From Digital via Smart to Sustainable 2020-2025-2030-2035

A TNO initiative made possible by a subsidy of the Dutch Min. of Economic Affairs & Climate and the province of Noord-Brabant.
Smart Industry – the Dutch Industrie 4.0 Program

The Netherlands has developed the best and most flexible and digitally connected production network in Europe and using less energy and and materials for a sustainable & competitive economy with a culture in lifelong (digital) skills training

8 Industry transformations and 45 Smart Industry Fieldlabs are the core of the program → now 5 EDIH in spe (North, East, South, West, and Northwest (A’dam))
Ambition and Roadmap for Factories

Zero paper:
100% of stations/workcells are digitalized

Zero defect: e.g.
100% automated Q-control at each step

Zero programming:
Robots, cobots, AGV with sensing & Digital Twin

Zero tooling:
3D printing/additive manufacturing

Zero delay:
just-in-time, lot size n=1,

Zero surprise:
predictive maintenance and servitisation

Zero waste:
recycling and sustainable energy

Zero drop-out: lifelong learning for everyone

Digital Factory
Robotics, Cobots, AGV, Industrial Internet of Things, Digital Twinning, AR/VR, Automated workcells, (zero ambitions)

1: known series of products

Smart Factory
Flexible, Robust, resiliency, downloadable design for 3D printing, lot-size-1

2: new products & variants

Sustainable Factory - Extreme Flexible (Re-) Manufacturing Autonomous systems, handling ‘never seen’ products

3: unknown products based on recycled materials and products
Ambition and Roadmap for Value Chains

Digital orders to factory and inside factory to all process steps digitalized/paperless from all robotic/operator stations to ERP/customer portals with realtime info.

Real-time deep chain planning & control, paperless product changes, full traceability for flexible, more robust, resilient smart value chains,

Product digital twin over design, manufacturing, use and (optimal) recycling of products

Digital Chain (digital customer portals) 2025

Smart Chain
Subtiers – 1st-tier supplier – OEM - customer 2030

Sustainable Chain/eco-systems 2035
Vision: from digital via smart to sustainable

Roadmap (inside) Factories

- Digital Factory
- Smart Factory
- Sustainable Factory

Roadmap (inside) Value Chains

- Digital Chain
- Smart Chain
- Sustainable Factory
- Sustainable Chain/Ecosystems

Roadmap phases are dependent progress in other roadmaps, in particular for the value chain as the majority of supplier factories should be on par too.
NWO Smart Industry call 2020 (but practically 2021/2)

- Mass customization / use-based adaptation
- Human Centered Technology / Human Technology Interaction
- Digital Twin
- Cyber Physical Systems
- (Trusted) data sharing
- Advanced Manufacturing
- Robotics

HTSM (hollandhightech.nl)
Commit-2-Data (dutchdigitaldelta.nl)
Creative Industry (click.nl)
Research area 2: Human Centered Technology / Human Technology Interaction

To design new personalized products, industrial systems and product service systems we should employ an integrated approach to value creation, system thinking, human technology interaction (HTI) and scenario-based design involving all stakeholders. Human technology interaction will change because products & systems get smarter and become connected through the internet. As the use of sensors has become widespread, smart products and systems will increasingly present their users with actual information on their operation, giving usage, maintenance and repair instructions.

Main focus of this theme for this call is the combination of sensor data, autonomous robotic systems (in unstructured environments) and human actors in collaborative environments with tailor-made user interfaces for human technology interaction. The focus is on optimal support for human actors by new technology and proper user interfaces. Challenges aimed at for SI2020 projects are an inclusive technology design of intuitive and logical interfaces and interactions between humans, robots and manufacturing systems.
Research area 1: Mass customization / use-based adaptation

In mass manufacturing, the optimization of production processes is the primary driver for price competitiveness. Drawbacks of this approach are that it leads to “one-size-fits-all” products with standardized components, conservative product designs, limited shapes, rigid supply chains and pressure to minimize product variety.

Customization is a game changer in high-value manufacturing and requires a much closer integration of design with manufacturing. High product variability should be offered in combination with scalable and viable manufacturing.

Mass customization must be supported by computational design tools and tools which ensure first-time-right manufacturability to avoid scrap or unnecessary material waste.

**Main focus of this theme for this call** is coupling heterogeneous and distributed data to model based engineering. This will allow for condition and usage/user based adaptation (in/before production), but also for products to be adapted to changing usage conditions and context. The challenges we call for in projects to address is how to realise mass adaptation from the perspective of the total system and how to cope with such adaption from the data-technical point of view. This calls for autonomous systems with customized solutions. An important aspect is how to enable an end-user not skilled in digital solutions, to select the best digital solution. Mass customization also calls for highly integrated and adaptive service design solutions; services are by definition customisable and can increase the adaptation options of physical systems.
Research area 3: Digital Twin

A digital twin is a digital representation of the physical system (including processes, sub-systems, materials, products and assets). Physical system-based models have been used in model-based design and virtual prototyping of high-tech systems. Key technical challenges are solution robustness and system interoperability: maintaining, reusing and exchanging information among different models. Data-driven digital twins are based solely on data collected from the realized processes/systems/products. These models are typically used for monitoring, real-time process control and maintenance of the assets. Similar to the physical model-based approach, these different data-driven digital twins also face interoperability problems and do not allow the support of design cycles of non-existing products or processes. Future Twin will combine different types of information (data fusion).

The consequences of mass customisation are an increasing variety of products and solutions, matching individual human needs. This could open a road towards human based digital twin concepts.

Main challenges we aim for in this theme are interoperability, machine learning algorithms creating the Artificial Intelligence of the Twin digital twin representations of humans and matching of the human twin with the system and product twins. A challenge is the fact that models and simulations are needed for very rare instances that faults occur; pattern recognition of almost never occurring flaws.

The digital twins should cover for IP sensitive data, e.g. manufacturer proprietary information, and hence a strong link exists to the separate theme of ‘Trusted Data Sharing’.
Digital Twinning in design (type) & production & use phase (indiv.)

Digital Twin is a “living (historic + real-time)” digital representation of the physical object. DT (Digital Twin – design of the object) and DTI (Instance – individual object) are key components.

- **3D model (CAD, AR/VR visualization)**
- **Physical Process model**
- **Manufacturing & Product information**
- **Simulation Model (AI Learner)**
- **Key value & legal data (immutable data)**
- **Historical usage data per object**
- **Bulk data (e.g. cloud)**

**Blockchain (DLT)**
- e.g. of DT;s:
  - a product
  - a machine
  - a sensor
  - a factory

**Object Type**
- Individual object

**Digital Twin = AAS (Asset Admin Shell)**

**Physical object**

**Machine Learning (AI)**
Research area 4: Cyber Physical Systems

The digitization trend at the industrial level leads to a merger of the physical world of production with the virtual world of information, data and computational power. The importance of cyber physical systems (CPS) of systems in the context of Smart Industry is increasing. It involves integrating digital information technologies in products, processes and factories and connects them to perform a certain function, provide a service or produce a product with the goal to achieve better quality and to adapt automatically and instantly to, for instance, changing material conditions or customer demands. Compared to the digital twin of the previous section, CPS is in fact the runtime coupling of the digital twin with the real world system. Examples of CPS include communicating manufacturing systems/lines, systems to track and analyse emission, communicating (wireless) sensor systems, and systems to provide situational awareness.

Main focus of this theme for this call are semantically interoperable systems that collect and process detailed data about embedded and physical states, events and processes, Internet-enabled decentralized monitoring and control algorithms using wireless sensor systems. Those CPS solutions are aimed at improving process and product performance and enable proactive maintenance strategies using local and global information. The CPS requires effective, reliable, real-time and secure data collection, multi-physics predictive modelling, and data analytics under industrial conditions. It should include solution strategies for failing sensors, and feed the model strategies into the digital twin.

Obviously, the networked and information intensive nature of CPS, brings about big challenges with respect to security. This is covered by a separate challenge ‘Trusted Data Sharing’.
Research area 5: (Trusted) data sharing

More and more products (and services) will be designed, developed and produced (provided) by multiple parties, often industrial parties, but more and more also in combination with public parties and customers.

To achieve a smooth and data-safe cooperation data and information about the product, the design, subsystems, use of the product, etc., have to be shared among all these parties. However, that what is being shared, here called ‘data’ for short, lies typically at the heart of the intellectual property and the competitive edge of the parties involved. Hence, the way the data is shared should ensure that the data can only be shared with the intended parties, and only for the intended purposes, hence, cannot be illegally handed to other parties, nor be used for other purposes than intended; this notion of sharing while keeping control is often referred to as ‘data sovereignty’.

**Main challenges we aim for in this theme** are applications as servitization (‘new business models based on digital platforms where multiple applications and components work together’), DLT (Distributed Ledger Technology) solutions for autonomous products with digital IDs and their own DLT history, data interoperability being compliant to (privacy) regulations and the secure and dependable storage itself. Abstractions of models for certain applications and usage patterns allowed (or not) on proprietary data are important challenges to cover in proposed projects. These issues closely link to the themes of digital twins and cyber physical system (of systems).

Of course, we expect that proposed solutions will make use of international I40 (industry 4.0) standards like IDS (Industrial Data Space) and OPC-UA or Reference Architectural Model Industry 4.0 (RAMI 4.0).
Research area 6: Advanced Manufacturing

Advanced manufacturing technology contributes to the realization of three major trends in production systems, i.e. increased efficiency, quality and reliability. It requires process monitoring and modelling approaches, associated with novel optimization and maintenance strategies. Improvements in manufacturing technology will be data-driven and can be based on measurements or models (deep-learning techniques, statistics, and physically based models).

In this call we aim in particular at solutions using data and personalisation to enable smart design both for smart end-user products and for smart factories with e.g. smart equipment or smart robotic systems supporting humans.
Research area 7: Robotics

Smart Industry themes such as high mix, high complexity, low volume manufacturing, introduce new challenges to robotics such as zero-programming. The added value of robotics innovations is potentially very big, e.g. through integration of many sensors, wireless networks, and information technology (digital twins, artificial intelligence and control algorithms) across the industrial environment (but also other sectors such as food processing, and smart agriculture). This typically leads to integration of more feedback and feedforward control approaches and production automation/robotics technologies into the manufacturing and assembly environment.

Of particular interest in the context of SI2020 project proposals are adaptive/learning or robust control loops, autonomous reconfiguration of control algorithms, human robot interaction and decision-making systems for robotics, the development of novel sensor technologies and metrology, vision integration, in-line inspection and monitoring, fast data processing and transport with the ambition to maximise the flexibility and to minimise the time and cost of programming robotics for large varieties of products.
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Other calls:
- NWA Smart Industry - gesloten
- NWO Perspective – 5 okt definitief
tbd AI Groeifonds - ? 2021

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