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# Report on Organisation and Governance Issues: Deliverable DN5.0.2,4

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Author: Robin Arak (Archway Computer Associates)  
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## 0 Abstract

This deliverable contains the results of the EARNEST sub-study into organisation and governance issues. The EARNEST foresight study is activity NA5 of the GN2 project.

## 1 Executive Summary

The EARNEST foresight study has looked at the expected development of research and education networking in Europe over the next 5-10 years. The study was carried out between March 2006 and November 2007. EARNEST was funded by the European Union through the GN2 project, which also provides the funding for the current generation of the pan-European research and education backbone network, GÉANT2.

The aim of EARNEST was to provide input for initiatives that could help to keep the evolution of European research networking at the forefront of worldwide developments and enhance the competitiveness of the European Research Area. EARNEST has prepared the ground for the planning of the development of research and education networking infrastructure and services after the completion of the GN2 project, at the local, national, European and intercontinental level.

EARNEST can be seen as the successor of the very successful study that was carried out in the SERENATE project in the period from May 2002 until December 2003. The results of the SERENATE study, and in particular the recommendations in its Summary Report, have been very influential on the planning and development of research and education networking in Europe in subsequent years.

After an initial preparatory phase, the EARNEST work has focused on seven study areas: researchers' requirements, technical issues, campus issues, economic issues, geographic issues, organisation and governance issues, and requirements of users in schools, the healthcare sector and the arts, humanities and social sciences. Reports have been published on the results of each of these sub-studies, as well as an additional report on regulatory issues. The EARNEST study is rounded off by a Summary Report that contains recommendations for the relevant stakeholders.

The study of organisation and governance issues has looked into the way in which National Research and Education Networking organisations (NRENs)<sup>1</sup> in Europe and beyond are governed, funded and organised. The study is mainly based on the results from a questionnaire sent to NRENs. That questionnaire focused on several areas, namely, governance, organisation and policy setting within NRENs, general operational support for the National Research and Education Networks, provisioning and support of end-to-end services, support and funding for special projects and developing new strategic services, and connection and support of primary and secondary schools. Other input for the study came from other EARNEST study areas and from information in the TERENA Compendium of National Research and Education Networks in Europe.

The study has concluded that there are many different governance models in place for the different NRENs, and that the funding and charging mechanisms and the methods of making decisions are also diverse. Many NRENs do not have budget planning in place for more than one year ahead, which potentially could lead to problems when planning medium- and long-term programmes for network service developments and upgrades.

NRENs are all taking a wider role in the support of their countries' research and education programmes by getting involved in strategic projects in addition to continuing to provide high-quality networking services. This move by NRENs to take a broader role is building on the success of the provision and support of networking services for the research and education communities. Several NRENs have already connected a wider range of institutions than just universities and research institutes. Others are planning to connect such a wider range of institutions, which can include primary and secondary schools, tertiary and professional institutions, organisations supporting health services and government departments.

Several NRENs are delivering or aspiring to deliver end-to-end services, which allow projects to be supported that require more than just a commodity network service, without the necessity to build separate network infrastructures. Some NRENs are planning the automated set-up of end-to-end services, which will allow network services to be configured quickly and cost effectively.

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<sup>1</sup> In this report, the acronym "NRENs" is used to denote National Research and Education Networking organisations as well as the national networks provided by them.

The study report ends with several recommendations, which if implemented should improve the governance and organisation of NRENs and the support that they can offer to the research and education communities.

The report concludes that NRENs are in a good position to continue to provide strong support to research and education, provided that they continue to improve the collaboration amongst themselves and with the research and education communities.

## 2 Introduction

National Research and Education Networks are part of a multi-level network and support structure that serves the research and education community in Europe and beyond. The SERENATE study recognised that NRENs have become key in supporting many areas of research and education. The NRENs in Europe and beyond have been created to support research and education institutions by providing networking services; increasingly they are developing and supporting other value-added services as well. On the whole, NRENs have been effective at providing networking services; often they provide new services ahead of those that are available cost effectively in the commercial telecommunications market. NRENs support areas of scientific endeavour where research would be impossible to conduct without the use of advanced networking services. Staying at the leading edge of the provision of networking and other value-added services brings challenges, particularly when there are often many competing demands for resources, both financial and human.

If National Research and Education Networking organisations are to maintain support from their user communities and funding bodies, they must continue to innovate and provide cost-effective and reliable services that are required by the research and education communities that they serve.

The GN2 project provides a high-bandwidth pan-European network infrastructure, GÉANT2, which allows NRENs to connect to each other, facilitating and supporting collaborative research and education across Europe. One of the key aims of the GN2 project is to enable GÉANT2 to move towards the delivery of definable and reliable end-to-end services in line with some user and project requirements. In order to achieve this, the GN2 project includes some Joint Research Activities (JRAs), some of which will feed into the development of Service Activities (SAs). Of particular importance in this respect are:

- SA3: Introduction of Multi-Domain Services
- JRA1: Performance Measurement and Management
- JRA3: Bandwidth Allocation and Reservation (Bandwidth on Demand).

Work being carried out nationally by NRENs in Europe is also moving towards delivering definable and reliable end-to-end services, and several of the NRENs have already programmes in place to further develop the provisioning of end-to-end services. However, NRENs must also serve the majority of their users who generally require just standard Internet services as would be available from most commercial Internet Service Providers, but with a high performance and reliability. The different types of services that are provided by NRENs to the research and education communities must be carefully planned and managed, so that the limited funding available is used as efficiently and effectively as possible.

It is anticipated that in the future some automatic end-user provisioning of end-to-end services across Europe should be possible. Although in many cases the basic technologies to provide such services are available and in some cases have been proven, the issues of delivering end-to-end services are wider than just getting the various technologies to function correctly across multiple network domains. The organisation and governance issues surrounding the planning and delivery of new services will become much more significant as the move from the delivery of best-effort network services to definable, configurable and guaranteed end-to-end services is made.

The purpose of the EARNEST study of organisation and governance issues was to investigate what issues need to be addressed in the organisation and governance domain and to suggest ways in which the organisation and governance models for European research and education networking can be developed so that the service aspirations of the entire research and education community in Europe and beyond can be met.

## 3 Issues investigated by the study

The following are some of the key issues that affect the organisation and governance of NRENs and that were investigated in the study:

- The funding and charging models and funding levels used by the different organisations in the chain of delivery of network services; often the funding models will dictate the level of services and support that can be provided by a particular network organisation, and the funding models and level of funding will not necessarily be geared to the service levels demanded by some groups of users
- The current governance models used by National Research and Education Networking organisations
- The level of autonomy that the various individual networking organisations (National Research and Education Networking organisations, regional network operators, universities, colleges and research institutions) wish to maintain in deciding on the standards that they will adopt and on the methods used to implement and support their network services
- The variability of network support and service availability in different network domains
- The variability of network performance in different network domains and the methods by which performance issues can be and are addressed
- The variability of the policies in place for the provisioning of services that can support end-to-end services; for example, policies for supporting Virtual Private Networks
- The differing attitudes of different National Research and Education Networking organisations to self-provisioning of networking
- The way in which National Research and Education Networking organisations support projects that need 'special' facilities or arrangements, both when projects are within the user community of their own organisation and when projects span the user communities of multiple National Research and Education Networking organisations
- The arrangements that National Research and Education Networking organisations have for communicating with their user base, particularly with those users that may require specialised services, including those who may rely on guaranteed end-to-end services.

Not all the planned areas for investigation revealed notable results with regard to the organisation and governance structures used by NRENS. The report focuses on the significant findings, and the recommendations and conclusions are drawn from these.

## 4 Methodology

The study has benefited from the responses to questionnaires that were sent by EARNEST to different communities. The main questionnaire that provided input to this study area was the one sent to NRENS. That questionnaire not only included questions relating to organisation and governance, but also covered issues that were relevant for the other EARNEST study areas.

The questionnaire sent to NRENS was divided into six sections:

1. Funding
2. Governance, organisation and policy setting within NRENS
3. General operational support for the network
4. Provisioning and support of end-to-end services
5. Support and funding for special projects and developing new strategic services
6. Connection and support of primary and secondary schools.

The questionnaire was sent to the main NREN contacts obtained from TERENA and DANTE. NRENS were given a month to answer the questions, but several took longer to reply. The response rate was good, with 33 responses obtained as a result of sending out 45 questionnaires. Not all the questions were answered by all NRENS, but sufficient responses were obtained to allow conclusions to be drawn and recommendations to be made with a good degree of confidence.

Two consultation workshops were organised by EARNEST, one with NREN representatives and one with representatives of the funding bodies of NRENS. In these meetings, some of the results obtained in the study area were presented, and the workshops offered an opportunity for the two different groups to make comments

and give feedback on the results, and to suggest how organisation and governance structures can be improved.

Many of the NREN representatives were not surprised by the results, as they were well aware of the high degree of variability in the way that NRENs are funded, governed, organised and managed. Nevertheless, they found some of the information about the way in which other NRENs are governed and organised to be helpful.

The consultation with the representatives of the funding bodies did not reveal any controversial points for debate. Again, the representatives found the information to be of interest, and the study may offer opportunities for benchmarking NRENs in some areas.

Other EARNEST surveys also dealt with some questions associated directly with NRENs. For example, in the context of the EARNEST study of researchers' requirements, end users were asked about the perceived performance and reliability of the network. However, those answers must be treated with caution as there are many different places in the chain of delivery where network performance and reliability can be degraded, and those may not be part of the NREN infrastructure or under the control of the NREN.

The study also commissioned from a limited number of NRENs a more detailed description of how those NRENs are organised and governed. These documents are useful reference documents. For some organisations that deal with NRENs it may be very helpful to have such descriptions available for all NRENs, so that an understanding can be obtained of their structures and decision making bodies. It would also be useful for the communities that are served by the NRENs to have such documents available, so that they understand in more detail how policies are formed and decisions taken by specific NRENs.

## 5Key results

The results mentioned in this chapter are all drawn from the responses to the various surveys conducted as part of the EARNEST study or from the TERENA Compendium of National Research and Education Networks in Europe. The results are presented in different sections that relate to the different parts of the questionnaire sent to NRENs. They are presented in the order of the issues that were planned to be investigated as listed above. A copy of the questionnaire is available from the EARNEST website at <http://www.terena.org/activities/earnest/gov.html>.

The respondents to the questionnaire sent to NRENs are given in the table below:

Country	NREN name	EU
Algeria	ARN	N
Austria	ACOnet	Y
Cyprus	CYNET	Y
Czech Republic	CESNET	Y
Denmark	UNI•C	Y
Estonia	EENet	Y
Finland	CSC	Y
France	RENATER	Y
Germany	DFN	Y
Greece	GRNET	Y
Hungary	HUNGARNET	Y
Ireland	HEAnet	Y
Israel	IUCC	N
Italy	GARR	Y

<b>Jordan</b>	JUNet	N
<b>Latvia</b>	LATNET	Y
<b>Lithuania</b>	LITNET	Y
<b>Luxembourg</b>	RESTENA	Y
<b>FYRoMacedonia</b>	MARNET	N
<b>Malta</b>	University of Malta	Y
<b>Montenegro</b>	MREN	N
<b>Morocco</b>	MARWAN	N
<b>Netherlands</b>	SURFnet	Y
<b>Norway</b>	UNINETT	N
<b>Portugal</b>	FCCN	Y
<b>Romania</b>	RoEduNet	Y
<b>Serbia</b>	AMRES	N
<b>Slovenia</b>	ARNES	Y
<b>Spain</b>	RED.ES / RedIRIS	Y
<b>Sweden</b>	SUNET	Y
<b>Switzerland</b>	SWITCH	N
<b>Turkey</b>	ULAKBIM	N
<b>United Kingdom</b>	JANET(UK)	Y

**Table .1:** Respondents to the NREN questionnaire

## **NREN budget allocation and management**

The way in which NRENs set their budgets and use their budgets, has an influence on how they operate and plan their activities. Budgets also influence how and when upgrades to the network are planned. The following sections examine some of the details of the budget allocation and management by NRENs.

### **NREN budget setting and funding**

NRENs obtain their budgets from various sources, including government, connected institutions, the European Union etc. The funding and management of NREN budgets, including forward budget planning, is examined in this section. Table 5.2 shows a summary of the types of funding of the respondent NRENs and the budgeting period of the NRENs.

<b>Type of funding</b>	<b>Number</b>	<b>Multi-annual budget</b>	<b>Annual budget</b>	<b>No response</b>
Central government grant	6	1	5	0
Mixed (including government grant and users)	18	5	13	0

Mainly user funded	2	0	2	0
Government + EU	5	3	2	0
Not stated	2	0	1	1
<b>Total</b>	<b>33</b>	<b>9</b>	<b>23</b>	<b>1</b>
<b>Total percentage</b>	<b>100%</b>	<b>27%</b>	<b>70%</b>	<b>3%</b>

**Table .2:** Type of funding of NRENs and budget setting

A very significant majority of the NRENs (70%) only set annual budgets, while 27% set multi-annual budgets (3% didn't respond to the question). Of the six NRENs that are funded solely by a central government grant, only one sets multi-annual budgets. These figures indicate that the planning horizon for NRENs that are funded only by government grants might be limited to one year. However, although some governments will not promise government funding more than a year ahead, there may be an expectation that funding will be continued, and in fact the funding could be relatively stable. But in some countries, government funding at a particular level will not necessarily be guaranteed. This means that planning the development of an NREN could be difficult, particularly when the NREN is expanding the infrastructure or developing new services, which span a planning period of more than one year.

Of the eighteen NRENs that receive funding from mixed sources, only five set multi-annual budgets. The significant majority of these NRENs (72%) only set annual budgets. This leads to the conclusion that long-term planning horizons of NRENs funded from mixed funding sources could also be hampered.

Five NRENs state that they predict multi-annual budgets but do not set them. The forward prediction of budgets is good practice when planning the operation and development of NRENs, but the survey reveals that only 42% of all NRENs set or predict a multi-annual budget.

Type of budget setting	Number	Percentage of NRENs
Set a multi-annual budget	2	6%
Predict a multi-annual budget	5	15%
Set a multi-annual budget and change it if required	7	21%
Only set an annual budget	18	55%
No response	1	3%
<b>Total</b>	<b>33</b>	<b>100%</b>

**Table .3:** Budget setting of NRENs

The budgeting period of the NRENs that set or predict multi-annual budgets varies considerably, from a minimum of two years to more than five years. Only 33% of NRENs budget or predict budgets three or more years ahead. There is therefore considerable scope for NRENs to improve their budgeting, so that they can plan their developments, operations and upgrades over a longer time period.

Number of years ahead for which budget is predicted or set	Number of NRENs
2	3
3	5

4	3
5 years or more	3

**Table .4:** Budget look-ahead of NRENs that predict or set multi-annual budgets

The use of the budget by NRENs as a tool to control the finances of the NREN is variable. More than 67% of NRENs use their budget as a way of monitoring and controlling expenditure, which follows best accounting practice. Some NRENs (15%) only use their budget as a way of monitoring expenditure, while others (12%) use it purely as a tool to control spending. It would be sensible for all NRENs to use budgets for monitoring and controlling expenditure.

Use of budget as a tool	Number	Percentage of NRENs
Budget used as monitoring tool for expenditure	5	15%
Budget used as a way of controlling spending	4	12%
Budget used for monitoring and controlling expenditure	22	67%
No response	2	6%
<b>Total</b>	<b>33</b>	<b>100%</b>

**Table .5:** Method of using budget as a tool

Carrying forward NRENs' budgets from one financial year to the next enables NRENs to redeploy unused budgets or to change the budget profiles of particular expenditure items. This is important because projects may be delayed or savings may be made on particular expenditure items that can be usefully redeployed elsewhere.

Only 42% of NRENs are allowed to carry forward budgets between different financial years without either seeking permission from their funding organisation(s) or having to make a justification to carry forward particular budgeted items. Only 21% of NRENs are allowed to redeploy their budgets on particular budget lines and use the budget for different unbudgeted items. A minority of NRENs (15%) have to return their budgets to the funding organisations that provide the budget, although one of the NRENs in this category can get permission to carry forward its budget. There is considerable scope for some NRENs to achieve more budget flexibility, allowing them more certainty in planning and budgeting for longer-term support and developments. If NRENs are to be encouraged to plan further ahead, the flexibility in, and the certainty about, budgets over a longer time period needs to be increased.

Carry forward of budget at year end	Number	Percentage of NRENs
Allowed to redeploy the budget and use for something else	7	21%
Have to return the budget to the organisation providing the funding	5	15%
Allowed to carry forward to next financial year without permission	14	42%
Make a justification to carry forward budget for particular items	9	27%

Get permission from the funding organisation to carry forward	8	24%
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**Table .6:** Carrying forward of NREN budgets

### Use of NREN funding for service enhancements and upgrades

This section examines how NREN funding is used to enhance services and upgrade networks. It focuses in particular on the source of funding for different aspects of NREN upgrades and enhancements to NREN services.

The funding of enhanced services or new developments cannot always be accommodated within an existing NREN budget. Often additional funding may be required. Several NRENS obtain the additional funding from several different sources, depending on the amount of funding required and the type of project to be funded. The majority of NRENS (52%) obtain such funding in the form of a government grant, but 24% of NRENS receive contributions from user institutions connected to the NREN. A small minority of NRENS receive additional funding for enhanced services or developments from industrial sponsorship. A significant minority of NRENS (42%) fund enhanced services or new developments by making savings elsewhere in their budget, and 33% find the necessary funding within their allocated budget. To obtain additional funds, only 27% of NRENS use a project or business plan. Even if NRENS do not need project or business plans to justify receiving additional funds, it is good practice to develop business and/or project plans. In some instances this may assist some NRENS in obtaining additional funding when they need it for the enhancement of services or the development of new services.

Funding for enhanced services or new developments	Number	Percentage of NRENS
Central grant	17	52%
User institutions	8	24%
Business sponsorship	3	9%
Raised on the basis of a project plan	9	27%
Make savings elsewhere to redeploy budget	14	42%
Use reserve funding of the NREN	9	27%
Fund services or developments within the allocated budget	11	33%
Funded by other means	3	9%

**Table .7:** Funding for enhanced services or new developments

NRENS often have different funding models for different parts of the network. Because of time constraints, not all details of these funding models have been studied. However, the questionnaire revealed that different parts of the NRENS' infrastructure are often funded from differing sources. For example, often the links to user institutions – e.g., universities - are funded by the institutions. The table below shows the variation in the funding provided by the government directly to the NREN for different parts of the network infrastructure. The number of NRENS receiving government funding as shown in the table is indicative of some government funding being received (not always 100%) by the NREN for the different parts of the network infrastructure.

A high percentage of NRENS receive some government funding for the NREN's link(s) to GÉANT2, for the NREN backbone and for links to commercial Internet Service Providers (89%, 72% and 72% respectively). However, moving away from the network core to Regional Area Networks (RANs) and Metropolitan Area Networks (MANs) the percentage of NRENS receiving government funding is smaller: 50% for the provision of RANs and MANs and 44% for the links from the core of the NREN to the RAN or MAN. Links to the main users

of NRENs, i.e. universities and research establishments, are not funded to the same degree from government funds provided to the NRENs as the core of the networks is.

Regional and Metropolitan Area Networks may be funded in different ways from the ways in which NRENs are funded, and this may be reflected in the types of institutions that are allowed to be connected to RANs and MANs, and also in the type of services that are offered.

Direct government funding to NRENs for different parts of the network	Number	Responses	Percentage of NRENs that responded
Link to GÉANT2	24	27	89%
NREN backbone	18	25	72%
Link to commercial ISP	18	25	72%
RANs and MANs	5	10	50%
Links from RANs and MANs to NREN	4	9	44%
University links	12	24	50%
Research establishment links	8	23	35%
Links to tertiary/professional institutions	4	18	22%
Links to primary and secondary schools	4	13	31%
Links to other public sector organisations, e.g. in the healthcare sector	2	20	10%
Links to commercial R&D establishments	0	14	0%
Links to other commercial organisations	1	7	14%

**Table .8:** Funding of different parts of the NREN by government funding

Upgrades of the various parts of the network infrastructures of NRENs depend on user requirements for bandwidth and on the funding available. These upgrades are carried out at varying intervals. The most popular intervals for network upgrades are between three and five years.

Network core/backbone upgrade period	Number	Percentage of NRENs
Variable	1	3%
When more bandwidth required	1	3%
Continuous	3	9%
Maximum 1 year	3	9%
Maximum 2 years	0	0%
Maximum 3 years	6	18%
Maximum 4 years	6	18%
Maximum 5 years	7	21%
Maximum 6 years	0	0%
Maximum 7 years	0	0%

Maximum 8 years	1	3%
No response	5	15%
<b>Total</b>	<b>33</b>	<b>100%</b>

**Table .9:** Network core upgrade period

Funding for upgrades of NRENs' backbones may come from a variety of sources. However, the majority of NRENs who responded receive contributions from government sources to upgrade their backbones (71%). Only one NREN obtained funding to upgrade its backbone solely from connected institutions. This shows that NRENs are very dependent on new injections of government funding to upgrade their backbone infrastructures. It is therefore important that NRENs plan their upgrades well in advance and involve their funding bodies in the planning process, particularly in the budget planning phase, so that funds can be allocated when required.

<b>NREN backbone upgrade funding</b>	<b>Number</b>	<b>Percentage of NRENs that responded</b>
Government	10	42%
Government and connected institutions	5	21%
Government and EU / NATO / others	2	8%
NREN budget	6	25%
Institutions	1	4%
<b>Total responding</b>	<b>24</b>	<b>100%</b>

**Table .10:** Funding source for network core upgrades

The timing of upgrades of links to institutions that are connected to NRENs is decided in different ways. Just over half the NRENs that responded stated that the decision whether to upgrade links to institutions is taken by institutions. The institutions would also pay for their link upgrades. Some NRENs have multiple ways of deciding when to upgrade links to institutions, including combinations of regular upgrades with a decision to upgrade when the capacity of the link is reached or when funding becomes available. A significant percentage of responding NRENs (32%) allow the institutions alone to decide and pay for the upgrade of their institutional links. The variation in the responses reflects the different funding and budgeting methods that NRENs use.

<b>Institutional link upgrade</b>	<b>Number</b>	<b>Percentage of NRENs that responded</b>
Regularly	4	14%
When the capacity of link is reached	15	54%
When funding becomes available	6	21%
When institutions decide and pay	12	43%
On an ad-hoc basis	1	4%
<b>Total responding</b>	<b>28</b>	<b>100%</b>

**Table .11:** Decision making about institutional link upgrades

For 61% of the NRENs that responded, upgrades to links from NREN backbones to institutions are funded by the institutions. The low number of NRENs that responded to this particular question does not allow to draw a firm conclusion. But because the upgrade of a link to an institution generally only affects the institution concerned, it is sensible that each institution should have the ability to decide about upgrades and also either contribute to the cost or fully fund upgrades to its institutional link.

Funding of institutional upgrades	Number	Percentage of NRENs that responded
Institutions	11	61%
Government	4	22%
Government and institutions	1	6%
NREN budget	2	11%
<b>Total responding</b>	<b>18</b>	<b>100%</b>

**Table .12:** Funding source for institutional links upgrades

### Methods of charging user institutions

Many different charging mechanisms are used by those NRENs that make a significant charge to the institutions connected to the network. (In this context, a significant charge was defined as 20% or more of the total annual funding of the NREN.) The most popular model is to charge based on the bandwidth of the interface used to connect the institution; a quarter of the responding NRENs use this mechanism. Other NRENs use the bandwidth consumed or usage (15%), or a combination of several different parameters including the size and type of institution as well as the bandwidth of the interface used to connect the institution. Other charging models are based on linear cost sharing or on the bandwidth of the commercial Internet subscription that the institution takes. The proportion of user funding varies considerably from NREN to NREN, so the impact of the type of charging model on the charges to institutions will also vary considerably. The details of the proportion of user funding for each NREN can be obtained from the TERENA Compendium. At the time of writing this report, the most recently published version of the Compendium was the 2006 edition, which shows that user-institution funding of NRENs can vary from 0% to 100%.

Models used by NRENs to charge user institutions	Number	Percentage of NRENs that responded
Bandwidth of interface to institution	5	25%
Bandwidth consumed/usage	3	15%
Size of institution and bandwidth consumed/usage	2	10%
Type of institution and bandwidth of interface	2	10%
Type of institution and bandwidth consumed/usage	1	5%
Size and type of institution and bandwidth consumed/usage	1	5%
Size and type of institution and interface bandwidth	1	5%
Size of institution and bandwidth	1	5%

consumed/usage and interface bandwidth		
Linear cost sharing	1	5%
Other	1	5%
None	2	10%
<b>Total responding</b>	<b>20</b>	<b>100%</b>

**Table .13:** Models used by NRENs to charge user institutions

Of the NRENs in the survey, 28 stated whether they use different charging models for different categories of user institutions; a significant minority of them (43%) do. Hence the charging mechanisms for some NRENs are even more complicated than the models shown in the table above. Some of these models must be complex to run and process.

NRENs can also make a distinction in pricing between national and international usage of bandwidth. Making such a distinction may be encouraged by the difference in costs between provision of international and national bandwidth, particularly in some regions of Europe where the provision of international bandwidth is a high cost. Again, 28 NRENs indicated whether they make a distinction between the charges for international and national usage of bandwidth, and 36% of them do.

Some NRENs also make a distinction in pricing between use of the network for research and education collaboration between the connected institutions and use of the network to transit to the commercial Internet. Only 14% of the 28 NRENs that responded to this question make that distinction.

The future plans for user-institution charging by NRENs vary. Of the 28 NRENs that responded to this question, 43% were planning or expecting changes to user-institution charging in the next five years. The other 57% were not expecting user-institution charging mechanisms to change. Of the five NRENs that disclosed their plans for future user-institution charging, four were planning to increase the proportion of user-institution charging, while one was planning to reduce the proportion of user-institution charging by 5%. One NREN was planning or expecting to increase the proportion of user-institution charging from 20% in one year to 50% in five years' and then to 100% in ten years' time, totally moving from central government funding to full user charging.

The plans for changing the user-institution charging models in future are also varied. Some NRENs are planning to make their model more complex by including additional parameters. Others are planning to simplify their model by reducing the number of parameters used. The survey definitely produced no evidence of NRENs generally moving to simpler charging models. Some NRENs are not planning to simplify models, but want to move to using different parameters, for example, by including the type of institution in the model. The table below shows the parameters planned to be used as part of NREN charging models in the future.

Type of charging model	Number of NRENs
Actual bandwidth of connection	12
Type of connected interface bandwidth	5
Usage of bandwidth	10
Size of connected institution	7
Type of connected institution	7
Other mechanisms	2
No charging model	1
No response	10

**Table .14:** Planned NREN user institution charging model parameters

## Support and funding for wavelength provision

Some NRENs are now supporting or planning to support the provision of wavelength services to end-user sites. GÉANT2 supports the provision of wavelengths across certain parts of Europe and similarly some individual NRENs can support wavelengths across their backbones and to some end-user institutions. Six NRENs (19% of the 32 NRENs that responded to this question) indicated that they currently support the provision of wavelengths to end-user sites. Fourteen (44%) are planning to support the provision of wavelengths in the future, while a significant minority of twelve NRENs (38%) have no plans to support wavelengths to end-user sites. This is of some concern: if collaborative research projects require the provision of wavelengths to the sites of institutions where that research is to be conducted, it may in some cases not be possible to obtain wavelengths because of the limitations of the NREN in a particular country.

NRENs will have to fund the provision of wavelengths and therefore may impose charges to end-user institutions. Of the seventeen NRENs who responded to this question, nine (53%) were not planning to charge end-user institutions for the provision of wavelengths. Six (35%) planned to charge for the provision of wavelengths at cost, and two (12%) were planning to subsidise the costs of the provision of wavelengths to end-user institution sites. It is clear that the mechanisms for the provision and charging of wavelengths are still under development in many NRENs. The collaborative research projects that are predicting the use of wavelengths to end-user institution sites must therefore ensure that their NRENs are kept informed of potential developments; otherwise the provision of wavelengths may not be possible, or may have costs that are prohibitively expensive to the research projects.

## Funding of current and future versions of GÉANT<sup>2</sup>

The funding of the current and future versions of GÉANT is an issue of concern to NRENs because GÉANT provides the necessary infrastructure to support collaborative research and education across Europe and beyond. Some collaboration can be carried out using just the commodity Internet, which is pervasive across much of Europe. However, for some projects the use of the commodity Internet is not feasible and GÉANT offers the necessary infrastructure to support high-bandwidth connections with QoS and dedicated wavelengths if necessary. The current funding of GÉANT is based on a significant contribution from the European Union and contributions from each NREN that is connected to GÉANT. Questions have been raised about the future funding of GÉANT. In particular, the question whether the direct contribution from NRENs connected to GÉANT should be increased and EU funding decreased. Most NRENs have opinions on this. In the questionnaire, a question about the future funding of GÉANT offered several options:

- a. GÉANT funded as in the current situation where half the funding is provided through the European Union's Framework Programme administered by the Information Society directorate general and the other half by contributions from the NRENs connected to GÉANT.
- b. GÉANT funding being provided through the European Infrastructure Fund (which is a loan); thereby the GÉANT infrastructure would be funded to support research and education by the member states whose NRENs connect to GÉANT. The loan would ease cash-flow problems of continually funding GÉANT.
- c. GÉANT funding being provided entirely by the NRENs that connect to GÉANT.
- d. GÉANT funded by some other form of European infrastructure funding with an EU contribution of e.g. 50% that would not have to be repaid, and an equal contribution from NRENs or their governments.
- e. GÉANT funded by other means.

Of the 26 NRENs that responded to the question, 19 (73%) preferred option (a) and therefore wanted the funding for GÉANT to remain the same as in the current situation. Three NRENs (12%) responded with options (a) and (d), so they would either prefer the current funding situation or have the current source of EU funding replaced by European infrastructure funding. Three NRENs (12%) responded with a preference for option (d), with 50% of the funding provided in the form of European infrastructure funding. One NREN wanted the dependency on European funding to be reduced, so that GÉANT would be wholly funded by the connected NRENs. It is clear from these results that the overwhelming preference of NRENs is that GÉANT will continue to be co-funded by European Union funding. Other comments were that the funding model for GÉANT should

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<sup>2</sup> Since 1993 there have been five consecutive generations of the pan-European research backbone network: EuropaNET, TEN-34, TEN-155, GÉANT and GÉANT2. For simplicity's sake, GÉANT2 and future generations of the pan-European research backbone network are referred to in this and later sections as "GÉANT".

be different for smaller and less advanced countries, and also that the cost to NRENs of funding GÉANT should not rise significantly.

## Governance and decision making by NRENs

The governance of NRENs and the way in which decisions are made influences how effective NRENs are at developing and supporting services. In this section, key factors that affect decision making are described.

### Governance of NRENs

The governance of NRENs varies widely between NRENs. This section explores the current NREN governance models.

The questionnaire asked NRENs to indicate which of the following statements apply:

- a. The NREN is part of the government or a government department.
- b. The NREN is not part of the government or a government department but the government or a government department control it.
- c. The NREN is a separate legal entity.
- d. The NREN is part of a larger legal entity that has a wider remit than just the NREN.
- e. The NREN legal entity is controlled by the senior officers (e.g., directors) of the legal entity.
- f. The NREN is controlled by a committee of nominated people from the education and research communities.
- g. The NREN is controlled by a committee of nominated people from the government or appointed by the government.
- h. The NREN is controlled by a committee of nominated people from the education and research communities and the government.
- i. The NREN is controlled by an individual lead institution (e.g. a university), with a committee that sets policy and strategy.

The details of the responses are given in the table below:

No.	Country	network name	EU	a	b	c	d	e	f	g	h	i
1	Algeria	ARN	N				X				X	
2	Austria	ACOnet	Y									X
3	Cyprus	CYNET	Y			X					X	
4	Czech Republic	CESNET	Y			X			X			
5	Denmark	Forskningsnettet	Y						X	X		
6	Estonia	EENet	Y	X								
7	Finland	FUNET	Y									
8	France	RENATER	Y			X					X	
9	Germany	DFN	Y			X			X			
10	Greece	GRNET	Y		X							
11	Hungary	HUNGARNET	Y		X			X			X	
12	Ireland	HEAnet	Y			X			X			

13	Israel	IUCC	N			X			X			
14	Italy	GARR	Y			X			X			
15	Jordan	JUNet	N					X				
16	Latvia	LATNET	Y				X					
17	Lithuania	LITNET	Y		X							
18	Luxembourg	RESTENA	Y			X	X				X	
19	FYRoMacedonia	MARNET	N				X			X	X	
20	Malta	University of Malta	Y				X					X
21	Montenegro	MREN	N	X							X	
22	Morocco	MARWAN	N	X			X					X
23	Netherlands	SURFnet	Y			X		X	X			
24	Norway	UNINETT	N		X	X						
25	Portugal	FCCN	Y			X					X	
26	Romania	RoEduNet	Y	X							X	
27	Serbia	AMRES	N				X					
28	Slovenia	ARNES	Y							X		
29	Spain	RedIRIS	Y				X			X		
30	Sweden	SUNET	Y	X			X				X	
31	Switzerland	SWITCH	N			X					X	
32	Turkey	ULAKBIM	N	X								
33	UK	JANET(UK)	Y			X						
	<b>Total</b>		<b>23</b>	<b>6</b>	<b>4</b>	<b>13</b>	<b>9</b>	<b>3</b>	<b>7</b>	<b>3</b>	<b>11</b>	<b>4</b>

**Table .15:** Current governance forms of NRENs

The current models used for governing NRENs vary widely, but three models are the most common. They are:

- A legal entity or part of a larger legal entity controlled by a stakeholder committee.
- Part of a government department with a stakeholder committee.
- Not a government department but controlled by a government department.

A majority of NRENs (66%) are legal entities or part of a larger legal entity, and 62% of NRENs are controlled by a committee of stakeholders, who could be government representatives and/or representatives from the research and education communities. Very few NRENs have a 'normal' company structure where the NREN company is controlled solely by its senior officers such as directors. A significant minority of NRENs are part of a government department or are controlled by a government department (31%).

Some NRENs do not have any stakeholder representation from the research and education communities in their governance structure. It may be perceived that this is not required if there is government representation in the NREN governance structure. However, to follow best practice it would be desirable that all NRENs have representation from all key research and education stakeholder groups, so that those groups (who are often providing funding) can have an input into the management and decision making processes of the NREN.

NRENs connect and support different types of organisations. Not all organisations are represented in the governance structure of the NRENs. The table below gives the details of the organisations that are represented in the governance structure. The traditional users of NRENs, i.e. universities and research institutions, are reasonably well represented in NREN governance structures, at 82% and 61% respectively. However, it is quite surprising that 18% of NRENs have no university representation and 33% have no representation of research institutions in their governance structures. Other types of organisations that are connected to NRENs are not well represented. As is to be expected, commercial organisations connecting to NRENs are not represented in the NRENs' governance structures at all.

Type of institution	Number of NRENs in which represented	Percentage of NRENs in which represented	Number of NRENs in which not represented	Percentage of NRENs in which not represented	Number of NRENs from which do not receive service	Percentage of NRENs from which do not receive service
Universities	27	82%	6	18%	0	0%
Research institutions	20	61%	11	33%	2	6%
Tertiary/professional institutions	9	27%	11	33%	12	36%
Primary/secondary schools	5	15%	13	39%	14	42%
Government departments	13	39%	9	27%	11	33%
Health service / hospitals	5	15%	11	33%	17	52%
Commercial organisations with links to R&E	0	0%	9	27%	24	73%
Commercial organisations with no links to R&E	0	0%	3	9%	30	91%
Other organisations	2	6%	4	12%	27	82%

**Table .16:** Representation of different NREN user communities in governance structure

### Decision making in NRENs

The development and agreement of general policies by NRENs is an important part of their management. The table below shows that there are three main methods of agreeing general policies. Approximately one third of NRENs adopt each of the top three methods. The methods adopted show that that some NRENs have a good deal of autonomy to develop policies by the NREN management team and then either agree policies within the NREN management team (39%) or agree them within the management committee of their legal entity (30%) and/or with a committee representing universities and research institutions (30%). Some NRENs have multiple ways of developing and agreeing policies. This is why the percentages in the table add up to more than 100%. When policies have to be agreed by committees, it may take several months to get agreement, depending on how often committees meet, although the use of electronic mail may improve the time needed for decisions to be made.

Policy development and agreement method	Number	Percentage of NRENs that
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		<b>responded</b>
Developed and agreed by NREN organisation management team	13	39%
Developed and agreed by the NREN organisation management team and the management committee of the NREN's organisation legal entity, e.g. the 'board' of the legal entity.	10	30%
Developed by NREN management team and the management committee of the NREN's organisation legal entity and agreed by a committee representing universities and research institutions	10	30%
Developed and agreed by a committee representing universities and research institutions	2	6%
Developed and agreed by the government department of education or research	2	6%
None of the above	2	6%

**Table .17:** Methods of developing and agreeing general policies in NRENs

The development and agreement of technical policies by NRENs is also an important aspect of NREN management: NRENs need to ensure that the network policies developed and implemented meet the needs of the communities that they serve and also the various technical constraints of the NREN infrastructure.

A high proportion of NRENs (67%) have a large degree of autonomy and can develop and agree technical policies within their own management team. A large minority of NRENs (30%) develop the technical policies in their management team but get the agreement of the policies through a committee with members representing universities and research institutions. The decision making for the development of technical policies is therefore predominantly with the NRENs. This would imply that development of technical policies can be carried out quickly if necessary and in many cases the policies can be agreed quickly. Some NRENs have multiple routes for the development and decisions about technical policies. This is why the percentages in the table below add up to more than 100%.

<b>Technical policy development and agreement method</b>	<b>Number</b>	<b>Percentage of NRENs that responded</b>
Developed and agreed by NREN management team	22	67%
Developed by NREN management team and agreed by a committee representing universities and research institutions	10	30%
Developed and agreed by a committee representing universities and research institutions	1	3%
Developed and agreed by the government department of education or research	0	0%
Developed and agreed by network operator	1	3%
Developed by working groups with NREN and university representatives	1	3%
Developed by other methods	1	3%

**Table .18:** Methods of developing and agreeing technical policies in NRENs

## Connection of new user communities to NRENs

Many NRENs have expanded the communities that connect to their network or are in the process of doing so. NRENs have moved away from connecting only universities and research establishments and may connect schools, hospitals, commercial science parks etc., or they have plans to connect such new communities of users. In such cases, an explicit decision to connect a particular new user community has to be made. This decision could be contentious if the current NREN user base is not happy with the NREN expanding its activities into other areas and thereby possibly diluting its support effort. The way decisions are made about connecting new communities of users is therefore important. In the survey, 64% of the NRENs indicated that they are planning to connect new types of user institutions. The other NRENs have already connected new types of institutions and have no further plans for connecting others, or they still only support the research and education communities and have no plans yet to connect new types of user institutions.

More than a third of the 25 NRENs that responded to the question can make a decision about connecting new types of user institutions without consulting any other body other than their senior management team. It is surprising that so many NRENs have this high degree of autonomy, particularly because many NRENs are funded by government, their existing research and education user base or a combination of both. However, all other NRENs that responded to the question needed to consult their governing body or their government before being allowed to connect new types of user institutions. Consulting with stakeholders about important strategic decisions is best practice. Therefore NRENs that do not consult with stakeholders about strategic decisions, such as who should be allowed to connect to the network, should consider putting in place some form of stakeholder consultation.

Permission to connect new types of users	Number of NRENs with no other constraints	Percentage of NRENs with no other constraints	Number of NRENs with further constraints	Percentage of NRENs with further constraints
NREN senior management team	9	36%	4	16%
NREN governing body e.g. the legal entity governing body or committee	3	12%	7	28%
The NREN has to seek approval from the government to make the decision	0	0%	6	24%
The NREN has to seek approval from its existing education and research user base to make the decision by consulting with a representative committee	0	0%	0	0%
The NREN has to seek approval from all the organisations that currently fund the NREN to provide the network and the network services	0	0%	1	4%
The national telecommunications regulator has to be involved in the decision to connect new types of user institution outside those involving education and research.	0	0%	1	4%

**Table .19:** Methods of obtaining agreement to connect new types of users

NRENs have several concerns about connecting new types of institutions to their networks. Five NRENs think that if they wish to connect new types of institutions outside the research and education sectors, their government may not or will not approve the proposal. Two NRENs think that if they wish to connect new institutions outside the research and education sectors, their country's telecommunications regulator will not approve.

One NREN has registered as a telecommunications operator to get around potential regulatory problems, while two other NRENs have pending issues with their country's telecommunication regulator that need to be

resolved. NRENs from countries in the European Union should not face regulatory problems if they only provide services to closed user groups. However, there may be regulatory issues if NRENs decide to connect very wide groups of users, because the term 'closed user group' may be open to interpretation<sup>3</sup>.

Some NRENs also had concerns about the time it took for consultations to be carried out and for decisions to be made. This was the case for five NRENs; two had concerns about the length of the consultation process and three had concerns about the long time it took the organisation responsible for taking the decision to take decisions. Long consultation or decision processes hamper NRENs from developing and getting their plans approved. It would be desirable for these minority cases that the speed of consultation and decision making would be improved.

### Service Level Agreements and service levels

NRENs are delivering various types of services to the research and education communities and to other user groups. Many commercial telecommunications providers that provide services to many different types of users have Service Level Agreements. The questionnaire revealed that only six NRENs (18%) deliver services in line with an agreed Service Level Agreement. There were 24 NRENs (73%) that had no formal Service Level Agreements but delivered services to 'best efforts', while three NRENs (9%) had no defined service levels at all. The lack of Service Level Agreements does not mean that NRENs are delivering poor services or that they are not effectively monitoring and maintaining services. However, not having Service Level Agreements could be a point of weakness or even a threat when organisations have to justify using NRENs rather than commercial providers, particularly in the case of new potential user communities, which are not familiar with the ethos of the way in which NRENs function and provide services. The development and use of service level definitions would go some way towards addressing this issue and would assist the users and potential users of NRENs in knowing the level of services that they can expect to be delivered by their NREN.

The services offered to institutions by NRENs may depend on the type of institution or on whether an institution wishes to pay for additional services. Half of the responding NRENs provide a uniform set of services to all their connected institutions, while almost a quarter provide a base level of services to all institutions plus additional services at no cost to specific institutions or institutions of a particular type. Another quarter of the responding NRENs provide a base level of services to all connected institutions, but will offer additional services for an additional cost to the institution.

Services to institutions	Number	Percentage of NRENs that responded
A uniform set of services are offered to all	16	50%
A base level of services with additional services offered to some institutions at no additional cost to the institution	7	22%
A base level of services with additional services offered to some institutions at an additional cost to the institution	8	25%
Different services offered depending on type of institution	1	3%
<b>Total responding</b>	<b>32</b>	<b>100%</b>

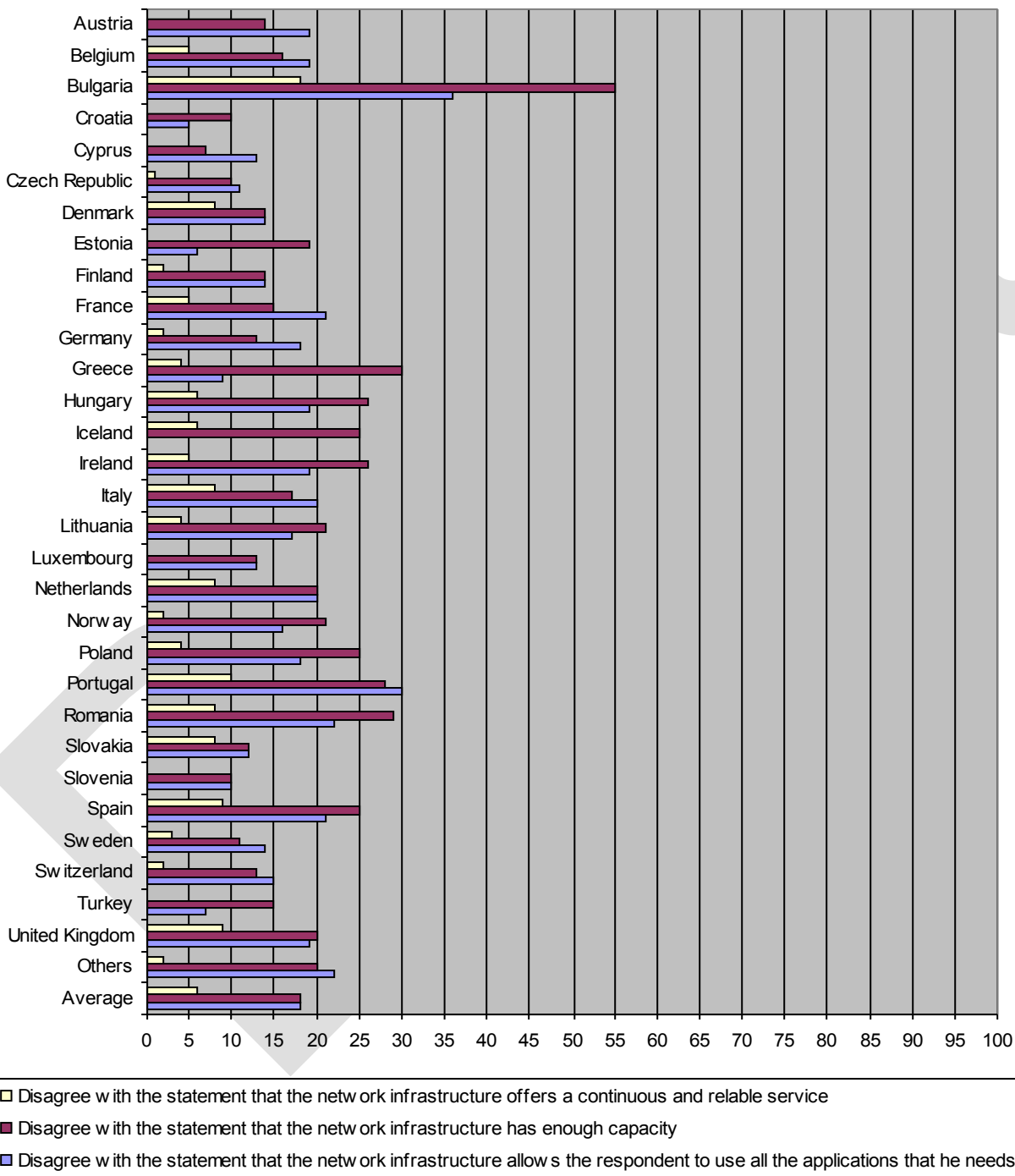
**Table .20:** Variability of services provided to institutions

Some NRENs may monitor services fully, but NRENs may not conduct formal user satisfaction surveys so they may have no independent view of how their services are perceived by their users. The EARNEST questionnaire sent to researchers included some questions about the performance of the networks and satisfaction with network services. The results of the relevant part of this survey are presented below and

<sup>3</sup> See also the EARNEST report on regulatory issues by Claire Milne and Robert Milne.

reveal that on the whole there is a high level of satisfaction with services. However, in order to focus in on where there might be areas for improvement, the level of dissatisfied users needs to be ascertained.

The results must be treated with a degree of caution because the researchers responding to the questionnaire are not only using NREN services but services and networks available from their own institutions, with the NREN just being part of the chain of delivery of network services. However, the results give indications of where there might be room for improvement, subject to carrying out investigations into the detailed reasons for the dissatisfaction. It should be noted that dissatisfaction is defined as the percentage of people who disagree or strongly disagree with the statements given in the figure.



**Figure 5.1:** Percentage of dissatisfaction for different aspects of network services (results from the EARNEST study on researchers' requirements)

## NREN liaison with pan-European networking

NRENs are responsible for running research and education network services in their own country, but also have a responsibility to provide services to their users that reach outside their countries. For services that specifically support European collaboration in research and education, NRENs need to participate in the development of pan-European networking policies, which will have an impact on the development of policies in their own countries. NRENs have different attitudes to the level of their participation in the development and implementation of European research and education networking policies. The table below summarises the findings.

It is clear that the majority of NRENs that responded want to be involved in the development and setting of European research and education networking policies, but only wish to implement European policies when they are in-line with existing and/or future policies of the NREN. In other words, the majority of the responding NRENs do not wish to be subservient to European research and education network policies, even though they themselves have an influence on the development and setting of European research and education networking policy through bodies such as the NREN Policy Committee<sup>4</sup>.

Type of participation in pan-European research and education network policy development and implementation	Number	Percentage of NRENs that responded
The NREN fully participates in the development and setting of policies at a European level and implements the agreed and recommended policies.	7	28%
The NREN participates in the development and setting of policies at a European level and implements the agreed and recommended policies only when these policies are in-line with the existing or future policies of the NREN or government.	9	36%
The NREN participates in the development and setting of policies at a European level and implements the agreed and recommended policies only when these policies are in-line with the existing NREN or government policies.	2	8%
The NREN monitors European policy setting and does generally not implement European policies unless they have a direct relevance to networking services in existing use on the NREN.	7	28%
<b>Total responding</b>	<b>25</b>	<b>100%</b>

**Table .21:** NREN participation in European networking policy setting

## NREN operational support for the network

### General and end-to-end support

The level of support by NRENs for the different sections of their network will be one of the factors influencing whether end-to-end services can be reliably delivered within their national research and education network and also across different national research and education networks. The support for different parts of the NREN's network is very different with different NRENs, and the fine details are too lengthy to explore in this report.

Not all NRENs offer a uniform level of service throughout the different parts of the network. However, 76% of NRENs do offer a uniform level of service, but this does not always include 24x7 support. Generally, the core of a national research and education network is better supported than links to institutions. For example, 68% of the responding NRENs provide 24x7 cover for their core backbones, whereas only 42% provide 24x7 cover for links to universities. The support for links to research institutions is very similar to that for universities. The support cover for links from NRENs to GÉANT2 is similar to that for backbone support, with 67% of the responding NRENs providing 24x7 cover. If large pan-European collaborative projects require high levels of on-

<sup>4</sup> The NREN Policy Committee is the highest ranking body in the management structure of the GN2 project.

call support to universities or research establishments, it might not be possible to guarantee service levels throughout all NRENs at all times of the day. It may be that special levels of targeted support are necessary for particular collaborative research projects. But some NRENs do not support their backbones on a 24x7 basis, so high levels of continuous support for pan-European collaborative research projects may not be possible for all participating countries and institutions. However, if the network infrastructure of NRENs is reliable, levels of continuous support may not be necessary to support collaborative pan-European projects, which are running in a 'production' mode; human intervention may be rarely necessary, except when technical problems arise.

The way in which support for different parts of national research and education networks is provided varies. There are many possible combinations of different staff participating in support, including NREN staff, university staff, regional network staff and staff of subcontracted companies.

Backbones of NRENs are supported by a combination of NREN staff (79%), staff of subcontracted companies (18%) and university staff (3%). Links from NREN backbones to universities are supported by a combination of NREN staff (70%), university staff (30%) (including staff members of regional networks) and staff of subcontracted companies (30%).

The support chain for end-to-end services can therefore be very complex when multiple NRENs are involved. It is the responsibility of the NRENs to put appropriate support mechanisms in place when end-to-end services are to be delivered reliably for long- or short-term pan-European collaborative research projects.

The bandwidth of links to various institutions may be too small for some types of collaborative research. The TERENA Compendium of National Research and Education Networks in Europe gives information about the variability of the bandwidth to universities connected to the different European NRENs. Several NRENs may have to upgrade the bandwidth to some institutions if those institutions start to participate in certain pan-European collaborative research projects. The issue of funding for upgrades is therefore important, and funding for such upgrades needs to be made available from the research projects' budgets or from NREN or institution budgets.

Troubleshooting of performance problems for end-to-end services is necessary. The complexity of troubleshooting end-to-end service performance problems is determined by the number of organisations involved. NRENs use support structures for troubleshooting end-to-end performance problems that are very similar to the ones that they use for general support. The GN2 project has established a Performance Enhancement and Response Team (PERT) that can assist in troubleshooting performance problems.

End-to-end performance problems on NREN backbones are resolved by a combination of NREN staff (82%), staff of subcontracted companies (21%) and university staff (3%). Performance problems on links from NREN backbones to universities and research institutions are diagnosed and fixed by a combination of NREN staff (73%), university staff (36%) (including staff members of regional networks) and staff of subcontracted companies (18%). It is to be noted that subcontracted companies are used less for troubleshooting end-to-end performance problems on institutional links than for general support. This may be because the complexity of the problem of troubleshooting end-to-end services and the need to liaise with multiple organisations make this a task that NREN staff are more prepared to carry out than commercial companies.

### Provisioning and support of end-to-end services

The way in which end-to-end services are set up will determine how easy it is to quickly configure and use end-to-end services effectively. Some NRENs have aspirations to allow end-users to configure end-to-end services when required. The technology to do this is available, but has not really been widely used in the field. The problem of configuring end-to-end services across multiple NREN domains and between multiple NRENs adds to the complexity. The current state of the art with relation to the setting up of end-to-end services is given in the following table.

Responsibility for setting up end-to-end services	Number	Percentage of NRENs that responded
NREN staff	11	33%
Outsourced to a commercial company	3	9%
Combination of both NREN staff and outsourced	2	6%

Provided by institution staff from universities and research establishments	3	9%
Combination of NREN staff and institution staff from universities and research establishments.	16	48%
Provided by one or more lead institutions responsible for supporting the NREN	0	0%
Totally automated under the control of the NREN organisation	0	0%
Totally automated with devolution of control to end-institutions within a policy framework set by the NREN organisation	0	0%
Totally automated with devolution of control to nominated end-users within institutions within a policy framework set by the NREN organisation	0	0%

**Table .22:** Organisations responsible for setting up end-to-end services

At present, NREN staff is involved in the setting up of end-to-end services, although with nearly half of the NRENs institution staff is also involved in setting up the services. As the technologies to support user self-provisioning of network services mature, the responsibility for setting up end-to-end services may shift from the NREN to user institutions and may also be automated.

The plans for self-provisioning of Virtual Private Network services (VPNs) show that the majority of NRENs that have plans are aiming to allow technical staff at institutions to configure VPNs. However, nearly 60% of NRENs do not have plans for the self-provisioning of VPN services. One NREN has already implemented self-provisioning of VPNs, so it is clear that this is indeed feasible.

Plans for self-provisioning of VPNs	Number	Percentage of NRENs that responded
Technical staff responsible for the network in a university / college / research institution	9	27%
General IT support staff of the university / college / research establishment	0	0%
Trained end-users	2	6%
Any end-users	2	6%
No plans	19	58%
Already supporting self-provisioning	1	3%

**Table .23:** NREN plans for self-provisioning of VPNs

The plans for self-provisioning of services using QoS show that the majority of NRENs that have plans are aiming to allow technical staff at institutions to configure services using QoS. However, about 70% of NRENs do not have plans for the self-provisioning of QoS enabled services.

Plans for self-provisioning of QoS services	Number	Percentage of NRENs that responded
Technical staff responsible for the network in a university / college / research establishment	6	18%

General IT support staff of the university / college / research establishment	0	0%
Trained end-users	1	3%
Any end-users	2	6%
No plans	23	70%
Already supporting self provisioning	0	0%

**Table .24:** NREN plans for self-provisioning of QoS services

The development of self-provisioning facilities for end-to-end services will become more important as more research and education collaboration is carried out across Europe and beyond, using applications that require high bandwidth and/or quality of service in order to be delivered reliably. The development of such self-provisioning is underway in some NRENs, although there is scope for more collaboration in this area, so that resources and effort are not wasted in developing the same or incompatible self-provisioning services by teams of technical staff in different NRENs. This is where policy setting at a European level will be important. There is scope for organisations such as TERENA and DANTE to co-ordinate work on self-provisioning, provided that the policies to be implemented are agreed by the NRENs.

### Support and funding for special projects

In the context of this report, *special projects* are projects that require special networking facilities that are not simply available as part of the standard service offered by an NREN to the majority of its users. Such projects may need end-to-end services to be configured or novel applications to be implemented on the network. Special projects may use Grid applications or might have special requirements in terms of bandwidth and quality of service.

The support that NRENs provide to special projects is an important form of support that is characteristic for the research and education networking environment and that will normally not be provided by commercial network operators or Internet Service Providers. NRENs are close to their communities of users and therefore are in a good position to assist with special projects. However, special projects take up resources and need to be funded.

There are different methods adopted by NRENs for the funding of support to special projects. The particular model that is used needs to be taken into account when planning special projects; otherwise the funding to support special projects may not be available. This implies that the research collaborators must be aware of the funding implications of the network aspects of special projects and must work with their NRENs to set budgets before asking for funding for special projects, especially if the network provisioning costs are potentially high. The required collaboration effort is generally modest when a special project is run within a country, but for pan-European collaboration there may be many NRENs involved and therefore the complexity is increased, particularly when there are different budgeting and support models. These issues are explored in this section.

There is the possibility that project teams develop their own network infrastructure for projects rather than using the NRENs' network infrastructure. Among the NRENs there are differing attitudes to this, as shown by the table below.

Providing support for special projects	Number	Percentage of NRENs that responded
Agrees that when an NREN organisation is not funded to support a special project, the organisations running the project should be allowed to acquire and run their own networking services.	18	55%
Agrees that when an NREN organisation could be funded to support and is technically able to support networking services required for special projects, the NREN should always be offered the option to do so.	24	73%

Agrees with using alternative arrangements to the use of GÉANT when developing pan-European collaboration projects or links to other countries' NRENs, when more cost effective	15	45%
Agrees with using alternative arrangements to the use of GÉANT when developing pan-European collaboration projects or links to other countries' NRENs, when costs of the alternative arrangements are similar to those for using GÉANT	7	21%
Agrees with using alternative arrangements to the use of GÉANT when developing pan-European collaboration projects or links to other countries' NRENs, when costs of the alternative arrangements are higher than those for using GÉANT	5	15%

Table .25: Opinions on providing support for special projects

The majority of NRENs taking part in the survey (73%) think that they should always be offered the option to support special projects. But if they choose not to support the special project or are unable to do so due to funding, resources or technical constraints, then 55% of NRENs taking part in the survey think that the special project has the right to acquire and run a special-purpose networking infrastructure to support the project. Acquiring and running special networking infrastructures for particular projects can be very expensive, so it is important that NRENs and project teams explore all the options of using the NRENs' existing network infrastructures or enhancing those infrastructures to support special projects.

Some NRENs have an interesting attitude about the use of GÉANT. When the use of GÉANT is less cost effective than using alternative arrangements, then 45% of NRENs taking part in the survey agree with using network infrastructures other than GÉANT. This is justifiable on grounds of cost. However, 21% of NRENs taking part in the survey still agree with using alternative network infrastructures to GÉANT when the costs are roughly the same as the cost of using GÉANT. A significant 15% of NRENs taking part in the survey even agree with using alternative networking infrastructures to GÉANT when the cost of using GÉANT is lower. Because NRENs are contributing towards the costs of running GÉANT, it is clear that costs are not the only consideration for some NRENs, and that in some cases there may be reasons for them to use, develop or fund parallel infrastructures to GÉANT, even when using GÉANT would be more cost effective.

### Support and funding of support for special projects within one country

Support for special research and education projects within a particular country by the country's NREN is an important activity for NRENs. It is not surprising that 91% of NRENs who responded to the NREN questionnaire are supporting special projects. The table below shows how the projects are supported. The support for special projects is organised predominantly in two ways: by setting up project teams or through informal dialogue with the project user community.

Technical support for special projects in the NREN	Number	Percentage of NRENs that responded
A project team with NREN staff and the user community staff is set up to manage the project	16	48%
Informal dialogue with the user community staff takes place	16	48%
Other arrangements are put in place	6	18%

Table .26: Provision of technical support for special projects in a single country

The funding of support for special projects within a single country varies considerably between different NRENs, as shown in the table below, ranging from the NREN paying all the costs to the user community paying the costs.

Funding of support for special projects in the NREN	Number	Percentage of NRENs that responded
The user community that benefits by the project pays	9	27%
The NREN and user community (benefiting by the project) pay	8	24%
The NREN pays	8	24%
All participants pay their own expenses	7	21%
None of the above	1	3%

**Table .27:** Methods of funding support for special projects within a single country

### Support and funding of support for special projects across multiple countries

Support for special research and education projects across multiple countries by several NRENs is an important activity for NRENs and essential for collaborative research and education between different countries. It is not surprising that 82% of NRENs who responded to the NREN questionnaire are supporting special projects of this kind. However, 18% of NRENs do not support collaborative research and education projects spanning multiple countries. The support for such special projects is organised in several different ways, as shown in the table below.

Technical support for special projects across multiple NRENs	Number	Percentage of NRENs that responded
A project team with NREN staff and the user community staff is set up to manage the project	8	24%
Informal dialogue with the user community staff takes place	6	18%
Other arrangements are put in place	12	36%

**Table .28:** Provision of technical support for special projects across multiple countries

The funding of support for special projects across multiple countries varies considerably between different NRENs, as shown in the table below, ranging from the NREN paying all the costs to the user community paying the costs.

Funding of support for special projects across multiple NRENs	Number	Percentage of NRENs that responded
The user community that benefits by the project pays	10	30%
The NREN and user community (benefiting by the project) pay	6	18%
The NREN pays	6	18%
All participants pay their own expenses	4	12%
None of the above	0	0%

**Table .29:** Methods of funding support for special projects across multiple countries

One potential problem with NRENs funding the networking infrastructure to support special projects is that when a new infrastructure needs to be developed, the costs may be high and the necessary funds may not be

available in the NREN's budget. This could cause problems with the implementation of special projects. It is therefore important that NRENs that pay the costs of support to special projects are aware of (plans for) potential projects and their associated networking infrastructure development costs. This can only be achieved by strong liaison between the NRENs and the research and education communities.

### Support for wider strategic developments

NRENs mainly serve their user communities by developing and providing advanced network services as well as basic services of the kind that could also be provided by Internet Service Providers. However, NRENs can get involved with wider strategic developments than just the provision of standard – be it advanced or basic -network services. All the NRENs responding to the questionnaire are involved with wider strategic developments. This indicates that NRENs have ambitions to be more than just 'vanilla' network service providers. The fact that their user communities, funding bodies and governments are happy that NRENs take this wider role, shows that NRENs are perceived as credible organisations that understand the needs of the research and education communities. It also shows that NRENs are perceived as organisations that can effectively deliver projects.

Examples of projects that are currently being carried out by NRENs include, among many others, Grid strategy, Grids, identity management, security services, middleware, high-performance computing, mobility, advanced applications, Voice-over-IP (telephony), videoconferencing, video archives, e-libraries, remote backup, distributed gateway systems, dynamic lightpath provisioning, e-learning, e-conferencing, user collaboration services, e-business services, technology innovation, and information services and databases for research, education and administration. Some of these projects are large scientific research projects funded by the European Union.

A large majority of NRENs (82%) think that they should offer more services. Examples of such services are multicast, video streaming, e-learning, Grids, identity management, VPN, multimedia for collaboration, school networks, off-campus student access, information services for research and education, administration services for research and education, support for high-level applications, middleware, data storage curation, Computer Security Incident Response Teams, Voice-over-IP, videoconferencing, QoS, security services, IPv6, e-learning, lightpath services, MPLS QoS, bandwidth on demand, supercomputing, storage management, etc.

It is clear that NRENs are involved in many projects that have a direct impact on enhancing research and education and have aspirations to get more involved in these types of projects.

### Communication with users

NRENs serve the research and education communities, so it is vital that they have good communication channels with those communities. These communication channels have been established in a variety of ways. Larger NRENs in large countries would find it very difficult to provide a direct communication path with end-users. Often there is a mechanism of devolved support set up, whereby nominated staff members at institutions deal with support queries from the staff in the institution and these persons provide the liaison with the NREN. The table shows how support is provided by NRENs. Some NRENs have user committees and, as already described in the section on governance, NRENs often have user representation at the highest management level of their organisation.

Communication with end-users	Number	Percentage of NRENs that responded
Communication is direct between the end-user and NREN user support staff	5	15%
Communication is direct between the end-user and NREN technical support staff	12	36%
Communication of the end-user is via the end-user's institution IT or network support staff, who communicate with NREN staff	16	48%

**Table .30:** Methods of communication with end-users

Without conducting surveys, it is difficult to measure how effective these different communication methods or support structures are.

Not all users are aware that NRENs exist, because they just use a set of services and are not aware of the underpinning infrastructure. Even less users are aware that they are connected via their NREN to the pan-European backbone network, GÉANT2. One measure of the effectiveness of NRENs' public relations is to measure whether users are aware of their NREN. Similarly, a measure of the effectiveness of DANTE's public relations is to measure whether users are aware of GÉANT2.

The EARNEST questionnaire sent to researchers asked questions that enable to measure approximately the end-users' knowledge of NRENs and GÉANT2. The results from the relevant part of that questionnaire are shown in the figures below. The results are revealing, showing that there is considerable scope for NRENs and DANTE to improve their public relations. It is clear that some NRENs are more known by their research user base than others. Public relations is not just the responsibility of the NREN, and institutions connected to the NREN should also be involved in making end-users aware of the networking services available and about how they are provided.

Although awareness of NRENs within the end-user community may not always seem important because NRENs are mainly providing infrastructure services, the importance of public relations will increase as more collaborative research and education is developed that needs non-standard network services. Then the communities that use the services of NRENs will need to know how to liaise with NRENs and how to influence NRENs' policies, particularly if the NREN concerned does not yet support services that are required by the research and education communities.

There is a similar issue for GÉANT2, although NRENs can provide the liaison with general end-users and DANTE can focus in particular on pan-European collaborative research and education projects.

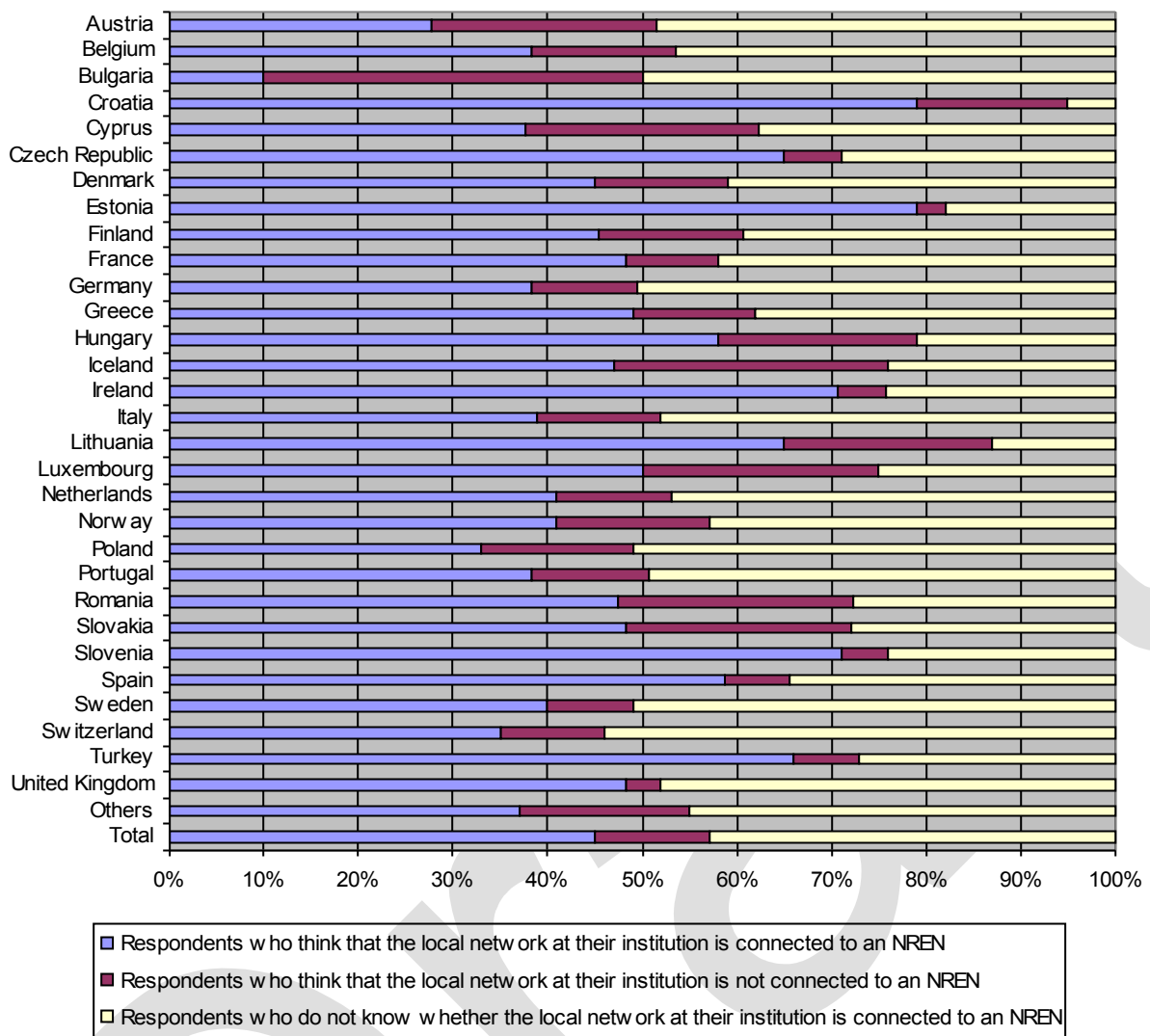
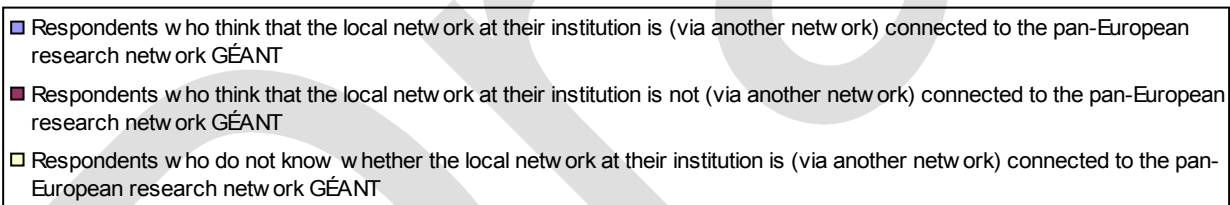
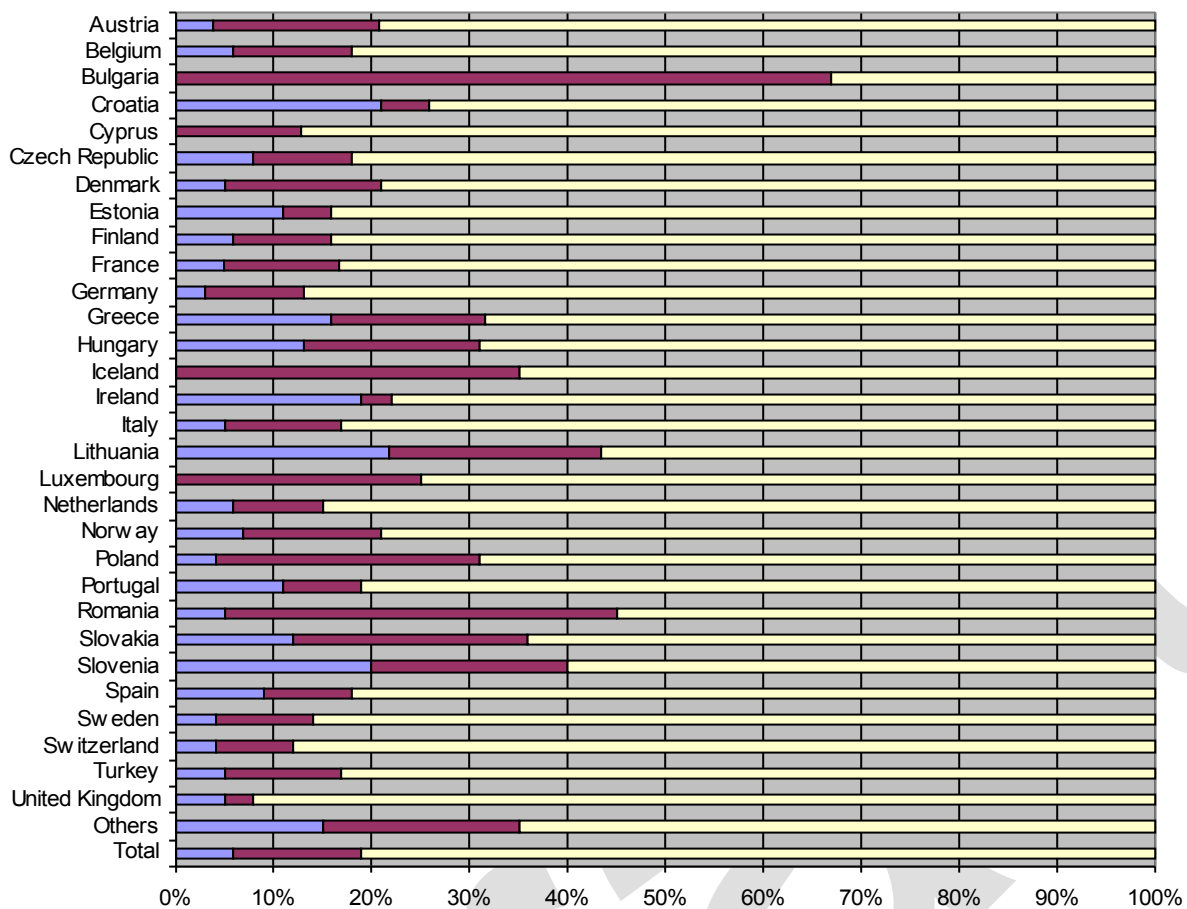


Figure 5.2: Researchers' awareness of NRENs



**Figure 5.3:** Researchers' awareness of GÉANT

## 6 Possible best-practice governance and organisation models

In the first chapters, this report has mainly described and interpreted the results from the EARNEST questionnaire sent to NRENs. That has revealed that there are many different organisation and governance structures in place in the different NRENs throughout Europe and beyond, as well as widely varying management and budget allocation policies and practices.

It is clear that the way in which governments organise and influence the public sector in their countries and manage budgets will continue to have a huge influence on how NRENs are governed and managed. However, some areas of best practice have emerged from the analysis of the responses to the questionnaire. It is also possible to learn from other sectors about the best practices in running any business with a complex array of stakeholders and customers.

### Requirements for NREN governance

A set of requirements for NREN governance models has emerged from the analysis of the governance models that are currently in place in NRENs and from the aspirations of NRENs to move towards delivering reliable end-to-end services and to continue meeting the needs of their key stakeholders.

The requirements for a suitable NREN governance model are:

- Accountability to the organisations financing the NREN
- Accountability to the research and education communities and any other important strategic users of the NREN's infrastructure and services
- Ability to take into account the needs of key stakeholders
- Clear and efficient processes for the development and approval of strategies and policies
- Ability to effectively set performance targets, to monitor them and to improve performance
- Ability to enter into legal agreements with suppliers and user institutions
- Ability to take into account changing circumstances and develop new NREN strategies and policies, and to commission new services in an appropriate way to align them with the requirements of the research and education communities
- Ability to shape policies so that they align with policies developed at a European level in order to allow effective inter-domain working, so that pan-European collaborative research and education can be conducted effectively and efficiently.

## **NREN governance models**

The current governance models of European NRENs vary widely, but the most common model is that the NREN is a legal entity or part of a larger legal entity. This model is a sound model: it has proven to work for NRENs and also works for many other types of organisations. By law, a legal entity is able to take decisions autonomously. Nevertheless, when taking decisions the views of key stakeholders have to be taken into account carefully.

In order to meet the requirements for NREN governance stated above, some form of stakeholder representation should be built into the governance and organisation structures of NRENs. Many NRENs already have representatives from the research and education communities in their governing structures or on committees that feed into the governance of the NREN.

Possible models for effective NREN governance are:

### **Model 1**

1. The NREN is a legal entity with a supervisory board. In the Anglo-Saxon legal system, where there is no legally required separation between the Board of Supervisors and the General Managers, this would be a Board of Directors including both supervisors and managers.
2. The board comprises of members who represent key stakeholders from the research and education communities and from the government (e.g., the government departments for education, for research etc.). In the Anglo-Saxon system, the General Manager(s) of the NREN will be members of the board as well.
3. Other, minor stakeholders are represented on a committee of stakeholders, and the chair of that committee is also a member of the board.
4. The Chief Executive Officer or General Manager of the NREN chairs the NREN management team, which consists of the senior managers of the organisation.

### **Model 2**

1. The NREN is not a legal entity but has a board.
2. The board comprises of members who represent key stakeholders from the research and education communities and from the government (e.g., the government departments for education, for research etc.). In the Anglo-Saxon legal/organisational culture, the General Manager(s) of the NREN will be members of the board as well.
3. Other, minor stakeholders are represented on a committee of stakeholders, and the chair of that committee is also a member of the board.

4. The Chief Executive Officer or General Manager of the NREN chairs the NREN management team, which consists of the senior managers of the organisation.

Variations of models 1 and 2 can be developed to meet the requirements of the national government or other influential stakeholders. For example, if the government does not want many, or even any, representatives of the research and education communities to sit on the board, the models can be adapted so that all stakeholders are represented in the committee of stakeholders.

#### **Example of variation of Model 1**

1. The NREN is a legal entity with a supervisory board. In the Anglo-Saxon legal system, where there is no legally required separation between the Board of Supervisors and the General Managers, this would be a Board of Directors including both supervisors and managers.
2. The board comprises of representatives of the government (e.g., the government departments for education, for research etc.). In the Anglo-Saxon system, the General Manager(s) of the NREN will be members of the board as well.
3. Other stakeholders are represented on a committee of stakeholders, and the chair of that committee is also a member of the board.
4. The Chief Executive Officer or General Manager of the NREN chairs the NREN management team, which consists of the senior managers of the organisation.

The models above are examples of governance models that meet the key requirements. Others could be devised. However, governance models that do not include representatives of the research and education communities and other stakeholders such as the government should be avoided.

### **Protocols for the management of end-to-end services**

It was an aim of the EARNEST study of organisation and governance issues to look into the development of models and protocols for setting up and managing end-to-end services. It has become clear that this is likely to be a complex and iterative process that needs to be led at a European NREN policy making level. One reason is the wide variety of the ways in which individual NRENs develop and set policies. Another reason is the different attitudes of different NRENs to implementing (or not implementing) policies that are agreed at a European level.

One way forward would be to agree first on a set of standard technical solutions, and then establish a working group to develop common and acceptable policies for setting up end-to-end services, including the methods by which they are self-provisioned by users and supported by NRENs. The policies developed by the working group would then need to be approved and adopted by the NRENs.

Some NRENs have no plans for self-provisioning of services by users. However, if policies would be developed, tested and implemented by a representative group of NRENs, then it would be easier for other NRENs to implement agreed policies. Indeed, it would save them time by not having to carry out the development themselves. An extension of some of the Joint Research Activities of the GN2 project might facilitate the development of models and protocols for setting up and managing end-to-end services.

## **7 Recommendations**

The study has shown what the current governance and decision making practice is in NRENs. It is outside the scope of this study to provide very detailed recommendations regarding individual NRENs. However, based on the findings of the study, several general recommendations have been devised. These recommendations aim to improve the organisation and governance of NRENs, and also to improve the collaboration with the research and education communities.

### **Recommendations for NRENs**

1. If one wants NRENs to develop in a cost effective and efficient way, then the ability of NRENs to plan ahead is very important. Many NRENs are only setting annual budgets. It is recommended that all NRENs

set multi-annual budgets covering at least a period of three years, even if their funding organisations do not guarantee a budget over this period.

2. If NRENs are not provided with multi-annual guarantees of funding, they should enter a dialogue with their funding organisations in an attempt to improve the budget planning and commitment process, so that longer-term (multi-annual) budgets can be agreed and set.
3. NRENs are recommended to develop project and/or business plans for new projects or enhanced services, particularly when seeking additional funding.
4. Where possible, NRENs should aim to simplify user-institution charging models, while maintaining transparency and fairness of charging. For example, if the actual use of bandwidth is part of the charging model, then it takes resources to measure the bandwidth use, to report on it and to invoice institutions based on the bandwidth used. Simpler models would be ones with just one or two parameters that are more constant, such as the type of institution, the type/bandwidth of the interface connecting the institution, or the bandwidth limit configured on the interface.
5. The study has commissioned from a limited number of NRENs a description of how these NRENs are organised and governed. These documents are useful reference documents. It would be very helpful to organisations that deal with NRENs to have such descriptions available for all NRENs, in order to provide an understanding of the structures and decision making bodies of the NRENs. All NRENs are recommended to develop such reference documents.
6. NRENs that have not already done so, must look into the future possibility of providing wavelengths to the sites of end-user institutions, in order to support future collaborative research projects that require wavelengths. Charging mechanisms for the provision of wavelengths should also be put in place, so that research groups can budget appropriately when writing research proposals and costing research projects. Where wavelengths cannot be provided, suitable alternative arrangements should be investigated and appropriate alternative solutions put in place when required.
7. NRENs that do not have representation of key stakeholders in their governance structures should consider including these stakeholders in their governance structures, allowing all key stakeholders to have an input into the decision and policy making processes of the NREN.
8. NRENs should consider consulting with existing stakeholders when taking very important strategic decisions, such as who should be allowed to connect to the national research and education network.
9. NRENs whose plans get delayed by too lengthy consultation and/or decision making processes should seek to improve their circumstances, either by planning further ahead or by attempting to streamline the necessary consultation and/or decision making processes.
10. NRENs should consider developing Service Level Definitions or Service Level Agreements in line with best practice.
11. NRENs should work together to develop robust self-provisioning of end-to-end services, assisted by the co-ordination efforts of TERENA and DANTE. This will allow supporting in a better way collaborative research and education activities that use applications requiring end-to-end quality of service and/or high bandwidth.
12. NRENs that pay for the development of additional networking infrastructure or services for special research and education projects need to maintain close contacts with the research and education community so that they can plan together the necessary budgets.

## **Recommendations for funding bodies of NRENs**

1. If one wants NRENs to develop in a cost effective and efficient way, then the ability of NRENs to plan ahead is very important. Many NRENs are only setting annual budgets, probably because the funding is not guaranteed over a period longer than one year. It would be helpful if there is a longer-term commitment to providing a stable budget, subject to other constraints, so that the budget horizon for NRENs can be extended.
2. Some NRENs are not allowed to carry forward budgets from one financial year to the next. This will cause budgetary problems with longer-term projects that get delayed or have to be re-profiled. It should be considered to allow all NRENs to carry forward their budgets from one financial year to the next. This could be done by requiring justification for carrying forward budgets, based on a business plan.

The process to decide about giving permission for carrying forward budgets needs to be streamlined, so that the decision can be made in a reasonable time period.

3. Funding bodies need to be aware that certain projects may need the development of additional networking infrastructure to support collaborative research or education. This needs to be budgeted either in the budget of the research or education project or in the NREN's budget, depending on the funding models used.
4. Funding bodies may need to provide help, or where applicable give permission, to NRENs to modify their governance structures in order to improve stakeholder representation on NREN governing boards.

## **Recommendations for the research and education community**

1. Researchers who develop research proposals that require the provision of high bandwidth or, even more importantly, dedicated wavelengths to end-user sites must liaise with the NRENs concerned to ensure that the costs of the provision of the networking infrastructure is taken into account in the budget of the research project.
2. Rather than developing plans for implementing dedicated network infrastructures in isolation from NRENs, researchers should consult with NRENs and aim to use NREN network infrastructures whenever it is possible and cost effective to do so.
3. The research community needs to work with NRENs on developing and testing self-provisioning of end-to-end services, so that research and education collaboration can be better supported using applications that require end-to-end quality of service and/or high bandwidth.

## **Recommendation for the European Commission**

1. The European Commission should continue to provide funding for GÉANT and provide further support to develop policies for the development of end-to-end services.

## **8 Conclusions**

The EARNEST study of organisation and governance issues has revealed that many and varied governance structures are being used by NRENs throughout Europe and beyond. These have served NRENs reasonably well, because most NRENs are successfully delivering services to the research and education communities in their countries. NRENs are widening their remits by taking on the development of a wider range of services than just networking services. This shows that the stakeholders of NRENs have sufficient confidence in them to allow them to take on a wider strategic role in support of research and education.

The challenge for NRENs is how to support more complex services across Europe, so that collaborative research and education can continue to flourish and expand. The delivery of end-to-end services is going to be key for several major projects, and actually increasingly for any collaborative project that needs some degree of network quality of service.

The report provides information about how NRENs are governed, organised and managed and how they make decisions about services and budgets. The development of best-practice models for governance has been started in this study, but it is the NRENs themselves that need to put in place the structures that will allow them to better plan, develop, implement and support state-of-the-art services that will be needed to support collaborative research and education throughout Europe and beyond.

NRENs are in a good position to provide crucial support to the research and education community. However, they cannot do this by acting alone. They need to increase collaboration on policy-making issues within the community of NRENs but also with the research and education community. This can be done by building on existing and successful collaborative structures such as TERENA, and by ensuring that NRENs make best use of work carried out elsewhere so that duplication of effort does not occur.

## **9 References**

EARNEST <http://www.terena.org/activities/earnest/>

GN2 <http://www.geant2.net/server/show/nav.749>  
SERENATE <http://www.serenate.org/>  
TERENA Compendium <http://www.terena.org/activities/compendium/>

## 10 Acronyms

<b>DANTE</b>	Delivery of Advanced Network Technology to Europe Ltd.
<b>EARNEST</b>	Education And Research Networking Evolution Study
<b>EU</b>	European Union
<b>GÉANT</b>	Gigabit European Academic Network Technology
<b>GN2</b>	Multi-Gigabit European Academic Network
<b>IP</b>	Internet Protocol
<b>IPv6</b>	Internet Protocol version 6
<b>ISP</b>	Internet Service Provider
<b>JRA</b>	Joint Research Activity
<b>MAN</b>	Metropolitan Area Network
<b>Mb/s</b>	Megabits per second
<b>MPLS</b>	Multi Protocol Label Switching
<b>NREN</b>	National Research and Education Network
<b>NREN</b>	National Research and Education Networking organisation
<b>PERT</b>	Performance Enhancement and Response Team
<b>QoS</b>	Quality of Service
<b>RAN</b>	Regional Area Network
<b>SA</b>	Service Activity
<b>SERENATE</b>	Study into European Research and Education Networking As Targeted by eEurope
<b>TEN-155</b>	Trans-European Network Interconnect at 155 Mb/s
<b>TEN-34</b>	Trans-European Network Interconnect at 34 Mb/s
<b>TERENA</b>	Trans-European Research and Education Networking Association
<b>VPN</b>	Virtual Private Network

## 11 Acknowledgements

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