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Inhoudsopgave

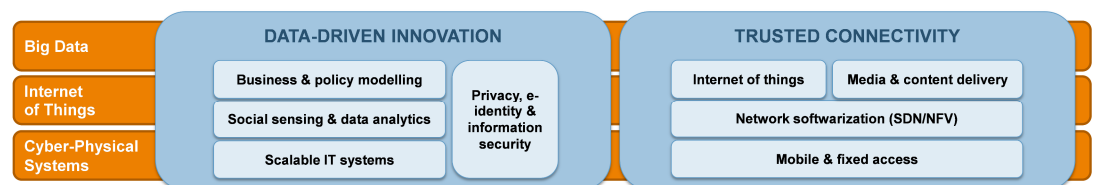
1	VP ICT	3
1.1	Introduction	3
1.2	Program execution and results 2015.....	4
1.3	Publications	7
2	Ondertekening	12

1 VP ICT

1.1 Introduction

TNO has one of the largest groups of experts working on a wide range of ICT innovations in the Netherlands. Networked information has become the backbone of our economy, and one of the main drivers for the transitions that are taking place in domains such as mobility, energy, health, and manufacturing ('Smart Industry'). Three interrelated technological developments are expected to transform every sector and even society at large. The first is the emergence of cyber-physical systems that will result in an ever more intertwined virtual and physical world. The second is big data, which will see an enormous increase of (unstructured and real-time) data. The third is the internet of things, leading to unprecedented connectivity of devices. Trusted connections are paramount to accommodate these developments as they depend on high quality, secure and reliable networks of systems and devices. These transformations create economic opportunities, and they are expected have great impact on society as a whole, on organizations, and on individuals.

The Theme ICT focuses its activities in two main areas: data driven innovation and trusted connectivity. *Data driven innovation* concerns the development of data services and platforms, including research into privacy and information security. *Trusted connectivity* comprises innovations in networks, to allow for the transmission of more data than ever before, to connect every imaginable device to the internet and the delivery of high quality video. In 2016, both areas include four focal points (see figure). In 2015, social sensing, business and policy modelling, and media content delivery were part of P705 Theme Creative, and are reported on separately.



Data driven innovation

Data driven innovation concerns all activities regarding the increase and wide-spread use of (big) data, from the collection via sensors and development of algorithms for data processing (*social sensing and data analytics*) to architecture for processing large quantities of data (*scalable IT systems*). While social sensing allows for personalization, big data services can also develop into scalable IT systems allowing for extreme interconnectedness of sensors and devices. The transdisciplinary nature of ICT means that research does not only involve technological developments, but also domain knowledge and expertise on user interaction is required. As a result, the boundaries between ICT and other domains, such as agrifood, energy and healthcare, are expected to blur. As data driven Innovation is shaping these domains, TNO aims to set up PPPs for developing (big) data based services and systems.

Data driven innovation also includes activities regarding the development of business models and policy options (*business and policy modelling*), as well as activities ensuring safe and reliable processing of data (*privacy, e-identity and information security*). In this field, privacy-friendly service architectures are

developed together with partners. Frameworks describing identity attributes and the protocols how to authenticate them, how to assign and review rights related to the identity are of key importance when it comes to societal adoption of data services. Information security is paramount to realizing reliable connections in a hyperconnected world. Therefore, anomaly detection and autonomous response to attacks are important topics within this research line. Within TNO, privacy and information security are treated as an opportunity for services development rather than as an obstacle for the development of data services.

Trusted connectivity

Trusted connectivity concerns the development of next generation network access. TNO is a European center of excellence in the area of xDSL technology and further develops *fixed access*. Furthermore, the program influences the 5G landscape and 5G ecosystem in the Netherlands and Europe regarding *mobile access*. TNO actively helps shaping the 5G standard through its association in the 5GPPP board. *Network Softwarization* (Software Defined Networking or Network Function Virtualization) can provide an extremely powerful concept to increase robustness, but also increases flexibility and thus improve business case when demand is uncertain or highly irregular.

This new generation of network access, allows ever greater data flows that are necessary for the development of the *internet of things* and machine to machine interaction and *media content delivery*. The 5G standard is expected to encompass internet of things and M2M connectivity and thereby provide a comprehensive standard for future connectivity. Within the internet of things, In Home connectivity brings challenges related to fixed and mobile access together and addresses them in the specific environment of the home. An important aspect of the work in this field concerns ICT Standards. TNO has a long track record in contributing to the development of network standards. The standardization efforts are an integral part of the program.

For VP ESI (Embedded Systems) see the TNO 2015 progress report Theme HTSM.

1.2 Program execution and results 2015

Research projects that were carried out are a mix of three types of projects: TNO knowledge investment projects, mixed-funding European and national projects, and Topsector HTSM TKI projects. Most projects are mixed-funding European and national projects. Projects were often carried out in cooperation with leading industry partners. This allows gaining knowledge close to the applicability of the research, getting feedback from industrial partners and incorporating this feedback directly into the research. Furthermore, an important objective is stakeholder management and standardization.

Data driven innovation

In the field of *data analytics* mainly mixed-funding European and national funding projects were carried out. For this topic, collaboration with partners is especially relevant as innovations in this field often consist of combining several relevant data sources or algorithms for processing data. A highlight in this field is the long term research project SWELL carried out within the COMMIT framework. SWELL addresses workers' stress conditions, combining social sensing, data processing and visualization techniques. Another example of such a systems is the EIT Digital project Fit to perform. Fit to perform provides personalized advice for truck drivers,

making sure that they are not too fatigued to drive safely. Furthermore, to strengthen TNO's expertise in the field open data, a knowledge development project was carried out, gaining insight into best practices of open data platforms and policies.

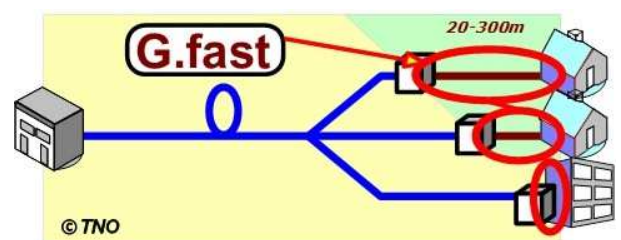
Scalable IT systems concerns the development of large interconnected (sensor) systems. A notable example is the TKI project Smart Dairy Farming that was developed in collaboration with several knowledge institutes, and the companies Agrifirm, CRV, and FrieslandCampina. This project collects data from individual cows, processes these data centrally and subsequently provides the farmer with customized information on nutrition per cow. A second example of such a scalable IT system is the TKI project STOOOP, which develops a smart gas network. By measuring the state of gas pipelines using sensors and big data processing this project supports maintenance decisions. A third example is the eSense project has developed a platform providing a archetypical broker architecture that can be used for similar data infrastructures supporting scalable IT systems.

The *privacy, e-identity and information security* research line consists of mixed-funding European and national research projects. Within this research line TNO's board membership of the PI.lab collaboration with Radboud University, TILT (Tilburg University) and SIDN is an important asset to strengthen ties with fundamental research conducted in this field. The mixed-funding European PRISMS FP7 project has conducted research into the mutual dependencies between privacy and security and developed a decision model facilitating decision makers to consider privacy protection when taking security measures. In the field of security, research activities are joined up in the Shared Research Program Cybersecurity that focuses on targeted attack and anomaly detection and on autonomous response to attacks. The SRP is set up in collaboration with financial partners such as banks and insurance companies and will continue in 2016. In the field of cybersecurity, three projects are co-sponsored within the NWO program, that allow TNO to gain insight into fundamental research in the field of deep packet inspection and visualization, anomaly detection, and privacy patterns, via supervision of PhD's. Regarding risk management, networked risk management aspects for cybersecurity will be further developed in 2016.

Trusted connectivity

In the field of *fixed access*, TNO has long been a center of excellence on xDSL. To remain involved in world-wide developments in this area, TNO participates in the CELTIC-Plus GOLD project that aims to develop cost-effective ultra-broadband access level based on the G.fast

standard. G.fast has demonstrated an increase the throughput of copper cables to nearly 1Gbps, and the GOLD project aims to push G.fast even further to multiple-gigabit copper access rates for fifth generation fixed broadband.



In the field of mobile access, the main goal of the research line is to contribute to and shape the 5G mobile standard. This standard is expected to encompass internet of things and M2M connectivity and thereby become a comprehensive framework for future connectivity. Multiple mixed-funding European projects, such as FP7 projects Sunseed and SemaFour are carried out in this field. SemaFour, which obtained an 'excellent' in the final evaluation by the European Commission, has designed and developed a unified self-management system, which enables network operators to manage and operate their complex heterogeneous mobile

networks with enhanced quality of user experience, and reduced operational costs. Furthermore a TNO knowledge development project, in close cooperation with TNO's ICT cluster, aims to develop a facility named Operator 3.0, which will allow experimentation with future network technologies in the field of mobile access. Part of this is a pilot project that integrate and extends KPN's 4G Lab (a research live network based on the latest LTE innovations in commercial radio networks) to TNO's Hi5 platform (a virtualized software-only core network).

Network softwarization is expected to become paramount in order to facilitate the ever increasing data throughput over networks. Software Defined Networking and Network Function Virtualization are the main technologies in this field. Besides testing these technologies in the Hi5 platform, a mixed-funding national research project is carried out. In the Multidomain CoCo (Community Connect) project SURFnet and TNO designed, developed and validated an on-demand connectivity service. This project will be followed up in 2016.

The *Internet of Things* research line is comparable to the scalable IT systems research line, but rather than focusing on big data, data analytics and visualization, it focuses on the development of the internet of things, that will see the interconnection of every imaginable device. Highlights in this field include the mixed-funding ITEA project Enhanced M2M grid. While this project develops quality aware sensor data processing for electricity networks, the technology that is developed can be used in different domains. Furthermore, the H2020 project Wi5 focuses on the interference of wifi signals in the Home environment. Within the Internet of Things, In Home connectivity brings challenges related to fixed and mobile access together and addresses them in the specific environment of the home. Another specific area of interest of this research line is Smart Industry, such as the TKI project Fieldlab Digital Factory.

Stakeholder management and standardization

Important objectives of the Theme ICT are stakeholder management and standardization. This is concerned with maintaining a good connection with to national and international ecosystems, such as R&D&I programs (FP7/Horizon 2020, EIT Digital, COMMIT, ICT Doorbraakprojecten). Furthermore, for TNO standardization activities are important, as is representation in various standardization groups and industry fora (e.g. ETSI, 3GPP, W3C, HGI, Broadband forum). The standardization efforts of this Theme include working on more than twenty standards, including mobile networks, media content delivery, M2M service development, networked risk management, and privacy.

Several part-time professors are associated with the program, connecting to relevant Dutch universities (Rijksuniversiteit Groningen, Universiteit Twente, Universiteit van Amsterdam, Technische Universiteit Delft, Radboud Universiteit). Hans van den Berg's research on performance and quality of service in ICT in different domains connects TNO to the CTIT research group at Twente University. Rob Kooij (Delft University of Technology) investigates the robustness of networks and has a strong link with cybersecurity. Wessel Kraaij (Radboud University) is active in the data science field, especially in relation to applications in health. Jan van Erp's research into tangible user interaction looks at value creation based on (big) sensor data on the personal level and the tactile internet. David Langley, as associate professor at the Rijksuniversiteit Groningen in the field of internet, innovation, and strategy investigates emerging business models, for example, for the internet of things.

TNO is also active on multiple government levels and TNO holds several board

memberships. On EU level the most notable development is the creating of the Big Data Value Association (BDVA). Furthermore, TNO is also active in industry fora such as NESSI. On the national level TNO played a leading role in the composition of the COMMIT2DATA proposal, based on the KIA-ICT, and TNO will intensify cooperation with NWO. At the local level TNO participates in the Big Data Value Center (with the Economic Boards of Almere, Amsterdam, Utrecht, eScience Center).

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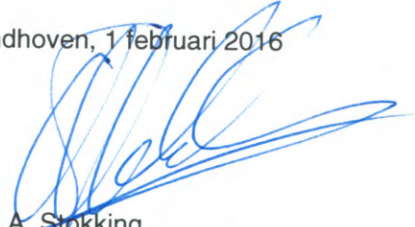
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2 Ondertekening

Eindhoven, 1 februari 2016

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