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Executive Summary

1.1 Study Context and Objectives

The SITPRO project is the 'Study of the Impacts of the Transport RTD Programme'. This is a study of the European Union 4th Framework Transport Research and Technological Development Programme. The Programme started in 1994 and formally ended in 1998 when the final contracts for research projects were let. The SITPRO project was carried out at a time when much of the research within the Programme, including the SITPRO project itself, was still ongoing.

SITPRO had the objective of identifying and assessing the impacts of the Programme. A specific objective of the project was the development of a method to carry out this task. Through the research, the study has sought to shed light on mechanisms by which positive impacts can be enhanced – for example through the type and extent of dissemination activity, and by proactive exploitation management.

1.2 Research Impact Pathway

The '*research impact pathway*' is the key concept and innovation of the project and is used to describe the mechanism by which impacts are reached. The concept has been developed in recognition that many impacts of the Programme will not materialise for several years, and provides a framework for examining the progress being made towards eventual achievement of impacts. This insight has meant the study has moved away from considering '*real life impacts'* directly. Table E1 summarises the main characteristics and descriptive variables of research impact pathways relevant to the Programme.

On the left of Table E1, the distinct stages along the research impact pathway are mapped out. The first stage, *production of output*, occurs as part of the project. *Dissemination* is needed if the research is to be used by those outside the immediate project environment. *Exploitation* or use of the research is a necessary, but not sufficient, step along the pathway towards impacts. In many cases it is too early to say the extent to which exploitation will ultimately occur, as it may take place over several years. *Impacts* can occur over a very long time span, and are unlikely to be directly observable.

Conjectures have been made about the defining characteristics of the research impact pathway, and revised in the light of research findings. These are also summarised in Table E1. The *network environment* is a term used to describe the strength of relationship between promoters of research and users of research. The *network environment* is a particularly important descriptive variable for defining the type of research impact pathway, and progression along the pathway.

Two extremes in the range of different types of network environment have been considered. A *closed network environment* is where there are few target users who are often actively involved in the project, possibly as members of the research consortium. Impacts in this case tend to be much more readily realisable and quick to occur. An *open network environment* is characterised by many potential stakeholders, the majority of whom may not know of the project's existence. Much research necessarily operates in open environments, but the barriers to exploitation, and hence to impact, are greater.

Table E1: Defining Features of Research Impact Pathways

Key steps along the pathway	**Descriptive variables of pathway**
Production of research output ↓ **Dissemination** of output ↓ **Exploitation** or **use** of output ↓ **End impact** on society	Type of **output** – tools, assessment exercises, guidelines and standards Type of target **user** – researchers, policy arena and industry The **network environment** of project actors (two extremes defined – open and closed) The **time** needed to progress along the impact pathway

Different theoretical research impact pathways have been constructed based on these descriptive variables. Figure E1 shows how these variables may be related for

a particular research topic. As the research develops, it moves from being highly innovative and theoretical, in a fairly open network environment, to being directly applicable, perhaps in a closed environment where industry are target users.

1.3 Method

Impacts are only considered to be of relevance if they contribute towards the achievement of Programme objectives. Programme objectives naturally form two clusters, which in turn means that *two quite different types of impact should be considered.*

The first set, termed *high level objectives*, are the Community policies most closely associated with transport. 'Real life' or '*material' impacts* contribute to the achievement of these objectives. The second set, termed *research capability objectives*, are common to all 4th Framework RTD programmes and are based on goals for enhancing research quality and capacity. The associated impacts to improve the Community's research capability.

The Programme contains 283 research projects and it is only at project level that progress towards impacts can be properly understood. Therefore the principal assessment of the Programme has taken the form of studies of projects. 20 projects have been selected to be as representative of the Programme as possible, within the constraints of sample size and with random selection.

The method of the project studies seeks to establish the extent to which research is progressing along its impact pathway. The findings are contrasted with *expectation* concerning progression along the pathway, as a means of measuring the performance of the project. *Exploitation to date* is the most credible and robust indicator of such progress. Exploitation means that outputs have a value. Exploitation to date means that the use of the outputs can be both verified and assessed.

Some analysis must necessarily occur at the Programme level also. An understanding of the Programme structure was needed in order to attempt a randomised selection of projects. Certain aspects of the functioning of the Programme are also better examined at this level. Programme level assessment has encompassed interviews regarding Programme objectives and achievement of impacts, with Commission officials and national representatives respectively,

analysis of Programme statistics and an experiment investigating the ease of dissemination of Programme results.

1.4 Results

1.4.1 *Research Capability Impacts*

1,300 institutions participated in the Programme, averaging 2 projects per institution. Widespread collaboration is in evidence, spanning both countries and types of institution. Most consortia were planning to work together in further framework programme activities, including 6 of 7 consortia in the project studies that had not worked together before. Evidence of future collaboration outside the framework programmes was significant, if less widespread, affecting 7 of the 20 projects surveyed. Future collaboration, particularly outside the framework programme, is an endorsement of the added value the network brings to its participants.

Both benefits and disbenefits of large consortia were in evidence in the project studies. Many researchers asserted the benefits that different, complementary, skills have brought to the consortia. However organisation and administration of these large groups has been very time consuming.

1.4.2 *Material Impacts*

For most projects it is too early to say the extent to which material impacts have occurred and will occur. Important indicators of progress towards impacts are dissemination and exploitation of research to date. In many of these cases, the exploitation will not in itself guarantee an eventual impact. A further implementation stage is needed.

It is clear that there has been much dissemination activity promoting the substantial majority of projects. However lack of availability of projects' results and information on projects' progress was seen as a major problem by users and national representatives. Problems with dissemination will result in potential impacts not being realised. Some of these criticisms are being addressed by the Programme's project EXTRA, concerning exploitation of research, but should continue to be monitored.

Of the sample of 20 projects, 13 had already been exploited, though this use may be limited and includes examples of use by members of the consortium in further research. Considering practical application alone (ie ignoring examples of exploitation in other research) 10 of the 20 projects had outputs that have already

been used, or there is a clear indication on the part of the user that they will be used in the future. Of these 10 examples of exploitation, five are being used to modify procedures or systems and will have a rapid impact (within the next two years). The others are being used to develop policy or strategy, and further stages are needed before impacts will occur.

Our assessment of these findings is mixed. It is clear that progression towards impacts is already occurring, which is very positive considering the SITPRO study is taking place when much of the research is still ongoing. However much potential for exploitation remains, and it has been difficult to establish the extent to which this will still occur. Results indicate that progress towards impacts may be occurring more successfully in projects that have characteristics of closed market environments, in particular *where there are strong links between the project and its target users*, than in open market environments.

1.5 Recommendations

The key recommendations of the study are discussed below.

1. Set out the research impact pathway at the project's inception i.e. understand the key stages that occur between output and eventual impacts.

- Do the potential impacts meet Programme and project *objectives*?
- Is the impact pathway *feasible*?
    - What are the project's outputs? Are they going to be useful and useable? How can research users' views be taken account of?
    - Who are the target users? How are they going to find out about the research and obtain the outputs?
    - These questions must be answered with specifics, not generalities, using examples where necessary.
- The act of *monitoring* increases the conceptualisation of the pathway. A method for monitoring impacts has been developed in SITPRO.

2. Encourage the characteristics of closed network environments

In cases when there are few target users, and in some other instances:

- Ties with target users can be strengthened, hence making the network more 'closed', by including target users in the consortium.

- Construct formal liaison with target users and allow them to influence project output. Examples of such activities include liaison meetings and working groups. Incorporate views of users in project development. Concerted actions and thematic networks are very effective, even in more 'open' network environments.

3. Minimise barriers in open network environments

- The open network vision is that *the Programme would be a major source of reference for all Community practitioners.* Potential users would be able to quickly identify which section of which project is useful for them. They could then download the information in a matter of minutes.

- In view of this, Programme infrastructure is needed for an efficient distribution of project outputs. This requires information to be structured so that it is easily accessible – e.g. a search system by key words that allows potential users to rapidly determine which project is relevant for them.

- Results in open network environments need stamina to survive, because users may be reluctant to adopt new practices, or because the research is not immediately policy relevant. Action is always needed to mitigate these problems, including widespread dissemination aimed at the research community, application of the product in test cases, appropriate marketing after the research is finished, and appropriate further research.

1 Objectives

The Study of the Impacts of the Transport RTD Programme had the objective of identifying and assessing the impacts of the Fourth Framework Programme of Transport Research and Technological Development (RTD). A specific objective of the project was the development of a *method* to identify and assess research impacts.

The Transport RTD Programme commenced in 1994, and has contained around 283 transport projects, of which SITPRO is one. It spanned strategic transport research, integrated transport chains, rail, air, urban, waterborne and road transport, as well as projects designed specifically to maximise the benefits of the Programme's research. The types of study also varied, for example they may have provided policy or management advice, be technologically based or produce planning tools.

SITPRO sought to trace the links between the specific objectives of research projects, the Programme's research goals, and wider socio-economic impacts directly related to the Common Transport Policy, such as improvements in safety or the environment. Through the process of impact assessment, the study sought to shed light on methods by which positive impacts could be enhanced – for example through the type and extent of dissemination activity.

2 Means Used to Achieve Objectives

The following tasks, under five groupings, were undertaken to achieve the project objectives.

2.1 1 – Project Definitions and Information Structuring

- Classification of all research projects in the Programme according to criteria relevant to impacts.
- Development of a method for sampling projects from the Programme, and selecting a sample of projects according to the method.
- Gathering of existing Programme statistics and results, and analysis of Programme-wide statistics.
- Examination of Programme formation and objectives through a literature review and expert interviews.

2.2 2 – Development of the Assessment Approach

- Review of research evaluation literature and studies of the Transport RTD Programme.
- Specification and agreement of Programme objectives, as a basis from which impacts could be assessed.
- Identification and classification of relevant impacts and method of identifying expectation of impacts being realised. The focus of this task has shifted from identifying and classifying the impacts themselves to identifying and classifying the mechanism by which impacts will be realised, termed the *research impact pathway*.
- Development of Assessment Method

2.3 3 – Assessment of Research

- The project studies. The information for these was predominantly drawn from interviews with the project co-ordinators, the project officer and the users of the research.

- An experiment concerning ease of obtaining project outputs, based on a simple request made to 100 institutions.

- Interviews with national representatives of the Programme.

2.4 ***4 – Assessment Synthesis***

- A synthesis of the results from the project studies and Programme level findings to provide an overall picture of the Programme.

2.5 ***5 – Conclusions and Recommendations***

- Conclusions on the impacts of the Transport RTD Programme.

- Recommendations on methods to enhance impacts in the future.

- Recommendations on methods to be applied to monitor future RTD programmes.

The structure of the remainder of the report is as follows. Chapter 3 reviews research material of relevance to the project. Chapter 4 presents the key concept developed and applied in the SITPRO project, the research impact pathway. Chapter 5 describes the method developed and applied to assess impacts of the Programme. Chapters 6 and 7 present the results of the findings, with respect to research capability impacts and material impacts respectively. Chapter 8 gives recommendations as to how impacts may be enhanced. Chapter 9 lists the outputs of SITPRO and describes their relevance to potential users. The main text ends with a glossary of terms and a list of references.

3 Literature Review

3.1 *Introduction*

A study of research impacts has limited precedence. The literature review therefore concentrates on two germane fields of study: that of research evaluation and that of EU Framework Programme studies. The relevance of these approaches is made explicit in the final section of the chapter.

3.2 *Evaluation in Research: Insights and Barriers*

Evaluation as a discipline goes back to the sixties, and has developed in parallel with public policy analysis and management. 'Management by objectives', 'zero-base budgeting', 'cost-benefit analysis', 'total quality management', 'reinventing government' or 'performance plans' are terms as frequently used by evaluators as they are by policy analysts or policy managers (Wholey, 1997). The current evaluation methodological tool kit is wide-ranging, including survey-based techniques, case studies (alone or in combination with other methods like document analysis), research syntheses or meta-analyses, cluster evaluation and interrupted time-series. (cf. Cook *et al.*, 1992; Cook, 1997; Chelimsky and Shadish, 1997; Stake, 1995; Gilbert, 1982; Sander 1997; Rossi and Freeman, 1993).

The last two decades witnessed two major developments in the field of evaluation research:

- first, the acceptance of qualitative methods in evaluation
- second, the incorporation of performance evaluation tools in the planning or pre-implementation phase of a programme or projects.

Regarding the legitimacy of qualitative methods in evaluation research, Cook (1997) notes the following:

"Qualitative methods are very useful for making explicit the theory behind a program, for understanding the context in which a program operates; for describing what is actually implemented in a program; for assessing the correspondence between what the program theory promised and what is actually implemented; for helping elucidate the

processes that might have brought about program effects; for identifying some likely unintended consequences of the program; for learning how to get the program results used; or for synthesizing the wisdom learned about a program or a set of programs with somewhat similar characteristics...There is no doubt of the relevance of qualitative work to reducing uncertainty about both causal propositions and generalization to specific populations..." (p. 34).

One of the main outputs of qualitative evaluation research has been the understanding of the elusiveness of the concept itself of performance, especially in the field of public policy (Mawhood, 1997). This, in turn, has led to the adoption of performance measures already in the planning phase. The design of the Fourth Framework Programme is a good case in point: the guidelines to proposers about how to write a research proposal reproduce none other than the Logical Framework approach to specifying objectives and relating these to implementation procedures. The Logical Framework approach has been widely used by the World Bank and the Overseas Development Agency (ODA) in the U.K. for planning purposes as well as for establishing a base for the so-called 'on-line' evaluation or continuous monitoring (cf. also Riley, 1998).

Of particular interest in the application of the Logical Framework approach to evaluation is the explicit recognition of the importance of contextual factors for performance. This is also acknowledged in scientific realist evaluation, as well as by empowerment or self-assessment techniques which are quite common in the field of education (cf. Dawson and Tilley, 1997; Fetterman, 1997).

Evaluators likewise do not operate in vacuum. It is therefore important that evaluators take stock of the political environment of their work and recognise the implications. According to Chelimsky (1997), in order to be able to produce 'credible and defensible' evaluation reports and to be able to withstand political pressure, it is important to develop linkages with several disciplines and with basic research as well as insert 'political realism in evaluation training' (p. 65).

Developments in the field of RTD evaluation have paralleled those in the field of evaluation research more generally. As noted above, the design of the Fourth Framework Programme has gone hand in hand with the specification of performance indicators for research

proposers and proposal evaluators alike. Similar strategies were adopted in numerous European countries, especially those where the research funding landscape is dominated by research councils, academies or other intermediate organisations or agencies.

At the national level, attention has also been given to the organisational or institutional aspects of RTD performance. Hence, it is common to evaluate RTD performance by evaluating RTD institutions, like universities or research organisations. Such institutional evaluations include financial auditing but focus primarily on the assessment of research output and of institutional performance with respect to human resource management, networking and research contracting. The OECD Frascati Manual for Evaluating Institutional RTD Performance specifies many of the relevant performance indicators in this field (cf. also Pohoryles and Giorgi, 1996, Institutional RTD Assessment in Slovenia).

At the aggregate level, and for the purpose of international comparisons, a variety of indicators have been used to assess national RTD performance and national innovation systems: on the input side, government financing for RTD as a percentage of GDP; the business share of RTD expenditures; and the number of research or academic personnel per 1.000 inhabitants; on the output side the number of patents, or the number of publications. Needless to say there is a high correlation between the input and output indicators at the aggregate level (cf. European Indicators for S&T, 1997; OECD, 1998).

There are not many examples of research programme evaluation, either at the national or at the international level. Having said that, there have been more evaluation studies of the EU research programmes than of other programmes (Luukkonen, 1998).[1] The

[1] In a review of such studies, Luukkonen (1998) notes that many of the evaluation exercises concerning EU programmes were undertaken at national level and especially by the new member countries (like Sweden and Finland) as well as by Norway. Other national research programme studies are those of the East-West bilateral co-operation programmes in the Netherlands, the UK, Germany and Austria. At the European level, the Commission has been undertaking regular five-year evaluation studies of its research programmes (at aggregate level) and of some specific programmes (like the ESPRIT programme).

five-year evaluation studies of the EU research activities do not focus on any particular programme and report mainly on basic research statistics such as funds granted, number and type of institutions benefiting, number of researchers funded, number of international publications, conferences organised, etc. and on the opinions of experts on the likely or expected impacts for industry or the academic community and the barriers to achieving these. Similar is the orientation of programme-specific evaluations, like the Mid-Term Evaluation of the Transport RTD Programme.

The extent to which the thematic objectives of the research programme have been achieved has rarely been addressed, or if so only in a superficial way, i.e., as a function of the number of projects funded to study a specific research theme (cf. Pohoryles, 1992). This is no surprise considering the plurality of interpretations allowed by any research agenda effected through the interaction of the demand and supply sides in the process of agenda setting (cf. Hajer 1995; Giorgi and Redclift, 1999). This, in turn, creates methodological and conceptual problems for measuring the attainment of objectives (Luukkonen, 1998).

Of particular interest for European and national policy-makers has been the impact of European research on European industry (distinguishing between the major actors and the small and medium-size companies) in terms of economic output or performance as well as in terms of organisational behaviour and management strategies. Organisational and management effects have been easier to tap – albeit better in a longitudinal rather than cross-sectional fashion – than economic impacts in terms of competitiveness. The problem is primarily one of attribution: participation in the EU research programmes through one or more projects represents even for smaller research organisations only 'one phase or part of a wider spectrum of activity or research portfolio' (Luukkonen, 1998, p.602, referring to the work of Georghiou, 1994 among others). Thus it is not possible to assign any specific positive or negative impact to participation alone to the European research programme. The same problem is faced by the notion of 'additionality' (Georghiou, 1994) – an operationalisation of the value added concept in terms of input,

behaviour or output[2] – despite the fact that this was developed in order to overcome the problems with attribution. Nevertheless if investigated in conjunction with opinion surveys (of research managers) and in a wider context (i.e. not in relation to one research project alone), the notion of additionality can contribute to a better understanding of the role of European research programmes as a stimulator and catalyst for collaboration (inter-European as well as between basic and applied research) which over time can lead to an increase of European industrial competitiveness.

3.3 Evaluation of the Transport RTD Programme

The last years have witnessed a surge in evaluation activities with regard to the Transport Programme.

The ***Five Year Assessment of the Transport RTD Programme*** completed in 1997 (Baanders *et al.*, 1997) looked at the transport research activities in the Third Framework Programme and the first two years (1995-1996) of the Fourth Framework Programme.[3] As well as providing an overview of the type of studies commissioned under the Fourth Framework Programme (by sector), the type of institutional participation (comparing research organisations with universities and the private sector), the budgetary assignments and other such output tangibles, this study focused primarily on identifying the organisational and thematic constraints at management level that could be said to influence the successful implementation and dissemination of the Programme.

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[2] According to Georghiou (1994) input additionality taps the situation that some projects would not at all been possible without EU or more generally public funding; behavioural additionality describes the changes in behaviour brought about in a firm through participation in a European research programme (this could concern changes in human resource management as it would changes in collaboration patterns, i.e. regional as well as institutional). Output additionality is a situation where there are permanent changes in the behaviour of a firm more generally.

[3] In this connection, it ought to be noted that there was no Transport RTD Programme in the Third Framework Programme representing a comprehensive agenda. There were nevertheless a series of research activities undertaken (specifically the EURET and APAS studies) which prepared the ground for the establishment of the full programme under the Fourth Framework Programme.

The Five Year Assessment Report came up with ten main recommendations (see also Giorgi and Pohoryles, 1999;). In order to monitor progress with meeting the recommendations, and more generally the progress of the Transport RTD Programme, an external committee of experts was established.[4] The results of the work of this committee are reported in the ***Annual Monitoring Reports***.[5] Like the Five Year Assessment Report, the monitoring reports focus mainly on the programme level, i.e. they do not report on the impacts of any specific project other than as examples for more general trends.

In order to study more systematically the impacts of the Transport RTD Programme with information from its implementation at project level, two studies were commissioned towards the end of the Fourth Framework Programme. One is the SITPRO study to which this current report relates. The SITPRO ***Study on the Impact of the Transport RTD Programme*** aims at outlining the impact pathways of research funded under the Fourth Framework Programme in the field of transport. The second study has been conceptualised as a ***Technical Review*** of the Programme (ARTTIC 1999). It also focuses on the project level, and is set up as peer-evaluations for examining scientific validity and content. The above studies are being supplemented by ***financial audits*** of specific projects to examine the appropriate use of public funds in the field of research.

Other framework programme studies, running in parallel to SITPRO, have been examining socio-economic impacts of the research. The ***TAP-ASSESS*** project (Teleport Sachsen-Anhalt, 1999) is a 'Socio-Economic and Industrial Assessment of the Fourth Framework Programme Telematics Applications Projects completed between 1996 and 1998'. Early liaison with TAP-ASSESS revealed that it was adopting a scenario approach to tackle the high level of uncertainty associated with forecasting research impacts. The scenarios differ by the extent to which the research is valued and promoted at national /

[4] This committee currently is made up of two external experts, namely, Dr. Jose Viana Baptista and Prof. Peter Jones.

[5] The most recent report refers to the year 1998 (1998 External Monitoring Report on the Specific Programme for RTD in the Field of Transport; Authors, Baptista and Jones).

supranational and local levels. TRANSINPOL (NEI 1999) assesses the socio-economic effect of telecommunication applications in transport; its methodology was developed at a later stage to that of SITPRO.

Several of the recommendations of the Five Year Assessment Report underlined the importance of dissemination for the exploitation of research. In order to facilitate dissemination, the ***EXTRA project*** (AEA Technology) was commissioned to disseminate project findings at cluster level as well as for defining a corporate identity for the Programme in terms of presentation style. Also relevant for dissemination – this time vis-à-vis the nation-states' administrations – are the ***concerted actions*** initiated in the framework of the Transport Programme. Even though none of these activities are conceptualised as evaluation exercises, the use of cluster techniques for dissemination purposes also permits their use as information sources for evaluation purposes.

3.4 Relevant Lessons from Literature Review

From the above analysis four principal alternative approaches to reviewing research programmes have been identified. The relevance of each to SITPRO is discussed in turn.

1. Analysis of Research Inputs and Readily Accessible Outputs

The compilation of basic statistical data describing the project inputs (research time, budget etc.) and basic outputs (number of papers published, seminars held etc.) is a common approach. Although such data is fundamental to understanding the nature of research programmes and will be drawn upon, this approach is of marginal relevance to SITPRO because:

- the data is already collected and collated by the European Commission for the Transport Programme, so that SITPRO cannot add value in this area;

- little of the data collected is directly related to exploitation of outputs, or the eventual impacts that occur.

2. Speculation about Long-Term Impacts

This method attempts to assess the eventual outcomes that are predicted to result from any given research programme. Luukkonen (1998) provides a comprehensive review of attempts to assess the impact of European research programmes on industrial competitiveness. The limitations of such approaches are readily apparent:

- the process of making long-term forecasts of impacts is problematic - this would commonly involve making forecasts, perhaps 20 years into the future[6];

- the "without-research programme" case is impossible to define – "what would have happened if the research had not gone ahead?" is a very difficult question to answer. Would the same discoveries have been made? Would the researchers have made more progress if their efforts had been invested in national research programmes?

- many benefits of research are indirect – examples include the development of researcher skills and capabilities and the creation of research networks, which are outputs of research projects, but are difficult to associate with individual projects or indeed research programmes.

- Indeed, over a 20 year time horizon, the impacts of the research project /programme could be added to, detracted from and generally distorted by all sorts of other influences on innovation, technology and policy.

3. Peer Review by Experts in the Field

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[6] Consideration of research outputs also reveals how difficult it is to characterise impacts. Take for example a road project which examines the implications of using safer types of car. The project derives values for how many fewer accidents one could expect if these types of car are used. This is a projected real life impact. But it is an impact that can only be reasonably assessed by the project itself, and not by SITPRO. Immediately we run into difficulties because most projects do not come up with such assessment (only those classified as 'assessment exercises', see chapter 2, would do so), and the assessments should in any case be challenged.

Another common approach is post-completion assessment by experts in the field in question. An example of this being the approach of the UK Economic and Social Research Council. Typically, such assessments are limited to a review of the quality of the research outputs. Often, this assessment is supported by interviews with the potential users of the research output. Drawing from this approach, the experiences of research output users can clearly be a source of objective, high quality evidence of relevance to research impacts.

4. Logframe Approach (and related approaches)

The logical framework or 'logframe' approach is one in which different tiers of Programme objectives, research project objectives and research outputs are explicitly inter-linked. At each of these levels, "objectively verifiable indicators" and corresponding "sources of verification" are sought that enable credible conclusions to be drawn on, for example, the extent to which the project objectives have been met.

The logframe approach has particularly relevance in respect of:

- the need for a strong hierarchy in the SITPRO assessment framework, for example, between Transport Programme and research project objectives;

- the need to identify objectively verifiable indicators and corresponding sources of verification – the most credible evidence relates to exploitation that has occurred to date, and this evidence should lie at the core of the approach.

However, the research objectives of relevance are not the *scientific objectives of the project*, but *objectives related to achieving real life impacts*. In order to formulate appropriate objectives it is necessary to gain an understanding of pathway of events from which impacts will emerge. This concept has been termed the *research impact pathway*, and lies at the core of the SITPRO approach.

In summary, *analysis, of research inputs and readily accessible outputs,* is a useful supporting approach, and has been used in this study as such. *Peer review by experts* is not readily applicable in this context, but expert interviews are and have been used as the central method for

compiling evidence. *Speculating or forecasting long term impacts* has been explicitly rejected in favour of an approach that uses 'objectively verifiable evidence', drawing on the *log frame* concept. However the log frame approach requires adaptation to the context of examining impacts, and the *research impact pathway* concept has been devised to achieve this.

4 Research Impact Pathway

4.1 *Stages along the Pathway*

The concept of the *research impact pathway*[7] has been developed by the SITPRO project. It has been adopted in recognition that most of the impacts of the Programme have yet to materialise, that a chain of events may be involved before an impact occurs, and that impacts will occur over a long time span, beyond the actual lifetime of individual research projects. The research impact pathway provides a framework for understanding how impacts can be expected to be realised. Observations can then be made relative to expectation.

Although the Transport Programme is highly heterogeneous, the key steps along the research impact pathway can be identified as:

1. production of research outputs – creation of the "product";

2. dissemination of outputs – raising the level of awareness about the product;

3. exploitation, or use, of outputs – by key intermediaries or end-users of the research; and - much longer term:

4. end impacts on society – on consumers and producers.

The result is that there are three, fairly clearly linked steps (1-3), followed by a final, much less clearly defined, step (4).

The transmission mechanism from step one to step four can take several years, and possibly even decades, to observe. Despite this, the strength of the research impact pathway concept is that a research project's progress along the pathway, e.g. through steps one, two and

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[7]The "Impact Pathway" is a term originally adopted in ExternE (Friedrich et al, 1998). In ExternE the concept provides an approach to tracing through the environmental impacts of transport, such as air pollutants from cars, based on a bottom-up approach. The key steps for environmental pollutants are: emission→ dispersion→ concentration→ physical impacts→ long-term effects. Research has a similarly complicated transmission mechanism (although its impact is generally positive!).

three, can be charted and evaluated, even where its final impacts may be some years away.

It is important to note, however, that progress along the impact pathway can differ quite widely amongst different projects, for the following reasons:

- Whilst projects generally need to be disseminated before they can be exploited by users, this may not always be the case; in some instances the main users of research may be the researchers themselves (e.g. prototypes for industrial products).

- There may be a 'feedback mechanism' between exploitation and dissemination, whereby a project's findings are disseminated, then exploited by one user and then this exploitation is publicised leading to greater awareness and further exploitation by other users. The final impact is then the product of these multiple rounds of dissemination and exploitation.

- Good, well disseminated research may have varying levels of exploitation potential, depending upon political or other considerations external to the project; for example, urban road pricing has received considerable research attention, much of which appears to have been well disseminated, yet very few urban road pricing schemes have been implemented. The production and dissemination of that body of research has, nevertheless, helped to bring closer a more widespread implementation of urban road pricing.

4.2 Defining Characteristics

Research impact pathways are heterogeneous, but nevertheless some defining characteristics emerge that typify the pathway that can be followed. The four characteristics are considered to be:

- The strength of relationship between promoters of research and users of research, the so-called *network environment*.

- The type of research *output*.

- The target *users* of the research output.

- The *time* period over which stages along the research impact pathway are expected to occur.

Research impact pathways will be identified with the above four characteristics. They are described below.

- **Network Environment of the research**

Two extremes of the 'network environment' may be identified: closed and open.

A *closed* network environment is characterised by a well-defined inter-organisational structure of the research project's stakeholders. There are a limited number of target users, perhaps less than 10 key institutions who are easy to identify. They are well defined and often actively involved in the project, possibly as members of the research consortium. A disadvantage of this may be that it becomes difficult for target users outside the immediate project environment, if any such users exist, to gain access to project information and results. Examples of such networks include rail operators and associated interest groups for rail research, the air traffic management (ATM) community in the air sector, and car manufacturers and associated bodies in the road sector.

An *open* network environment is characterised by fluid inter-organisational structures. There are many potential target users, the majority of whom are not concerned with the project and may not know of its existence. Examples include the wider research community, whose main source of access to the research will be publications and public conferences; the many local transport authorities who have an interest in urban transport research; and inland waterway operators.

Table 4.1 shows institutional participation in the Programme, disaggregated according to the transport sectors by which the Programme was structured and managed. It shows that the air and rail sectors have substantially fewer participating institutions than other sectors, relative to the budgets devoted to their sectors. In contrast, the urban sector has a relatively high number of participating institutions. These statistics provide a tentative alternative indication that air and rail sector projects have tended to

operate in closed network environments, and the urban sector in an open environment.

Table 4.1: Programme Participation and Funding by Sector

Sector	Number of institutions participating	Projects (%)	Total full cost budget (%)
Road	247	14	11
Rail	126	7	20
Waterborne	317	20	18
Air	123	16	16
Intermodal	207	10	10
Urban	323	14	12
Strategic	236	17	13
Total	(1579)	100%	100%

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

- **Outputs of the research**

Projects in the Transport RTD Programme, have been classified in four categories according to the types of research output. They are listed below.

1. *Standards / Criteria* Projects producing outputs to be used as inputs to standardisation exercises or the specification of criteria. For example projects designed to establish EU transport databases, or to establish standards concerning car design would fall in this category.

2. *Guidelines / Handbooks / Best Practice Models* Projects delivering primarily policy recommendations in the form of guidelines or through the explication of best-practice conceptual 'models'. Examples may include a handbook to show local authorities practical examples of ways to encourage walking and cycling, or guidelines concerning the design of cars to enhance road safety.

3. *Tools / Models / Methods* Projects delivering tools, models, methods or technical frameworks for use in policy or impact assessment or for measurement purposes. For example, a model to forecast travel characteristics at points in the future; or a tool to assess safety risk

associated with different air traffic management operations; or a method to test the impact of car design on car safety.

4. *Assessment Exercise* Projects comprising assessment exercises where the emphasis is placed on the results of the assessment, rather than on the method or tool used. Examples include an assessment of the potential efficiency savings associated with increasing competition in the railway sector; or an assessment of the feasibility of implementing an enhanced communication system between ports; or an assessment of the safety attributes of certain kinds of car designs.

Table 4.2 classifies the principal output of each project in the Programme according to the above. Some general points about the Programme outputs are given below:

- The development of standards is the main research output for only a minority of projects in practically all sectors. This is not surprising considering the pre-normative, pre-regulatory or pre-competitive type of research promoted by the Fourth Framework Programme – standards are highly practical and applied.

- The focus on management issues or implementation strategies, especially with regards policy advice, is reflected by the second category of research output, namely, 'guidelines, recommendations or best-practice models'. The waterborne and urban sectors account for more than half of all projects displaying this as their main research output. In the urban sector this type of output corresponds mainly to those projects which involved benchmarking activities or information exchange between cities; in the waterborne sector to the projects dealing with human resources and the issue of safety.

- Close to one third of all projects delivered assessment tools, methods or methodologies. In the mode-specific sectors, the development of assessment tools is often considered in close conjunction with traffic or information management systems, i.e. for measurement and/or monitoring purposes and with cost-efficiency in mind. In the strategic sector it has more often to do with the evaluation of projects or policies.

- Another one third of all projects focused on assessment as such. In the mode-specific sectors, assessment exercises comprised

primarily market or economic analyses or forecasting; in the strategic sector the emphasis was instead placed on evaluation, either of projects or of policies.

Table 4.2. Research Output by Sector in the Transport RTD Programme

Sector	'Standards'	'Guidelines'	'Tools'	'Assessment'	N projects
Road	**8**	7	10	**13**	38
Rail	4	5	8	4	21
Waterborne	5	**15**	**16**	**15**	51
Air	6	8	**14**	**15**	43
Intermodal	1	8	5	9	23
Urban	0	**16**	**12**	9	37
Strategic	3	2	**19**	**17**	41
Totals	27	61	84	82	254

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

Notes: Projects within the Programme but outside these sectors have been excluded, as have some projects for which information was missing at the time of carrying out the research.

- **Users of the research output**

There are three main research impact groups or primary users of research, namely:

1. ***policy and decision makers***

2. ***industry***

3. ***research community***.

Ultimately the end user of research – whether of policy or industrial relevance – is the citizen. It is important to remember this aspect of social legitimacy for research even if we do not include the citizen or the public as the fourth category of users. The reason for not doing so is simple: the outputs of transport research are not directly relevant for citizens as such; they only become relevant if implemented.

Table 4.3 shows the primary users targeted according to Programme sectors. Waterborne, air and intermodal transport have a relatively

high number of practically based projects where industry is the end user. Outputs from the road and urban sectors are primarily intended for policy makers such as public transport authorities, and national and EU policy makers respectively. The strategic sector is alone in having a significant number of projects aimed at the research community.

Table 4.3. Main targeted users by sector

Sector	Policy Users	Industry	Research
Road	**23**	5	10
Rail	11	10	0
Waterborne	15	**32**	7
Air	18	**25**	3
Intermodal	6	**14**	3
Urban	**24**	8	5
Strategic	**23**	1	**18**
Total	120	95	46

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

- **Timing**

The time taken to advance along the different stages on the research impact pathway was considered an important descriptive variable. Some impacts need speed and momentum to materialise; others need stamina to last over a series of years. The time period over which exploitation can be expected to occur, and subsequently impacts to fall, is of great interest and relevance.

In particular, a closed network environment would typically exhibit fast progression along the impact pathway, at least to the exploitation stage, because the output is often developed with a view to that specific need. Impact in an open network environment can be much slower and less direct. A particular extreme case is when the output is contributing to policy development, which can even take decades to mature.

4.3 Pathway Typologies

Figures 4.1 to 4.6 show different typologies for ideal research impact pathways. They seek to illustrate how impacts increase over time. In practice, research impacts can be much less direct, requiring further

development and specification of the output prior to its application. Some general notes about the diagrams are made here.

- The pathway for *research capability* impacts[8] (Figure 4.1) is simple. Most of these impacts (concerning research skills and networking) start occurring at the project's inception and concern the research consortium itself. Impacts related to innovation, which are new skills and knowledge being made available to the wider research community, take longer and are more diffuse.

- Implementation of *standards (*Figure 4.2) relates to harmonisation. Harmonisation tends to be a relatively slow process, though less so in a closed network environment. The implementation of standards should enforce harmonisation, for which there are direct impacts.

- Application of a *tool or model or method* (Figures 4.3 and 4.4) normally does not result in a direct impact. Instead they may result in an *assessment exercise*, which again must be applied prior to impact being realised.

- Use of *guidelines and best practice* models (Figures 4.5 and 4.6) may or may not directly result in an impact. For example if the guidelines are designed to improve the planning process, the decision to implement the planning must be made prior to impacts being realised.

- Research impact pathways for *closed* networks are more greatly influenced by single decisions: large impacts occur as a result of the decision to use the impact, on behalf of the few target users concerned.

- In contrast, an *open* networks typically has a large number of target users. Each target user's application of the research has only a limited impact relative to the whole. The impact thus rises gradually over time.

[8] A discussion of types of impacts is given in the next chapter. Definitions are given in the glossary.

For closed networks, the *timing* of the impacts are relatively fast, as the output is more likely to be produced in response to a specific demand and needed instantly. For open networks, the impacts tend to occur over a much longer time span. The research needs stamina so that it is not forgotten or discarded over this time.

4.4 Integrated Research Impact Pathway

Figure 4.7 shows how the defining characteristics of the research impact pathway may be related for a single research theme. The pathway is devised for material impacts achieving high level objectives. The figure represents a pathway for a research topic, rather than individual projects. It spans a long time period, of ten years or more. An example of such a topic might be the European Railway Traffic Management System (ERTMS).

As time elapses the research theme develops from initially being highly innovative to becoming more practical and applied. Impacts increase at an accelerated rate as progression along the pathway occurs.

The different types of output of research have a natural progression, though other combinations are possible. The model/method is applied to produce an assessment exercise. Assessment exercises are used in turn to produce guidelines. The guidelines are then applied to develop standards.

The research community would tend to be the main developer and user of models and methods, though these can be used more practically also, for example for monitoring purposes. They would create assessment exercises. Policy makers are 'users' of assessment exercises to develop policy. The assessment exercises can be consolidated in the form of guidelines, which are relevant to both policy makers and industry. The standards are of direct relevance to industry.

The network environment of the stakeholders shifts as progress along the impact pathway is made. Initially the network environment is 'open'. There are many potential stakeholders within the research community that could use the model output. As the pathway develops, the target users shift from many (the assessment exercise

has general relevance for many different levels of policy) to few (specific details of implementation of the guidelines). At the very practical end of research, industry is frequently involved directly as a member of the research team. This is typical of a closed network environment, though the potential for impacts may be greater if the network environment is made more open, particular for sectors with many operators.

The time needed to achieve impacts also changes along the pathway. With highly innovative theoretical research, the impacts will only be achieved indirectly and hence the research needs stamina to survive. For highly practical research, the use is very well defined and impacts may occur very quickly.

4.5 Policy Relevance

The diagram illustrates that different strategies are necessary to enhance impacts depending on the nature of the research. In an open network environment, wide dissemination is of great importance, so that the wider research community is able to exploit the innovative research. Forms of dissemination should reach a large audience, for example, web pages, journal articles, seminars and conferences, readily available outputs.

The policy relevant outputs need stamina to continue through the slow process of policy development, and dispersed knowledge amongst the research and policy communities facilitate this.

As progression along the pathway is made, dissemination should be more tightly focused on the smaller group of target users. Workshops and concerted actions allow more in-depth investigation of the research to take place (though concerted actions are also effective for more open network environments, if the delegates in turn disseminate their findings to other potential users). They allow the user to understand the relevance and utility of the research.

Within the 'closed' network environment, dissemination is often less critical for material impacts to occur, as the target users will often be contributing to the development of the output. The relevant question here is whether the network environment should be made more open. An open network environment may enhance impacts by allowing others in the industry to benefit from the research. However, opening the network environment may make the research

consortium less willing to participate as they have less to gain from the research. The EU funding may have, in any case, made the network environment more 'open', by facilitating the co-operation of natural competitors, who would ordinarily carry out research work entirely within their company.

It is important to emphasise that each of the categories of research identified here has a legitimate place in the Programme. An important implication of this typology is that expectations over timing and strength of impacts should be modified in line with the nature of the project. Furthermore, different actions will be needed to assist with exploitation and maximise impacts.

5 Principles of the Method

5.1 *Core Aspects of the Methodology*

The characteristics of the Transport RTD Programme and the resources and timing of the SITPRO project determine many of the core aspects of the SITPRO methodology. In particular:

- the Programme is relatively "*young*" and most RTD projects are either ongoing or are very recently completed – implying the need to develop a methodology that focuses on the *early stages* of the research impact pathway;

- the expected impacts of the Transport Programme will take a *number of years* to materialise – implying that the assessment framework will facilitate a more *qualitative* than quantitative approach;

- *individual RTD projects* provide a clear route for determining potential impacts – implying that emphasis should be placed on *project* reviews with less emphasis on reviews conducted at the programme level;

- the main objectives of the 4FP Transport RTD Programme are reasonably *well defined* – indicating that the methodology should adopt these objectives as the *starting point* in a hierarchy of inter-linked objectives.

5.2 *Relating Impacts to Objectives*

Impacts are only of value per se if they can be related to achievement of Transport RTD Programme objectives[9]. Programme objectives naturally fall into two clusters, which in turn means that two quite different types of impact should be considered. These are known as:

[9] With respect to its impacts, as opposed to its implementation and management.

1. *High Level Objectives* – It is enshrined in the Maastricht Treaty that the framework programmes should seek to achieve Community policies. For the Transport RTD Programme, this means Community policies most closely associated with transport, particularly but not exclusively those of the Common Transport Policy.

2. *Research Capability Objectives* – These objectives are common to all 4th Framework RTD programmes and are based on goals for enhancing research quality and capacity.

The high level objectives have been summarised as the promotion of:

- Transport System Efficiency;
- Safety;
- Environment;
- Market Access and Structure;
- Integration and Interoperability; and
- Social Dimensions (cohesion, equity).

The impacts associated with these objectives, for example a reduction in road traffic accidents, are termed *material impacts*.

Research capability objectives have been determined as:

- Creation of effective research networks;
- Development of knowledge base / awareness;
- Innovation; and,
- Promotion of European added value.

The impacts associated with these objectives, for example an increased understanding of issues concerning the implementation of road pricing amongst community researchers, are termed *research capability impacts*.

There are interesting methodological differences between the two sets of objectives. Whilst a project might be expected to assist in achieving only one or two of the higher level objectives, it is often expected that it may contribute to all of the research capability objectives. Furthermore, whilst impacts related to the high level objectives are difficult to isolate, and for that reason the impact pathway is examined, research capability impacts can happen in a shorter timeframe and are typically more tangible.

5.3 Expected Research Impact Pathway

When constructing the method for examining impacts it is important to consider the distinct stages along a research impact pathway. To reiterate, they are:

1. production of research outputs – creation of the "product";

2. dissemination of outputs – raising the level of awareness about the product;

3. exploitation of outputs – by key intermediaries or end-users of the research; and - much longer term:

4. end impacts on society – on consumers and producers.

5.4 Evidence of Progress along the Pathway

Having explored the expected impact pathway of research, the method requires an examination of what is occurring in practice. This approach seeks as far as possible to be based on evidence rather than speculation.

Considerable emphasis is placed on the value of *exploitation to date*, as the most credible and robust indicator of the actual and future impacts of the Transport Programme. Exploitation means that outputs have a value. Exploitation to date means that the use of the outputs can be both verified and assessed, and are not subject to speculation.

Figure 5.1 illustrates the process by which the potential for impacts is examined.

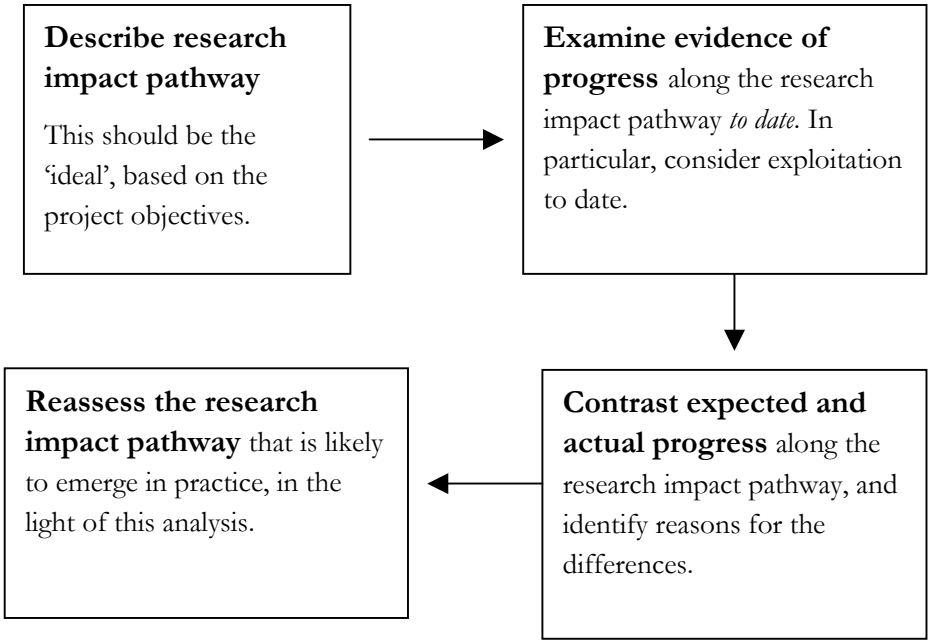

Figure 5.1: Process for examining impacts

5.5 Implementation

Within this project the balance of evidence sought has been more at the individual project level than super-project or Programme level. This is because:

- It is only by investigating research outputs and the research impact pathway in detail that a meaningful assessment can be made;
- A large number of individuals and organisations are involved in producing and consuming the RTD projects: most effort is undertaken at project level.

The Programme contains 283 research projects. The **project level** analysis has taken the form of studies of individual projects. 20 projects have been selected to be as representative of the Programme as possible, within the constraints of sample size and with random selection.

Programme-level analysis is important because it provides a context to the projects, to the research themes and gives a holistic view of the Programme. An understanding of the Programme structure was needed in order to attempt a randomised selection of projects. Certain aspects of the functioning of the Programme are also better examined at this level.

5.6 Programme-level Implementation

Activities carried out at the Programme level are as follows:

1. Classification of all research projects in the Programme according to criteria relevant to achieving impacts.

2. Data gathering of existing Programme statistics and results, and analysis of Programme-wide statistics, particularly with respect to research capability impacts. Much of this work is discussed in the next chapter.

3. Examination of Programme formation and objectives through a literature review and expert interviews (reported in Giorgi and Pohoryles, 1999).

4. An experiment concerning ease of obtaining project outputs, based on a simple request made to 100 institutions.

The experiment spanning 100 institutions was used to test the ease by which information from the Programme could be disseminated. It was prepared in response to anecdotal evidence that dissemination of the Programme could sometimes be poor.

5. Interviews with national representatives of the Programme.

In the experiment, a sample of 100 projects, selected so that no institution was contacted more than once, was taken and a fax sent to each project coordinator. The fax requested that the project coordinator provide a list of basic details concerning the project's deliverables[10]. A response was received for around one in two

[10] Deliverables are the project outputs formally submitted to the Commission, in accordance with the project contract. They are typically reports, but may also be databases or software.

projects, and the findings of this experiment have been used to draw up recommendations concerning the Programme.

A 'national representative' is a term used in SITPRO to denote a government official or expert within a member state who is closely connected to transport research within their country and within Europe. Their connection with the research makes them well placed to comment on use of the Programme's research by national government and other national users. They were questioned on the following themes:

- **Context**. Their involvement in the Programme and its projects.
- **Examples of Impacts.** Principal examples of project outputs being used (and thereby potentially creating impacts).
- **Comparison with Programme's Intentions**. Relating the Programme to the national 'position paper' at the Programme's formation; if research themes were particularly promoted by the government, whether they have been useful in practice, and exploited.
- **Recommendations**. What may enhance the extent to which projects have a positive impact.
- **Additionality**. Comments on the 'added value' of providing the Programme at the European level.

Users of the research have also been interviewed as part of the project studies. Collectively, they provide an opportunity to interview a spectrum of the European 'research user' community. The users were asked questions that could be answered in a more general way, in particular concerning their awareness of other Programme impacts beyond the project concerned. In most cases the sphere of their views have been adequately captured in the project studies, but in some cases reporting at the Programme level has been more appropriate.

5.7 Project-level Implementation

Table 5.1 provides the template used for the review process of the 20 project studies. It has been intended that the template is adjusted

according to the information needs of a particular project review and according to practical constraints.

Interviews provide the main source of information for the studies and are structured around questionnaires. Other information can be gathered through independent research and corroboration, including referencing articles and conferences. European Commission organised data sources are a useful basis for study preparation.

There are three target groups for the interviews:

- Researchers – ideally the coordinators of the project;
- clients of the research – ideally EC project officer; and
- users of the research.

Table 5.1: Guidance of Tasks in Conducting a Project Study

1. Collate factual information about the project (summary fiche, EC questionnaires for the Transport Programme, progress reports, DG Transport database)
2. Document initial views on:
• likely Research Impact Pathway(s)
• relevant High Level and Research Capability Objectives
• likely exploitation to date
3. Fax questionnaire to interviewees
4. Conduct coordinator interview
5. Conduct DG Transport project officer interview
6. Conduct user interviews
7. Summarise review
8. Allow interviewees opportunity to submit comments

The first group, researchers, are in a good position to report on all aspects of the research and how it has impacted on their organisations' research capability. The project officers are able to provide a valuable alternative perspective to that of the co-ordinator. They add an additional dimension when the Commission is itself a target user of research. The third group of users have a more limited

perspective of the research, but are invaluable as they are able to comment on the usefulness of the research and describe the type of exploitation they have undertaken in the "real world".

Having carried out the structured interviews, raw data from interviews must be subject to a process of judgemental review before writing up in the form of an assessment table with supporting text. Any contradictions may be resolved, by reference to secondary sources or by checking with the interviewees if necessary. Verbal evidence of exploitation where possible should be corroborated by written (i.e. printed and if possible published) evidence. Any explicit or implicit magnitudes relating to the final impact (e.g. range of potential beneficiaries; nature and scale of benefits) should be carefully considered before finding a form of words for the assessment which sets these clearly in perspective from a European viewpoint. Any risks and uncertainties remaining in the exploitation process should be explored in greater depth to ensure that statements made in the reporting for each project can give a meaningful impression of the likelihood that the exploitation will lead to the final impacts as suggested.

The outputs from each review of an individual research project consists of:

- a summary assessment table;
- background information, that is factual for classification purposes;
- supplementary evidence, that covers the key points on the impact pathway; and
- further comments, both by the researcher carrying out the study, concerning information not adequately captured so far, and feedback from the project co-ordinator and officer.

For each criterion an assessment of the strength of evidence is given. A description is given to explain the context to the score, and the source of the evidence is stated (for example, it may be information from the project co-ordinator, or independent evidence from conference papers).

The summary assessment table attempts to bring these separate items together, and assess overall evidence. This is then measured with respect to a priori expectations of evidence, based on the nature of the project and how far developed it is.

6 Research Capability Impacts

6.1 Introduction

The research capability objectives concern increasing skills and knowledge, of individuals and institutions both directly concerned with the project / Programme and those beyond. They also concerns networking skills so that knowledge can become more widespread and be applied more effectively.

Detailed data concerning research capability is being collated by the Commission through questionnaires that co-ordinators are required to answer upon the completion of their project. At the time of carrying out this study only a fraction of the questionnaires were available[11], so could not be analysed in any representative way.

Given this background, the study has consisted of:

- a top-down analysis of institution participation using statistics collated for the entire Programme; and
- investigation of research capability impacts through the 20 sample project studies.

6.2 Institutional Participation

Various evaluation studies of the EU research programmes (see Chapter 3) have argued that perhaps the greatest impact of the latter has been the exploitation of research capability, specifically with regards the promotion of networking across national boundaries and across institutional profiles.

A general Programme analysis relying on project data can provide an overview of the main patterns of participation and of interaction of institutions, from which impacts concerning an increased knowledge base and the creation of effective research networks can be inferred respectively.

[11] 3 of the sample of 20 projects.

Overall, 1,228 institutions participated in the Fourth Framework Transport RTD Programme, the average participation rate being two projects per institute. However, there is a great degree of variation with two thirds of all institutions displaying participation in only one project and some 3% displaying more than ten entries. Table 6.1 displays these results by type of institution: we distinguish between research organisations (ROR), higher education institutions like universities (EDU), commercial manufacturers or industry, including SMEs (IND) and service providers, including consultants (CON).[12]

Table 6.1 Frequency of participation by institutional profile

Type	Once	Twice	3-5 times	6+ times	All
ROR	101	19	24	25	169
EDU	101	25	31	19	176
IND	376	85	63	32	556
CON	236	50	26	15	327
Total	814	179	144	91	1228

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

Research organisations and universities are less likely than industrial partners and consultants to display only one entry. On average, research organisations and universities participate in three projects; industries and consultants in two.

The set of dominant institutions in European transport research (measured by frequency of participation in the Programme) comprise mainly research organisations and higher-education institutes. The exception is the rail sector where a few industrial partners dominate the research arena, which again is not surprising considering that one of the main objectives of the rail programme was to bring national railway companies together to co-operate; and the air sector where major service providers dominate, again no surprise considering the orientation of the programme towards the development of a European Air Traffic Management System.

The predominance of research organisations and higher education

[12] It would seem from the data available to us that caution is called for in terms of interpretation of these categories, as these have in turn been interpreted differently by the participating institutions.

institutes among the frequent players in the Transport RTD Programme speaks positively in favour of the Programme in terms of exploitation of research capability. What this suggests is that it has been possible for the Programme to first acquire a research profile and second to establish a European research community with some fixed reference points in terms of expertise. It is nevertheless important also to underline that such a development ought to be carefully monitored through time. A higher institutional concentration in terms of participation at the early stages of emergence of a research community may be positively valued; this, however, need not be the case at later stages as we know from innovation theory.

Table 6.2 displays the frequency of co-operation between different types of institutions, using the same institutional classification as in Table 6.1. It provides insight into the extent to which the Programme has been successful in affecting closer co-operation between basic and applied research or user-orientation. Table 6.3 displays the frequency of co-operation between countries. Note that the figures do not correspond to institutions, but to projects. The figures across the leading diagonal correspond to the number of projects where, for instance, research organisations participated; the entries off the leading diagonal relate to the number of projects where we find a participation of both, say, research organisations and universities.

Table 6.2. Project co-operations between different type of institutions.

	ROR	EDU	IND	CON
ROR	**216**	145	190	156
EDU		**175**	146	130
IND			**248**	192
CON				**211**

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

The Transport RTD Programme seems to have been successful both in terms of promoting inter-European co-operation and in terms of supporting co-operation between the industry, consultancies, research organisations and universities.

Industry participated in 248 of the 282 projects, i.e. to almost 90 % of all projects. In 190 projects i.e. in 68 % of the cases, co-operation

between the industry and research organisations was observed; in an equivalent number of cases (N=192) co-operation between the industry and the service sector, including consultancies, was observed. Co-operation between universities and the industry was the lowest: only in slightly over half of all projects could such co-operation be observed.

Turning finally to the regional distribution of co-operation, we find that the Transport RTD Programme has consolidated co-operation between the major actors in the field of science and technology, i.e. between the UK, France, Germany, Italy and the Netherlands, and has encouraged the inclusion in research consortia of smaller or more peripheral countries. Regional patterns of co-operation, i.e. for instance between the Scandinavian countries or between Spain and Portugal, are less evident.

Table 6.4 shows participation in the Programme by Member State. Central and Eastern European participation in the Fourth Framework Programme was limited to partnership and that only during the last years of the programme. The highest participation of East Europeans is displayed by Hungary (with 15 entries), Russia (with 9 entries) Poland (with 8 entries), Romania (with 8 entries) and Slovenia (with 7 entries).

Table 6.4. Participation in the Transport RTD Programme by nationality

Country	Co-ordinating ... % projects	Participating in ...% projects
UK	23	72
France	15	58
Germany	13	66
Netherlands	10	57
Italy	8	49
Belgium	7	31
Greece	5	33
Spain	4	40
Austria	4	18
Sweden	3	29
Denmark	2	17
Norway	2	16
Finland	2	25
Ireland	1	10
Portugal	1	15
	All=100%	Maximum=100%=282

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

Table 6.3. Project co-operations between countries

	UK	DE	FR	NL	IT	ES	GR	BE	SE	FI	AT	DK	NO	PT	CH	IE	HU	RU	CZ	PL	SL	RO	BU	EE
UK	**203**	130	125	124	98	83	74	59	60	56	39	33	32	32	25	25	10	8	7	7	6	6	3	2
DE		**185**	117	102	95	75	59	63	57	48	37	29	30	25	21	14	12	6	7	6	6	2	3	3
FR			**165**	101	86	78	45	52	50	35	27	25	23	27	20	18	8	4	6	5	5	1	3	3
NL				**161**	74	60	57	54	49	37	28	29	24	26	19	17	12	4	8	6	5	2	1	2
IT					**139**	69	49	45	35	39	27	24	19	18	16	16	8	5	3	6	1	5	3	3
ES						**113**	37	37	41	29	21	22	19	17	12	14	7	4	2	4	3	2	0	1
GR							**94**	29	32	33	19	25	16	20	10	14	6	5	6	3	4	3	2	2
BE								**88**	32	24	16	16	10	17	11	13	9	0	2	2	5	3	1	1
SE									**82**	29	19	17	17	20	4	12	4	3	4	1	4	0	0	0
FI										**70**	21	21	18	15	13	14	8	6	3	6	4	3	2	3
AT											**51**	14	10	12	12	7	6	2	4	4	3	1	1	1
DK												**48**	10	10	7	7	4	1	4	3	3	3	2	1
NO													**44**	9	4	5	1	4	2	1	1	1	0	1
PT														**42**	8	8	5	3	3	2	3	1	1	3
CH															**29**	6	5	0	2	2	3	1	0	0
IE																**28**	2	2	1	1	4	2	0	0
HU																	**15**	1	0	5	3	1	2	2
RU																		**9**	0	3	0	1	1	0
CZ																			**9**	0	1	0	0	0
PL																				**8**	1	1	1	1
SL																					**7**	0	0	0
RO																						**6**	1	1
BU																						1	**3**	1
EE																						1	1	**3**

Source: DG Transport PACMAN Database, 12/98; derived by Giorgi and Pohoryles (1999).

UK = United Kingdom; DE = Germany; FR = France; NL = Netherlands; IT = Italy; ES = Spain; GR = Greece; BE = Belgium; SE = Sweden; FI = Finland; AT = Austria; DK = Denmark; NO = Norway; PT = Portugal; CH = Switzerland; IE = Ireland; HU = Hungary; RU = Russia; CZ = Czech Republic; PL = Poland; SL = Slovenia; RO = Romania; BU = Bulgaria; EE = Estonia..

It is well known that European countries differ significantly with respect to both innovation potential and research performance. The four countries that dominate the Transport RTD Programme are also those with the strongest performance indicators in terms of innovation.[13]. The differences among them – i.e. the dominance of the U.K. over Germany or France – can be explained by the existence of indigenous research programmes, also in the field of transport. For UK institutions and industry, internationalisation has been more important because of the lack of national research funding.

It has been the objective of other Union policies – in particular those relating to the Structural or Cohesion Funds – to raise the research capability of those countries which by reason of peripherality, historical conditions or economic underdevelopment were not in the position to elaborate own research programmes nor to consolidate an indigenous research community. Indirectly, by encouraging regionally-balanced research consortia, the Fourth Framework Programme also supports this policy. However, so long as there is variation in the performance of the national innovation systems, there will also be variation in the national participation rates to European research programmes.

6.3 Creation of an Effective Research Network

It is clear from the above analysis that much pan-European collaboration has taken place. It is also important to examine the quality of the collaboration, and the added value that the Programme has provided. This has been achieved through studying 20 sample projects. These studies, primarily, form the basis of the evidence drawn upon for the remainder of this chapter.

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[13] Thus Germany, France and the UK all display a GERD which is above the European average: France at 2.34%; Germany at 2.27% and the UK at 2.20%. In the Netherlands the GERD is just below 2% but still above the European average. The share of business expenditures on RTD is higher than 50 %. All four countries have between 10 and 12 research personnel per 1.000 inhabitants. All four account for 37% of all European patents (whereby all other European countries account for not more than 7%); 16 % of all international patents (in comparison to 2% for all other European countries); and for 22% of all world publications (in comparison to 12 % for all other European countries). The only other countries displaying high GERD are the Scandinavian countries: Sweden, Norway and Finland also display high figures of research personnel per 1.000 inhabitants. Spain, Portugal and Greece all have a GERD which is below 1% and less than 5 researchers per 1.000 inhabitants. Data were derived from the OECD (1996) and EC S&T indicators (1994).

Without the Programme, this range and depth of collaboration would not be in evidence. Whilst many of the consortia interviewed had worked together to some extent before, their collaboration had often been on a framework programme and so the Programme, if not the individual project, was the driving force behind the network formation. Expert interviews reinforce the impression concerning the depth of collaboration: researchers made contacts through seminars previously, but there was limited shared work, which requires a far greater depth of collaboration.

The success of the consortia is in some way demonstrated by the extent to which further collaboration has been undertaken or is planned. 18 of the 20 reviewed projects[14] contain partnerships which plan to work together subsequently, including participants in 6 of the 7 consortia that had not worked together before. However many of these future collaborations are for framework projects. The evaluation criteria of such projects favours pan-European consortia, and so the networks may exist as a convenient mechanism to win contracts, rather than because of the added value the partnership provides.

An indicator of greater independence is the extent to which subsequent collaboration occurs outside framework programmes, which was in evidence for 7 of the 20 projects.

Expected benefits and disbenefits of consortia were in evidence in the project studies. Many interviewees asserted that different researchers brought different, complementary, skills to the consortia. Researchers learnt from enforced co-operation, and from each other's skills, research cultures and geographical differences.

Disbenefits were that organisation and administration has at points been very time consuming. Disagreements on technical issues disrupted projects. Co-ordinators have occasionally been disappointed with quality of work produced by partners. Property rights of partners inhibited transfer of tools and data. However many of the disbenefits diminished with repeated collaboration.

[14] The co-ordinator for each consortium was interviewed. These results reflect the perspective of the co-ordinator, who may not be aware of activites being undertaken by other participants.

6.4 Other Impacts

Dissemination of *innovative* work increases the skills and knowledge of the research community. The evidence for the extent of this impact is mixed. Whilst several projects were judged to be highly innovative, a significant component of many projects consisted of consolidating previous work, 5 of the 20 projects exclusively so. Consolidation can represent a major step forward, particularly in terms of harmonising findings and making them more accessible, but is not innovative in any commonly recognised sense.

The Programme also had significant impact on the parts of institutions undertaking the research. These impacts could include a change in focus of the research undertaken by the institution, and the employment of additional researchers.

6.5 European Added Value

The criterion of 'European added value' has not been seen as an impact itself, but rather an assessment of the extent to which the impacts would occur in any case without the presence of the Programme funding. Indeed most of the research carried out is only part funded by the Programme.

It is clear that *most projects have a strong European dimension*, so could not be carried out to the same extent nationally. For some the apparent added value was weaker: for at least 4 of the 20 projects the EU funding was essential but only at the margin, as the EU dimension was a *catalyst for co-operation between companies*, and served to unlock benefits and impacts. In a closed network environment in particular, there is European added value of bringing together the major partners in a particular industry, who are also the main target users of the research. National representatives from smaller countries all emphasised that the Programme allowed their researchers and practitioners access to a *far greater scale and range of research than would be possible nationally*. Reinforcing that point, at least 4 projects specifically cited that funding was not available from elsewhere.

6.6 Summary

The research capability impacts are found to be extensive and profound, particularly with respect to research networking. The benefits of these networks have been demonstrated for several of the projects studied through consortia's repeated collaboration outside the framework programmes.

Consortium size influences how it operates. There is little doubt that a larger consortium can reduce the operating efficacy of the project, because of the larger administrative burden it brings. However collaboration has definite benefits, and it is shown elsewhere that a network of associated partners, particularly target users, has advantages of significantly facilitating future impacts.

7 Material Impacts

7.1 *Introduction*

This chapter presents and examines the findings concerning impacts at the overall Programme level. The main focus of the study has been the examination of a sample of 20 projects belonging to the Programme. Programme level assessment has also fed into these findings using three means:

- Through interviews with national representatives, who are taken to be a key link to policymakers and transport research within their country and within Europe.

- Through an experiment designed to examine the ease of dissemination within the Programme, through testing a very specific type of dissemination over a large sample size.

- Through an examination of Programme formation and objectives through a literature review and expert interviews (reported in Giorgi and Pohoryles, 1999).

As only 20 project studies have been undertaken, the results from these studies can only be used to provide broad conclusions about the Programme as a whole[15]. However, even though the sample size limits the statistical inferences that can be drawn, strong commonality of findings between the studies have allowed a convincing understanding of progress towards Programme impacts to develop.

7.2 *Dissemination*

Dissemination is vital for the projection of impacts beyond the immediate confines of the 'closed network' environment of the immediate project researchers and promoters.

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[15] For example, if a particular characteristic is found in 50% of the projects, then it can be inferred that the characteristic will feature in 50% ± 23% of projects within the Programme as a whole, assuming the sample is representative. This is deduced from the sample size of 20, with a 95% confidence limit.

It is clear that there has been much dissemination activity promoting the substantial majority of projects. It has been argued in chapter 4 that dissemination has differing relevance for different impact pathways: it is essential for an open network environment, but less critical within a closed network.

Whilst the dissemination activity is clearly beneficial, evidence from users and national representatives suggest that problems concerning dissemination remain. Lack of availability of project results and information on projects' progress was seen as a major problem. It was thought that a more comprehensive web site is required[16]. An experiment carried out by the SITPRO project spanning 100 projects confirms that project outputs are not readily available to interested parties. Potential research users and other stakeholders admitted that they did not always know which projects were relevant to them, and it was difficult to assess the quality of the projects in advance. Concerted actions were a very helpful means for participants and their colleagues to overcome these issues (as well as having other benefits, including raising awareness of the research and networking).

7.3 Evidence along Pathways towards Material Impacts

For most projects it is too early to say the extent to which material impacts have occurred and will occur. The most important indicator on progress towards impacts is *exploitation of research to date.* Even so, in many of these cases, the exploitation will not in itself cause end impact. A further implementation stage is needed.

Table 7.1 summarises the incidence of use of the outputs to date. A distinction is made between use for further research, which is possibly the intention for the more innovative theoretical projects, and use in practical application. A distinction is also made between use by consortium members, which is generally easier to initiate, and use beyond the consortium. *It shows that 65% of projects have already been used, though this use may be limited and includes examples of use by members of the consortium in further research.*

[16] The EXTRA project has resulted in some improvements in Programme dissemination, including a one-stop web site. However project results are limited to short papers.

Table 7.1: Number of the 20 sample projects that have been exploited to date

User	Used in research or consultancy		Used in practical application	Total
	With the 4FP	Outside the 4FP		
Not a consortium member	4	2	2	5
A member of the consortium	2*	4	5	8
Total	**6**	**6**	**7**	**13**
No known use to date	7			7

Note: Totals are not simply the sum of categories as some projects appear in more than one category.

*The true figure is likely to be much higher, but not known to the individual researcher interviewed.

Use in further research is a relatively rapid impact. The impact of practical application can occur over a much longer term. The above analysis is limited to activities that had already started prior to the project studies. In contrast, the following analysis attempts to project into the future, based on current substantive or indicative evidence.

- 10 of the projects had outputs that have already been used in a practical way, or there is a clear indication on the part of the user that they will be used in the future. *This finding infers that between a quarter and three quarters of projects within the Programme will have outputs that will be practically applied.*

- There is some confidence that a further 3 projects have outputs that will be practically applied, though the evidence is less substantive.

- For the remaining 7 projects, there is no current indication that the project output will be *practically* applied (though some of these projects have already been applied in the research field).

Of the instances of practical exploitation that have already occurred or are clearly going to occur[17]:

- *Three have influenced European policy development in quite concrete ways*. In each of these cases, the subjects are in any case generating much interest currently. Developments, in the form of regulations and action plans, are expected within the next five years, or less. Impacts would not occur prior to such implementation and would have a long time span.

- *Three are to influence strategy* (two in the national policy arena, one in industry) in substantive ways, though 'uses' are not well defined, and impacts are expected to be quite remote.

- *Five have or are expected to change the procedures and systems* used by companies or national government. For four of these the impacts are already occurring, or will occur within the next two years. For the fifth project a further step is required to implement the results that the tool produces. Some of the impacts are related to harmonisation and interoperability benefits, and therefore wider implementation is needed for significant interoperability benefits to be realised.

7.4 Barriers and Facilitators to Impact

The study has placed great emphasis on trying to identify facilitators and barriers to impact, and they have been discussed in all interviews. The key findings are given below. The statements are not scientifically proven, but are reoccurring themes emanating from practitioners intimately involved in projects within the Programme.

The research consortium

- Partners should be selected to reflect the complementary skills needed and geographical diversity.

- Methodological differences can cause great delays and problems, as many researchers have limited experience in managing a project with "conflicting"

[17] 11 instances are given for the ten projects referred to previously, as one project has experienced two separate uses.

methodological perspectives. Partners do not always produce contributions of adequate quality. A culture of collaboration, good personal relationships and repeated co-operation alleviate such difficulties.

- A small consortium can certainly facilitate the research. Large consortia can lose the focus of the study if they are not effectively managed, and also create much additional bureaucracy.

- Communication and language problems can be significant, and these are greater with larger consortia. On the other hand, the widespread use of email and the internet are great facilitators.

- Organisations that are not primarily research focused can be less committed to the project as they have many competing short-term demands. This is particularly true if they are involved in several research projects.

- Including potential users of the research in the consortium greatly enhances the chances research outputs being tailored to users' needs, and hence of quick exploitation and higher probability of eventual impacts.

The output

- Projects must be conceptualised with clarity of objectives, to satisfy a real need and to produce a well-defined product (which can be highly innovative, theoretical research). The potential users of the project should be identified. If the project is too large in scope, its focus and hence usefulness can be lost.

- In practice, outputs are not always appropriate for their intended use. In particular the documentation can be too long, or the output may need experts or specialist equipment to apply.

Dissemination

- For an end impact to occur, the research often needs stamina to survive. For example it may need widespread dissemination in the research community, further studies, a strategy for marketing the product *after* the research is complete, and promotion by the Commission and others.

- Currently many potential users are unaware of Programme research relevant to them; the large number of projects in the Programme is partly responsible for the confusion.

- The dissemination must be relevant to target users, and be carefully thought out so that the potential for errors is minimised. There should be clear lines of communication with target users, including formal liaison if appropriate.

Exploitation of research

- Confidentiality of results and intellectual property rights are a great barrier to impacts. Classification of project outputs with the status "public availability" certainly overcomes this barrier (although researchers' interests in protecting knowledge may often mean that "public availability" must be combined with an easy way of obtaining the output).

- There can be great reluctance and caution on the part of users to apply a new product, particularly if it is highly innovative. This emphasises the need for the research output to be widely disseminated, so that it has the stamina to become more established, through application by those mostly closely involved in the research, before it is able to diffuse further.

7.5 Comparison of Expected and Actual Exploitation to Date

The project studies sought to clearly ascertain where each project was on its research impact pathway. In order to project into the future, it was then necessary to consider where the project should be if its potential impacts are to be realised.

In practice the contrast with 'expectation of exploitation' has been difficult to judge. Several projects have been used in further research and it is not anticipated that they will be used in a practical context. Project promoters may then justify the limited exploitation by saying that the research area is new and the output is intended as a 'first step'. It is not clear whether this is really the case, or if the explanation is a post hoc explanation of failure to produce a practical output.

The results for this measure are shown in Table 7.2. There is diversity in the scoring, which in turn reflects diversity in projects' performance. The results show that generally the projects are performing well, with a slight bias in favour of over performance relative to a priori expectation. However, for the above reasoning, the results must be viewed as indicative only.

Table 7.2: The extent to which Exploitation to Date compares with Expectation

Unit = number of projects	Physical Output	Research Capability
Falls a great deal short	1	0
Falls a little short	3	2
Matches expectation	10	14
Exceeds expectation	6	2
Total	20	18*

* Two projects were not assigned a score for this category.

7.6 Conclusion of Impacts

The findings of the sample of 20 projects indicates that a substantial proportion (more than 50%) of projects within the Programme are being applied practically. A further number are being applied in other research fields.

Whilst this is a reassuring result, it is worth noting that some of these uses can be marginal compared to the *potential* use of the research. In addition, how these cases of exploitation are translated into impacts are far from certain: for many, a further implementation stage is necessary.

The results show that *impacts are tending to occur in closed network environments*. The instances of application on the European policy level have occurred in a context where liaison between the promoters of research (the consortium or project officer) and the target users is integral to the project. In other words the formalised liaison (in these cases, participation of consortium members in working group, participation of target user in project development, liaison meetings organised) has allowed a 'closed network environment' to develop. The closed network has proved to be a positive environment for exploitation of the research to occur[18].

[18] Though an implication, typical to closed network environments, is that the EC may be drawn into a closed relationship with a particular supplier, with repercussions for competition between suppliers later on.

Evidence concerning progress towards impacts in an open network environment is mixed. Incidences of use do exist. Projects report many requests for project outputs, particular in the wake of other forms of dissemination such as conferences. Each such request could hide a form of exploitation and impact. However only two projects, out of the 20 sampled, have a clear indication that use has or will occur in an open network environment.

This relatively small number is in part explained by the characteristic that exploitation under open network conditions is less readily observed and will normally occur over a longer time scale than that in a closed environment. However, the barriers to exploitation in an open network environment, compared to a closed network environment, are substantial. Users and national representatives have mentioned the difficulty of obtaining information about the projects, and confusion about which projects will be relevant to them. This, coupled with limited evidence of exploitation, suggests that there may be cause for concern that potential impacts are not being realised in this kind of environment. Whilst the EXTRA project is in the process of mitigating some of the shortcomings, the issue would benefit from further review, particularly in terms of understanding what information potential research users would like to be able to obtain, and how they would like this information structured.

8 Recommendations for Enhancing Impacts

8.1 *Overview*

Each project study was required to focus on barriers and facilitators to impacts. Other research assessment, and Programme level interviews, also put great emphasis on this subject. This chapter structures these findings into recommendations, within the framework of the research impact pathway concept.

When considering means for enhancing impacts, it is useful to re-consider the stages of a typical research impact pathway:

1. production of research outputs – creation of the "product";

2. dissemination of outputs – raising the level of awareness about the product;

3. exploitation of outputs – by key intermediaries or end-users of the research; and, typically in the much longer term:

4. end impacts on society – on consumers and producers.

The first stage, production of output, is a function of the project itself. This aspect is the subject of Programme evaluation exercises including the Technical Review being carried out in parallel to this study. When considering impacts, the *usefulness* and *applicability* of the output are of more relevance.

The second and third stages are critical to progress along the research impact pathway and can be greatly influenced by actions of the promoters of the research. The final stage can be much longer term, particularly if further steps to implementation are required after the initial exploitation of the output. *It is much more difficult for the project and Programme promoters to influence the final stage, and it is largely omitted from these recommendations for that reason.*

Table 8.1 summarises the different generic barriers to research use. The table distinguishes the relevance of these barriers to two extreme contexts of the

Table 8.1: Barriers to Overcome along the Research Impact Pathway

Barrier	Means of Reducing Barrier	Responsibility	Is barrier relevant?	
			Closed network environment	**Open network environment**
Research is of poor quality.	Promote scientific and technological excellence and good project management. Ensure that the subject is useful and contributes to Programme objectives.	Research consortium directly; European Commission (EC) indirectly.	Yes. If the research is of low quality, it has limited use.	Yes. If the research is of low quality, it has limited use.
Existence of the research is not widely known.	Effective dissemination of research.	Typically the consortium and the EC.	No. The target users, by definition, know about the research.	Yes.
Applicability of research not well understood.	Independent assessment of the research's quality and limitations. Well targetted types of dissemination. Concerted actions work well because the research is explored in detail.	EC must ensure appropriate infrastructure is in place. There is room for further initiatives in this area.	Limited. The target users are able to influence the nature of the project outputs and so understand its applicability.	Yes. The target users may not readily understand the relevance of the research to them.
Research outputs not readily available.	Good infrastructure to promote access to research outputs. Consideration of property rights is crucial: restrictions severely constrain impact.	EC must take the lead, through consultants if necessary.	Limited. The research may even be in-house, though even within a consortium property issues do arise.	Highly relevant.
Research outputs not user friendly.	Minimise training requirements associated with the output and maximise ease of use: the research needs to be clear to understand and apply.	Research consortium.	Yes, some relevance, though target users will have some prior familiarity with the output.	Yes, particularly as the user would typically apply the output without help from the consortium

research impact pathway, namely a 'closed' and an 'open' network environment. It is argued that most of these barriers are of less significance in a closed network environment.

To reiterate:

- A *closed network environment* is characterised by a close inter-relationship between research producers and potential research users. There are few target users. They are well defined and often actively involved in the project, possibly as members of the research consortium.

- An *open network environment* is characterised by fluid inter-organisational structures. There are many potential stakeholders, the majority of whom are not concerned with the project and may not know of its existence.

The recommendations are structured with reference to these barriers. They can be summarised as follows:

- Ensure in advance that the research impact pathway (or pathways) are well understood and are feasible.

- Strengthen the lines of communication between the producers of the research and the target users – ie enhance 'closed' network environment characteristics.

- Minimise the barriers, and maximise facilitators, for impacts to be achieved, particularly in open network environments.

8.2 *Establish the likely Research Impact Pathway (s)*

The act of examining the impact pathways that the research might take, forces the project promoters to undertake the necessary steps to ensure that the research impact pathway is feasible, so that progress through the key chain of events towards successful exploitation can be facilitated. Lines of responsibility of the research consortium and the Commission should be considered and agreed.

This recommendation is clearly highly complementary to the Commission requirement for much more emphasis on pro-active exploitation management that is apparent for the 5th Framework Programme.

The impact pathway is only likely to progress if the output is suitable for its intended use, relevant types of dissemination occur, if the research output is sufficiently accessible and available, and if the necessarily liaison is undertaken. For pre-competitive research, follow up activities are likely to be needed so that the pathway has the stamina to be maintained.

It is an explicit objective of SITPRO to recommend methods to be applied to monitor future RTD programmes. Monitoring of impacts requires explicit consideration of the impact pathway the research will follow, and we recommend programme monitoring as a method for enhancing impacts.

A simplistic monitoring devise was proposed in D5. It is based on the log-frame concepts of verifiable indicators, and linking the verifiable indicators to project performance and hence programme performance. The act of monitoring differs fundamentally from the activities carried out in this study as *it requires objectives concerning project exploitation to be formulated at the project's inception.*[19]

For each project the 'main research output' to be monitored, and what constitutes 'substantive use' of that output must be defined. These are the indicators used for defining targets. Statistics are measured relative to the targets.

[19] There are difficulties with basing performance on objectives specified at project inception as it is not always possible to specify the outputs at that stage. Indeed, it is often those projects that combine good planning with adequate flexibility (to react for instance to new policy or other demands) that are also the most 'successful' in terms of making an impact on any particular user group. However some specification should be possible, and monitoring is of programmes rather than projects, so project-specific distortions contribute little to overall conclusions.

Use is differentiated in four ways:

{research used for further research}	Or	{research used in practical application}
	And	
{research used by consortium member}	Or	{research used outside consortium}

The differentiation is made because practical research needs to break out beyond the research community in order for the intended impacts to materialise. The distinction between consortium members and others allows a simple monitoring of the extent to which the research is able to diffuse beyond the immediate confines of the project stakeholders.

8.3 Enhance Closed Network Characteristics

Closed network environments can only readily occur when the target users are well defined and few in number. In these circumstances, the environment can be made more closed by strengthening the ties between the researchers and the project users by involving them in some way with the project. Open network environments do not benefit from this strategy to the same extent because increasing the strength of ties with some users may mean excluding others from opportunities to use the research. However, as discussed below, in some circumstances involving users in the project can be beneficial, even when the network environment has open characteristics.

The main means by which the network environment can take on more 'closed' characteristics is by including some *target users as members of the project consortium*. As Table 8.1 shows, there are few barriers to the consortium member exploiting the research. There are other advantages of involving a target user in the research: probable greater access to data, the industry participants have a real vested interest in developing the work further, and the user is able to influence the product to enhance its practicality and usability.

There is another advantage of making the network environment more closed in this way, even when there are potentially many target users. Some users will have a natural *resistance to change* and so will be reluctant to adopt new practices in an open network environment, particularly highly innovative practices. If the user is part of the research consortium, they have a greater commitment to the product and so

are more likely to apply it. The Commission as promoter is also invaluable in these circumstances. Promotion of the output will allow it to gain some credence amongst other users, and give the research stamina to continue along the impact pathway, perhaps through further research development as well as exploitation.

A potential serious disadvantage of making a network environment more closed is that the research consortium may be reluctant to disseminate their findings to competitors. Thus property rights, and how their detrimental effects can be minimised, must be considered at an early stage. Another disadvantage may be that the industry participant is not as focused on the project as a purely research based participant would be, as research may not be their first priority.

There are other means by which network environments with few target users can be made more closed in character, by formalising the relationship between the consortium and target users. The user could be allowed to influence the content of the project, and indeed the original task specification. Formalised ties, such as working groups and concerted actions, are already quite well established in the Programme and are recommended.

Concerted actions, or thematic networks, also work effectively in an open network environment. The relationship between the research output and national representatives participating in a concerted action is formalised and 'closed' in nature. The national representatives are then able to disseminate their findings to other policy makers, researchers and relevant users nationally, thus re-opening the research network.

8.4 Minimising Barriers in an Open Network Environment

Some aspects of the research should always be expected to go beyond the immediate network of the consortium and other project promoters, so it is almost always important to consider how impacts may develop in an open network.

Progress towards impact can be very slow, particularly in an open network environment. Research in an open network environment needs stamina to survive the many difficulties that are likely to be encountered. Such difficulties include: reluctance by the user to adopt new practices; resistance from particular interest groups; or that the output is not immediately policy relevant, but may be some time in the near future. Action is always needed to mitigate these problems, for example: widespread dissemination aimed at the research community; application of the product in test cases or by consortium members, so that the product gains

in acceptability; appropriate marketing after the research is finished; and appropriate further research.

Initiatives in the Programme have already contributed to the reduction of many of the barriers to use. In particular, much dissemination activity in the Programme is already widespread. The EXTRA (EXAploitation of TRAnsport research) project has been a major promoter of dissemination. Its activities have included the publication and wide circulation of newsletters, the preparation of project profiles and summaries, and the establishment of a new unified web site.

Two main problems appear to remain:

- That it is difficult to obtain project outputs, particularly project deliverables (these are the outputs required as part of the project contract).

- That it is not immediately clear what research is relevant to whom.

There are compelling reasons for making project deliverables readily available. Deliverables will typically contain more detailed information than is available in the final report (all final reports are published), so can be more helpful for specialist use and for practical implementation. Furthermore, research within the Programme has been criticised for lasting too long and so losing its policy relevance. Easy availability of deliverables mitigates this problem by allowing early results to come on stream much sooner. A single internet site providing direct links to publicly available and restricted deliverables which can then be downloaded, is by far the most superior means of achieving this.

The second specific recommendation is that a guide is produced to help potential users determine what research may be useful to them. There is widespread evidence of confusion over what research is available. An interactive guide, and equivalent brochure, that demonstrate what research is relevant to which user is an ideal way of mitigating such problems, leading users directly to the research that is most useful to them. The EXTRA project has already made some advances in this area, notably by labelling all projects by key words. The type of information contained in the DG Transport internal database (although not all of it is suitable for public release) is an example of well-structured information about the overall research Programme and its component projects.

8.5 Research Network Impacts

The research capability impacts are found to be extensive and profound, particularly with respect to research networking.

Results in Chapter 6 showed that large consortia have benefits and disbenefits. Policy concerning the size of the research consortium can be informed by the findings of this project, but also by the more comprehensive evidence that will be provided to the Commission as part of each project contract. In general, a smaller core project team can certainly reduce the administrative burden. However a network of associated partners, particularly target users, has advantages of significantly facilitating impact.

It is perhaps worth noting that the disbenefits of collaborative action could reduce network impacts over time. The disbenefits of collaboration are greatly mitigated when partners are familiar with working together. The risk with this development is that it may in turn encourage established partnerships to perpetuate, as was widely in evidence in the project studies. Institutions that may consider participating in a programme for the first time therefore face an entrant's disadvantage, and the incidence of new participants may substantially reduce over time.

8.6 Summary

This chapter has described the different types of barrier that exist with respect realisation of impacts from research, from which the following areas of recommendation are derived:

- Ensure in advance that the research impact pathway (or pathways) are well understood and are feasible.

- Strengthen the lines of communication between the producers of the research and the target users – ie enhance 'closed' network environment characteristics.

- Minimise the barriers, and maximise facilitators, for impacts to be achieved, particularly in open network environments.

In addition, recommendations specific to enhancement of research capability impacts have been discussed.

9 Exploitation and Further Developments

In keeping with SITPRO's recommendations, this chapter seeks to clarify who SITPRO may be useful to and in what way it may prove to be of interest.

Table 9.1 lists outputs produced by SITPRO. It gives the relevant project document in which the information is given. Full reference to all official SITPRO documents ('deliverables') is given in the references.

Table 9.1 Exploitable Outputs of SITPRO

	Output	Deliverable	Type
1	The SITPRO Method for examining research impacts.	2	Method
2	A classification system for all transport research projects, which provides a framework to understand how their impacts will develop and may be enhanced.	4	Standards / criteria
3	A monitoring methodology for monitoring progress towards impacts.	5	Method
4	Presentation of Programme objectives by sector.	1	Assessment exercise
5	Analysis of institutional participation and collaboration.	1	Assessment exercise
6	Results concerning impacts that enhance EU research capability.	1&4	Assessment exercise
7	Results concerning progress towards material impacts of the Programme.	4	Assessment exercise
8	Recommendations concerning how impacts may be enhanced.	5	Guidelines

Target users of the project are thought to be as follows:

1. Those setting up and managing comparable research programmes in the future, including the Sustainable Mobility and Intermodality key action of the

Promoting Competitive and Sustainable Growth Programme in the 5th Framework Programme.

2. Researchers and project officers who would be motivated to enhance the positive impacts of their research.

3. Researchers concerned with programme evaluation.

For the first group, if involved in the Transport RTD Programme, all outputs are relevant. For the second group, only outputs 2 and 8, concerning enhancement of impacts, are likely to be of interest. The third group, those concerned with programme evaluation, would be interested in outputs 1, 2 and 3, concerning evaluation and monitoring of impacts.

There are various ways in which these outputs could be developed further or made more specific to the needs of individual users. Namely:

- The study has been undertaken when much research is not even complete. A follow up study, in around a year's time, would be able to establish much more evidence of the extent to which progress towards impacts is being made.

- It will be valuable to establish the extent to which the EXTRA project is filling the current identified gaps in information diffusion, what further action is needed, and consider whether such an initiative should in general occur earlier in a programme's life cycle.

- Monitoring impacts for the 5th Framework Programme would raise awareness concerning the importance of impacts and hence enhance performance. SITPRO has set out a method for monitoring progress towards impacts which would require refining and some adaptation prior to implementation.

- The project has provided a framework to conceptualise the research impact pathway of projects, and better target a project's dissemination and exploitation strategy. The insights could be fed into programme management, to encourage adequately conceptualisation at each project's inception.

- The innovative SITPRO method has been developed to suit the constraints of the project resources and information available. It could benefit from strengthening through tighter structuring of the project studies, in particular

with respect to the scores assigned to certain criteria and with respect to 'expectation of exploitation' as the benchmark against which performance is measured.

Glossary

The purpose of this section is to clarify our understanding of important terms that are used in the SITPRO project. Those with an asterisk (*) are terms which are of particular importance in SITPRO and which may be new to many individuals.

Term	Meaning
*Research Impact Pathway**	• The process by which a project makes an impact. • The term "impact pathway" comes from the ExternE[20] project, and relates to the way in which pollutants such as car exhaust gases are emitted into the atmosphere, disperse, and, for example, are absorbed and have impacts on human health. This complex, multi-stage process is also found in the way in that a chain of events have to occur before research can make an impact.
Dissemination	• Making the research known to the public.
Exploitation or Use	• 'Exploitation' and 'use' are used interchangeably: the research results or outputs are applied or acted upon, thus allowing the potential for future impacts.
*High level objectives**	• Reflect Community policy within the context of the transport sector • For the purposes of SITPRO the high level objectives have been taken as the Specific objectives of the RTD Programme in Transport. • Material impacts are related to these objectives
*Material Impacts**	• Also called 'real-life impacts'. These are impacts that occur in 'real life' as opposed to impacts within the research field • Examples: impacts related to enhancing the environment, improving transport safety or other aspects associated with high level objectives. • Impacts related to research capability, such as increases in the knowledge of researchers, are *not* material impacts.
*Research Capability Objectives**	• Goals for the enhancement European research potential; • Research capability impacts are related to these objectives.

[20] Friedrich et al, 1998.

Term	Meaning
*Network Environment [of a project]**	Used to describe the strength of relationship between promoters of research and users of research. See below for specific examples.
*Closed Network Environment**	Characterised by the rigid inter-organisational structure of its stakeholders. There are few target users who are often actively involved in the project, possibly as members of the research consortium.
*Open Network Environment**	Characterised by fluid inter-organisational structures. There are many potential project stakeholders, the majority of whom are not concerned with the project and may not know of its existence.
Output: Standards / Criteria	1 of 4 classified types of research output. To be used as inputs to standardisation exercises or the specification of criteria. Examples include projects aiming at establishing databases.
Output: Guidelines / Handbooks / Best Practice Models	1 of 4 classified types of output. The output is primarily policy recommendations in the form of guidelines or best-practice conceptual 'models'. For example, guidelines concerning junction design to improve safety.
Output: Tools / Models / Methods	1 of 4 classified types of output. Tools, models, methods or technical frameworks for use in policy or impact assessment or for measurement purposes. For example, a tool to monitor freight reliability.
Output: Assessment Exercise	1 of 4 classified types of output. Emphasis is placed on the results of the assessment rather than on the method or tool used. For example, an assessment of the benefits of marginal cost pricing.
4FP	• The European Union 4th Framework Programme, a multi-disciplinary programme of research. • Duration 1994-ongoing (1994-98 for letting of projects). • Budget = 12,300MECU.
The Programme	• The Transport Research and Technological Development Programme. • The Programme being studied by SITPRO. • Part of the 4th Framework Programme. • Budget = 264 MECU.
Project	• An individual research project in the *Programme*. • There are approximately 300 projects in the Programme.
[Project] Deliverables	These are project outputs that are formally submitted to the European Commission as part of the project contract. They typically take the form of reports or working papers, but may also be databases, software, or other items.

Term	Meaning
Project objectives	• Each project has defined objectives, summarised in the project summary fiche. • Additional objectives may be defined as the project progresses.
Concerted Action / Thematic Networks	• A project which clusters research projects and draws their individual results together in order to direct policy developments or and/or research priorities. • There are approximately 15 Concerted Actions in the 4th Framework Transport RTD Programme. • Members of concerted actions typically include representatives from each member state.
National Representatives	A nationally nominated participant in European research. More specifically, in certain instances, a member of the now disbanded Transport Research Committee of the 4th Framework Programme.

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