Roadmap ICT for the top sectors

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The ICT Roadmap team:
Amandus Lundqvist, skipper
Peter Apers, scientific skipper
Arnold Smeulders, scientific secretary
Erik Huizer, innovation secretary
Peter Mandersloot, civil secretary

0. This roadmap

The roadmap describes the ICT innovation common to more than one top sector. The Minister of Economic Affairs, Agriculture and Innovation, has asked for a trans-top-sector roadmap for ICT-themes important to all or many top sectors following a motion by Schaart (VVD) / Verburg (CDA).

The goal of the ICT Roadmap is to identify instances of high-potential ICT-innovation in top sectors. Primary input to this roadmap was given by the nine top sectors and their innovation tables. Secondary input comes from industry, TNO, and NWO, and help and inspiration from the following actors, for whom the ICT roadmap provides an action plan:

- companies: businesses with stakeholders in the top sectors for modern and breakthrough ICT,
- TNO: applied research and innovation,
- Government: the generic elements in the Digital Agenda,
- NWO, including STW: for use-inspired ICT-science,
- EIT ICT-Labs and the universities: breeding a new generation of ICT-entrepreneurs,
- COMMIT and ICT~Office: promoting public-private partnerships.

These actors are well positioned to put their international connections of ICT-innovation into action.

The goal is achieved by focusing on 7 ICT-themes as carriers of ICT for direct economic benefits in more than one top sector. The action lines range from use-inspired fundamental and applied ICT-research to enabling innovation by the application of modern ICT for monitoring and control. The impact ranges from immediate ICT-application benefits to large-scale economic and societal innovation in the long run.

The ICT Roadmap describes the following means:

- priorities and themes for the public-private research and innovation agenda in ICT,
- the governance in a TKI implementing the agenda
- a (growing) list of industries and institutions supporting public-private ICT innovation.

More and more top sectors will realize their dependence on advances in ICT. In 2012, we start with the program in the Roadmap. And, we will start with the further articulation of ICT-needs of companies in top sectors for future updates, strengthening the relationships even further.

Chapter 1 will give an overview of the broad impact of ICT in all (top) sectors of society. In Chapter 2, the ICT-part of the top sector roadmaps and the Digital Agenda will be summarized. On the basis of this demand-inspiration from each top sector, Chapter 3 will follow with a list of relevant ICT-themes shared by more than one top sector. In Chapter 4, we will discuss the means per stakeholder to implement the roadmap. In Chapter 5, the shared ICT-challenges as collected in Chapter 3 from the input of the top sectors in Chapter 2 will be described.

0.A Relationship with the Digital Implementation Agenda

In May 2011, the Dutch Government announced the Dutch Digital Agenda [24]. It describes the government's policy on value-added use of ICT for (business) innovation. It also describes the government's goal to reduce the regulatory burden for enterprises for the purpose of enhancing productivity and economic growth for the years 2011 to 2015. The scope covers the complete chain from the ICT-infrastructure at the bottom to a smarter use of modern ICT-tools at the top. The focus of the Agenda is primarily on business-to-government processes. In December 2011, the Digital Implementation Agenda was published, which describes the approach to meet the challenges of the Digital Agenda in more detail.

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1. ICT, part of all top sectors

The chapter gives an overview of ICT in (top) sectors.

ICT is the enabler of innovation in many sectors of our economy. Under the technology waves of ICT, little remains the same. Time and again, the competition is who will pick up the viable applications first.

For manufacturing industry the impact of ICT has been enormous. Producing *just in time* and cutting back on large stocks is now a viable strategy. Production is simpler, logistics far more efficient and creating spare parts on demand (rather than having them in stock) is becoming more efficient. And, manufacturing will further profit from the inclusion of modern ICT: for monitoring during production to delivering. The time where all products are connected to services on their condition and content has only just begun. Manufacturers shift from production to production and services. Océ now manages printers remotely as a service rather than selling printers. The functionality of products will profit from more ICT. The users and consumers no longer accept awkward interfacing or uncontrollable machinery. In short: ICT is changing the whole landscape of both the manufacturing both in a fast and significant way.

For government, who would have thought 10 years ago that income tax forms in the Netherlands would be collected via Internet only? In fact, who would have thought just 5 years ago that the Dutch *Tax Administration* would be filling in your form before sending it to you? The achievement in logistics of systems and data is an indicator of the broad civil acceptance of ICT technology and support Internet shopping in the Netherlands.

There are many, many sources of information in the world. The potential gain in connecting them and in exploring their content is too big for economy to let go.

Creative industries rose with the most recent branches of ICT: social media, virtual worlds and interaction. These new branches of ICT are here to stay. They deliver a new insight into information in society, for example to influence the behaviour of people in their audio or water consumption.

ICT technology is becoming smaller and smaller in size every year. This comes in handy for the surveillance of products in the supply chain and in the food chain. Tiny computers also provide new opportunities in production. Computers and sensors can be employed to supervise individual plants, thus helping industry to improve their products, and to learn how to improve their production in the

ICT-projects fail sometimes. More insight is needed as to why they fail, what the possibilities and impossibilities are of ICT, and how to practice realism during tendering.

future.

Modelling energy consumption, logistics route layout or resource planning has become indispensable. ICT and mathematics work hand in hand for innovation. The cargo distribution based on GPS navigation were developed hand in hand by computer scientists and mathematicians and then applied in ICT.

In many parts of society ICT is vital. Healthcare systems, energy, water, and many other aspects of society need ICT systems to function. As a society grows more and more dependent on ICT, it is essential that we invest in the level of trustworthiness of this technology. Trust implies reliable, dependable, safe, and secure systems. Recent events have shown that trust does not come easily but goes quickly. And,

ICT is indispensable, so much so that we rely on it. In ICT, we cannot do without secured access and trust.

trust is not only a technical issue. Reliability and dependability of ICT systems need to be developed further, explicitly modeling risks.

Where the reputation of ICT has often been that ICT is capable of everything, time has made clear that reality is different. The ICT-systems have frequently appeared difficult to construct. The fact of the matter is that ICT has never been impeccable, but that it is a discipline like all others: with impossibilities, design failures, and legacies. It is important to know more about design for existing information streams.

For health and many other sectors, the privacy of the individual has to be respected and protected, technically and procedurally. The issue of privacy sensitive data deserves more research. We see examples of ICT-projects that go awry because of privacy concerns.

In Agro & Food, in Logistics, and in Health, open data from governments, from NGO's or from commercial sources are essential to close the chain of information processing. Standards are a key issue, and at the end of that also interoperability between standards. Systems based on open data in a closed community also offer many a new opportunity.

ICT is the key to innovation and productivity, more than any other discipline.

The Dutch ICT Sector is an important factor in the Dutch economy in its own right. With an annual turnover of €30 billion it provides 5% of the GDP. And it is growing, as ICT is responsible for 20% of the economic growth and 70% of all innovation. The sector provides over 250,000 highly skilled jobs, and many times that are working in ICT elsewhere. The majority of ICT-companies in the Netherlands with more than 100 employees have based their headquarters in the Netherlands, implying a substantial production capacity. The ICT-sector consists of hardware, software, services, telecommunication, and office technology companies, but also of media, gaming, logistics, and social media. Other information intensive companies will soon emerge. The software sector especially contributes considerably to the Dutch export. The total ICT R&D expenditure equals a surprising 31% of all R&D in the Netherlands. ICT companies spend approximately €2 billion on R&D here equivalent to 18,000 jobs. The public R&D expenditure on ICT is 1/8th of the private expenditures. In light of the Barcelona objectives, this urges for an increase in the public expenditure to bring it up to par with private expenditure.

In conclusion, time and again the information technological revolution has proved: we cannot do without ICT. ICT plays an important role in technological innovation of the top sectors, and ICT plays an important role in the innovation of businesses and supply chains of not just the top sectors. And ICT plays an

important role in social innovation, among other things for the reduction of regulatory pressure. Innovation with ICT implies innovation in ICT. In this ICT-Roadmap we will describe the ICT-innovation common to all or most of the top sectors.

2. ICT in top sectors

In this chapter, the ICT-part of the top sector roadmaps and the Digital Agenda will be summarized.

2.1 ICT in High Tech Systems makes Intelligent Products

ICT is present almost everywhere in the roadmaps of the top sector High-Tech Systems and Materials [4], ranging from the equipment for communication, aerospace, automotive industry, solar energy, and advanced medical diagnostic and treatment equipment. We select a few highlights here.

Embedded systems Embedded systems are the core and a major component mostly of High Tech Systems, and through them to many other top sectors such as Health, Logistics and Agro. Embedded Systems are integrated hardware/software systems built into devices that are not necessarily recognized as computerized devices or computers, however, these embedded processing units do control and actually define the functionality and quality of these devices. Embedded systems are typically not monolithic, but consist of multiple processing units, connected through wired or wireless networks. The size of the system components ranges from tiny battery-powered intelligent sensors and actuators, to large multiple-rack computing devices. Key concern for embedded systems is that they have to fulfil a wide variety of strict resource constraints, ranging from limited energy-usage, memory-footprint and limited processing power to space and weight constraints. At the same time, they have to fulfil strict requirements regarding performance and dependability. The limited resources and strict extra-functional requirements distinguish embedded systems from ICT systems in general. The design of embedded systems is (therefore) intrinsically a multi-disciplinary activity, requiring skills from computer science, electronics and mechatronics and control, next to a thorough understanding and interaction with the application field.

Software controlling the machines is making the required accuracies and speeds possible. The complexity of the embedded systems is immense, yet new system aspects need to be taken into account to improve product specifications. A main theme in embedded software development is time-to-market, requiring adaptability and dependability. In addition there is a strong need for efficiency improvement. A special remark concerns the importance of mathematics, as an instrument to deal with the increasing system complexity. More and more, mathematical models are used to reason, measure, and optimize system behaviour. As equipment challenges are increasing, so are the mathematical skills and tools required to solve them. Contributing industries are NXP, ASML, Philips, FEI, Vanderlande Industries, Thales, Philips, and many others. The topic is discussed extensively in a separate roadmap in the top sector HTSM.

Security As our reliance on the ICT infrastructure increases, so do concerns about its security. The growing complexity of ICT systems means that bugs and vulnerabilities are harder to avoid, creating new opportunities for increasingly sophisticated attackers. The recent attack on a uranium enrichment facility in Iran by the Stuxnet worm shows that strategic interests can attract cyber-attackers. ICT security issues are no longer limited to traditional computer systems, such as PCs and laptops. Rather, they surface everywhere, from electricity and water supply

systems to the health service, from public transport to smart cars, from implants to supply chains, and from banking and logistics to the emergency services. Trust is a *conditio sine qua non* for normal economic transactions and inter-human communication. It is at the core of social order and economic prosperity, and in an increasingly ICT-dependent world, the security of ICT plays an ever more important role here. Addressing cyber security involves many domains of expertise, or disciplines. We do not just need technical expertise to detect and stop attacks - or better still - prevent them. We also need laws and regulations that better cope with computer crime, and we need to better understand the forms and causes of cyber-crime, the effectiveness of measures, including law enforcement, the underground economy, and to see where economic drivers for implementing security measures are lacking and regulation may be needed. Relevant industries are banking, industries operating in the critical infrastructure and utilities.

Automotive Smart Mobility is focusing on ICT making vehicles more intelligent with the aim to realize safe and efficient traffic solutions. The theme Vehicle Dynamics Control uses mechatronics and software for safety and driver support. Therefore, VDC is also the area of Advanced Driver Assistance Systems (ADAS) and hence the enabling technology for the future of autonomous driving. The theme Connected Car uses wireless technology with other cars and/or infrastructure making new services in the car possible. The priority towards 2020 is to develop applications and large scale implementations to improve traffic flow, CO_2 reduction, safety and comfort. An additional challenge is to create compatibility and standardization through international cooperation on open platforms, testing and valorisation. The theme Traffic Management focuses on efficient traffic control based on an integrated system of vehicles and infrastructure. Topics of investigation are both central and de-central control systems. In the focus Smart Mobility many technologies are available, but the real breakthrough is a matter of the realization of large-scale applications in the real world.

Healthcare systems Clinical Decision Support systems will significantly increase productivity and quality by accessing data from a remote location via (reliable) Internet connections. Low latency high-volume data mining and decision support algorithms in massive image bases enable better understanding of the cause and evolution of diseases, enabling better patient-oriented treatment planning before and after intervention. This all requires effective, large data sharing and managed access as well as interoperability, massive data fusion, storage and transport, and similarly it needs fast extraction of the right information, preferably from a very large data base of biomedical relevant models. It requires the digitization of the vast amount of biomedical data, from general practitioners, vaccine programs, pharmacists, clinical practice as well as clinical research, and advanced IT solutions to find the right information at the right moment, also from a remote perspective using all kinds of (mobile) Internet connections. This remote perspective crosses organizational borders and requires specific attention to security and privacy for patient data and the setup of trusted networks. Another extension to such networks will be the safe, secure and smooth integration with mobile communication and visualization devices, leading to optimized medical data transmission, modelling and visualization applications for mobile devices.

2.2 Smart Grids for an Energy Future in the top sector Energy

Smart Energy Grids Apart from an ICT role in the surveillance and prediction, ICT will play a crucial role in future energy networks and systems based on a low-carbon energy supply: the smart grids. Due to the large-scale incorporation of varying, decentralized, and renewable energy sources (like solar, wind, and biogas) as well as new devices with intensive energy consumption (like e-vehicles and heat pumps), the management and control of energy networks and their users become substantially more complex. In addition, energy consumers will also become producers. This demands for a substantial amount of new ICT techniques for future energy systems, in order to efficiently match the demand with the uncertain supply, in the networks as well as at the side of the users and their devices. Also, in order to work well in real life, the stochastic aspects in the management of Smart Grids will have to be studied closely with stochastic operations research and statistical learning from mathematics. In order to enable such smart grids, substantial research is thus required in agent systems, data processing and mining, semantic sensor networks, security and privacy, embedded systems, modeling, control, network theory and optimization techniques. The urgency for enabling smart grids is clearly visible in industry.

ICT and the gas infrastructure Measurement and control of quality are essential elements in a decentralized gas-infrastructure. Kema, TNO, GTS, industrial gas-consumers are key companies. For the macro and micro gas-infrastructure, ICT plays an important role in planning and dispatching. Smart energy grids are expected to deliver an important contribution to the dynamic supply and demand of the future. A key company here is IBM. Measurement and quality control are also essential ingredients of *green gas*, to supervise the quality of gas from a distance. The international trade in certificates is in fact an information chain traded on virtual platforms.

Societal awareness for energy consumption For a broad societal awareness of energy consumption, social media are essential. In a manner similar to the creative industries, patterns of use are kept and used for personal feedback as well as feedback on the gas delivery. The aim is to influence consumer choices in the use of energy by smart meters, apps, and personal data displays. Consortia have been formed around *local living lab* test beds like Amsterdam Smart City with among others Alliander, KPN, Cisco and focusing on smart meters. Other initiatives are more experimental like PowerMatching Cityin Hoogkerk with Essent, Humiq, TNO, KEMA, and Enexis addressing core network challenges.

Smart energy Smart Grid systems have layers to abstract hardware infrastructure from the services. In between them is a virtualization layer where ICT is essential for interaction between the layers. An important aspect of the virtual infrastructure is that the real infrastructure can be monitored and controlled at the level of the virtual infrastructure, but that the physical infrastructure does not rely on the virtual infrastructure. If – by whatever cause or through whatever reasons – the link between the virtual and physical infrastructure is severed, the physical infrastructure will revert to a default and secure autonomous mode of operation. Another important aspect of the virtual infrastructure is its distributed nature. There will be many different ICT-platforms distributed throughout data centers or local computational and communication hubs. The more impact

a component has on the performance of the smart grid, the more restrictions there are with respect to access to that component.

There are ample connections between ICT research & development and the energy industry. The *Building Brains* consortium led by TNO is working on new concepts. For electronic cars, smart grids have successfully been demonstrated by Enexis and e-Laad. In the Rotterdam area smart grids are being considered around the Clean Tech Delta with Dura Vermeer, Arcadis, Deltalinqs, Eneco and TNO. The *Smart Energy Collective* with Eneco, Tennet, Essent, and the Gasunie as its members also including IBM, Heijmans, KPN, KEMA, and Logica, are developing pilot projects. Also, the *Smart Energy Systems* research program focuses how ICT can contribute to more energy efficient networks with partners NWO and STW, and NXP, TNO, Intel, Philips, KEMA, Nedap, Ambient systems.

ICT in the constructed environment Buildings need flexible ICT-systems for evidence-based monitoring on top of an open-source architecture for energy management. Data and information modelling from districts to the user with useful feedback systems provide insight into how to manage energy supply. Another key element is the information chains around energy consumption and for the relief of regulatory pressure. Energy saving in buildings should be based on sensor measurement and control, improvement of energy efficiency by the availability of modelling tools during *parametric* design, effectiveness by providing ample energy management information to the end-user, and by being conscious of embedded energy at the end of the building's lifetime.

2.3 eLogistics for the societal heart beat in the top sector Logistics

The key to success in logistics is to get the flow of data right. The data around the physical movement of goods is complex as there are many data sources each with different owners, and in addition regulations from many sides. The data are unpredictable as logistics is about connecting any good to any organization. And, a major issue is the cargo planning of vehicles as the current load is 50% only. At the same time the data are increasingly individualized and available in real time. The ICT-Logistics research community is centered on Dinalog and its partners. Interoperability is one of the key ICT issues in this topic. In addition, advanced operations research from the field of mathematics is crucial for optimal scheduling of trains, modeling and management of traffic and optimal transportation of goods even when data are uncertain.

ICT is important to logistics. Most of all, ICT dominates the NLIP (Neutraal Logistiek Informatie Platform). But we also see ICT in many of the other actions in the top sector agenda, for example, decision support systems and remote monitoring & control in the formation of information chains and the volume of information in them.

The Neutraal Logistiek Informatie Platform takes care of the national and international logistics connections by standardization and information integration. The platform aims to provide a well-connected chain of logistic information, including standards, and planning with realistic information. That means, some of the information may be missing, some of it may be false, some of it may be

outdated. Relevant industries are KLM Cargo, Cargonaut, Portbase, Swissport, Tata Steel, Geodis, and Amsterdam Harbour.

Cross chain control centres provide control for several supply chains simultaneously by information integration and planning under constraints. This does not only affect the logistics of physical goods but also information and financial streams such as forecasting, financial engineering and data management. The aim is to achieve better coordination and better supervision over these transport activities for efficiency, less pressure on the environment and better sustainability in general. In the end this will provide a competitive edge over other countries. Companies involved are Kuehne Nagel, Unilever Benelux, Nabuurs, Jan de Rijke Logistics, TNT, Ortec, Ahold, Flora Holland.

Service Logistics is directed towards capital-intensive systems and their maintenance to achieve closed loop supply chains. The aim is to significantly improve the availability at lower cost, lower maintenance and fewer new materials. ICT is important to remote monitoring and supply chain information systems. The aim is also to become a leader in business service management and service logistics. Companies involved are Océ, IBM Nederland, Thales, VanderLande Industries, KLM, ASML, Marel Stork, Fokker Services.

Supply Chain Finance aims amongst other things to smoothen the international payments, with industrial partners such as Control Pay, ING, Rabobank, Philips, ASML, Neways, DSV.

Synchromodality aims to improve reliability, predictability, efficiency and sustainability of streams of goods by flexible planning. This requires information intensive services from a wide variety of sources. Companies involved are ING, Sony, Fuji Film, ECT, Versteijnen, DB Schenker, MCT Terminal Moerdijk, KLM Cargo, Aviapartner.

2.4 Quality of Life for an Aging Population in the top sector Health

Home care, self-management and ICT In the Netherlands, 1.2 million people are employed in care. Between 2007 and 2025 the work force will shrink by 10% while the need for care increases. The population of Europe is ageing. The older the population, the higher is the frequency of chronic diseases. This poses an increasing burden on healthcare and social service systems and affects the quality of life by inducing both physical disabilities with frequent hospitalizations and social impairment. It has been estimated that for one third of the future population, professional care is at stake in 2025. As a result, new concepts in care and self-reliance are needed as well as a new balance between professional care and supported care. A shift from intramural care to extramural care or even self-care requires more intensive communication, and hence a crucial role for new concepts in care and ICT. The Ambient Assisted Living program in the EU supports the need for a paradigm shift from the specialized care centres to the home as self-care and self-coaching environment. In this vision, person-centric healthcare solutions are essential for patients with chronic conditions - especially elderly people – as well as their informal caregivers. This emphasizes the role of the home as care environment, by providing real-time support to patients in order to monitor, self-manage and improve their physical condition according to their specific situation.

Quality of life Increasingly, healthcare insurers are expected to have a prominent steering role in the provision of healthcare. How can this role be supported by information obtained from the variety of sources? Similarly, how can these data be put to good use? There are still many questions concerning the use of these data sources. Which legal, social and ethical issues are at stake? What types of data are useful and how can they be gathered efficiently? What types of analysis and tools are needed to translate the data into relevant information to ultimately decrease costs, and to improve productivity and quality of care?

Medical imaging Medical imaging techniques enable earlier, more accurate and less invasive diagnosis and eliminate the need for unnecessary invasive interventions. Fusion of diagnostic and therapeutic procedures will transform many of the current clinical practices. Imaging applications have become an important integral part of different stages in the care cycle. Imaging technology will become indispensable for treatment planning. In conjunction with increasing technical achievements, these new opportunities will have to be validated with existing technologies and compared with current standards. Unexpected findings further accelerate diagnostic and therapeutic healthcare costs and induce over-medication: unnecessary treatment of perceived medical conditions in the general population for which thorough Health Technology Assessments (HTA) will be required for containment and where HTA outcomes also take patients' values into account.

Medical data storage Bio-banking with large-scale medical data storage, patient privacy protection and the interpretation of trends are essential for the further exploration and shortening of clinical trials. In epSOS thirty companies are developing cross border exchange of health information and ambient assisted living solutions. Another initiative, eHealth-nu by TNO, KPN, Philips, Menzis and others is targeting chronic patients. The Dutch Health Hub is a promising crossover where data search technology from the media-sector is applied to the radiology archives, with participation of the AMC, EUR, regional hospitals, media companies and data centres.

Mathematics plays an important role in Health: in unravelling the mysteries of DNA and understanding the nature of complex metabolic pathways, in optimal patient scheduling saving millions of euros to helping doctors to process gigabytes of data produced by modern imaging technologies.

2.5 Empowering Individuals in the top sector Creative Industries

Creative Industry is the fastest growing sector in cities such as Amsterdam (and also in London and Berlin for that matter). The field is dispersed over many different activities and the notion industry does not have a classical meaning anyway. The essence of the creative field is mostly small and very versatile companies as the front-runners while larger companies follow. The best perspective for the ICT-connected Creative Industry is a connection between high-content, high-science and high-tech. IIP/CREATE has been the best representative for the ICT-part of the creative field [16]. A collective from industry, SMEs and universities, it has been instrumental in defining the field as an economical sector of innovation. Given the high degree of high-tech SME and the necessary versatility of high-content, three regional concentrations dedicated to ICT in creative industries are formed: one focused in Amsterdam including Hilversum, with a focus on media, data and news, one focused in Eindhoven for lifestyle products including man-machine interaction, and one focused in Utrecht for gaming.

ICT and Media has identified the following ICT-topics. Smart & Social Media: the advent of new, intelligent technology and the user as prosumer will have an enormous impact on media consumption. Big data will be generated by digitizing all visual and textual data. What are required here are new ways to search and access open and closed data, and new ways to store them. Virtual Interactive worlds will provide interactivity to media. And ICT in cultural heritage is an essential ingredient to provide access to text, picture and sound from the past and the future.

Gaming has led to a research agenda for three themes: game worlds, users and interaction, and transfer of gaming. At the same time it has led to an innovation program on games in context. These elements are strongly related to the ecosystem and project initiatives. Game worlds include engaging virtual worlds and also hybrid environments in which the real and virtual worlds are intertwined. And game worlds of the future must be populated with meaningful virtual characters. Users should be able to interact with games in intuitive ways. When using games in an applied context, it is important to understand game design principles to obtain the best motivation, flow, and transfer of gaming and it is important to measure the effectiveness of serious games. Games are focused on the domains of safety, health and education.

Architecture and the built environment has an ICT interest in open data and standardization.

Cultural heritage mentions the large quantities of (media) data, and the (automatic) addition of standardized metadata, including the interoperability and conservation of data and tools for a sustainable future. Technical innovation, consumer innovation by crowdsourcing and business innovation are of prime importance for cultural heritage. Annotation is important, the incorporation of novel approaches in the archival workflow including media mining technology. For access: user contextualization and recommendation. Contextualization and semantic interoperability delivers semantic interoperability between archives. And interaction with and visualization of large data sets and new services based on archives and location provide new possibilities for storytelling.

The top team for Creative Industry envisions a virtual Creative Industry Top Institute where the emphasis is not on traditional science but rather on creativity and connection. Another variation of high-tech SME parallel to the creative industry, i3B is a set of successful SMEs forming a living lab of SME's in brain, cognition and behaviour [14].

2.6 The top sectors Agro & Food and Horticulture ICT

The top sectors Agro & Food and Horticulture share their high-tech nature, using advanced sensor technologies to monitor crops and stock. Adding more high and medium tech ICT to their diet will offer many opportunities.

Over the years, productivity per capita has improved significantly. And, the productivity per kg input - base materials and resources - has improved significantly as well. We continue to look for ICT tools such as sensors, embedded systems, decision support systems, location-technology, future internet, robots to improve productivity even further but in a green, clean and lean way. This *smart farming* aims at better and predictable yields in quality and quantity, efficient use of resources and a transparent

production system generating information relevant in the chain. Information on the production process is needed for optimizing, for delivery, and for agriculture's compliance to regulations as a license to operate.

ICT is changing the production chain, starting at the farm and through a sequence of processing and handling ending at the consumer. Each partner is challenged to be more efficient, more sustainable and more effective. Information is added to the produce along the chain and producers and customers are increasingly looking beyond one chain-partner back or ahead. Allergy information, fair production and trade, footprints and many other quality characteristics are not only relevant to consumers but in the end all chain-partners need the information.

In the Netherlands opportunities arise in smart farming as a breeding place for integrated ICT applications. This will improve farming and simultaneously offers opportunities for businesses in exporting applications. Agro & Food [3] is active in many ICT-projects AgriXchange, SmartFood, MyPig, Smart Dairy Farming, FieldCopter, E-Track, UNIFARM-FP7, Bioscope ESA, Programma Precisie Landbouw EL&I, I3B-4-Livestock-Agro. WUR is the main science partner with contributions from other universities, higher education and TNO. At the same time, EL&I is developing a National Satellite Databank to provide weekly imagery for precision agriculture. Agroconnect, VIAS and others are bringing Dutch specialists together to work on the improvement of ICT-based systems. ICT advances enable the farmer to track the health and welfare of each individual animal (precision livestock farming). AeroVision, Agrometius, Agrovision, BLGG AgroXpertus, Dacom, DLV Plant, eLeaf, Holst IMEC, Lely, Nedap, Noldus, Ordina, Rovecom, SAC, SBG Innovations, TerraSphere, Q-Ray and many more are active. Challenges lie the field of standardization and interoperability, embedded systems and sensor networks. Particular issues in agriculture also comprise the governance of information, privacy and security of data and information.

From an ICT perspective, the top sector Horticulture [1] has similar needs to the ICT for Agro and Food. The sector proposes the establishment of *Tuinbouw Digitaal* as an integral Greenport Digital Community; this program will focus on connecting, accelerating, providing and cross-supply-chain development of knowledge, standards and technology. The community proposes four activities: a Horticulture-knowledge centre for ICT, a business to government agenda, a human capital agenda and an ICT R&D agenda.

The main issues for ICT research and innovation for the sector are standardization and interoperability along the information chain, support for supply chain management, tools for modelling and visualization, tools for secure online trading and information exchange and single window administration solutions. Business connectivity, seamless interaction with the business processes and system integration (both within organizations as well as across the chain) are essential for the success of *Tuinbouw Digitaal*. To achieve less regulation, the sector urges for process alignment, data alignment and single window administration solutions. A specific suggestion in this regard is to remove person identifiable characteristics and make everything available as Open Data for the sector to benefit from. A specific reason for Standardization is to avoid a single solution (single service-supplier) resulting in vendor lock-in. Therefore standards should cover a broad spectrum with several viable options.

Research should focus on: e-information standards, e-information integration, e-business to government, e-recognition (online secure identification between organizations) and e-competences.

Internationalization of the standardization, interoperability and service integration is a must. There is a commitment from the Horticulture industry and organizations such as Florecom, VKC, VBN, Floraholland, VGB, Frugicom, Edibulb, KAVB, and NAKT.

As growth in a glasshouse is much better controlled in greenhouses, Horticulture is more high-tech by nature than *Agro*. In the sector, climate control in greenhouses by PRIVA, Hoogendoorn, GROW-technology is essential as well as energy saving using smart grids. A close connection to *Energy* is obvious. Other important aspects are robotics for harvesting and vision for quality assessment. Monitoring (sensors) along the whole food chain from plants to food in shops is a new but inevitable part of the future of the sector. Food chain monitoring can only be achieved by ICT sensing networks, and ICT embedded tags. In general, ICT Logistics can play an important role in the flower trade for delivery just in time to the customer. Dinalog has contacts on this topic with the companies such as Logics Agro, and CODEMA. Internal logistics are covered by AW Systems.

2.7 The top sector Water and ICT

ICT is important to Water [6]. 20% of the 70 business cases underlying the sector plan focus on ICT, and a further 20% have an important ICT component. The top sector has noted that IBM might be interested in moving her activities on R&D to the Netherlands as part of her Smart World strategy if new initiatives on water and ICT innovation are generated in the Netherlands.

National information infrastructure Many smaller companies such as Alert Solutions, FutureWater, Hydrologic, HKV, will profit from a national ICT infrastructure around water also employing Internet and cloud computing. A recent study by the TUDelft commissioned by I&M demonstrates that 70 companies, from large to small, are interested in such an infrastructure. The dispersion of data, different styles of data handling, software of various legacies, and restricted compute capacity hamper the development of effective business models. The Digital Delta is a new showcase for a national infrastructure for the purpose of acquiring information, simulation, measurement and control and decision support [38].

Open Data A positive point is the open geo data initiative from EL&I. The top sector expects that this will result in an enormous wave of innovation, including a competitive advantage for foreign markets. Open data will further enhance cooperation along the knowledge chain in the sector. The extension of the use of the Satellite Databank of the National Space Office towards the water sector would be especially interesting. Examples of companies involved in water and satellites are NEO, Hansje Brinkers and eLeaf.

Basic level ICT It is felt that much of the modern ICT is not being employed in Water. There is a world to be gained by education and awareness campaigns. Also from a scientific point of view, better use of ICT in the water sector is needed. A recent workshop organized by NWO on major scientific challenges in water science and hydrology, concluded that there was a need for

a national ICT-infrastructure to take advantage of recent possibilities with regard to data storage and processing. In this light, the inclusion of *water* as a theme by the eScience Centre is promising.

Two prominent initiatives under this topic of the sector plan are the Digital Delta and the *Convenant Informatieketen Water en Klimaat* [18]. Applications of ICT are needed for water technology. In view of the international opportunities of water technology, investments in ICT state of the art will improve the speed of water quality control, the security of water plants, maritime safety (nautical, terrorist and environmental), and the efficiency of back offices. ICT companies combine smart ICT solutions in public databases on water, creating real-time insight into water shortages or surpluses, such as HydraLogic.

Today, in Water, mathematics deals with many of the problems in this discipline: from ship manoeuvrings to modelling of climate change leading to floods and droughts, to modelling ground salinity, sandbank dynamics and dredging in coastal areas. Modern water management requires advanced numerical mathematics, as well as extended modelling and analysis, both from deterministic and stochastic points of view.

One of the spearheads in Water is *Enabling Deltalife* [20], with close relations to IIP Water & ICT [13]. Maintenance of dikes is a first priority for our low lands, as various disasters throughout the world show. Sensor-enabled smart dikes enable timely maintenance, as a prototype for dike data service centres of the future. These centres will provide advanced services for professionals, such as anomaly detection, and enhanced water safety for citizens. IBM has opened two Centres of Excellence in Water Management worldwide, one of which is in Amsterdam for the Dutch Flood Control 2015 Program.

2.8 The top sector Chemistry and ICT

Chemistry [9] is a high science sector with a direct yet variably developed relation with ICT in terms of visualization, data and knowledge management. The sector generates a great wealth of measurement data, where it is known under the name of analytical science and technology [49]. The transport, storage, processing, modelling and visualization of data require advanced ICT. Also remote experimentation for the efficient use of expensive instruments is important in research. The public-private partnership is organized around COAST with more than 50 partners, varying from large multinationals to SMEs and from academic groups to institutes for higher vocational education. It will bring together private and public partners that have an interest in this line of work and are willing to contribute. It is planned to have sessions with the sector in 2012 whereby the ICT sector will demonstrate its innovations relevant for the Chemistry sector.

2.A The digital agenda

The Dutch Digital Agenda [24] focuses on smarter use of ICT to increase (business) innovation and economic growth, mainly for business-to-government (B2G) processes. Many topics of the agenda apply also for the top sectors. In the agenda, which is neatly related to the European Digital Agenda [24], the Dutch government identifies four action lines for making benefits of the economic opportunities of ICT.

Action Line 1: Making enterprises work smarter.

Use of ICT leads to better efficiency for enterprises as well as creating a government that is small and effective. The government aims to reduce the regulatory burden. This will enable enterprises to operate more efficiently.

Financial digital data exchange The government has opted for the international Standard Business Reporting (SBR) standard for financial reporting leading to cost savings for business enterprises as well as for government within all sectors.

Productivity and Cloud Computing The government sees Cloud Computing as an important development for enlarging economical productivity. The government is exploring the requirements needed to enable enterprises to exploit the potential of cloud computing. The opportunities of cloud computing have already been identified by the Creative Industry. However it is relevant for all top sectors.

Open data The government possesses a lot of data that have considerable economic value once the data can be accessed easily and commercially reused on the basis of open data. The government is developing activities on: *Geo-ICT* The government is making its geographical information available through open data platforms that will be developed for this purpose. As a result the Netherlands Space Office will implement a National Satellite databank on which actual satellite-images will become available to the public. Geo-ICT will create many opportunities initially for all sectors, initially for the sectors Agro & Food, Horticulture and Logistics. An open data pilot will start regarding the use of open data for export regulations of especially the top sector Horticulture. Depending on the success of the pilot, new projects in other fields of export will follow in the coming two years, such as for Agro & Food and Creative Industry.

Standardization and interoperability leads to a reduction of transaction costs and supports business innovation. Focus in Standardization will be on digital transactions (business tot government, business to business). Interoperability solutions ABS standards will be developed and implemented in the top sectors Logistics, Horticulture and Agro & Food). In creative industry, life science and energy (smart grids) the focus is on business innovation.

Reduction of regulatory burden for enterprises ICT can substantially reduce the regulatory burden by further digitalized information-exchange between enterprises and government. The government has several programs running.

Electronic Business File The government is investing the opportunities to implement the Electronic Business File in top sectors such as Agro & Food, Horticulture en Creative Industry. A report will be available in the spring of 2012 for the selection of new leading sectors, *Agro & Food*.

Chain approach for sectors A program is running with a focus on specific public and private cases where ICT might successfully reduce regulatory burden and also contribute to (cost) efficiency within the government. Opportunities for new cases have been identified within the sectors Logistics, Agro & food, Horticulture and Chemistry (case *asbest toezicht*, National Single Window for Trade and Transport).

Compliance and Inspection authorities Opportunities have been identified for the sectors Chemistry, Logistics (esp. inland shipping). *Authentication by e-Recognition* offers enterprises one 'key' for authentication at digital governmental offices. It uses different levels of reliability and allows an enterprise to grant authorization to employees.

Action Line 3: Digital security and trust

The focus of this action line is how ICT-services can be provided safely and reliably and how they can be used with confidence.

Cyber security The key here is confidence in ICT. With the growing use of ICT, confidence is undermined by disruptions of networks, services, applications and abuse of ICT, for example in the form of botnets (a network of infected PCs), viruses or breaches of security with personal data. Therefore, Cyber security is a generic theme for supporting secure use of ICT.

Action Line 4: Knowledge

Preserving the quality of the ICT research infrastructure for achieving higher return on ICT research together with obtaining sufficient digitally skilled people are main topics.

eSkills Digital Skills for smart use of ICT is gaining more importance. However the supply of skilled employees, both in numbers and in competence, does not cover the demand. This means that the Netherlands cannot fully profit from the use of ICT. In cooperation with trade and industry, and educational organizations the government is realizing more and more compliant e-skilled employees and other decision makers. Through the Human Capital Agendas of especially the top sectors High Tech Systems and Materials and also Creative Industry, and Logistics the lack of skilled people will be addressed.

Research on the ICT-infrastructure SURF is acting as the coordinator of the ICT R&D-infrastructure in the Netherlands. The top sector High Tech Systems and Materials is arranging general support by e-Science and the national e-infrastructure for all top sectors. For this purposes a special board will be established with representatives from Science and Business enterprises.

Netherlands: Digital Gateway to Europe The Netherlands has a strong position in physical infrastructure (main ports, roads, waterways and ICT-networks). The Netherlands as an intelligent digital gateway and virtual hub to Europe is a promising concept for generating value added services and more profit with ICT in an international arena. The challenge for success is to generate added value to data by intelligent handling of international and national data streams. A digital gateway consists of ICT-infrastructure, standards and services/applications. Good practices of digital gateways are in financial services and logistics on a single window. The keys to success of digital gateways in top sectors are entrepreneurship by the innovative ICT-sector, talent and e-Skills, public-private cooperation and research. Logistics, Horticulture, Creative Industry and Health are most promising for exploration of the digital gateway perspective. These challenges are described in a recent report [40] on the digital gateway to Europe, supporting the approach of the ICT-roadmap for top sectors. ICT is a generic enabler for analytical science and technology, which in turn is crucial for technological innovation in many sectors. The needs vary from embedded systems to data communication, to calculation and (in the

future) to semantic analysis. The positioning of the Netherlands as digital gateway to Europe will help the positioning of the country as an analytical centre that powers technological innovation.

2.B i-Overheid: data quality, accountability and the *multiplier effect* of ICT

Today's innovation processes are – similar to our present-day society - characterised by the process of interlinking and sharing data and the results of technology-based *reproductive information processes*. As part of many different business and organisational processes (whether in healthcare, energy supply or the automotive industry) data are circulated and effectively distributed between different actors and partners in chains of networks. It is crucial to have an awareness of the consequences of these processes: the multiplier effect of ICT and the constant re-use of data in new business contexts owing to the network character are often not factored into the monitoring of information quality, the accountability for data and information distribution and possible consequences for responsibility and liability. For, increasingly making use of the same *pooled* information of part of, for example, open innovation, open data or other business and governmental strategies and concepts leaves actors with the risk that no one knows precisely who is responsible for the information (or its accuracy). Individual initiatives related to ICT and information sharing are not – or scarcely ever – assessed on the basis of their impact or potential impact on business chains, organisational processes and society as a whole. The most significant omission is the failure or near-failure to view such initiatives within the context of the fast-expanding and rapidly diversifying information flow. It is all too easy for this quality and accountability gap to remain unnoticed, especially in networked situations, without anyone being *to blame*. It is therefore required that businesses become much more aware of various features of a networked economy and information chains than is now the case. If such awareness is not on the innovation agenda, paper-based reality and *real reality* may diverge quite dramatically, see also [48].

The concern about the quality of and accountability for data should not be limited to the information itself, but should also extend to the metadata. Metadata acts as an indispensable signpost in information management systems. It plays a crucial role in tracing information and identifying the original context and origins of that information. The quality of an information management system depends on the presence of good quality metadata. In addition, the quality of the information depends on such technical, legal and organisational prerequisites as data security, well-designed work processes, and a reliable authentication and identification infrastructure. But this brings, for example, the key question of ownership in metadata onto the agenda.

In sum, the quality of the *information factor* in R&D and strategic innovation processes requires strategic attention and consistent policy across the breadth of businesses and partnerships. The assumption that the use of ICT is primarily a matter of technology must be replaced by the realisation that at a (technological or organisational) network level it is networked data that matters as well. This then requires sufficient awareness of the consequences of the multiplier effect of networks and composite information and the challenges owing to the networks. These challenges relate in particular to governance issues on information quality, accountability, ownership and responsibility as well as liability in networks and data chains.

3. ICT research and innovation themes

In this chapter summarizes ICT-themes shared by many top sectors.

1. *ICT one can rely on*

*Secure and Vital IC*T is important to many top sectors, HTSM, Health, Logistics, Horticulture, Energy and Water. Two primary areas of security challenges to address are: *security and trust of citizens* including security of mobile services, data and policy management, and accountability, and *security and trustworthiness of infrastructure*, including malware detection and removal, intrusion detection and prevention, trustworthiness of networks and hardware, software security, security of industrial control systems, secure exchange of business information and administration, and secure operating systems. The two primary areas of vital ICT challenges are *technical robust infrastructures* and *quality and reliability*. The first challenge aims at the creation of robust fixed and mobile networks. The second challenge aims at the quality and reliability through design and process management. Robustness of ICT-systems should be built into the architecture from the moment of design onwards. Secure and vital ICT is promoted by RABO, ABN, Alliander, CPNI.nl, KEMA, Vodafone, KPN, Ericsson, Eurocontrol, and Translink.

Privacy is important in many top sectors such as Creative Industry and Health. Privacy is the protection of user-related data possibly during their use on the network. Privacy forms an increasing problem in the digital society. Larger databases imply more vulnerable data about people, their credit cards, their habits and their lives. ICT secure technology protects privacy. For one thing, privacy of mobile telephone calls asks for advances in cryptography. *e-Identity* is the identity users deploy on the network. Identities are often only protected with plain-text passwords, making it easy for others to capture those identities and perhaps misuse them, as was recently the case with DigiD. TNO works closely in this area with Thales, Atos, Philips, Irdeto, Buurtlink, Tastelink and SIDN as well as with IBM, Vodafone en Nokia.

2. *ICT systems for Monitoring and Control*

Control is an important aspect of ICT-systems. *Embedded system* developers face many and sometimes conflicting challenges. To increase efficiency and to drive down hardware costs, they must aim for ever higher levels of system integration. But to keep applications manageable and scalable, they need solutions that are as general and modular as possible. At the same time, embedded system complexity is rising, quality standards are going up and development time needs to decrease. With such opposing forces, how can the development of embedded systems still remain successful, maintainable and reliable? Embedded systems can be found in many top sector disciplines: in diagnostic equipment in medicine, in utilities such as water and energy to control processes reliably, and of course in HTSM. Companies such as ASML, Philips and Océ are working on solutions for the future of real-time embedded systems for example for lighting, consumer and healthcare systems.

Monitoring and sensor networks have an impact in High Tech Systems, but can also be of crucial importance to Health, Agro & Food, Chemistry, Horticulture, and Water. All types of sensors are

measuring the state and the presence of things. They pass the data to one another and the rest of the world with a potential impact in the way we live, work, and do business. Examples are found in smart mobility by cooperate driving, in safety & security for reconfigurable sensor networks, and in intelligent camera networks. Other applications lie in energy in the Couperus Smart Grid Consortium. Monitoring for properties surveillance is also a topic covered by quite a few SMEs. Great progress can be made in monitoring and sensing when ICT and Analytical Science and Technology work together.

3. ICT for a Connected World

Four top sectors mention *the need for information chains* for the innovation of their businesses: Health, Agro & Food, Horticulture, and Water. *Standardization* helps to make the information flow between various elements in the supply chain more efficient. *Open data*, making large (government and non-government) databases available to the public with a standardized API, is part of the Digital Agenda. *Services* trim down the obstacles for doing business abroad in many industry sectors. Integration of service exports with legislative administrative tools is required for the global society. They are being used in 70% of all Dutch commercial activities.

Open data are endorsed by TNO, Logica, IBM, the Netherlands production software sector, and many others. Relief of regulation may be facilitated by open ICT with proper standardization. They might be made available after removal of any sensitive data in the form of Public Census. The essence of services is in the pricing per use rather than per product. Services turn traditional product-oriented industries into ICT-driven service industries, as recognized in EU-program FP8 [19]. Geo-ICT is an emerging, yet important aspect of open data and new services.

4. Data, data, data

All around us, small data is growing to *big data*. Not just on the Internet but in science, in industry, and in lifestyle by recording all interactions and sensor data, datasets are growing to unprecedented proportions. E-science is the software infrastructure to model or to access big data. This is a support function for science and medicine. *Cloud computing* provides the hardware and the data storage backbone, important to the top sectors such as Creative Industries, Energy, and High Tech Systems. Making computational power and storage online available gives businesses the opportunity to use ICT in a flexible way, weighing down less on investments. Companies such as Microsoft, Google, Philips, and Amazon deliver cloud computing solutions, and software companies such as SAP, AFAS, and Exact deliver cloud-software.

Data and content exploration is critical for the competitive position of all top sectors, in particular Agro & Food, Creative Industries, and High Tech Systems, to name just three. Society drives on data and content. Social data, informal data, formal data, written data, observed data. The more we know about the data, the better we are able to predict them, or to communicate them to a controller, or to protect them, the better we master the stuff progress in society is made of. Companies are found in publishers such as Elsevier and Wolters Kluwer, in new data-intensive services such as Ziuz, and WCC. Data mining is a key issue for Elsevier, Marktplaats, Hyves, Bol.com, and Philips.

Value and information chains

In addition, ICT is the driving force behind innovation, not only transforming topic by topic and top sector by top sector, but also transforming business models and value chains. For an agile society it is important to act on opportunities by forming new business chains and by developing the skills for rapid business model innovation. For global ambitions in top sectors, the only relevant frame for business is the international theatre. Therefore, international networks are vital to develop businesses. And, to reduce the regulatory pressures on administration it is important to remove the obstacles to a smooth flow of information.

Human and societal capital

In addition to the technical themes, an agile and entrepreneurial workforce is a key to success in global competition. This pertains to breeding ICT top talent from current educational programs, but also to attracting talent from abroad, and rendering the current workforces agile and entrepreneurial. In addition, ICT also provides capital to society as it shepherds all information and all knowledge.

Future themes

The ICT roadmap is not static. Topics to consider for future roadmaps are games, social media, man-machine interaction, software engineering, and bio-informatics. They are among the themes that will connect several top sectors. The ICT Roadmap will be reviewed every year for the urgency of its themes.

4. ICT research and innovation implementation drivers

In this chapter we will discuss the means per stakeholder to implement the roadmap.

4.1 EIT ICT Labs

A sustained transformation in innovation through the integration of education, research, and business

EIT ICT Labs is a European public-private initiative intended to turn Europe into the global leader in ICT innovation by:

- Breeding entrepreneurial ICT top talent via the transformation of higher education to promote creativity and entrepreneurial spirit;
- Speeding up ICT innovation through ICT Labs for researchers, innovators and entrepreneurs;
- Generating world-class ICT business via broader and faster industrialization of research results.

EIT ICT Labs offers a joint program of international Master's schools, doctorate schools and professional schools as well as thematic action lines, research action lines and business action lines. All action lines integrate the knowledge triangle of education, research and business co-located in 6 nodes in Berlin, Paris, Eindhoven, Stockholm, Helsinki and Trento. Core industrial members for the Netherlands are Philips, Siemens, Nokia, Ericsson, Alcatel, SAP, Deutsche Telekom and France Telecom, where 3TU also plays a key role.

EIT ICT Labs mobilizes the Entrepreneurial Support Systems as currently organized by the Dutch (technical) universities and research institutes into an *international business strategy*. In a similar way, EIT ICT Labs leverages educational programs to boost international mobility and entrepreneurship, through its partner network of academia and large enterprises. Public-private research & development projects such as COMMIT, FP7-8 and ITEA2 projects, serve as important carrier projects for the EIT ICT Labs activities, especially in health and well-being, and smart energy systems.

Netherlands focus

The Dutch partnership in EIT ICT Labs has a focus on ICT technology for Health & Wellbeing, new business creation and professional and lifelong learning. In 2011, EIT ICT Labs established an international business-coaching infrastructure to support ICT spin-offs and SMEs. In 2012, EIT ICT Labs will launch the first year of the international Master's School, and the Doctoral Training Centres. In 2013, EIT ICT Labs will launch the program to address the educational needs of professionals. All programs feature international mobility, exchanges between enterprises and academia, and entrepreneurship.

4.2 COMMIT

COMMIT is the public–private program for research into ICT. It is the most experienced current vehicle to express the interest of companies in public-private research into ICT having registered €25 million in contributions in programs topically preceding the ones listed here. ESI, one of the key participants in COMMIT, has registered a substantial amount of company support. Also GATE, the Utrecht-centered program for gaming, another participant in COMMIT, has registered a substantial amount of additional company support. COAST invests in COMMIT research for the benefit of the analytical science and

technology community [49]. Support in the Roadmap ICT from companies will be arranged in public-private partnership contracts under the COMMIT consortium agreement.

To promote the national coordination of ICT – research, especially in the public – private segment, COMMIT will be transformed into a TKI.

4.3 TNO

The TNO contribution to the ICT roadmap is in the form of research capacity. Part of the TNO budget will be allocated to subjects described in this roadmap, always in programs together with industry from the top sectors and from the ICT-sector. The exact amount is to be discussed between TNO and EL&I and is dependent on TNO budget reductions that are foreseen in the period 2013-2016. TNO instruments to be used in the context of the ICT-roadmap are diverse.

Small Business Innovation Program

In the Small Business Innovation Program [31] innovative businesses are being challenged to combine their market knowledge and entrepreneurship with innovative technologies of TNO to develop new products or services and bring them to market. TNO supports SMEs in their process to market with technological and financial means: €25 thousand for feasibility and max €250 thousand for product development.

Co-financing

This is an investment instrument [32] based on policy and applied research means funded by the Ministry of EL&I. The total yearly amount is €23.5 million. To increase effectiveness for top sectors a small adjustment is desirable. This will allow for co-financers to contribute in kind. This is a good instrument for pre competitive knowledge development and research that can be used as a basis instrument for PPP programs.

Branch Innovation Contracts and Innovatie Prestatie Contracten

TNO research means that up to €4 million are available for the realization of BICs. The BIC with iMMovator is an example in the Creative Industry sector. BICs target knowledge transfer and network capacity building.

FP7/8 en PPPs

TNO participates in approximately 1/3 of all European ICT-research programs. Given the nature and topic of the specific research programs, consortia are being formed which often include private companies. Example projects can be found in the creative industry such as Fascinate [33] for media and ICT and Open garments in the textile industry [34]. The European Commission also uses public-private partnerships, such as Future Internet [35] to collaborate with (local) authorities, civil society and companies.

4.4 ICT Office

Since the publication of the top sector plans, analysis has shown that ICT has a role in every single sector. The role is either explicitly stated in the ambitions, or implied in the plans as an enabling technology to become reality. ICT Office and TNO have developed the Innovation Accelerator to clearly

define the ICT ambitions and needs of the sector, the steps needed to reach those goals, and the opportunities and threats the sector faces. The result of the accelerator is a plan for the short, middle and long term where ICT goals are being laid out, including spillover effects to other sectors. The Innovation Accelerator will give sectors insight into their ICT needs. It will provide clear business opportunities for ICT companies and research goals for knowledge institutes.

4.5 NWO

NWO is responsible for enhancing the quality and innovative nature of scientific research and for stimulating new developments in scientific research. NWO also facilitates the dissemination of knowledge. The ICT roadmap is implemented along two lines both in a national competition: supporting talented researchers, fundamental research and public-private partnership research programs. Each line will be strengthened by valorisation activities and may be supported by an international component.

Supporting Talent and Fundamental Research

Supporting talented researchers in their scientific career is a vital condition for scientific innovation. Encouraging the development of groundbreaking ideas is a key aspect of NWO policy. At the same time, reinforcing the knowledge chain from the start at fundamental research will return economic benefit, as countries around us recognize. Therefore, NWO will allocate budget for a *free competition*, with the only constraint that the research topic has to fit within this ICT roadmap. A similar construction might be foreseen with the Talent Line of NWO (a top sector *Vernieuwingsimpuls*). Financial commitment from companies will not be required for this implementation line. Establishing active connections between scientists and companies through user committees, for example, is part of this scheme.

Public-private partnership research programs

NWO has a long-standing tradition in public-private partnership programs, the thematic programs such as Jacquard with several sequential calls and the STW *Perspectief* program. The goal here is to be inspired and to inspire research. Also, the education of future personnel is a key motivation for the participation of the sector. The actual implementation in this line is by competition where public-private partnerships will be invited to submit a proposal under one of the themes of the ICT roadmap. As selection is on the quality of research and the quality of use-inspiration, some themes may have more than one project, whereas other themes may have none. In public-private programs, dissemination is a key activity and part of the budget will be reserved for this. Additional schemes, such as the Valorisation Grant or the *kenniswerkersregeling*, may be used for this as well.

The industry participation in the use-inspired or insight-inspired research is warranted by an in-kind active or an in-cash contribution of at least 25% of the program. The private commitment in the NWO programs will be arranged on a per-program basis. The actual participation of a specific company may be on the project level, in order to ensure maximum interest and benefit. In use-inspired or rather insight-inspired research, private partners will be invited to take the lead in the selection of the topic, similar to the standing practice in the successful ICT-FES programs, the STW *Perspectief* program and the NWO Technology Areas. Similar to COMMIT, the theme will be defined by industry. But unlike COMMIT, and similar to *Perspectief* and Technology Areas, the competition will be open. The arrangement warrants the best proposition in competition as is customary in science.

International activities

Science is international by nature. A strong embedding and benchmarking against international programs will ensure a maximum return for the Dutch science and industry communities. Furthermore, European schemes (EIT, FET, Horizon 2020, ERC) may provide additional financial matching for the national programs. NWO has a co-operation with ministries and science foundations in strong research nations such as China, India and the United States. These agreements lead to international cooperation through joint workshops, student and staff exchanges and research programs (including public-private programs).

Relations with other disciplines

Given their large impact in society, it is essential to engage other disciplines in the top agendas. Design of wind turbines and management of energy networks are based on complex mathematics. In the future, mathematics will also help to reduce energy consumption in homes by, according to some estimates, up to 30%. Shorter innovation cycles and the complexity of modern products demand wide-scale application of modelling, simulation and optimization techniques. Mathematics is instrumental in bridging various scales: from nano to macro. Comprehensive mathematical models are used routinely already. Future developments such as sensor networks will require development of a new mathematical foundation.

The impact on the foundations of public and private life is simply too big to leave it to ICT alone. Who owns the data on a social website? In an i-Phone? About your moods? About your body language? The commercial interest of these questions is the foundation of all social media. One could argue that data on a social website are completely private, and probably at the surface they are. But what level of anonymisation is needed to protect one's privacy? The discussion may be relevant and interesting here, but it is no less than life-essential in countries of repression. Philosophy and ethics should answer these questions and provide the grounds for a firm judicial foundation, and behavioural sciences should provide a commercial basis: what will the limits of practical use be?

Waves of technology will induce waves of social innovation, when the impact is broad. And in the case of ICT the impact is broad, as is also the case for bio and (expected) for nano. To some, ICT is social innovation, and quite rightly so. As ICT has shifted from automation to information, and information is the stuff power is made of, ICT has transformed the societal relations. Therefore, an essential political, sociological and psychological element comes with the current state of ICT. Study is needed to improve the ergonomics of interfaces, to predict user acceptance, and to summarize the influence on decision effectiveness in governments.

Democracy changes under ICT and digital media. A key notion in the digital agenda of Europe and the Dutch government promotes measures to avoid a digital divide. That does not only raise questions for ICT research into the simplicity of man-machine interfaces, but also for demography research of computer use in the population, and the conditions thereof.

ICT-theme, selective use and insight-inspired competition

The competition is within one, NWO-broad ICT-theme. Selection is on the quality of research and the quality of use-inspiration.

a. The roadmap is supported by a very broad and diverse set of industries with more than €25million in cash and in kind.
b. Among the many themes suggested, where no endorsing companies could be found, the theme has been removed from the list of themes.
c. It has been verified that the selected ICT themes have the consent of the top sectors, and that they are each useful to more than one top sector.
d. The implementation is by competition inviting public-private partnerships to submit a proposal under one of the themes. Industry participation in the use-inspired and insight-inspired research is warranted by an active in-kind or an in-cash contribution of at least 25% of the program.

As selection is on the use-inspired question *and* the scientific quality, some themes may have more than one project, whereas other themes may have none.

5. ICT Roadmap Action Lines

The action lines along the ICT-themes will be described in this chapter.

For each of the common ICT themes, the stage in the knowledge chain is indicated by:

immediate application of modern ICT,
the application of ICT-science,
use-inspired, fundamental ICT-science.

These are marks on a continuum of stages of knowledge as it becomes more and more practical during its development. For each theme, a tailored approach is chosen. Some common ICT-themes require immediate solutions and these solutions already exist in principle. For other themes, the distance between science and application is short, for example in cryptology for security. This is the preferred solution as the time-to-market for new ideas is shortest. Yet other themes require a longer incubation of science before they can be put into practice, yet the future need may be equally urgent. An example here is content exploration of the very databases that are growing everywhere. In such cases an intermediate step from science to application needs to be provided.

For the 2012 action plan, see chapter 7.

5.1 ICT one can rely on

5.1.1 Secure and vital ICT

Security is a multidisciplinary field that cannot be approached from the technological viewpoint only, and requires consideration for human, regulatory, and legal aspects as well. Specific topics that will be covered are: identity, privacy and trust management, malware, forensics, data management, cybercrime, risk management, and secure design. The topics range from scientific study to tooling and engineering. The National Cyber Security Research Agenda has been adopted by the Dutch Cyber Security Council. Under the umbrella of this agenda several research programs will be proposed with stakeholders who have demonstrated their support to the agenda both in the private and public sectors and ranging from applied to fundamental use-inspired research. Specific technical and scientific challenges include improving malware detection, prevention and removal. Also, finding usable solutions for privacy preserving identity management and for usage control of sensitive data and improving forensics tools and implementing accountability of users in distributed systems are key elements. And, improving the security of the critical infrastructure as well as analyzing the economics of security and the evolution of cybercrime. Realizing security and privacy by design as well as better tools supporting writing secure software and analyzing the security of software and hardware is important too. Finally, it is important to study the link between cyber-security, economics, risk management and regulations and the secure exchange of business information and administration: e-recognition, for example. Industries interested in the topics include: NvB, Rabobank, ABN-Amro, ING, Alliander, TNO, Riscure, Ericsson, Novay, SecurityMatters, Irdeto, Fox-IT, Civolution.

Vital ICT We observe that actions in this field are mostly triggered by incidents that erode rather than increase the trust in ICT-services by society, government and organizations [42]. Vital ICT is also a

multidisciplinary field, which combines expertise on networking, architecture and process design and service, continuity and security management. Specific topics that need to be tackled include reliable Internet infrastructures, ICT-robustness, reliable ad-hoc communication infrastructures, trustworthy Internet banking, and reliable sensor-based mobility management. Apart from acting against (cyber) attacks, vital ICT also reduces the effects of system failures in general. Service continuity is a key notion here. The strategic research agenda for Vital ICT is broadly supported by industry. Six out of ten strategic research themes identified by KPN are in secure and vital ICT. The strategic agenda of *IIP Vitale ICT*, is supported by Thales, Eurocontrol, Alliander, Belastingsdienst, DNB, DBC Onderhoud, IBM Nederland, Philips Research Lab, Rabobank, SIDN, Strukton, SURFnet and Wiser Consultancy.

5.1.2 Privacy and e-Identity

Personal data is the new currency of the data society, according to a recent report of the World Economic Forum. Through the intense use of social media, of search engines and mobile services, people collect and share relevant data and services while leaving traces of personal data. Important societal activities, such as health (electronic patient records), energy (smart metering), and mobility (road pricing) depend on personal data, yet face problems in implementation due to inadequate handling of privacy and data protection issues. Adequate safeguarding and management of privacy and personal identities facilitates acceptance and adoption of online services and commodities. Transparency measures, offering a clear perspective on what data are collected, for what purposes, and how they are used, are required to increase trust in the online world. Confronted with the need to control identity information in a multitude of situations, tools that help in managing personal profiles and identities encourage the uptake of services that are based on personal data. Measures to promote privacy and to increase transparency of processes in which personal data are used, will enable the spread and uptake of innovative ICT-based services. Several top sectors acknowledge this by urging for appropriate approaches and solutions on privacy and identity measures.

The enabling features of privacy and identity management systems for furthering information society services require research investments in technologies, business processes, systems architectures, consumer behaviour and institutional issues. A grand challenge in the application of science is the creation of a nationwide, trustworthy, interoperable, privacy-friendly identity management infrastructure, allowing for secure authentication and identification services, and supporting digital signatures. Especially challenging is the implementation of revocation mechanisms and building the system without relying on a single point-of-trust, issues which are not only relevant for identity management of individuals but for business activities of commercial organizations as well. This infrastructure would foster trust in other infrastructures that are built on top of this, such as in health (electronic health records), and iGovernment (online tax forms, *Digitaal Loket*); it is key in realizing the ambitions of the Digital Agenda, and supports various top sectors.

The uptake of privacy and identity management solutions depends on the appropriate understanding of business and administrative drivers and barriers and the role of legacy systems. This challenge is enhanced by the need to understand consumers' behaviour vis-à-vis privacy issues on a broad spectrum of applications, running from social media to e-commerce and transactional services and understanding the effects and possibilities of regulatory interventions.

Challenges related to use-inspired science address new approaches towards privacy and identity management. Physical infrastructures (utility, transport and logistics) critically depend on ICT. Dedicated ICT infrastructures (increasingly mobile, such as mobile payment systems), underlie most if not all societal activities. The design of these ICT infrastructures determines, at a fundamental level, the privacy and trustworthiness properties of all services built on top of them. These values must therefore be incorporated into the design from the start. The challenge is to develop new techniques and business methods to apply privacy by design and data protection by design, while maintaining security, accountability and functionality at the infrastructure layer. This involves the development of privacy design patterns and privacy enhancing technologies, and further developing the concept of revocable privacy and privacy impact assessments, amongst other things. These techniques are fundamental to achieving the goals of top sectors High Tech Systems - Security, Energy - Smart Energy Grids, and Health - Quality of Life.

The confluence of cyberspace and physical space into one ambient intelligent system based on the Internet of Things poses fundamental research challenges in the area of privacy and trustworthy services. The challenge is to empower users to exert control over the implicit construction of their identities by this infrastructure, for example in a smart living scenario. Development of new lightweight cryptographic protocols and new intuitive security paradigms that are user friendly are part of new research to be undertaken. This challenge applies to top sectors Creative Industries - Empowering Individuals and Health - Quality of Life.

Industries ready to invest in privacy and e-identity include KPN, SNS, Rabo, SIDN, Google Nederland, QIY, and COLLIS.

5.2 ICT Systems for monitoring and control

5.2.1 Control and embedded systems

Many ICT-systems exercise *control* over a function. *Embedded systems* are integrated hardware or software systems built into devices that are not necessarily recognized as computers. However, these embedded systems do control and actually define the functionality and quality of these systems. Embedded systems consist of multiple processing units, connected through wired or wireless networks. The size of the system components ranges from tiny battery-powered intelligent sensors and actuators, to large multiple-rack computing devices. Key concern for embedded systems is that they have to fulfil a wide variety of strict resource constraints on energy-usage, memory-footprint, processing power, space and weight. At the same time, they have to fulfil strict requirements regarding performance and dependability. The limited resources and strict extra-functional requirements distinguish embedded systems from ICT systems in general. Embedded systems occur everywhere: transport infrastructure and transport means; advanced systems for leisure and lifestyle; healthcare and well-being; dependable and secure communications; production; environment. Embedded systems play a key role in society, in and outside of the top sectors.

Design challenges for embedded systems Starting from system requirements, the design process creates the concrete system components step-by-step. Key challenge here is to make the last step of

design, the mapping onto the hardware, more systematic and less costly; in current practice, well over 50% of system development costs are incurred in this phase. Furthermore, dynamic integration is a new and important issue, especially for systems of systems.

Scientific challenges for embedded systems System design refines high-level system architectures by decomposing them into smaller components, finally leading to system realization. This requires many design decisions, covering multiple disciplines, and a careful trade-off between extra-functional concerns regarding performance, reliability, resource usage, energy usage, and costs. Key developments are necessary to come up with new methods to assess multi-disciplinary design alternatives and new techniques to enable large-scale system implementation (hardware, software). A first set of challenges relates to the use of models throughout the entire system design process, from the very early stages of requirements capturing to system integration, system test, and system evolution: How to manage and relate many different models? Which models are cost effective in which phases of the design and development process? A second set of scientific challenges, relates to the type of models being used, in particular, to the required classes of models and analysis techniques, such as to really support the design process. What are appropriate types of models? How to systematically combine and use different types of models multi-domain? How to cope with complexity and scalability?

The design and scientific challenges as described above are treated in more detail in the more specialized Roadmap for Embedded Systems, as part of the HTSM top sector plans. Companies supporting that roadmap include Philips, NXP, Thales, ASML, Vodafone, KPN, Vanderlande Industries, FEI Company, Océ, Grass Valley, Sioux, Assembleon, and many more.

5.2.2 Monitoring and sensor networks

Monitoring is a key element in the modern worlds of surveillance, production and logistics. In real world applications such as the monitoring of pipelines, windmill farms, and subsea installations, large scale, internet-based ICT infrastructure is needed to process the data, to make sense of it and to initiate actions. In the past few years we have seen the powerful ICT infrastructures arise, mostly using cloud technologies.

Another type of monitoring is protection. Advances in real-time signal and image processing and pattern classification enable the development of systems that can automatically detect suspicious behaviour. The emphasis is shifting from sensors, communication and data logistics to sense making, data driven modelling, interpretation and reasoning.

Sensors and actuators embedded in physical objects — from containers to pacemakers — are linked through both wired and wireless networks to the Internet. When objects can sense the environment, interpret the data, and communicate with each other, they become tools for understanding complexity and for responding to events and irregularities swiftly. The real world in which sensor networks operate in is difficult to operate in. Challenges include interpretation of real world observations, and complexity when dealing with a large number of devices.

Pervasive deployment in increasingly networked sensing systems requires the use of tools, which are necessary to turn special-purpose solutions into generic network facilities, which can be applied for a

variety of purposes and in different operating conditions. There is a strong need to be able to rapidly develop sense-making applications through common tools, programming models, and development support. It is imperative to design and develop energy efficient and miniaturized hardware, for integrated and multi-functional sensing, for analogue and digital signal processing, and for effective actuation. Ease of deployment and accurate control will be provided through the design and development of energy efficient communication, synchronization, collaboration, and artificial intelligence techniques.

For use-inspired science, the development in the top sectors indicates grand challenges for sensor-based surveillance, large-scale sensor network communication, and the coupling of heterogeneous sensor networks, including the use of smart phones. As systems become more dynamic and more diverse, system engineering at all levels of the sensing system becomes important. A platform approach is needed that aims at a service architecture, tooling and middleware independent of the hardware platform, supporting a wide range networking paradigms and applications. The in-system processing of distributed data, leading to decisions based on incomplete and unreliable knowledge will prove to be important for achieving reliability, efficiency and scalability. Efficient and robust radio technologies are needed to collaboratively use the scarce spectrum reliably.

Companies investing in the technology are amongst others Ten Cate, Volker Wessels Telecom, Siemens, Thales, IBM, Shell/NAM, FUGRO, Witteveen en Bos and Arcadis.

5.3 ICT for a Connected world

5.3.1 Standardization and interoperability

Several top sectors have indicated a need for interoperable (data and) information chains in their sector to innovate the business. Achieving interoperability, high on the priority list of CIOs, is essential for organizations to be effective into the dynamic and connected world. Today, in an increasingly interconnected world, interoperability is more important than ever, and solving problems caused by non-interoperability turns out to be very costly. Studies of the US automobile sector, for example, estimate that insufficient interoperability in the supply chain adds at least $1 billion to operating costs, of which 86% is attributable to data exchange problems [43]. Later studies mention $5 billion for the US automotive industry and $3.9 billion for the electro technical industry, both an impressive 1.2% of the value of shipments in each industry [44]. The adoption of standards to improve interoperability in the automotive, logistics, aerospace, shipbuilding and other sectors could save billions [45].

The European Commission is emphasizing the role of standards [46]. Standards for ICT will play a more prominent role in the EU in an effort to stimulate innovation, cut administrative costs, and encourage interoperability between devices, applications, data repositories, services, and networks. The Commission will demand that European standards for innovative products and services be quickly elaborated and adopted. In addition, recent EU-programs on PPPs have stimulated the interaction between specific application domains and generic Internet functionalities. The interaction should stimulate the efficient use of and influence on generic ICT-technology to improve uptake of new services in various application domains, thanks to alignment with large ICT-industry back-up using the economy

of scale, and alignment with user-behaviour. Domains in the PPP-Future Internet program include logistics, mobility, agriculture and smart cities.

The importance of standards and interoperability will continue to grow. Networked business models are a reality in today's economy [47]. For governments it is also essential for reducing the administrative burden on companies. A new challenge is *semantic* interoperability, for which many semantic (industry) standards are being developed, or need to be developed. Standards contribute to achieving interoperability. However the benefits of standardization have not yet been fully achieved. To grasp the full potential more and improved development and usage of standards is needed. Solutions such as methods, tools and techniques are needed, just like setting up public-private partnerships for standardization. An example is e-invoicing, where both industry and government are working together on standardization to achieve the full benefits of e-invoicing and the government goals on this subject.

Different sectors have developed different solutions, some more successful than others. Some sectors are re-inventing the wheel because of lack of knowledge of what has been developed in other sectors. An essential role is foreseen for the *Informatie Knooppunt Interoperabiliteit*. IKI is meant for development, use or reuse and dissemination of solutions across sectors, and together with both industry and government. General methods for standardization are available, MOSES for the creation of standards, and BOMOS for development and maintenance. Quality of standards also needs attention, along with improving the adoption and use of standards. The IKI platform will become the bridge to provide the knowhow into the sectors. And finally, solutions are needed for achieving large-scale semantic interoperability in complex settings across different sectors. The IKI will gather experiences of standardization in science and society for dissemination between government and businesses.

For the application of science the issue of interoperability of information is already an actual and fundamental issue for developments within the government [24], healthcare with e-health, crisis response, and in transport and logistics [5]. The advent of new technologies and economic developments such as the Internet of Things demands new scientific knowledge to support public and private sector organizations with expertise in dealing with the organizational and managerial problems that arise from these new combinations of organizing and technology. This research domain - which combines Enterprise Interoperability, Enterprise Collaboration and Digital Ecosystems supported by the European Commission over a number of years - is one important elements of the overall research field of the Future Internet, and has a specific research focus on ICT adoption and usage by enterprises.

5.3.2 Open data and services

On December 12th, 2011, the European Commission announced its strategy on Open data in the Open data directive [48]. Based on a potential market value of tens of billions of euros the EC took a major step in signalling administrations to free up their data as to stimulate innovation, transparency and quality of service. Also a national master plan Open ICT-platform is needed to provide a template for chains of information where efficiency through standardization is the key. A try-out is planned for the logistics sector, to be followed later by one for the agricultural and horticultural sectors. Dutch companies participate in international consortia on standardisation for interoperable smart solutions as CONTINUA e-Health and Smart Grids in Energy. More focus will be on horizontal dissemination of

knowledge and experience with standardisation strategy and valorisation. Companies and government are working together on open standards for electronic transactions as invoicing, standard business reporting and an electronic company file for lower administrative costs. An annual meeting between government and business on the re-use of open standards will also be organized.

And there is more. In a narrow sense, open data may be defined as freely accessible, structured and machine-readable datasets. Innovation is aimed at the disclosure of these datasets and combining them to new perspectives on existing information services such as *Buienradar*. In a broad sense, open data may be viewed as the re-use of large public and private data files, opening many possibilities. Examples are the aggregated data of pension and payroll service providers. Research on open data should include economic and societal perspectives, policy and governance in a service based economy. Research topics encompass interoperability and data service management, visualisation technology, heuristics and content retrieval. Finally, open data requires research from the human perspective: how is the empowered citizen involved? How may user generated data support governments and how does this affect the way citizens interact with their local and national governments?

And, open data may become enabler for a service-based economy. Today services constitute an increasing part of the Dutch and EU's economic activity, being around 70% of total employment as well as of the gross value-added generated by EU27 (Pro Inno Europe 2010). For the most part, the share of services of the GDP is growing all around the world. The ongoing transition from a manufacturing economy to a service economy and from goods-oriented suppliers to service providers is gaining momentum. This change does not only concern industry, but society as a whole. However, these developments do not automatically sustain a sound economic development.

Services do have real potential to contribute. Deloitte, a consultancy firm, concluded in its study of services in the manufacturing industry in 2006 that *the average profitability of the service businesses benchmarked is more than 75 per cent higher than overall business unit profitability, and accounts for an estimated 46 per cent of total profits generated today*. Deloitte also concluded that *in many manufacturing companies there would be little or no profitability without the service business [49]*. By offering services companies are endeavouring to facilitate product sales, to expand the scope and the life time of their customer accounts, to lengthen product life cycles, to create new growth possibilities on already partly saturated markets, and also to respond to customer demands.

This, however, raises critical questions with respect to IT-support of service-based business. Common aspects of services are that in general they are executed within a specific timeframe, are people based and information intense. Digitizing services have increased the potential for efficient, customer centric services. In practice a lot of servitization has resulted in failed IT-projects, budget overspending and a loss of trust in the value of IT. Research should focus on the support of services by agile, smart technology that empowers the efficient execution of service processes. Challenges in service science and innovation are agent technology, service distribution, interoperability and standards, semantics, trust- and data management for transport and logistics, e-health, crisis response, and government.

Relevant here from an ICT-perspective is a restructuring of the software, converting it into a software-as-a-service, SaaS. The development of open-standards based software products with flexible mechanisms for semantic interoperability remains essential. However, the engineering of product variability requires research into the integration of specific services for an industry sector, for special legal or financial ruling, or for individual customer conditions. Shared server resources by multi-tenant deployment will facilitate cost effective ICT-infrastructures in the private and public sector. Small municipalities or SMEs sharing software through a web-interface will obsolete the cumbersome systems management. Companies are ABNAmro, Achmea, ING, Rabobank, RBS, APG, IBM, Cap Gemini, and KPMG. Other companies interested in the service software industry are: Centric, Circle, Davilex, GX, Exact, VitalHealth, Planon, PostNL BDS, Ultimo, and Yuki to name just a few.

5.4 Data, data, data

5.4.1 Big Data

As hidden worlds were revealed through Van Leeuwenhoek's lenses, innovative data management reveals the hidden worlds within data. In our modern world the stakes are high. To truly understand the complexities of global warming, gene diversity, and industrial complexity, flexible eScience-infrastructures to dissect and manipulate Terabytes to Petabytes of raw facts are indispensable. The route forward is marked with better compute infrastructures, modern database management and software innovations.

Compute infrastructure Modern compute infrastructures seek a balance between commodities, easy to deploy, (public) clouds and privately owned powerful compute/storage clusters. The infrastructures consist of modern many core processors and use virtual machine technology, which isolates many of the hardware/operating system specifics. The innovation agenda includes data storage location and data movements in large-scale, distributed data centers (e.g. SARA); optimal allocation and execution of software to reduce the center's energy footprint; remote visualization using high-speed optical networks; best-practice guidance for software development (e.g. NLeSC). Examples: The potential use is widespread and applies to various top sectors. In healthcare, for instance, for accurate medical history evaluation and care plan analysis, in logistics, for better search answers to queries on scenario alternatives or in finance, telecom, life sciences, security, and many social networks.

Database management Next generation database systems for business intelligence and science exploration are in high demand. The sheer data size creates query result sets that are often too large to interpret. Instead, the user should be given the means to stepwise explore deeper and deeper into the database, and stop when the result and quality reaches his satisfaction level. Response times should be close to instant, to allow for interactive explorations of Petabytes of data. Innovations required span the complete software stack, for example, one-minute database kernels; blending science file repositories with declarative query processing; post-processing result-sets using data mining; informative summarization to aid in finding the right query; optimization against emerging hardware (Solid State Disks), many core machines (Graphics Processing Units) and distributed compute infrastructures. Examples: Query terms are mathematical equations rather than search

keywords. Social networks (Hyves) and market places (eBay) may grind more than 1 Terabyte/minute for marketing opportunities and potential (spam) attacks and frauds.

Software innovations Software innovations are needed to deal with the data explosion, the scaling of simulation models, and with the complexity of the underlying distributed infrastructure. The sheer size of the data can be partly addressed with modern open source tools (and industry standards) like the Hadoop MapReduce framework. A challenge is how to extend those systems to support more complex functionality, such as multi-model simulations, supervised or unsupervised learning, querying and reasoning. In addition, software innovations in the base toolkit (e.g. domain specific languages) are needed to take advantage of modern infrastructure: tools to program complicated many core machines (e.g. GPUs), adaptive schedulers to allow on-demand scaling in clouds and robust tools to harvest the potentials of many cloud resources. Examples: enabling peak compute loads for water simulations during a crisis; coupling different models (atmosphere, water, land) in climate simulations.

Companies interested in the theme are Philips, MonetDB, Vancis, SIG, Serious Toys and high-tech SMEs.

5.4.2 Data and content exploration

More and more of everyday life is being digitized. This results in large and heterogeneous user data and user generated content streams. Digital data and content knowledge are stored, in very large amounts. The challenge is to create intelligence, to take better decisions, and to learn what the customer wants from streams of user data and content: to extract and exploit knowledge for individuals and organization across the various forms of information: text, sound, speech, image, and videos.

So far the world has been dominated by official content produced for a purpose: forms to fill in, media, new papers written, books, rules and regulations. Now, in a networked and sensor-rich world accidental content is also being observed: about humans, about growing stock in agriculture, about traffic in logistics. What is needed in the long run are intelligent algorithms that combine these sources of content with human centric interaction and intuitive user interfaces. It is important to track information over time to detect trends, to make predictions and to adapt to our environment.

At the level of implementation, the application of intelligent lighting solutions is a good example of integrating ICT in our living environment. Recent developments in solid-state lighting technologies open opportunities for the development of intelligent lighting solutions. Future lighting systems will consist of wirelessly connected distributed networks of small lighting devices that are controlled by smart sensor networks and intelligent algorithms that combine context information with human centric interaction concepts embedded in intuitive user interfaces. How does light affect the brain? How do people interact with light as a computer interface? How does lighting combine with outdoor clothing? How does ambient lighting optimize well-being and well-working? Can we contribute intelligence to light design?

For the application of science, linked open data is the key. A frequently perceived hurdle for the widespread usage of open data in the top sectors is the lack of standard formats and interfaces. The challenge is to automatically generate wrappers around open collections of spoken text, written text, image collections, video collections and/or sensory data so that they can be queried. Linked data

describes a method of publishing structured data so that it can be interlinked and become more useful. Linked open data uses open datasets to provide meaning to mentions of entities and locations in text, audio or video. The challenge of large-scale linking is to develop algorithms based on machine learning that automatically fuse spatio-temporal data into heterogeneous streams.

For use inspired science, the top sectors ask for semantic and cognitively plausible exploration solutions that are self-learning. The challenge is to transition access to information from a document-centric paradigm focused on returning disconnected atomic pieces to a truly semantic aggregation paradigm, eventually leading to devices and environments that understand a user's intent, discover and organize facts, and identify opinions and experiences around them. Manual ways of turning omnipresent streams of human signals into meaningful information are beyond the capabilities of most organizations. The challenge is to design exploration methods based on self-learning algorithms that exploit social signals to improve their functioning. Information is both a unifying scientific theme and a key resource. The challenge is to understand how the representation of external information aligns with internal (neural, intuitive, social) representations as these can now be observed through fMRI scans, internet-wide sentiment analysis or cognitive studies. The goal is to arrive at fundamentally new exploration methods at the level of human cognition.

Companies interested in the theme are Philips, Noldus, Euvision, Treezir, and many high-tech SMEs.

5.A Value and information chains

In addition to the technical components above, the impact on the value and information chains is important as well. ICT challenges existing chains and promotes new ones. ICT has an immediate impact in business value chains.

5.A.1 Business value chains

To implement the solutions as proposed by the top sectors, new approaches to innovation are required. Innovation chains are no longer organized in a linear or top-down fashion. In many cases, high-tech SMEs have become knowledge providers, competing with universities for state-of-the-art knowledge. Start-ups from universities, high tech SMEs and large companies should work closely together in both competitive and non-competitive settings, and in multidisciplinary teams. What is needed is a *networked innovation model* to match invention, innovation domain and business. To support the new innovation models, EIT ICT Labs supports the creation and growth of *new companies*, as well as the innovation in *existing value chains*, for example, through higher involvement from high-tech SMEs.

New Business Creation will receive integrated support for new, young research-based, market driven ventures. Entrepreneurship Support Systems stimulate the birth and growth of new and young ventures. EIT ICT-Labs builds upon and improves existing regional activities and provides international opportunities for growth, amongst other things by giving access to an EIT ICT Labs wide network of cooperating business developers. Its main goals are:

- Creating larger ICT-based spin-offs / spin-outs
- Fast and international growth.

In 2012, EIT ICT Labs will launch four new instruments:

- *Embedded coaching:* Embedded coaching supports young SMEs in their business approach and helps them to realize more global market propositions.
- *Soft landing places for companies and ideas:* Implementation of a roadmap to receive the soft landing NBIA accreditation or to develop a similar soft-landing EIT-label for the European market.
- *Specific training modules:* Aim of this training – which has to be developed - is to prepare entrepreneurs for doing business on a European scale.
- *Recruiting potential serial entrepreneurs and board members:* Increase the success of new ventures and their international growth by keeping a database with serial entrepreneurs and experienced board members.

Innovation in Established Companies & Value chains The underlying idea is to make the large companies more flexible and agile by using the SME ecosystem, and to strengthen the SMEs through the R&D resources of large companies or university expertise. EIT ICT Labs will provide:

- Access to new business models and experts: Business Modelling Catalyst
- Access to new partners in Europe: Business Club Catalyst
- Access to new technologies: Technology Transfer Program Catalyst

In 2012, the focus is on:

1. *Platform & services:* Providing a toolbox for SMEs and large companies for business models, scenario techniques, collaborative business modeling, and road mapping.
2. *Networking:* Reinforcing links between EIT ICT labs and the main actors of business development in each country focusing on high-growth corporations by Cross Cluster and Business Club Catalysts.
3. *Technology transfer:* A toolbox to detect, stimulate and support Technology Transfer opportunities between academic research organizations and industry.

A new instrument is *SMEs and soft landing services* for SMEs desiring to grow to new markets in Europe.

5.A.2 Accelerating Innovation

As the ICT Roadmap is not fixed, looking beyond 2012 will require a constant update to stay in tune with the needs of the top sectors as they are developing. One means to achieve that is to organize a dialogue with the top sectors throughout 2012 and further years to get insight into the developing demands for ICT in the top sectors. By organizing Innovation Accelerators per top sector, the current and future ICT needs of the top sectors may be articulated. The Innovation Accelerator will point out ICT business opportunities for each top sector. This way the top sectors can be stimulated to look beyond the horizon and develop new visions on how ICT can help them innovate to a new level and this can be added to the ICT Roadmap for 2013.

5.A.3 Cost reduction by ICT process innovations

The regulatory burden could be substantially reduced if the flow of information between public organizations and companies based on laws were to be handled electronically. ICT-solutions may support process-innovations by *chain reversal*. A higher reduction of the regulatory burden is achieved by simplifying data transmission by standardization. Currently, the government is running projects with companies for nationwide roll-out of Standard Business Reporting, e-recognition and e-Invoicing for business-to-government processes.

Bottlenecks in the information chain will not simply vanish and cannot be removed by individual companies. Therefore chain reversal and chain optimization with public and private partners are necessary focusing on cooperation, business cases, standardization and ICT-solutions with added value. In this approach companies can fully focus on their core-competence: doing business. Public organizations can be organized more neatly and the inspection of compliance with laws can be renewed. Two public-private programs have been set up to achieve an electronic and more simple flow of information to reduce regulatory costs: Company File (OD) and smartly connected, smoothly organized.

The purpose of the program Company File is that information entered once by a company can be used repeatedly by public authorities. The simplification of data exchange within a chain and the introduction of an electronic business file could reduce the administrative costs by at least 15% for companies involved. Implementation of the Company File started in the fourth quarter of 2011. The Company File will be introduced in the hospitality and recreation sectors and in the rubber and plastic industry. Following an evaluation, a decision will be made in the second quarter of 2012 on broadening of the introduction of the Company File during the period 2012-2014. The government will launch a study on the possibilities of introducing the Company File in leading sectors as Agro & Food, Horticulture and Creative Industry.

The program smartly connected, smoothly organized (SGGV) facilitates organizations that are operating under tight control chains to communicate more efficiently by appropriate ICT-solutions (chain optimization). This could reduce the administrative costs by 10 – 30% for companies involved. Keys for success are commitment of chain-partners, demand driven solutions, reuse of information and public-private partnerships. There are several successful cases, based on a positive business case - of public and private organizations working together to cut red tape and perform better. These cases provide a solid basis for further optimization in a sector by the chain partners themselves. This approach is successful: more than 100 companies, 20 branch-organizations such as VNO-NCW and MKB Nederland, departments, provinces, municipalities and inspections are involved.

Running and closed cases are in the sectors Agro & Food (administration of calves, e-Journal fishing), Logistics (import of flowers and plants by air, import of veterinary goods via Schiphol), Creative Industry (licenses for events) and Construction sector (supervision on handling of asbestos). Cases in research for reducing the regulatory burden by chain optimization have been identified: registration and usage of herbicides (Horticulture), registration of emissions (Energy) and registration of substances in REACH (Chemistry).

A *National Single Window for Trade and Transport* will be launched soon, allowing companies to supply information once for repeated use by various public organizations, thereby increasing the efficiency of freight transport and, consequently, strengthening the competitiveness of the Dutch logistics sector.

Furthermore the Ministry of Economic Affairs, Agriculture and Innovation is carrying out an investigation for chain optimizations specifically for the top sectors Agro & Food and Horticulture. As a result the investigation identifies specific bottlenecks and solutions - by means of the use of ICT – for further reduce regulatory burden in these sectors. Results will be available during 2012.

The entrepreneur plaza will be the portal for companies through which e-transactions can be made with the government. The first phase of this portal will be realized in 2012 and it will be in full operation in 2015.

5.B Personal and societal capital

The pervasiveness of ICT and its immediate impact does stop at borders. It is important for the success of the ICT-Roadmap to invest in the international orientation of entrepreneurs and the societal capital of ICT.

5.B.1 Personal capital

EIT ICT-Lab equips students, researchers and professionals with creativity and entrepreneurial capacity by seeding and breeding entrepreneurial skills and attitude, craftsmanship and knowledge of innovative technologies. Guiding principles are robust entrepreneurship education, stakeholder involvement in educational programs, hands-on experience on innovation and entrepreneurship, and international mobility. In 2012, EIT ICT Labs will start new programs through the Master's School, the Doctoral School and the Professional Learning Program. *Co-location centres* will be the nucleation points for co-operation between various stakeholders.

EIT ICT Labs Master in ICT Innovation Students will be enrolled in international Master's programs in *ICT innovation* in which they will be awarded an EIT ICT Labs labelled degree referencing EIT ICT Labs specific learning outcomes. The Master's School will have a uniform structure:

- a set of technical majors that include a common technical competence base and a specialization/ thesis part that has a thematic area focus (90 ECTS);
- a fully standardized minor in Innovation and Entrepreneurship (30 ECTS);
- thematic workshops and Summer Schools in societal sectors of interest, such as Smart Energy Systems, Health and Wellbeing and Intelligent Transport Systems.

The Master's School consists of 7 technical majors: Human Computer Interaction and Design, Digital Media Technology, Service Design and Engineering, Internet Technology and Architecture, Distributed Systems and Services, Security and Privacy, Embedded Systems. Students will be provided with real hands-on experience through extensive embedded project work with external project owners. Innovation, entrepreneurship and industrial embedding are key components.

EIT ICT Labs Doctoral School The EIT ICT Labs Doctoral School will address the needs of PhD students through the set-up of environments where young doctors may grow business projects founded on their thesis research, inspired by the British *doctoral training centres* experience, that integrate industrial involvement and MBA like studies in ICT innovation and entrepreneurship. In Eindhoven, a Doctoral Training Centre will be started in the focus area of Health and Wellbeing.

Professional and Lifelong Learning The need to attract and foster talent is not limited to students and researchers at the PhD level. Companies such as ASML, Philips, Océ, and Thales need to install entrepreneurship in their current workforce, and also need an influx of insightful, talented people to speed up innovation processes and to enter new products and services domains. EIT ICT Labs will outline a *professional learning program* to make professionals more dynamic through thematic

workshops, summer schools, specific courses and exchange programs. This program will feature inspiration from new technologies and different domain contexts, as well as Innovation and entrepreneurship competencies, and quality in ICT through certification. Change of (professional) context, as possible through the international EIT ICT Labs partnership, is a recurring element of this program.

5.B.2 Societal capital

The multiplier effect of ICT The *information factor* in R&D and strategic innovation processes will be researched on its strategic merit. It is a most important enabler of business and partnerships. The research will take away the emphasis of ICT primarily as a matter of technology in favour of the realisation that information is the stuff by which networks (organisational, productional, innovative) are defined. Hence, this intrinsic network quality matters as well. It is important how sufficient awareness of the consequences of the multiplier effect of networks and composite information and the challenges owing to the networks is reached. Is it by transparency? By standards and precision? By an evolutionary process? These challenges relate in particular to governance issues on information quality, accountability, ownership and responsibility as well as to liability in networks and data chains.

Philosophical aspects of ICT Other aspects of ICT in society cover the philosophical issue: what in fact is information? Information grows in its use. And, the meaning of information is not strict but highly context-defined. A systematic semantic and ontological meaning is of importance as the grounding of future generations of complex information systems. In times where new media fall under digital interpretation, what is the essence of the information content of pictures as it differs from categorical information? When someone enters social information, who is the owner? Is it the consumer or is it the industry providing the service? If the latter choice is preferred, what ethical and moral consequences are connected to the transferral of the most intimate data? These are just a few practical, philosophical questions to be studied now for the benefit of future generations of information system users.

6. Operation

This chapter discusses the governance, budget and IPR.

6.1 Governance

The funding of the roadmap is from private and public sources: government, companies, NWO, STW and TNO. Investments in general purpose technology, as ICT is, will stall when others than the driving company have an unreasonable advantage. Therefore, it is generally accepted that investment in ICT-research and ICT-infrastructure needs public support.

TKI for ICT For the exchange of experience, which is an important part of ICT-knowledge, a TKI is the preferred form of cooperation. We adopt the model developed in Bio-Based Economy [41], another top sector transecting roadmap. The development towards a broad coverage of modern ICT in all top sectors is dynamic and highly interactive. The process will involve participation of industries, knowledge institutions and governments in a public-private partnership or partnerships. The core should be use-inspired research or the application of research. The model of governance should allow for a flexible and ad-hoc definition of partnerships geared towards the shortest time-to-market. It should balance an instant response to opportunities and the time and tranquillity it may take to study a difficult problem. It should be capable of being steered by commercial consideration without jeopardizing the academic integrity, which in the end serves the best interest of the industry as well. All of this will lead to new coalitions all the time. The governance of the top sector is geared towards the innovative and open dynamics on the basis of the following principles:

- Strategic choices will be supervised from the *ICT-Raad*, see below, identifying new opportunities and recommending new chances to the stakeholders to form new coalitions.
- Attention will be paid to the scouting of new uses, to be delivered as new forms of use-inspired research items on the agenda.
- Attention will be paid to technical and scientific themes, up for reconsideration and possible renewal every year.
- Attention will be paid to the aspects of human capital, business development including business model innovation to which ICT is so prone, and ICT-aspects affecting society at large.
- Shelter will be provided for the high-tech SME, as well as for the data-intensive SMEs in their transition towards an ICT-intensive company. The shelter will aim to accelerate business opportunities when the science is at too high a level to be ready for market.
- The TKI will be grounded on a joint effort as laid down in a consortium manifesto directed towards the joint development.

Part of a TKI is a concentration of all knowledge institutes aimed at high-tech SMEs from the same branch where the innovation and connection of expertise is essential to survive competition. The core of the rotating-door institute would be academic expertise and the combined know-what of the companies. The purpose would be to research and provide technology to fill the technology gaps of companies. An example would be to provide software design technology for game companies to make their design processes more efficient. Another example would be to provide search engines on digital

databases replacing the need for manual annotation. The contribution to the institute is in cash in exchange for providing a fellowship to the contributing company. The ownership of the know-how is provided to the company on a non-exclusive basis.

ICT-Raad Ownership and Governance go hand in hand. Primary owners of the ICT Roadmap part-by-part are those organizations that contribute to the funding of this Roadmap. They are:

1. NWO/STW/IPN: fundamental and application-oriented research
2. TNO: applied and innovation-oriented research, accelerator
3. EIT ICT Labs: education and mobility with a European dimension
4. Digital Agenda (Min EL&I): reduction of rules
5. Companies: cash contribution to research (still to be identified)

Secondary owners are those that contribute in kind, large Public-Private Partnerships, or as matching. They are:

6. Academic organizations (NIRICT/CWI/Non-tech universities): research
7. Companies: in-kind contribution (still to be identified), demand-articulation
8. ICT~Office/CIO Platform: representative of ICT providers, producers, and users, accelerator
9. Surfnet/e-Science: universal ICT infrastructure
10. PPP hosting organization: COMMIT+

The ICT-Raad will be formed consisting of the primary owners and representatives of the various secondary owners. The ICT-Raad will be chaired by an independent chairman with a strong background in ICT. All yearly and multi-annual plans will require approval of the ICT-Raad.

6.2 Budget

The budget for the execution of the ICT Roadmap is drawn from several sources as required below.

Companies, large and small, have signed a public-private contract or letter of intent. They are motivated to spend their R&D-activities in the context of this roadmap in return for participation in the ICT Roadmap TKI. The industry turnover in R&D in the Netherlands for ICT covers 10 – 50% of all top sectors. On average it is estimated at 30%. For a total estimated participation to the top sectors of €1 billion each year, this boils down to €300 million each year in ICT, a part of which will go to ICT innovation.

For one, the industry and non-profit organizations part of COMMIT are prepared to support the use-inspired research after its conversion to a TKI under this Roadmap. The topics covered in COMMIT comply with the action lines 5.2 Embedded Systems, and 5.4 Data in the Roadmap. The Roadmap will offer new opportunities to the partners of COMMIT and the use-inspired research it endorses.

Funding from the EU is estimated to be €10 – €15 million each year, mostly to universities and knowledge institutions.

The partners of TNO have indicated they are prepared to participate in the application of science under the Roadmap. They have indicated that they will increase their R&D-budget spend on topics of this

research agenda. For one, KPN has announced it considers spending in excess of €6 million each year on R&D activities in TNO's institute. The Roadmap offers new opportunities for these industries.

[in Millions of €]	2012	2013	2014	2015	2016 & beyond	
Companies 40% cash & kind	50	60	70	80	90	Estimated for COMMIT TKI
EU - funding	12	12	15	15	15	Estimated current
EU-EIT ICT-Labs / person & business	5	7	8	8	8	Conditionally committed
NWO incl STW / current	10	10	10	10	10	Required for 2012, under negotiation for later yrs
/ additional for ICT Roadmap	10	15	20	20	20	
TNO	6	6	6	6	6	Required
Digital Agenda	8				8	Required
Research institutes 10% cash & kind	9	10	11	11	11	Roadmap
Total	110	120	140	150	168	

The companies connected to ICT Office are prepared to help to execute the implementation of the Roadmap, especially where they see opportunities to accelerate the innovation per top sector.

EIT – ICT – Labs is a large EU – funded enterprise for the acceleration of innovation and know-how in ICT, where the Netherlands is one of six nodes, next to France, Germany, Finland, Great Britain and Italy. Their participation in the Roadmap activities provides an excellent forum for the EU-connectivity of research and emerging business from the Roadmap. The EU – funding requires 75% co-funding from the national funding, either in cash or in kind.

Apart from transecting top sectors, the Roadmap is also aligned with the implementation of the *Digital Agenda* of the Netherlands, moulded after the European Digital Agenda by EU – Commissioner N. Kroes. The Roadmap includes action lines for relieving the regulatory administrative burden by information integration along the information chain, applicable to many top sectors. For the Digital Agenda the PRIMA-regulations will demand 50% co-financing.

NWO will increase its investments dedicated to ICT-research for the action lines in this Roadmap.

TNO will deploy several instruments for funding applied research, valorisation projects and proof of concept projects. The instruments include Small Business Innovation Program, Branch Innovation

Contracts and the EL&I co-finance program. All programs suit specific types of innovation. TNO has been invited by the Minister of EL&I to apply ICT-funding to the order of €6.2 million a year to the ICT-roadmap and the top sectors for the next 5 years. The €6.2 million is partly EL&I co-financing to be matched by industry, and partly it is knowledge building funds to be applied with less matching funding. For 2012 and 2013, part of the budget is assigned in FP7 programs and COMMIT. Most of these long-term obligations match with the scope of the ICT-roadmap. Part of the remaining funds will be allocated to top sector specific ICT-projects, see chapter 2, and aimed at the Creative Industry, HTSM, Water, Energy and alike. The other part of the budget will be allocated to generic ICT-subjects described, see chapter 5. However, the budget is insufficient to meet the requested budget based on the combined requirements of the top sectors as voiced in this roadmap. Therefore, the final allocation of the budget will be done by TNO together with EL&I, taking other TNO contributions to top sectors into account.

The yearly ICT Delta conference will be the natural place to meet for public-private research and innovation in ICT.

In this stage we register the well-motivated intent of top sectors indicating the relevance of ICT, the motivation of the stakeholders such as NWO, TNO, companies and their representatives, and the Government. When projects are concrete, a conditional factor in the selection of projects is the commitment of companies *for that project*. Only when projects are sufficiently concrete (including IPR), will the various stakeholders sign a contract.

6.3 Intellectual Property Rights

The intellectual property in ICT takes several forms.

One variant is a contribution of cash in exchange for the IPR potentially developed in the program. In another variant, the contribution of cash is used to invite a scientist to contribute specific know-how to the industry. In practice, these two variants may be combined leading to the exchange of IPR for know-what and cash in proportion to the added value. These variants will work for the larger industries with well-protected knowledge in an R&D unit of the company.

At the same time it is often the case in ICT that advanced *know-how* is the key-ingredient of the competitive edge. In ICT new ideas often have a broad impact and they are difficult to police. Therefore, ICT differs considerably in their handling of IPR compared to other disciplines where the protection of IPR in patents is the key to success.

On the basis of these observations, for the publicly funded part of the roadmap, the default option is to create open and open-source standards enabling the free exchange of information between vendors.

For the NWO-part of the roadmap, we will follow the IPR-statement of NWO, developed for the HTSM top sector [39]. The statement describes a tailor-made solution to IPR differentiating between cash and in-kind contributions, and enabling industrial innovation by regulating the limits of the free flow of knowledge and know-how. The purpose is to enhance innovation in short time-to-market by open communication in the consortium while safeguarding the legitimate rights on the use. Open communication in a limited environment is the best way to fundamental, use-inspired research of top

quality. As a standard policy all partners in a public-private consortium under this roadmap will agree on IPR as part of the consortium agreement, which will include an agreement on licensing, the ownership and handling rights of patents, and an agreement on the commercial validation of the research results.

7. Roadmap 2012

This chapter discusses the plan for 2012 and the budget by partner.

TNO has defined specific actions for 2012 most of which take the form of multiple projects in close co-operation with Dutch industry. The actions as cited below have been specified in the TNO-mission statement for 2012 [51]. In general, TNO-projects depend on participation of the private sector.

NWO-programs are defined in competition where both the quality of the problem articulation, its relevance to the roadmap and its precision, and the quality of the proposed research, its novelty and its estimated impact, are key elements in the ranking.

The projects under the Digital Agenda comply with the *Uitvoering Digitale Agenda 2012*.

7.1 The 2012 roadmap actions

1. *ICT one can rely on*

In 2012, given the need for ICT industry and utilities one can rely on, NWO in the context of the Roadmap will initiate programs of science, and the application of science in secure and vital ICT, as well as on privacy and e-identity. The projects will start in the first half of 2012.

TNO will continue to deploy projects to research cyber-security issues, robust access technologies, and cyber continuity. Mobile technologies, secure DNS, IPv6 and agile service provisioning are also subjects for programs to start in 2012. In 2012 the privacy and identity lab of TNO, University Tilburg, University Nijmegen, and SIDN will contribute by performing research projects in the area of privacy and e-identity. TNO will participate in the FP7 project PRISMS on privacy by design. In addition, TNO will explore with industry the option to establish an expert knowledge transfer point aiming to respond quickly to questions from industry how best to deal with privacy issues in ICT projects.

And, implementation projects will be run as part of the implementation of the Digital Agenda, implementing parts on security and e-identity.

2. *ICT Systems for Monitoring and Control*

In 2012, embedded systems will be part of the execution of the Roadmap Embedded Systems in the HTSM top sector agenda. For monitoring and sensor networks NWO / STW, a program will be defined by competition. Projects will start in the first half of 2012.

TNO has several projects in 2012 in this area varying from community based environmental monitoring to advanced application of sensors in dikes to establish flood control.

3. *ICT for a Connected World*

In 2012, the connected world will be supported by the program for open and standardized data exchange for mass data exchange and streamlining the information chains. The *Informatie Knooppunt Interoperabiliteit* will commence to provide knowhow. A national master plan Open ICT-platform will start around open geo-data. Research effort is needed in semantic interoperability and service science.

TNO will cooperate with ESI to improve networking options within embedded systems to improve efficiency. TNO will be involved in projects in 2012 to further research the application of intelligent sensor networks for flood control and other forms of monitoring.

4. Data, data, data

In 2012, given the need to do something with large amounts of information and data everywhere, NWO in the context of the Roadmap will initiate programs of science, and the application of science in big data and cloud computing as well as in content exploration. The projects will start in the first half of 2012.

TNO is owner of various large public datasets. Some will be used for experimenting with Open Data uses. TNO will work with government to investigate whether the government can be more efficient through the usage of open data. TNO will conduct projects in the field of data mining and adaptive content to explore the content of large datasets. Business modelling for data collections is another, new topic of study for TNO in 2012.

Value and information chains

In 2012, by means of the EIT ICT Labs four activities on new business development the Roadmap will employ: embedded coaching, soft landing places for companies and ideas, specific training modules and recruiting potential serial entrepreneurs and board members. And, for the innovation of established companies and value chains, the roadmap by means of the EIT ICT Labs will commence platform & services, networking and technology transfer. In addition, for the reduction of the regulatory burden, the first phase of the entrepreneur plaza and the pilots on information chain optimization will be ready by 2012.

An Innovation Accelerator to be organized per top sector in 2012 will articulate the current and future ICT needs of the top sectors. The result of Innovation Accelerators will point at the ICT-business opportunities and research needs of each top sector. A budget of €250 thousand will be required.

A budget is required for the yearly public-private national conference *ICT Delta* as the natural meeting place for ICT research exchange. NWO, STW, COMMIT, TNO, ICT Office, ECP, the Digital Agenda will each be invited to invest €25 thousand plus an additional €25 thousand in kind to organize the meeting.

TNO will deploy projects in 2012 in the areas of agile service provisioning, adaptive content, and quality of standardization of information exchange, financial logistics and secure transaction solutions.

ICT and society

The impact of ICT on society in terms of capital and skills. will be addressed by several projects from EIT ICT-labs, NWO, all universities, colleges and TNO.

TNO will establish a Dutch Learning Lab 2012 to address the e-Skills issues in the Digital Agenda and to promote lifelong learning opportunities. Furthermore TNO will contribute in this area through privacy research. Finally TNO will sponsor the establishment of a professorship for research on the philosophical aspects of ICT.

7.2 The 2012 financial plan

The following budget needs are indicated.

Plan 2012 [in Kilo €]	1 ICT one can rely on	2 System for monitoring & control	3 ICT for a connected world	4 Data, data, data	*In addition* Value and information chains	*In addition* ICT and society
Companies for ICT Roadmap	8000	8000	8000	12000	8000	6000
EU funds	2000	2000	2000	6000		
NWO incl STW for ICT Roadmap	5000	5000	2500	7500		
TNO	2000	1000	1000	1000	1000	
ICT Labs personal + business					3000	2000
Digital Agenda	1000			1000	4000	2000
Research institutes 10% in cash & kind	3000	3000		3000		
total	21000	19000	13500	30500	16000	10000

8. Conclusion

8.1 Summary

ICT is an important ingredient in all top sectors. The estimated level of activities in ICT is 10 – 50% of all activities. It is safe to conclude that 30% of all innovation is ICT-involved innovation. This is also supported by evidence from other sources. ICT is by far the largest technical discipline of innovation.

All top sectors underline the importance of ICT for their plans. The activities sort according to 4 different ICT-themes:

1. *ICT that one can rely on* to make ICT secure, vital, and private.
2. *ICT systems for monitoring and control* practically all production and business processes.
3. *ICT for a connected world* filling gaps in information chains to run businesses more smoothly.
4. *Data, data, data*, to store, to move and to interpret the data for business opportunities.

As well as these technical and scientific themes, attention also needs to be paid to:

A1. Value and information chains

A2. Personal and societal capital

They will be part of the human capital and valorisation agendas of the top sectors combined.

Top sectors have shared their vision. For the ICT part of the vision, the top sectors may profit from innovation acceleration to further articulate their ICT innovation needs.

All signs indicate that an increase is required in the ICT research and innovation budget by a substantial amount to respond to the overwhelming interest in all top sectors. As the public budget for ICT research and development is growing, so should the public budget to warrant long-term ICT research.

Attention is needed for the high-tech SME as part of the execution of this Roadmap.

The Roadmap aligns with the goals of the Digital Agenda.

A few new aspects of ICT: software engineering, social media, games, man-machine interaction, to name just a few elements, are not yet on the radar of the top sectors at large. More dissemination will be done.

8.2 The further impact of ICT

ICT delivers. It is the driver of innovation, disruption and productivity. While in the past ICT has been primarily *supportive* to render societal and economic processes more efficient and effective, we have witnessed in recent years that innovations in ICT are increasingly *disruptive*. Fibre broadband connections have enabled large-scale outsourcing to emerging societies. Business models for a 100-year old music industry have been turned upside down within a two-year timeframe through 'cloud'-like services such as iTunes. Immediate interconnected control in the financial industry is at the root of recent financial turbulences. And in politics, global interconnectivity causes turmoil when information-empowered individuals take little for granted. Hence, ICT is also the driver of *social innovation*. Have you read your email in the last hour?

And, as the next step, all things will receive an Internet address. They will participate in the information-connected world. Stores with RFID-stock, all goods labelled from production to consummation. And even prior to that, all goods will exist as an information entity at the moment of ordering. Mass individualization is the result, from conception to the end of a lifetime. Investing in mass individualized information will pay off immediately as soon it has become the standard level of expectation. The consumer is taking over the driver's seat. New business models and new businesses are necessary to adjust to these new developments.

ICT contributes to sustainability in production, service offerings and products themselves. Smarter energy through ICT is almost always a direct cost saver, matching efficiency to sustainability. Smarter observations by sensor networks will evolve to the standard where everyone in a society wants to be informed immediately. And last but not least the ICT-systems themselves need to be greener in order to make sure that ICT worldwide starts to consume less energy.

Personal data can help our society where bicycles are used to gather information on noise, air-pollution and travel-times in Copenhagen [29]. The essence of this innovation is information, everywhere, attached to everything. All that data allows for data storage in the cloud, modeling and monitoring all in real time. This will help to increase the quality of life in terms of comfort, ease and safety. But data has more uses. It is hard to imagine that any business will do without customer profile data 5 years from now. Businesses will analyze their customers routinely, from video, from profiles, from sales. Production and service delivery chains will be shortened and individualized by ICT and ICT only.

ICT innovation is getting closer to the human and closer to the skin. Man-machine interaction is improved by every new generation of systems, is improved by sensors everywhere, and it has improved by going mobile. Man-machine interaction using voice and video will come soon. Deploying efficient man-machine interaction [15] has been demonstrated to be a driver of new ICT-businesses.

Increasing the trustworthiness of ICT is hampered because of the complexity of today's software and ICT systems. Software legacy is a key problem in the operations of businesses. The science of software engineering, the science of information management and the science of systems of systems prevent the disasters of failing large-scale system introductions we have seen too often in the past.

The recent success in the service industry has been largely driven by ICT. To continue this path, radical changes are required in the software systems that are key to agile service compositions. The components of many popular services contain a limited number of generic and re-useable components, such as *location*, *payment*, and *connectivity*. Hence, it is expected that the launch of new services does not require a design-from-scratch, resulting in short lead-times.

And, yet, all of this is just the beginning. It was argued by Ray Kurzweil [38] that technological capabilities increase exponentially in time due to their very nature. Intelligence is part of web crawlers indexing the Internet, stock-market transaction systems, camera surveillance systems with violence detection analysis. Information goes beyond the boundaries of specific hardware systems, and at the same time beyond the boundaries of countries and companies. Some processes will monitor or control others for a specific purpose. In short, the information society will become *an organic information*

society. An intelligence similar to that of humans (as illustrated by the defeat of world champion Kasparov by the Deep Blue computer) marks another new era.

ICT delivers and will continue to deliver. It is the driver of innovation, disruption and productivity. In an OECD study, almost 60% of the economic growth in 1985 – 2000 is deduced from the application of ICT [26]. And, also in the US, it has been demonstrated time and again [10] that investing in ICT improves productivity, more than anything else and increasingly more than previously expected.

9. References, organizations and contributors

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1. Jan Maas, chairman IIP Sensor Networks
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18. Tim van der Hagen, top sector Energy, TUDelft
19. Han la Poutré, CWI voorzitter NWO-thema Smart Energy Systems
20. Aart-Jan Smits, Thales, roadmap Security HTSM
21. Frits Verheij, KEMA, Smart Energy Systems in Energy
22. Patrick Strating, node director EIT ICT Labs Eindhoven
23. Saskia Goetgeluk, secretary top team Horticulture
24. Evgeny Verbitskiy, Wiskunde Platform Nederland
25. Inald Lagendijk, TUDelft, COMMIT
26. Nick van de Giesen, ICT co-ordinator ICT in the top team Water, TUDelft
27. Nicole Kroon, director Ministerie EL&I
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35. Wessel Kraaij, TNO, COMMIT
36. Anwar Osseyran, CEO SARA
37. Marc van Lieshout, TNO
38. Jurjen Veldhuizen, TNO
39. Tamme van der Wal, Aerovision, IIP Agro
40. Erik Fledderus, TNO, director kennis ICT
41. Henri Bal, VU, COMMIT
42. Corien Prins, UvTilburg
43. Jantine van der Weerdt, TNO
44. Rein Willems, top sector Chemie
45. Oscar van den Brink, TI-COAST
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Abreviations of some of the organizations in the field of ICT

1.	ICT Office	Branch organization for ICT-industry
2.	CIO	Platform organization for CIO professionals
3.	NWO	National (funding) agency for research
4.	STW	National (funding) agency for technological research
5.	TNO	National organization for the application of sciences
6.	EIT ICT-Labs	Knowledge Centre for the ICT economy sponsored by EU
7.	IPN	National platform for the advancement of ICT Science
8.	NIRICT	The 3 Technical Universities cooperative institute for ICT
9.	CWI	National research institute for Computer Science and Mathematics
10.	COMMIT	The national public-private national research program in ICT
11.	eSC	National center for software application in arts and sciences
12.	SARA	National center for compute services in arts and sciences
13.	SURF	National center for network infrastructure in arts and sciences

The following industries, currently 130 in number, large and small are all engaged in ICT-research. They are currently investing in public-private research in ICT (under the COMMIT-agreement), or, they are expressing their intent to do so by Letter of Intent:

AARVO, LoI
Actian NL, LoI
Adapticon, LoI
Adversitement, LoI
Agripartner, LoI
Alliander, LoI
Almende, COMMIT, LoI
Ambient Systems, COMMIT
ANP, COMMIT
Arcadis, COMMIT
ASML, LoI
Auxilium, COMMIT
Axini, COMMIT
Beeld en Geluid, COMMIT
Beijer Automotive, LoI
Better.be, LoI
Bicore, LoI
Blue4Green, LoI
Boxplosive, LoI
Broadfield Security Services, COMMIT
Bronkhorst, LoI
Bruco, LoI
BusinessBase, LoI
Capgemini, COMMIT, LoI
Centric Tsolve, COMMIT
Centric IT Solutions, LoI
Cinop, COMMIT
Circle, LoI
CIT, COMMIT
Cordys, LoI
Cybermind Interactive, COMMIT
DANS, LoI
Davilex, LoI
De Persgroep Printing A'dam, COMMIT
Demcon, LoI
Devlab, COMMIT
Diesveld Query Technology, LoI
Eagle Vision System, LoI
Elsevier, COMMIT
Ericsson Telecom, COMMIT, LoI
eTech Connect, LoI
Eurocottage, COMMIT
Europeana, COMMIT
EUVision, COMMIT
Exact, LoI
Food & Biobased Research, COMMIT
Game Academy, LoI
GN ReSound, LoI
Green Dino, LoI
GridLine, COMMIT, LoI
GX Software, LoI
Human Interference, LoI
Hyves, COMMIT, LoI
IDQuest, LoI
Inertia, LoI
INQA, LoI
InRoads, LoI
Inspearit, LoI
Irdeto, COMMIT, LoI
KITT Engineering, COMMIT
KNMI, COMMIT
Koninklijke Bibliotheek, COMMIT
Korps Landelijke Politie Diensten, CMMT
Logica Nederland, COMMIT
Maars, LoI
Magnaview, LoI
MobiHealth, LoI
MonetDB, COMMIT, LoI
Motek Medical, COMMIT
MP-Objects, LoI
M-Proof, LoI
Ned Centrum Sociale Innovatie, COMMT
Noldus Inf Technology, COMMIT, LoI
Océ, LoI
OV9292, LoI
Personal Space, LoI
Philips Research, COMMIT, LoI
Phuntronix, LoI
Planon, LoI
Politie Regio Gelderland Zuid, COMMIT

PostNL, LoI
Prodrive, LoI
Recore Systems, LoI
Re-Lion, COMMIT, LoI
Relyon, LoI
Roessing, Het, COMMIT, LoI
RRD, LoI
Salland Engineering, LoI
Security Matters, LoI
Serious Toys, COMMIT
SIDN, LoI
Siqura, LoI
Smart Dutch, LoI
Software Improvement Group, LoI
SolidSourceIT, LoI
Sound Intelligence, LoI
Stabiplan, LoI
Stichting GreenICT, LoI
SURF, LoI
Synerscope, LoI
Talking Trends, COMMIT
Target Holding, LoI
Technolution, LoI
TechToBizz, LoI
Teezir, COMMIT
Telecats, LoI
Textkernel, COMMIT
Thales NL, COMMIT, LoI
ThirdSight, COMMIT
TI-COAST, LoI
TIE, LoI
TomTom, COMMIT
TrendLight, COMMIT
Trimergo, LoI
TurpinVision, LoI
Ultimo, LoI
UNIT4, LoI
Vancis, LoI
VicarVision, COMMIT
Video Dock, COMMIT
ViNotion, LoI
Vipsnet, LoI
Vital Health Software, LoI
Vortech, LoI
VSTEP, LoI
Waag Society, COMMIT
WCC Development, COMMIT
Witteveen+Bos, LoI
WMC, LoI
Woodwing, LoI
Yuki, LoI

As COMMIT will be transformed to a TKI, and more parties are expressing their willingness to join had they had more time, the list is steadily growing.