperial College of Science and Technology
Robert Keown
Level-7
Logica
Loughborough University of Technology
Lucas Industries
Pilkington
Science and Engineering Research Council
Senetek
Strathclyde University
THORN EMI
HM Treasury
University College London

CONTENTS

SUMMARY: CONCLUSIONS AND POINTERS FOR FUTURE INITIATIVES

(i) Background

This report presents the findings of a study on European collaboration in science and technology, based on case study interviews of participants in a representative set of over 20 cooperative research and development projects. One of the main purposes of the study was to identify good practice and factors that lead to success in collaborative research and development. Thus, an important criterion for selecting almost all the case studies was that they should be perceived by independent observers and/or participants to have been successful.

It was not difficult to find successful projects. Generally speaking, participants in such projects experienced many benefits arising from collaboration, though a few had met major problems. They also identified the critical factors for success, including external stimuli such as official umbrella programmes and public funding. On the basis of their recent experience and current practice we have identified pointers for future initiatives. If these stimulate follow-up action they may help West Europe as a whole, and the UK in particular, to compete more effectively.

(ii) Getting started

The road to getting an approved project with suitable partners was hard, but rarely rocky. For European Community (EC) programmes, European Commission officials in Brussels were very approachable and willingly gave assistance. Regular face-to-face contact with them was deemed to be essential, in accordance with Continental practice of communicating orally whenever possible.

Motives

Industrial collaboration in science and technology was driven by perceptions of future markets and opportunities for marketable products, processes and services. The main commercial reasons for joint research and development were risk sharing, improvement of competitive position, access to the larger international market, access to other organizations' complementary knowledge and expertise, and, more specifically, development of international standards.

Science has always been international, but UK academic interest in collaboration with other European countries was increasingly being driven by financial considerations. Domestic competition for limited academic funds made cooperation within this country comparatively harder and encouraged links abroad, where there was often found to be a better match of specialist interests.

Choice of partner

Companies were more constrained than universities in their choice of partners, owing to business considerations. The prior existence of a national common interest community helped them to find partners and to make the UK a credible participant in international consortia.

Universities generally found it relatively easy to find academic partners. Many of the academic collaborations we studied were based on pre-established links. In addition, the best UK university departments had an international reputation and were courted by foreign firms as well as

UK firms to join EC industrial R&D programmes. If technology transfer from university to industry in these programmes is to be of direct benefit to the UK, UK organizations should be encouraged to participate as a company-university duo. For the same reason, UK industry, like its competitors overseas, should also be seeking partnerships with the best university departments and research institutes in other countries.

Initiation

Not surprisingly, start-up funding could be a problem. A specific difficulty was lack of funds in universities to support exploratory visits before a collaboration was started. In some cases, however, UK funding agencies had provided pump-priming for emerging science and technology projects on a national level that had later formed the foundation for UK participation in an international project with European funding.

Such a two-stage strategy could provide the necessary national infrastructure to allow the UK both to contribute soundly to, and to benefit effectively from, a wider international initiative. UK initiatives, in schemes like JOERS and Alvey, to establish a national community and competence in key areas of science or technology were perceived by the participants to have been successful. They had provided a springboard not only for credible UK participation in international programmes but also for UK organizations to start to exploit the results competitively in world markets.

(iii) Umbrella programmes

Value of programmes

Brand names were important for marketing and identity. The umbrella European programmes strengthened the credibility of individual initiatives in transfrontier collaboration in R&D. They could be potent and potentially pervasive agents of change. The benefits extended beyond the projects to the market place, with much evidence that association with particular programmes brought favourable international publicity and credibility with customers.

Money was naturally a most powerful stimulus for participation in an umbrella programme, particularly for projects beyond company or national capacity, but it was by no means the only motive. Umbrella schemes provided effective management frameworks and convergence on key initiatives that reduced duplication and accelerated progress.

Regulations

The rules for European and UK publicly funded programmes differed in a number of important respects—level of support, criteria for support and intellectual property arrangements. It would seem that there could usefully be greater openness on, and clarification of, these differences. Similarly, decision timescales in different countries could be synchronized, at the same time removing unnecessary obstacles and differentials.

Science programmes

We studied two of the science programmes—the European Science Foundation (ESF) and the EC Stimulation Programme. Both were perceived by participants to be of great benefit. The ESF provided a useful, low-cost pump-priming mechanism for scientific research, particularly in unfashionable or under-resourced subjects of potential significance. The Stimulation Programme appeared to be particularly effective for a relatively small average unit cost. While we would not urge disproportionate expansion against other programmes of proven value, further extension of the Stimulation Programme would seem to have considerable advantages.

(iv) Problems and constraints

None of the projects was entirely trouble-free, but only two had problems that the participants considered to be severely disabling. The specific problems most commonly met concerned conflicting aspirations, large project management and intellectual property. Other important constraints were bureaucracy, shortage of university funding, recruitment and communication.

Conflicting aspirations

The funding agencies were probably responsible for unsatisfactory situations in three cases, through inept formation of consortia either by merging two or more proposals into one or by introducing inappropriate partners. This led to conflicting aspirations, emphasizing incompatibilities rather than common interests. Conflicts also arose even in successful examples of industry-university collaboration. This was because industry targeted work at a specific end result whereas academics often preferred to investigate interesting new science without direct application.

Large consortia

Despite best intentions management of large consortia was a problem. There was no pool of knowledge on good and bad practice. When management capacity fell short of what was required, the project suffered through inadequate groundwork, lack of overall direction and failure to achieve its original goals. We conclude that succinct guidance for all new consortia, for example a brochure or a short seminar, would be nationally cost-effective. Funding agencies might make funding conditional on attendance at such a seminar.

IPR

The comparative lack of major problems associated with intellectual property was notable. This was probably due partly to the painstaking efforts taken to reach agreement during preliminary negotiations and partly to flexible and positive attitudes shown by the participants. Goodwill went a long way to counteracting the naturally cautious legal background prevalent in joint commercial ventures.

Bureaucracy

Bureaucracy—that is the funding agencies—is an easy target for attack. In fact, the following few shortcomings apart, in neither Brussels nor London did central bureaucracy emerge as a major problem. There was one extremely frequent criticism, however, that concerned delays and inefficiencies in both places in negotiating contracts and paying claims. We also received comments from participants in UK programmes about the inconsistency and variable quality of official interventions. No such comments were made about European Commission interventions.

University funding

Shortage of university funding was a grave constraint. Two perceived needs were paramount. The first was short-term travel grants to attend conferences, which were increasingly being organized on a European rather than a national basis. The second was grants to allow young researchers to be exposed to overseas research exchanges at an early stage in their careers.

These funding constraints had a knock-on effect. Universities were unacceptably affected by the bureaucratic delays mentioned above. There were many instances where such delays exacerbated difficulties in academic recruitment arising because specialists were in short supply or the grant period was not long enough to attract good benchworkers. The result was suboptimal rescheduling and excessive remodelling of project goals because requisite skills were not available.

Communication

Communication between scattered groups and different nationalities was difficult. Nevertheless establishing and maintaining an effective means of communication was crucial for team-building. It was important to define terms unambiguously, especially in contract negotiation, vendor-user collaboration and interdisciplinary work. Intending collaborators should be made aware how difficult communication could be, even within groups for whom English was the mother tongue.

International standards

Remarkable progress had been made technically through European cooperation to develop and demonstrate international standards in a number of areas. Yet we found little political and commercial urgency to introduce them to the market. Other constraints included unhelpful approval procedures for standards, which depended too much on national bodies, and delays in take-up by the public sector.

(v) Management

Investment in management

There was strong agreement that a prudent level of management/administration overhead was close to 10%, typically half as high again as for an in-house project. There was an almost universal expression of the importance of direction-setting at the executive level and of focused preparatory work. Ultimate success of projects depended on substantial investment in management and planning.

Feasibility studies

Large projects carried immense investment. They also had the potential to go badly astray. In the interests of all parties, it may be that every substantial publicly supported project should be required to have a pilot feasibility study with a breakpoint. This pilot study should be eligible for proportionate public support.

Clubs

In certain circumstances the club arrangement was increasingly being used to handle a large number of organizations. In a club a number of companies joined together to sponsor industrial R&D in a single independent laboratory or occasionally a small number of laboratories.

Management structure

Our case studies showed the importance of a framework separating policy and leadership from technical management and from administration. We were able to identify some outstanding best practice in each of these categories.

Large projects required a senior policy committee with a representative from each organization. Success also depended on strong, yet unselfish, leadership from the prime contractor. This leadership was important in obtaining consensus, channelling democracy and avoiding the divisive effect of invoking the voting mechanism.

There was overwhelming evidence that technical success hinged on having a capable project manager, who had to be clear about the strategy and be a good communicator. He or she was responsible to the policy committee for technical progress, a full-time job in large projects. In all but the smallest projects a technical committee was also required, comprising a technical coordinator/project leader from each organization. These project leaders were accountable to the project manager for their team carrying out agreed actions towards clearly defined goals.

In most projects the lead contractor handled the overall administration of financial matters, documentation and report collation. Generally project control seemed to be most successful when kept simple. Only in the very largest projects were computer-based systems essential.

Electronic messaging

Experience at the project level of electronic messaging was positive. We heard about pioneering demonstrations of its power for strengthening inter-site dialogue on project management. We also established its importance for joint text preparation and editing. Nonetheless there were inhibitors: inability to agree communication and equipment standards, and apparently inadequate security in public systems for transmitting commercially confidential information.

(vi) Critical factors for success

Our study examined in depth critical factors for success. Remarkably there was no discernible difference in the views of those participating in successful projects. All readily identified the same few important factors at the corporate, project and personal levels. The more complex a project was, the more critical these success factors became.

Corporate level

At the corporate level, an influential champion was essential, supported by a strong leadership cadre committed to a common goal. The project should fit comfortably with the overall strategy and commercial aspirations of each organization and provide a clear exploitation route for each partner. Thorough preparation was key, as were high calibre management and a high quality science/engineering base. A deliberate and managed process of dovetailing complementary interests and skills invariably accomplished results greater than the sum of the parts.

Project level

At the project level, milestone management provided a challenge and focus for a project. A project manager/principal investigator was required to foster the common purpose and to coordinate the technical work.

Teamwork

Trust and teamwork had to be established, and then sustained, at both the management and project level. This required, generally speaking, considerable patience and application and, most particularly, continuity of personnel. In every successful project effective working relationships were built on personal contact and the teams demonstrated group responsibility.

Individual motivation

Finally, and just as important as the other factors, was motivation of every researcher.

(vii) Benefits and achievements

International collaboration

There was copious evidence from our sample that European collaboration was good for the participants, for the UK and for Europe. Many of the benefits were unexpected. Besides numerous examples of direct and tangible achievement—commercial pay-off, academic recognition, improved competitive position, application of other people's knowledge and skills; spin-off science and technology—there was ample evidence of less tangible benefits in almost every project. These included: new project concepts; changes in attitude, such as a less insular approach to overseas developments and a greater awareness of international affairs; improved management experience and practices; and rewards to the individual in terms of enhanced career development and scientific reputation. The majority of those interviewed confidently expected to maintain their links with the same or similar groups.

Intranational collaboration

For comparison we selected a few examples of UK collaboration. These showed that fruitful cooperation bringing similar returns and international success was possible at home. Our small sample suggested that products based on UK-only programmes were particularly appropriate for specialized products aimed at niche markets and for emerging technologies. Public funding and the stimulus of umbrella programmes were crucial start-up factors.

European umbrella programmes

Our observations so far have been about individual projects and their success. Although our remit did not address the enabling European umbrella programmes themselves, our evidence showed that their objectives, although extraordinarily ambitious, were largely being realized at the individual project level. We saw examples of superlative cooperation that our evidence indicated would have been most unlikely before the advent of the umbrella schemes. Studies of projects at or near completion showed that industrial programmes had seeded a strategic competitive advantage for Europe and provided a springboard for a timely, credible and visible entry to the global market. The umbrella science programmes had had similar success. They had, probably not surprisingly, produced high quality science, but they had also generated technical world-firsts that were of strategic relevance to Europe. Participants and the European Commission alike were proud that they had demonstrated good value for money. Our study suggested that their pride was well justified.

Achievements

The last word must be market-related. In this case the audience is widespread—opinion formers, policy makers and prospective participants. The problems and constraints of international collaboration tend to attract wide publicity. The achievements are too rarely reported. This study has shown that, even without the improvements suggested, the benefits can far outweigh the costs.

1. BACKGROUND AND OBJECTIVES OF STUDY

Background

Significant opportunities for many forms of joint research and joint development occur across Western Europe. Although anecdotal evidence of their value is widespread, the Royal Society and the Fellowship of Engineering believe that there is a continuing need in the UK to stimulate further successful international cooperation. The Science and Engineering Policy Studies Unit of the Society and the Fellowship has therefore carried out a two-phase study targeted at a wide audience including Government, industry, universities, research councils and other research bodies.

First phase publication

The first phase entailed publishing a guide* in December 1987 whose purpose is to help the UK scientist and engineer to identify opportunities for collaborating in research and development with partners in Western Europe and to facilitate applications for funding.

Second phase

This report describes the results of the second phase—a critical appraisal of selected policy issues. The intention is to support and stimulate new initiatives. The report is therefore aimed more at policy makers and opinion formers than at practitioners of R&D.

The project was carried out by Dr Malcolm P. McOnie while on secondment to the Unit from ICI. The SEPSU Steering Group appointed a Task Group to guide the project, chaired by Dr I.D. Nussey, F. Eng. The other members of the group were Dr H.H. Atkinson, Dr M.J. Crumpton, F.R.S., Mr J.R. Fryer, Dr A.W.C. Keddie, and Professor A. Ledwith.

Aims

The appraisal was carried out as an in-depth analysis based on case studies. The purpose was:

- to identify positive benefits and achievements from collaboration: tangible and direct, less tangible and indirect, and unintended additional benefits;
- to understand problems and constraints, and hence to identify aspects for improvement;
- to examine the value of external stimuli, such as umbrella schemes and public funding;
- to determine critical factors for success;
- to propose pointers for follow-up action that would help West Europe as a whole, and the UK in particular, to compete more effectively.

---

* *European Collaboration in Science and Technology: A Guide for the UK Scientist and Engineer* (ISBN 0 85403 342 4). Available from SEPSU, price £25.00 (UK addresses), £27.00 (overseas addresses).

2. DESIGN OF STUDY

Case study approach

The subject was examined through case studies of individual projects, a bottom-up approach complementing numerous previous top-down studies by others generally evaluating entire programmes. Each of our case studies was conducted by direct interview with one or more partners in the project, often at different levels within each organization.

Using a standard framework of questions (Appendix 1), we asked the interviewees to select and concentrate on those issues that they considered were most important and relevant. They all made frank and instructive responses and, for related reasons of confidentiality, asked that their remarks should not be attributed.

In the interests of speed and cost-effectiveness the number of case studies was limited (to 22), but carefully chosen to form as representative a set as possible, covering different types of R&D activity, fields, types of partnership, scales of project and modes of collaboration, as shown in Table 1.

The study covered a broad spread of scientific and technological fields and ranged over all types of R&D activity, including basic research and the exchange of people and ideas, strategic and precompetitive research, and market-led R&D aimed at wealth creation through products, processes and services. Joint business ventures in the market place were excluded. So too were large dedicated organizations, like CERN and the European Molecular Biology Laboratory, and 'big' science, such as space science and astronomy.

Case studies were fairly evenly divided between academic, industrial, and joint academic-industrial partnerships, with costs ranging from under £100k to over £10m. A balance was also sought between programmes to which the UK had contributed substantial public funds, programmes that included many teams with relatively modest public or private funding, and other types of collaboration, e.g. club or private arrangements for the duration of a project. Many of the important European umbrella programmes for collaboration (EC, EUREKA, ESF) were represented. Two national schemes—the Alvey Programme and JOERS—were included for comparison.

One of the main purposes of the study was to identify good practice and factors that lead to success in cooperative research and development. Thus, almost all the case studies were chosen because independent observers and/or participants perceived them to be successful. This criterion notwithstanding, none was entirely trouble-free, but only two had problems that the participants considered to be severely disabling.

Headings of analysis

The discussion following is based exclusively on the evidence presented and the findings have been summarized under six main themes:

Getting started	Management
Umbrella programmes	Critical factors for success
Problems and constraints	Benefits and achievements

The Task Group has drawn certain conclusions of its own from the evidence and, where appropriate, these are identified.

TABLE 1 : MATRIX OF CASE STUDY CHARACTERISTICS

Type of research	Type of partnership			Scale of project					Arrangement for collaboration			
	Industry/ Industry	Industry/ University	University/ University	Under £100k	£100k to £900k	£1m to £9m	£10m and over	Confid-ential	European Umbrella Programme	UK Umbrella Programme	Club	Other
Basic Research			6	4	1	1			3 Stimulation 2 ESF			2
Strategic/ Precompetitive Research	4	5	1		4	4	2		2 ESPRIT 1 RACE 2 BRITE 1 Stimulation	3 Alvey 1 JOERS	1	
Market-led Research and Product Development	4	3			3	1	1	2	1 EUREKA		2	4
TOTAL	8	8	6	4	8	5	3	2	11	4	3	6

The figures give the number of case studies with the relevant blend of characteristics. Since a small number of case studies fall into more than one category, the totals do not always cross-check.

For each type of research, there are examples of group sizes from 2 or 3 partners to nearly 20 partners.

Fields represented

Advanced materials
Aerospace
Artificial intelligence
Biology
Biotechnology
Chemistry
Clinical medicine
Computer science
Consumer market
Design
Electronics & optoelectronics
Engineering
Environmental science
Information technology
Manufacture
Materials science
Mathematics
Medical research
Pharmaceuticals
Physics
Process industry
Standards formation
Telecommunications

3. GETTING STARTED

(i) Summary

We first asked participants why they had collaborated and how they had chosen partners. Their answers indicated that the road to getting an approved project with suitable partners was hard, but rarely rocky.

Perceptions of future markets and opportunities for marketable products, processes and services drove industrial cooperation in science and technology. Financial considerations were also increasingly driving UK academic interest in international collaboration, owing to domestic competition for limited funds.

University groups often selected partners they had worked with before. A company's choice of partner was more constrained because of business considerations. The prior existence of a national common interest community helped in finding partners. National competence in key areas of science and technology was also regarded as important so that the UK was both a credible contributor to international consortia and able to benefit by exploiting the results.

(ii) Reasons for collaboration

Industrial collaborators

The principal concern of our industrial respondents was the market and the provision of competitive products for market opportunities envisaged in the future. Among the many drivers for European collaboration with this business objective in view were risk sharing; improvement of competitive position; access to the larger international market; access to other organizations' complementary technical or commercial knowledge and expertise; and development of international standards.

Assessment of potential collaboration

With joint product development and its aim of immediate exploitation in a fiercely competitive market, we were told that there was no alternative to assessing a potential collaboration by detailed preliminary market analyses and quantitative feasibility studies on marketable products.

For joint precompetitive research, however, companies went more by instinct and with less quantitative rigour than for internal projects. Indeed, they found it extremely difficult to quantify likely benefits, generally citing the potential for earlier market entry, improved customer service and consistency with company strategy. They took a long-term view of the importance of building up broader understanding and experience for the future health of the business and of influencing developments beyond the home market.

Standards formation

One of the most potent stimuli for European cooperation was the development of international standards through to demonstration and implementation in the manufacturing environment and in the marketplace. Participants were convinced that programmes like ESPRIT and EUREKA made it easier for European companies to lead world standards formation, thus imposing a pan-European dimension on a global market.

Both vendors and users in successful multi-million pound projects were interviewed. The former saw harmonization enlarging the market and the latter saw it reducing costs and providing greater choice. The two parties had relatively few conflicts of interest and could adopt common and non-competing aims. One compelling reason for a joint endeavour was that no single company, however large, could muster the necessary resources, perception of market opportunities, or technological know-how.

SMEs

Political trends are to encourage small and medium-sized enterprises (SMEs) to take part in European programmes. We did not study this aspect in depth. We did note, however, that the larger projects tended to attract predominantly the larger companies. This was understandable, since only the big suppliers had the muscle and market knowledge and only the big users possessed the resources to prototype on a large scale.

Some of the case studies involved SMEs, including small research institutes, often as a subcontractor. Their larger partners clearly valued their contributions, which normally took the form of a specialist service, e.g. in software or equipment testing. SMEs were also more flexible in project organization and personnel relocation. On the debit side larger organizations felt that SMEs lacked the management expertise and financial resources to tackle more general assignments in big projects. In one case, however, a small consultancy firm possessed sufficient technical and commercial expertise to be the project manager.

Academic collaborators

Increasingly it is financial considerations that are driving the UK interest in academic research collaboration with other countries in Europe. UK universities are looking to European schemes as a source of funding because the total amount available in the UK for the practice of research is diminishing and money for certain purposes is not available through the research councils. There was strong evidence that careful formulation of new programmes for university collaboration was required in order to emphasize other non-pecuniary factors recognized as critical to successful cooperation. Aspects cited included high quality of researchers, laboratories and science; good personal relationships and networking; assembly of complementary knowledge and skills; and opportunity for serendipity.

Serendipity is an overlooked, but important, element in identifying opportunities for worthwhile collaboration, requiring exposure to developments outside one's speciality and an appreciation of the potential when other fields converge on one's own. This was found in two cases where the original ideas for revolutionary advances in clinical practice across the world were seeded by fortuitous meetings in which one researcher recognized the important implications of another's chance remarks.

(iii) Choice of partner

University–university collaborations

International academic links appeared to be well established at the professorial and other senior levels. It was therefore not surprising that virtually all the academic collaborations studied were based on international links that had been developed over many years. We were told that there was frequently a better opportunity overseas to match skills. Choosing another academic partner of sufficient merit and with complementary skills therefore did not pose a problem. These complementary skills arose not only between disciplines but also through the differences in training in the same subject at different schools.

Industry–university collaborations

We found that links between individual companies and university departments were generally much less developed across frontiers than within the UK. To a large extent UK companies still chose UK universities that they had worked with successfully before, and vice versa, for European as well as UK projects.

The best UK university departments had an international reputation. They had been courted by foreign firms as well as UK firms to join EC industrially oriented programmes such as ESPRIT and BRITE. One of the universities had adopted a policy of having at least one UK industrial partner whenever possible, so that technology transfer from university to industry in these international programmes would be of direct benefit to the UK. For this reason the Task Group would like to see UK university-company duos encouraged more widely and also UK industry, like its competitors overseas, more actively seeking partnerships with the best university departments and research institutes in other countries.

Industry–industry collaborations

Industrial companies often found it difficult to identify the right partner, as, unlike the universities, they had to minimize potential conflicts of business interests with both existing and potential competitors.

Intranational community

There was widespread evidence that prior existence of a national common interest community helped in finding partners. There was also a consensus on the importance of getting the national act together first, so that the UK was seen as a credible partner in international consortia and was able to exploit the results in competition with the other nations. Some companies in our survey had belonged to groups of UK companies that, stimulated by a UK government department or contract laboratory, had previously examined the case for a UK joint project, e.g. to develop advanced materials or standards for consumer goods. They had concluded that a UK initiative was not a viable proposition because the UK on its own lacked the necessary resources or market opportunities. When programmes like BRITE and EUREKA later presented the opportunity for assembling the critical mass of resource, the groups were able to provide a real force in wider European initiatives with much improved technical and commercial prospects.

4. UMBRELLA PROGRAMMES

(i) Summary

Brand names were important for marketing and identity. The European umbrella schemes with their official blessing strengthened the credibility of individual initiatives for transfrontier collaboration in R&D. The benefits extended beyond the projects to the market place, with much evidence that association with particular programmes brought favourable international publicity and credibility with customers.

(ii) Selection of case studies

EC umbrella programmes

The European Community (EC) and the European Space Agency (which we did not study) are easily the largest sponsors of European science and technology. Most of the former's R&D activities are conducted under a multiannual Framework Programme, through which various broadly targeted programmes are developed and operated. We chose eight projects in all from four of these programmes. Three were pre-competitive industrial research programmes—ESPRIT I, RACE (Definition Phase), and BRITE for information technology, telecommunications and traditional industries respectively. The fourth—the Stimulation Programme, now renamed the Science Programme—was aimed at stimulating cooperation and mobility of researchers in exact and natural sciences. It was of particular interest to, but not restricted to, academic researchers.

EUREKA

We selected one project from the EUREKA Programme, a pan-European framework for transfrontier collaboration in market-led high technology projects. EUREKA's aim is to produce internationally competitive products, processes and services, complementing EC pre-competitive research.

ESF

We looked at two, much smaller, projects under the auspices of the European Science Foundation, an international non-governmental organization, whose members are academies and research councils with national responsibility for supporting scientific research. The ESF seeks to identify areas for beneficial European cooperation, to promote the mobility of researchers and to provide the initial stimulus for setting up collaborative programmes.

UK umbrella programmes

Finally, for the purpose of comparison, we studied four examples of industrial and university collaboration in the national Alvey and JOERS precompetitive research programmes in information technology and optoelectronics respectively.

(iii) European Community programmes

Motives for participation

Structured European R&D programmes could be potent, and potentially pervasive, agents of change, facilitating initiatives that were formerly inconceivable. Although by no means the only motive for participation, money was naturally a most powerful stimulus, particularly for projects beyond company or national capacity. Other factors cited were effective management frameworks and convergence on key initiatives that reduced duplication and accelerated progress. The programmes provided a nucleus on which a project champion could credibly base an initiative and build a consortium.

Although the average unit cost of the Stimulation Programme for science was quite small, the universities perceived that the benefits were great. The very act of collaboration imposed extra academic rigour. In addition, with the discipline of a formal arrangement, participants and funding bodies alike gained from greater commitment to targets and persistence in overcoming problems.

Science is international, but overseas travel was said to be the first victim of financial pressures on UK budgets for small science. Our evidence showed the vital part EC grants were playing in facilitating transnational visits, exchanges and collaboration. Although the schemes emphasized the academic exchange element, it was felt that money should be made available to pay also for specialist technicians, where essential. In larger projects, a management allowance provided welcome flexibility and desirable control.

Communication with EC officials

As in so many decision-making processes, *face-to-face contact* with the European Commission (Commission of the European Communities) in Brussels was deemed essential. This accorded with the Continental practice of communicating orally whenever possible and held whether one was aiming to keep abreast of general developments or one was seeking more specific advice on individual project proposals. The domestic habit of written communication placed the British at a considerable disadvantage in contacts with Brussels compared with other nationalities. Virtually all of our survey respondents had adopted the Continental practice of visiting or telephoning rather than writing. All our respondents praised the commitment and helpfulness of Commission officials they had met.

Despite being somewhat obscured by the style and Eurospeak of standard contracts (though at least these are now being harmonized), the genuine wish of the Commission to see projects successfully completed was demonstrated in helpful and flexible responses to particular concerns of participants. Typical comments from participants concerning European Commission management were that it was clear and firm about what it wanted, was able to distinguish between good and problem projects, and devoted more effort to the latter while not interfering with the former.

Administrative procedures

The main criticism voiced many times, by companies and universities alike, was directed at the EC and UK administration procedures and concerned specifically the delays and inefficiencies in negotiating contracts and paying claims. These shortcomings apart, neither in Brussels nor in London did central bureaucracy appear to be the unwieldy problem that it is so often made out to be. The Commission was well regarded, for example for its effectiveness in assessing a large number of proposals and for its workshops and conferences to share and disseminate experience.

Universities, without in any way hiding their own shortcomings on the administrative and management side, were less happy than companies with the requirements of the EC programmes. They had particular problems in extracting the information required from their own financial officers. Some universities had appointed European Community Liaison Officers, but, in the absence of a concerted UK university initiative, research councils had taken the lead by setting up their joint office in Brussels to improve communication between the UK academic sector and the Commission. One company was similarly helped greatly by having a local office in Brussels to interpret the policy and workings of the Commission.

Follow-up projects

We tried to test the willingness of respondents to repeat the exercise even without the stimulus of public support. It was suggested that Government was under a misconception that, having completed one publicly funded project, companies would automatically be prepared to finance all of the follow-up work themselves. In several cases successful collaboration was a spur to generating new precompetitive research proposals that addressed even more novel and higher risk technology, for which industry would continue to seek further external support.

It was deemed not only acceptable, but also desirable, to have some interval between projects in order to reflect and regroup. The recent delay, however, in European Council approval for the Second Framework Programme had been long enough to be particularly frustrating for organizations seeking funds for follow-up projects. It was suggested by them that some bridging mechanism should be provided to maintain momentum and credibility.

(iv) EUREKA

We studied one very large and successful UK-led EUREKA project in the standards area. Unlike the uniform conditions of EC programmes for all nationalities, the means and level of support in EUREKA projects were bound by national rules. It was here only that we met strong criticism of DTI policy. The UK companies involved in the EUREKA project perceived that other countries had more generous rules than the UK. The way the DTI had debated and applied its 'additionality' criterion (see p.18) was felt to have been inequitable, particularly in relation to the preparatory phase, which was key to the ultimate effectiveness of a complex project. Since that time procedures have been greatly improved by the DTI decision to contribute funds towards a definition phase for many EUREKA projects. Nevertheless, the Task Group believes that greater clarification is desirable of anomalies created by unevenness of funding criteria and procedures, and by different national tax regimes. Similarly, decision timescales in different countries could be synchronized, at the same time removing unnecessary obstacles and differentials.

(v) European Science Foundation

ESF activities were examined in two fields, both of which were on a relatively modest scale and judged by participants to have been successful. We concluded from their remarks that the activities of the ESF provided a useful, low-cost pump-priming mechanism over a prescribed time. ESF initiatives were not allowed to compete with the activities of member research councils, but could fill gaps in EC support and lead to larger European research and training projects with more substantial EC funding. For this reason the participants felt the ESF to be particularly worthwhile for promoting joint research and exchange of results in unfashionable or under-resourced subjects of potential significance, and in topics where a shortage of data magnified the value of sharing field and laboratory results. The UK, which like other countries could not afford to do everything, continued to benefit from such access to other countries' data.

The ESF mode of operation involved little formality and the outcome depended on the contribution from nominated individuals. The value of this approach was exemplified by rapid intelligence on topical information, the development of a united international approach to research proposals, and scientifically excellent workshops. A mark of success was the subsequent pervasiveness of these interactions.

Respondents identified a risk that this reliance on individuals made ESF initiatives vulnerable to established interests, rivalry between individuals and splinter activities. Given that ESF funding is in the gift of the research councils, it was suggested that they did not do enough to encourage opportunities presented by ESF programmes for unusual combinations of disciplines and young blood participation. Protection of these important aspects should not be yielded to large grants in fashionable subjects for established researchers.

(vi) UK programmes

Development of national competence

We heard of several examples where SERC and DTI had provided pump-priming for emerging science and technology projects at a national level that had later formed the foundation for a project with European funding. Such a two-stage strategy could help to provide the necessary knowledge and skill base to allow the UK to contribute to and benefit from a wider international initiative. Evidence supported this proposition. Added to this, participants said that, both at home and abroad, the Alvey and JOERS label had been a distinct marketing aid, lending credibility to the research and its outcome.

Three projects in the Alvey Programme and one in the JOERS Programme were studied. There was general agreement that these programmes had established a national community and competence in key areas of science and technology and provided a competitive springboard for credible UK participation in international programmes. UK industry at the same time had become much more aware of the stiff overseas competition.

Among the favourable comments by participants, who had wider experience of the programmes than the case studies being examined, were the following: the programmes had made high risk projects possible, broken down historical organizational barriers in this country, strengthened industry-university links that were previously fragmented and sporadic, facilitated technical progress by concentrating resources and avoiding repetition, and generally created a positive mood towards collaboration.

One senior academic with longstanding experience of joint applied research with various industrial companies observed that the greater openness fostered by these UK fora for technical exchange was a good counter to inter-company suspicions and rivalry that increased as R&D approached commercialization.

Precompetitive collaboration

We detected a genuine confusion regarding '*precompetitive*'. In the national endeavour to create an identifiable and competitive community, partners in UK programmes were expected to share in all the tasks and to exchange all the knowledge arising from their project, working in concert through a series of closely interdependent targets. This sometimes proved to be a very painful experience. For example, one project was difficult to manage principally on account of the national programme policy to allow every UK company with a justifiable commercial interest to participate. This led to an unwieldy number of partners, all of whom were potential competitors. As a result progress was hindered by politics at the management level, unevenness of commitment and problems in communication. The project was ultimately successful only because of the enthusiasm of individuals at the laboratory level and their willingness to exchange information more freely than their senior management.

The same organizations had a different opinion of European collaboration. They found that it was layered in such a way that each partner was allowed and expected to carry out a separate and clearly defined share of the work. Thus, although partners were required to disclose information to one another, each could concentrate on its own part. These two approaches brought different benefits. EC programmes were easier to manage, while UK programmes probably achieved a greater sharing of technology amongst the participants.

Administrative problems

Although our evidence indicated that the principles behind the UK programmes were well founded, we met two areas of criticism in the practice. The first was the inconsistency and variable quality of official interventions, which might have been remedied by using independent professional contract managers. Partners in problem projects felt that a more active role by external assessors could have resolved project management difficulties earlier and assisted organizations that were not accustomed to collaboration.

The second, and more severe, criticism from a number of sources was frustration at the administration. Participants cited major difficulties in obtaining the initial contracts, mismatch between the short funding periods and a realistic length of contract (probably at least three years) for attracting good academic researchers, extreme delays (sometimes more than six months) in settling claims, and lack of synchronization between the funding decisions of DTI and SERC. Although these shortcomings did not negate the overall benefits described above, they did produce a long-term detrimental effect on the projects.

(vii) Harmonization of programme rules

Level of financial support

The differences between the rules for EC and UK programmes—level of public support criteria for support and intellectual property arrangements—caused appreciable confusion and unease. In its industrial programmes the European Commission negotiated the size of a project and then offered a fixed proportion (50%) of industry's eligible costs. On the other hand, for UK industrial projects, the DTI negotiated rates of support. It therefore did not automatically offer industry 50% of costs, although it often did so in certain designated areas.

With the increasing attention being paid in universities to costing projects realistically, we detected support in some academic quarters for UK funding to be related, like Government support to industry, to full economic costs instead of marginal costs. One witness noted that trading in marginal costs was a route to bankruptcy. He approved of the new rules being introduced in several EC programmes allowing universities to opt for recovering 50% of actual costs instead of being constrained to 100% of marginal costs.

Additionality

The DTI considered Government support only where it could be shown to influence the existence, scope or scale of the project. An applicant had therefore to show that the project would not go ahead without assistance, or would take longer to complete, or would be on a smaller scale. The EC did not impose this '*additionality criterion*'.

IPR

UK programmes such as Alvey and JOERS required a university to assign to its industrial partner(s) all intellectual property rights that it generated within a joint project in return for a royalty. The EC contract now being adopted for the latest industrial R&D programmes offers universities that are full partners the same rights as companies to exploit common results. Alternatively universities may, in return for giving up those rights, ask for a revenue or suitable other recompense for exploitation by the commercial partners. UK universities naturally saw these new EC arrangements as more even-handed than UK practice.

Scope for harmonization

These were several examples where respondents felt that UK rules should tend towards EC practices. The Task Group feels, however, that the arguments for complete harmonization are by no means compelling. Harmonization does not take into account that some work is better done nationally, for which European rules are not necessarily optimal for local conditions. Also, public support contributions ought to reflect the extra costs carried by international collaboration. Nonetheless, the Task Group believes that the differential may at the moment be set too wide, since some UK companies were currently not joining in UK programmes but were waiting for EC programmes.

5. PROBLEMS AND CONSTRAINTS

(i) Summary

None of the projects was entirely trouble-free, but only two had problems that the participants considered to be severely disabling.

Everyone agreed that a joint project, especially an international one, took longer to set up than an internal project, required more effort to run, carried a higher administrative overhead and was subject to greater constraints.

More specifically, the problems most commonly met concerned conflicting aspirations, large project management and intellectual property. Other important constraints were bureaucracy, shortage of university funding, recruitment and communication. We consider each of these in turn.

(ii) Conflicting aspirations

Misaligned consortia

The funding agencies were probably responsible for unsatisfactory situations in three cases through inept formation of consortia, either by introducing inappropriate partners or by merging two or more proposals into one. This led to conflicting aspirations, emphasizing incompatibilities rather than common interests.

In one example, two academic groups in different fields were unable to agree shared goals that satisfied the aspirations of both parties. In a second example, four proposals were force-fitted into a single project, creating many complications, but especially a lack of commitment to a common objective. This was demonstrated by absence of sponsorship at the highest level and lack of continuity of personnel. Much of the project management effort was dissipated in educating new individuals within the project team, a process that took up to six months.

Supplier-user collaboration

Supplier-user links were amongst the most fruitful collaborations. Yet suppliers and users had different perceptions, which could be difficult to reconcile. The former saw the activity as a research project and therefore liable to modification as results emerged, while the latter had definite requirements for applications and obligations to their customers. Thus the extent to which real manufacturing lines could be used for experimental demonstrations or prototypes was constrained by more immediate production needs.

Industry–university collaboration

Industry's natural approach was to target work at a specific technology or end product. Even so, some industrial project managers had trouble in convincing their creative research scientists of the importance the company attached to obtaining commercial applications out of their work. Both industrialists and academics told us that university researchers working alongside industry were likewise often more interested in exploring new science than in solving specific problems for commercial exploitation. In addition, industrialists did not have the resources to follow up all the leads provided by the more creative university departments. Industry might therefore be perceived, often wrongly, as not interested. Inevitably, then, conflicts could arise in industry-university collaboration. Everyone acknowledged the need for research to be focused on agreed objectives without stifling creativity; no-one had the answer. The most favourable conditions arose with an enthusiastic and powerful project champion.

(iii) Large projects

Management aspects

Large international consortia posed a special challenge in the art of management on account of sheer size, variety of organizational and national cultures, and fragmented and distributed resources. In one case, when management capacity fell short of what was required, the project suffered through inadequate groundwork, lack of overall direction, and failure to achieve its original goals.

With linked targets, work on different sites had to proceed in unison and the project could move only as fast as the slowest member. Several project mangers said that joint projects were therefore particularly frustrating for their technical staff, who could not see the whole picture and yet had to rely on other partners to deliver their contributions on time.

Assessment

The emphasis in many projects on complementary skills from the various partners made it difficult to ensure objectivity and validity of the results. The greater the diversity of activity and specialisms, the more difficult it was for project management to assess the value of contributions from the disparate sources independently and accurately.

(iv) Intellectual property

Problems often pre-empted

We had been led to expect many problems associated with intellectual property. While no one suggested that intellectual property rights were unimportant except in purely academic projects, the comparative lack of major problems was notable.

There were probably several reasons for this. First, most of the publicly funded industrial research schemes supported precompetitive research and any commercial conflict would normally not be apparent until the later exploitation phase.

Second, mindful of the pitfalls, experienced industrialists made a conscious and painstaking effort to anticipate all foreseeable eventualities in the agreements drawn up during preliminary negotiations and to ensure that each partner had a suitable exploitation route. Negotiations over the participation in EC programmes of European subsidiaries of multinationals based in the USA were particularly tough.

Goodwill

The final point is very important. In several cases we were impressed by the flexible and positive attitudes to collaboration shown by very different organizations. Their goodwill went a long way to counteract the naturally cautious legal background prevalent in joint commercial ventures. Like them, we would like to see more creative legal minds addressing the question of how best to support, rather than constrain, cooperation.

Such problems as did arise in the course of a project were generally satisfactorily resolved. Examples included publication procedures in industry-university cooperation, conditions for a new partner joining an established consortium and supplementary provisions for extending a project. Ongoing problems included reward for academic contributions to product commercialization; differences in patent law between countries; and difficulties found by universities and smaller companies in understanding the patenting process.

(v) Bureaucracy

We have already noted in Chapter 4 the frustrating delays and inefficiencies in the funding agencies over negotiating contracts and paying claims.

(vi) University funding and recruitment

Lack of facilitating funds

Shortage of university funding was a grave constraint. University staff identified a number of consequently unsatisfied needs. The first was short-term travel grants to attend conferences, which were increasingly being organized on a European, rather than a national, basis. Secondly, the professors we spoke to were keen that their young researchers should take part in overseas exchanges and visits so as to be exposed to the international dimension at an early stage in their careers. British Council and similar grants were available, but were nowhere near sufficient to satisfy all the perceived requirements. Thirdly, mathematicians felt that their modest requirements for overseas travel and subsistence were too often forgotten in competition with substantial grants for equipment to their fellow natural scientists and engineers.

Recruitment problems

These funding constraints had a knock-on effect. Universities were unacceptably affected by the bureaucratic delays mentioned above. There were many instances where such delays exacerbated difficulties in academic recruitment arising because specialists were in short supply or the grant period was not long enough to attract good benchworkers. The result was suboptimal rescheduling and excessive remodelling of project goals because requisite skills were not available.

(vii) Communication

Multi-site projects

Management control and communication were immensely easier if a central team was created on a single site. However, our respondents found that this was rarely a practical proposition because of the difficulties in relocating staff temporarily, although smaller companies appeared to be more flexible in this respect.

Multinational companies

Multinational companies started with advantages. They often had common structures and planning systems that facilitated cooperation between subsidiaries. Even they, however, found that they were constrained by cultural differences and that these differences introduced further complexity when other organizations were involved. Notwithstanding their common vocabulary, their experience underlined the importance of defining terms unambiguously. This was particularly difficult in contract negotiation, vendor-user collaboration and interdisciplinary work, even within groups for whom English was the mother tongue.

(viii) Sector-specific examples

We have described above the most common problems and constraints. It may be instructive to show that each sector had, in addition, its own set of constraints. Four examples below respectively illustrate such experience on the part of a start-up company, a medical researcher, an aerospace company and several consortia developing standards for international exploitation.

Start-up biotechnology company

International links in molecular biotechnology are well developed, based on the vigorous growth in leading edge academic research. The well-connected start-up biotechnology company we interviewed had made good use of this high quality scientific network both for selecting projects and for carrying out R&D. However, it lacked the breadth of expertise required to be commercially successful on its own. As the funding moved from start-up to top-up, it found that the transfer of emerging technology from academic research to European industry was impeded by the cautious or impatient attitude of European investors and the reluctance of large corporations to stimulate the new technology. When the small company wished to move its novel products towards the market, therefore, it had difficulty in obtaining good advice, finance and suitable joint venture arrangements with a larger company with manufacturing and international marketing expertise.

Medical research

A second case study highlighted an instance, which was apparently not exceptional, of medical research identifying a drug or a procedure that was useful in treatment but not commercially viable. A charitable research institute played an important role in carrying through the research and development activity without needing to resort to commercial justification, but had neither the facilities for scaling up to production nor the resources to cover more than a small proportion of such cases. Hence the requirement for investment in medical research with little or no perceived commercial return frequently goes unfulfilled. The extent to which the public sector should intervene is a matter of government policy, but such intervention would be more feasible on the larger European scale and would be assisted if the regulatory dimension in Europe, which adds substantially to development costs of new treatments, were less fragmented.

Civil aerospace

We heard about the great constraints faced by the aerospace industry over selection of partners from a small pool of increasingly specialized companies or consortia. Collaboration was often imposed as part of the project specification, but choice of partner was usually strictly limited by political considerations at the national level as well as business factors. On the rare occasion when there was a free choice of partner, the company had to choose between an existing competitor, with attendant problems of intellectual property rights, or a non- competitor, at the risk of creating a new competitor.

International standards formation

From four of our case studies, we found that standards formation meant considerably more than just technical definition. Remarkable progress had been made technically in developing and demonstrating European standards in a number of areas, but project managers had found that there was little political and commercial urgency in introducing them to the market. There was evidence that international exploitation of the initiatives was also being held up by unhelpful processes for developing and approving standards, which depended too much on national bodies, and by public sector delays in take-up. At the same time, industry needed to anticipate better the difficulties inherent in the approval mechanisms.

6. MANAGEMENT

(i) Summary

There was strong agreement that a prudent level of management/ administration overhead was typically half as high again as for an in-house project. Ultimate success of projects depended on substantial investment in management and planning. Management of large consortia was especially difficult, but there was no pool of knowledge on good and bad practice. Our case studies showed the importance of a framework separating policy and leadership from technical management and from administration. Outstanding best practice was identified in each of the these categories, some of which was not unique to cooperative projects.

(ii) Setting the direction

Focused preparatory work

During the study there was an almost universal expression of the importance of focused preparatory work. The rate of change in the market and the complexity of the technology made direction-setting at the executive level crucial. Lead contractors in ESPRIT and BRITE projects quoted 3 to 4 man-months gainfully occupied in negotiation and planning. A similar level of effort was required to set up a new industrial R&D club.

Key tasks

The consensus was that this preparatory phase should build up the optimum framework for cooperation, management structure and support systems. Not surprisingly, key tasks included

- reaching clear agreement on the nature of the collaboration, its broad objectives and the role of each partner;
- setting out an overall work plan defining activities, timescales and resources;
- drafting a clear and comprehensive set of contractual agreements;
- agreeing an appropriate management structure and lines of accountability for each participant;
- establishing a robust system of communication between all groups.

Feasibility studies

Large projects carried immense investment. They also had the potential to go badly astray. In the interests of all parties, it may be that every substantial publicly supported project should be required to have a pilot feasibility study with a breakpoint. It would seem from the case studies that the threshold project size might lie somewhere between £1m and £10m, depending on the complexity and perceived risk of the proposed project. This pilot study should also be eligible for proportionate public support. The DTI has already adopted such a procedure for certain EUREKA projects.

(iii) Management structure and systems

Optimum number of partners

Managerial and financial control were cited as the reasons why partnerships could not realistically exceed 12 to 15 members. Even then, in the interests of clear objectives, it was advisable to split up the work into virtually autonomous smaller projects, each with fewer teams. In small consortia, each team could more readily contribute a large resource to a well-defined and substantial slice of the work.

Clubs

In certain circumstances the club arrangement was increasingly being used to handle a large number of organizations without significantly fragmenting the work. In a club a number of companies joined together to sponsor industrial R&D in a single independent laboratory or occasionally a small number of laboratories. One international club, which the participants saw as successful, was developing enabling technology for the offshore industry. Another was carrying out generic research in advanced materials for an alliance of suppliers and users.

(iv) Best practice

Dissemination of best practice

Despite good intentions, management of large consortia was a problem. There was no pool of knowledge on good and bad practice, though clearly there was a need. The Task Group concludes that succinct guidance for all new consortia, for example a brochure or short seminar, would be nationally cost-effective. Funding agencies might make funding conditional on attendance at such a seminar. Any such guidance would cover best practice considerations such as

- agreeing a leadership role among nominal equals;
- a procedure for reaching timely consensus;
- a process for ensuring agreed actions were carried out;
- the ingredients of the collaborative agreement.

Separation of functions

Our case studies showed the importance of a framework separating policy and leadership from technical management and from administration. We were able to identify some outstanding best practice in each of these categories.

(v) Policy and leadership

Policy committee

Large projects required a senior policy committee with a representative from each organization. It was responsible for overall policy and direction, resource allocation and determining actions. Projects were impeded where management representatives had to report back before decisions were ratified, showing how important delegated responsibility was.

Leadership

Success also depended on strong, yet unselfish, leadership from the prime contractor. We saw how important this leadership was in obtaining consensus, channelling democracy and avoiding the divisive effect of invoking the voting mechanism. Successful projects rarely called on the latter device, which suggests that it might be irrelevant.

Teamwork

Critical success factors included establishing, and then sustaining, trust and teamwork at both management and project level. This required, generally speaking, considerable patience and application and, most particularly, continuity of personnel.

In-house dissemination

Given that participants would wish to use the results of the collaboration as widely and effectively as possible within their own organizations, dissemination processes were required. Few had thought about this. In-house management intentions could beneficially be defined during the planning stage.

(vi) Technical management

Project manager

There was overwhelming evidence that technical success hinged on having a capable project manager, normally funded by the consortium. He or she was responsible to the policy committee for technical progress, a full-time job in large projects. The project manager had to be clear about the strategy, a good communicator, and able to achieve a balance between cooperative teamwork and the natural human desire to compete.

Technical committee

In all but the smallest projects a technical committee was also required, comprising a technical coordinator/project leader from each organization. These project leaders were responsible for their organization's technical direction, budgeting control and reporting. They were also accountable to the project manager for their team carrying out agreed actions towards clearly defined goals.

Electronic messaging

Experience at the project level of electronic messaging (e.g. electronic mailboxes) was positive. Those who were pioneering its use for communicating with another partner were able to demonstrate its power and benefits for strengthening inter-site dialogue on project management. We also established its importance for joint text preparation and editing. Nonetheless there were inhibitors: inability to agree communication and equipment standards, and apparently inadequate security in public systems for transmitting commercially confidential information. It was not surprising that electronic messaging played little part in sensitive matters such as, policy formulation.

(vii) Administration

There was strong agreement that a prudent level of management/administration overhead was close to 10%. This was typically half as high again as for an in-house project. For example, one of the largest projects had a permanent management/administration staff of four serving fifty researchers from several companies and universities.

In most projects the lead contractor handled the overall administration of financial matters, documentation and report collation. Generally project control seemed to be most successful when kept simple. Only in the very largest projects were computer-based systems essential.

7. CRITICAL FACTORS FOR SUCCESS

(i) Summary

Our study examined in depth the critical factors for success. Strikingly, there was no discernible difference in the views of those participating in successful projects. All readily identified the same few important factors at the corporate, project and personal levels. We noted that, the more complex a project was, the more critical these success factors became. In describing these factors, however, we are not suggesting that a simple two-way academic exchange should be subjected to the same rigour as a large alliance of big companies.

(ii) Corporate level

Project champion

An influential champion was quintessential. He (in our case studies we met no women in this role) should be supported by a strong and committed leadership cadre. To succeed, that cadre too should be confident of a successful outcome.

Preparation

Thorough preparation was key. Establishing the right framework, technical activities, management structure and support systems needed significant commitment of management time.

Management and technical calibre

Ambitious goals were not achieved without high calibre management coupled with a comparable high quality science/engineering base. The commitment implied in this must be sustained.

Relevance to each partner

The project should fit comfortably with the overall strategy and commercial aspirations of each organization. Senior respondents in particular showed a wider vision in noting that potential problems and disadvantages of collaboration could be outweighed by unanticipated benefits.

Each partner needed to identify a clear exploitation route. In addition the project required a recognizable common goal and a structure that avoided conflicting interests so that competitors could pool experience. Respondents emphasized strongly the importance of a deliberate and managed process of dovetailing complementary interests and skills. We saw many instances where this process built team interdependence and accomplished results greater than the sum of the parts.

(iii) Project level

Milestone management

Milestone management, i.e. delivery of results to an agreed standard of performance, timescale and cost, provided a challenge and focus for a project. It worked even if the exact nature of that focus could not be defined at the outset and it inhibited degeneration into a luncheon club. This said, initial arrangements had to allow for tactical changes.

Project manager

A project manager/principal investigator, usually appointed from the lead organization, was required. Responsibilities included fostering the common purpose and coordination. The job was certain to involve exceptional amounts of travel and workload.

Group responsibility

In every successful project the teams demonstrated enthusiasm and group responsibility. This resulted in rapport and trust, which in turn drove forward technical aspects. Notwithstanding the additional advantages of electronic communication, effective working relationships were built on timely personal contact.

(iv) Personal level

Motivation

Every individual researcher needed motivation. For those from industry, external relationships often enhanced career prospects. University researchers sought wider recognition from their peers. Suitable rewards for academic scientists working jointly with industry were less obvious, though one company had agreed to share the income from patents.

8. BENEFITS AND ACHIEVEMENTS

(i) Summary

In Chapter 3 we introduced the reasons for collaborating internationally and the anticipated commercial and scientific benefits. In this chapter we present the benefits that participants actually experienced. There was some mismatch between the two, principally because many participants had gained unforeseen advantages in addition to the intended ones.

(ii) International versus intranational collaboration

Relative merits of international and intranational collaboration

It has sometimes been mischieviously implied that international collaboration is valuable for personal reasons. Our evidence suggested the contrary since for most of our respondents international travel itself had become a chore, though they greatly enjoyed the congenial hospitality of colleagues overseas. Much more significantly, the majority of our respondents believed that they had achieved more by collaborating internationally than intranationally, despite the expense and distance. Given that we had chosen the sample with success in mind, this finding was unremarkable.

We have already noted the competition for limited academic funds and the frequently better opportunity overseas for matching skills. One professor had found his prospects for UK funding enhanced by having carried out a successful international collaboration.

With one exception we found no real difference in the effort required to build up trust and understanding between companies in our country or in several. That exception, a company with wide experience in many types of collaboration, was convinced that the European dimension required less effort.

International collaboration

For successful industrial projects some form of direct commercial payoff had been obtained or was in prospect. In academic projects the equivalent pay-off was international recognition—papers, invitations to chair conferences and numerous visitors. In over half the projects, industrial organizations or university researchers had in addition improved their competitive position in science and technology and benefited through knowledge transfer from their partners.

Minority opinions of further benefits included spin-off science and technology and new project concepts; changes in attitude resulting from greater knowledge of international developments; a higher profile abroad and a correspondingly less insular approach; development of management experience and improved management practices; enhanced career development. The majority of those interviewed confidently expected to maintain their links with the same or similar groups.

Intra-UK collaboration

We selected examples of intra-UK collaboration for comparison. These showed that fruitful cooperation bringing similar returns was possible at home. The very act of collaboration built better awareness of overseas competition as well as unexpected spin-off in adjacent fields. The small sample suggested that, for specialized products in niche markets or products based on emerging technologies, cooperative efforts were best mounted nationally.

Two out of the four domestic projects studied had been completed. In one of them the UK was out on its own with no discernible competition. Although the resulting publicity had spawned new mainstream business, this generic achievement had found the market development side of UK industry unprepared. In the other project the UK had caught up with the USA and Japan and developed its own world-class product. These two projects achieved international success without overseas collaboration. Public funding and the stimulus of umbrella programmes had evidently been crucial start-up factors.

International markets

Unlike the above, the remaining case studies had no such domestic opportunity to draw on. We remarked earlier on the scale of the benefits from international collaboration and especially the enlarged market increasing the benefits of investment. We noted also enhanced reputation of participants arising from public demonstrations of their achievements, spin-off business opportunities for products and consultancies, and the frequent need for a pan-European initiative to match US and Japanese competition. This last point appeared particularly important.

(iii) Achievements of particular types of programme

European umbrella programmes

Our observations so far have been about individual projects and their success. We noted, however, that the enabling umbrella programmes had been highly successful as well. We were told that, as recently as the early 1980s, the perceived wisdom in national governments and industry had been that Europeans were not clubbable and that a regime dealing satisfactorily with intellectual property held in common was not conceivable. The Brussels proposals were thus extraordinarily ambitious. It was therefore instructive to find that the participants felt the programme objectives were, in their individual projects, largely realized. We saw examples of superlative cooperation that would have been most unlikely only a few years ago before the advent of the umbrella schemes. Studies of projects at or near completion showed that industrial programmes had seeded a strategic competitive advantage for Europe and provided a springboard for a timely, credible and visible entry to the global market. This was illustrated by two large projects for standards formation—an ESPRIT precompetitive project to develop and demonstrate manufacturing application standards and a EUREKA market-led initiative for consumer goods standards. Participants were in the forefront of world developments, thereby imposing a pan-European dimension. Products will follow quickly in both instances to the benefit of the customer.

Privately funded programmes

One successful example of privately funded work was the joint development of a revolutionary drug. Another was the development of an outstanding clinical procedure. Neither would have been possible without a critical mass and range of skills unavailable at home. Both developments brought substantial scientific and therapeutic spin-off globally—more than 100 publications per month in one instance arising from research around the world.

Basic research programmes

By basic research standards, the European Science Foundation is a relatively small organization. Yet its well-developed network resulted in considerable leverage right across Western Europe in two ways. First, it could seed activities in areas not covered by EC schemes and in other unfashionable or under-resourced subjects of potential scientific, social or economic importance. Second, the UK, which like other countries could not afford to do everything, continued to benefit from access through ESF to other nations' work.

In small two-way academic exchanges the academics claimed with a great deal of conviction that the dovetailing of their knowledge and expertise with those of their overseas colleagues had produced more effective problem-solving and a greater output of high quality publications.

Strategic research programmes

This effect was also shown on a larger scale in one big basic and strategic research project involving some 50 researchers across Europe. Admittedly the project was carefully selected by the EC as one of the prototypes for support under its Stimulation Programme. It had the right mix of political and technical ingredients for the EC. First, the field was not only scientifically exciting but it was of long-term economic importance to Europe in competition with the USA and Japan. Second, the subject was ripe for a concerted transnational effort. Third, the participants included all the dominant European teams with interests covering the whole range from theory through experiment to demonstration of the technical effect.

The achievements were impressively broad and were recognized globally. Scientifically, the team achieved many world firsts of significance and a prodigious list of publications. Technologically, it demonstrated the first device and expected substantial spin-off in other fields. Finally, and very important, both the participants and the European Commission justifiably took pride in the value for money from this one 1.8 MECU (over £1 million) investment.

APPENDIX 1. FRAMEWORK FOR INTERVIEWS

1. **Background**

1.1 What were the main reasons for collaborating and your principal objectives?

1.2 When and how did you choose your partner(s)?

1.3 What was the nature of

- the scientific/technical field
- the target market
- your organization and your partner organizations (academic, industrial etc)
- the arrangements for the collaboration (formal, informal etc)
- the funding (EC/UK Government/own)?

2. **Experience and lessons**

Current Perceptions

2.1 How did the process/outcome of collaborating with a partner overseas compare with your experience of collaborating with (i) a UK partner and (ii) going it alone?

Achievements

2.2 What went right and would you do it again?

2.3 What was the nature and timescale of the achievements?

- tangible and direct results, eg a product, process, service, new standards, demonstration of feasibility, prototype
- longer term eg new science or technology
- less tangible or indirect, eg diffusion of knowledge and skill base, build-up of mutual confidence leading to new forms of partnerships and new initiatives

2.4 How did you measure success and achievement?

eg

- objective(s) achieved
- sales
- patents
- results disseminated
- publications
- magnifying factor/return on investment/value as opposed to cost
- improvement in competitive position (of company, UK, Europe)
- access to partner's science and technology
- speed
- new methodology/systems
- exercise repeated/extended
- other measurements (please specify)?

2.5 What factors can you identify as being critical to your success?

Problems and Constraints

2.6 What were the main problem areas?

2.7 What factors were critical?

2.8 What went wrong and why?

2.9 What corrective actions did you need to take?

3. **Partners**

3.1 Do you think your partners have different perceptions about the collaboration?

3.2 Which of your partners would be worth interviewing if possible?

4. **Management**

Issues

4.1 What kind of management issues arose (before/during/after)?

4.2 Is there a corpus of information/experience on these issues on which UK organizations can draw?

Systems

4.3 What kind of management systems were set up?

4.4 Were these modified?

4.5 How did you assess progress towards objectives?

4.6 What forms of exit from the collaboration were provided?

Investment

4.7 What investment did you make in management time and methodology?

4.8 What is the minimum additional investment needed to collaborate?

4.9 What was the balance of your investment (initial planning/time/money/management/ skills and other less tangible items)?

4.10 What did the other partners contribute?

4.11 Was there comparable/unequal commitment from each partner?

5. **External stimuli**

5.1 What were the relevance, value and effectiveness of external stimuli eg public funding? (if applicable)

5.2 Would you do it again, even without some of the external stimuli?

6. **Administration of formal schemes** (if applicable)

6.1 How necessary/unnecessary and helpful/unhelpful were the procedures and formal systems?

6.2 How could formal schemes be improved? eg are there significant gaps in their scope and nature?

7. **Intellectual property issues**

7.1 How did you tackle the issues of intellectual property and exploitation rights, eg was there a clearly defined policy on rewards?

7.2 How satisfactory was the outcome?

7.3 What particular problems arose?

7.4 May your organization be mentioned by name in the final published report?

8. **Communication**

8.1 What were the means of communication between partners at various stages?

8.2 What was the role/benefit of electronic text as a means of communication?

APPENDIX 2. GLOSSARY OF ABBREVIATIONS

BRITE	Basic Research in Industrial Technologies for Europe
CERN	European Organization for Nuclear Research
DTI	Department of Trade and Industry
EC	European Community/Communities
ESF	European Science Foundation
ESPRIT	European Strategic Programme for Research and Development in Information Technology
EUREKA	European Market-led High Technology Programme
IPR	Intellectual property rights
JOERS	Joint Optoelectronics Research Scheme
RACE	Research and Development in Advanced Communications Technologies in Europe
SERC	Science and Engineering Research Council
SME	Small or medium-sized enterprise

SEPSU 6 Carlton House Terrace, London SW1Y 5AG