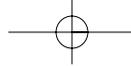


Focus Study on Funding, Management and Operation of European Research Networks

> analysed by network hierarchy //

TERENA REPORT > / MAY, 2004





Focus Study on Funding, Management and Operation of European Research Networks

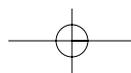
analysed by network hierarchy

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May 2004

<http://www.terena.nl/compendium>



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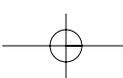
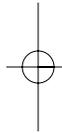
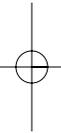
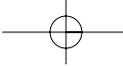
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Executive Summary // >

> Introduction

This report presents the results of a focus study carried out in spring 2004 to complement the information collected in the annual TERENA Compendium of NRENs. This focus study was funded under the COM-REN project of the EU's Fifth Framework programme on research networks.

The objective of the focus study was to examine a selected number of features of research networks in Europe in more depth than had been possible in the context of the Compendium. In particular, the study was intended to look at funding levels and trends in funding, analysed across the levels of the network hierarchy.

The main data collection was by means of a questionnaire distributed to selected European NRENs. The design and execution of the survey was carried out with the advice and active participation of TERENA Compendium Review Panel. The draft questionnaire was refined as a result of testing with some of the NRENs represented on the Review Panel. This resulted in an improved and simplified design. Further, an extra section was added to the questionnaire to cover multiple domain issues since these are closely related to the organisation of the network hierarchy. It was apparent that NRENs were a source of valuable information in this area and that this would enhance the analysis by network level.

> Response and Follow-up

The questionnaire was circulated to 28 NRENs of the EU member states and the EEA. This choice was made to limit the total number of respondents in a survey which was anticipated to involve a substantial follow-up programme. The questionnaire was lengthy but easy to fill in. However, it must be acknowledged that the information being sought is not necessarily easy for NRENs to supply, since it involves a financial breakdown of both their own and external costs which has not previously been requested. It is therefore understandable that four NRENs, under pressure of work, were unable to respond. Nevertheless, the 24 NRENs who eventually responded by the end of April formed a very satisfactory sample, providing a good distribution in terms of country population and network budget.

The follow-up to the questionnaire comprised 54 questions of clarification to 17 countries. In the event, the majority of these could be handled by email rather than by telephone or face-to-face interviews.

Results 1: Analysis of Funding, Management and Operations by Network Level

The initial sections of the questionnaire looked at the current situation of the NRENs, broken down by network level. The network hierarchy used was the same as that used in the main Compendium, namely:

External:	international and commodity Internet links
Backbone	NREN core
Access	links from the backbone to the client institutions
Regional	regional or metropolitan networks
Campus	client institution LAN

The analysis of these factors displayed a consistent pattern. At the campus level, responsibility was almost always with the user institution. At the external and backbone levels, it was predominantly with the NREN, although there was a substantial amount of co-funding. At the access and regional levels, the picture was very mixed, with the NRENs, user institutions and regional bodies all involved.

It was clear from the responses that NRENs have almost no detailed information about expenditure at the campus level. Hence, this survey, which was directed exclusively at the NREN contacts, is unable to provide any reliable data on this particular item. However, the frequent occurrence of performance bottlenecks at this level is evidence of under-investment by some institutions.

The sources of funding and the levels of expenditure at the other levels were fully analysed on the basis of cost breakdowns from 22 countries. The average annual expenditures at the external and backbone levels were €2.72 million and €5.10 million respectively. In those countries (14 and 8) which reported at the access and regional levels, the average expenditure was €1.84 million and €3.26 million respectively. The individual figures are included in the text of the report.

A separate analysis was carried out at the external level in order to determine the costs of general Internet connectivity as well as connections to other research networks. This revealed that the costs of Internet connectivity were, on average, about 60 per cent of the costs of international research connectivity, although there were large differences between countries.

User contributions to the external or backbone costs were found in two-thirds of the countries. The average contribution is substantial, amounting to 28 and 37 per cent of the external and backbone costs respectively.

Results 2: Current Trends

The survey looked at changes in all of the above factors that had either occurred during the last year or were expected during the coming year. Exactly half of all countries reported some significant changes over this three-year period. The majority of year-on-year variations in expenditure were associated with one-off capital programmes. These resulted in expenditure variations of up to 60 per cent in some cases.

It was difficult to discern any strong trend in recurrent expenditure. It was either stable or perhaps rising slightly. This is consistent with the general picture which has emerged through previous Compendium surveys, which demonstrate that there are very substantial increases in bandwidth year-on-year within roughly constant total expenditure.

There were some changes of responsibility. A few NRENs were given an increased role at the regional level. There were changes to the level of user contributions in two countries: one an increase, the other a decrease.

Results 3: Multiple Domain Issues

A number of issues are known to be associated with multiple domains, and these are similarly associated with the hierarchy of network levels, especially where these are separately managed and funded. It is also expected that these will become increasingly significant as grids and e-science enter production. There was, therefore, a section of the questionnaire inviting NRENS to give details of their experiences in the last year, under the headings of performance bottlenecks, security, premium services, end-to-end services, and other.

The majority of countries reported performance bottlenecks. These were most frequent at the campus and access levels. This is consistent with the evidence from the SERENATE studies in 2003. As noted above, there were many reports that these were due to under-investment by some user institutions.

Similarly, the majority of countries reported denial-of-service attacks and other security incidents. The main problems were worms and viruses, other deliberate attacks and spam. It was often reported that the existence of multiple domains made it more difficult to diagnose and resolve such problems. Co-ordination between the network management at the different levels was also time-consuming. A further factor was the lack of sufficient, trained network staff at the user institutions.

The responses on premium and end-to-end service showed many similarities and these were consequently analysed together. Many NRENs have experience in offering these services on a limited scale, particularly through deploying videoconferencing and multimedia. There were also reports on IPv6 and the high-bandwidth research user. These services are demanding and stressed the network; frequently, this revealed performance weaknesses which had not been visible to the general user. Diagnosing and eliminating these weaknesses was again a difficult and lengthy business. The detailed engineering of multiple domains was often a source of such difficulties, for example, through differing technologies, and they were again associated with issues of diagnosis and co-ordination.

A full analysis of the multiple domain issues is included in the main text.

Results: Two Wider Issues

In two countries, it was reported that some network bottlenecks were due to the high cost of telecommunications. This had been reported previously in the SERENATE studies in 2003 on Eastern Europe. Neither of the two countries are among the ten recent accession states. Hence, it must be concluded that this phenomenon is also present, but perhaps not as widespread, in Western Europe.

In two countries, it was reported that some performance bottlenecks were the result of a charging policy, under which user institutions paid a connection fee related to the bandwidth of their connection. This is evidence that some institutions are unwilling, or unable, to fund an adequate network at for their members.

> Scope and Limitations of the Survey

This was the first survey of its type and it has resulted in much new and significant information. It represents a benchmark which could be used as a starting point for future studies.

There were three principal limitations in this study. Firstly, the number of countries included in the survey was limited, as explained at the outset. Secondly, no meaningful information was collected on expenditure at the campus level. Thirdly, trends were assessed only over a three-year period centred on the current year. Any or all of these aspects could be addressed more fully in future surveys. It is clear that obtaining information about campus network expenditure will require much greater investigative effort.

1 Introduction }

This report presents the results of a focus study carried out in spring 2004 to complement the information collected in the annual TERENA Compendium of NRENs (see <http://www.terena.nl/compendium> for more information). This focus study is funded under the COM-REN project of the EU's Fifth Framework programme on research networks.

The objective of the focus study was to examine a selected number of features of research networks in Europe in more depth than had been possible in the context of the Compendium. In particular, the study was intended to look at funding levels and trends in funding, analysed across the levels of the network hierarchy.

The methodology of the study is described in chapter 2. The main data collection was by means of a questionnaire distributed to the European NRENs. This was supplemented by follow-up contacts with the correspondents.

The main body of the results of the study is presented in chapters 4 through 7. These start with coverage of the current situation, as of early 2004, with regards to the funding, management and operational responsibilities, broken down by network level. This is followed by trends in these areas over a three-year period. Chapter 7 looks at the issues of multiple network domains, which are closely linked to the network hierarchy. These are particularly significant for the high-performance connections which are becoming increasingly important with the growth of e-science and grid-based projects. In this context, multiple domains are known to give rise to a variety of problems. The study therefore covered the level of occurrence of these problems and their affect on network performance.

The conclusions of the focus study are reported in chapter 8. Where applicable, we have compared our results with those of earlier studies. However, most of the observations of this study represent new data not previously collected, which are presented here for the first time.

2 Methodology ~

~ 2.1 Extension of TERENA Compendium Work

The focus study was conceived from the outset to be an extension of the existing COM-REN work and the annual TERENA Compendium of NRENs. In a number of areas, it was therefore natural and efficient to use the same procedures:

- data collection via an electronic questionnaire;
- distribution to TERENA NREN correspondents;
- wherever possible, use of the same terminology and definitions as the main compendium;
- oversight of the design and execution of the study by the Compendium Review Panel.

~ 2.2 Design and Testing of the Questionnaire

The first drafts of the questionnaire were subject to a period of testing and review by the Compendium Review Panel. As a result of the comments and experiences of the testers, the design of the questionnaire was substantially modified. The particular changes to the design were as follows:

- addition of more explanatory text to the questionnaire to promote more consistency in the answers and to make the form easier for the respondents to complete;
- laying out the sections relating to trends in funding in a very clear way, thus making it faster to complete, especially for NRENs whose circumstances were stable;
- expanding the section on funding of external links to distinguish between connections to the general Internet and to other research networks;
- expanding the section on multiple network domains and improving the classification of related issues.

The questionnaire was tested twice with the members of the Compendium Review Panel. This resulted in five completed returns as well as a considerable number of comments and suggestions. There were also a number of follow-up emails and telephone calls during this process. There were two outputs from this phase. The first is the final version of the form, which is included as Annex I. In addition, the response provided by one NREN was so comprehensive that it was possible to adapt this as a 'sample answer' which was placed on the TERENA website for reference by other NRENs during the full survey.

~ 2.3 Response Levels and Follow-up

The Compendium Review Panel approved the design of the questionnaire for distribution and it was then sent to the TERENA NREN correspondents of 28 European countries. These

correspondents had been alerted by email about ten days previously about the focus study and to expect this questionnaire. Responses were requested by the end of March.

In the event, responses were returned over a period that went well beyond this deadline. This was not surprising in view of the workload of many NRENs and the fact that the questionnaire requested a breakdown of expenditure figures which would not necessarily be immediately to hand within the NREN. Eventually, 24 completed questionnaires were returned, from the following countries:

Belgium	Croatia	Cyprus
Czech Republic	Denmark	Estonia
Finland	Germany	Greece
Hungary	Ireland	Italy
Latvia	Lithuania	Luxembourg
Malta	Netherlands	Norway
Poland	Portugal	Slovakia
Spain	Switzerland	United Kingdom

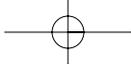
These countries comprise the bulk of the EU member states including the recently acceded countries, plus Croatia, Norway and Switzerland. There is a balanced distribution of countries by population, income and size of NREN.

Upon receipt, the questionnaires were analysed and the initial results tabulated. At the same time, a list of clarification questions was compiled. These were reviewed by the survey team, and a list of agreed follow-up questions was sent out to the correspondents. It turned out that the majority of these clarifications were straightforward, indicating that the questionnaire had been well understood on the whole. It also made it possible for this follow-up stage to be handled by email without the need for any interviews. In all, a total of 54 follow-up questions were sent out to 17 countries. In addition to these follow-up questions, the survey team also contacted the four member states who had been unable to provide responses, in an attempt to obtain 100 per cent coverage.

~ 2.4 Structure of the questionnaire

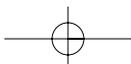
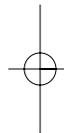
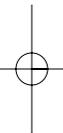
The text of the questionnaire is included as Annex I. It was structured as follows:

- A covering letter giving the background and purpose of the focus study. This also referenced the 'sample answer' available on the TERENA website;
- A note on the definition of the levels of the network hierarchy. This followed that used in the TERENA compendium;
- Section A, which covered a number of funding and managerial issues, by network level. Specifically, it requested information on who is responsible for funding research networking (A1), current levels of funding (A2), sources of funding (A3) and funding of external connectivity (A4);
- Sections B and C, which requested information on operational and managerial responsibility, by network level;
- Section D, which addressed issues of multiple domains. These issues are already significant for research networking; they will be of increasing importance in the future with the growth of grid



technology, premium services, optical networking and hybrid networks. They are naturally linked to the question of multiple managerial responsibility for the various network levels. Information was requested specifically in four areas: performance bottlenecks, security, premium services and end-to-end services;

- Sections E and F, which were designed to collect information on trends in funding and management responsibilities. Section E covered changes over the preceding 12 months whilst section F covered expected changes over the following 12 months. Both sections used identical classifications to those employed in sections A, B and C for the current situation;
- Space for general comments was given at the end of the questionnaire.



3 The Network Hierarchy >

The network hierarchy that was used in this study was the same as that used previously in collecting data for the TERENA Compendium. Five network levels are defined as follows:

- External: This comprises the international connections to other research networks (most commonly via GÉANT) and connections to the general Internet;
- Backbone: The core of the national research and education network;
- Access: Those connections linking the LAN of a client institution to the backbone network;
- Regional: In many countries, the geographic reach of the research network is achieved up by a combination of a core plus a number of regional networks or MANs (Metropolitan Area Networks);
- Campus: The LAN of the client institution.

This is an established description of the network hierarchy and one which is familiar to the correspondents. It should, however, be borne in mind that these distinctions are not clear-cut in many cases and that correspondents will have used their judgement in completing the questionnaire.

4 Funding of Research Networking -/

-/ 4.1 National Responsibility for Funding

The initial section of the questionnaire, section A1, asked who, in each country, was responsible for funding the various network levels in the current financial year. (If figures for the current year were not available, correspondents could use figures from the previous year. Throughout this report, we shall simply refer to all such figures as ‘current year’.) In replying to this section, some countries gave the names of the relevant bodies, whilst others indicated the general source of funding. Initially, some countries omitted identification of the EU as a source of funding, since the contribution is channelled via DANTE rather than the NRENs. This has been corrected in this and subsequent tables.

The table below summarises the responses.

Network level	National government	Regional government	Local government	User institutions	EU	NREN	Other
external	13			10	23	8	2
backbone	13			8		8	
access	7	1		16		5	
regional	8	2	2	12		2	2
campus	1			24			

Summary of 24 responses

Table [4.1-1]. Types of body having responsibility for funding research networking, by network level

The numbers indicate the number of replies from a country for each category. In most countries, a number of bodies share responsibilities for funding and this means that the total numbers across the table may add up to more than 24.

In many cases, countries reported multiple sources of funding for a single network level, as shown in the table below.

Network level	Countries with single funding source	Countries with multiple funding sources	% multiple
External	1	23	96
Backbone	19	5	21
Access	15	7	32
Regional	7	10	58
Campus	23	1	4

Summary of 24 responses

Table [4.1-2]. Number of countries having single/multiple bodies with responsibility for funding research networking, by network level

It is possible to make some further observations on these responses:

- Responsibility for funding the campus level, in the vast majority of cases, rested solely with the user institutions. There is only one exception reported;
- At the external level, all countries except one are part-funded by the EU via DANTE. The number of countries that reported multiple sources, not counting the EU, was seven. At the backbone level, the number was five. Despite the multiple funding sources, NRENs seemed to have good oversight at both these levels;
- Where regional networks or MANs were reported, the majority were multiply-funded. A significant number of the funding partners were bodies over which NRENs often lack oversight, such as regional and local government and consortia of user institutions. To a lesser extent, this also applied to the access level;
- The 'other' sources referred to in Table [4.1-1] were neighbouring NRENs in respect of a short-haul non-GÉANT interconnection, and other partners in MAN consortia.

-/ 4.2 Current Funding Levels

Section A2 covered expenditure in the current financial year, by network level. The individual responses are shown in Table [4.2].

Country	External	Backbone	Access	Regional	Campus	Total
BE	3.60	4.40				8.00
CH	1.70	6.10		0.20		8.00
CY	0.50	0.10	0.10			0.70
CZ	2.00	1.80	1.60			5.40
DK	1.60	2.10				3.70
EE	0.38	0.47				0.85
ES	3.48	11.59				15.07
FI	1.20	4.50				5.70
GR	4.60	4.50	3.70		2.00	14.80
HR	2.15	3.56	0.81		2.35	8.87
HU	2.90	2.50	2.00			7.40
IE	6.20	3.50	1.00	1.00		11.70
IT	2.80	14.00	10.50	5.00		32.30
LT	1.17	0.67	0.41			2.25
LU	0.65	0.27	0.74			1.66
LV	0.48	0.06	0.02	0.01	0.01	0.58
NL	6.00	14.00	3.00	3.00		26.00
NO	2.80	8.90	0.70	0.10	0.50	13.00
PL	4.70	13.20				17.90
PT	1.30	0.70	1.20			3.20
SK	1.04	0.51	0.03	0.12		1.70
UK	8.50	14.76		16.67		39.93
Average	2.72	5.10	1.84	3.26		

Table [4.2]. Current expenditure on research networking, by network level (€ million)

The NRENs were able to provide comprehensive figures for expenditure at the external, backbone and access levels. However, they noted that they had incomplete information at the regional, and especially, at the campus level. Two countries were unable to provide detailed figures of expenditure at any level. Nevertheless, these figures provide a representative sample of expenditure both by larger NRENs (16) with annual budgets over €3 million, and by smaller NRENs (6) with budgets under €3 million.

Some observations can be made about these responses:

- Most NRENs said that they were unable to give any figures for expenditure at the campus level. Where given, most of the amount referred only to the NREN contribution. No reliance can therefore be placed on the figures at this level, and hence no average is quoted;
- Expenditure on external connectivity is, on average, about 50 per cent of the expenditure on the backbone. However, for the smaller NRENs, it is often much higher than this, exceeding the backbone expenditure in a number of cases;
- Where regional networks exist, expenditure at this level is substantial in comparison with the backbone level;
- The total expenditure figures were calculated as the sum of the expenditures at all network levels. These were compared with the total NREN expenditure reported in the 2003 TERENA Compendium. The accounting basis, in particular, the attribution of overheads, is different, and

hence, these figures were not expected to be exactly comparable. However, in the case of four countries, the discrepancies were sufficiently large to merit more detailed follow-up; these were all due to one-off capital programmes.

-/ 4.3 Sources of Funding

Section A3 covered sources of funding in the current year for each of the network levels. Countries were asked to give figures for the proportion of funding from each source. The principal sources of funding were identified as user institutions, local government, regional government, national government, the EU and other. A summary of the responses is given in Table [4.3-1].

Network level	User institutions	Local government	Regional government	National government	EU	Other
external	28			49	22	1
backbone	37		1	60		2
access	61		1	38		
regional	47	12	11	28	2	
campus	88	3	1	8		

Summary of 24 responses

Table [4.3-1]. Per centage of funding from various sources, by network level

It is possible to make some observations on these responses:

- Funding at the campus level is usually single source, usually by the user institution itself;
- User contributions to the external connectivity (average 28 per cent) and to the backbone network (average 37 per cent) are substantial in most countries. In eight countries there was no user contribution at these levels;
- The funding at the regional/MAN level shows the greatest variety and mixture of funding sources.

-/ 4.4 Funding of External Connectivity

Section A4 looked, in more detail, at the funding of external connectivity. Three types of external connectivity were identified. These were connectivity to other research networks (e.g., via GÉANT), national connectivity to the general Internet and international connectivity to the general Internet. Respondents were asked to give information on the expenditure in the current year and on the sources of funding. The results of this section are summarised in Table [4.4-1].

External connectivity to:	Sources of funding					Average expenditure (€ millions)
	User Institutions	National government	EU	NREN	Other	
Other research networks	5	14	18	3	2	1.78
General Internet (national)	4	7		2	1	0.09
General Internet (international)	7	10		3		0.94

Summary of 18 responses

Table [4.4-1]. Sources of funding and average expenditure for various categories of external connectivity

The following observations may be made on these figures:

- The major part of expenditure at the external level (63 per cent) is on connectivity to other research networks, principally via GÉANT;
- The expenditure on connectivity to the general Internet is substantial, amounting to some 60 per cent of the expenditure on connectivity to other research networks.

5 Network Management and Operations | -

| -5.1 Operational Responsibility

Section B of the questionnaire covered the question of who had responsibility for network operation for each of the network levels. This is a well-defined function for research networks. It is often vested in a NOC (Network Operations Centre) which may be in-house or out-sourced. The responses are summarised in Table [5.1] below.

Network level	Operational Responsibility			
	NREN	Out-sourced	User Institutions	Regional government
external	21	4		
backbone	24	2		
access	19	3	6	
regional	7	7	6	1
campus			24	

Summary of 24 responses

Table [5.1]. Responsibility for network operations, by network level

A number of observations can be made on these figures:

- At the external and backbone levels, operational responsibility is very largely exercised by the NRENs;
- At the campus level, operational responsibility is reported to rest wholly with the user institutions;
- There is a significant degree of shared responsibility at the access and regional levels;
- There is a small but significant degree of out-sourcing at most network levels.

| -5.2 Network Management Responsibility

Section C of the questionnaire covered the question of who had responsibility for network management for each of the network levels. This was defined as functions such as network design, choice of technology and implementation of premium services. These are well-understood functions for research networks and clearly differentiated from network operations. The results are summarised in Table [5.2].

Network level	Network management		Responsibility	
	NREN	Other	User institutions	Regional government
external	21	3		
backbone	24			
access	20	1	4	
regional	9	5	6	1
campus	2		24	

Summary of 24 responses

Table [5.2]. Responsibility for network management, by network level

A number of observations may be made:

- At the campus level, responsibility is exercised almost exclusively by the user institutions. In two cases only, the NREN reported some involvement in network design;
- At the external and backbone levels, responsibility is exercised exclusively by the NREN (or equivalent body);
- At the access and regional levels, responsibility is exercised through a variety of bodies. At the regional level in particular, network management is often exercised by bodies other than the NREN.

The responses of 'other' at the external level refer to the NORDUnet countries, and at the access and regional levels to MAN bodies.

6 Trends in Funding and Management -}

An important aim of the focus study was to investigate trends in funding and other aspects of research networking. This was done by asking NRENs to describe, in two separate sections, changes that had occurred in the past year and changes that were expected in the coming year.

This methodology enabled inclusion all the aspects of funding and management that had appeared in the first sections of the questionnaire relating to the current year. Whilst this approach meant that the questionnaire was lengthy, it was very much easier for the respondents to complete. This was particularly true for those countries where the funding and organisation of research networking is stable, and this turned out to be the majority.

For consistency, respondents were asked to include changes within the past twelve months and expected changes within the next twelve months. Whilst these time periods were arbitrary, this stipulation ensured that responses were all given on the same basis.

The summary of changes reported since the previous year is given in Table [6.1].

Country		Changes since previous year			
		No change	Increased expenditure	Decreased expenditure	Other changes
BE	Belgium	√			
CH	Switzerland	√			
CY	Cyprus	√			
CZ	Czech Republic	√			
DE	Germany	√			
DK	Denmark				√
EE	Estonia				√
ES	Spain	√			
FI	Finland	√			
GR	Greece		√		
HR	Croatia		√		
HU	Hungary	√			
IE	Ireland				√
IT	Italy	√			
LT	Lithuania				
LU	Luxembourg		√		
LV	Latvia	√			
MT	Malta	√			
NL	Netherlands	√			
NO	Norway		√		
PL	Poland	√			
PT	Portugal	√			
SK	Slovakia	√			
UK	United Kingdom	√			
Total		16	4		3

Table [6.1]. Countries reporting changes in funding or responsibilities compared with previous year

The majority (two-thirds) of countries reported no changes. The individual changes reported by the remaining countries were as follows.

Four countries reported overall increases in expenditure:

GR. A significant capital programme had been put in place for the current year, increasing backbone expenditure by about 100 per cent and access expenditure by about 50 per cent;

HR. Backbone expenditure up by about 40 per cent;

LU. External expenditure up by about 20 per cent, backbone expenditure up about 40 per cent, access expenditure up about 35 per cent;

NO. Additional capital programme in the current year, increasing backbone expenditure by about 40 per cent.

Two countries reported detailed changes in expenditure by network level, within an approximately constant total:

EE. External expenditure down about 15 per cent, backbone expenditure up about 30 per cent.

LT. External expenditure up about 50 per cent, backbone expenditure up about 20 per cent, access expenditure down about 60 per cent. These were mostly capital expenditures.

Two countries reported changes in responsibilities:

DK. The user contribution had increased from 50 per cent to 100 per cent.

IE. National government had increased its contribution at the access level, up from 30 per cent to 70 per cent. Also, the NREN had been given an increased role at this level.

Outside of the questionnaire, it was learnt that a major restructuring of the NREN in Austria is being undertaken. This may indicate that the non-response from some countries is linked to internal changes.

The summary of changes expected in the coming year is given in Table [6.2].

Country		Changes since previous year			
		No change	Increased expenditure	Decreased expenditure	Neutral or other changes
BE	Belgium	√			
CH	Switzerland	√			
CY	Cyprus		√		
CZ	Czech Republic	√			
DE	Germany	√			
DK	Denmark				√
EE	Estonia			√	
ES	Spain	√			
FI	Finland	√			
GR	Greece			√	
HR	Croatia			√	
HU	Hungary	√			
IE	Ireland		√		
IT	Italy				√
LT	Lithuania				√
LU	Luxembourg				√
LV	Latvia		√		
MT	Malta	√			
NL	Netherlands	√			
NO	Norway				
PL	Poland	√			
PT	Portugal				√
SK	Slovakia	√			
UK	United Kingdom	√			
	Total	12	3	3	5

Table [6.2]. Countries reporting expected changes in funding or responsibilities in coming year

Half of all countries reported no changes. The individual changes reported by the other countries were as follows:

Three countries reported overall increases in expected expenditure:

- CY.** External expenditure up about 40 per cent, mainly due to increase in GÉANT costs;
- IE.** Increase in external and backbone expenditure of about 15 per cent;
- LV.** External expenditure up about 10 per cent, backbone expenditure up about 60 per cent.

Four countries reported overall decreases in expected expenditure:

- EE.** Overall decrease of about 5 per cent;
- GR.** End of major capital programme;
- HR.** Backbone expenditure down by about 55 per cent, access expenditure up by about 20 per cent (mostly capital);
- NO.** End of major capital programme. Backbone expenditure down about 65 per cent.

Two countries reported detailed changes in expenditure by network level, within an approximately constant total:

- DK.** External expenditure up about 5 per cent, backbone expenditure down about 15 per cent;
- LU.** External expenditure up about 25 per cent, backbone expenditure down about 20 per cent.

Three countries reported changes in responsibilities:

- IT.** The NREN was expected to be given an increased role at the regional level;
- LT.** There was expected to be a modest increase in expenditure, from EU structural funds;
- PT.** Change in structure of the funding body.

Some general observations may be made on these responses:

- There is significant year-on-year variation of overall expenditure within countries. Nearly half of all countries had experienced this in the three-year period covered by the study. In a number of cases, the expenditure at the country level was substantially affected by major one-off capital programmes;
- Overall expenditure had increased compared with the previous year; four countries reported increases, whilst none reported a decrease. Three countries reported expected increases in overall expenditure in the coming year, whilst four reported expected decreases;
- There were a number of countries where considerable variation of expenditure had been experienced or was expected at the different network levels, within an approximately level overall figure. Four countries in total reported this;
- Over the three-year period, only a small number of changes in the funding model or the management structure were reported. Of the two reported changes in the funding model; one resulted in an increased user contribution, the other in a reduction. The two changes in management structure both increased the role of the NREN at the regional level.

7 Multiple Network Domains -(.

The concept of network levels is closely related to that of multiple network domains. For example, a network path between two researchers in different countries, A and B, may be thought of as typically involving seven network levels: campus A – regional A – backbone A – external – backbone B – regional B – campus B. The path will also pass through multiple administrative domains. The relationship between levels and domains is not necessarily one-to-one. In the example given, the path might cross more or fewer than seven domains. However, when the various levels are funded and managed by different bodies, then this is very commonly reflected in the existence of a similar number of administrative domains. This is the typical situation found in Europe and world-wide today.

The existence of multiple network domains presents a number of challenges to the effective provision of research networking. Some of these are already experienced today, for example, network bottlenecks and the resolution of security incidents. Others, however, are particularly significant in the evolving e-science and grid environments. These include end-to-end performance and bandwidth management.

For these reasons, a section (section D) was included in the questionnaire on current issues experienced by NRENs arising from multiple domains. Responses were invited under four headings: performance bottlenecks, security issues, premium services and end-to-end services. Space was also provided to allow a description of any other issues that NRENs might have encountered. Respondents were asked to provide as much detail as possible about any incidents that had occurred in the previous twelve months.

-(.7.1 Performance Bottlenecks

The majority of countries had experienced performance bottlenecks. Their responses were followed up to enable the survey team to identify at which network level and how serious they had been affected. The summary is shown in Table [7.1].

Country	Performance bottlenecks					
	external	backbone	access	regional	campus	other
BE			2		2	
CH			3		3	
CY	2		3			
CZ			2		2	
DE						
DK						
EE			2			2
ES			2		2	
FI			2			
GR						
HR					2	
HU					2	2
IE				1	3	
IT			2		2	
LT	2		3			
LU						
LV	1	1				
MT			2			
NL						
NO					2	
PL					2	
PT			2			
SK						
UK			1			
Total	3	1	12	1	10	2

Table [7.1]. Countries reporting performance bottlenecks, by network level

The degree of seriousness was assessed on a five-point scale: 1=minor, 2=some, 3=serious at times, 4=widespread, 5=major.

The degree of seriousness shown is that attributed by the survey team, based on the actual responses. 'Minor' indicates only isolated problems; 'some' indicates more persistent but not severe problems; 'serious' indicates that severe bottlenecks were reported, but in limited locations or times (such as peak hours). No country reported widespread or major problems.

Some observations can be made on these results:

- The campus and access levels were reported as the main sources of bottlenecks. This is consistent with other recent surveys, including SERENATE, which show that the last mile is the principal location of bottlenecks;
- The cost of telecommunications was cited as the underlying cause of bottlenecks for a number of external, backbone and access connections. In other words, the current bandwidth was inadequate but the necessary upgrades were too expensive;
- In a small number of responses, it was noted that the practice of charging user institutions for their connection on the basis of bandwidth had resulted in bottlenecks affecting those institutions which were unable, or unwilling, to pay a higher subscription.

-(7.2 Security Issues

This section of the questionnaire requested information on security incidents, such as denial-of-service attacks (DOS) or viruses. The majority of countries had experienced problems of this type, some of them serious and in many cases difficult to diagnose and resolve.

A wide range of incidents was reported. Many countries reported virus problems; the more serious attacks in the past year (Nachi, Slammer) had resulted in denial-of-service. Numerous other DOS attacks were reported, affecting routers, servers, mail systems and websites. Whilst these were deliberate attacks, there were further problems caused by inappropriate use. Spam was mentioned, as was the use of P2P (file-sharing) programs.

Many countries reported that these incidents had been difficult to resolve. This was often the case when NAT (Network Address Translation) was used at the campus level. Problems of co-ordination between the NREN team and the user institutions were commonly reported. Many institutions lacked sufficient, trained network staff; others were simply unaware of the risks.

The summary of responses is shown in Table [7.2].

Country	Security incidents and problems				
	Viruses/ Worms	DOS	Spam	P2P	Co-ordination issues
BE					√
CH					
CY	√	√			
CZ	√	√			
DE	√				
DK					
EE	√		√		√
ES	√	√	√		√
FI	√	√			
GR	√				√
HR					√
HU	√	√	√	√	
IE	√	√	√		√
IT					√
LT					
LU					
LV					√
MT	√	√	√		
NL					
NO	√	√		√	√
PL	√	√			√
PT	√				
SK	√	√	√	√	
UK	√	√	√		√
Total	15	11	7	3	11

Table [7.2]. Countries reporting security incidents or problems

Note: co-ordination issues here refers to the co-ordination that would be needed between various institutions in order to prevent the spread of the problem, etc..

-(.7.3 Premium and End-to-end Services

Premium services can refer to a number of special services offered by the research network. One of the most important is the provision of 'guaranteed bandwidth' in the context of overall bandwidth management, or of some other scheme for offering a limited number of high-capacity network paths.

The ability to offer such 'guaranteed quality' paths, whether charged for or not, is seen as essential for the research infrastructure required to support e-science and grid-based projects. At the present time, most NRENs only offer a limited service of this type. One reason is the lack of technical options in current all-IP networks, in contrast to the ATM-based networks which were commonplace until a few years ago. However, NRENs are aware of the importance of such services in the 'next generation' networks.

The most important applications today, as many NRENs reported, which require such 'guaranteed bandwidth' are IP-based videoconferencing and other multimedia services. In fact, these services require more than simply guaranteed bandwidth; they also require low packet-loss, latency and jitter. These wider requirements will be equally important for other end-to-end services within the e-science and grid contexts.

In their responses to these sections of the questionnaire, a number of NRENs provided detailed accounts of their experiences in testing, deploying and supporting videoconferencing and multimedia services. Some NRENs also reported on experiences with establishing native IPv6 connections and some research-driven high-bandwidth end-to-end connections. Table [7.3-1] below shows which countries mentioned such services in their responses.

Country	Experience of premium/e2e services	Context of experience					
		video-conferencing	multicast	voip	IPv6	research user	general
BE							
CH	√	√					√
CY							
CZ	√						√
DE							
DK							
EE	√	√					
ES	√		√		√		
FI	√	√					
GR	√						√
HR	√	√					
HU	√	√		√		√	
IE	√	√			√	√	
IT	√						√
LT	√		√		√		
LU							
LV							
MT	√	√					
NL	√	√					
NO	√				√		
PL	√						√
PT	√						√
SK							
UK	√						√
Total	17	8	2	1	4	2	7

Table [7.3-1]. Countries mentioning experience of premium or end-to-end services

Note that countries were not asked specifically whether they offered such services, and hence the total figures of this table are likely to be underestimates.

In implementing these services, NRENs reported that they had typically required the resolution of many problems. Frequently, the network had been previously under-performing compared with its nominal specification, for example, due to firewall restrictions or packet-loss, but this had not been particularly visible to users accessing such services as email and websites. Conversely, this had been highly visible in its effect on videoconferencing sessions when these were first introduced. A range of problems had been encountered, which are summarised in Table [7.3-2].

Country	Problem areas						
	'Middle boxes'	Different technologies	NAT	Local equipment	Local capacity	Congestion packet-loss, etc.	Unspecified
CH	√				√		
CZ							√
EE						√	
ES	√	√					
FI	√						
GR		√				√	
HR					√		
HU				√	√		
IE				√		√	
IT							√
LT							√
MT	√		√		√	√	
NL	√						
NO				√	√		
PL		√			√		
PT				√			
UK							√
Total	5	3	1	4	6	4	4

Table [7.3-2]. Problem areas of a technical nature experienced in implementing premium or end-to-end services

Middle box problems included firewalls, routers and bandwidth shapers. Local equipment problems were usually because of out-of-date or under-performing systems. Some LAN capacity-issues were due to congestion (or packet-loss or high latency), but similar problems were also found at the access and regional levels.

The issue of different technologies was related to mismatches between network levels, and instances were reported at the backbone-regional, backbone-campus and regional-campus interfaces. Sometimes this reflected differences in the underlying technologies between the backbone and the MAN; in other cases the campus equipment could not offer the necessary support and needed upgrading.

It was apparent that many of the problems were difficult to diagnose and resolve. In some instances, the solution was to bypass the problem. This was done in several instances of

videoconferencing services by bypassing the campus LAN and connecting directly to the videoconferencing location. It was also applied in one instance to a high-bandwidth research application, where the researcher's equipment was co-located on the backbone.

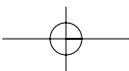
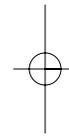
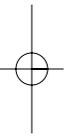
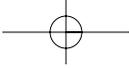
Apart from these technical problems, there were numerous administrative, operational and managerial issues reported, as shown in Table [7.3-3].

Country	Problem areas			
	Co-ordination	Local support	Access control	Bandwidth broking
CH				
CZ	√			√
EE				
ES	√			
FI	√			
GR	√		√	
HR				
HU		√		
IE				
IT				
LT	√		√	
MT				
NL				
NO				
PL	√			
PT	√			
UK	√			
Total	8	1	2	1

Table [7.3-3]. Problem areas of a co-ordination or management nature experienced in implementing premium or end-to-end services

Some observations can be made on these responses:

- The NREN community has built up a useful body of experience in a range of premium and end-to-end services. One lesson is that successful implementation of these services can take considerable time and effort;
- These services place high demands upon the underlying network, which can reveal hidden weaknesses or underperformance. It is possible to detect these by regular monitoring. Work done in advance to remove them will ease the effort of deployment;
- Many bottlenecks are at the campus level;
- Multiple domain administration, at the technical level, is difficult to achieve successfully, particularly where co-ordination between managers at different network levels is necessary. This can result in many types of problems on the network paths and make them more difficult to diagnose and remedy.



8 Conclusions ≠

Overall, the study has provided a mass of new data about the detailed funding, operation and management of the diverse spectrum of research networks that is currently found in Europe. From these data, it has been possible to discern a number of significant conclusions, which are summarised below.

≠ Funding and Responsibilities for Research Networking

At the external and backbone levels, and again, at the campus level, there is a clear picture of who is responsible for funding research networking. There are often multiple sources of funding at the external/backbone levels but NRENs appear to have a good overview and understanding. At the campus level, there is generally only one funding source, the user institution; however, the performance bottlenecks at the campus level could be evidence that funding levels are too low. In contrast, at the access and regional levels, the picture is much more complex. Multiple funding sources are common, and the NRENs' overview appears to be not as good.

Expenditure at external level was, on average, €2.7 million per annum. This is higher than expected from consideration only of the GÉANT figures. The cost of connection to the general Internet, on average, is some 60 per cent of the cost of GÉANT. Expenditure at the external level appears to be relatively higher for smaller NRENs.

Where regional networks exist, an average expenditure of €3.2 million per annum is reported. This is a substantial portion of the average spent at the backbone level of €5.1 million per annum. The average reported expenditure at the access level was €1.8 million per annum. Many NRENs were unable to provide accurate figures for the campus level; it is likely that the true level is much higher than the partial responses would suggest.

Contributions of the user (or user institution) to funding of the external/backbone are found in the majority of countries. The average contribution is substantial, amounting to 28 and 37 per cent of the external and backbone expenditures respectively.

≠ Network Operations and Management

There is a clear picture at external/backbone, and again at campus levels, of who is responsible for network operations and management. However, at the access/regional levels the situation is frequently more complex. It is clear from some of the NREN responses that the management of these levels often enjoys a high degree of independence from the NREN.

≠ Trends in Expenditure and Funding

There are significant year-on-year variations in expenditure. Nearly half of all countries experienced this over a three-year period. These variations were reported at the external, backbone and access levels. They were usually associated with major one-off capital programmes. It is difficult to discern any strong trends in levels of recurrent funding, as these were masked by the capital variations. The limited evidence available suggests that recurrent funding is stable or slightly rising. This is consistent with the previous results of the Compendium survey, which indicate strongly increasing bandwidth provision but within a relatively constant budget.

No evidence was discovered of any trend in the level of user contributions, in either direction.

≠ Multiple Network Domains

Campus and access levels were the major sources of performance bottlenecks. This is consistent with the conclusions from the SERENATE studies.

There has been widespread experience of denial-of-service attacks and other security incidents. The main problems were viruses, other deliberate denial-of-service attacks and spam. Many NRENs reported that co-ordination problems had made these harder to diagnose and resolve. In particular, many user institutions lacked sufficient numbers of trained network staff.

Many countries have built up experience of end-to-end and high-performance services, particularly through deploying videoconferencing or multimedia services. There is also some experience of IPv6 and the 'gigabit' research user. This experience shows most clearly that implementing such services is likely to reveal hidden weaknesses in performance. Prior monitoring on a regular basis could detect these and is recommended. As with security incidents, the existence of multiple domains can be a major challenge, as can the lack of support staff at the user institutions.

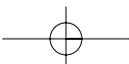
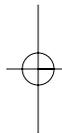
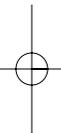
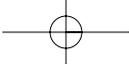
≠ Some Wider Issues

In a small number of cases, NRENs reported that some performance bottlenecks were the result of a policy of charging users according to the bandwidth of the connection. This is evidence that some institutions are unable, or unwilling, to fund an adequate network environment for their members. NRENs also reported under-investment by institutions in the campus LANs, although this is not caused by a policy choice at a national level.

In some countries, the high cost of telecommunications is a cause of performance bottlenecks. This has been previously reported in the SERENATE studies, especially in the report on Geographic Issues.

Glossary

AAA	Authentication, Authorisation and Accounting
ATM	Asynchronous Transfer Mode
COM-REN	Compendium of Research & Education Networks
DANTE	Delivery of Advanced Network Technology to Europe
DoS	Denial of Service
e2e	End to end
EEA	European Economical Area
EU	European Union
Gb/s	Gigabits per second
GÉANT	Gigabit European Academic Network Technology
GN2	Multi-Gigabit European Academic Network
IP	Internet Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
IST	Information Society Technologies
LAN	Local Area Networks
MAN	Metropolitan Area Network
NAT	Network Address Translation
NOC	Network Operation Centre
NORDUnet	Nordic Internet highway to research and education networks in Denmark, Finland, Iceland, Norway and Sweden
NREN	National Research and Education Network
QoS	Quality of Service
SERENATE	Study into European Research and Education Networking As Targeted by eEurope
TERENA	Trans-European Research and Education Networking Association
VoIP	Voice over IP



Annex I

Dear TERENA Correspondent

TERENA is carrying out this focus study on Trends in Funding of Research Networks in Europe in order to complement the work of the existing TERENA Compendium. This study is funded by the European Commission under the COM-REN project within the IST Programme of the Fifth Framework Programme. The purpose of the focus study is to look in more detail at the funding and management of the different levels of the network hierarchy in European countries, and also to look at recent and future trends. The TERENA Compendium already contains information on overall expenditure on NRENs. This study will provide important new information which will provide a more detailed picture of how NRENs in Europe are funded.

We are asking your help in carrying out this study by completing and returning the attached questionnaire, which is being sent to all TERENA member NRENs. The questionnaire will be followed up with telephone or face-to-face interviews with selected respondents

We have tried to keep the form easy to complete, and we have tested it with a number of “guinea-pigs” from the Compendium Review Panel. We recognise that it is next to impossible to devise one form which is completely suitable for every country. Please complete it as best you can. We have left plenty of space for comments if you need to explain your answers.

In order to help you complete the questionnaire, we have posted a sample response on the web. http://www.terena.nl/compendium/FocusStudy/sample_answer.pdf It is based on the actual replies given by one NREN (HEAnet) to the draft questionnaire in its test phase. We are grateful to HEAnet for permission to use it as an example.

We would like to stress again that estimates are acceptable, and that, whilst we would like replies to be as complete as possible, we are aware that the area of funding is often very complex and it can be time-consuming to unearth all the details. If this is so in your case, then please feel free to give us quick, approximate answers rather than long, more exact ones.

Please return the completed questionnaire form to focusstudy@terena.nl by 31 March 2004. Any questions that you have can be sent to the same address.

The focus study is being overseen by the TERENA Compendium Review Panel. The work is being carried out by John Martin and Baiba Kaskina, under the direction of Bert van Pinxteren. The results of the focus study will be published by TERENA.

Thank you for your co-operation.

Baiba Kaskina
John Martin

TERENA COMPENDIUM FOCUS STUDY

Questionnaire on Trends in Funding of Research Networks in Europe

Note on Definition of Network Hierarchy

The TERENA Compendium identifies five distinctive network levels:

- 1 External connectivity
- 2 NREN backbone
- 3 Access network
- 4 Metropolitan or regional network
- 5 Campus LAN

This questionnaire uses the same classification, although for some countries the actual situation may be significantly different from this picture. In such cases, please feel free to amend your answers accordingly or to add explanatory comments.

A. Funding: the current position

A1. Please indicate who, in your country, is responsible for providing the funding for each of the network levels at the present time (1Q2004).

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

A2. Please estimate the amount spent in the current financial year (or if more convenient use the last completed financial year) for each of the network levels. Your answers should refer to the total spend in your country on each level, not just to that part which passes through the NREN's accounts. For example, if user institutions pay for the access network, then this should be included whether they pay directly or indirectly through the NREN.

We also ask you to indicate the split between recurrent and capital expenditure. This distinction is known to be difficult or impossible in some countries: if, so just complete the first column and leave the others blank.

	Current total expenditure p.a. (€ million)	% of this which is recurrent expenditure	% of this which is capital expenditure
External connectivity			
NREN backbone			
Access Network			
Metropolitan or regional network			
Campus LAN			

A3. Please indicate in the table below the per centage of funding which each network level receives from the different sources.

	From user institutions	From local government	From regional government	From national government	From the EU	Other sources (Please specify below)
External connectivity						
NREN backbone						
Access network						
Metropolitan or regional network						
Campus LAN						

If you have indicated funding from 'Other Sources' please give details here:

A4. *The TERENA compendium only identifies one level of “external connectivity”. Some NRENs however have several forms of connection and funding. If this is applicable to you, please complete the following.*

If you distinguish between external connectivity to research networks and to the general Internet, please indicate the expenditure and sources of funding below:

External connections to research and education networks (e.g. via GÉANT)

Current annual expenditure:

Source(s) of funding:

External connections to general Internet (national, via IX)

Current annual expenditure:

Source(s) of funding:

External connections to general Internet (international)

Current annual expenditure:

Source(s) of funding:

Management Responsibility

This part of the questionnaire looks at which bodies (e.g. user institutions, NREN, regional network consortia etc.) have managerial and operational responsibilities for the different levels.

B. Operational Responsibility

Please indicate who, in your country, is responsible for the operation of each of the network levels.

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

C. Network Management Responsibility

Please indicate who, in your country, is responsible for the network management and network engineering of each of the network levels (e.g. network design, choice of technology, implementing premium services, etc).

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

D. Multiple Management Domains

This is an extra question which we have slipped in. It covers a topic which is very relevant to the future direction which research networks are expected to take in the next few years (see the SERENATE Report) as end-to-end QoS becomes important. It is of course related to the fact that the various network levels may be funded and managed by different bodies.

It is often said that multiple management domains can give rise to network problems of many different sorts. We would therefore ask you to tell us of examples of any particular problems which you have experienced in your country which could be attributed to this cause. Please give us as much detail as possible, for example, whether you have experienced this problem in the last 12 months, how serious it was, what caused it (if you have been able to find out), and how you solved it (if you have).

D1. Performance bottlenecks:

D2. Problems of network security (e.g. denial of service attacks or spread of viruses):

D3. Difficulties in establishing premium services:

D4. Potential problems with establishing end-to-end services between end-users.

D5. Others (please specify):

Trends in Funding: past and future

The next two sections address trends in funding and, in particular, any significant changes that have occurred in the past 1-2 years or are expected in the near future. They are laid out in the same format as sections A-C, and you need only fill in any part that is different. Hence, if the situation in your country is stable, you will be able to leave most of the answers blank and complete this section very quickly.

However, before returning the form, make sure you have looked at section G.

E. Changes During the Past 1-2 years

In this section, please indicate any significant changes in funding or responsibility which have occurred over the past one to two years. If no significant change has occurred, leave the answer blank.

E1. Funding responsibility: please indicate any significant change in who is responsible for providing the funding for each of the network levels.

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

E2. Please indicate the amount spent in the previous financial year for each of the network levels, if it was significantly different from the current year.

	Previous year's total expenditure p.a. (€ million)	% of this which is recurrent expenditure	% of this which is capital expenditure
External connectivity			
NREN backbone			
Access Network			
Metropolitan or regional network			
Campus LAN			

E3. If significantly different from the current year, please indicate in the table below the percentage of funding which each network level received from the different sources.

	From user institutions	From local government	From regional government	From national government	From the EU	Other sources (Please specify below)
External connectivity						
NREN backbone						
Access network						
Metropolitan or regional network						
Campus LAN						

If you have indicated funding from 'Other Sources' please give details here:

E4. If you distinguished above between external connectivity to research networks and to the general Internet, and if significant changes occurred between the previous and current years, please indicate the previous year's expenditure and sources of funding below:

External connections to research and education networks

Previous annual expenditure:

Source(s) of funding:

External connections to general Internet (national, via IX)

Previous annual expenditure:

Source(s) of funding:

External connections to general Internet (international)

Previous annual expenditure:

Source(s) of funding:

E5. Operational Responsibility

Please indicate any significant change over the past two years in who is responsible for the operation of each of the network levels.

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

E6. Network Management Responsibility

Please indicate any significant change over the past two years in who is responsible for the network management and network engineering of each of the network levels (e.g. network design, choice of technology, implementing premium services, etc).

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

F. Expected Changes During the Next Year

In this section, please indicate any **significant changes** in funding or responsibility which are expected or planned during the next year. If no significant change has occurred, leave the answer blank.

F1. Funding responsibility: please indicate any significant change expected in who is responsible for providing the funding for each of the network levels.

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

F2. Please indicate the expected amount to be spent in the next financial year for each of the network levels, if it is significantly different from the current year.

	Next year's expected total expenditure p.a. (€ million)	% of this which is recurrent expenditure	% of this which is capital expenditure
External connectivity			
NREN backbone			
Access Network			
Metropolitan or regional network			
Campus LAN			

F3. If significantly different from the current year, please indicate in the table below the percentage of funding which each network level is expected to receive from the different sources.

	From user institutions	From local government	From regional government	From national government	From the EU	Other sources (Please specify below)
External connectivity						
NREN backbone						
Access network						
Metropolitan or regional network						
Campus LAN						

If you have indicated funding from 'Other Sources' please give details here:

F4. If you distinguished above between external connectivity to research networks and to the general Internet, and if significant changes are expected to occur between this year and next year, please indicate the expected level of next year's expenditure and sources of funding below:

External connections to research and education networks

Expected annual expenditure:

Source(s) of funding:

External connections to general Internet (national, via IX)

Expected annual expenditure:

Source(s) of funding:

External connections to general Internet (international)

Expected annual expenditure:

Source(s) of funding:

F5. Operational Responsibility

Please indicate any significant change expected during the next year in who is responsible for the operation of each of the network levels.

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

F6. Network Management Responsibility

Please indicate any significant change expected during the next year in who is responsible for the network management and network engineering of each of the network levels (e.g. network design, choice of technology, implementing premium services, etc).

External connectivity:

NREN backbone:

Access network:

Metropolitan or regional network:

Campus LAN:

G. General Comments

Please add here any other comments which you feel are relevant to amplify the answers above.

Please provide here the email address of the person in your organisation whom we can contact for follow-up questions and a possible interview:

If you have any queries about this questionnaire please contact focusstudy@terena.nl. The completed questionnaire should be returned to focusstudy@terena.nl by 31 March 2004.

Thank you very much for your co-operation.

Baiba Kaskina
John Martin

