Holland High Tech
Global Challenges, Smart Solutions

High Tech Systems and Materials

Knowledge and Innovation Agenda 2018-2021

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Preface

The Top Sector High Tech Systems and Materials (HTSM) unites the technology industry and research organisations of the Netherlands in a world-class value chain of bottom-up collaboration and close interaction with the national government.
HTSM develops key enabling technologies (KETs) for solutions to the grand societal challenges of our time, by realising products and services that make these solutions economically feasible.
HTSM technologies are omnipresent in consumer and business applications ranging from telecommunication, the internet and energy supply through to medical instrumentation, automobiles, airplanes and satellites.

HTSM technologies are omnipresent in consumer and business applications

The present HTSM Knowledge and Innovation Agenda (KIA) combines the priorities of the 2017 Dutch government coalition agreement with the Top Sector's experience in collaboration through public-private partnerships. This KIA offers a top-down framework for building bridges between the HTSM key enabling technologies and mission-driven programming for societal themes in national and regional agendas. Such programming demands a solid knowledge base for application-oriented and applied research in key enabling technologies, which is supported by effective human capital, internationalisation and go-to-market policies. A KIA update is planned for 2019, in anticipation of the currently evolving missions of government ministries.

Summary

Societal framework

To facilitate interactions on HTSM key enabling technologies between key stakeholders, HTSM has established a thematic top-down framework with five grand societal challenges: health, security, climate (including energy and water), mobility, and sustainability (including circular economy and food). These societal themes are enabled bottom-up by the HTSM technology roadmaps. Each roadmap is managed by a dedicated team of experts from enterprises, institutes and universities.

Key enabling technologies

The HTSM technology roadmaps largely overlap with the key enabling technologies (KETs) defined by the European Commission. All technologies in the Top Sector are intimately connected with ICT. KETs are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and high-skilled employment. They are multidisciplinary, cutting across many areas, and assisting leaders in other fields to capitalise on their research effort.

Sustained economic development

The HTSM industry consists of 86,000 enterprises employing 490,000 people, many of them in innovative Small and medium-sized enterprises (SMEs), start-ups and scale-ups. Together, these enterprises create 139 billion euro in production value, and 49 billion euro in export. They invest 4 billion euro in R&D annually, of which over 500 million euro in public-private partnerships. HTSM targets sustainable economic growth supported by enhanced public and private R&D investments.

Human capital and internationalisation

Success in the Top Sector critically depends on the availability of qualified personnel. Knowledge workers in technology continue to be scarce. Education and training in applied and application-oriented science are essential, as is access to the international labour market. The industry and research organisations operate in a global value chain. HTSM actively collaborates with the international innovation attachés to enlarge the global Dutch network.

Building bridges with new stakeholders

HTSM aims at active partnering with government ministries and regional public organisations to realise a long-term alignment of scientific research, technological innovation, and societal challenges. With the societal framework in the HTSM-KIA, value is added by building top-down bridges with the bottom-up HTSM roadmaps. Cross-over collaboration with other top sectors is increasingly important for enhanced partnership, with explicit involvement of ICT.

Leverage from international R&D

As HTSM competes in a global market, participation in joint European R&D is a priority for both science and industry. Results gained from European projects leverage the Top Sector's national contribution. The HTSM roadmaps closely follow the headlines of the European Horizon 2020 programme and its foreseen successor.

Transparent programming with science and industry

The Holland High Tech Foundation coordinates governance and programming of knowledge and innovation for the Top Sector, co-finances research at institutes and universities with public-private partnership (PPP) grants, and supports SME in the Holland High Tech Partner organisations through the Mkb-innovatiestimulering Regio en Topsectoren (MIT) scheme. Holland High Tech aligns regularly with TNO, NLR and NWO on the programming of research in applied and application-oriented research. Long-term collaboration exists with the universities of Delft, Eindhoven and Twente, and the focussed research centres in the HTSM domain.

Technology transfer and go-to-market

Process innovation and digitisation are essential in the deployment of new manufacturing technologies. The Smart Industry Fieldlabs have created a basis for joint experimentation and learning. Government policy and instruments should be put in place that support SME through smart manufacturing assessment and individual stimulation. Market introduction of products and services that directly serve innovation in societal challenges does not come automatically. Public procurement, as in Small Business Innovation Research (SBIR), can bridge the gap between R&D results and the creation of economic value, especially for SMEs. Successful implementation requires systemic improvement, as well as processes for structural alignment with the involved ministries.

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Vision and ambition

Societal framework

To facilitate interactions on HTSM technologies between key stakeholders inside and outside the Top Sector, HTSM has established a thematic framework with five grand societal challenges: climate (including energy and water), sustainability (including circular economy and food), health, security, and mobility. In this new set-up, the Top Sector will stimulate R&D collaboration in cross-overs between key enabling technologies and societal innovation, and build bridges between the HTSM community and the mission-driven programming in national and regional public agendas.

HTSM supports the Organisation for Economic Co-operation and Development (OECD)[1] vision that there is more to life than the cold numbers of economic statistics. Throughout society, awareness is growing of the importance of the humanities for science and vice-versa. It is becoming increasingly clear that responsible innovation requires mutual interaction between knowledge workers from both sides. HTSM fosters the visibility of this approach in relevant higher education and national research programmes.[2]

Key enabling technologies

Key enabling technologies (KETs) are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and high-skilled employment. They enable innovation in process, goods and services throughout the economy. They are multidisciplinary, cutting across many areas, and assisting leaders in other fields to capitalise on their research effort. The paramount importance of KETs and high-tech industries for society at large was reconfirmed in the 'Re-finding industry: Defining Innovation' study recently published by the European Commission.[3]

There is more to life than the cold numbers of economic statistics (OECD)

The HTSM technologies largely overlap with the KETs defined by the European Commission. HTSM technologies are present in virtually all consumer and business products and services, but they are seldom visible. Quantum technology and nanotechnology deal with phenomena on a scale of a millionth of a millimetre. Evidently, such phenomena cannot be observed with the naked eye. Electronics comprises an invisible host of technologies essential in all devices and systems that are dependent on electricity, be it batteries, mains connection or self-powered. Photonics is in anything operating with light.

All technologies in the Top Sector HTSM are intimately connected with ICT. Digitisation of society has led to the rise of cyber-physical systems (CPS), ubiquitous as networked computing devices and software that enable and enhance the performance of all except the simplest technical systems. CPS are key enablers in disruptive areas such as artificial intelligence, cybersecurity and cloud computing.[4]

Collaboration in key enabling technologies is the connecting factor between scientists and engineers in this domain worldwide. The Top Sector has appointed dedicated teams with experts from enterprises, institutes and universities. Each team maintains an HTSM technology roadmap for R&D in public-private partnerships.

Over 50% of the collaborative activities in the roadmaps are executed in the context of major European platforms. Multiple links exist between the HTSM roadmaps and the Dutch National Research Agenda (NWA)[5], as in the routes for materials, quantum-nanotechnology and smart industry.[6]

Sustainable economic development

The Centraal Bureau voor Statistiek (CBS) monitor 2017[7] reports that the HTSM industry consists of 86,000 enterprises employing 490,000 people, many of them in innovative SME, start-ups and scale-ups. Together, these enterprises create 139 billion euro in production value and 49 billion euro in export. The HTSM industry invests 4 billion euros in R&D, of which over 500 million euro in public-private partnerships, in a network enabled through the Dutch government's top sector policy.

TABLE 1 Top Sector HTSM economic data: status and target (billions of euros per year)

Year	2012*	2015*	2025**
Production value	121	139	182
Export	45	49	75
R&D	3.5	4.0	4.9

* CBS 2017

** HTSM ambition

The Top Sector targets sustained growth in production value and export, supported by enhanced R&D investments in application-oriented and applied science. By doing so, HTSM aims to secure economic and innovation leadership for the Netherlands in the global technology market. Through its role as a technology enabler of sustainable innovation in the grand societal themes, the Top Sector fosters broad prosperity for future generations.

Human capital

Success in the Top Sector HTSM is critically dependent on the availability of technicians, engineers and researchers in the field of applied and application-oriented science. HTSM actively supports national and regional initiatives in education and training, such as the Platform Bèta Techniek (PBT)[8] triple-helix[9] national network.

Despite positive trends in relevant populations in schools and universities in the Netherlands, knowledge workers in technology continue to be scarce. Access to the international labour market continues to be essential for the Top Sector, for enterprises large, medium and small. This requires continuous attention and adequate public regulations.

Internationalisation

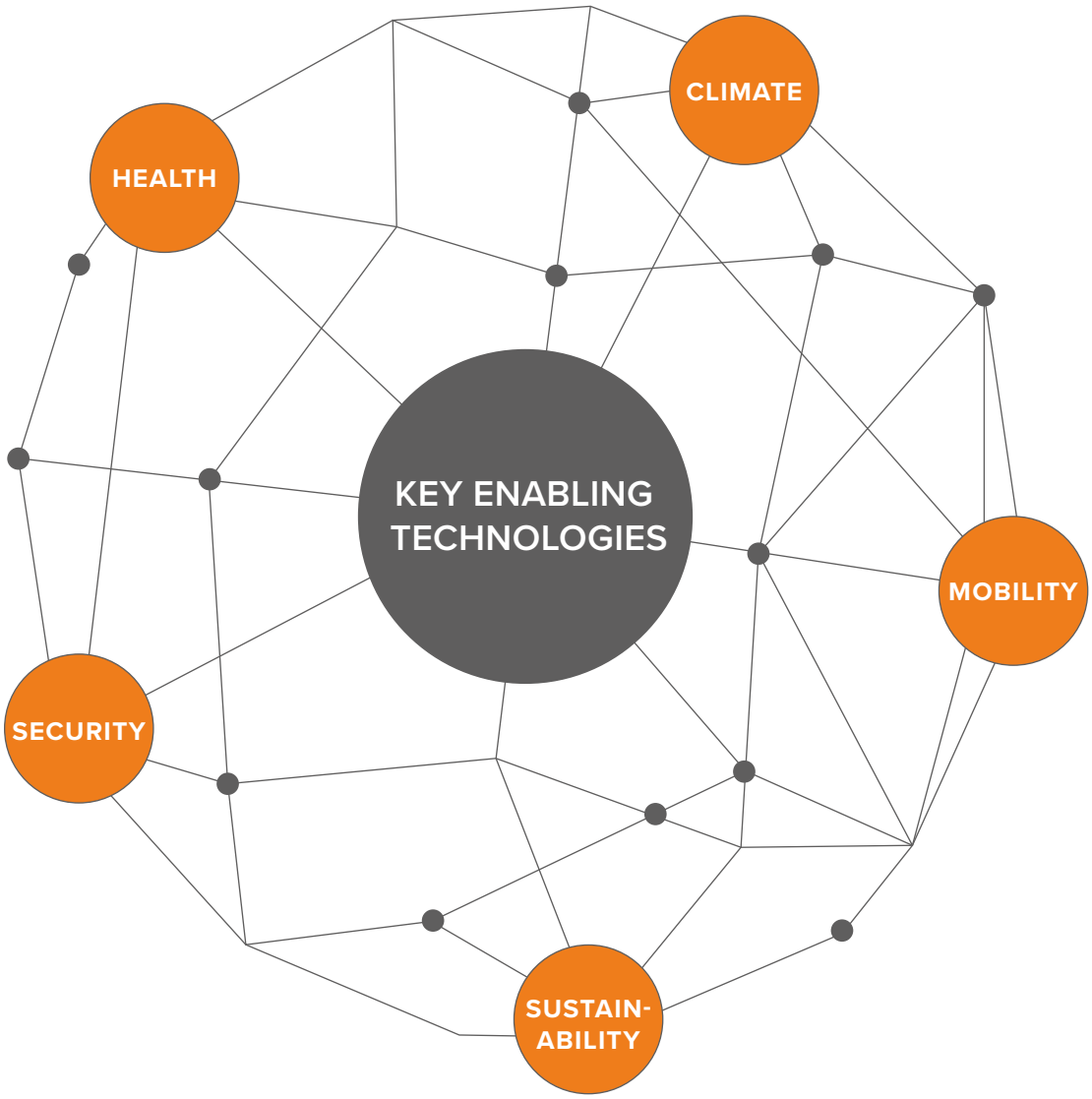
Enterprises and research organisations of the Top Sector HTSM operate in multiple value chains of regional supply and global demand. Digitisation of society has resulted in a network where everything and everybody is linked, with strong mutual dependences throughout the HTSM network and its partners worldwide.

The unique value proposition of the combined HTSM competences is a strong selling point for the Netherlands, both in exploring foreign markets and in attracting international enterprises, institutes, and talent. Participation in international exhibitions and trade missions abroad is an important instrument in realising the Top Sector's ambitions, especially for the many innovative SMEs. HTSM actively collaborates with the international innovation attachés network[10] to enlarge the worldwide network of the Netherlands.

2

Global challenges, smart solutions

Public-private collaboration on societal themes powered by key enabling technologies



Climate

Climate, including energy and water, is a theme with significant industrial and scientific strength for the Netherlands. At the same time, it is also an arena filled with threatening societal challenges. Faced with global warming and decreasing access to fossil fuels, innovative scenarios must be developed in joint efforts with public and private partners, if we are to mitigate and adapt to future problems.

The need for energy transition is imminent. Heating buildings and transporting people and goods in the absence of fossil fuels is a major challenge for society and there are no affordable solutions for this yet. Breakthrough innovations are needed in renewable energy, in electrified transportation and in advanced heating, all of which depend on HTSM technologies. The energy transition requires sound implementation of smartness and flexibility throughout the value chain. Sensors, connectivity and high-efficiency power electronics are essential in connecting systems as diverse as solar systems, wind turbine farms, public and private buildings and electric vehicles to a very smart grid.

Solar panel systems need further improvements in cost efficiency and integration in buildings, through photovoltaic material development, smart connectors, transparent interlayers and functional coatings. Wind farms operate under harsh conditions, requiring ever-larger blades produced from reliable and recyclable composites manufactured in robust processes. Offshore energy fields will operate without human interaction, depending on robotic construction, drone inspection and space surveillance, enabled by HTSM technologies. Synchronising energy demand and production is still in its infancy and breakthrough developments are needed in energy conversion and storage.

Research project **DCSMART** (ERA-NET H2020) explores low-loss smart grids based on Direct Current (DC)distribution rather than the usual Alternating Current (AC), innovating in converters, modularity and algorithms. **dcsmart.tudelft.nl/**

The **TROPOMI** instrument launched with the ESA Sentinel-5P satellite measures atmospheric pollution with unprecedented spatial resolution. **tropomi.nl/?lang=en**

NWO programme **'Breakthroughs for interferometry technology in space'** supports the development of small satellites for climate research that will be deployed as interferometers in the terahertz domain. **nwo.nl/onderzoek-en-resultaten/programmas/perspectief/programma-initiatieven/initiatieven+17-18/P17-27**

The **Solliance** research institute combines forces from the Netherlands, Belgium and Germany in research with industry and academia into next-generation technologies for thin-film solar cells. **solliance.eu**

HTSM parties collaborate in the European Joint Undertaking **Clean Sky**, which is developing innovative, cutting-edge technology aimed at reducing CO2, gas emissions and noise levels produced by aircraft. **cleansky.eu**

Sustainability

Sustainability is a key driver for research and innovation in smart industry, smart farming, and smart construction. The ideal circular economy has 0% wastage and 100% re-use for all production and all products, while fulfilling the highest quality requirements with 0% defects. HTSM technologies enable the eco-efficient production needed to achieve these long-term circular economy goals.

A sustainable production facility uses as little energy and material as possible, with as much sustainable energy as available, and as much recycled material as feasible. Its products are designed for deconstruction, with end-of-life re-use and recycling in mind. In future, the sustainable factory should be able to assemble and disassemble in a lot-size of one.

Less waste, closed cycles and automatic disassembly are key concepts in smart industry. Additive manufacturing allows production with minimal use of raw materials. Artificial intelligence with digital twins of full-product development cycles will allow real-time analysis, testing and qualification of products before physical production has started. Local, regional, integrated value chains and closed cycles are inherently more efficient than the traditional globalised production processes.

Securing resource and energy efficiency are key drivers to improve sustainability of buildings and civil constructions. Novel designs incorporating multifunctional material elements are needed, produced by large-scale 3D printing of buildings, as well as re-use of waste facilitated by ICT solutions including material databases, and energy extraction through advanced coatings.

The High Tech to Feed the World programme fosters innovations to feed a growing population in a sustainable manner. Project **DISAC** researches precision farming with data-intensive, real-time control for improved sustainability in agro-food chains. **subsites.wur.nl/nl/plb/PL-Projecten/DISAC.htm**

The Metalot Circularity Centre Cranendonk (**Metalot3C**) develops breakthrough technologies using metal powders for energy storage, including circular regeneration for the oxidized powders. **metalot.nl/metalot-3c/?lang=en**

NWO-TTW project **ZERO** researches low-power circuits and new ways of generating and storing energy to prevent an energy drain from wireless connected sensors and actuators in the Internet of Things. **nwo.nl/onderzoek-en-resultaten/programmas/perspectief/Perspectief-programmas/2016/programma+1**

Smart Industry Fieldlab **UPPS** is a project that frames 3D scanning, cloud services and additive manufacturing in an integrated design methodology that enables full-custom, zero-waste, mass personalisation. **upps.nl**

HTSM parties participate in the European **SPIRE** programme that aims to build a sustainable processing industry through the efficient use of energy and resources. **spire2030.eu**

Health

The key question in health is how to keep access to facilities and services affordable while raising the number of healthy life years for an aging and growing population. Addressing this challenge requires innovation inside and outside the hospital, through the full chain of prevention, cure and care. HTSM enables solutions across this chain, bridging disciplines and building convergence between professional and consumer care environments.

Treatment of diseases is supported by image-guided intervention (MR, CT, ultrasound), surgery supported by advanced robotics and artificial intelligence in analysis and decision-making. The Internet of Things will affect how health is monitored and measured. Wearable sensing can replace bulky hospital equipment, enabling monitoring at home and giving doctors remote access to medical data for diagnosis. Wireless systems to monitor brain and cardiac activity have already entered hospitals, with advances in low-power design and energy harvesting.

Future medical action may occur anywhere in a person's day-to-day life, enabled through concepts like personal Digital Twins through smart industry manufacturing. Digitisation of personal data and cloud-based services require advanced security levels ahead of current regulations. Robotics requires safety testing, such as in the aerospace industry. Miniaturisation allows embedding of ubiquitous systems for sensing and interaction in our daily environment. Future functionalities extend to bioelectronics on and in the human body, with targeted delivery of medicines enabled by nanotechnology.

HTSM parties participate in the European programme Active and Assisted Living (**AAL**) on ICT for active and healthy ageing. **aal-europe.eu**

The Innovative Medical Devices Initiative (**IMDI**) links technical universities and university medical centres. It focuses on image acquisition and processing, minimal invasive surgery and neuro-rehabilitation, home care and assistive devices. **imdi.nl**

The Plug and Play Design Centre (**PPDC**) in Nijmegen focuses on fast med-tech prototype development and testing in a real-life medical setting. **bcsemi.nl/shared-infra**

ITEA3 project **PARTNER** explores systems for personalised care in chronic diseases. **itea3.org/project/partner.html**

INTERREG project **NANO4SPORTS** builds applications of health monitoring in sports optimisation. **www.nano4sports.eu**

Security

Security is a vital condition for a prosperous society. The world faces rapid and fundamental changes due to technological advances, geopolitical shifts and climate changes. The barriers between the physical and digital world are dissolving, transforming the way vital infrastructures and societal functions are built.

Everything and everyone will be connected through networks, across distances, frontiers and time. These networks and their underlying infrastructures and functions are essential but also vulnerable. To keep them safe, HTSM technologies are needed, including electronics, photonics, space, quantum technology and nanotechnology.

In addressing the above challenges, continuous innovation is required in the areas of digital security, operational security and physical security. Digital security requires secure communications including data authorisation and authentication, integrating cryptographic techniques for applications from connected cars to data centres, from healthcare to industrial control. Sensor and data integration together with a capability to transform data into user-required information are crucial for the operational security of future-proof and adaptive law enforcement and armed forces. Physical security entails wearable sensor and communication devices, virtual and augmented reality, artificial intelligence and robotic support in dividing tasks between man and machine. Cybersecurity through both software and hardware elements is a universal requirement in all HTSM-enabled solutions.

Platform Nederland Radarland combines and expands the knowledge in radar technology of public and private partners through consolidating knowledge, synchronising R&D and initiating training. **defensie.nl/actueel/nieuws/2017/11/08/defensie-loopt-voorop-met-radar**

With EFRO support, Smart Industry **Fieldlab The Garden** builds innovative solutions for collaborative cybersafe digitisation and secure data sharing, specifically targeting the SME community. **smartindustry.nl/5-the-garden**

The **QuTech** research centre for quantum computing and quantum internet explores the possibilities of quantum communication to provide security that is guaranteed by the laws of nature. **qutech.nl**

ECSEL project **SCOTT** aims to build trust and increase social acceptance of the Internet of Things by transforming ‘things that are connected’ into ‘trustable things that securely communicate and value the privacy rules of end-users’. **scottproject.eu**

The **dcypher** platform unites researchers, lecturers, manufacturers, users and policy makers to increase knowledge and expertise in the Netherlands in the area of cybersecurity. **dcypher.nl/en**


XF
EUROPEAN
TRUCK
PLATOONING
DAF

Mobility

The challenges in mobility encompass an interlinked set of issues in air pollution, global warming, energy security, traffic safety and accessible transport. These issues require developments that will reduce emissions and enable the transition to sustainable fuels. Together with the growing need for accessibility, affordability and safety, these developments will be drivers for new options in smart and green mobility.

Future mobility will see multiple innovations facilitating the transition to greater cleanliness and safety as well as a reduction in CO2, pollutants, casualties, traffic jams, noise and occupation of public space. HTSM technologies are key in future vehicles as well as the integration of these vehicles into full-size systems. Similar considerations apply to aeronautic and marine transport.

Modern cars are already gigantic data-generating engines, requiring much more lines of operating code than an aeroplane. Such cars will act as sensors in public traffic management systems, through vehicle to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. The transition to e-mobility boosts the demand for innovate power handling in both the vehicle and the charging network.

Automated and autonomous driving is emerging as a major disruption of the traffic system, revolutionising both passenger and freight transport. It takes a broad range of advanced sensors including radar, lidar, ultrasound, optical and infrared, together with strong computational effort to achieve the necessary safety-critical solution. The Netherlands actively supports trials with autonomous vehicles and is poised to become a large-scale early adopter of this technology.

HTSM parties engage in **ERTRAC**, **ACARE**, **EUCAR**, **EGVIA**, **EARPA**, and **ERTICO**; European programmes covering intelligent transport systems (ITS), traffic safety, vehicle electrification, future energy carriers, networked transportation and vehicle control, and mobility for an ageing community.

The EcoTwin project demonstrates truck platooning in large-scale trials in the Netherlands. This is extended in the European project **ENSEMBLE**, piloting multi-brand platooning across Europe. **cordis.europa.eu/project/rcn/216001_en.html**

The European project **CONCORDA** will prepare European motorways for automated driving and high-density truck platooning with adequate connected services and technologies. **connectedautomateddriving.eu/project/concorda**

ECSEL project **PRYSTINE** deals with programmable systems for intelligence in automobiles, with fail-operational sensor-fusion and safety-compliant integration of artificial intelligence approaches for object recognition, scene understanding, and decision-making. **hipeac.net/network/projects/6910/prystine**

ECSEL project **3CCAR** will demonstrate next-generation, high-reliability and high-efficiency power systems for electric vehicles. **3ccar.eu**

3

Making it happen

Enabling national and regional strategies

HTSM aims at active partnering with government ministries and regional public organisations to realise a long-term alignment of scientific research, technological innovation, and societal challenges. The Top Sector will use the societal framework outlined in this Knowledge and Innovation Agenda for building bridges between the bottom-up, key enabling technologies and the top-down, mission-driven programming in national and regional strategies. In this process, the Top Sector will leverage its strong processes and networks for developing knowledge and innovation programmes.

Building bridges with new stakeholders

The core process in the Top Sector HTSM is the broad stimulation of public-private partnerships through bottom-up teams, with open and transparent participation by large and small enterprises, institutes and universities, government ministries and regional public organisations. With the societal framework in the HTSM-KIA, value is added by building top-down bridges to and from HTSM, with new stakeholders stepping in and act when and where action is required.

Collaboration with other top sectors is increasingly important for enhanced partnership between public and private stakeholders inside and outside HTSM. Cross-over activities are in place with the Top Sectors Agro-Food, Horticulture and Chemistry, with explicit involvement of ICT[11]. HTSM is actively pursuing further extension of activities into other cross-sectoral domains.

Broad stimulation of public-private partnerships through bottom-up teams

Leverage from international R&D initiatives

As HTSM parties compete in a global market, participation in joint European R&D programmes is a priority for both industry and science. Results gained in international collaboration leverage the contribution of HTSM in the Netherlands. Consequently, the key enabling technologies in the HTSM roadmaps closely follow the headlines of the European Horizon 2020 framework programme and its foreseen successor. HTSM parties actively participate in the top-sector wide programmes of Joint Undertaking ECSEL and the Eureka Clusters ITEA3 and PENTA. These European initiatives are co-financed by industry and national public authorities, including those in the Netherlands.

Transparent programming with effective governance

The Holland High Tech Foundation (HHT)[12] coordinates the governance and programming of knowledge and innovation for the Top Sector HTSM. It supports research projects and programmes in HTSM and ICT by co-financing public research and technology organisations through the PPP grant. Network activities and innovation brokerage for SME are supported through the MIT scheme.[13] HHT also facilitates the national SME stimulation plan for collaborative innovation in HTSM and ICT. Through the HTSM roadmap teams, HHT actively engages with hundreds of innovative SME's and leading scientists.

Process innovation and digitisation are essential in the deployment of new manufacturing technologies

Alignment with science and industry

HHT aligns regularly with TNO, NLR and NWO on the programming of research in applied and application-oriented science. Long-term collaboration exists with the focussed research centres Holst Centre, ESI, M2i, QuTech, and ARCNL, and the universities of Delft, Eindhoven and Twente. The Holland High Tech Partner organisations[14] interface with the innovative industry at large, through joint activities in communication, networking, innovation brokerage, human capital and internationalisation, and they provide the connection with regional platforms.

Technology transfer and go-to-market

Process innovation and digitisation are essential in the deployment of new manufacturing technologies. The Smart Industry Fieldlabs have created a basis for joint experimentation and learning. The challenge at hand is to extend into more areas of expertise, and to spin out knowhow to the broad business community. This requires enhanced and consolidated public and private investment in a mission-driven Smarty Industry programme[15].

Following and implementing the rapid developments outlined in the HTSM KIA is difficult for many SME across the value chain. This situation is a major hurdle in technology transfer and a serious risk for sustained economic development in the Netherlands. Government policy and instruments should be put in place that support SME through smart manufacturing assessment[16] and individual stimulation involving both in-house resources and external experts.

Market introduction of products and services that directly serve innovation in societal challenges does not come automatically. Government ministries acting as launching customers and drivers of public procurement in mission-driven programming are very relevant for HTSM, especially in go-to-market strategies for the many innovative SMEs, start-ups and scale-ups in the Top Sector.
The SBIR[17] instrument is a recognised tool for bridging the gap between successful R&D and the creation of economic value. Effective exploitation requires systemic improvement of the present set-up, as well as structural alignment and long-term collaboration with the involved government ministries.

4

Appendix

Organisation

The Top Sector HTSM is governed by a Top Team[18] of leaders from industry, science and government. It is supported by a secretariat from industry, research organisations and the Ministry of Economic Affairs and Climate Policy.

Holland High Tech (HHT) is the Top Consortium for Knowledge and Innovation in the Top Sector HTSM (Stichting TKI HTSM). It coordinates the programming of public-private activities with science and industry. HHT provides the secretariat for the Top Sector HTSM in close collaboration with the Holland High Tech Partners.

The HHT Foundation is governed by a board with executives from the public and private sectors; the HTSM Top Team members participate in this board. A supervisory council with key stakeholders from the Top Sector HTSM advises the board on strategy. Day-to-day management of the Foundation is delegated to the HHT director, who is supported by an HHT office.

R&D programming for the Top Sector is mandated to the HTSM Roadmap Council; its members chair the HTSM Roadmap Teams. Each roadmap is kept up to date by a team of experts from public and private organisations and chaired by a representative from industry who is appointed by the board.

HHT is mandated by the Ministry of Economic Affairs and Climate Policy to execute the PPP grant instrument for R&D and the MIT scheme for networking activities and innovation brokerage in Top Sector HTSM. NWO-TTW supports the HTSM-KIA through an annual call for collaborative research projects within the scope of the combined HTSM roadmaps.

Roadmaps

The HTSM roadmaps are bottom-up initiatives from science and industry within the Top Sector. In their subdomain, they explain societal challenges and economic relevance, applications and technologies, priorities and implementation, partners and process, and foreseen investments in public-private research. The collective investments of the individual roadmaps sum up to the Top Sector HTSM multiannual public-private R&D budget.

TABLE 2 Top Sector HTSM multiannual public-private R&D budget (millions of euros per year)

Year	2018*	2019*	2020**	2021**
Private	545	570	590	610
Public, specific	104	105	105	105
Public, non-specific	111	125	135	145
Total	**760**	**800**	**830**	**860**
Sub-total, European projects only	**470**	**500**	**530**	**560**

* topsectoren.nl/publicaties/publicaties/rapporten-2017/december/11-12-17/kic-2018-2019

** HTSM proposal, not confirmed

ADVANCED INSTRUMENTATION

Systems and technology for measuring radiation, light and particles; determination and monitoring of location, movement and vibration; management, processing and interpretation of big (sensor) data for Big Science; instruments for R&D and production processes.

AERONAUTICS

Technology and innovation for more sustainable and safer air transport: aerostructures, engine subsystems and components, maintenance, repair and overhaul, aircraft systems, and novel materials.

AUTOMOTIVE

Solving problems like emission, congestion and noise disturbance, and promoting safety. Research topics: sustainable powertrain, smart mobility.

ELECTRONICS

Developing new generations of (chip) technology, electronic components, ICs and electronic systems for use in alternative energy, electric cars, mobility and transport, logistics, communication, safety and security, privacy, healthcare, climate and water, intelligent cities, aviation and space.

EMBEDDED SYSTEMS
Integrated hardware/software systems that add intelligence, decision-making and other possibilities to high-tech products that foster economic activities and quality of life.

HEALTHCARE
People-centred nanoelectronics, embedded systems and mechatronics for prevention, diagnosis, intervention and therapy, informal and formal primary care and homecare, and enabling technologies for healthcare.

HIGH-TECH MATERIALS
Understanding materials and their properties during production, processing, use and re-use as well as cost-reduction and safe handling of novel (nano) materials.

LIGHTING
Lighting technology from components and solid-state lighting (SSL) systems, to people-centred, energy-efficient and intelligent lighting solutions.

NANOTECHNOLOGY
Cross-sectoral technologies in materials, electronics/optics and sensors, for applications like lighting, energy, health and water.

PHOTONICS
Translating applications into requirements for components and performance, technologies for photonic-electronic integration, and processes for fast and smart design and production.

PRINTING
Printheads and functional materials, reliability and advanced measurement and control engineering, and architecture of digital print platforms.

SECURITY
Protecting the security of people and society in the event of violence as well as situations that arise from crises and disasters. This is realised with technology in the domains of systems-of-systems solutions, cybersecurity and sensors.

SEMICONDUCTOR EQUIPMENT
Innovation with respect to the equipment for producing advanced integrated circuits: miniaturisation of components, enlargement of chips and substrates, and fabrication techniques.

SMART INDUSTRY
Mechatronics, production technology linked to ICT, fast and accurate sensing, integration of micro and nanotechnology and smart materials, and smart industry field labs.

SPACE
Development of products for satellites and launching vehicles, and new products and services based on satellite data in agriculture, food, water, energy and logistics.

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Pictures

Climate: National Wind Technology Center | Dennis Schroeder
Sustainability: GrowWise Center | Philips
Health: Azurion Hybrid Operation Room | Philips
Security: Privium Iris Scanner | Schiphol Airport
Mobility: Truck Platooning | DAF