Innovation considered

ICT innovation as practised by SURFnet

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1. Introduction

This essay is about how to tackle innovation – a topic of great interest at the moment. Indeed, innovation is one of the key concerns of the Dutch Government, which has set up an Innovation Platform chaired by the prime minister himself. That in itself shows how important innovation has become as a political issue in recent years. The policy agenda of the European Union has contributed to this growing interest, with the Lisbon targets serving as a yardstick for the Netherlands' innovation policy. What is less clear, however, is how the Netherlands is to achieve those targets. It is precisely on that point that we would like to share the lessons learned by SURFnet and to make a few suggestions.

What in fact is innovation? In the business world, it is often defined as an *accepted* invention[1]. Its acceptance must be demonstrated by the value that a company creates with it. That is the definition of innovation that we will apply here. The popular image often associates innovation with industrial application of the results of scientific research. According to that view, innovation is preceded by scientific research, and mainly comes down to the international commercial success of "nerdy" Dutch ingenuity. That link between innovation and research is also made in policy. Policy-makers have a mechanistic image of a production chain, with scientific knowledge going in at one end and successful products emerging at the other. According to this view, the Netherlands is said to be having trouble with innovation because the results of publicly financed research are not being transferred to businesses[2]. Policy measures like the BSIK scheme or the setting up of the Telematica Institute and ICTRegie[3] are supposed to improve this situation.

Without wanting to underestimate the importance of publicly financed research as a prerequisite for an innovative climate, we do not believe that the transfer of research results is in fact one of the distinguishing properties of innovation. After all, an invention need not be based on new research results; it can just as easily be the outcome of recombining existing elements. The Voice over Internet Protocol (VoIP) is a good example of an innovation that combines existing elements: it is not a new service or a new network, but a new combination

1 OFCOM, the telecom regulator in the United Kingdom, uses the following definition: Innovation is the successful exploitation of new ideas.

2 Dutch Ministry of Economic Affairs, In actie voor innovatie, de Nederlandse kenniseconomie naar de Europese top, http://www.minez.nl/

3 The BSIK scheme was set up under the third investment incentive for the knowledge infrastructure (ICES/KIS-3) and subsidised from the Economic Structure Enhancement Fund (FES). The Telematica Institute has been renamed and is now known as the Dutch Institute for Networked Innovation or Novay. ICTRegie is a platform established by the Dutch Government to help boost the country's knowledge infrastructure and maximise its benefits for society and the economy.

of an existing service and an existing network within a familiar concept. Nor does the accepted invention need to be technical in nature. The most successful innovator on the mobile telephony market was the Italian who invented the *prepaid card* in 1996. A crucial bit of knowledge that led to this invention was the man's sales report, which showed him that he would probably be unable to meet his sales quota before Christmas. The essential knowledge that makes such inventions successful is of a different nature than the results of scientific research. It tells us how to implement VoIP or *prepaid cards* efficiently and on a commercially relevant scale – preferably here rather than elsewhere, so that we can get a head start in developing applications and services. The knowledge needed for this is mainly technical and operational in nature – a knowledge of applications, of purchasing, of implementation, of utilisation, and of making "new" inventions commercially viable. That knowledge focuses on getting the invention accepted. It is always essential to innovation, it is usually not generated in the laboratory, and it cannot simply be acquired from outside an organisation. The situation is otherwise when it comes to the technical and scientific knowledge used to achieve innovation. That knowledge may well be the result of focused scientific research, but it can also be purchased directly, "packaged" in industrial prototypes, new industrial products or services. In terms of innovation, it is not essential for scientific knowledge to be generated in the Netherlands. Quality is the only criterion for input of this kind.

This essay is about taking a practical approach to successful innovation, one that is not primarily based on Dutch knowledge input but that focuses mainly on ensuring the key feature of innovation: acceptance in the Netherlands of new inventions. We illustrate this by describing the aims and set-up of SURFnet and the lessons it has learned in its GigaPort projects[4], in which new products and new combinations gained more rapid acceptance in the Netherlands than elsewhere.

GigaPort sets an example of successful innovation. Its network facilities for the Dutch education and research sector have for years been considered[5] groundbreaking within the international community, and are among the most advanced in the world. They are often used as a model for developments within the European Union.[6] The Netherlands also plays a leading role in creating international connectivity[7] for higher education and research, and Amsterdam has become the most important node for international lightpaths in Europe. The concepts that SURFnet is trialling within the context of GigaPort are gaining growing

4 The first GigaPort project (1998-2003) consisted of two separate parts, GigaPort Network (carried out by SURFnet) and GigaPort Applications (carried out by the Telematica Institute). This essay does not cover GigaPort Applications. By "GigaPort", we mean GigaPort Network. The second and current GigaPort project is GigaPort Next Generation Network. For the sake of clarity, we will refer in this essay to GigaPort, unless we mean only one of the two projects.

5 http://www.terena.nl/activities/compendium/2005/Chapter%203.pdf

6 The networks concerned include X-WIN in Germany, SuperJANET5 in the United Kingdom and Europe's GÉANT2, http://www.dfn.de/content/fileadmin/5Presse/DFNMitteilungen/heft68.pdf, http://www.ja.net/sj5/index.html and http://www.geant2.net/

7 Along with the United States, Russia, China, Korea and Canada, the Netherlands participates in the worldwide GLORIAD network, http://www.gloriad.org/gloriad/index.html

recognition among heavyweight users of telecommunications in the Netherlands.

The GigaPort projects are subsidised through the Economic Structure Enhancement Fund (FES), and the outcome of the first such project was given high marks. Not only had the project achieved its direct objectives, but it had also had its intended effects for society. It is still too early to evaluate the current GigaPort project, but the international accolades[8] that it is already gaining are certainly a good sign.

We were happy to comply with the request of the Directorate-General for Energy and Telecom (DGET) to produce an essay describing what we think is behind this success and what can be learned from GigaPort for innovation policy and innovation-driven projects in the Netherlands. We believe that much of what has been learned can be generalised and applied to the government's innovation policy, or in any event to the policy that concerns itself with the application of new information and communication technology (ICT). But there are other lessons to be learned, for example when government is defining its policy on electronic communication in the broader sense, particularly how to facilitate market-driven innovation in the Dutch telecommunications infrastructure by involving user organisations such as SURFnet and demand-driven projects such as GigaPort. We will not, however, discuss that issue in detail in our conclusions.

We begin by briefly describing GigaPort and SURFnet, which proposed GigaPort and is responsible for it. We describe the organisation as offering a model of the kind of administrative system that should be put in place whenever ICT is utilised in a social sector. We also look at the position that the project occupies in the innovation cycle and its role as a test factory – somewhere between experiment and "fully operational" – where we perform quantitative analyses of the usefulness of new products and services. We also look at a number of features of an ICT test factory: its position within the ICT market[9] and the international context in which it is rooted.

8 In his address at the official launch of the SURFnet6 network, the chairman of the Steering Committee, Dr Reinder van Duinen, reported that the Committee's international scientific advisory committee had given the plans a positive assessment.

9 The period after 1997 is the best reference for this, because it was only then that the PTT was privatised, the Dutch telecommunications market liberalised, and credible competitors to KPN (the PTT's successor in the telecom market) began to present themselves.

2. Innovation at SURFnet and GigaPort

SURFnet bv was founded in 1987 and is one of the operating companies of Stichting SURF, the higher education and public/private research partnership organisation for network services and ICT.

SURFnet connects the networks of approximately 180 higher education and research organisations with one another and with the worldwide Internet. These organisations are research universities, universities of applied sciences, regional education centres, research institutes, industrial research laboratories, science libraries, and hospitals with research capabilities. The students and staff at these organisations, who number approximately 750,000 in all, make almost daily use of the network. They are able to access SURFnet from their workplace and, increasingly, from their home, and are therefore able to consult information and communicate with other network users regardless of their location, anywhere in the world. Thanks to ongoing innovation, SURFnet's users have access to one of the fastest and most advanced networks on earth, offering high-speed international connections. In addition to speed, network security and reliability are top priorities.

SURFnet works closely with national and international organisations on research networks. SURFnet not only wishes to be the leader when it comes to Internet infrastructure, but it also keeps a close eye on trends in new Internet applications. New services are regularly added to its package, which is tailored to suit its target group.

SURF and SURFnet are the result of the Dutch government's 1984 Information Science Incentive Plan. The Education Minister at that time, Wim Deetman, challenged the universities and research institutions to set up a partnership focusing on ICT in general and computer networks in particular. At the time, the Netherlands was lagging far behind other European countries in that respect, for example the Scandinavian countries, Germany and the United Kingdom. Its poor performance then has been now been turned around into a leading position internationally.

In order to achieve this turn-around, SURFnet needed more than the network services that the state-run telecom, the PTT, offered on the commercial market. International experts have estimated that the communication requirements of higher education and research anticipate those of the markets in which operators are obliged to make their money – including the market for *corporate networks* – by up to about five years. Developments in the United States made it clear by the mid-eighties that it would only be possible to develop an advanced network for higher education and research if all the users joined forces in a single organisation whose purpose was to make the telecom industry's latest concepts, products and services available to its target group. SURFnet would therefore have to work as closely

as possible with the PTT[10] and with the telecom industry. In other words, from the very start SURFnet was engaged in innovation as we defined it earlier: operationalising new inventions from the telecom industry and, later, from the international world of the Internet.

Electronic networks are basically ICT applications. They are made up of ICT building blocks. In electronic networks, innovation is the result of the ongoing and rapid improvement of the building blocks that process, transport and store digital information. The basic premise is to keep coming up with new concepts that will enable electronic networks to transport data more efficiently using new and ever-faster building blocks. The relevant concepts and their related functions and standards are referred to as the "architecture" of a network. But architectures too become obsolete, in the sense that it becomes impossible to keep inserting ever-faster or ever-cheaper building blocks into an existing architecture. After four or five years, it becomes clear that these new building blocks will be more technically and economically valuable if they are used in an entirely new network architecture designed specifically to accommodate them. Figure 1 shows how a steady stream of new concepts and standards has been introduced into successive "SURFnets".

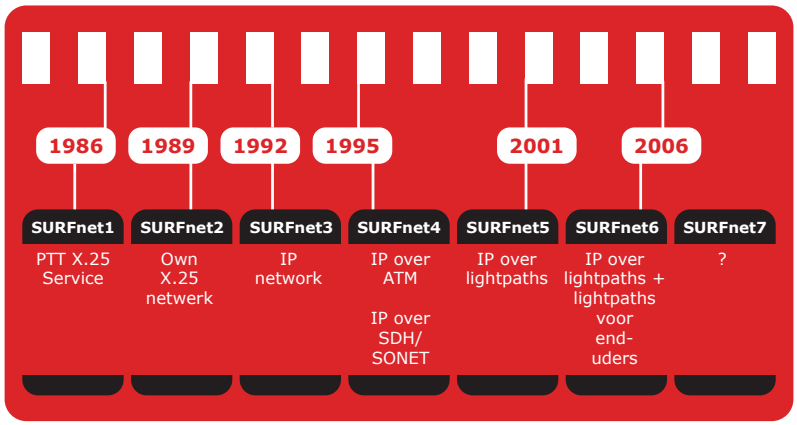

Fig. 1: Continuous conceptual innovation at SURFnet.

That is why network innovation at SURFnet takes place in a succession of network generations, each with its own new, as-yet untested architecture, intended to make the most economical use of the latest building blocks. SURFnet is now in the midst of its sixth network generation, SURFnet6. Figure 2 illustrates this dynamic progression by showing how network transport capacity has increased over the course of twenty years.

10 NB: At that point, PTT Telecom was the only organisation permitted to construct and operate telecommunication facilities in the Netherlands.

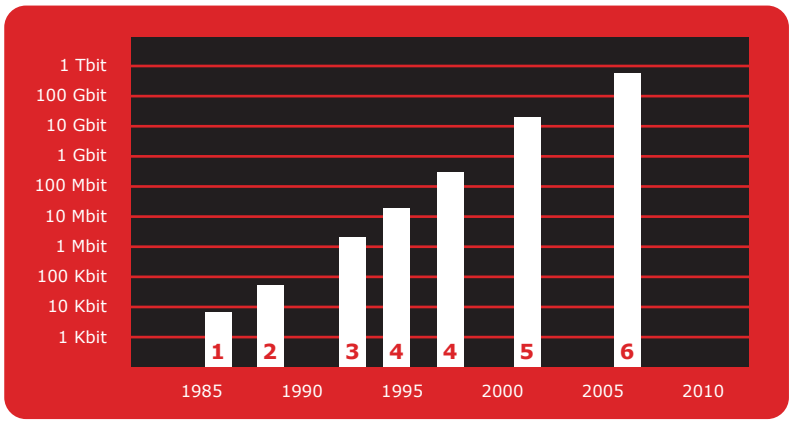

Fig. 2: Transport capacity of successive generations of SURFnet networks. The exponential growth is shown on a logarithmic scale from 9.6 Kbit/s for SURFnet1 to 720 Gbit/s for SURFnet6.

A new network architecture should naturally give users continuity with respect to utilisation; on the other hand, technically and economically obsolete utilisation should not prevent network innovation. Such utilisation can be regarded as the "legacy" of old networks, and it is indeed referred to as such in the jargon. SURFnet is constantly pressuring its users to terminate legacy utilisation, because the task of building *legacy functionality* into a new network is a complex affair and impedes innovation.[11]

Needless to say, SURFnet's operational and innovation targets are sometimes at odds with each other. There is always tension between exploitation and innovation, but everyone at SURFnet knows that service ultimately comes first. There is no room at SURFnet for "innovation" without the possibility of such innovation actually being used.

As time went on, SURFnet began to attract attention beyond its direct circle of users and foreign networks. Suppliers became increasingly interested in SURFnet for strategic reasons, and there was growing recognition of its importance to overall market trends in the Netherlands. In 1998, this growing recognition resulted in the Directorate-General for Innovation (part of the Ministry of Economic Affairs)[12] actively supporting GigaPort, the project that produced SURFnet5 and SURFnet6.

11 Compared with many foreign research networks, SURFnet is very strict about its "keep-it-simple" policy.
12 Telecommunications was then the policy domain of the Dutch Ministry of Transport, Public Works and Water Management.

3. The organisation and the innovation model

3.1 SURFnet's innovation model

To users, networks are infrastructure, but to suppliers of ICT products, networks are applications. Suppliers of network services find themselves caught between the two – between the ICT industry and the network's users. These may be users in a particular sector, such as higher education and research in the case of SURFnet. Network innovation can therefore be the result of two contrary movements: "*demand pull*" and "*supply push*". Both movements have their pros and cons, and any organisational model must combine them in a way that does justice to both.

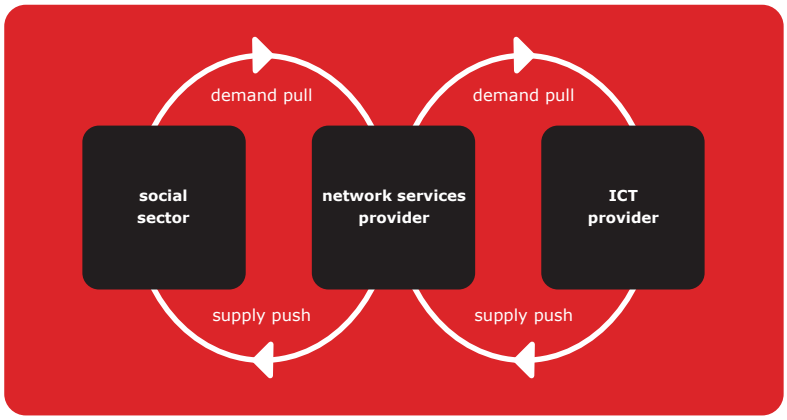

Fig. 3: Network innovation can be driven by the demand for ICT products and the supply of those products (*demand pull* vs. *supply push*).

SURFnet has always chosen a position on the demand side of the ICT market; its role is to consolidate the demand for advanced network services. It therefore bases its approach to the market on the *demand pull* of the entire target group, and purchases as much as possible from businesses, in accordance with relevant European legislation. We will look at this in greater detail in section 5. In addition, SURFnet encourages the use of the latest ICT by individual members of its target group, an example of *supply push*. Combining the two methods, *demand pull* and *supply push*, makes special demands on the administrative system that SURFnet agrees with the sector.

In strategic terms, SURFnet plays the role of a target group network, and it is therefore the property of its users. It is a task-driven[13] organisation in the higher education and research sector. A task-driven organisation carries out a task on the instructions of a policy-making body. That policy-making body, Stichting SURF, is responsible for the continuity of the task-

13 Dr M. Simon, De Strategische Functie Typologie, Kluwer Bedrijfswetenschappen, 1989.

driven organisation, while the task-driven organisation is responsible for the quality of the task it performs. The relationship between SURFnet and its users is twofold: there is an administrative relationship with the collective, and a self-imposed supplier relationship with the separate members of the target group. The two relationships are kept strictly separate.

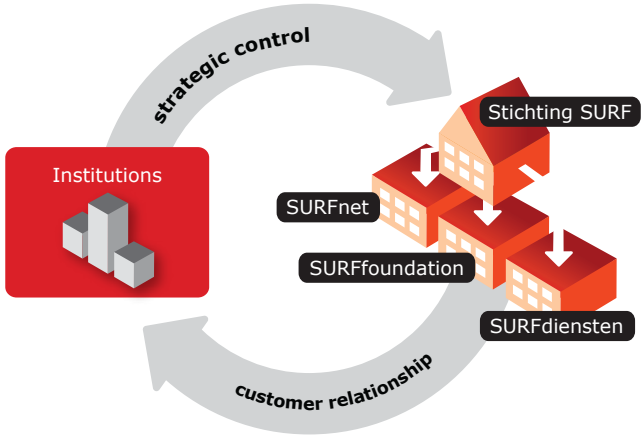

Fig. 4: The twofold relationship between SURFnet and its connected institutions.[14]

The administrative relationship focuses on strategy. While the target group does have the final say, it gives SURFnet's management the discretionary power and responsibility to turn the agreed strategy into an operational policy and to implement that policy for the members of the target group. The administrative relationship exists because SURFnet is a legal entity, a private limited liability company (in Dutch, a "BV"). SURF is the sole shareholder in that company and appoints its Supervisory Board [Raad van Commissarissen].

One key advantage of giving the users primacy within the administrative system is that innovation is only pursued at the specific strategic wish of the target group as a whole, which also assumes the associated obligations, in particular to see that the prerequisites for innovation are met. Innovation is, after all, the process of making new inventions operational and convincing people to use them. The problems that arise in this connection are not by any means all technical ones; they are related to the users' power of imagination and vision, to their organisation, and to their willingness to take new user methods and new standards on board and invest in the facilities that they need if they are to adopt the new working methods.[15]

14 Like SURFnet, SURFdiensten is a Stichting SURF subsidiary. SURFdiensten makes ICT products and services available by concluding licensing agreements with ICT suppliers.

15 Along with the national network facilities, for which SURFnet bears responsibility, the connected institutions also make a substantial investment in setting up their own local networks according to the latest targets and standards.

But user primacy within the administrative system is not the only important factor for innovation. Innovation is induced by external technological advances that are of little interest to most average users. Innovation means change and risk, and therefore requires sacrifices to be made. At first, there may be only a latent general need for new technical functions.[16] The pressure to innovate that the market places on established commercial parties is not enough[17] to ensure that new technical functions will become available through the normal commercial channels at the right time for SURFnet's target group. We have already seen that the communication requirements of the higher education and research sector anticipate those of other sectors by up to about five years. That means that the general demand, which is as yet "invisible", can only be activated by an expert user organisation such as SURFnet. The innovation model can therefore also accommodate a technology-driven *supply push* that is applied to the target group via SURFnet. That means that a great deal is expected of the organisation. The innovation model requires the organisation to maintain an administrative system of *checks and balances* with "built-in" tension between the "know-all" innovative professionals and *leading-edge* users on the one hand and the larger body of users on the other who do not wish to imperil continuity of use and are keen to minimise their financial risks.

It is the administrative system that defines the main properties of SURF/SURFnet[18]:

- There is a regular, formalised process of strategic planning that involves the broad group of users and their local organisations, resulting in long-term support from the leaders of the user organisations.
- Stability and continuity of administration are achieved at all levels.
- There is sufficient distance between the institutions' role as users and their decision-making role with respect to strategy.
- There is strict financial separation between innovation and exploitation activities.
- Parties other than users (such as the ICT sector) are not represented in the organisation but become involved in activities strictly on a commercial basis.

Besides the administrative system, the working method is also important for the "innovation model":

- SURFnet tries to focus on its core tasks, the development and use of networks and network services. It must therefore have enough of the necessary expertise within its own organisation; that is what makes it a fully fledged partner for ICT companies.
- Anything that the market can do as well or better is outsourced whenever possible.
- Innovations commence with a *technology assessment*. This is an investigative project set

16 Everyday life today is dominated by the mass use of ICT products and services that were thought to be unnecessary, for example the mobile phone, text messaging, home computers, e-mail, PDAs and iPods.

17 Innovation is threatening to established commercial parties because it puts their tangible and intangible investment in "old" ICT at risk.

18 A separate steering committee was indeed set up to develop SURFnet6 within the context of the GigaPort project, but it too functions in accordance with the model described here.

up to explore the future potential of a new technology.

- Input by innovative *leading-edge* users is important.[19] This is always a smaller external group that presses for network innovation.[20]
- Knowledge dissemination, group support and information on key activities are needed to reach the broader group of users. SURFnet therefore focuses primarily on encouraging user groups and also participates in advanced application projects.[21]
- End users can be approached both through their institution or directly, as a group, with national and international connections being encouraged between users who utilise the same types of application.
- Advanced facilities call for advanced user concepts. To encourage use, SURFnet devotes much of its efforts to developing *middleware*, for example for authentication and security purposes, and to the necessary generic applications.
- Knowledge generation that is funded from the public purse is subject to a policy of openness, in accordance with the funding conditions: everyone may access the results subject to the same conditions.
- Quality assurance is an issue of great concern.
- Honest communication is necessary to gain the confidence of the users and their institutions. Keep expectations realistic and bear in mind that innovation may also involve taking risks and suffering setbacks.
- The focus for all activities is on collaboration abroad and on participation within an international framework, for example with the ICT industry, sister organisations abroad, and standards organisations. SURFnet's position vis-à-vis foreign organisations is the most important quality benchmark.

3.2 How can government use this innovation model?

The government's ICT policy focuses on applying "innovative ICT" in those sectors of society for which the public authorities have a special responsibility. According to the authorities,[22] better utilisation of innovative ICT applications and services is the key to resolving various public issues (in those sectors) and to innovation. Advanced ICT applications can help improve information management, allowing these sectors to perform more efficiently and effectively as a whole. The sectors that authorities have selected in this regard are the healthcare sector, the mobility sector, education, and security.

19 The late Hans Rosenberg, astronomer and first chairman of Stichting SURF, called advanced academic end users SURFnet's "natural allies". Since the advent of the Internet, they have been joined by students.

20 Acceptance of ICT innovations generally grows exponentially. That means that the initial growth is steady but that the outside world scarcely notices it at that point.

21 SURFnet participates in the Dutch Institute for Networked Innovation (Novay) and collaborates on such projects as VLe and Kennisnet.

22 Social sectors and ICT, http://www.minez.nl/content.jsp?objectid = 34924/

It would not be possible to apply all the lessons learned by SURFnet to the government's policy on "Social Sectors and ICT". There are huge differences between the various social sectors, specifically in terms of the organisational problems they face, but also because the impact of ICT and technical innovation differs from one to the other. There are, however, a number of lessons learned that can be effectively applied in other sectors: the structure of the administrative system and the organisation, the working method and implementation priorities, and the administrative "watershed" employed in the GigaPort projects that divides the world of the sector from the ICT industry.

If a social sector wishes to use ICT to innovate, then it must first focus on defining and structuring its sector-level information management system. There should be agreement about the division between the information domains of the individual parties and the sector-level information structure,[23] in other words a collection of tangible and/or intangible facilities, conventions, standards and so forth about which it is understood that a collective approach will serve the parties' interests better than an individual one. If the parties cannot reach that understanding, then sector-level use of new ICT has little chance of succeeding. The key players in the sector must be prepared to provide long-term strategic and financial support, as this establishes an administrative basis for the common information infrastructure in the longer term. The parties need to agree sufficiently on the role that advanced ICT ought to play in this regard and on the organisational facilities, procedural arrangements, information standards, technical standards, levels of authority and so forth that must be laid down first.

Sectors must be prepared to solve their sector-specific information problems themselves – although in collaboration with external *stakeholders* – and to accept the far-reaching consequences of introducing ICT. Utilising ICT will, after all, have a major impact on the sector's internal relationships, on its organisation, its transparency, and the balance of power, including its relationship with external parties such as the public authorities.

It is naturally important to start by defining the boundaries within which "sector-level ICT" is desirable and feasible and what targets are realistic in that respect.[24] The broader the definition of the sector, the more concessions will have to be made concerning those targets. But however the boundaries are defined, the sector must avoid setting unreasonable targets and objectives for internal collaboration, for example because it is under pressure from the public authorities to do so. The more complex the administrative relationships are in a sector,

23 See also J. Truijens, F.M.M. van Iersel et al. Informatie-infrastructuur, een instrument voor het management, Kluwer Bedrijfswetenschappen 1990.

24 All kinds of variations are imaginable in the healthcare sector, for example: the whole sector, front-line care, general hospitals, pathological anatomy, and all of these at either national or regional level. Every choice has its own specific level of ambition.

the less chance there is that a sector-level approach to ICT will succeed. Excess pressure by funding providers is also a risky business, especially if the funding targets technological innovation, because it can then easily have the wrong effect. If government funds ICT innovation, then it will have to exercise considerable self-control when defining the aims. Initially, that was also a problem in the higher education and research sector. The authorities recognised the need to collaborate on technology sooner than many parties in the sector, and set strict requirements to ensure that such collaboration would be anchored in the sector. Later, the authorities accepted that it took two years before the SURF/SURFnet structure was widely accepted and implemented. Rather than a serious delay, that time turned out to be a good investment.

SURF's multi-stage structure, in which the users are united and SURFnet functions as the sector's technical instrument, has been shown to work well and is sufficiently general in nature to be imitated in other sectors. It isn't always necessary to set up a new organisation. Sometimes it is more efficient to hand over the responsibility to existing organisations, although these are often not set up to plot out a far-reaching sector-level strategy and additionally – although at some remove – manage the organisation that is implementing the strategy among the connected institutions.[25]

In addition to the organisational structure, another of SURF/SURFnet's lessons learned can be applied without further ado: the relationship between the user sector and the ICT industry should take the form of consolidated demand in the ICT market. The point is to differentiate between the interests and aims of the social sector involved and the interests of the ICT sector. There are all sorts of reasons for doing this. For example, these parties have different objectives and work with different planning horizons. There are likely to be synchronisation problems if every introduction of new ICT means introducing new working methods and structures in the sector concerned. The two processes take place on differing timescales: the rapid pace of technological innovation means that ICT products and services are developed within just a few years, whereas structural reforms within a sector may take up to ten.

When the ICT sector is given a leading role or is even a partner in the administrative system, there is a danger that it will avoid unpopular organisational aspects and take refuge in technology. There is a risk that the requirements set for the applications will, unintentionally, be tailored to reflect the capabilities of the products offered by the firms that the sector is working with.[26] We have all heard the adage "It's not about the technology, it's about what you do with it". Unfortunately, many a government project has failed to heed those words,

25 At the time (1985), a conscious decision was taken to set up a new organisation to represent the collective interests of the Dutch higher education and research sector in ICT, because the existing organisations focused on federative representation in external matters and did not appear suitable for organising the strategic commitment of the various categories of parties.

26 Like the saying "If your only tool is a hammer, all your problems will look like nails".

especially if quick points need to be scored or if suppliers in the ICT sector are pouring on the commercial pressure. There is a risk that if ICT interests are allowed to influence decision-making, the introduction of innovative ICT will dominate, making it easy for the sector to hide behind the technical problems. And if the sector's problems are mainly administrative and organisational in nature, then the ICT sector will not be able to solve them.

Sector-level innovation means accepted innovation. Acceptance is essential and taking risks in ICT can put an entire project at risk. Setbacks in the technology will undermine confidence in the whole project. A social sector that lacks sufficient solidarity, that has had little success in the past in tackling large projects collectively (for example in implementing sector-wide information management systems) cannot afford to take technical risks owing to ICT innovations. Those innovations may, after all, come with their own set of problems that will draw attention away from the genuine information management problems that the sector is struggling with.[27]

Another point concerns the differing levels of technical sophistication that are feasible in a sector-level ICT innovation project. In every area of application, the sector – and only the sector – must consider how many new and therefore riskier ICT facilities are necessary and feasible. External commercial, financial or political interests can seriously disrupt this process of consideration and cause confusion about the sector's own strategic commitment. In the case of "hard" ICT applications, the level of sophistication is more important than for "softer" applications, where organisational factors will be more significant. Within the healthcare sector, for example, advanced ICT plays a more important role in instrumentation applications – for instance when using an MRI scan to help make a diagnosis – than when ICT is used for medical quality assurance purposes.

At SURF and SURFnet, the level of ICT sophistication has always been very important for the network services provided. For the GigaPort consortium,[28] use of the most advanced ICT is vital to the higher education and research sector. That means that the sector must itself have a very high level of technical competence, but it does not mean that the ICT sector should be involved in its administration. Section 5 looks more closely at how SURFnet did in fact involve the ICT sector in the GigaPort projects. Before that, in section 4, we look at which activities are the actual focus of innovation at SURFnet.

27 It seems, for example, that very few lessons have been learned in the Netherlands from the ICT history of such sectors as the police or hospital care.

28 This consists of more than fifty institutions of higher education and research.

4. Test-factory approach

4.1 GigaPort as a test factory

The innovation activities that SURFnet carries out within the context of GigaPort are intended to have an impact in two different directions. Figure 5 shows that they provide vertical leverage for innovating applications as well as crucial horizontal pressure for innovating networks. Applications innovation becomes possible because new networks are required as a platform for developing and exploiting new applications.

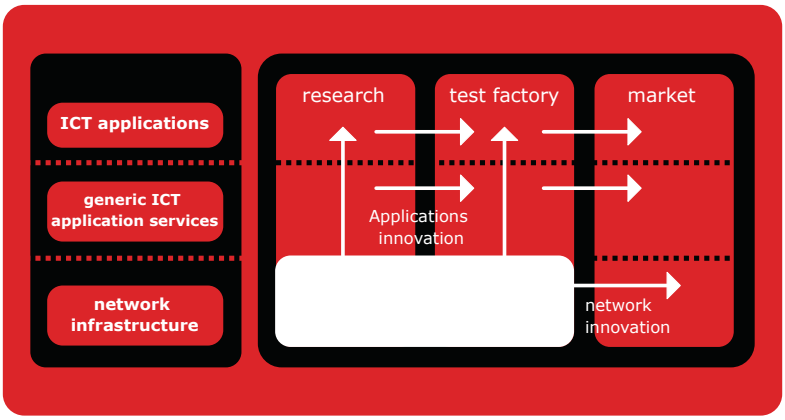

Fig 5: The two-dimensional influence of GigaPort.

Well-known examples of how GigaPort leverages new applications are the ICES/KIS projects, for example the Virtual Laboratory for eScience (VL-E),[29] LOFAR,[30] the LHC project,[31] DEISA[32] or eVLBI/JIVE[33] – all projects that would have been impossible without a new network. Many members of the GigaPort consortium are also developing other software that can only be run on SURFnet6. For example, there is currently enormous interest in "static" and switched (dynamic) lightpaths, including for international use, such as in medical research and for GRID computing.[34] We will not pursue this topic any further in this essay. We will focus mainly on the role that SURFnet, through the GigaPort project, plays in the network innovation cycle (see Figure 5). The test factory serves as an indispensable link in the chain that extends between invention and the market.

If acceptance is vital for innovation, then the innovation process should focus on gaining acceptance from the very start. Network services are intended for mass use, and they must

29 http://www.vl-e.nl/
30 http://www.lofar.nl/
31 Large Hadron Collider, http://lhc.web.cern.ch/lhc/general/gen_info.htm/
32 Distributed European Infrastructure for Supercomputing Applications, http://www.deisa.org/
33 Very Long Baseline Interferometry in Europe, http://www.evlbi.org/
34 http://www.nikhef.nl/grid/BIG/

therefore be accepted en masse. New technology should not function only in a restricted test environment, but also on an expanded scale. The process industry is well aware that a chemical process in a test tube is very different from an industrial process that produces thousands of tonnes of a particular substance. The key question is whether a process is "scalable". To answer that question, the process industry begins by studying the quantitative aspects of the process in a test factory. Scalability is tested before any money is invested in large-scale production facilities.

This step is frequently overlooked during ICT projects. SURFnet gives priority to the quantitative problem when new ICT is being utilised. Scalability is a recurring issue. Testing scalability is considered a vital part of any development process. SURFnet should therefore be seen as a test factory for new network technology. First, SURFnet examines the usefulness and scalability of the new network technology for its own target group. The new network is then made operational for that target group and serves as a test factory before the technology is commercialised by the market on a much larger scale. Even new applications that are only interesting to a small group of leading-edge users are still tested for scalability first. Experience has shown that such applications quickly become available to the entire target group, and then move on to the commercial market. The Internet is an example of this. Much of SURFnet's Internet experience has ultimately found its way to the market.

The scalability of new technologies is especially important when considering their later exploitation. Large-scale exploitation comes with its own set of problems. Asked in the 1960s why it was so difficult to computerise the post office giro system, someone replied: "The main process is actually very simple, but a 0.1 percent deviation requires the efforts of thirty employees". The organisational, operational and technical properties of a process also define its economic scalability. Mass exploitation requires economies of scale and economies of density. The test factory explores what large-scale exploitation means for the quality, security, availability and reliability of the new network functions. Another factor important in defining scalability is the way in which commercial parties can supply components most efficiently, and the outsourcing of such jobs as construction, maintenance and management.

Analysis of the quantitative aspects of processes should go beyond the current status of the technology. The test factory also considers the growth potential of the processes. The demand for network capacity doubles roughly every year. We said earlier that SURFnet tackles network innovation in generations and that every generation has its own technological paradigms. Every paradigm has an optimal scale, and every architecture runs up against quantitative limits. For example, SURFnet5 – which is still a very modern network by commercial standards – would have come up against its economic limits if it had been forced to cope with the anticipated growth in capacity demand by adding new or faster components (in this case, routers) to its existing architecture. GigaPort is currently testing the scalability of the new hybrid network architecture of SURFnet6, which does not have these limits.

SURFnet's role as a test factory does not mean that it is not a reliable network for its users. Continuity of service is naturally a priority in the higher education and research sector, but the sector is willing to compromise on that score in exchange for network services whose functionality and price are much more favourable than those available in the commercial market. The test factory function, for example, is being performed by providers in the telecommunications market, which wish to use the technology later on a much larger, commercial scale.

The needs of commercial parties and of academics and researchers have therefore converged.[35] Research networks are highly suitable for studying the technical, functional and operational behaviour of new networks, their scalability and their usefulness for new applications. In the United States, this collaboration began back in the 1970s with the Advanced Research Projects Agency (ARPA), part of the Department of Defense. The ARPA network[36] and the related working methods served as the model for SURFnet.

The test factory philosophy works not only within the network innovation cycle, but also for applications innovation. Every new generation of network should lead to new forms of communication. That means that there must be a quantitative leap to new forms of utilisation. The new network can facilitate specific test factories for large-scale network applications within the applications column (see Figure 5). That is why the GigaPort project is regarded as an "innovation engine"[37] for ICT applications in the Netherlands.

4.2. Conclusions for government policy

The government action programme "Social Sectors and ICT" focuses on the sectors of healthcare, education, mobility and security – sectors in which applications and services must be available on a mass scale and at a high level of scalability.

For innovation to genuinely take place in these sectors ultimately requires the mass acceptance of new ICT applications. But achieving that acceptance means satisfying requirements that large-scale government projects do not always meet. The public sector[38] has a poor reputation in this regard.[39] Projects such as the introduction of road pricing or the public transport chip card and major system changes such as the introduction of market forces in the energy sector have shown how risky it is to pay too little attention to

35 Kirstein, PT: Research on Networks versus Networks for Research: The Need for International, Internet, Testbeds, http://www.cs.ucl.ac.uk/research/radioactive/sigcomm-award.html

36 http://en.wikipedia.org/wiki/ARPANET

37 The first GigaPort Steering Committee, chaired by Dr P. Winsemius, described GigaPort as an innovation tool that had a broad effect on society.

38 This is equally true of the utility sectors, which are now being liberalised.

39 There are also examples of successful approaches in the Dutch public sector, however. Two of these are the introduction of the Municipal Personal Records Database (GBA) and most of the ICT projects carried out by the Tax and Customs Administration [Belastingdienst].

the quantitative aspects of a development cycle. ”Pilots” are usually not regarded as part of research, but as the first phase of the introduction, during which setbacks may or may not occur; not enough time is set aside for a separate and systematic study of the quantitative problems and the issue of scalability. This is well illustrated by the conflicting reports that the public comes to read concerning the status of the technology involved in such projects, for example the road-pricing project. Some of the parties involved say that the technology "is already available", whereas others say that this will only be the case in a few years' time. Evidently they have differing definitions of the word "available": to one, it means test tube results, and to another it means test factory results.

Public administrators seem to consistently underestimate implementation problems, and ICT companies and ICT consultants evidently do not do enough to disabuse them of their misconceptions. Political, legal and commercial pressure means that the quantitative aspect of the problem is all too easily neglected. ICT projects needlessly acquire a bad reputation in this way, leading swiftly to panicked reactions among politicians. Normal growing pains only become visible in the first stages of the roll-out in a "pilot region". The word "setbacks" is bandied about, but most of those setbacks could have been avoided if the quantitative aspects and the scalability issue had been investigated thoroughly during the project phase. It often turns out that the project coordinators had committed themselves to commercial suppliers too soon, without allowing time for the quantitative aspects of the systems to make themselves felt in the technical specifications.[40] If politically sensitive ICT projects allowed more time for examination of the quantitative aspects and scalability issues, they would have a better chance of succeeding, in part because the project coordinators would be able to communicate more effectively with end users and work on the basis of realistic user expectations.[41]

The Dutch government would certainly benefit by applying the test factory approach – which SURFnet spent years developing and which is now used in the GigaPort project – in innovation projects involving the use of ICT in social sectors.

Our most important recommendation is that the public authorities must make quantitative testing of new ICT applications one of their project priorities before committing themselves to system specifications. That requires them to leave sufficient time and throughput time, and to call in specific experts. If implementation is an "art", then preventing unnecessary implementation problems is that and more. What is also important to understand is that a test factory is not about relatively noncommittal "demonstration projects", the sort referred to in policy documents, where the suggestion is that everything has already been investigated

40 A similar suspicion is raised by the public transport chip-card gates, which stood uselessly at the entrances to the Amsterdam metro and elsewhere for months on end.

41 It certainly doesn't help matters when the minister concerned makes his or her political survival depend on it. That then becomes the most important driving factor of the project, with Parliament acting as the steering committee.

and it is only a matter of explaining it to the outside world. A test factory is not about demonstrating something; it is about gathering knowledge by means of testing. There is nothing noncommittal about that, not on the part of the testers, and especially not on the part of the users. During the test factory phase, the latter must be offered a realistic stake as regards their role and the success of that phase. That means that the test population cannot simply be a cross-section of the ultimate users group, at least in the beginning. The test population must be sufficiently ICT-literate, age may be important, and its attitude should be critical – even, if necessary, demanding.

SURFnet's target group, in particular the student population, is a good one for such pilots, especially if the emphasis is on using advanced technology. That has already been demonstrated, for example in the test factory for Internet data traffic via GSM (GPRS) in Eindhoven,[42] when testing the use of DSL in Amsterdam[43] or in Twente University's big WiFi experiment.[44] The SURFnet population can also be very useful in a test factory approach to authentication[45] and security, or when trialling new concepts such as *streaming video* and *streaming HDTV.*[46] But why not also use them in a much broader context, for example to test applications for the healthcare and mobility sectors? This is already happening in the education sector, where testing is carried out via the SURFnet and Kennisnet partnership.[47] In the mobility sector, a test factory involving a student population could, for example, precede a regional pilot.

5. Relationship with ICT companies: tendering

5.1 Outsourcing at SURFnet

Section 3 pointed out that SURFnet's innovation model makes a sharp distinction between the interests and aims of the relevant social sector and the interests of the ICT sector. As an innovative user on the demand side of the ICT market, SURFnet always examines how best to call in the ICT supply side. It must be able to take full advantage of the R&D that enterprises have carried out. That applies not only for suppliers of equipment, cables, software and systems, but also for the service sector, for example network operators, contractors or providers of installation and management services and consultants. This list itself indicates how complex the supply side of the market has become, with many different categories of provider competing and with supply substitution occurring at every level.[48]

42 Under a contract between SURFnet, Libertel and Eindhoven University of Technology.
43 The Snelnet ["Fastnet"] project, under a contract between SURFnet and KPN.
44 For a time the biggest wireless campus in the world.
45 A-Select, which was developed by SURFnet, was the basis for DigiD, the Dutch government's authentication system for the public.
46 In projects carried out with the Dutch broadcasting company NOB.
47 In the Samen snel op glas project, for example, operational network experience is conveyed to the education sector, http://www.samensnelopglas.nl/
48 For example, the tenders for SURFnet6 clearly involved substitution of operator services by suppliers of network equipment, installation and maintenance services, and management services.

In SURFnet's view, products and services that commercial firms can do as good or a better job of developing and supplying should in fact be outsourced to the ICT market. In actual practice, this mainly means outsourcing to all the many different branches of the telecommunication market. Since SURFnet was founded, that market has been transformed from a state-run national monopoly to a liberalised and internationally competitive market. The change is obvious in the way in which SURFnet has outsourced work to ICT firms in the past twenty years (see Figure 6).

It is important to note that SURFnet gradually gained recognition within the ICT market, ensuring it a stronger position in that market. Most of SURFnet's partnership projects with ICT firms have more than a direct commercial significance to the latter, especially since SURFnet's role as a test factory has been acknowledged in the Netherlands and abroad.

1986	Commercial collaboration with PTT Digital and Philips
1989	First open tender for SURFnet2 (X.25 network)
1994	Development agreement for SURFnet4 with KPN (SDH, ATM and IP)
1998	Open tenders for SURFnet5: network and network equipment, network management, access projects, local and international optical fibre, together with BT and Cisco, Libertel and others (DWDM and IP network; access pilots for GPRS, DSL and cable modems)
2004	Open tender for SURFnet6: hybrid network, network equipment, installation and maintenance, together with Nortel, Avici and Telindus
2005	Open tenders for network management, local access and international connections with Telindus/SARA and a number of network providers
Since 1996	A number of tenders for international optical fibre connections
Since 2001	A number of tenders for local, regional and national optical fibre connections

Fig. 6: SURFnet's commercial procurement history.

In 1986, only the PTT was permitted to provide telecommunications services, and the Dutch Government had to make an exception to allow SURFnet to offer network services. After 1989, the market for data-communication services was liberalised, but users were still obliged to use KPN's infrastructure. It was only after 1997 that competition on all products and services became possible. That meant that SURFnet5 was the first project that SURFnet was able to put out entirely to tender.

Since then, SURFnet has engaged as much as possible in "innovative tendering": it consolidates the target group's demands and describes these in terms of target specifications and preconditions for advanced ICT tenders. Industrial ICT partners are selected on the basis of the European Union's open and transparent procurement rules.

SURFnet's experience of these rules has been positive. They have never prevented it from doing what it needed to do. The strict legal framework makes heavy demands on the accuracy of the work and certainty as regards one's role throughout the entire process. This approach has mainly produced benefits and improved the quality of the work. The purpose of a tender is to encourage competition so that the best solution can be obtained at the lowest possible cost.[49] There are therefore two variables.[50] Competition between ICT firms has generated much more profit than anticipated. That can be seen not only in the price, but also in the quality of the tenders. Firms can submit a tender in keeping with their own strengths and development priorities. If SURFnet works with consortiums, it does so only for context-related and business reasons. The disadvantage of working with a consortium is that the sense of responsibility is dissipated; there must therefore be strong arguments in favour of outsourcing work to a consortium. If it is unavoidable to do so, then SURFnet prefers working with structures that identify a *main contractor* and *subcontractors*. The most important demands made on the tendering process are transparency and precision. The programme of requirements must clearly state what points it is worth firms competing on. In the event of complex innovative tendering procedures, the providers are given as much freedom as possible to contribute their own views and ideas. This can be done by breaking down the tendering procedure into phases, with the contacts with ICT firms differing in each phase. In some phases, there is a very intensive exchange of information; in others, the ICT firms play no role at all. Whatever the phase, SURFnet must always do its best to treat all providers equally and not to let personal preferences and established commercial positions play a role.

Project phases	Role of commercial ICT sector
Pre-specification phase	Open consultation with large group of ICT firms
Specification phase	Firms play no role
Tendering phase	Open international competition between interested ICT firms (individually or in consortiums) with intensive consultation rounds
Implementation phase	Flexible collaboration between SURFnet and ICT partners, based on a contract

Fig. 7: Various phases of collaboration with commercial sector.

Experience has shown that providers are interested in this approach as well, provided that transparency and equal treatment can be guaranteed. Even parties that are ultimately rejected have responded favourably to SURFnet's tendering procedure.

49 In procurement jargon, this is known as the economically most advantageous proposal.

50 This applies mainly to complex network tendering procedures in which the provider is allowed as much technical freedom as possible in its tender. When the invitation to tender involves products that can be specified in detail, such as optical fibre connections, the tender can usually be awarded on the basis of price (i.e. lowest price).

5.2 Conclusions for government

It is possible to make the clear distinction discussed in Section 3.2 between user interests and the interests of ICT providers by pursuing a strict tendering policy with respect to ICT firms. In response to the frequent complaint that knowledge in the Netherlands is not being passed on properly to ICT firms, the public authorities are inclined to have such firms work closely with the knowledge sector, preferably in consortiums. That is certainly conducive to collaboration in ICT research projects, but not when the project is situated farther along in the innovation cycle, closer to the market. It is also a misconception that the big problem in the Netherlands lies in the intensity of the contacts between the research sector on the one hand and business and industry on the other. A recent Danish benchmark study[51] gave the Netherlands the lowest marks in the group when it came to commercialising research results, but the same study also showed that the contacts between researchers and businesses were more intensive in the Netherlands than in all of the other countries studied. Our conclusion is that this may well be precisely where the problem lies in the Netherlands. Large-scale innovation projects involve too much collaboration between commissioning bodies, research institutions and ICT firms. Relationships should be more transparent and business-like and more conducive to competition between the ICT firms, instead of concentrating on setting up consortiums with these firms. The tender mechanism that is employed by SURFnet can certainly help achieve this.

The public authorities should look closely at existing cooperation premiums and be more critical about bringing firms and research organisations together in projects and consortiums. They should also take into account the position of the project in the innovation cycle:

research -> pilot -> test factory -> market.

Funding schemes intended for the right half of the cycle often require consortiums to be set up with ICT firms before an application for funding can be submitted – in other words, before the specification phase. The risk is that the ICT aspect of a project will be "frozen" too early on and unintentionally adapted to what the ICT provider involved can offer. It is impossible to tell in the application phase whether an ICT firm will turn out to be the most suitable partner later on. Even the BSIK scheme under the ICES/KIS3 programme appeared to have an "ex ante" cooperation provision of this kind, until it became clear that it would be counterproductive for projects such as GigaPort.

Institutes that operate at different stages in the innovation cycle would do well to consider the position of the project in that cycle when setting up a consortium. If, for example, the Telematica Institute's role is to consolidate the demand for advanced applications, then it would be logical for it to invite tenders in the ICT market.

51 Dutch Capacity for Productivity Growth, FORA, Copenhagen http://www.foranet.dk/

6. International context and standardisation

6.1 SURFnet as an international player

The ICT market is an international market. The most innovative companies operate globally. User trends are also increasingly influenced at the international level. Access to data and voice networks is subject to worldwide standards. The Internet contributes to the standardisation of applications, as do de facto commercial monopolies, for example by Microsoft, SAP or Google. The world of scientific networks became international in the early 1980s.[52] Users in higher education and research, who are themselves forced to compete with counterparts abroad, are able to compare the quality of their ICT networks. The Netherlands' policy on SURF and SURFnet was viewed within an international context from the very beginning, much more so than was the case in other countries. It was clear from the start that the quality of facilities in the Netherlands could only be measured by international standards, and that there was insufficient support for this in the Dutch ICT industry. Not having a strong national ICT champion has in fact turned out to be an advantage.[53] In some cases, other countries ran into practical impediments because of their ties with the national ICT industry.

In the past ten years, SURFnet has only been able to pursue its network-related ambitions by running projects of relevance within the international market and attractive to large international ICT companies. That means that all activities are essentially set up to have an international scope and to take international competition into account. It is nice but not of crucial importance that SURFnet works with "Dutch" companies, quite apart from the fact that using nationality as a selection criterion would have been contrary to international regulations.

6.2 Conclusions for government

The Dutch government could take the same international approach to the utilisation of ICT in other social sectors. The Netherlands has dropped far down in the telecommunication league tables as a production centre. Industrial telecommunication research has also virtually disappeared from the Netherlands. Although that is regrettable, it need not be a catastrophe. It would be such, if the Netherlands did not play a leading role in the innovation of ICT utilisation, as SURFnet has been able to do with GigaPort. The Netherlands no longer develops advanced network technologies, but it is the first country to make use of them. It is also no longer enough to focus on supporting "Dutch" ICT firms; instead, the Netherlands should court international ICT firms by presenting itself as an attractive testing ground for

52 One key contribution was IBM's decision to offer universities free access to its worldwide EARN network. In Europe, IBM's initiative induced the EU and the national governments to get involved in this particular field of policy.

53 PTT Telecom (later KPN) has never been anxious to take on this role, not even when it had a 49% stake in SURFnet.

applications innovation. That means that in the years ahead, its competitiveness in ICT will depend largely on the quality and international competitiveness of the applications demand. This factor should play an important role in the business location policy for foreign ICT firms, as it did in the case of GigaPort. The Netherlands should turn itself into an attractive test factory for ICT applications that have international appeal. That will undoubtedly make the Dutch ICT sector more competitive as well.

7. Summary of conclusions for Dutch policy

We have already seen that the Balkenende Government attaches great important to the innovation of crucial social sectors and that it wishes to make maximum use of the potential of ICT in this respect. That has led to ambitious projects, some of them on quite a large scale. Vital public interests depend on the success of these projects. In the past, however, many such projects were not really all that successful. As we indicated in the introduction to this essay, in our view innovation comes down to the acceptance of inventions. It is precisely with respect to acceptance that such innovation projects run the greatest risk.

The key to the success of SURFnet's innovation activities lies in its administrative system and in the transparent position it occupies vis-à-vis its target group, the public authorities and ICT firms. For sector-level ICT-related innovation, the quality of the administrative system is the most important factor. That system should lead to an organisation that can engineer a long-term strategic commitment by the sector to introducing new ICT, even if doing so has far-reaching consequences for relationships within the sector. It is vital for the sector to be willing to bring its own information management structure and procedures up to standard. That requires tackling the non-technical problems first, which are often rooted deep within the sector. Only the sectors themselves can solve these problems, although obviously under pressure from parties that have a direct interest in their doing so. The public authorities can be such a party, and can furthermore set the conditions, but they should not act as co-decision-makers based on the ICT policy.

We also do not believe that ICT firms should play a decision-making role in sector-level innovation. On the contrary, we believe that there should be an administrative watershed between the relevant social sector and the ICT firms. The targets and planning horizons of the ICT sector differ too much from those required by the application. Pressure from the ICT side of the equation can all too easily lead to the wrong technical aims, short-term thinking and opportunism. The sector's organisational problems must continue to be the focus of attention. The Ministry of Economic Affairs must start by making the quality of the administrative system the primary focus of innovation policy. If that system is not effective, stable and transparent, then the innovation project will grind to a halt, despite all the initial enthusiasm of the mixed group of parties assembled by the public authorities.

We have also argued that social sectors must take a strictly business-like, commercial approach to the ICT market. Consolidation of demand and tendering have proved to be suitable means to this end. That requires the sector to have enough competence to properly consider which ICT aims and specifications are most appropriate. External commercial, financial or political pressure can seriously disrupt this process of consideration.

Another lesson learned through GigaPort is the test factory approach. Acceptance ultimately depends on researching the scalability of a technology and its potential for exploitation, but such research costs money and takes time. The alternative is even more expensive, however. What must be avoided is ending up with a steady stream of projects that conclude with a report stating "…If nothing else, we learned a lot". That is of little use to end users in the sector, and they are likely to drop out of the next innovation project. SURFnet's test factory approach should be used much more widely in the Netherlands. That is rather different to orchestrating scalability by setting up noncommittal demonstration projects in which it is unclear who is running what risks and why.

Putting together consortiums between the sector and ICT firms when drawing up specifications narrows the field of vision imperceptibly. Consortiums work well for genuine research projects, but in the case of projects that have operational targets in the market, the point is simply to find the best ICT solution at the lowest cost. Where the right balance between the two lies and which firm can offer that balance are impossible to determine during the early stages of the project. It is also important to take an international approach to tendering. The best ICT is no longer of Dutch design, unfortunately, but it would be preferable to first test and use that ICT to scale in the Netherlands. Consortiums of ICT firms may create confusion about accountability and put extra pressure on management. They can also distort competition. Firms may not be able to avoid combining into consortiums, but they should only do so if the ICT products and services they offer will be demonstrably better as a result. The schemes run by Economic Affairs sometimes appear, however, to make the establishment of a consortium an end in itself.

The final question is: what role does the Ministry of Economic Affairs play in ICT-driven innovation in social sectors? The Directorate-General for Energy and Telecom (DGET) focuses in particular on ICT-driven innovation. The Ministry can consolidate its role in innovating ICT and in ICT-driven innovation by allowing our conclusions to influence the schemes, programmes and institutes that it supports. It must ask itself, however, whether it is realistically equipped to do so. More is needed than a knowledge of processes. That too is something experience has taught us: SURF and SURFnet were founded by politicians, public administrators and civil servants who coupled their process-related foresight and flair with content-related foresight and long-term commitment. They not only knew how they wanted things, they also knew what they wanted.

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Ministry of Economic Affairs

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