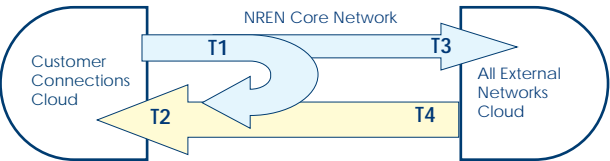


4 Traffic

In this section, a distinction is made between internal and external networking and network traffic. The figure below illustrates how these terms are being used for the purpose of the Compendium.

External traffic is all traffic to GÉANT, the Commercial Internet, Internet exchanges, etc. (made up of T3 and T4 in the diagram).



T1	all traffic from customer sites (outbound)
T2	all from customer sites (inbound)
T3	all traffic to external network clouds (outbound)
T4	all traffic to the NREN backbone (inbound)

Section 4.2 provides information about traffic volume, comparing 2002 with 2004. Section 4.3 looks at 'T3' (outgoing) traffic load and provide data from January 2002 through to January 2005. Section 4.4 provides further information about congestion. The overview section, 4.1, looks at all these and a few other aspects, provides information about NRENs from different groups of countries and tries to identify key trends.

4.1 Overview

Traffic trends

From the data that is presented in section 4.2, it is possible to quantify trends in traffic for the various NRENs. Grouping NRENs, we get the following summary of mean growth per annum, calculated using figures for 2002, 2003 and 2004. In each group of NRENs, the growth figures are weighted.

Table 4.1.1 Traffic Growth

Group of NRENs	'T3' (Outbound) growth per year		'T4' (Inbound) growth per year		'T3' growth per year	'T4' growth per year
	2002-2003	2003-2004	2002-2003	2003-2004	2002-2004	2002-2004
EU-15/EFTA ¹	56%	30%	53%	39%	42%	46%
New EU member states ²	119%	85%	119%	79%	101%	98%
EU/EFTA	67%	42%	63%	48%	54%	56%
Other ³	235%	17%	168%	40%	98%	94%
ALL	74%	40%	69%	47%	56%	58%

¹ Based on data from 11 out of 15 NRENs

² Based on data from 8 out of 11 NRENs

³ Based on data from 8 NRENs (AMREJ, CARNet, GRENA, MARWAN, RBNNet/RUNNet, RENAM, ULAKBIM, and URAN)

The distinction between the results for the different groups is significant. Growth rates in the new EU member states and in non-EU/EFTA countries are clearly higher than those in the 'old' EU member states.

NRENs were also asked to report the volumes of inbound and outbound traffic during the month of January 2005. The results here, while only a small and probably not entirely representative sample of annual traffic, seem to confirm the finding that the growth rate is slowing down.

It seems that in the EU, traffic is now determined more by (changes in) user demand, rather than by network capacity limitations. In the 'Other' group of countries, this is probably not yet the case. Thus, the high growth from 2002 to 2003 can be explained by important bandwidth upgrades for CARNet and RBNNet/RUNNet in that period.

Even for the EU/EFTA countries, it is unclear if the trend towards lower growth will persist – new applications, for example in the Grids area, may change the picture. However, in that case growth will be driven by demand, rather than by changes in the network capacities.

It is important to note that traffic growth is not a natural phenomenon, but can be and is being influenced by the policies both of NRENs and of their users. One noteworthy example in this context is that of FUNET (Finland), where traffic decreased more than 10% between 2003 and 2004. FUNET staff offered the following explanation for this: *“Last year was really exceptional for Funet. Our traffic decreased first time in our 20-year history. The reason is that some universities started to filter traffic that they suspect to include illegal copyrighted material. Another motivation was our charging policy, which punishes heavy-users.”* There may be other factors at work here as well, such as the adoption of anti-spam measures.

Traffic: outbound versus inbound

The figures on traffic, as given in section 4.2 have been used to provide an indication of the asymmetry of the data flows. By comparing inbound with outbound traffic, we can assign an NREN to one of the categories ‘net importer’, ‘balanced’ or ‘net exporter’. This is somewhat analogous to the concept of trade balance as used in international macro-economics. If the difference between inbound and outbound traffic is within 5% of the lower of these, we assign the NREN to the ‘balanced’ category.

The results from the 2002 survey, which give traffic figures for the whole of 2001, are as follows:

Table 4.1.2 Aggregated traffic import and export, 2002⁴

Group of NRENs	Importers	Balanced	Exporters
EU-15/EFTA	5	2	5
New EU member states	6	1	2
Other	6	0	1
ALL	17	3	8

The results from the current survey give traffic figures for calendar year 2004 and produce the following summary:

⁴ Based on the Compendium 2003, chapter 4.1

Table 4.1.3 Aggregated traffic import and export, 2004⁵

Group of NRENs	Importers	Balanced	Exporters
EU-15/EFTA	4	1	9
New EU member states	1	1	7
Other	16	1	2
ALL	21	3	18

Our findings are that the longer-established set of NRENs from the EU and EFTA countries are mostly net exporters of data, while the other NRENs are net importers. There seems to be a dynamic at work here, as the pattern has changed over time. Three years previously, there was a more uniform distribution of importers and exporters among the EU/EFTA countries. The new EU member states, tended to have importer NRENs; only two out of nine were exporters. So the trend has been towards more net export of data.

NRENs in the other countries, however, do not yet seem to follow this trend. In 2001, only one out of seven was a net exporter. In 2004, the proportion was more or less the same, at 2 NRENs out of 17.

One reason for this difference between the two populations is probably the fact that the EU/EFTA NRENs have been in operation

⁵ See section 4.2 for country-by-country data

for longer than the other NRENs, indeed for longer than most commercial networks. They are thus established as well-known repositories of educational and research resources, as well as hosting many distributed mirror sites of popular archives.

Another factor is the reality that established NRENs include institutions such as universities, research institutes and libraries with valuable and often unique resources. Many of these are now online and are much sought after by Internet users.

In the case of many of the emerging NRENs, there are factors that make access difficult. These include heavily used and often saturated external links, which inhibits access from the rest of the world, and also the fact that online resources are often confined to the native language.

Traffic with the general Internet

The level of NREN traffic **with the general Internet**, as distinct from inter-NREN traffic, is quite uniformly high. The table shows this as between groupings of NRENs:

Table 4.1.4 Traffic with general Internet as % of total 'T4' traffic ⁶

Group of NRENs	Traffic with general Internet as % of total 'T4' traffic
EU-15/EFTA	76%
New EU member states	82%
EU/EFTA	78%
Other	79%

Note that the proportion has been calculated for each NREN, and a simple average has been derived for each grouping.

For the EU/EFTA NRENs, the traffic to the general Internet exceeds traffic from the general Internet (80% of total versus 76%). This tallies with the findings on asymmetry of traffic above.

⁶ Country-by country data are in Appendix 1

Congestion

We have asked NRENs to give a rough estimate of the percentage of institutions connected to their network that experience none or little, some or moderate, or serious congestion at the different network levels. Table 4.1.5 shows the average percentage given by NRENs of institutions experiencing serious congestion⁷.

⁷ Section 4.4 shows the country-by-country data.

Table 4.1.5 Serious congestion

Group of NRENs	Campus LAN	MAN or regional	Access network	NREN backbone	External connections
EU-15/EFTA	6%	3%	6%	0%	0%
New EU member states	1%	2%	17%	2%	0.5%
EU/EFTA	4%	2%	10%	1%	0.2%
Other	0.3%	6%	7%	10%	25%

In EU/EFTA countries, NRENs report relatively little congestion in those parts of the network within their domain of responsibility. Uniformly, they see no serious congestion on external circuits, virtually none in their core networks and little in the MAN or regional network. Any serious congestion, they report, is largely confined to Access networks or to the campus LANs of connected institutions.

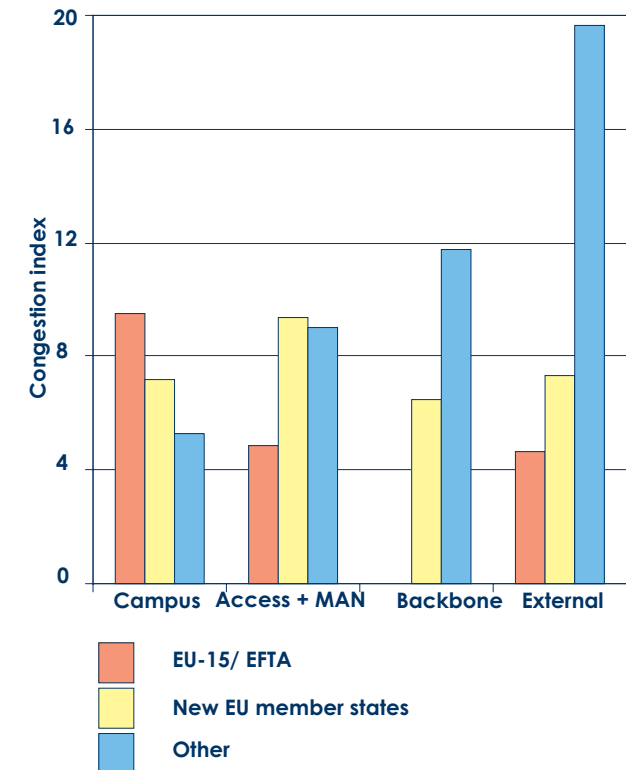
The 'Other' NRENs report most congestion is clearly on external connections. In those countries, the restrictions imposed by low-capacity external connections mean that constraints at the campus and other levels are less apparent. It is to be expected that these constraints will show up as soon as the problems at other levels have been solved.

To derive a single metric for the level of congestion in each network element from the subjective levels reported by NRENs, we use the following formula:

$$\text{Congestion Index} = 0.05 \cdot \text{little} + 0.2 \cdot \text{some} + 0.5 \cdot \text{serious}$$

We have combined the data for MANs and for Access Networks. Applied to all the reported values, this formula provides a single uniform metric. We believe that this is a better metric than looking only at serious congestion as in table 4.1.5 above, because it weighs all levels of congestion. The results confirm the analysis given above.

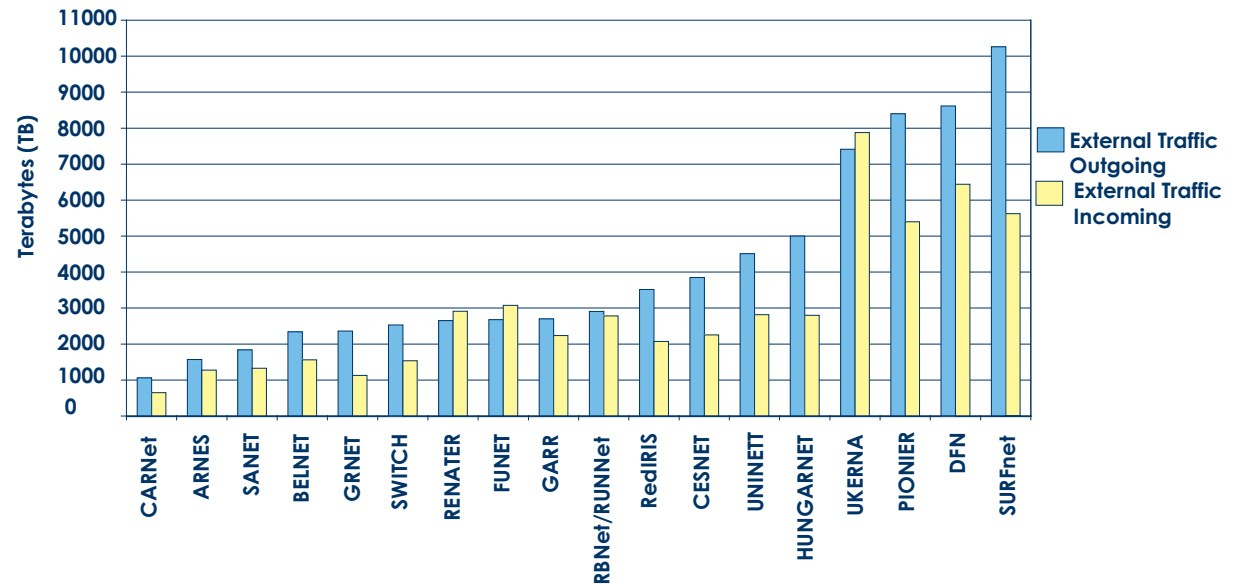
Graph 4.1.6 Congestion index



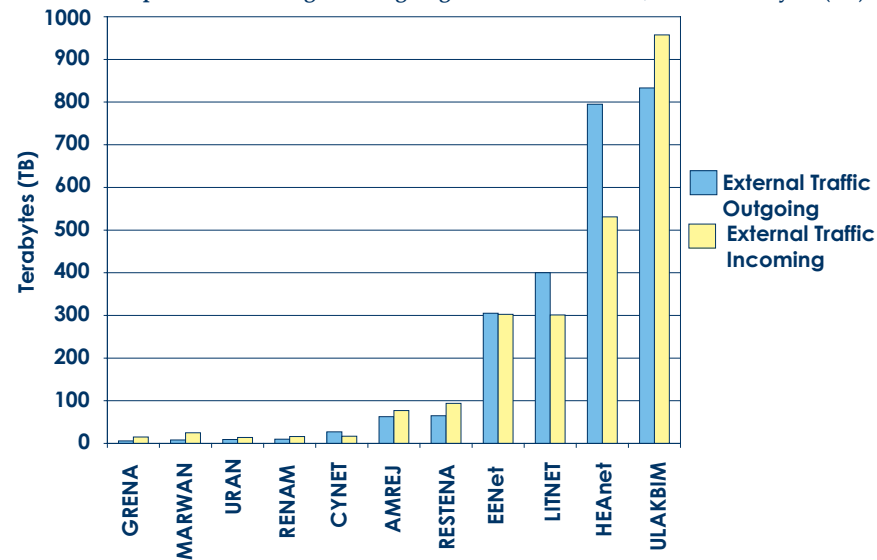
4.2 Incoming and outgoing traffic, 2002 and 2004

For presentation purposes, two graphs are presented: graph 4.2.1 shows the information for those NRENs with external traffic above 1000 Terabytes; graph 4.2.2 gives the same information for NRENs with external traffic below 1000 Terabytes.

Graph 4.2.1 Incoming and outgoing external traffic 2004, > 1000 Terabytes (TB)



Graph 4.2.2 Incoming and outgoing external traffic 2004, < 1000 Terabytes (TB)



4.3 Traffic load

Measuring the traffic load on the network is one potential way of measuring congestion and thus also an indicator of the extent in which customer demand for bandwidth is being satisfied. For the following graphs, the traffic load has been calculated by dividing the actual traffic in January of each year by the theoretical maximum capacity of all external links of an NREN in that month. The theoretical maximum capacity is calculated by multiplying the total capacity of the external links in Mb/s by the number of seconds in January.

In practise, it is impossible to reach the theoretical maximum capacity and therefore it is impossible to reach a 100% traffic load. This is because traffic is typically not evenly distributed over the hours in a day and over the days of the week.

For an indication of sustained peak usage, the load figures in the table should typically be multiplied by three. In other words, users will certainly experience serious congestion if the traffic load is above 33%; even at lower loads, users may sometimes experience congestion in network performance.

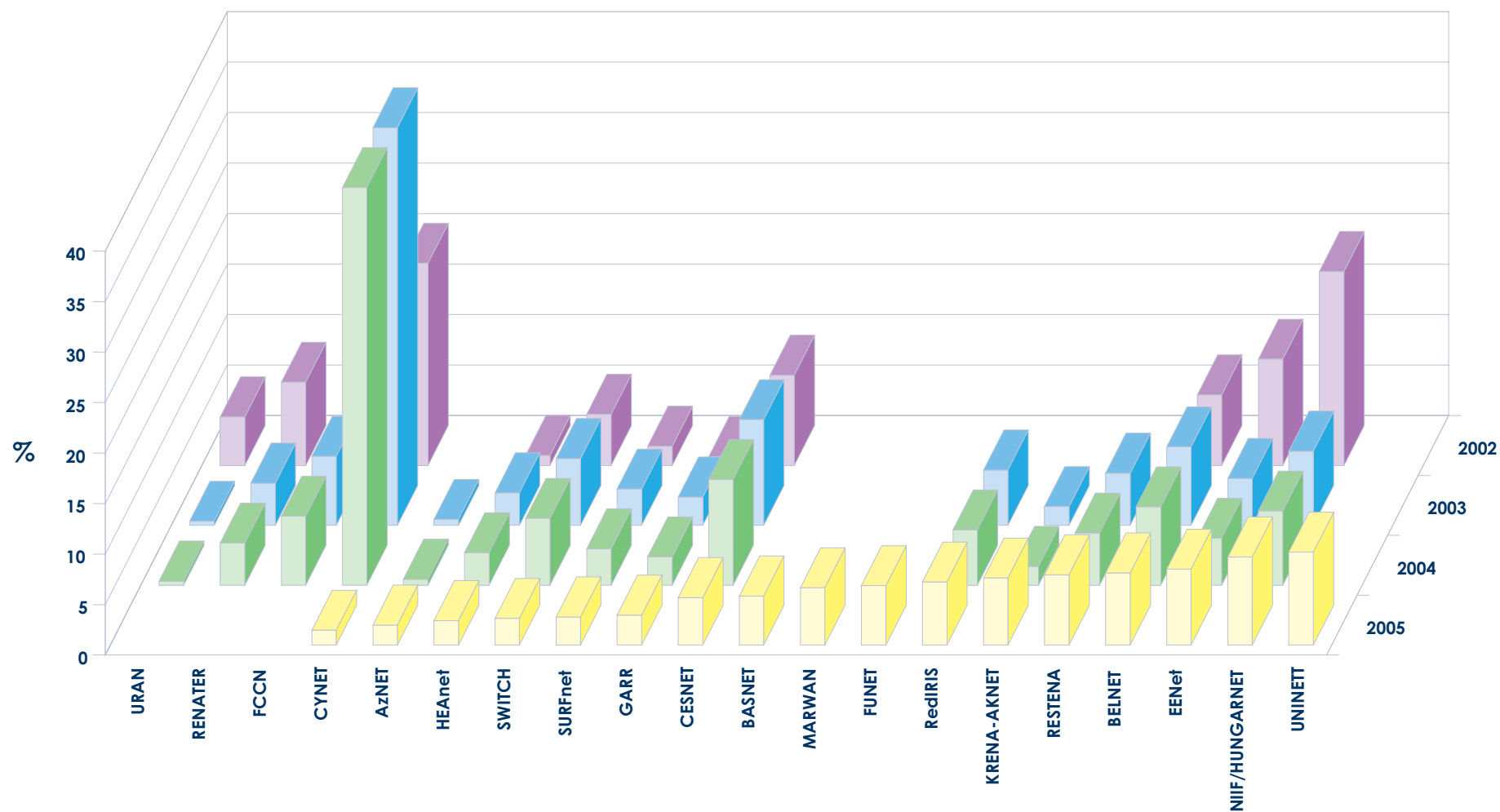
In addition, traffic is not distributed evenly over all the external links of an NREN, because not all links offer the same possibilities. Thus,

it could be that the overall traffic load as computed here is low but that certain links are still overloaded.

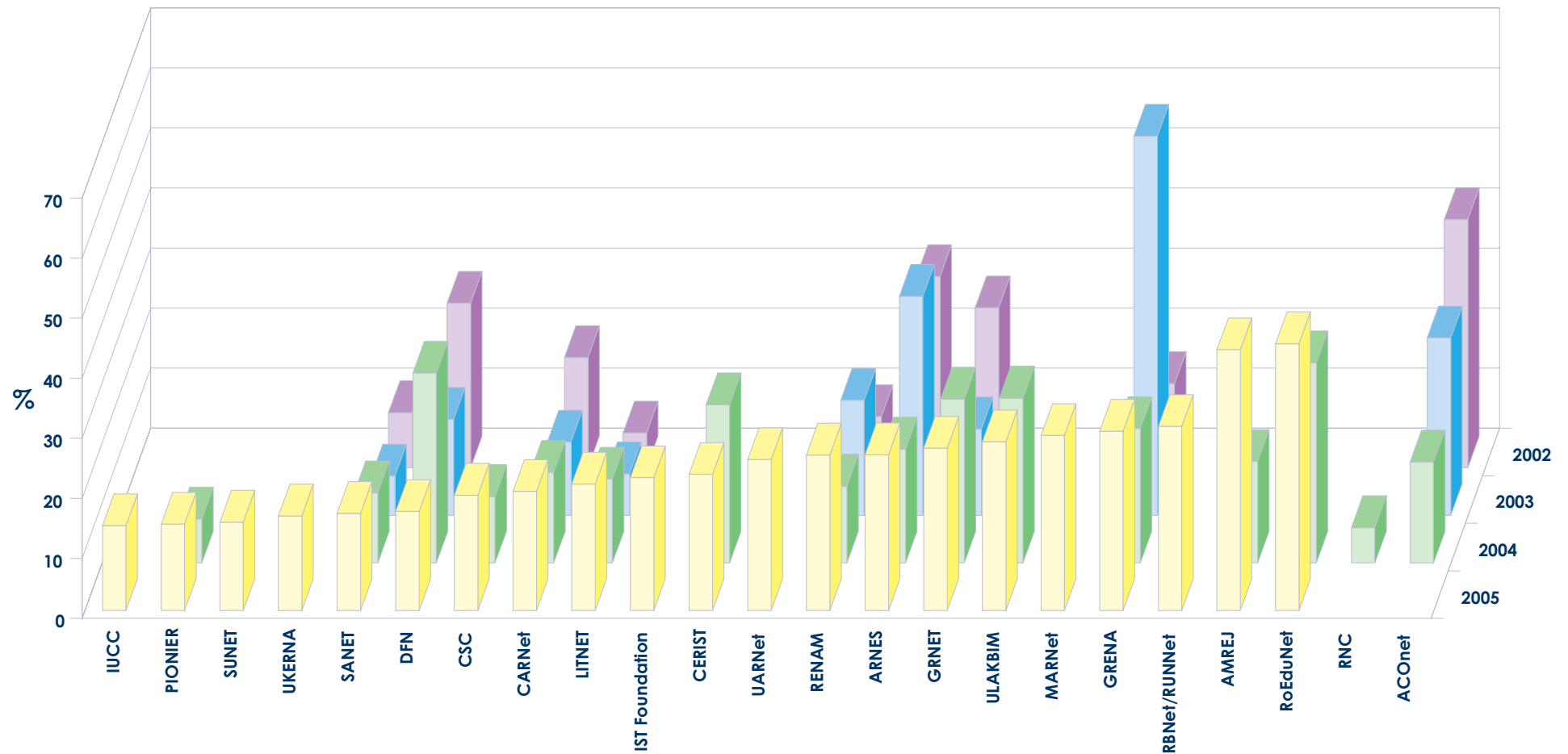
The graphs illustrate that NRENs need to upgrade their external links from time to time in order to keep up with increasing demand.

The fall in the traffic load for CYNET between 2004 and 2005 is largely due to the upgrade of the GÉANT connection from 34 Mb/s to 155 Mb/s and the addition of a 45 Mb/s EUMEDCONNECT link. Likewise, in January 2004 DFN's total external links were 6.5 Gb/s. In January, 2005 that figure was 17 Gb/s, more than double the previous capacity. In the same period, traffic had gone up by 37%.

Graph 4.3.1. Average outgoing traffic load January 2002 - 2005, NRENs with < 10% traffic load (as percentage of the theoretical maximum capacity) in January, 2005



Graph 4.3.2 Average outgoing traffic load January 2002 – January 2005, NRENs with >10% traffic load (as percentage of the theoretical maximum capacity) in January 2005.



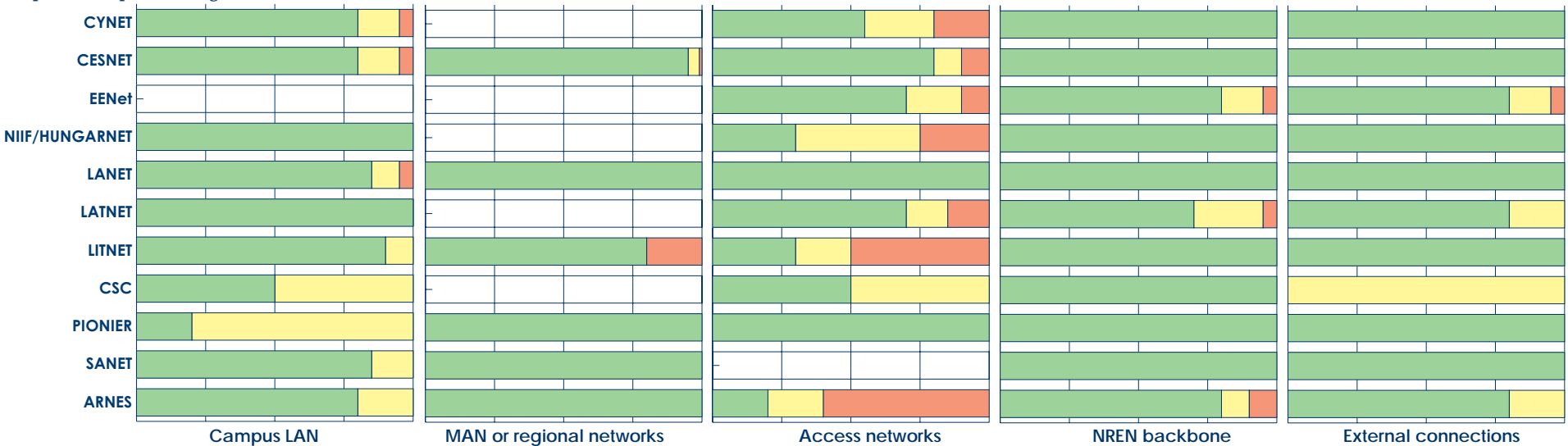
4.4 Congestion

NRENs were asked to give an estimate of where there is congestion (if any) in their networks and of the percentage of client institutions that are affected by congestion at that level. Note that not all NRENs gave an answer for all of the network levels and note also that not all levels exist in all networks (see also the “Focus Study on Funding, Management and Operation of European Research Networks analysed by network hierarchy” by John Martin and Baiba Kaškina, TERENA, May 2004).

Graph 4.4.1 Reported Congestion: EU-15 and EFTA countries



Graph 4.4.1 Reported Congestion: New EU countries



Graph 4.4.1 Reported Congestion: Other countries

