



# READY FOR DIGITAL TWINS

The TNO primer towards Smart Industry and Digitalization

# WHY DIGITAL TWINS?

## Just imagine

Your equipment constantly tuning its performance to current tasks, allowing lot-size-1 production runs and customized operations. Your workflows constantly optimizing towards high efficiency and no waste, reducing costs and preserving the environment. After-sales processes that are aware of your assets' conditions, directing maintenance to be just-in-time, preventing unscheduled downtime while never sending a service technician in vain.

We achieve this with the rise of Digital Twins in a digitalization push based on the fusion of IoT with system analytics and data science.

Digital Twins reduce total costs of ownership of assets with data-driven control and operations using real-time information to mirror and understand physical systems and their processes over their full lifecycle.

## Digitalization is an opportunity for your business

Digital Twins are excellent carriers of digitalization strategies in which we bring data, information, communications, processes and services together via digital platforms. Digitalization offers benefits through the automation and optimization of processes as well as through more flexibility and individuality of products and services for new business.

Digital Twins are

- > digital replicas of physical assets or systems
- > connected to live data from their physical twin

## Your starting position and your goals lead your way

Generating Digital Twins effectively from available engineering and process resources gives you a head start — but then again, a greenfield approach can let you build everything fit-for-purpose. Similarly, your business case determines the needed abilities and scope of your Digital Twins: predictive maintenance, e.g., only focuses on the equipment in the field, while process optimization also mirrors material flows.

Becoming aware of your position, time-line, needs, and goals is thus your first step.



## Digital Twins return their investment

But they are not free. As any complex undertaking, they take time to mature in your business, require skilled people, and a reliable infrastructure. We at TNO help you with that — but it is your journey.

Once started, Digital Twins provide a competitive edge that often leads to a return of the initial investment after 2 to 5 years; a time-span that shortens as full frameworks for their realization become available.

## Content

Understanding the what & the why

Your strategy in 7 steps

Your approach & how we help



monitoring



scheduling



optimization



smart logistics



diagnosis



predictive maintenance



## Typical business cases

# YOUR STRATEGY IN SEVEN STEPS

## Start with WHY **1**

### Determine your purpose

Total cost of ownership, needed guarantees for performance or uptime, and necessary efficiency are typical candidates.

### ↳ and your business value

What are the KPIs for the purpose?  
What are the main impact factors?

What offers an improvement?

### Choose your Digital Twin application



### More than one application?

Best to start with one or few applications that are closely related. Moving to several purposes later is possible by building dedicated twins for each application. Extending existing twins works *if* it is well prepared.

## Asset Selection **2**

### Choose the asset to twin

Criticality and business impact direct this choice about scope.

example

24/7 factory operations accept no downtime in costly equipment to have an acceptable TCO and ROI. No breakdowns + fast, plannable field service become key.

Preventive condition-based maintenance is thus the application of choice.

We twin critical manufacturing equipment.

## Infrastructure **3**

### Bring sensors live

Much, but not all, of the data a Digital Twins needs is available from existing sensors.

Enable live access to all the data needed to meet the application and action [see 6] requirements.

### Enable information flows

The right data at the right place at the right time to take decisions: a good Information Architecture ensures that, but is hard to do.

TNO experts have suitable blueprints and know-how to help.

### Vendor lock-in?

Infrastructure decisions last. Consider your dependency from vendors or providers.

## Twin Building **4**

### From physical to digital

If you twin an existing system or if you start with a virtual prototype, always use operational knowledge *and* engineering expertise to build the Digital Twin:

Observed data, failure modes and effects analyses, experiences of operators and service teams all provide for the generation of the model at the Digital Twin's core.

Knowledge elicitation techniques complement model-based design in this, with data-driven machine learning techniques available to determine parameters.

### Ensure trust

A Digital Twin is a system.

Validate it. Test it. Invest time to see what it can and cannot do.

## Live Operation **5**

### Always on, always in step

A Digital Twin runs concurrently to its physical twin. It uses live data to compare the observed with the expected, to detect anomalies, to reason about events, and to predict the assets' future behavior.

How to do that sensibly, e.g., how to set up the update frequencies, depends on the application as well as the system's time-critically.

### Detect autonomously & reason on-demand

Time-critical applications related to control and anomaly detection must run at least near real-time and autonomously - which entails a fully automated data pipeline.

Complex reasoning, like diagnosis, can be operated manually as well.

## Business Action **6**

### Reap your benefits

Information provided by a Digital Twin is information to act upon.

Implement the procedures to do so.

example

As the Digital Twin detects a high wear-out in a critical asset on the factory floor, pre-planned actions are set in motion:

- > Production automation shifts into an less demanding mode.
- > Online diagnosis determines affected parts
- > Logistics route necessary parts towards the factory
- > Maintenance is scheduled
- > The service team resolves the maintenance supported by up-to-date information before the wear becomes a tear.

## Cradle to Grave **7**

### Keep it alive

Digital Twins are specific to their physical twins, mirroring them as designed, manufactured, used, and maintained.

When operations or tasks change, especially if the physical system is altered or upgraded, the Digital Twin needs to be maintained, too, to reflect the new reality.

We have techniques for that.

### Knowledge management

Keeping both twins in sync and capturing the related information in a knowledge-base ensures that business processes have accurate data for the systems' full lifecycle.

The knowledge base is updated, capturing the maintenance, and the Digital Twin is updated.

# YOUR APPROACH

## There is more than one way...

Implementing the Digital Twin strategy following the steps above can be done very differently and there is no approach that fits all.

In some places, it is best to start small and grow: run a pilot with a small team that wants a real solution to improve your way of operation. They go fast, experiment to fail and to learn, then prove the value of their work. Take their success as showcase and seed, ensure visibility, provide means to form a network of enthusiastic early adopters and watch the transformation grow until there is critical mass for a full roll-out.

In other places, strong ICT and process departments that have a firm grasp of both business needs and technological ability are situated to plan and realize the introduction of Digital Twins. They manage change, organize the roll-out and training, and direct the process.

## but some things are always required



Management support:  
all in and clear on goals



Open communication:  
bi-directional and with trust



End-user involvement:  
do it right for them or not at all



Technical competence:  
to do major choices in-house

# AND WHAT WE OFFER

## Culture

**Adopting digital twins for system control, lifecycle management or smart systems is a journey.**

Such a journey works great within an organization-wide digitalization of engineering and business. But either in this way or undertaken by itself: it will always require a novel mix in the skills of employees and the ability to face change. In this, culture is key.

Thinking ahead to bring everyone along might well be the prime success factor.

## We are here to help

TNO connects people with knowledge to help you and your business.

We draw from our expertise in IoT, trusted ICT, monitoring and control, AI and data science to guide you towards Digital Twins, support you with information architects, and help you to digitalize your operations.

## Research with TNO

TNO develops knowledge to create innovation and practical applications that boost the competitive strength of industry and the well-being of a sustainable society.

By partnering with us in applied research, you can be part of this. Just get in touch!

## Further information

[ICT @ TNO.nl](#)

[Digital Twins @ ESI.nl](#)  
[+ ESI Research Position](#)

[Scalable IT Systems: Efficiency with IOT and Big Data @ TNO.nl](#)

[Smart Industry @ TNO.nl](#)

[Smart Industry Implementatie-agenda 2018-2021 @ TNO.nl](#)

[Flywheel of Innovation in the Netherlands @ TNO.nl](#)

[TNO and SMEs @ TNO.nl](#)

**TNO** innovation  
for life

## TNO ICT

Jeroen Broekhuijsen

Location Groningen

088 866 77 15

[jeroen.broekhuijsen@tno.nl](mailto:jeroen.broekhuijsen@tno.nl)

## The authors



Dr. Michael Borth  
Senior Research Fellow at ESI (TNO)



Jeroen Broekhuijsen  
Consultant at TNO-ICT

With about three decades in R&D among them, Michael's and Jeroen's work centers on smart systems and the use of state-of-the-art computing and data science in engineering.



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