2 Internet for R&D

2.1 Domain description

The diffusion of new information and communication technologies has affected society in general. The relationship between the research and development (R&D) system and the Internet must be considered as particularly important: R&D is an important source of inventions, technical knowledge and skills and is therefore a major motor of economic growth; and there can be no doubt that multiple feedbacks between the Internet and R&D are at work: the Internet has facilitated the access to information that would otherwise be difficult to obtain; E-mail has made asynchronous communication less formal and more frequent; R&D collaboration over large distances has been enhanced, as it has become easier to communicate and transmit information even if it is "large" and "bulky".

There are essentially three different perspectives to look on the relationship between the Net and R&D:

- **Internet-related ICT infrastructure for R&D:** This approach investigates the extent to which elements of the research infrastructure (research networks, on-line information sources, tools for computer-mediated communication, grid technologies, personnel input) are used and what impact they have on R&D.
- **Integration of new network technologies into research activities:** This view on the Internet could be labelled process-oriented, as it assesses how the Net has changed and more often than not enriched R&D processes (e.g. data collection or the dissemination of results).
- **Computer networks and R&D collaborations:** By reducing communication costs significantly, the Internet has created a strong incentive to substitute communication for other inputs into R&D. Hence, the growth of collaborative research has been supported and new ICT-based forms of collaboration have appeared (collaboratories, virtual teams).

2.2 Description of major problems and gaps in statistical coverage

Though the trends described above are well known and their importance is not disputed, there have not been any initiatives to benchmark national research systems on their way to the Information Society.[1] The SIBIS analysis on the Internet for R&D closes that gap and develops indicators which are appropriate for measuring the extent to which the Internet has been integrated into R&D and the effects of this. For this purpose, a review of scientific literature, statistical documents and policy documents was carried out in 2001. The main outcome of this is an indicator system which is appropriate for benchmarking national R&D systems and which will be implemented (and improved) in pilot data collections.

This indicator system is even more necessary as the European science and technology (S&T) policy increasingly develops an orientation towards ICT. The common thread of many goals and measures described in the Commission's documents on the European Research Area (ERA) is the creation of multi-layered networks within the R&D system as well as across its boundaries, including other socio-economic areas and political institutions. These networks

[1] The conclusion of a 1999 European Science Foundation conference still applies: "*There is a pressing need to increase efforts and resources to undertake in-depth empirical studies on the innovative uses of Internet in science and to carry out European-wide surveys on this issue. Such studies are the only way to generate a sufficient amount of data and information necessary to evaluate the impact of new, high capacity electronic communication facilities upon the organization, distribution and conduct of collaboration on fundamental research problems.*" Foray, D. (1999): Building the Virtual 'House of Salomon': Digital collaboration technologies, the organisation of scientific work and the economics of knowledge access. Report of the ESF-IIASA-NSF Workshop - 3 to 5 December 1999 - at the International Institute for Applied System Analysis, Laxenburg, Austria, p. 9. (http://www.esf.org/policy/pdf/iiasa.pdf)

have to be paralleled by modern and high-capacity communication networks. The European Commission acknowledges this fact and consequently promotes within its *e*Europe initiative the enhancement of Research and Education Networks for data transmission and the development of novel collaboration-oriented computer systems ("Grids"). The ERA communications cover the usage side of ICT and encourage the development and implementation of further computer-based tools for science, the training of researchers on the possibilities of ICT and the use of computer networks to connect the best researchers in Europe to form "virtual centres of excellence". Many European countries have developed new concepts of research policy over the last three years and some, *expressis verbis* Finland and the U.K. [2], expect ICT to contribute to the development of science.

2.3 New indicators overview

Whereas only few existing indicators could be found in the literature, a number of concepts and approaches were identified which are helpful to guide and direct the pilot work of constructing an indicator system on the Internet usage within R&D. Such an indicator system could be infinitely large and in order to make it feasible the useful indicators have to be differentiated from the less useful and useless. Besides measurement-related criteria as validity, reliability, direction, sensitivity to differences and accessibility, the range of applicability was an important criteria to chose an indicator. As the aim of the SIBIS project is to produce indicators which are suitable for reflecting the situation in the entire national research systems across the European Union and Switzerland we abstracted as much as possible from the specifics of an individual academic discipline. However, this does not imply that the indicator system ignores differences among the academic disciplines. But it will try to make them visible by assessing comparable indicators.

After discussing the different possibilities for measuring the amount of Internet use and the impact on R&D and selecting indicators which would not meet the required criteria the following list of indicators was assembled (see table). The largest number of indicators relates to the Internet-related ICT infrastructure for research activities, the other two sub-topics are covered to a smaller extent. However, most indicators produce more than one item of information; e.g. an indicator on the effects of information retrieval from and via the Internet includes as response categories: time budgets, contacts, productivity and quality of work results. Hence, the number of indicators is not really representative for the amount of information gained.

Except from two indicators on specialised computer staff, the indicators are not suitable to be tested in the SIBIS surveys: the GPS would need a heavy overrepresentation of researchers, the DMS would have to be targeted specifically to the management responsible for R&D, such as the heads of R&D units. This was not possible considering the budgetary constraints of the project. As an alternative the majority of indicators will be tested by means of a domain-specific survey among researchers which will be carried out as part of SIBIS at the end of 2002. Specific indicators for research networks can be taken from the Trans-European Research and Education Networking Association (TERENA) second survey of their member networks, which was carried out in January/February 2002.

[2] The Finnish Government elaborated "A National Strategy for 2000-2004. Education, training and research in the Information Society" which deals with ICT and the information society as research objects and also covers the multiple opportunities of employing ICT for scientific research. The British Government communicated its science and innovation policy in a White Paper on "Excellence and Opportunity: a science and innovation policy for the 21st century" together with an implementation plan.

Thematic Domain	Sub-domain	Selected new level 1 indicators	Piloting in SIBIS
Infrastructure	Expenditure on ICT infrastructure	R&D expenditure on ICT (total)	—
		R&D expenditure on different types of ICT	—
	Research Networks (RN)	Core usable backbone capacity on a national RN	Data from TERENA
		Congestion on the RN	Data from TERENA
		Budget size of a national RN	Data from TERENA
	Electronic library services	Number of titles in digital collections	—
		Staff providing electronic library services	—
	Researchers' web presentations	Information displayed on a researcher's web page	SIBIS survey of researchers
		Effects of researchers' web page(s) (on time budget, communication, contacts and recognition)	SIBIS survey of researchers
	E-mail	E-mail communication for R&D purposes	SIBIS survey of researchers
		Effects of e-mail use for R&D purposes (on information, contacts, collaborations, productivity, quality of work)	SIBIS survey of researchers
	Computer skills of R&D personnel	Computer skills of R&D personnel	SIBIS survey of researchers
		Effects of computer skills on R&D	SIBIS survey of researchers
	Specialised computer staff	Computer staff providing services to R&D	SIBIS DMS
		Unfilled vacancies in private businesses for computer staff providing services to R&D	SIBIS DMS
Research processes	Digital library and peer site usage	Frequency of information retrieval from electronic sources	SIBIS survey of researchers
		Documents/items from electronic sources	SIBIS survey of researchers
	Software usage	Frequency of software usage	SIBIS survey of researchers
	Information retrieval	Effects of information retrieval from and via the Internet (on time budgets, productivity, quality of work, contacts)	SIBIS survey of researchers
	E-publishing	Amount of work published in electronic media	SIBIS survey of researchers
		Impact of publications in electronic media (on size of readership, time to publication)	SIBIS survey of researchers
	Quality control	Review activities for e-journals	SIBIS survey of researchers
R&D collaboration		Participation in long-distance R&D collaborations	SIBIS survey of researchers
		Impact of computer networks on R&D collaborations	SIBIS survey of researchers

Source: FHSO compilation