Partner van de NL AIC

Ai hub NOORD NEDERLAND

Data delen

Gert Kruithof

Data Delen: het landschap

ELSA

- Ethisch
- Legal
- Societal

- AI
- Inter-operability
- Identity
- Trust
- MPC

iSHARE

Technologie

Inter-nationaal

Nationaal

In de regio

Peppol

DATA SHARING COALITION

gaia-x

INTERNATIONAL DATA SPACES ASSOCIATION

NL AI Coalitie

Data Delen

bytesnet
Geeft data daadkracht

DATACENTER GRONINGEN

smart connected supplier network

health RI
enabling data driven health

JoinData

NXT GEN HIGHTECH

TOPSECTOR ENERGIE
Innovatie voor een duurzame toekomst

Volgende slide

Infrastructuur

Harmonisatie / standaardisatie

Domeinen

Innovatie

Data Delen: wat is er in de regio?

DATA FRYSLÂN

Noorden Digitaal

rijksuniversiteit groningen
Groningen Digital Business Centre
Faculteit Economie en Bedrijfskunde

SNN
SAMENWERKINGSVERBAND NOORD-NEDERLAND
H- EN INNOVATIESTRATEGIE
MME SPECIALISATIE (RIS3)
VOOR NOORD-NEDERLAND
2021-2027

TechHub Assen

IT:HUB

NOM
EUROPEAN DIGITAL INNOVATION HUB Northern Netherlands

bytesnet
Geeft data daadkracht

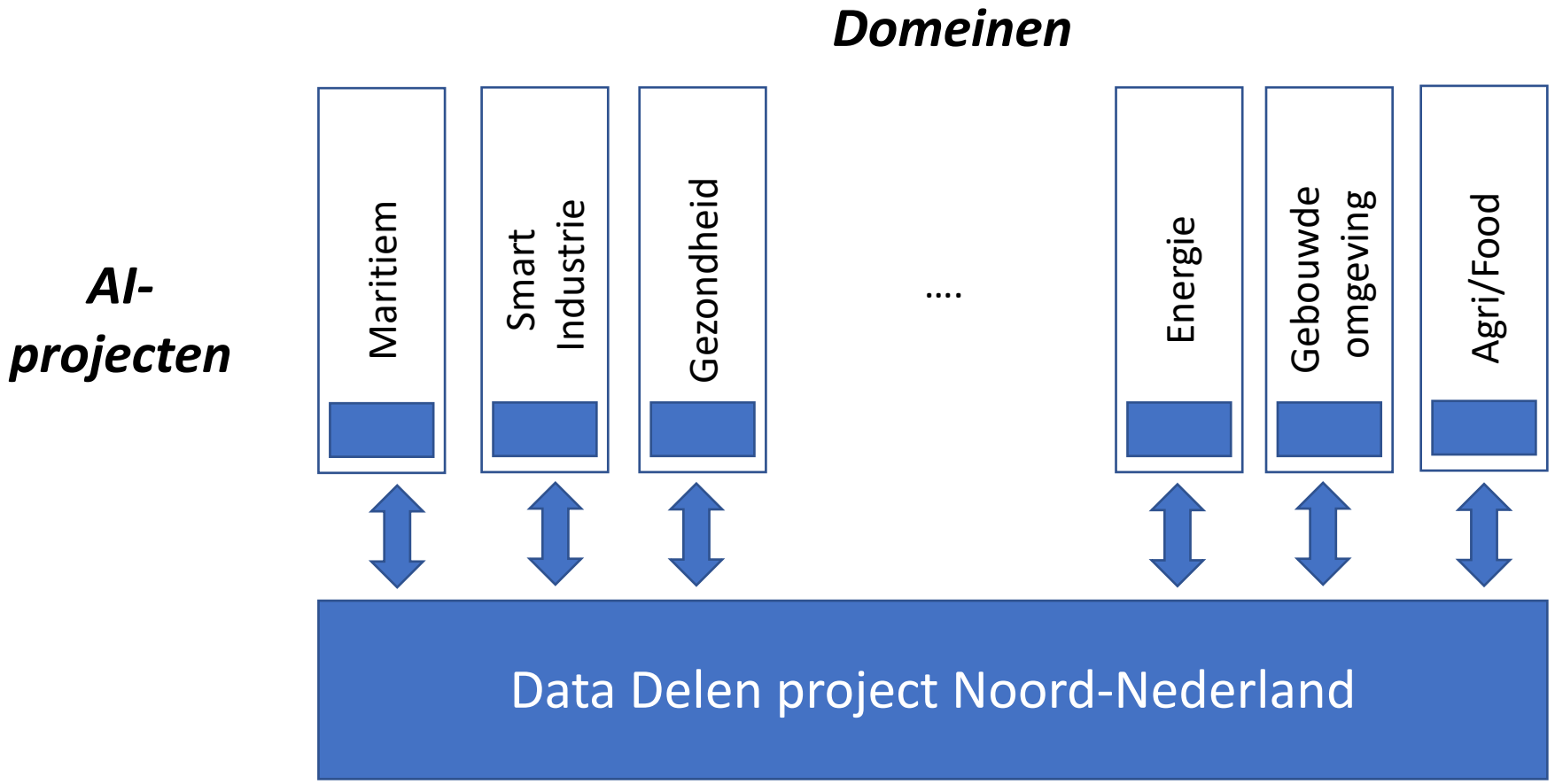
DATACENTER GRONINGEN

Urban Data Center
Regio Groningen

Hanzehogeschool Groningen
University of Applied Sciences
digital society hub

Ai hub NOORD NEDERLAND

Data delen Noord-Nederland next steps



Project-specifiek

Lange termijn

smart industry

Het AI-congress van Noorden –
Data Delen: Het bos en de bomen

SMART INDUSTRY (Fourth IR/I40 in NL) DUTCH INDUSTRY FIT FOR THE FUTURE

www.smartindustry.nl

Egbert-Jan.Sol@TNO.nl

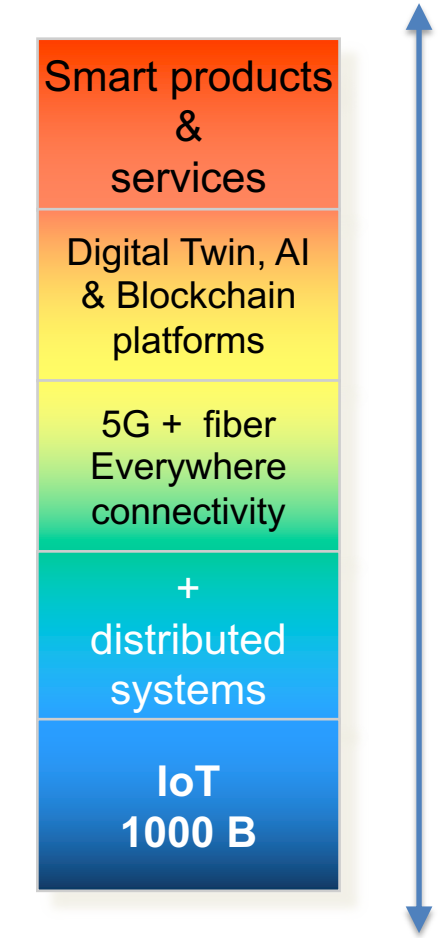
oct 2022 v1

A TNO initiative made possible by a subsidy of the Dutch Min.
of Economic Affaires & Climate and the province of Noord-Brabant

Provincie Noord-Brabant

AI apps will come, but first, we need to structure the data stack below

Internet of Apps/Services IoS:



Internet of Things IoT

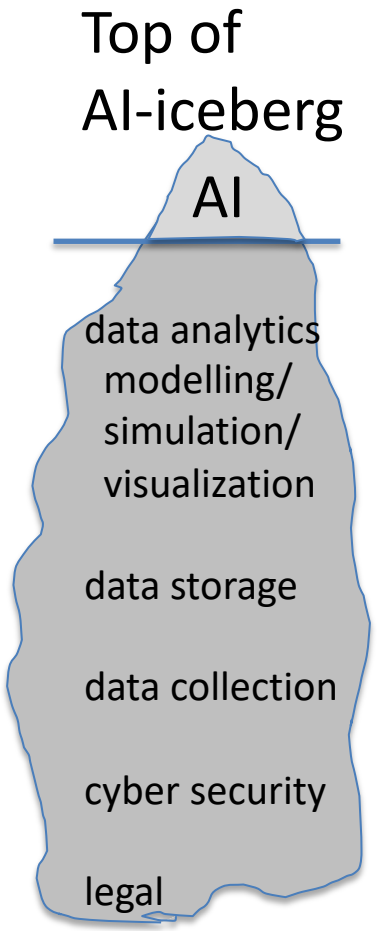
Control – smart AI

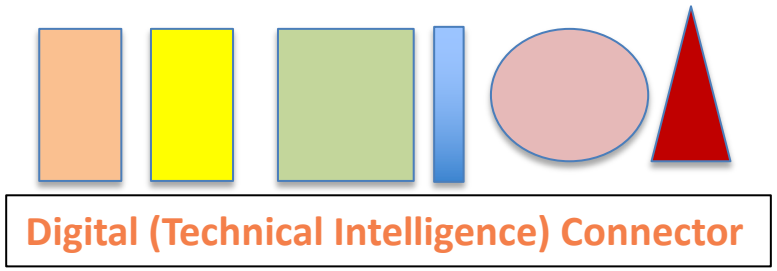
Control – direct

Data visualization & monitoring

Data collection & storage

Sensor data & communication

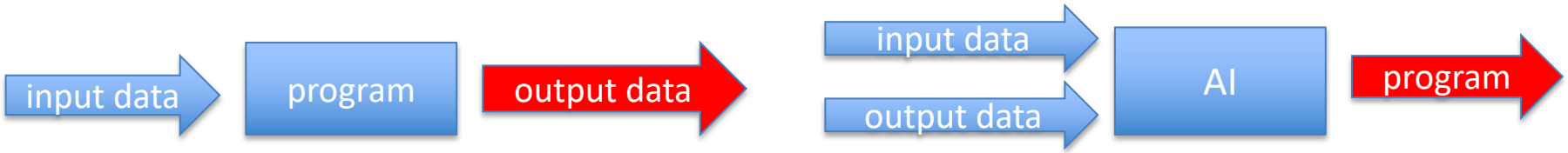




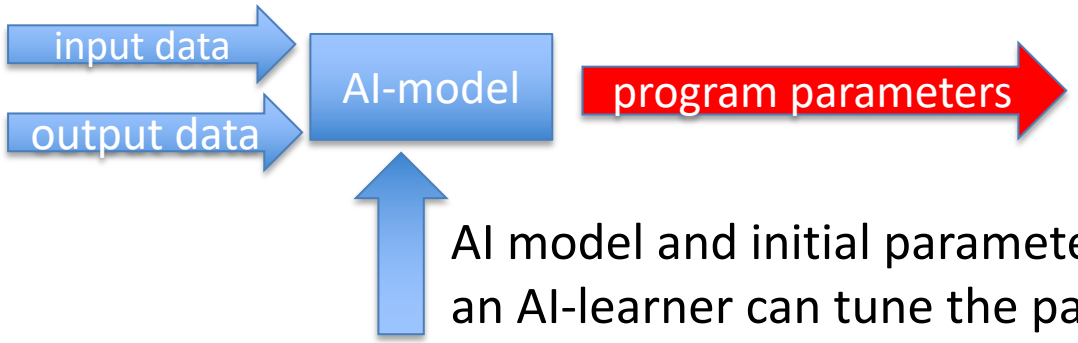
Artificial Intelligence or better Machine Learning

AI-hypes go up and down (already two or more AI winters since 1960)

The AI-holy grail & the misperception – input + output => program : no more programming



Now comes the small letters: In real life, there is no AI master algorithm fitting all problems or as silver bullet.



AI-models: neural networks,
evolving programs with selection,
physical process models, Bayes statistics, ..

AI model and initial parameters and with machine learning
an AI-learner can tune the parameters such that with new input produces new output

Will history (of industrial control engineering) repeat itself?

The 90-'ties: parameter estimation of advanced control systems
e.g., Kalman filters – linearization of large (process) plants around their setpoint
model fitting by estimation of the (linear) coefficients/parameters of (PID) control loops

After several years, those systems were not used anymore as the plant and their operational setpoint (product mix, remodified equipment,..) had changed and reality was drifting away into non-linear behavior

Artificial Intelligence, in particular, the popular & hyped CNN (neural network) faces the same lesson soon!!!
Once a model has been trained, but the environment change, you must retrain the model again.
Nice for stable millions of medial (X-ray, Pathology) or astronomical pictures, but not for many other apps.

USA big tech loves AI (and its sales), but VCs don't fund AI startups anymore,
75% of AI startup money goes to AWS/Alphabet/Microsoft for training AI models in their cloud platforms.

Universities love AI: it is a euphemism for statistics. Studying statistics doesn't recruit any student, AI does
and any research proposal should include AI to get funded by old reviewers who hardly understand it.

Let’s be sensible

Today AI tools require at least knowledge and usage experiences of Linux, Python/MatLab, and several of the many AI libraries and models, in general, a knowledge level only achievable by e.g., a PhD-student of last year’s MSc or smart BSc student with a technical or IT background.

And making a sensible AI application, you need to collect hundreds of labeled data sets (e.g., photos coupled with a decision e.g., good or wrong, often verified by so-called 100.000+ “Mechanical Turks”) or follow the opposite of the diminishing return idea now followed by Big Tech of investing Billions in AI calculations.

- The five fingers app and the statistical uncertainty of 50% that it are 4 (or 5) fingers

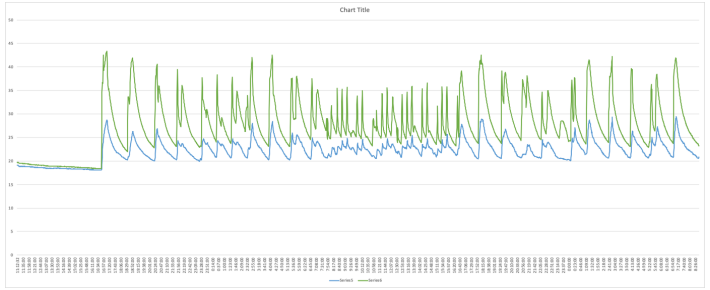
- The AGV example dropping off the table/against wall. => need combi of AI model and physical models

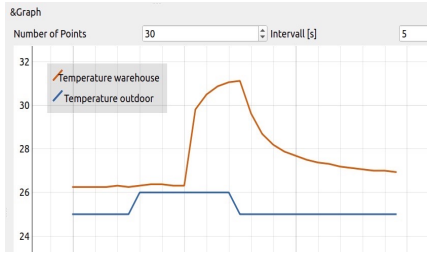
- Or enter the complete internet as the training set

And then, as in the large process control installations or industrial job shop/manufacturing sites, you know that the product mix is increasing, production series are getting smaller, and soon you need to retrain again.

Follow a 20/80 approach

Define an industrial AI project, but don’t go for 100 % of the project to get 100% of the results
but spent 20% of the cost to collect serious data and analyze it, you might realize already 80% of the results

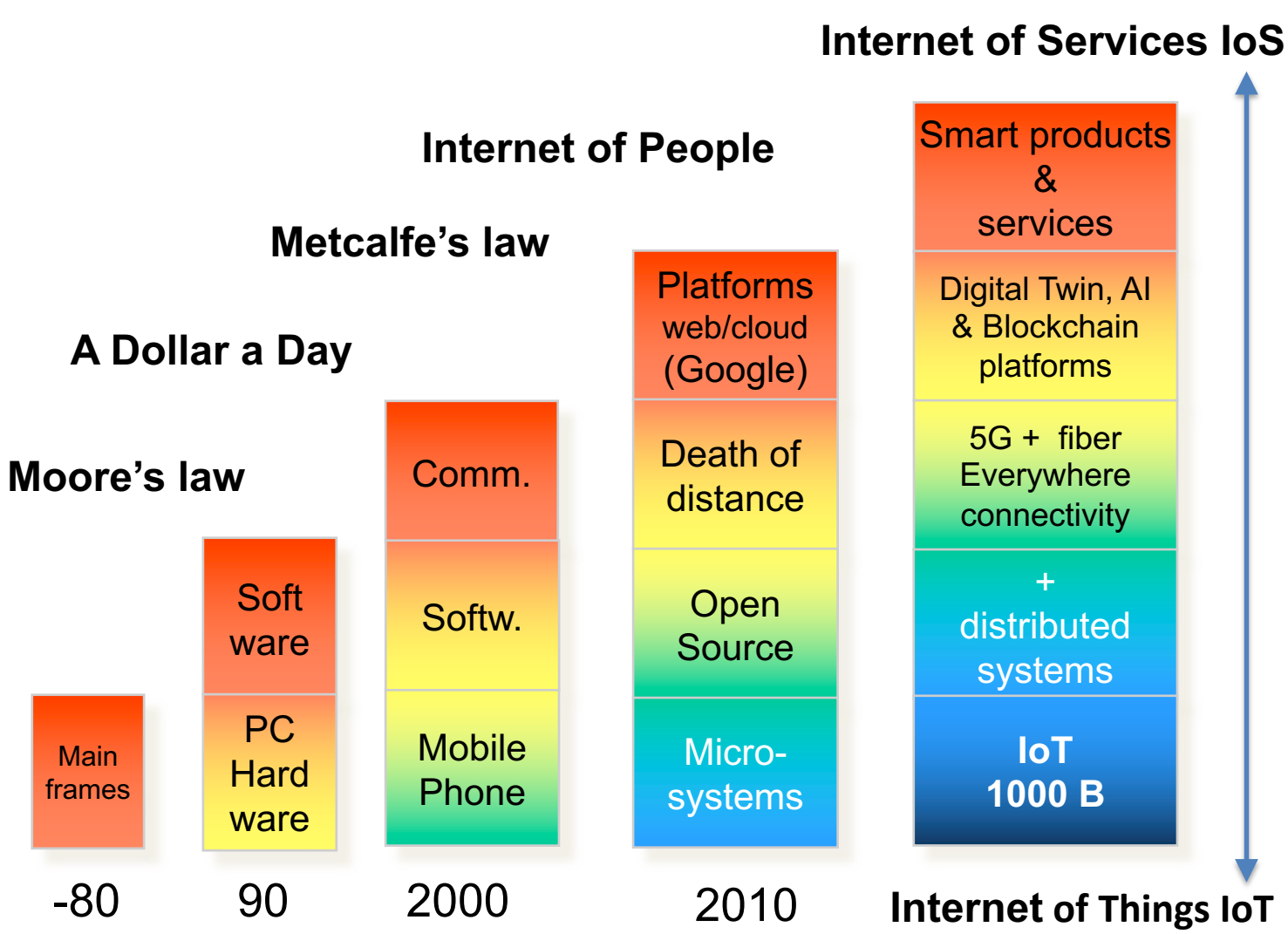


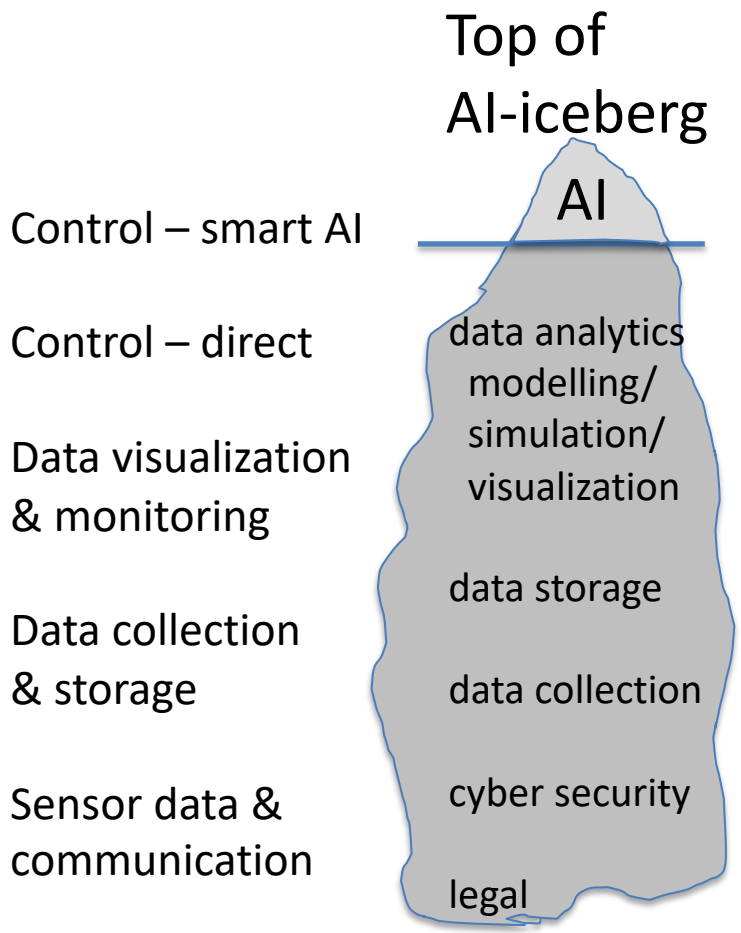


1: Vision - Zero defect – use vision to check every production step
    e.g., compare the output of a production step with a picture that you match with an inference model
    however, we need a model that can be trained not by hundreds of photos of good/wrong assemblies,
        but automatically by e.g., a rendered Digital Twin CAD model of (new) products and the work cell.

23: Prediction - Predictive maintenance (and similar trend analysis IAIA)
    e.g., use a model of what is/will happen, opt. MatLab based, and match data to that model

AI iceberg: the bulk of the work is on labelling clean data, not AI





Content:

Introduction – setting the scene

"Voordat we de Industrie boom in het AI bos groot laten groeien, moet eerst het wortel stelsel worden ontwikkeld vergelijkbaar met de ijsberg metafoor waarbij eerst de data collective op orde moet zijn"

Trends in Industry (Industrie 4.0/Smart Industry)

Digitalization and Sustainability

interoperability, autonomous operations and smart networks (supply/service)

How to digitalize?

– drive towards common (open systems) standards in the industry

- standard digital connector, DTI or I4.0 stack and apps

And then gradually create and grow the AI apps on top of a standard I4.0 stack

Kansgebieden voor toepassing AI

SMART SALES
- 24/7 PRODUCT CONFIGURATOR PORTAL
- SMART WEBSHOP

KLANT

PRODUCT

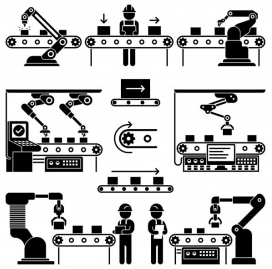
SMART PRODUCT
- INTELLIGENT & CONNECTED PRODUCTS

FABRIKANT

SMART LOGISTICS
- AUTONOMOUS SYSTEMS

SMART ENGINEERING
- GENERATIVE DESIGN
- DIGITAL TWIN

SMART EMPLOYEE SUPPORT
- AUGMENTED WORKER



SMART QUALITY CONTROL
- MACHINE VISION

SMART SERVICE & MAINTENANCE
- PREDICTIVE MAINTENANCE

SMART PRODUCTION
- **O**VERAL **E**QUIPMENT **E**FFICIENCY
- FLEXIBILISERING, N=1

FME POWERED BY DUTCH TECHNOLOGY

2030 VISION FOR INDUSTRIE 4.0

Shaping Digital Ecosystems Globally

PLATTFORM INDUSTRIE 4.0

Autonomy

Self-determination and free scope for action guarantee competitiveness in digital business models.

- Technology development
- Security
- Digital infrastructure

Interoperability

Cooperation and open ecosystems permit plurality and flexibility.

- Regulatory framework
- Standards and integration
- Decentralised systems and artificial intelligence

Sustainability

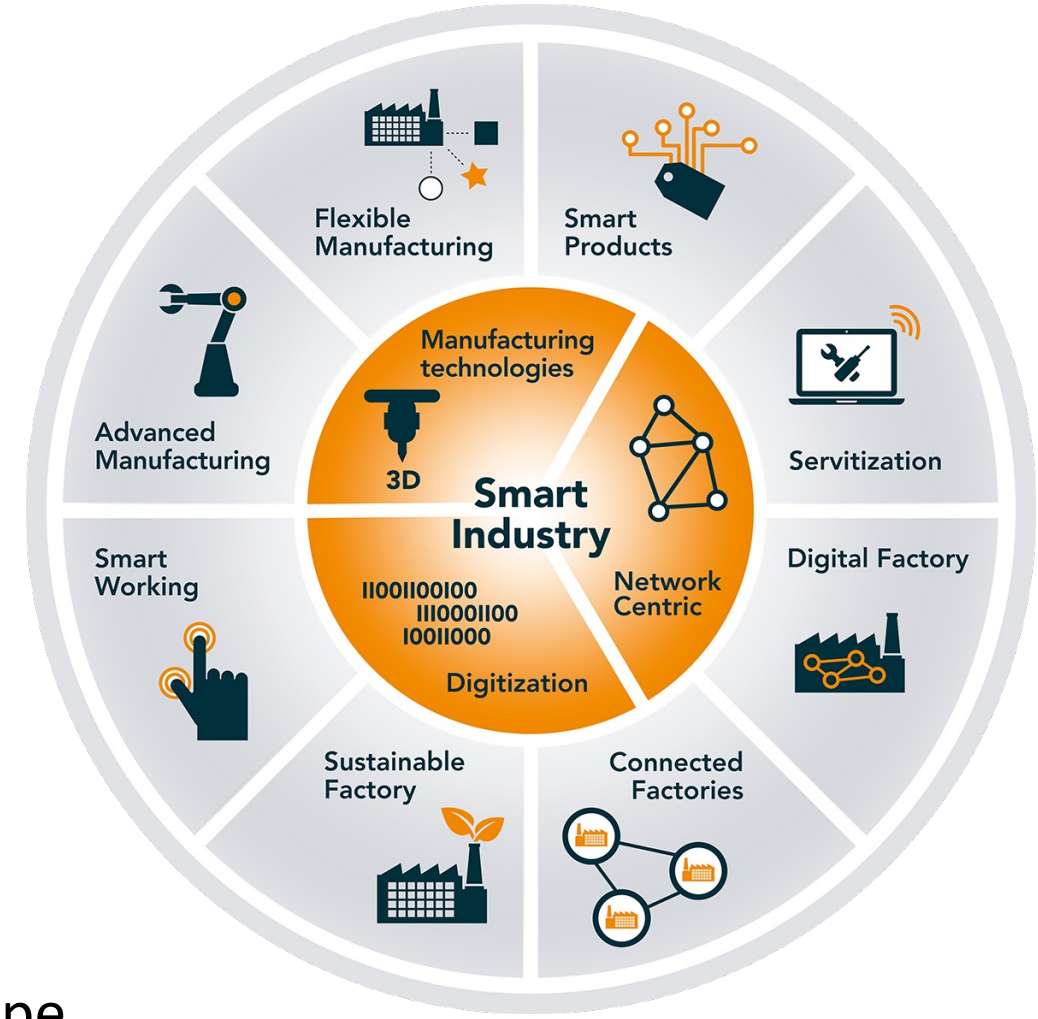
Modern industrial value creation ensures high standard of living.

- Decent work and education
- Climate change mitigation and the circular economy
- Social participation

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 materials
for a sustainable & competitive economy
with a culture in lifelong (digital) skills training

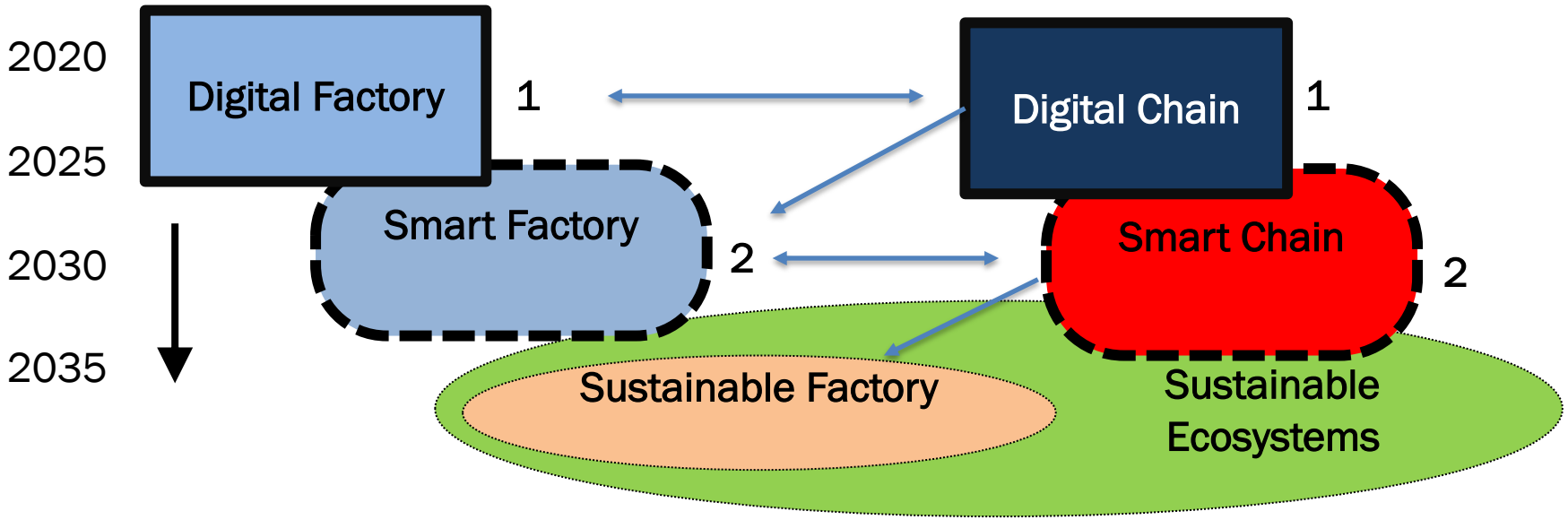


8 Industry transformations and
45 Smart Industry Fieldlabs
are the core of the program → now 5 EDIH in spe
(North, East, South, West, and Northwest (A'dam)

Vision: from digital via smart to sustainable

Roadmap (inside) Factories

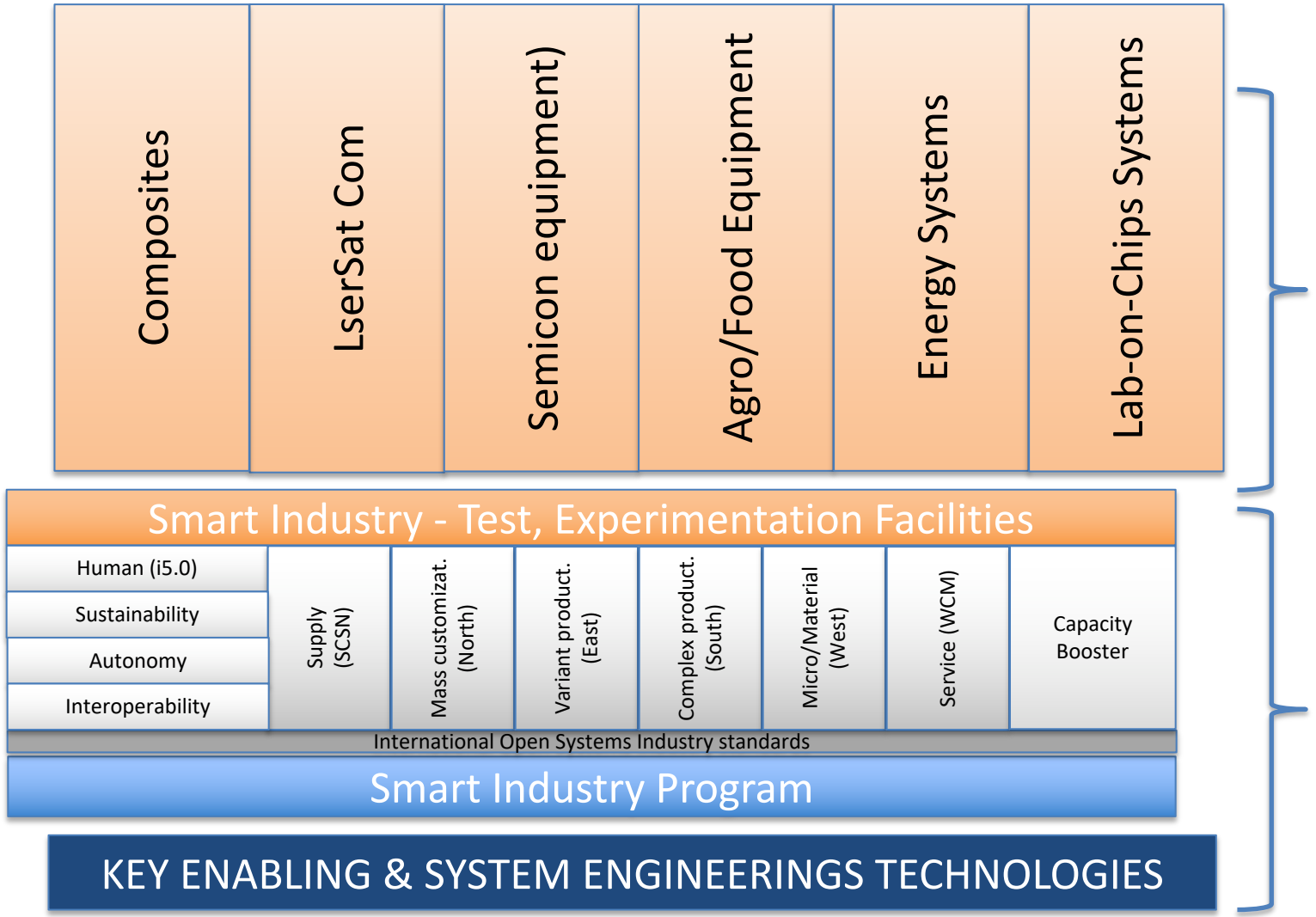
Roadmap (inside) Value Chains



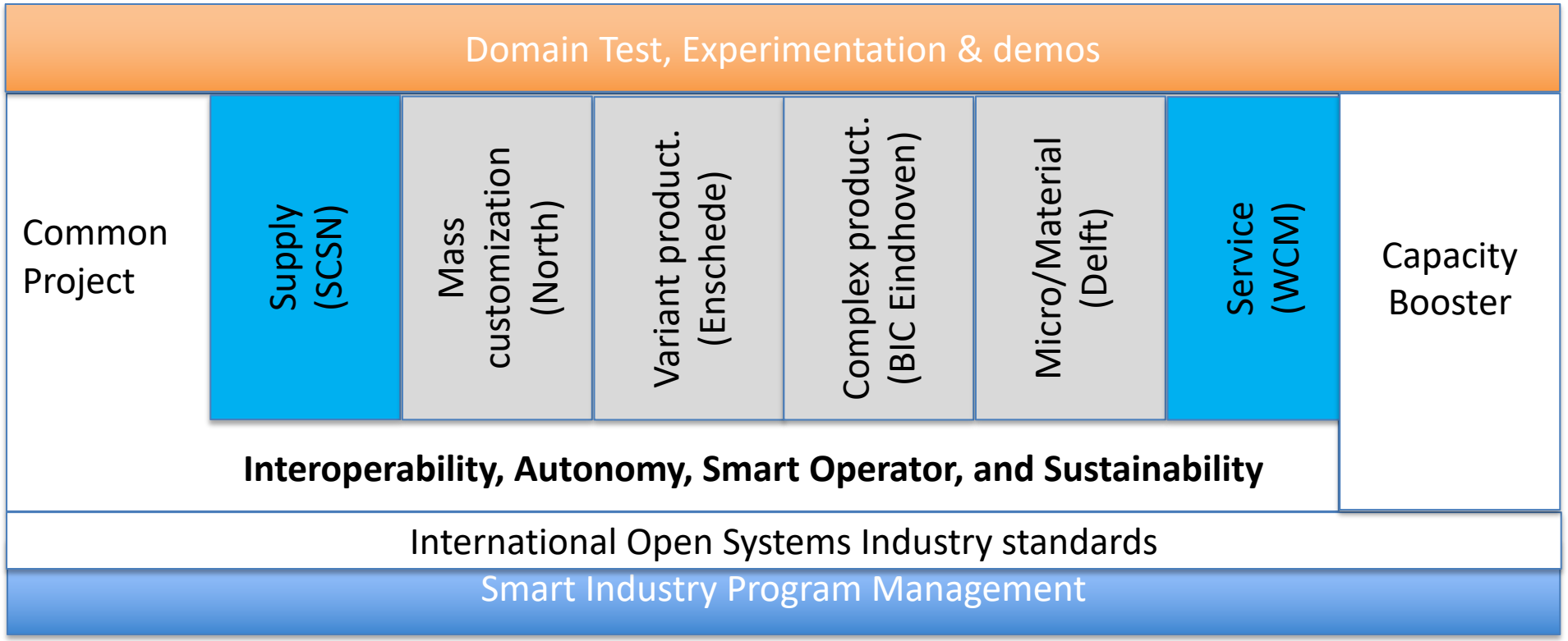
NXT GEN HIGH TECH growth fund (2023-2029):

Autonomous Factory and Smart (Supply/Service) Networks

NXT GEN High Tech program



NXT GEN High Tech - Smart Industry projects

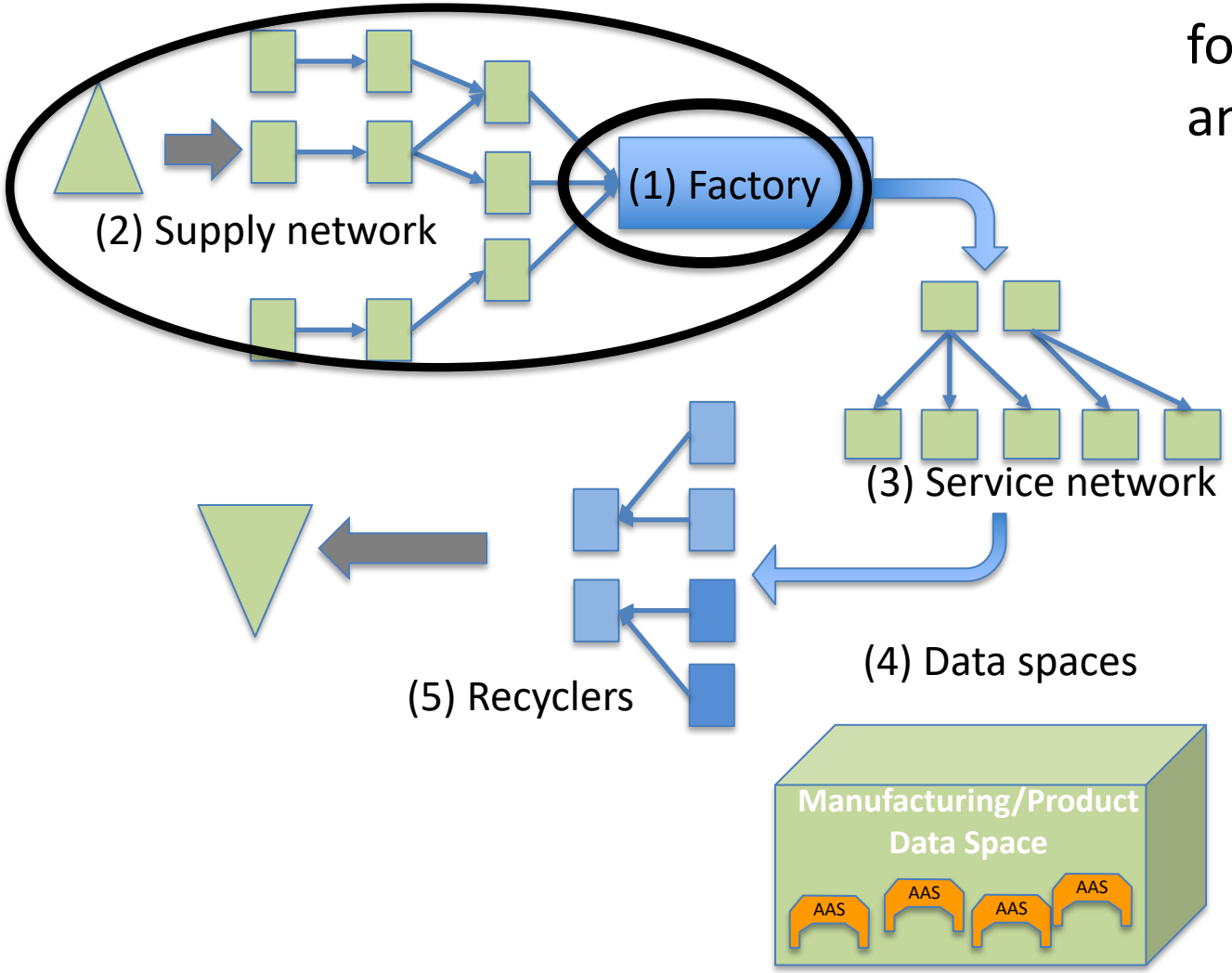


Autonomous Factory cluster (North, Enschede, Eindhoven, Delft)

Smart Networks (Supply and Services)

Support projects (prg mgt, standards, common & capacity booster=training)

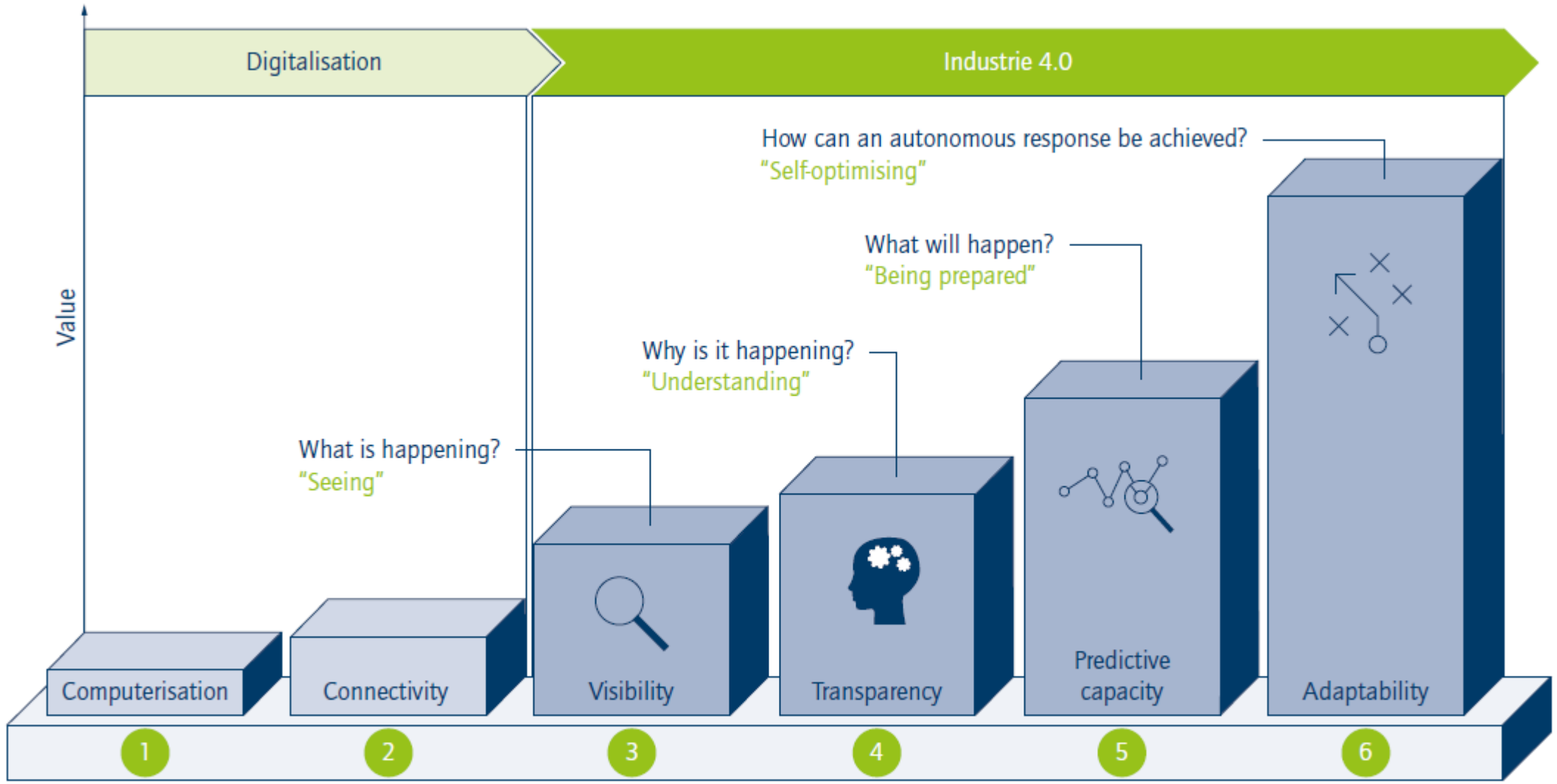
Digitalization is crucial for sustainability



The fourth industrial revolution
for the (1) factory
and with smart industry including
(2) the supply and
(3) service chains (servitisation)

we **prepare for a full sustainability and the use of digital product passports**
a digital twin of each product stored in
(4) manufacturing data spaces

and a new ecosystem of
(5) recyclers, a new role of suppliers as a kind of inverse factories



Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

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You ain’t seen nothing yet

“Every, everything in manufacturing will be digitized”

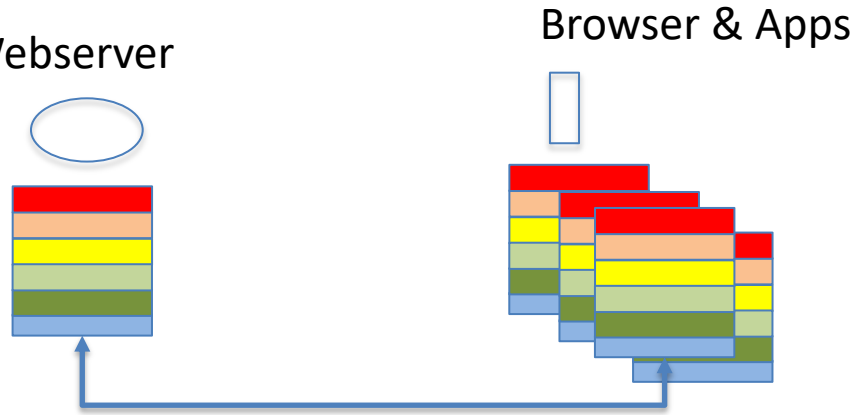
Like it or not, if you don’t, you will be out of business

The analogy with the rain radar apps:

Is there an I4.0 stack of standards/digital connector enabling a similar evolution?

Yes, next slide. ……

Internet rain radar app lesson:
use a standard stack (IP) and a standard interface/connector (HTML)



HTTP/HTML	Web ‘90 between computers and in ‘00 mobiles/handhelds controlling pixels on a screen
HTTPS & XML	Next to writing pixels, also more execution tasks (Java)
HTTP3, OPC-UA	Computers, mobiles, IoT devices from WhatsApp to Rain Radar usage

since the ‘90-ties, it led to web apps by 2000 and after 2010 an explosion of all kinds of mobile apps

The IP/HTML standards made it affordable, reliable and everywhere enabling you could 20 years ago, not think off or image.

The Manufuture – DTI vision & challenge EU Made-In-Europe R&D calls 2025-2027

2025-2030: Digital Technical Intelligence (basic requirement)

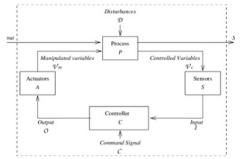
2030-beyond: Decentralised Tech. Intell. (autonomy apps)

Decentralised Technical Intelligence (DTI)

Next evolutionary step to boost industry performance

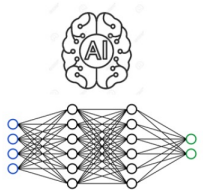
Control Theory & (Systems) Engineering

Feedback loops with sensors, actuators & controllers



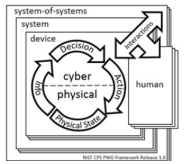
Artificial Intelligence

Simulation of some human intelligence processes by computer systems



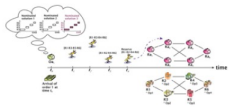
Cyber Physical Systems

Interconnection of 'cyber' (informatic, software) components with 'physical' (mechanical and electronic) parts that communicate via a data infrastructure, e.g. Internet-of-Things



agent-based/holonic manufacturing

Autonomous & cooperative agents provide manufacturing systems with flexibility, adaptability, agility, and dynamic reconfigurability ...



Decentralised Technical Intelligence

Next evolutionary step to revolutionise industry performance – going beyond the limits of today in an interdisciplinary approach.

⇒ self-x in real time

⇒ distributed, knowledge-based intelligence

⇒ process optimization in manufacturing systems

Digital Technical Intelligence (or Digital Connector)

From Research & Development to Innovation & Education:

Prerequisite for Deployment

- Business transformation

DTI Core Action Fields

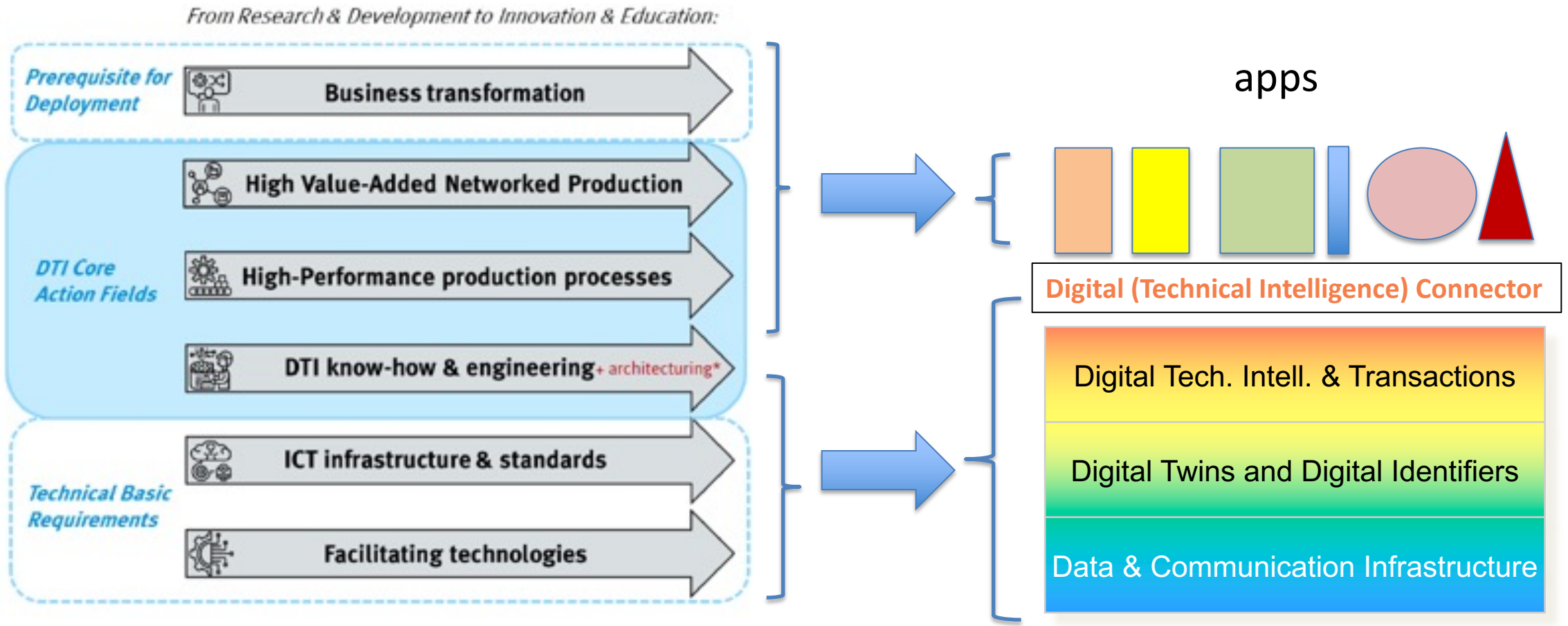
- High Value-Added Networked Production
- High-Performance production processes
- DTI know-how & engineering + architecturing*

Technical Basic Requirements

- ICT infrastructure & standards
- Facilitating technologies

The Manufuture – vision

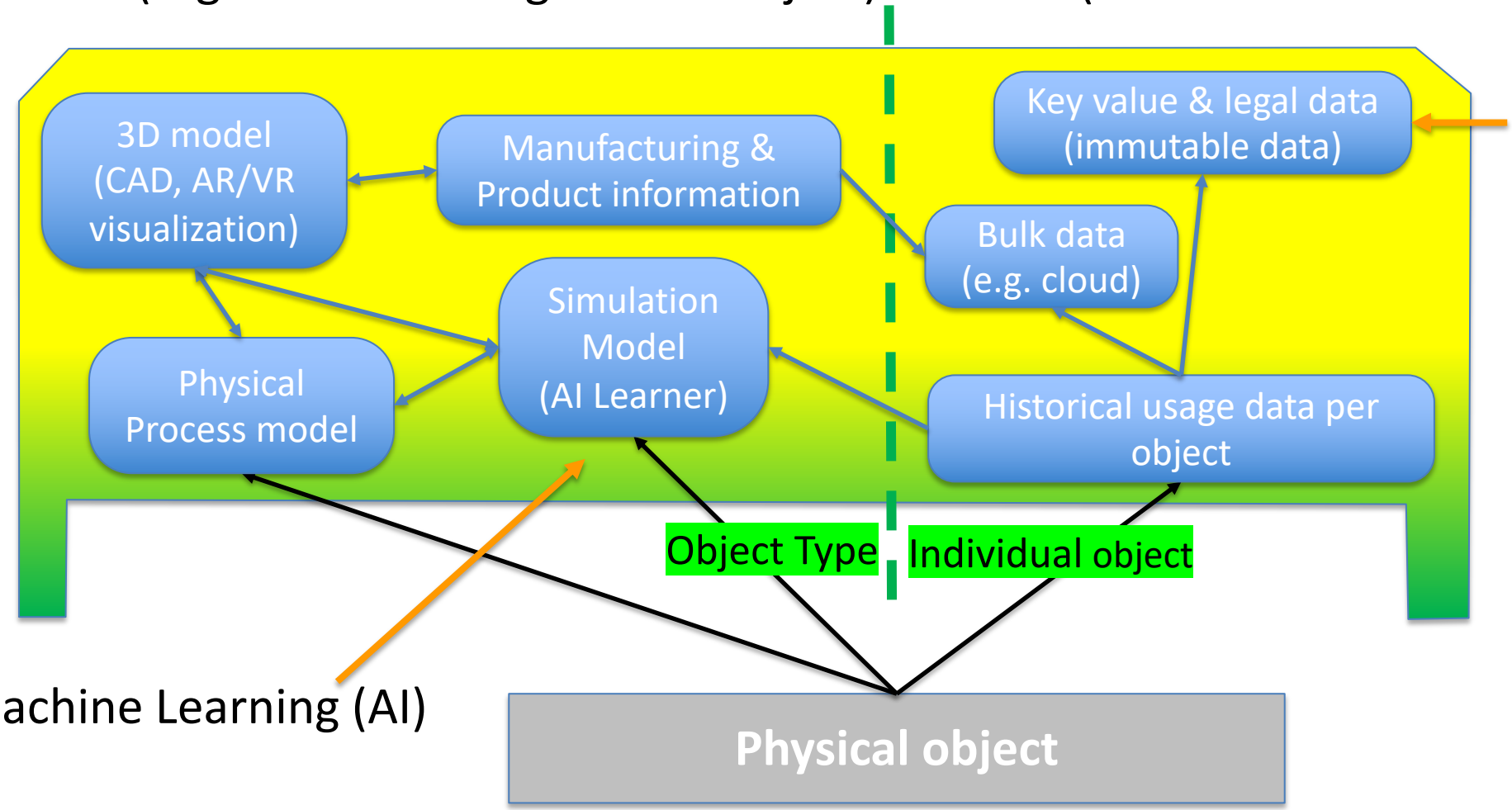
2025-2030: Digital Technical Intelligence (basic requirement)



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)



Blockchain (DLT)

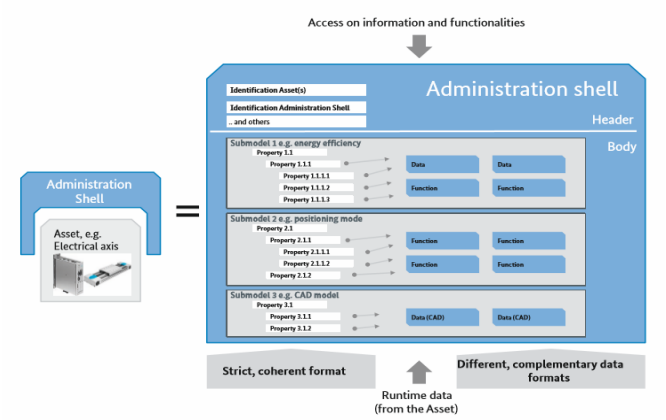
e.g. of DT;s:
- a product
- a machine
- a sensor
- a factory

Machine Learning (AI)

Digital Twin = AAS (Asset Admin Shell)

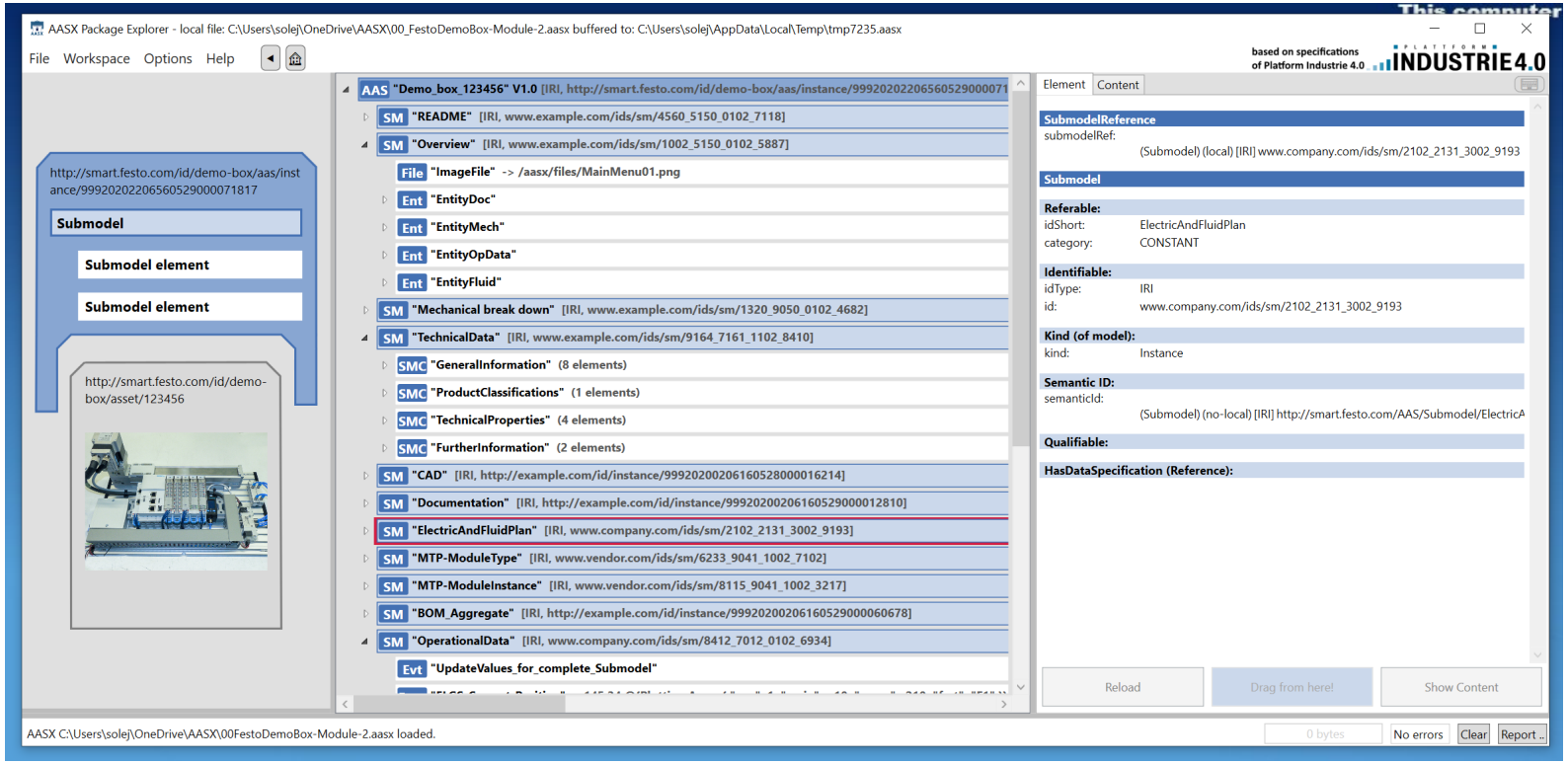
Product data: Digital Twin (DT) of Product Passport Data

A Digital Twin (DT) is a “living” virtual/digital representation of a physical (or virtual) product containing the information as: identifier (e.g. barcode nr), the history and status (and sometimes the planning/future) of a product and the references to locations where more information is stored (e.g. manufacturing and design data).



Digital Twin standard with AAS

(header / body similar to IP & HTML message header/body)



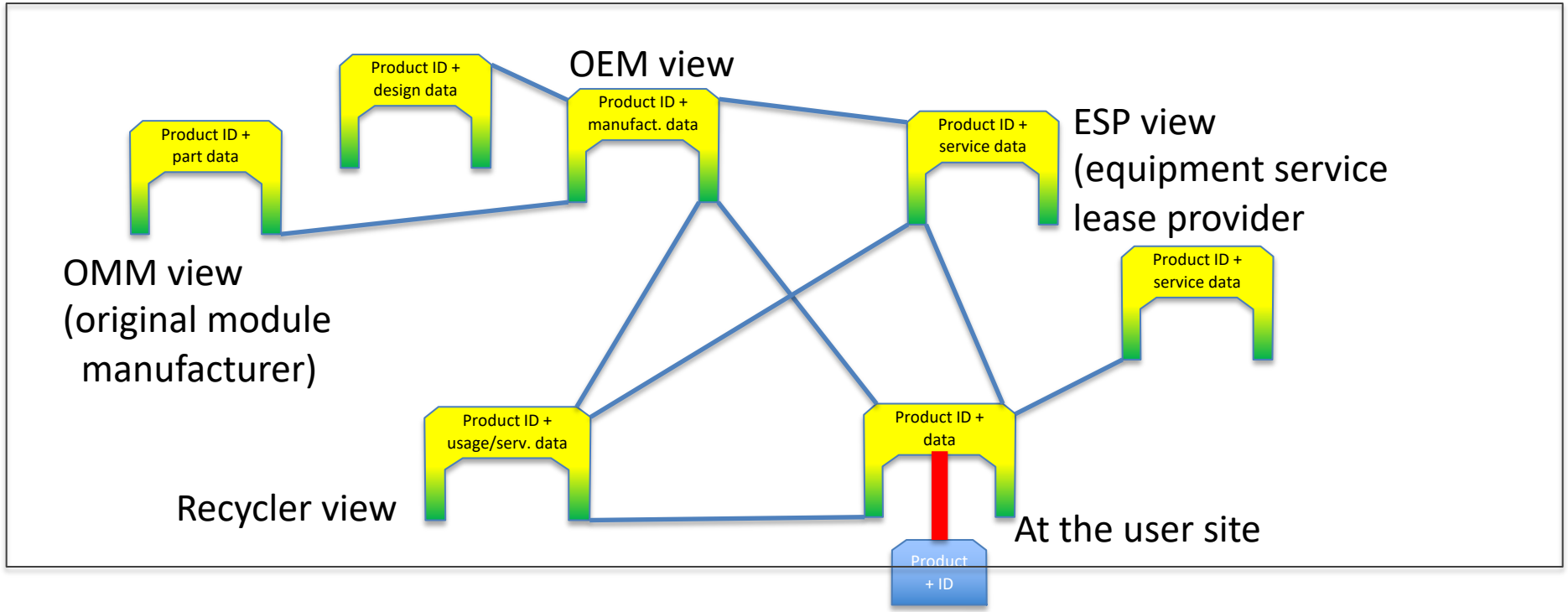
https://github.com/admin-shell-io/aasx-package-explorer/releases

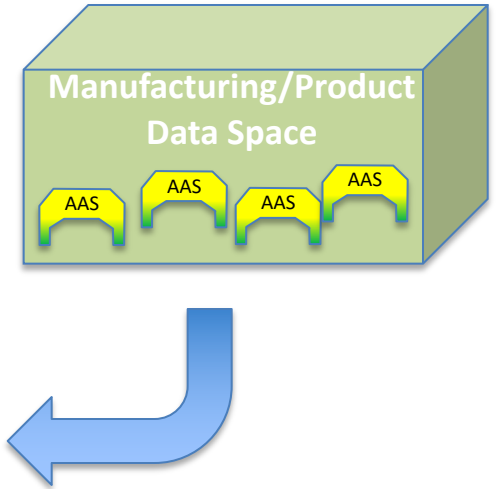
Relation Product and DT data stored a multiple locations/database/clouds

This is an more impactful slide then you might realize

Digital Twin data is a hypertext linked list with a hierarchy (product and its parts)
where product, part, usage and status data is stored at different places in a manufacturing data space.

To avoid data doubling (and inconsistency) data is updated and stored at only one place but can be by others

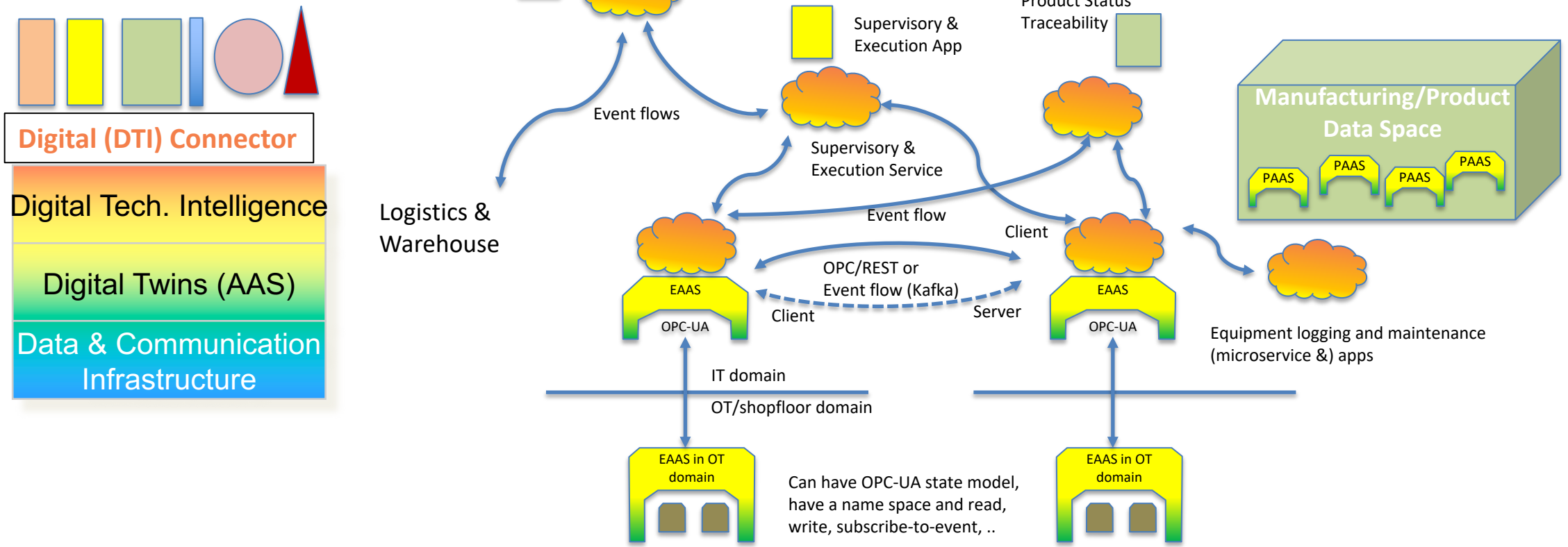




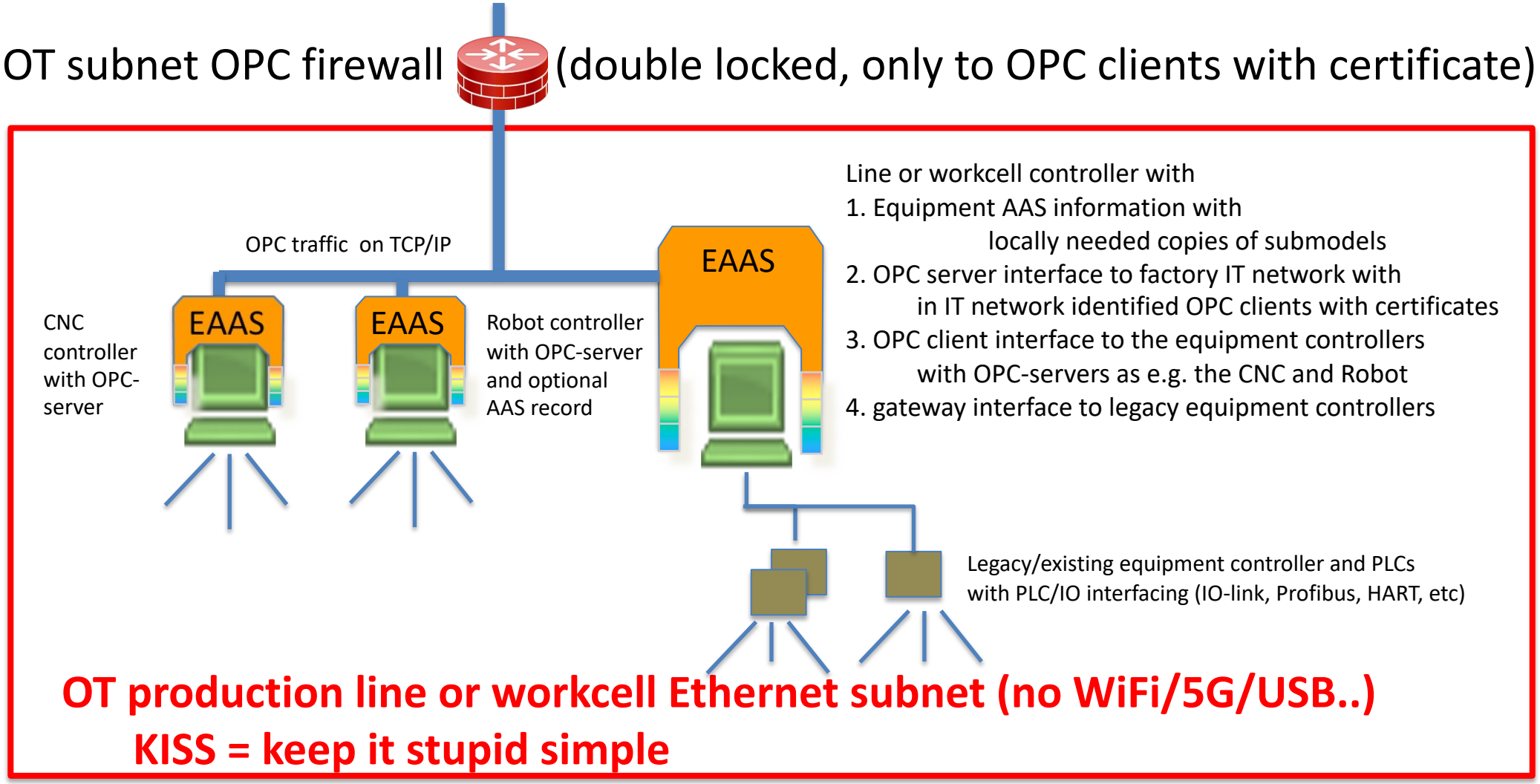
The link ▮ between product + ID and the product data + ID is critical and should not be modified

DT (Digital Twin) layer and active DTI (Digital Technical Intelligence) layer:

Product AAS (PAAS) in MDS (manufacturing data space) and Equipment-AAS (EAAS)+microservices as DTI's communicating with other DTI's, and I40 apps using event flows (=logs) and databases



OT OPC equipment subnet with OT cybersecurity and legacy



DTI (Digital Technical Intelligence) Connector

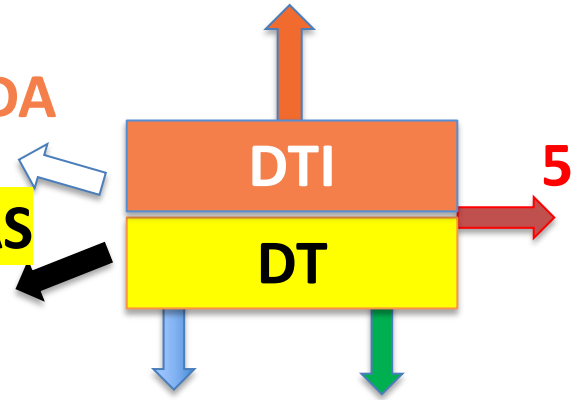
A Digital Technical Intelligence (DTI) connector has six standard interfaces:

Company logging
Event-Driven Architecture with event streams towards (micro)services, e.g. Kafka and business apps

6: Apps and app library

4: EDA

3: AAS



5: IDS **Towards customers, suppliers, and service providers,**
Industrial/international Data Space(s)

Company Product Data space
(Asset Administration Shell)

1: OPC-UA

2: REST/HTTP

IT

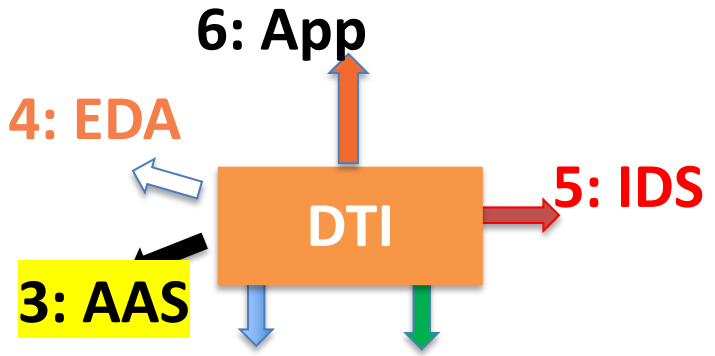
OT

OPC-UA between **equipment** in OT and DT in IT
(Open Platform Communication – Unified Archi.)

Human operator monitoring & control apps
(Representational State Transfer/HTTP/1.1)

OT-world (Operational Technology) with physical products, production equipment, and operators

Pre-DT/DTI I40 Digital Connector



Planning & Preparation

Control & Execution

Monitoring & Logging

Design & Descriptions

1000+ dedicated special programs

creating an intimidating legacy mess

100+ monolithically ERP, MRP, MES software packagers

10+ different fieldbus protocols

Modbus, Profibus, etc.

1-3 major CAD/Design environments

Industrial revolutions (0, 1, 2, 3)

Propritary software, vendor protocol/interfaces

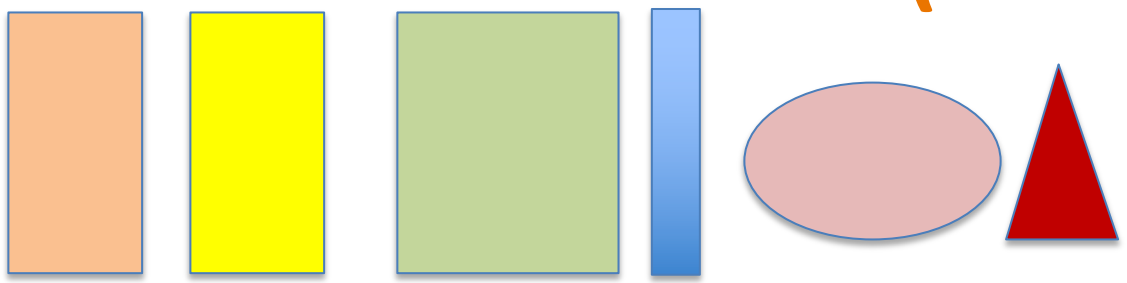
Interactive Digital Twins with digital (DTI) connectors (Digital Technical Intelligence) using OPC/REST/EDA/IDS

Digital Twinning with AAS (Asset Admininstration Shell)

Industrie 4.0/Smart Industry

Open Systems, International Standards

(DTI or I4.0) Digital Connector



DTI or I4.0 App Interface

New software:
Low-code when you can,
And for system software: Rust,
not in cyber unreliable C/C++ anymore

DTI
REST (and in OT network OPC) web interfaces with active virtual processors (OPC state/REST stateless) and web (inter)action & secure transactions (distribute ledger tech)

Plattform Industrie 4.0
OI4A, IDTA, tbd ISO/IEC
And UID, UUID standards

DT
Digital Twins AAS asset admin (sub)models and Digital Identifiers, Authentication and Authorization (IAA)

IT/OT
Information Technology Layer
(SQL) AAS Datastore, Gaia-X, IDS connector, OPC-UA/TCP/IP/Ethernet/IO Comm. & Cyber Security /Firewall Infrastructure

ISO/IETF/OPC/IEC
Common IT/OT standards

Content:

Introduction – setting the scene

"Voordat we de Industrie boom in het AI bos groot laten groeien, moet eerst het wortel stelsel worden ontwikkeld vergelijkbaar met de ijsberg metafoor waarbij eerst de data collective op orde moet zijn"

Trends in Industry (Industrie 4.0/Smart Industry)

Digitalization and Sustainability

interoperability, autonomous operations and smart networks (supply/service)

How to digitalize

– drive towards common (open systems) standards in the industry

- standard digital connector, DTI or I4.0 stack and apps

And then gradually create and grow the AI apps on top of a standard I4.0 stack

Building an AIM system

AI requires data sets with good/bad classification to train your application.

Separate in train/validate/test data sets (eventually augment data set)

To train the model, start with input layer and create the CNN layers, (convolutional neural network) and process/improve them if needed.

Then **build an industrial system** with

1. the input (e.g. camera, sensors, physical model/Digital Twin info),
2. load the AI model parameters in the control algorithm
3. and connect the output (robot, agv, operator screen)

Industriële AI – Wat is er al?

Gereedschapskist voor AI in de industrie:

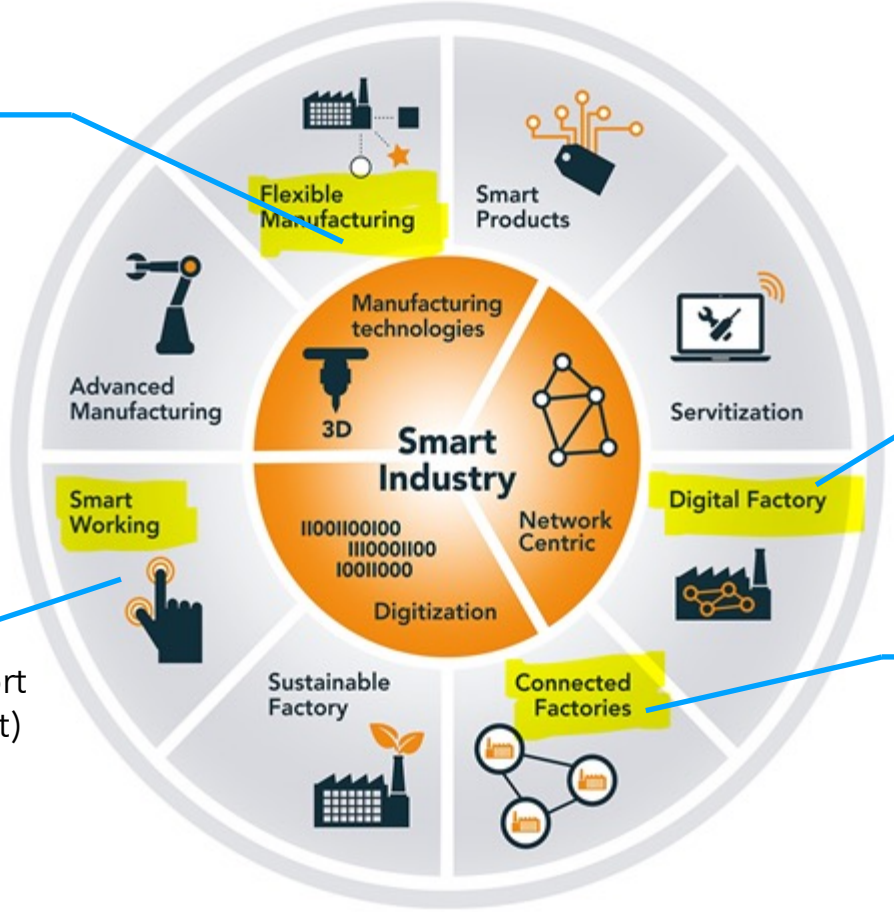
- Formats en infrastructuur voor data delen
- IoT, wireless connectivity
- Cloud services: AWS, Azure, Google
- Rekenkracht: centraal en decentraal, IIoT/edge computing
- Data analytics, machine learning tools (neural network) en libraries:

  Tensorflow, (Py)Torch, Numpy/Theano, Scikit-learn, Keras …
- Sensortechnologie, camerasystemen, beeldherkenning
- Digital twin, cyber physical systems, fysica modellen
- Robots, cobots, AGV's, Robot Operating System
- Operator support systemen, AR/VR tools
- AI experts : kennis van theorie en ervaring met toepassing

Voorbeeldprojecten om eerste oplossingen te ontwikkelen en demonstreren in Fieldlab setting, bv. BIC en SMITZH

4. Wat doen de eerste bedrijven nu al?

- Offline programmeren van robottaken voor geautomatiseerde productie
- Plannen van eenvoudige AGV logistiek
- Beeldherkenning van onderdelen in voorraadbakken



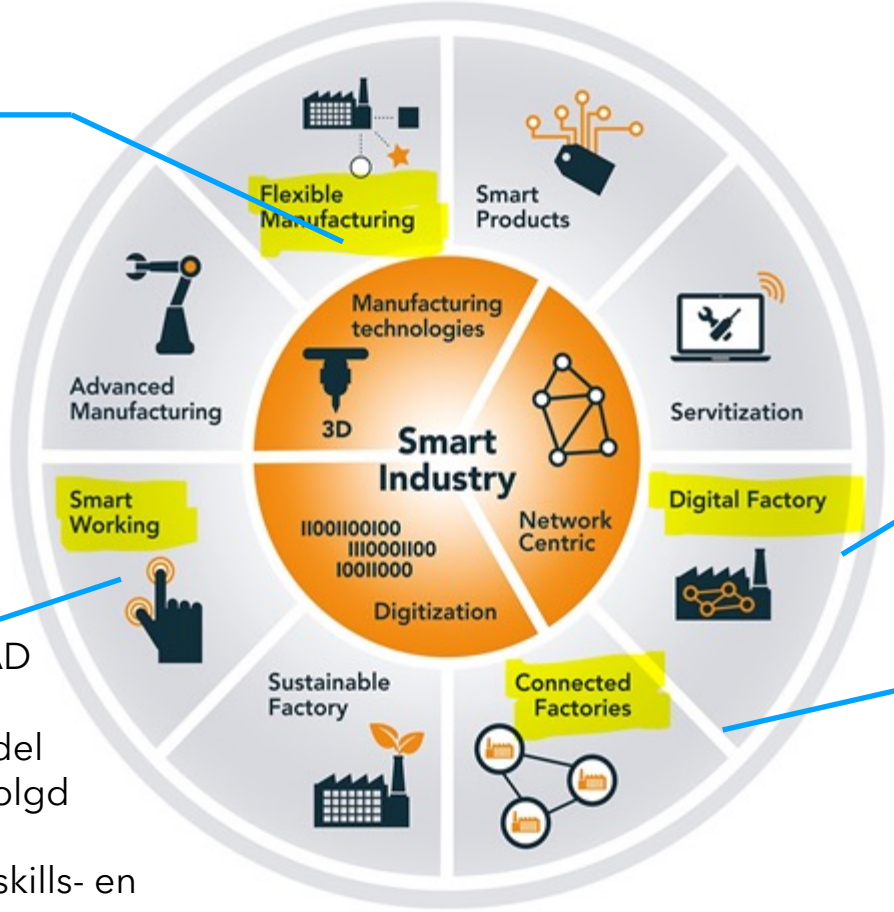
- Data gebaseerde condition monitoring (AI detecteert afwijkingen in performance)
- Decision support door analyse en statistiek van productiedata

- Geavanceerde interactieve operator support (projectietechniek, foutdetectie, pick to light)
- Veilige cobots in samenwerking met mens

- Data delen in de keten
- Data veiligheid en soevereiniteit

5. Wat kan de praktijk morgen met versnelling?

- AI genereert robotpaden voor geautomatiseerde productie
- AI leert omgeving inzichtelijk te maken voor robots en AGV's
- AI verdeelt mens-robot samenwerking
- AI herkent en onderdelen uit beelden van ongeordende stapels en pakt ze



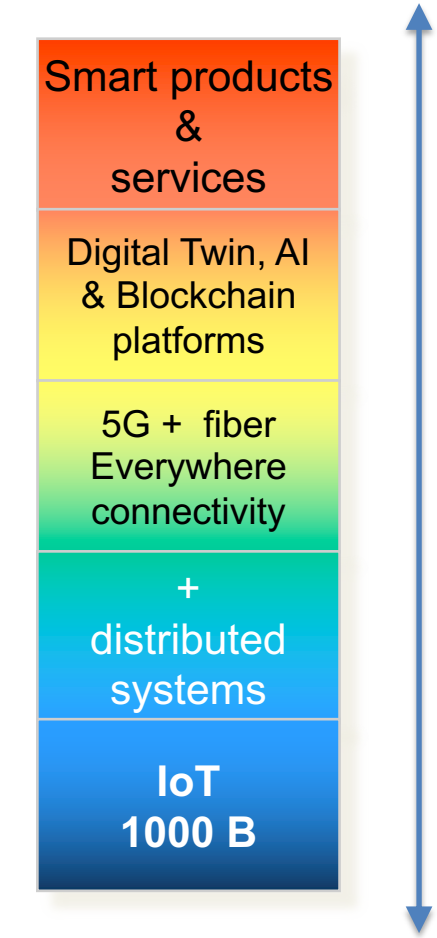
- AI leert gedrag van apparaten
- AI leert ondanks uniek gemaakte producten
- AI genereert mogelijke oplossingen gebaseerd op root-cause analyse

- AI genereert assemblagestappen uit CAD model
- AI genereert werkinstructie uit CAD model
- AI detecteert of assemblageproces gevolgd wordt
- AI past instructies aan aan de hand van skills- en ervaringsniveau operator

- AI leert semantische structuur van data
- AI leert welke fabrieksdata relevant is

AI apps will come, but first, we need to structure the stack below

Internet of Services IoS:



Internet of Things IoT

Control – smart AI

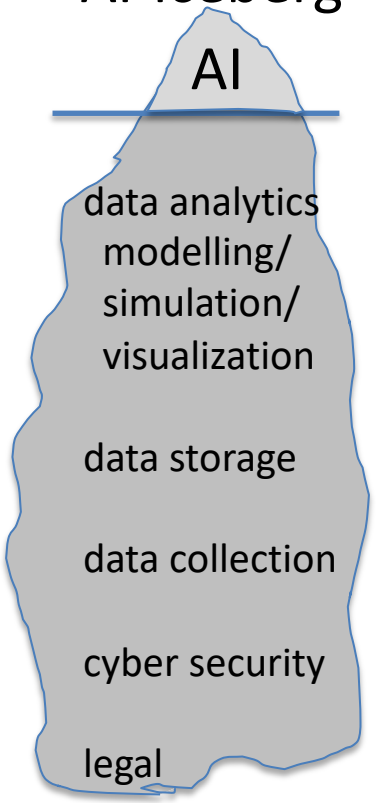
Control – direct

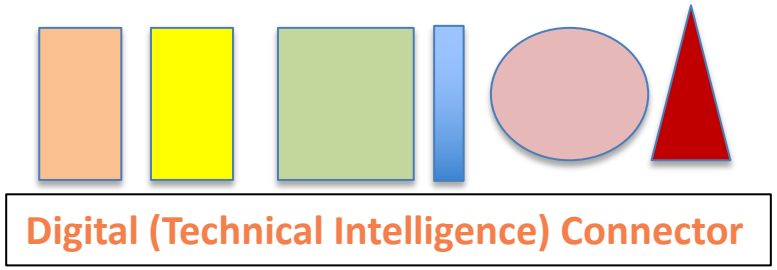
Data visualization & monitoring

Data collection & storage

Sensor data & communication

Top of AI-iceberg





Summary:

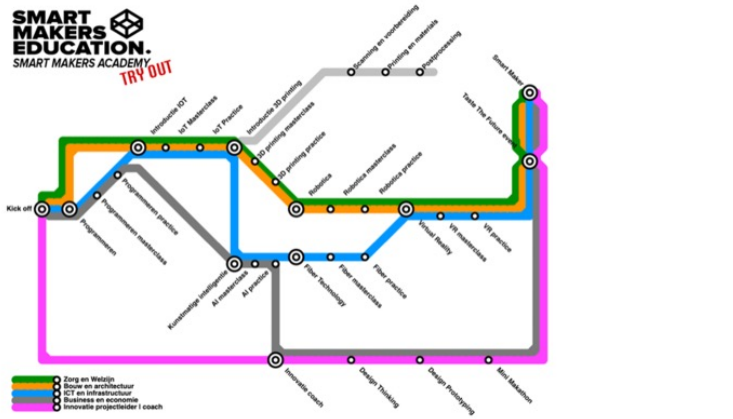
why After decades of vendor lock-in interfaces and monolithic software systems manufacturing should evolve, similar to Internet and web/mobile apps, towards

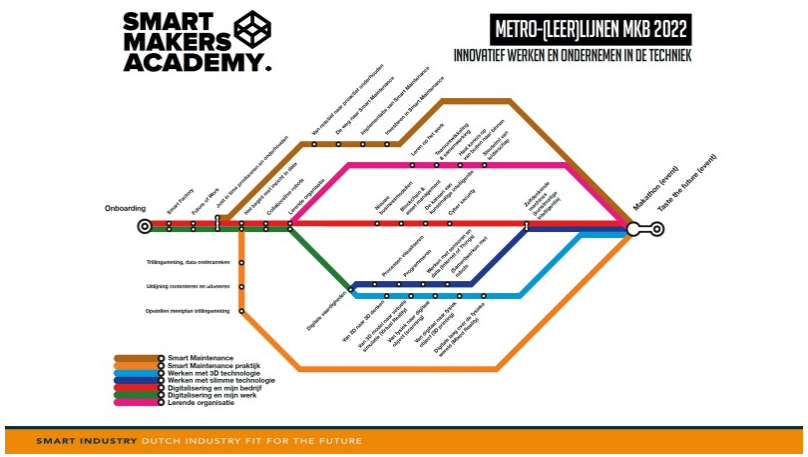
what the usage of apps on top of a digital technical intelligence with a standard, affordable, and reliable digital connector.

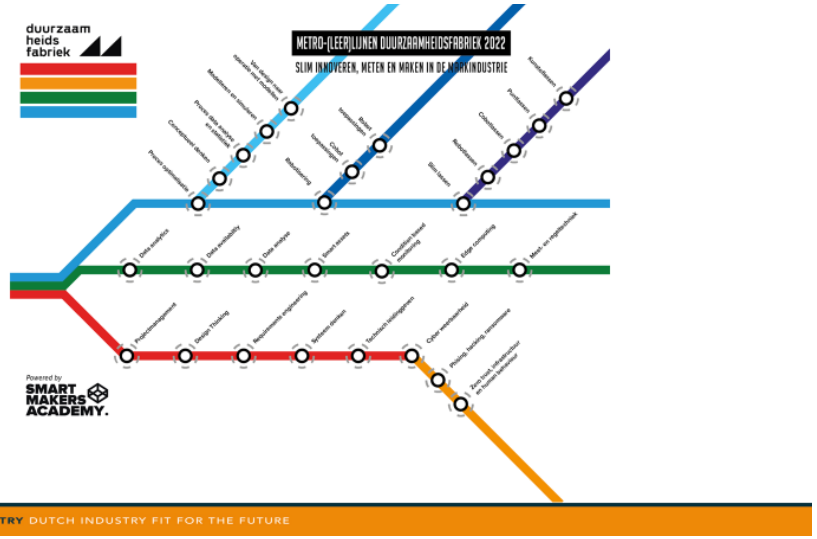
to enable autonomous data collection and exchange to improve productivity and sustainability using all kinds of apps, from simple up to advanced AI apps.

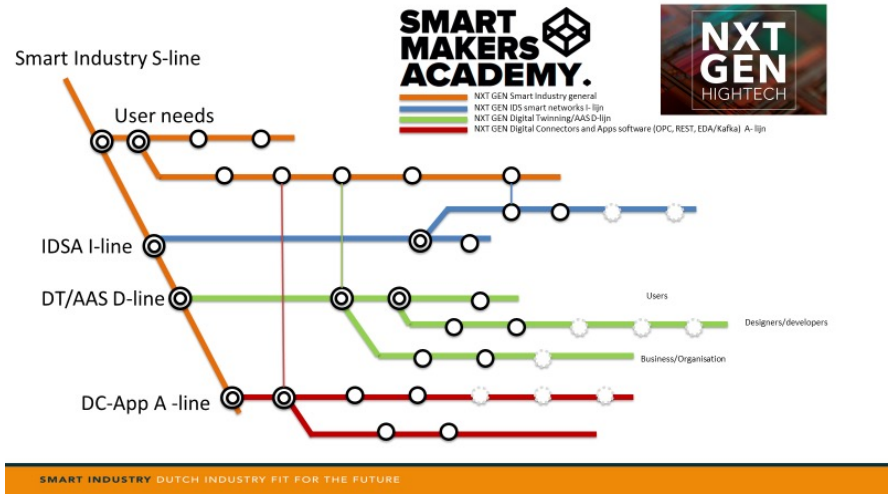
how But to turn this vision into projects, test and training facilities, and ultimate into real-life systems in factories are needed it has huge consequences for (re)training our workforce in digital skills.

Smart Makers Academy – 1-day training modules as stations in a regional metro transport model for individual trip planning









smart industry

Het AI-congress van Noorden –
Data Delen: Het bos en de bomen

SMART INDUSTRY (Fourth IR/I40 in NL) DUTCH INDUSTRY FIT FOR THE FUTURE

www.smartindustry.nl

Egbert-Jan.Sol@TNO.nl

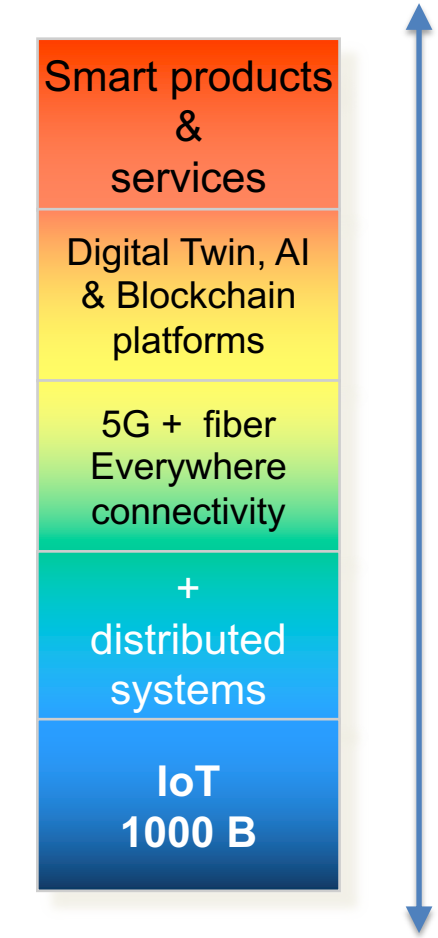
oct 2022 v1

A TNO initiative made possible by a subsidy of the Dutch Min.
of Economic Affaires & Climate and the province of Noord-Brabant

Provincie Noord-Brabant

AI apps will come, but first, we need to structure the data stack below

Internet of Apps/Services IoS:



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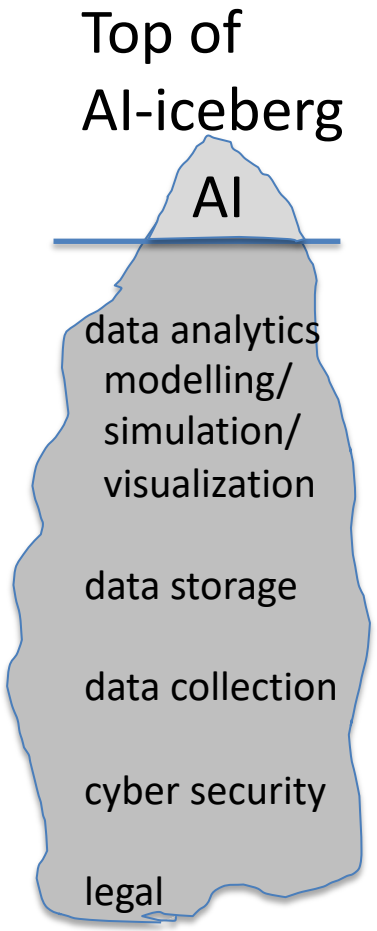
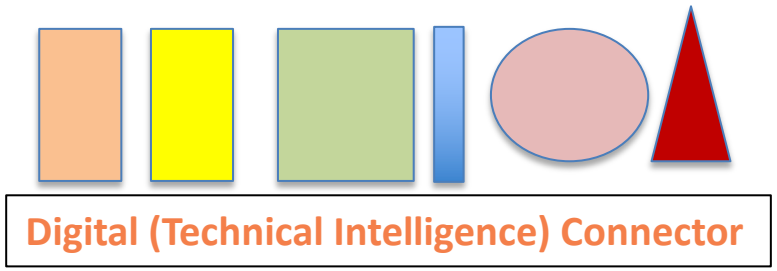
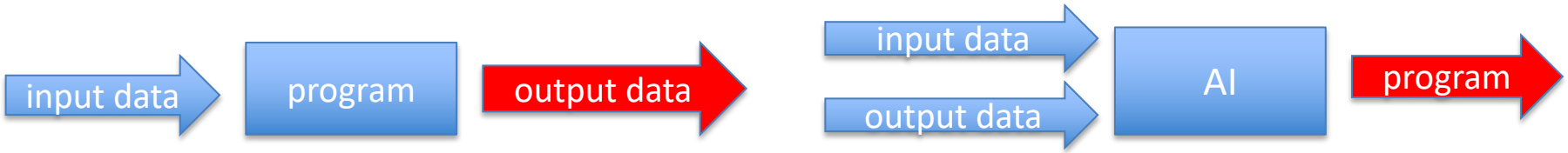




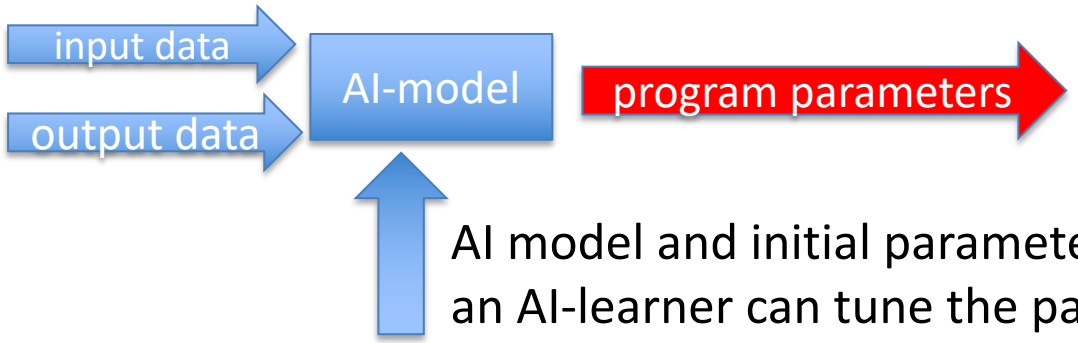
Artificial Intelligence or better Machine Learning

AI-hypes go up and down (already two or more AI winters since 1960)

The AI-holy grail & the misperception – input + output => program : no more programming



Now comes the small letters: In real life, there is no AI master algorithm fitting all problems or as silver bullet.



AI-models: neural networks,
evolving programs with selection,
physical process models, Bayes statistics, ..

AI model and initial parameters and with machine learning
an AI-learner can tune the parameters such that with new input produces new output

Will history (of industrial control engineering) repeat itself?

The 90-'ties: parameter estimation of advanced control systems
e.g., Kalman filters – linearization of large (process) plants around their setpoint
model fitting by estimation of the (linear) coefficients/parameters of (PID) control loops

After several years, those systems were not used anymore as the plant and their operational setpoint (product mix, remodified equipment,..) had changed and reality was drifting away into non-linear behavior

Artificial Intelligence, in particular, the popular & hyped CNN (neural network) faces the same lesson soon!!!
Once a model has been trained, but the environment change, you must retrain the model again.
Nice for stable millions of medial (X-ray, Pathology) or astronomical pictures, but not for many other apps.

USA big tech loves AI (and its sales), but VCs don't fund AI startups anymore,
75% of AI startup money goes to AWS/Alphabet/Microsoft for training AI models in their cloud platforms.

Universities love AI: it is a euphemism for statistics. Studying statistics doesn't recruit any student, AI does
and any research proposal should include AI to get funded by old reviewers who hardly understand it.

Let’s be sensible

Today AI tools require at least knowledge and usage experiences of Linux, Python/MatLab, and several of the many AI libraries and models, in general, a knowledge level only achievable by e.g., a PhD-student of last year’s MSc or smart BSc student with a technical or IT background.

And making a sensible AI application, you need to collect hundreds of labeled data sets (e.g., photos coupled with a decision e.g., good or wrong, often verified by so-called 100.000+ “Mechanical Turks”) or follow the opposite of the diminishing return idea now followed by Big Tech of investing Billions in AI calculations.

- The five fingers app and the statistical uncertainty of 50% that it are 4 (or 5) fingers

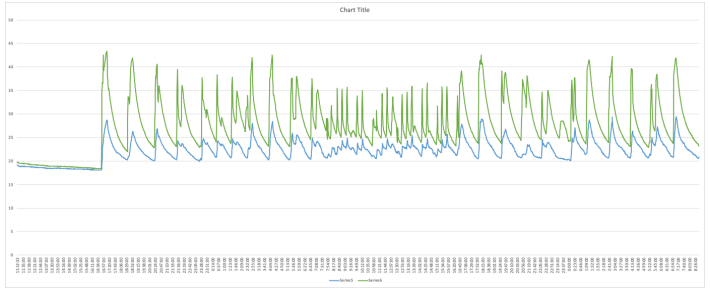
- The AGV example dropping off the table/against wall. => need combi of AI model and physical models

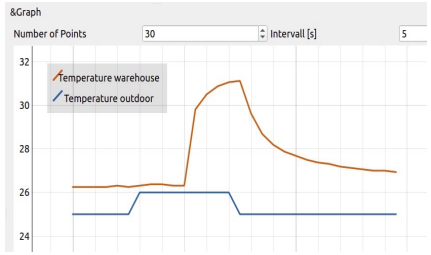
- Or enter the complete internet as the training set

And then, as in the large process control installations or industrial job shop/manufacturing sites, you know that the product mix is increasing, production series are getting smaller, and soon you need to retrain again.

Follow a 20/80 approach

Define an industrial AI project, but don’t go for 100 % of the project to get 100% of the results
but spent 20% of the cost to collect serious data and analyze it, you might realize already 80% of the results

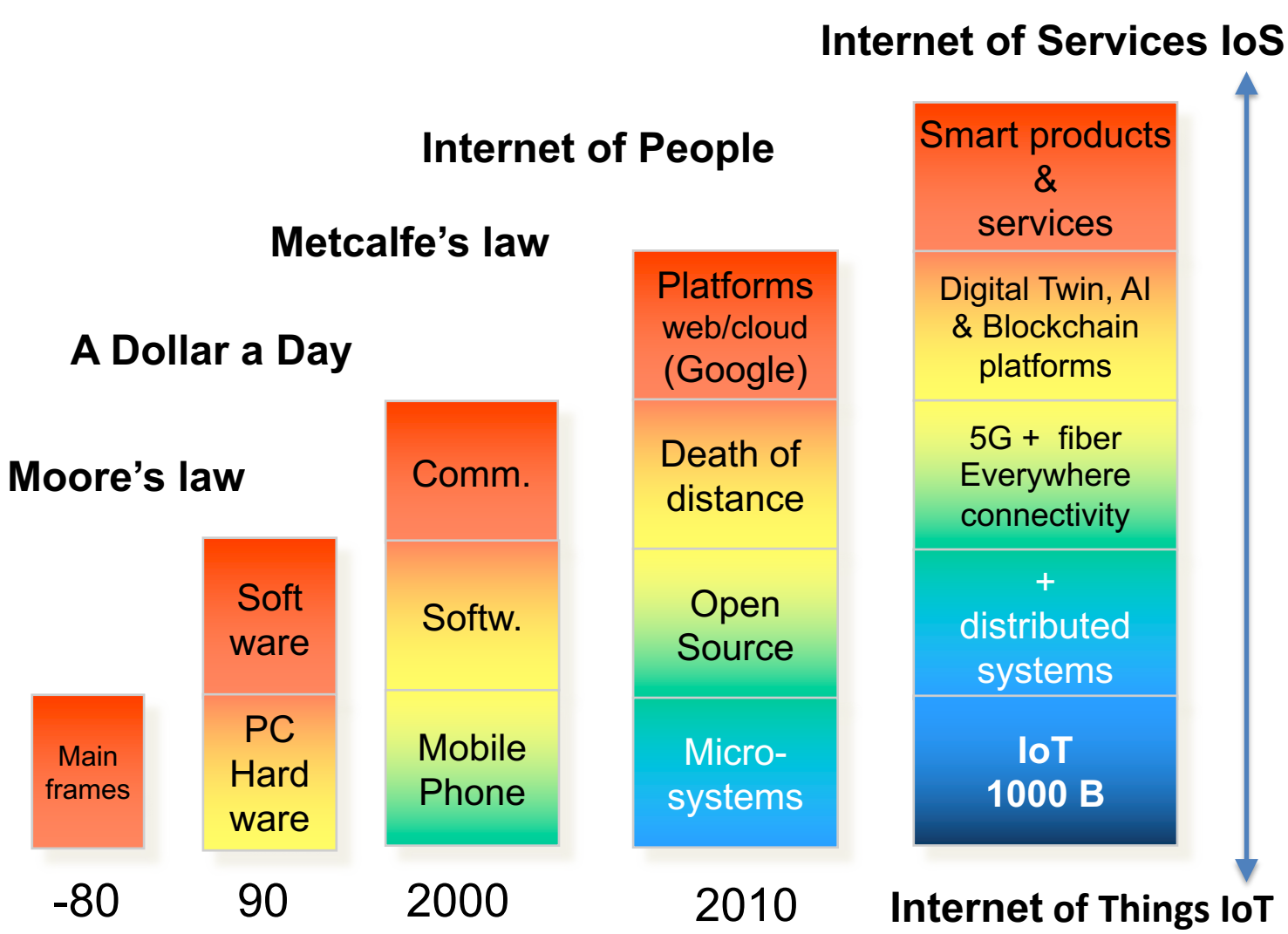


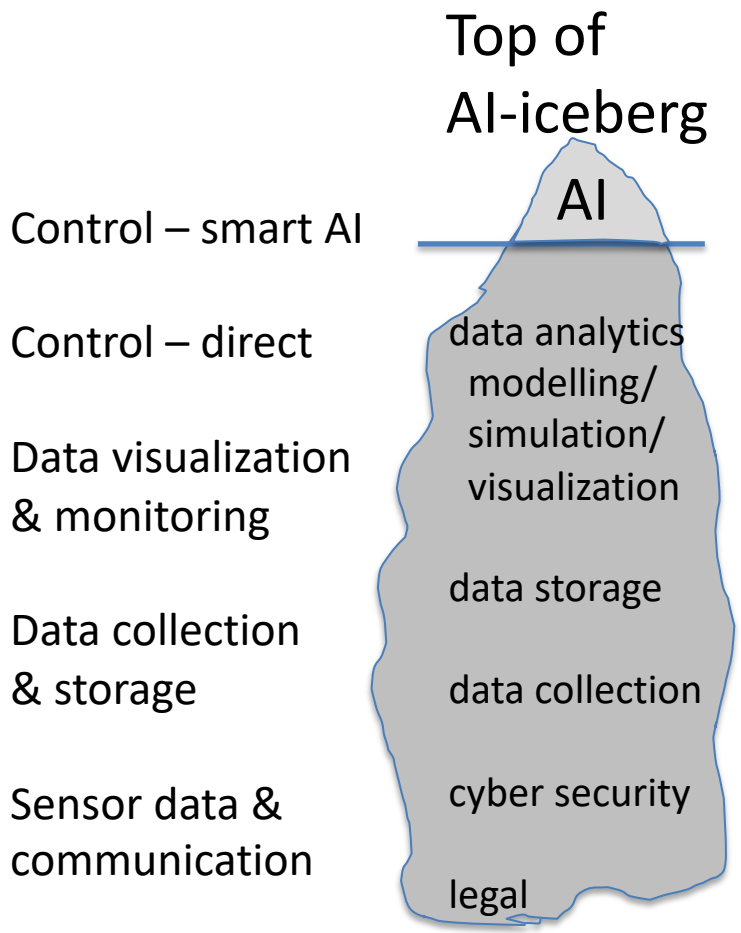


1: Vision - Zero defect – use vision to check every production step
    e.g., compare the output of a production step with a picture that you match with an inference model
    however, we need a model that can be trained not by hundreds of photos of good/wrong assemblies,
        but automatically by e.g., a rendered Digital Twin CAD model of (new) products and the work cell.

23: Prediction - Predictive maintenance (and similar trend analysis IAIA)
    e.g., use a model of what is/will happen, opt. MatLab based, and match data to that model

AI iceberg: the bulk of the work is on labelling clean data, not AI





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Digitalization and Sustainability

interoperability, autonomous operations and smart networks (supply/service)

How to digitalize?

– drive towards common (open systems) standards in the industry

- standard digital connector, DTI or I4.0 stack and apps

And then gradually create and grow the AI apps on top of a standard I4.0 stack

Kansgebieden voor toepassing AI

SMART SALES
- 24/7 PRODUCT CONFIGURATOR PORTAL
- SMART WEBSHOP

KLANT

PRODUCT

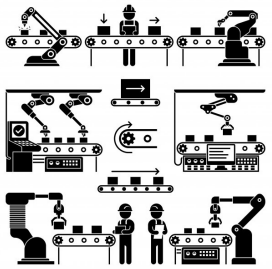
SMART PRODUCT
- INTELLIGENT & CONNECTED PRODUCTS

FABRIKANT

SMART LOGISTICS
- AUTONOMOUS SYSTEMS

SMART ENGINEERING
- GENERATIVE DESIGN
- DIGITAL TWIN

SMART EMPLOYEE SUPPORT
- AUGMENTED WORKER



SMART QUALITY CONTROL
- MACHINE VISION

SMART SERVICE & MAINTENANCE
- PREDICTIVE MAINTENANCE

SMART PRODUCTION
- **O**VERAL **E**QUIPMENT **E**FFICIENCY
- FLEXIBILISERING, N=1

FME POWERED BY DUTCH TECHNOLOGY

2030 VISION FOR INDUSTRIE 4.0

Shaping Digital Ecosystems Globally

PLATTFORM INDUSTRIE 4.0

Autonomy

Self-determination and free scope for action guarantee competitiveness in digital business models.

- Technology development
- Security
- Digital infrastructure

Interoperability

Cooperation and open ecosystems permit plurality and flexibility.

- Regulatory framework
- Standards and integration
- Decentralised systems and artificial intelligence

Sustainability

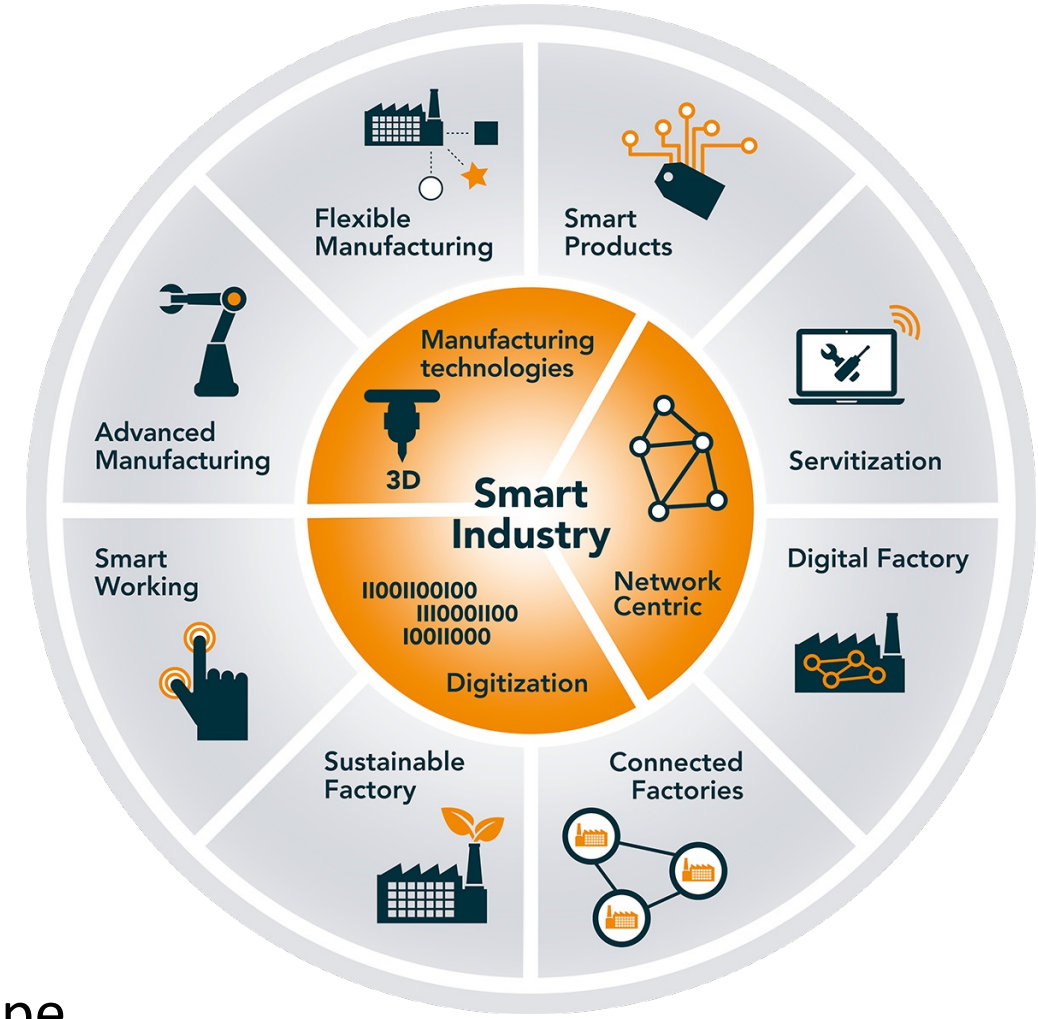
Modern industrial value creation ensures high standard of living.

- Decent work and education
- Climate change mitigation and the circular economy
- Social participation

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 materials
for a sustainable & competitive economy
with a culture in lifelong (digital) skills training

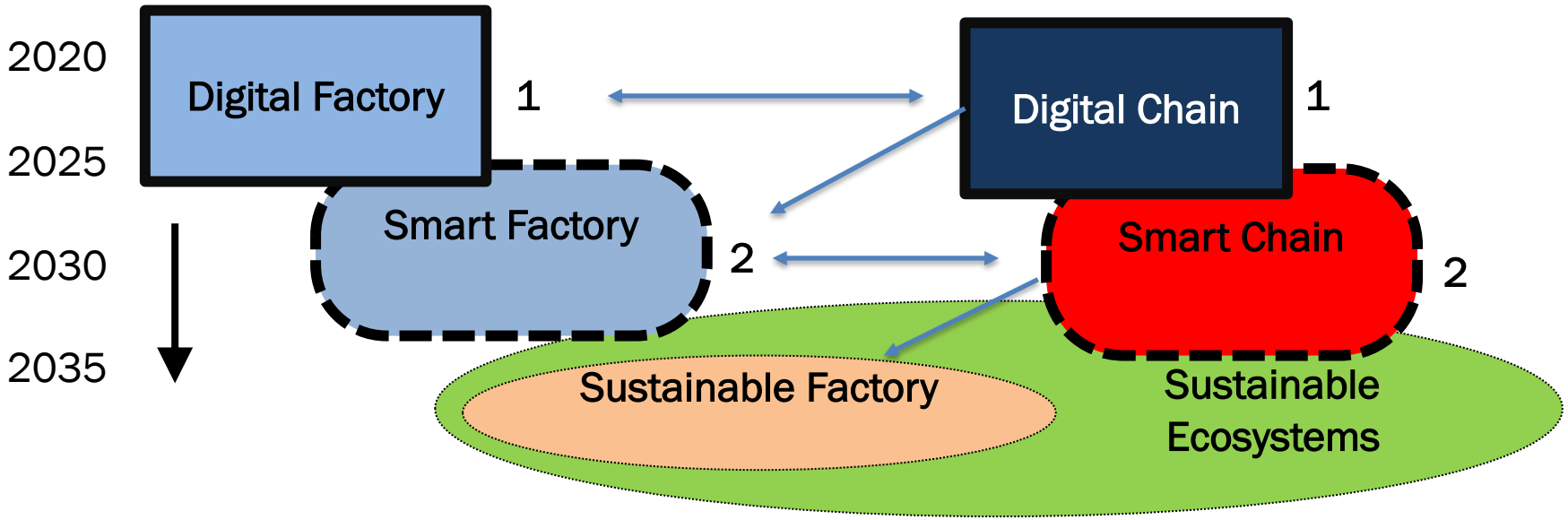


8 Industry transformations and
45 Smart Industry Fieldlabs
are the core of the program → now 5 EDIH in spe
(North, East, South, West, and Northwest (A'dam)

Vision: from digital via smart to sustainable

Roadmap (inside) Factories

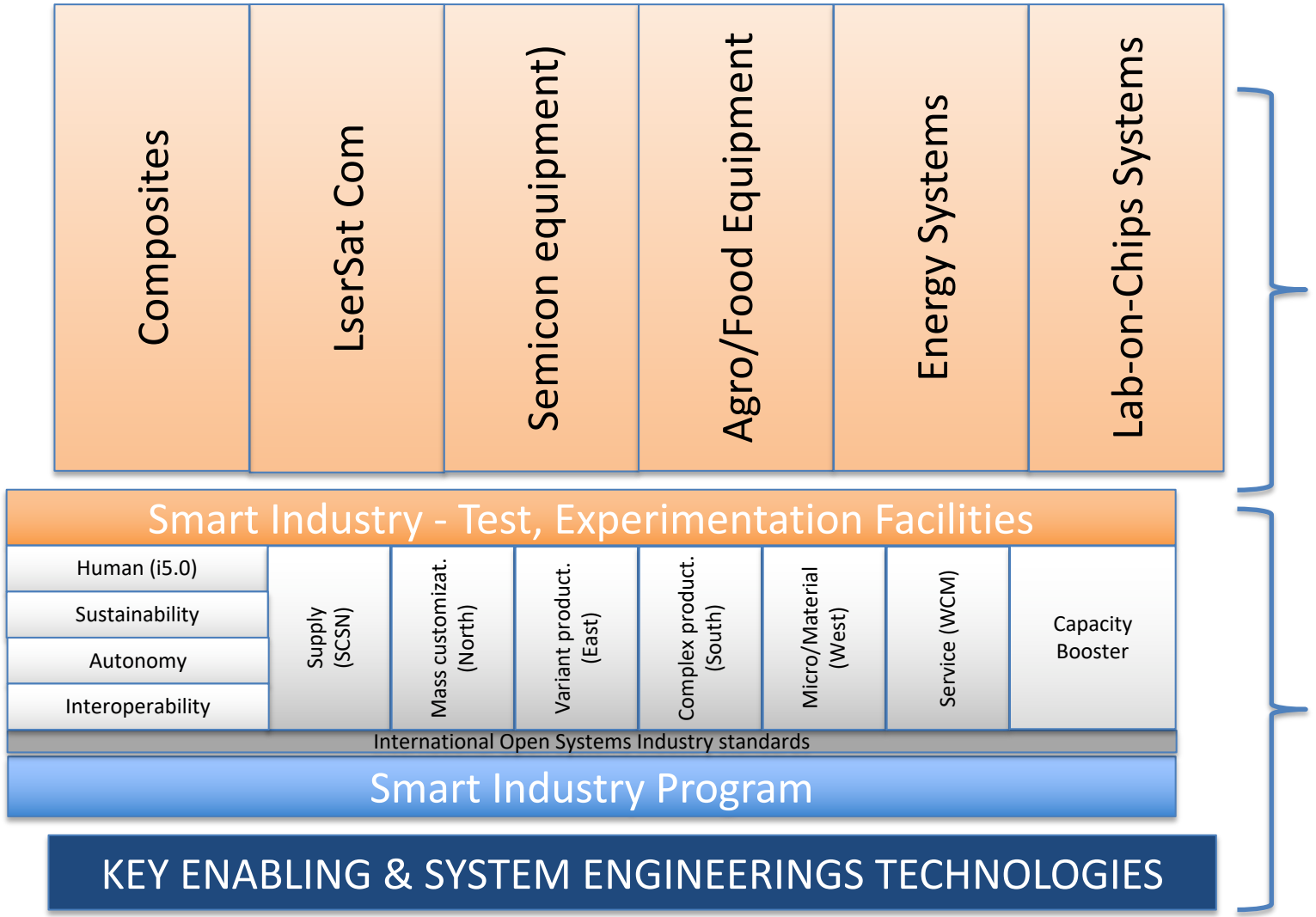
Roadmap (inside) Value Chains



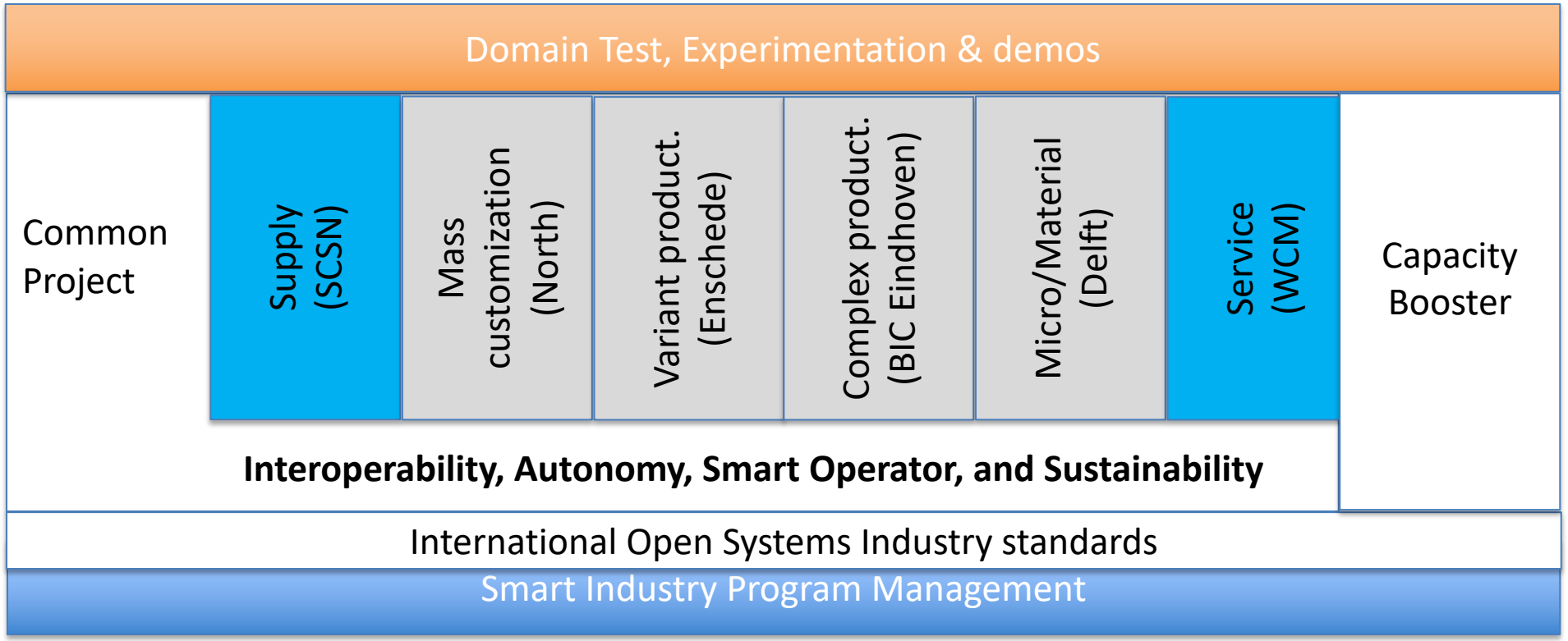
NXT GEN HIGH TECH growth fund (2023-2029):

Autonomous Factory and Smart (Supply/Service) Networks

NXT GEN High Tech program



NXT GEN High Tech - Smart Industry projects

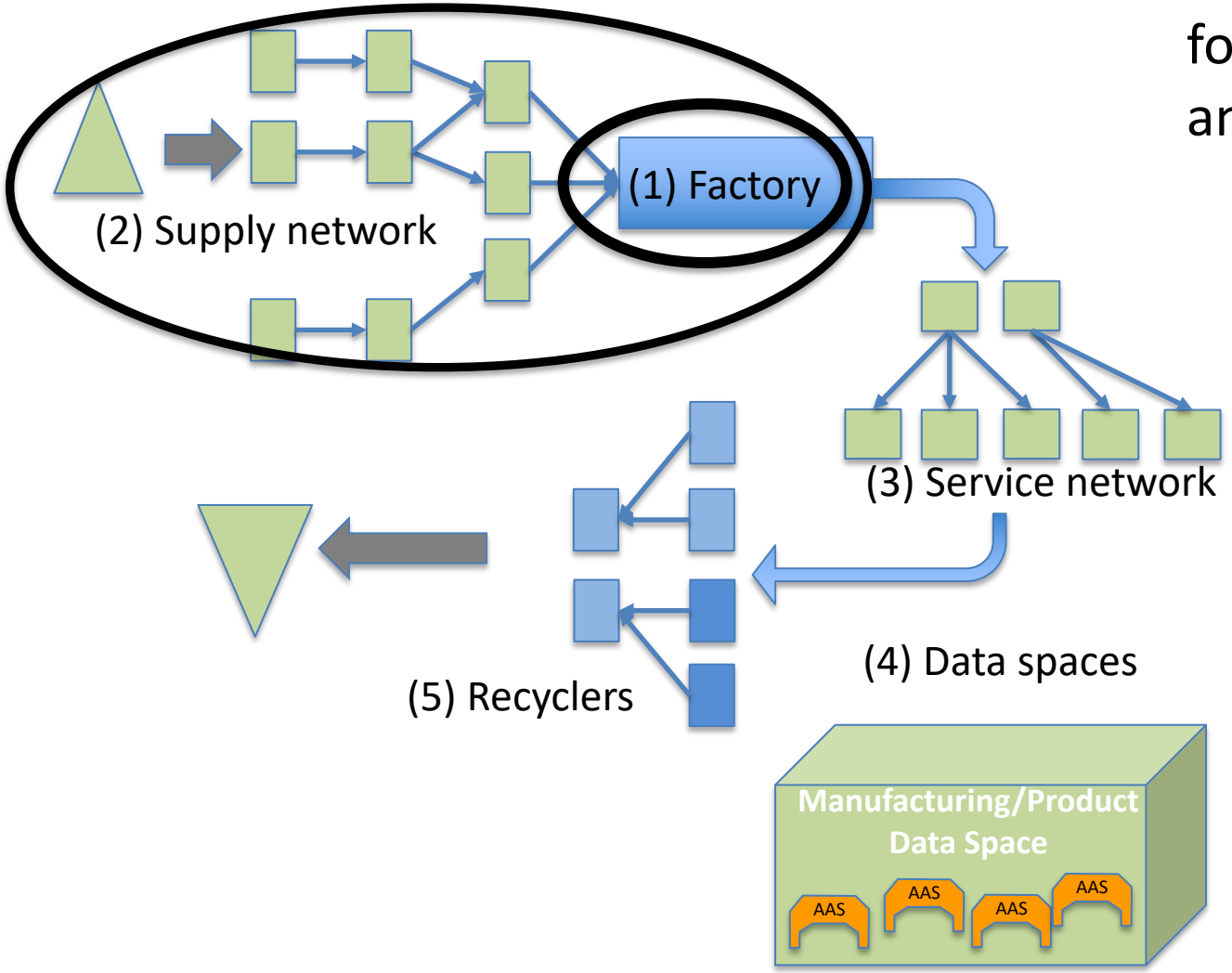


Autonomous Factory cluster (North, Enschede, Eindhoven, Delft)

Smart Networks (Supply and Services)

Support projects (prg mgt, standards, common & capacity booster=training)

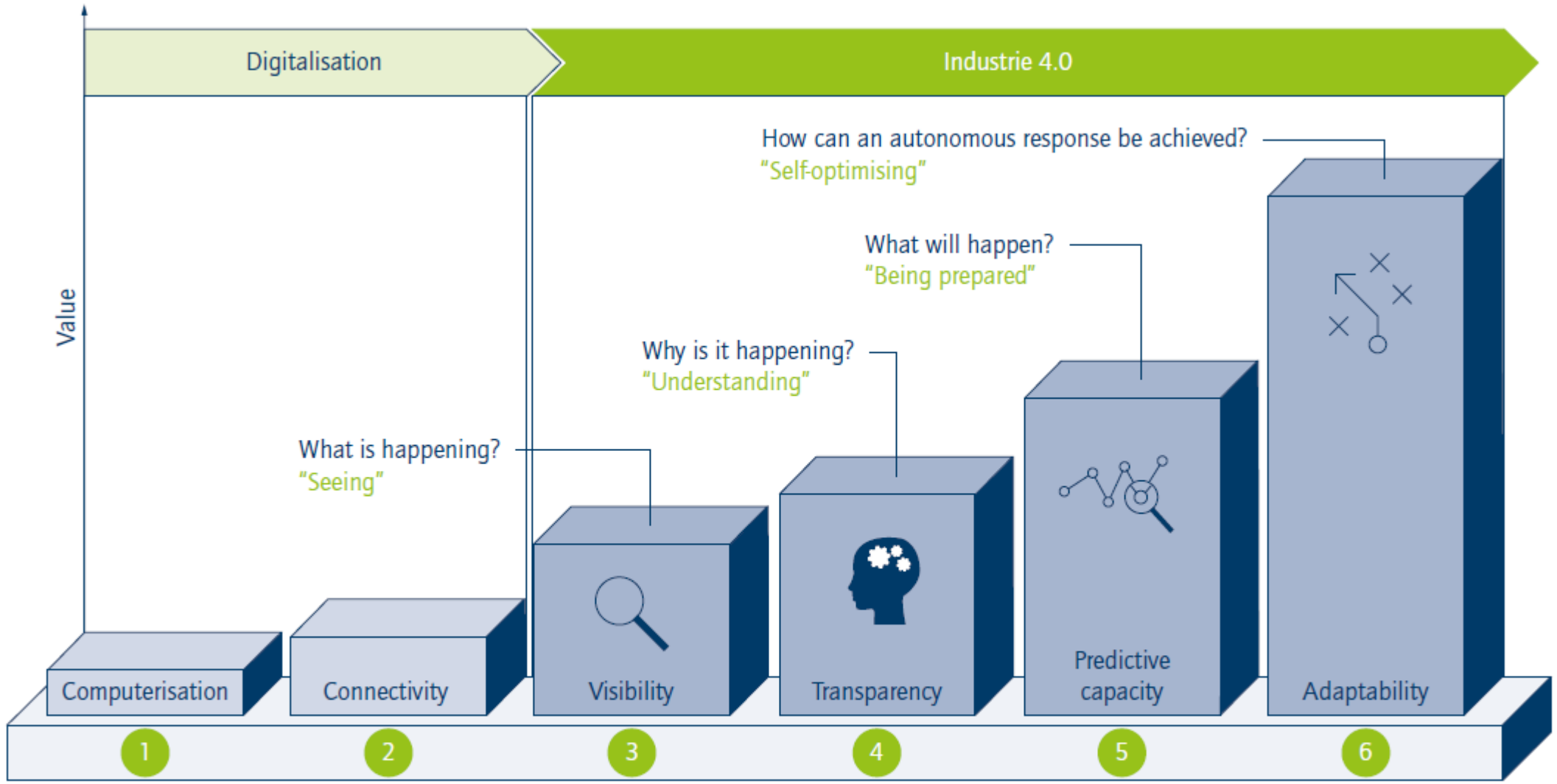
Digitalization is crucial for sustainability



The fourth industrial revolution
for the (1) factory
and with smart industry including
(2) the supply and
(3) service chains (servitisation)

we **prepare for a full sustainability and the use of digital product passports**
a digital twin of each product stored in
(4) manufacturing data spaces

and a new ecosystem of
(5) recyclers, a new role of suppliers as a kind of inverse factories



Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

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You ain’t seen nothing yet

“Every, everything in manufacturing will be digitized”

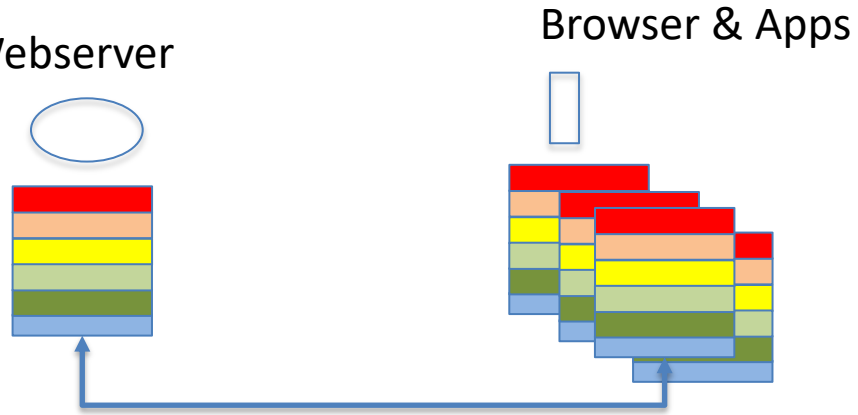
Like it or not, if you don’t, you will be out of business

The analogy with the rain radar apps:

Is there an I4.0 stack of standards/digital connector enabling a similar evolution?

Yes, next slide. ……

Internet rain radar app lesson:
use a standard stack (IP) and a standard interface/connector (HTML)



HTTP/HTML	Web ‘90 between computers and in ‘00 mobiles/handhelds controlling pixels on a screen
HTTPS & XML	Next to writing pixels, also more execution tasks (Java)
HTTP3, OPC-UA	Computers, mobiles, IoT devices from WhatsApp to Rain Radar usage

since the ‘90-ties, it led to web apps by 2000 and after 2010 an explosion of all kinds of mobile apps

The IP/HTML standards made it affordable, reliable and everywhere enabling you could 20 years ago, not think off or image.

The Manufuture – DTI vision & challenge EU Made-In-Europe R&D calls 2025-2027

2025-2030: Digital Technical Intelligence (basic requirement)

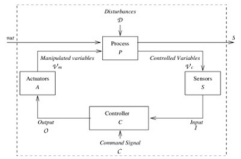
2030-beyond: Decentralised Tech. Intell. (autonomy apps)

Decentralised Technical Intelligence (DTI)

Next evolutionary step to boost industry performance

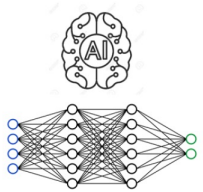
Control Theory & (Systems) Engineering

Feedback loops with sensors, actuators & controllers



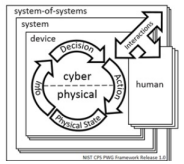
Artificial Intelligence

Simulation of some human intelligence processes by computer systems



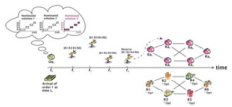
Cyber Physical Systems

Interconnection of 'cyber' (informatic, software) components with 'physical' (mechanical and electronic) parts that communicate via a data infrastructure, e.g. Internet-of-Things



agent-based/holonic manufacturing

Autonomous & cooperative agents provide manufacturing systems with flexibility, adaptability, agility, and dynamic reconfigurability ...



Decentralised Technical Intelligence

Next evolutionary step to revolutionise industry performance – going beyond the limits of today in an interdisciplinary approach.

⇒ self-x in real time

⇒ distributed, knowledge-based intelligence

⇒ process optimization in manufacturing systems

Digital Technical Intelligence (or Digital Connector)

From Research & Development to Innovation & Education:

Prerequisite for Deployment

- Business transformation

DTI Core Action Fields

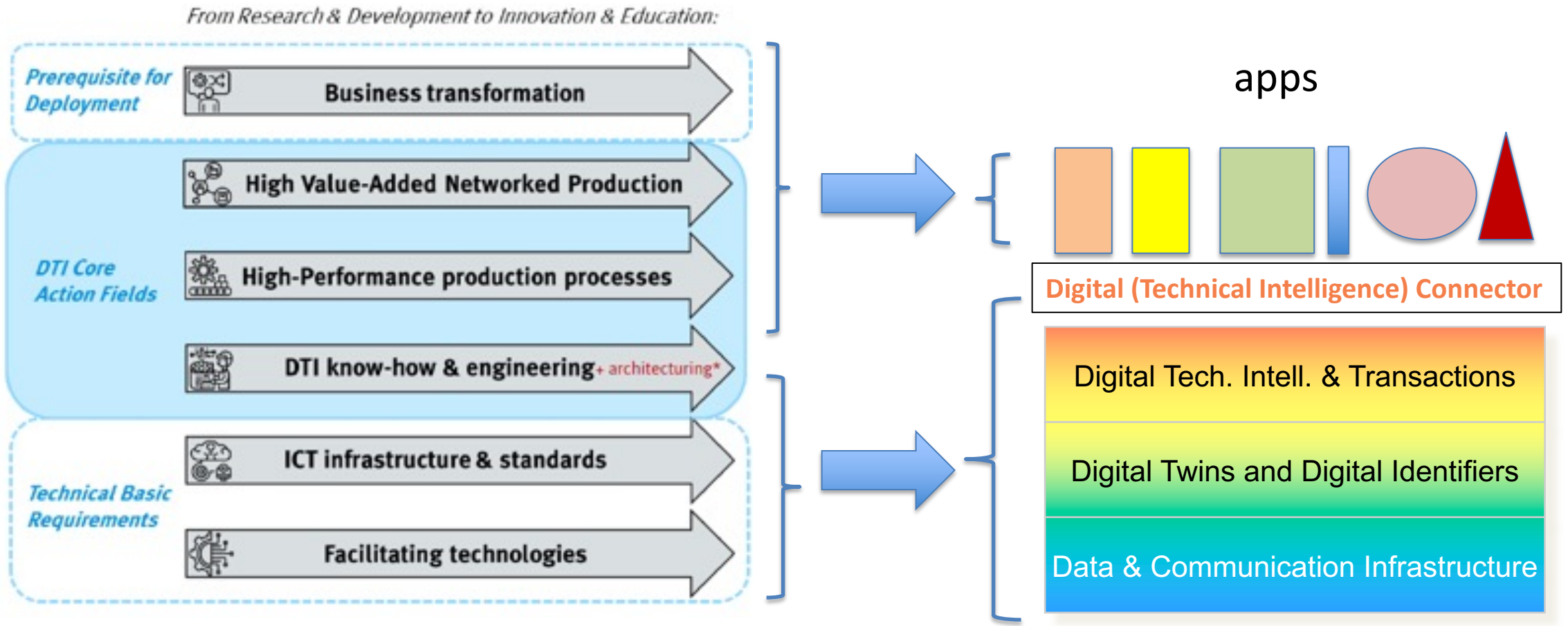
- High Value-Added Networked Production
- High-Performance production processes
- DTI know-how & engineering + architecturing*

Technical Basic Requirements

- ICT infrastructure & standards
- Facilitating technologies

The Manufuture – vision

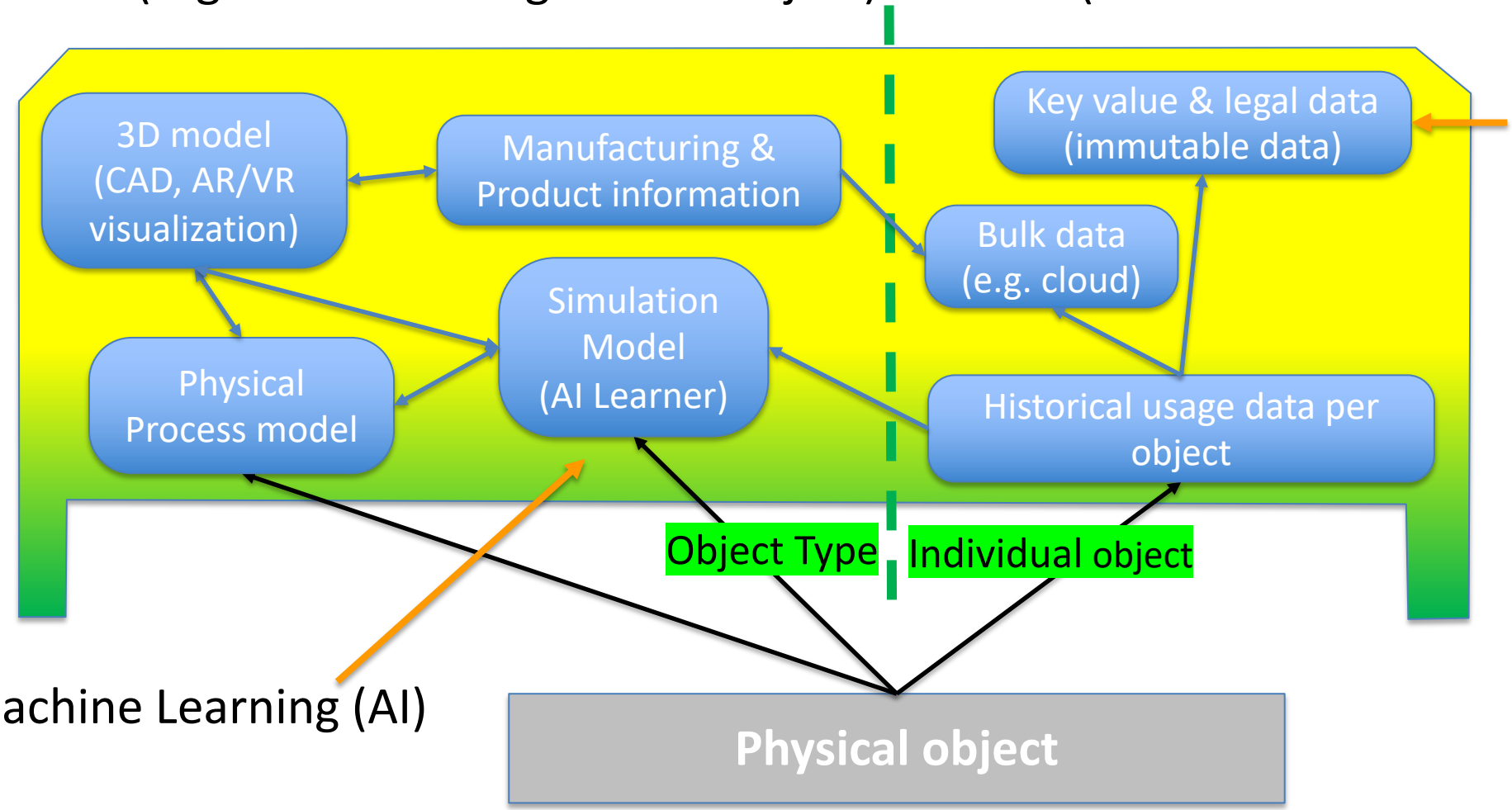
2025-2030: Digital Technical Intelligence (basic requirement)



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)



Blockchain (DLT)

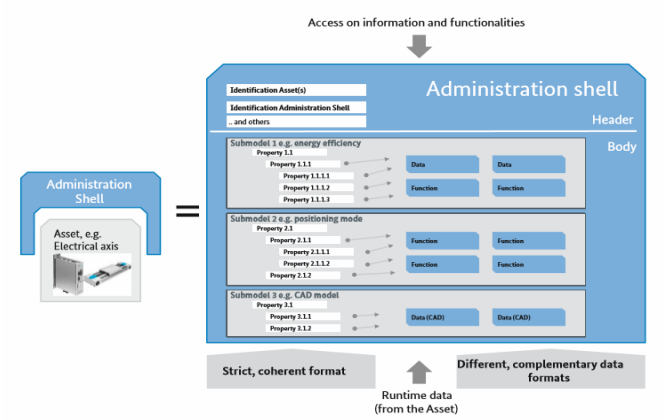
e.g. of DT;s:
- a product
- a machine
- a sensor
- a factory

Machine Learning (AI)

Digital Twin = AAS (Asset Admin Shell)

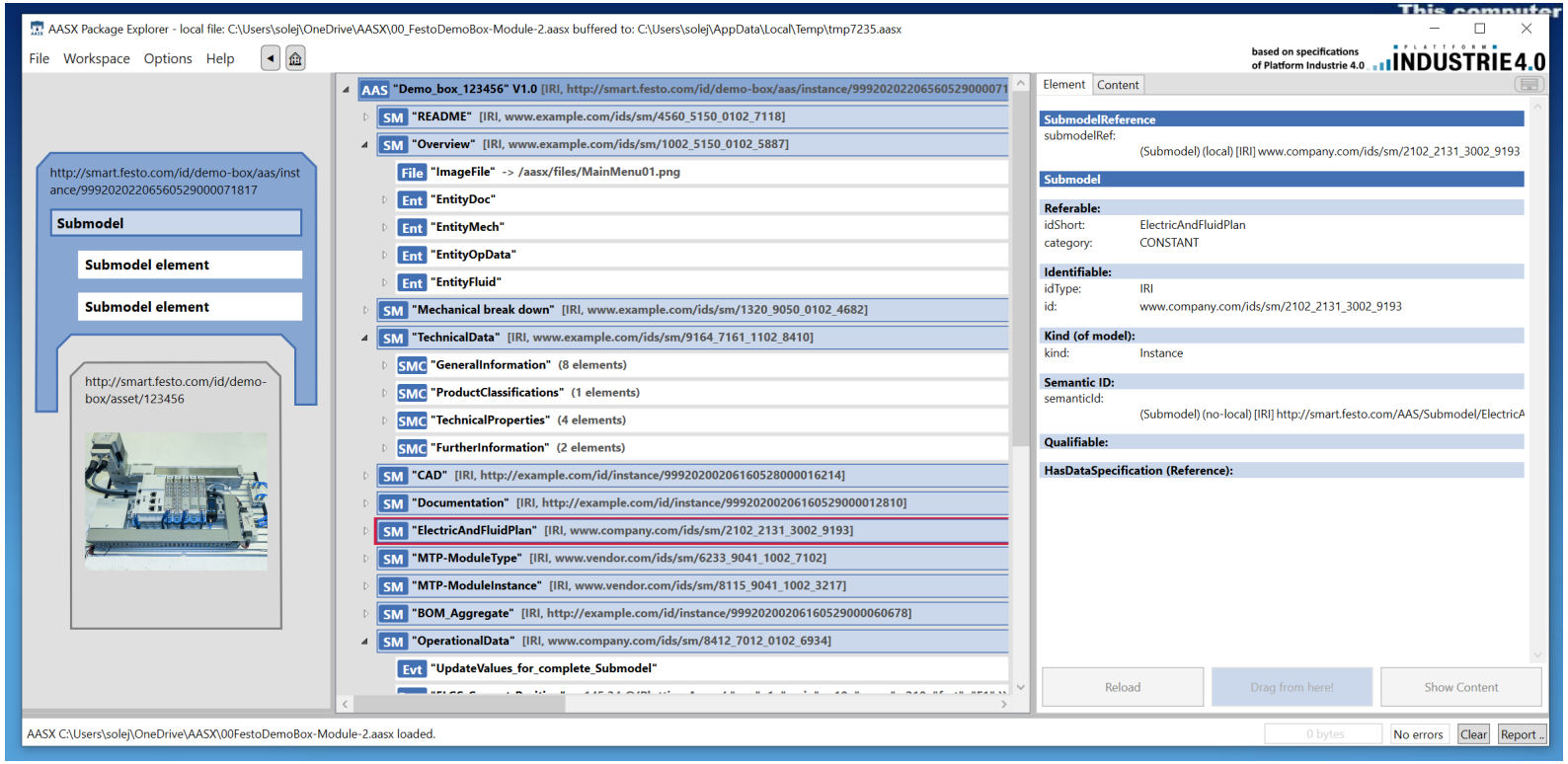
Product data: Digital Twin (DT) of Product Passport Data

A Digital Twin (DT) is a “living” virtual/digital representation of a physical (or virtual) product containing the information as: identifier (e.g. barcode nr), the history and status (and sometimes the planning/future) of a product and the references to locations where more information is stored (e.g. manufacturing and design data).



Digital Twin standard with AAS

(header / body similar to IP & HTML message header/body)



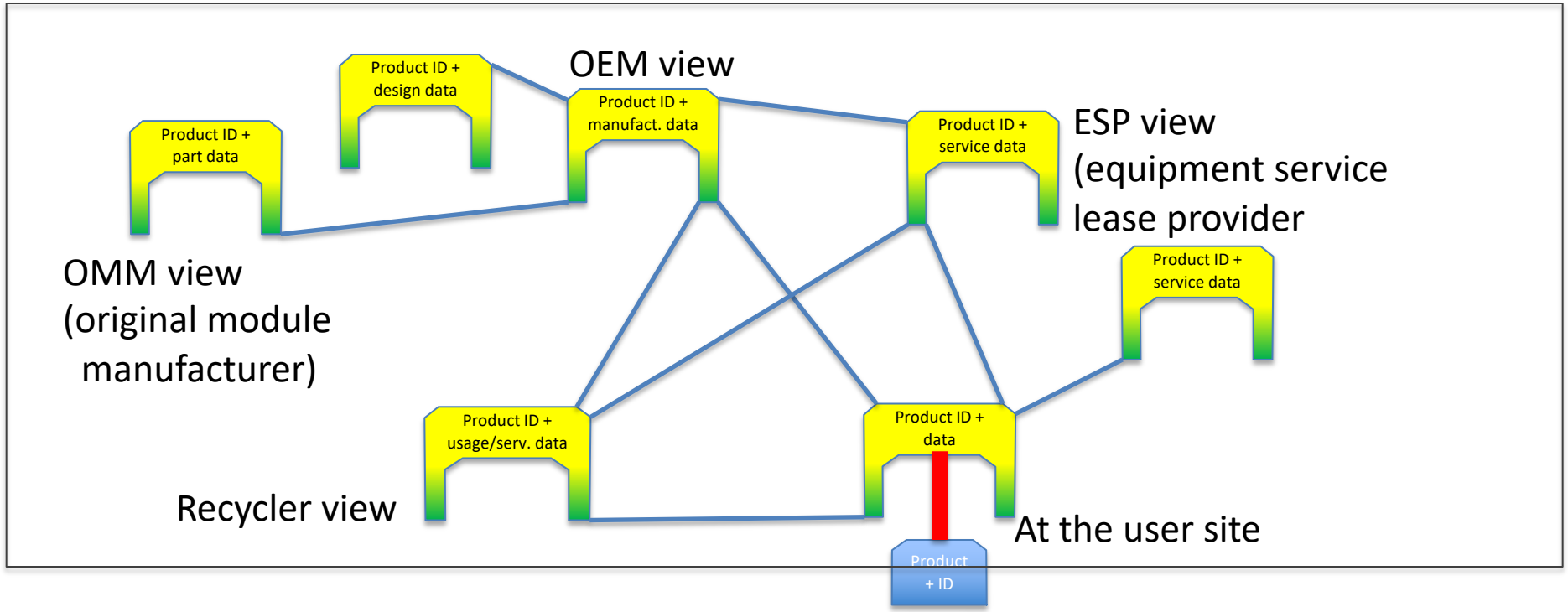
https://github.com/admin-shell-io/aasx-package-explorer/releases

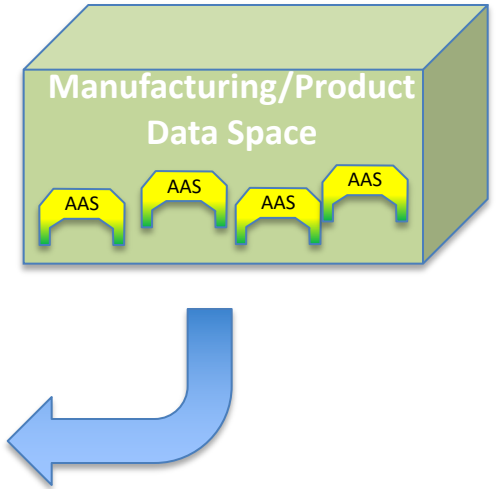
Relation Product and DT data stored a multiple locations/database/clouds

This is an more impactful slide then you might realize

Digital Twin data is a hypertext linked list with a hierarchy (product and its parts)
where product, part, usage and status data is stored at different places in a manufacturing data space.

To avoid data doubling (and inconsistency) data is updated and stored at only one place but can be by others

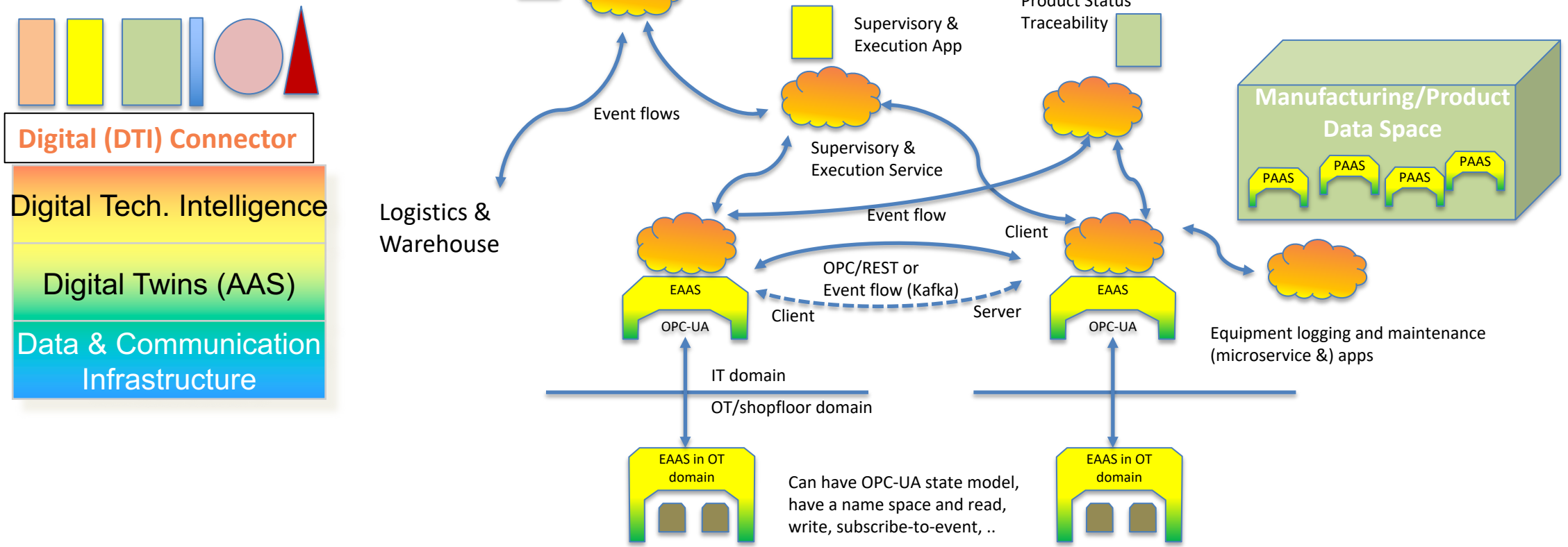




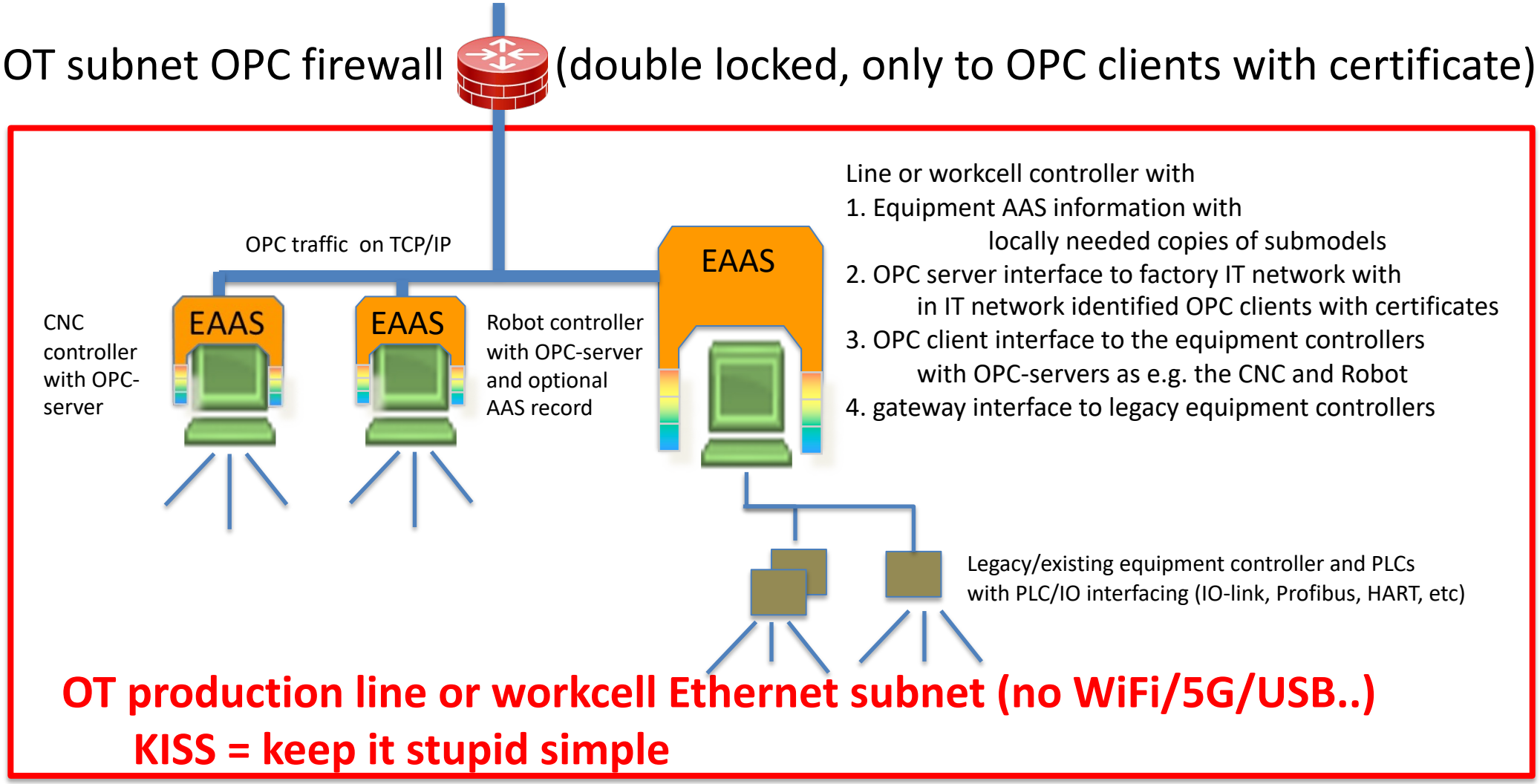
The link ▮ between product + ID and the product data + ID is critical and should not be modified

DT (Digital Twin) layer and active DTI (Digital Technical Intelligence) layer:

Product AAS (PAAS) in MDS (manufacturing data space) and Equipment-AAS (EAAS)+microservices as DTI's communicating with other DTI's, and I40 apps using event flows (=logs) and databases



OT OPC equipment subnet with OT cybersecurity and legacy



DTI (Digital Technical Intelligence) Connector

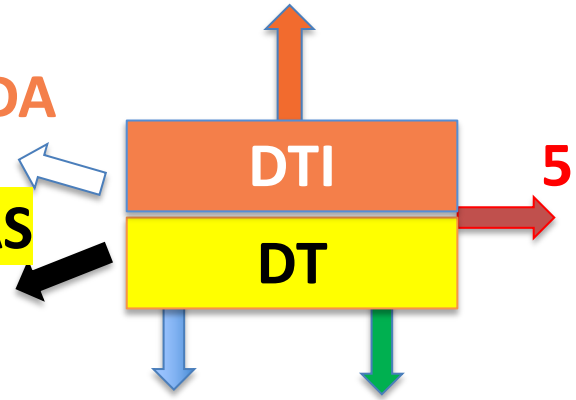
A Digital Technical Intelligence (DTI) connector has six standard interfaces:

Company logging
Event-Driven Architecture with event streams towards (micro)services, e.g. Kafka and business apps

6: Apps and app library

4: EDA

3: AAS



5: IDS **Towards customers, suppliers, and service providers,**
Industrial/international Data Space(s)

Company Product Data space
(Asset Administration Shell)

1: OPC-UA

2: REST/HTTP

IT

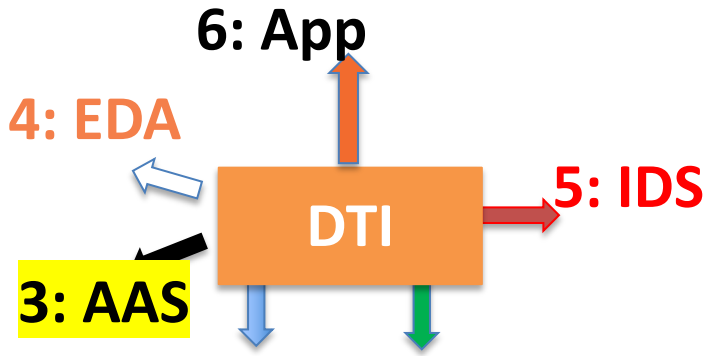
OT

OPC-UA between **equipment** in OT and DT in IT
(Open Platform Communication – Unified Archi.)

Human operator monitoring & control apps
(Representational State Transfer/HTTP/1.1)

OT-world (Operational Technology) with physical products, production equipment, and operators

Pre-DT/DTI I40 Digital Connector



Planning & Preparation

Control & Execution

Monitoring & Logging

Design & Descriptions

1000+ dedicated special programs

creating an intimidating legacy mess

100+ monolithically ERP, MRP, MES software packagers

10+ different fieldbus protocols

Modbus, Profibus, etc.

1-3 major CAD/Design environments

Industrial revolutions (0, 1, 2, 3)

Propritary software, vendor protocol/interfaces

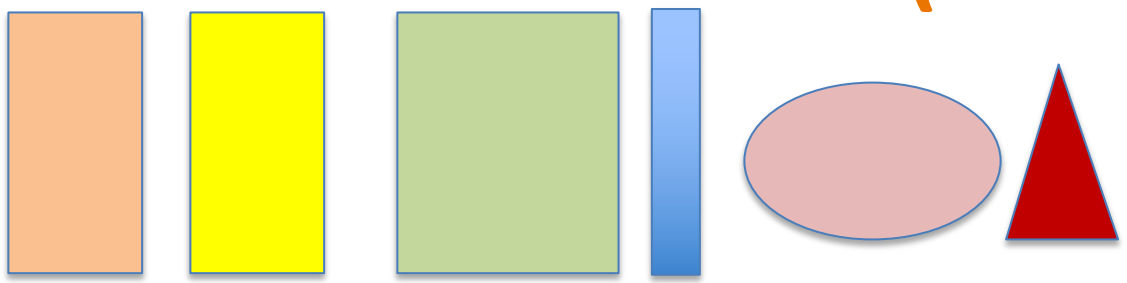
Interactive Digital Twins with digital (DTI) connectors (Digital Technical Intelligence) using OPC/REST/EDA/IDS

Digital Twinning with AAS (Asset Admininstration Shell)

Industrie 4.0/Smart Industry

Open Systems, International Standards

(DTI or I4.0) Digital Connector



DTI or I4.0 App Interface

New software:
Low-code when you can,
And for system software: Rust,
not in cyber unreliable C/C++ anymore

DTI
REST (and in OT network OPC) web interfaces with active virtual processors (OPC state/REST stateless) and web (inter)action & secure transactions (distribute ledger tech)

Plattform Industrie 4.0
OI4A, IDTA, tbd ISO/IEC
And UID, UUID standards

DT
Digital Twins AAS asset admin (sub)models and Digital Identifiers, Authentication and Authorization (IAA)

IT/OT
Information Technology Layer
(SQL) AAS Datastore, Gaia-X, IDS connector, OPC-UA/TCP/IP/Ethernet/IO Comm. & Cyber Security /Firewall Infrastructure

ISO/IETF/OPC/IEC
Common IT/OT standards

Content:

Introduction – setting the scene

"Voordat we de Industrie boom in het AI bos groot laten groeien, moet eerst het wortel stelsel worden ontwikkeld vergelijkbaar met de ijsberg metafoor waarbij eerst de data collective op orde moet zijn"

Trends in Industry (Industrie 4.0/Smart Industry)

Digitalization and Sustainability

interoperability, autonomous operations and smart networks (supply/service)

How to digitalize

– drive towards common (open systems) standards in the industry

- standard digital connector, DTI or I4.0 stack and apps

And then gradually create and grow the AI apps on top of a standard I4.0 stack

Building an AIM system

AI requires data sets with good/bad classification to train your application.

Separate in train/validate/test data sets (eventually augment data set)

To train the model, start with input layer and create the CNN layers, (convolutional neural network) and process/improve them if needed.

Then **build an industrial system** with

1. the input (e.g. camera, sensors, physical model/Digital Twin info),
2. load the AI model parameters in the control algorithm
3. and connect the output (robot, agv, operator screen)

Industriële AI – Wat is er al?

Gereedschapskist voor AI in de industrie:

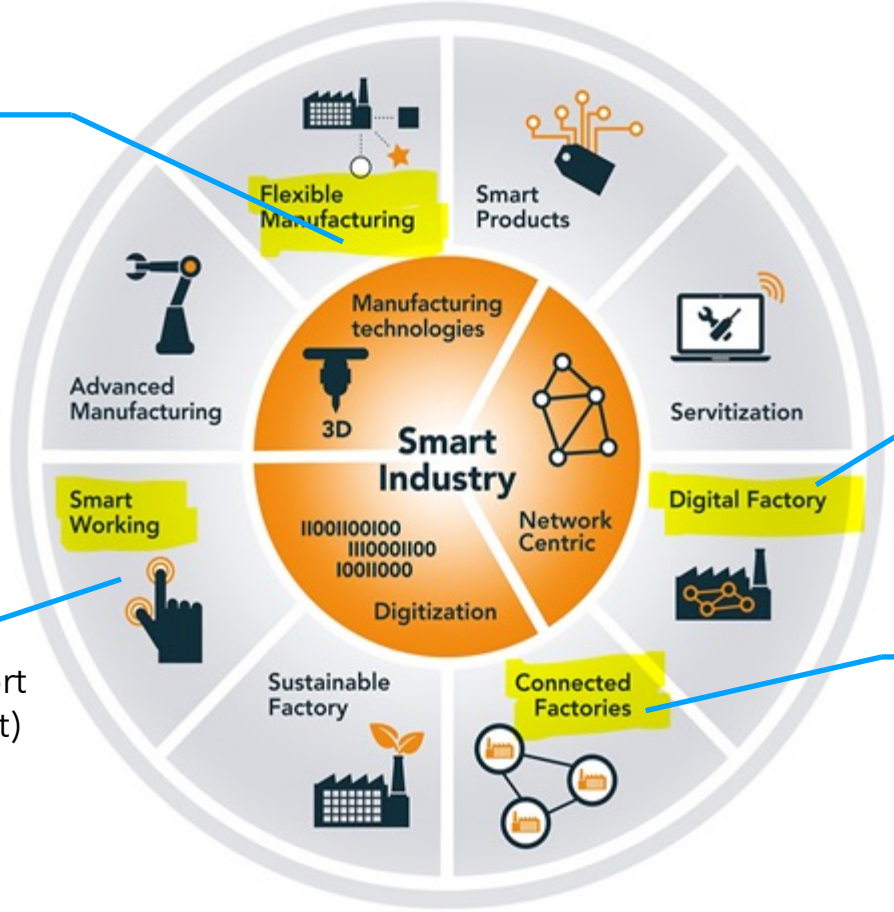
- Formats en infrastructuur voor data delen
- IoT, wireless connectivity
- Cloud services: AWS, Azure, Google
- Rekenkracht: centraal en decentraal, IIoT/edge computing
- Data analytics, machine learning tools (neural network) en libraries:

  Tensorflow, (Py)Torch, Numpy/Theano, Scikit-learn, Keras …
- Sensortechnologie, camerasystemen, beeldherkenning
- Digital twin, cyber physical systems, fysica modellen
- Robots, cobots, AGV's, Robot Operating System
- Operator support systemen, AR/VR tools
- AI experts : kennis van theorie en ervaring met toepassing

Voorbeeldprojecten om eerste oplossingen te ontwikkelen en demonstreren in Fieldlab setting, bv. BIC en SMITZH

4. Wat doen de eerste bedrijven nu al?

- Offline programmeren van robottaken voor geautomatiseerde productie
- Plannen van eenvoudige AGV logistiek
- Beeldherkenning van onderdelen in voorraadbakken



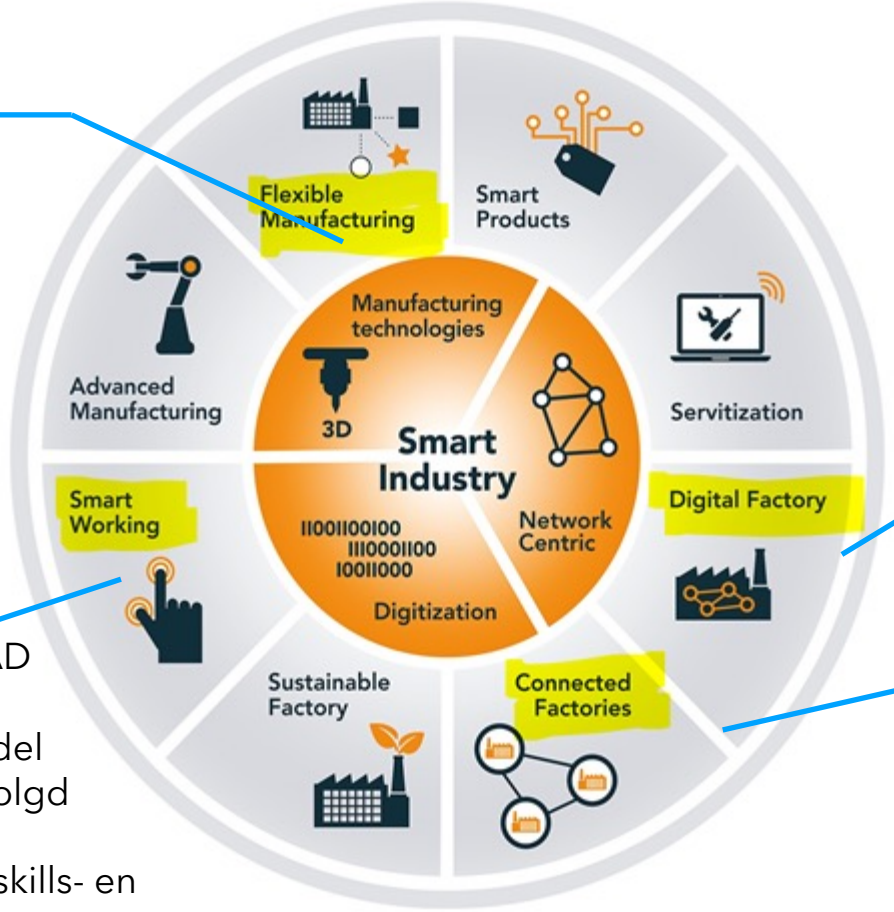
- Data gebaseerde condition monitoring (AI detecteert afwijkingen in performance)
- Decision support door analyse en statistiek van productiedata

- Geavanceerde interactieve operator support (projectietechniek, foutdetectie, pick to light)
- Veilige cobots in samenwerking met mens

- Data delen in de keten
- Data veiligheid en soevereiniteit

5. Wat kan de praktijk morgen met versnelling?

- AI genereert robotpaden voor geautomatiseerde productie
- AI leert omgeving inzichtelijk te maken voor robots en AGV's
- AI verdeelt mens-robot samenwerking
- AI herkent en onderdelen uit beelden van ongeordende stapels en pakt ze



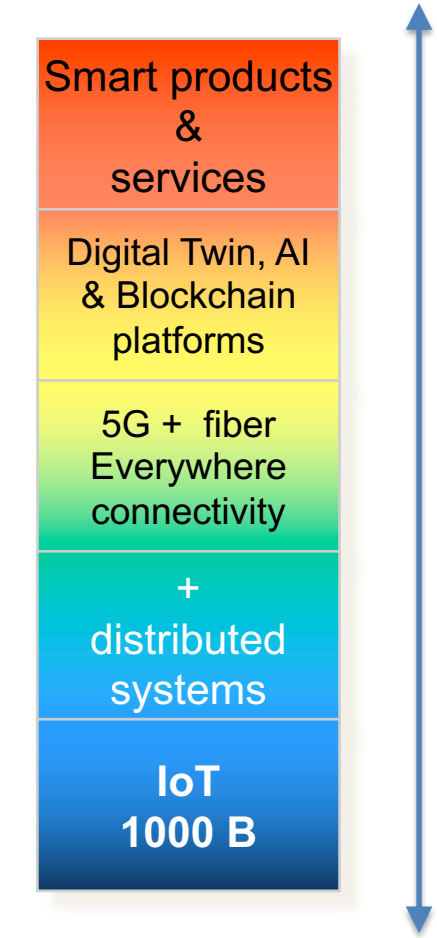
- AI leert gedrag van apparaten
- AI leert ondanks uniek gemaakte producten
- AI genereert mogelijke oplossingen gebaseerd op root-cause analyse

- AI genereert assemblagestappen uit CAD model
- AI genereert werkinstructie uit CAD model
- AI detecteert of assemblageproces gevolgd wordt
- AI past instructies aan aan de hand van skills- en ervaringsniveau operator

- AI leert semantische structuur van data
- AI leert welke fabrieksdata relevant is

AI apps will come, but first, we need to structure the stack below

Internet of Services IoS:



Internet of Things IoT

Control – smart AI

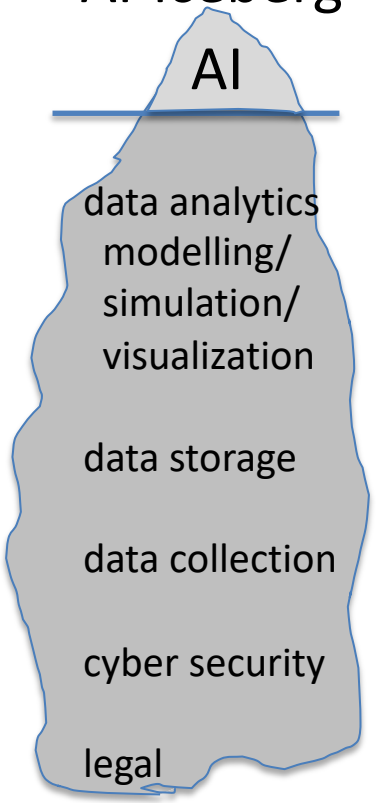
Control – direct

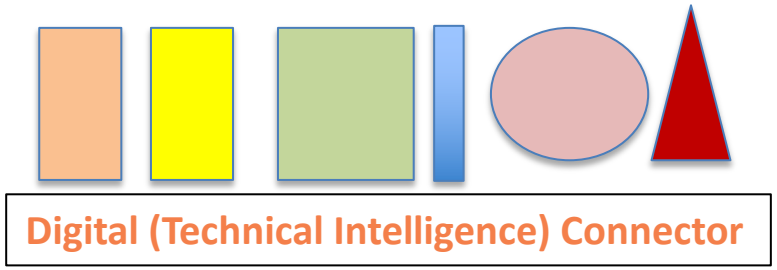
Data visualization & monitoring

Data collection & storage

Sensor data & communication

Top of AI-iceberg





Summary:

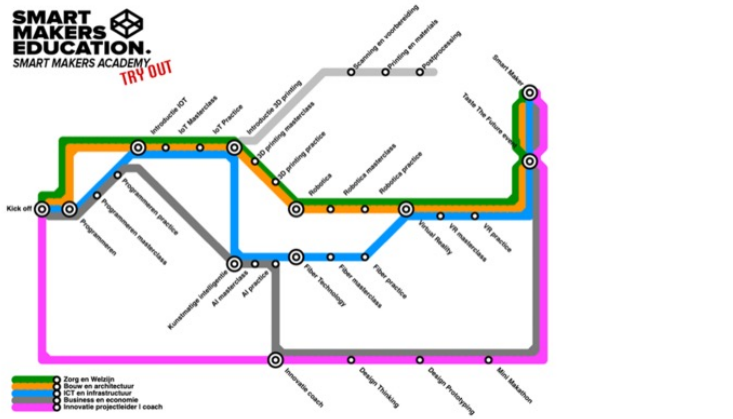
why After decades of vendor lock-in interfaces and monolithic software systems manufacturing should evolve, similar to Internet and web/mobile apps, towards

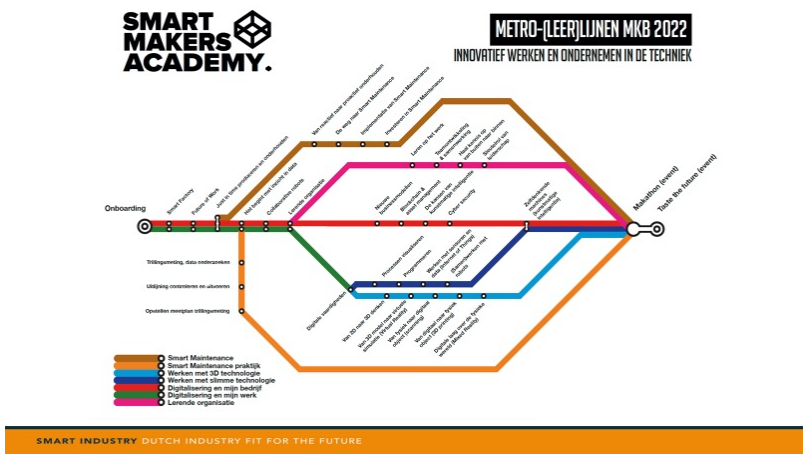
what the usage of apps on top of a digital technical intelligence with a standard, affordable, and reliable digital connector.

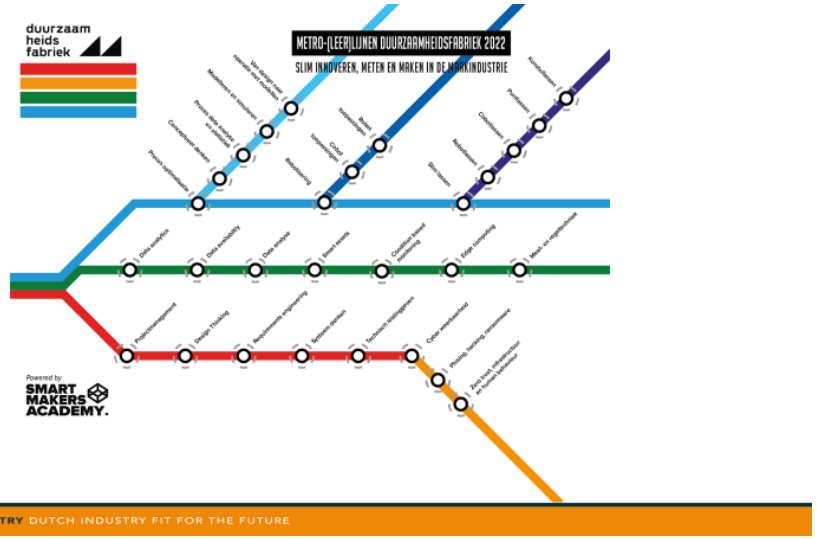
to enable autonomous data collection and exchange to improve productivity and sustainability using all kinds of apps, from simple up to advanced AI apps.

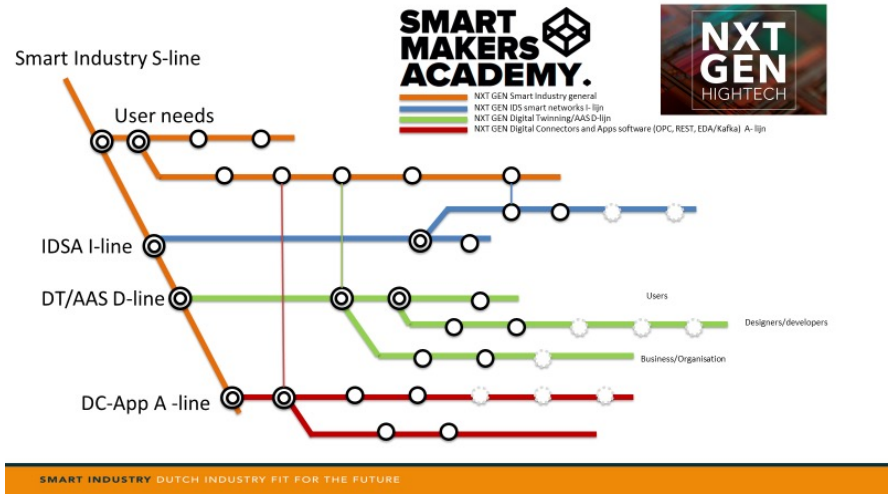
how But to turn this vision into projects, test and training facilities, and ultimate into real-life systems in factories are needed it has huge consequences for (re)training our workforce in digital skills.

Smart Makers Academy – 1-day training modules as stations in a regional metro transport model for individual trip planning









smart industry

Het AI-congress van Noorden –
Data Delen: Het bos en de bomen

SMART INDUSTRY (Fourth IR/I40 in NL) DUTCH INDUSTRY FIT FOR THE FUTURE

www.smartindustry.nl

Egbert-Jan.Sol@TNO.nl

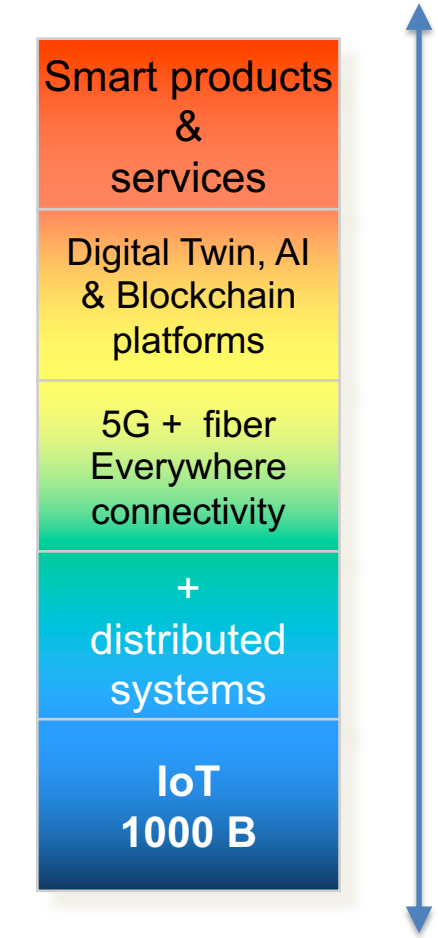
oct 2022 v1

A TNO initiative made possible by a subsidy of the Dutch Min.
of Economic Affaires & Climate and the province of Noord-Brabant

Provincie Noord-Brabant

AI apps will come, but first, we need to structure the data stack below

Internet of Apps/Services IoS:



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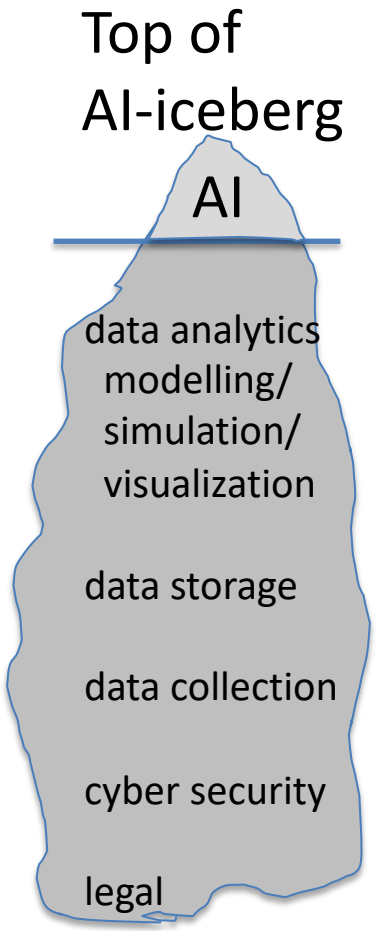
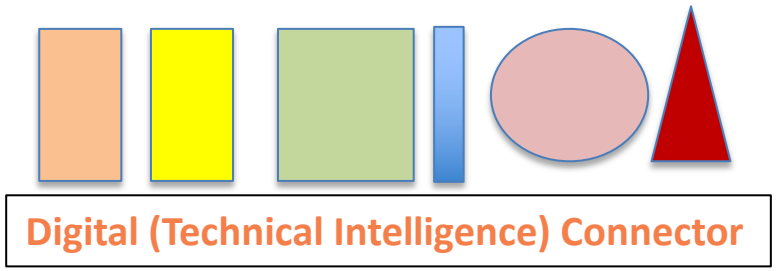
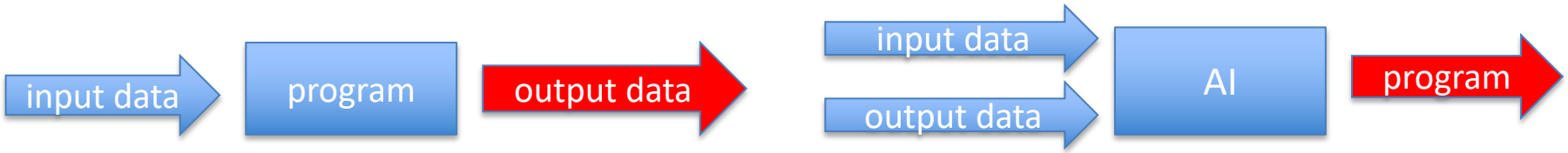




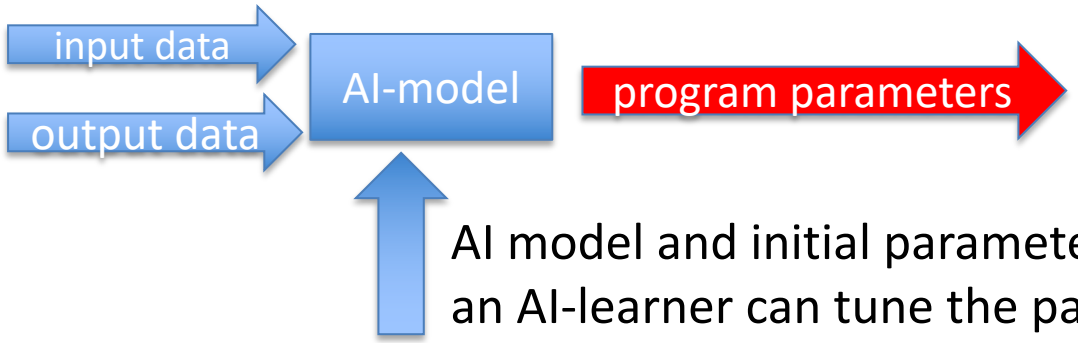
Artificial Intelligence or better Machine Learning

AI-hypes go up and down (already two or more AI winters since 1960)

The AI-holy grail & the misperception – input + output => program : no more programming



Now comes the small letters: In real life, there is no AI master algorithm fitting all problems or as silver bullet.



AI-models: neural networks,
evolving programs with selection,
physical process models, Bayes statistics, ..

AI model and initial parameters and with machine learning
an AI-learner can tune the parameters such that with new input produces new output

Will history (of industrial control engineering) repeat itself?

The 90-'ties: parameter estimation of advanced control systems
e.g., Kalman filters – linearization of large (process) plants around their setpoint
model fitting by estimation of the (linear) coefficients/parameters of (PID) control loops

After several years, those systems were not used anymore as the plant and their operational setpoint (product mix, remodified equipment,..) had changed and reality was drifting away into non-linear behavior

Artificial Intelligence, in particular, the popular & hyped CNN (neural network) faces the same lesson soon!!!
Once a model has been trained, but the environment change, you must retrain the model again.
Nice for stable millions of medial (X-ray, Pathology) or astronomical pictures, but not for many other apps.

USA big tech loves AI (and its sales), but VCs don't fund AI startups anymore,
75% of AI startup money goes to AWS/Alphabet/Microsoft for training AI models in their cloud platforms.

Universities love AI: it is a euphemism for statistics. Studying statistics doesn't recruit any student, AI does
and any research proposal should include AI to get funded by old reviewers who hardly understand it.

Let’s be sensible

Today AI tools require at least knowledge and usage experiences of Linux, Python/MatLab, and several of the many AI libraries and models, in general, a knowledge level only achievable by e.g., a PhD-student of last year’s MSc or smart BSc student with a technical or IT background.

And making a sensible AI application, you need to collect hundreds of labeled data sets (e.g., photos coupled with a decision e.g., good or wrong, often verified by so-called 100.000+ “Mechanical Turks”) or follow the opposite of the diminishing return idea now followed by Big Tech of investing Billions in AI calculations.

- The five fingers app and the statistical uncertainty of 50% that it are 4 (or 5) fingers

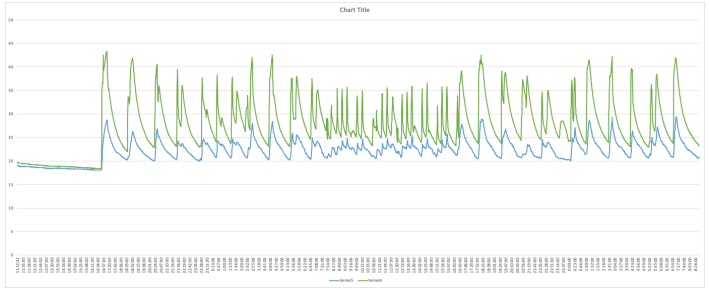
- The AGV example dropping off the table/against wall. => need combi of AI model and physical models

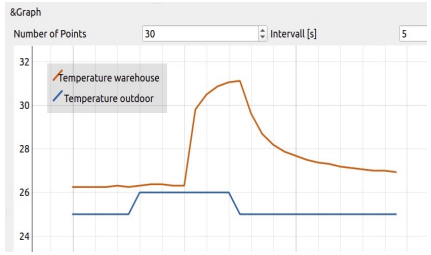
- Or enter the complete internet as the training set

And then, as in the large process control installations or industrial job shop/manufacturing sites, you know that the product mix is increasing, production series are getting smaller, and soon you need to retrain again.

Follow a 20/80 approach

Define an industrial AI project, but don’t go for 100 % of the project to get 100% of the results
but spent 20% of the cost to collect serious data and analyze it, you might realize already 80% of the results

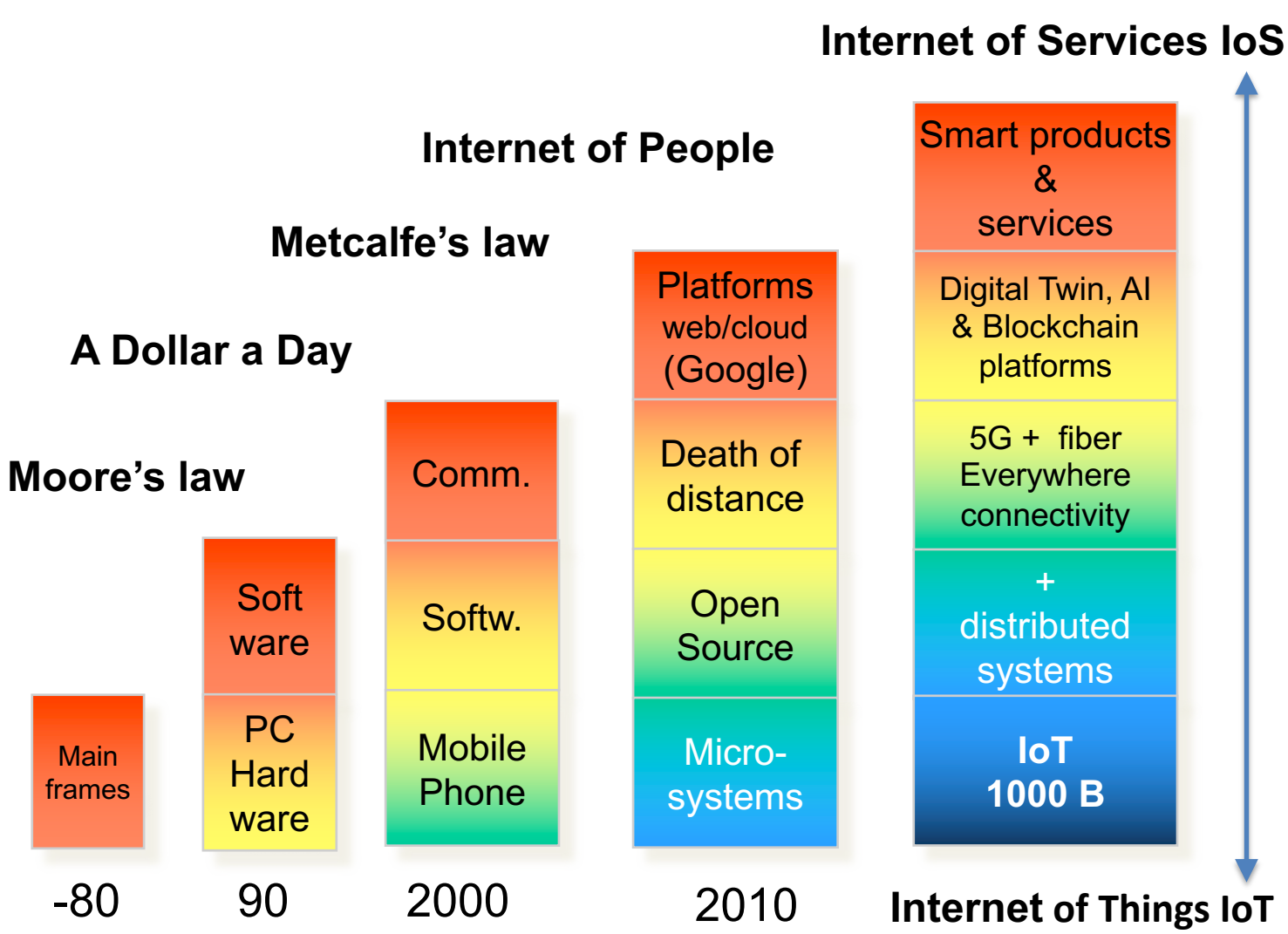


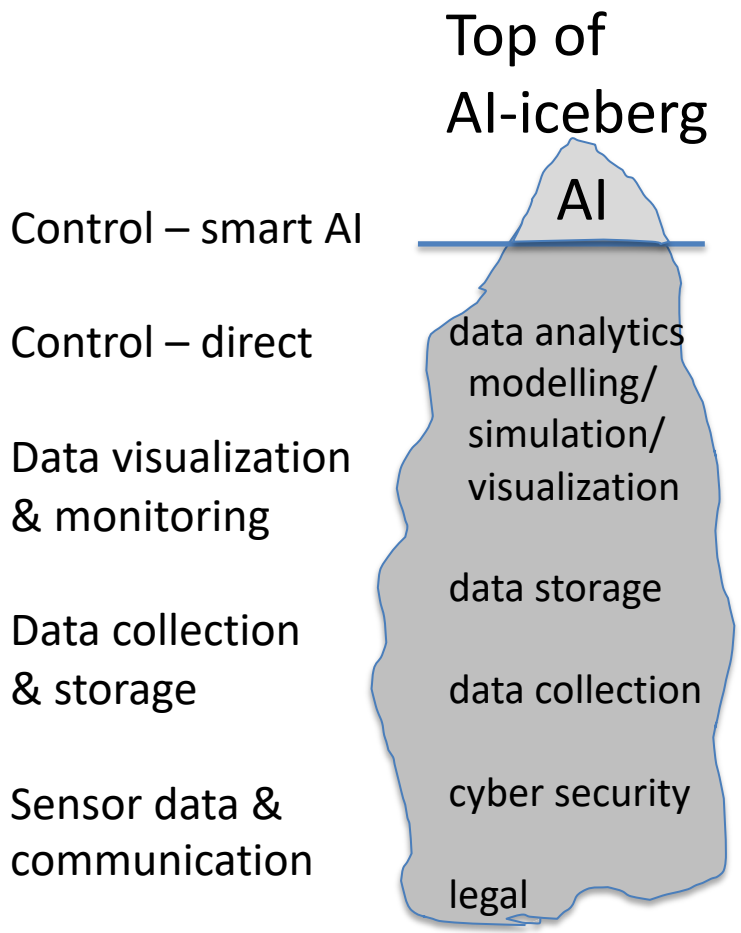


1: Vision - Zero defect – use vision to check every production step
    e.g., compare the output of a production step with a picture that you match with an inference model
    however, we need a model that can be trained not by hundreds of photos of good/wrong assemblies,
        but automatically by e.g., a rendered Digital Twin CAD model of (new) products and the work cell.

23: Prediction - Predictive maintenance (and similar trend analysis IAIA)
    e.g., use a model of what is/will happen, opt. MatLab based, and match data to that model

AI iceberg: the bulk of the work is on labelling clean data, not AI





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Digitalization and Sustainability

interoperability, autonomous operations and smart networks (supply/service)

How to digitalize?

– drive towards common (open systems) standards in the industry

- standard digital connector, DTI or I4.0 stack and apps

And then gradually create and grow the AI apps on top of a standard I4.0 stack

Kansgebieden voor toepassing AI

SMART SALES
- 24/7 PRODUCT CONFIGURATOR PORTAL
- SMART WEBSHOP

KLANT

PRODUCT

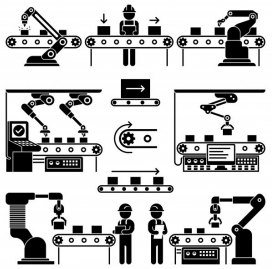
SMART PRODUCT
- INTELLIGENT & CONNECTED PRODUCTS

FABRIKANT

SMART LOGISTICS
- AUTONOMOUS SYSTEMS

SMART ENGINEERING
- GENERATIVE DESIGN
- DIGITAL TWIN

SMART EMPLOYEE SUPPORT
- AUGMENTED WORKER



SMART QUALITY CONTROL
- MACHINE VISION

SMART SERVICE & MAINTENANCE
- PREDICTIVE MAINTENANCE

SMART PRODUCTION
- **O**VERAL **E**QUIPMENT **E**FFICIENCY
- FLEXIBILISERING, N=1

FME POWERED BY DUTCH TECHNOLOGY

2030 VISION FOR INDUSTRIE 4.0

Shaping Digital Ecosystems Globally

PLATTFORM INDUSTRIE 4.0

Autonomy

Self-determination and free scope for action guarantee competitiveness in digital business models.

- Technology development
- Security
- Digital infrastructure

Interoperability

Cooperation and open ecosystems permit plurality and flexibility.

- Regulatory framework
- Standards and integration
- Decentralised systems and artificial intelligence

Sustainability

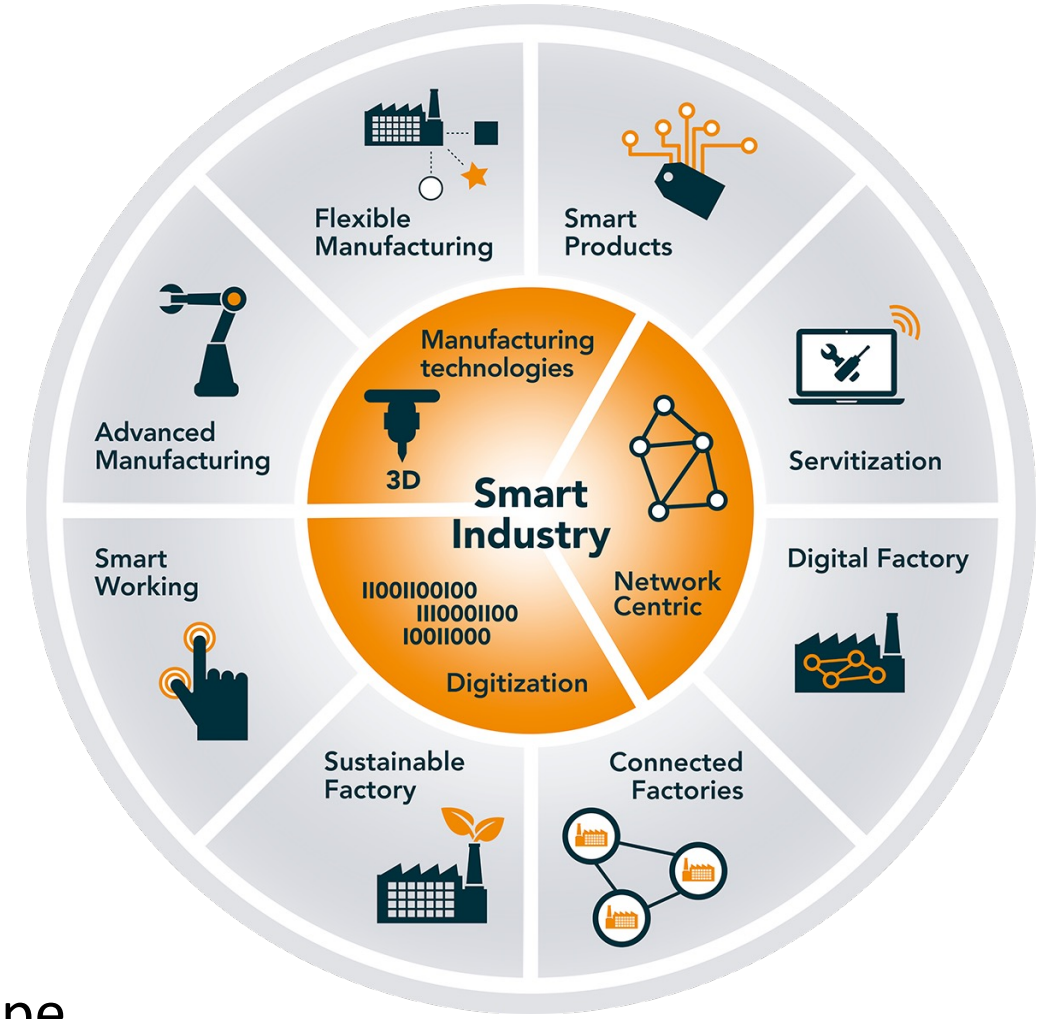
Modern industrial value creation ensures high standard of living.

- Decent work and education
- Climate change mitigation and the circular economy
- Social participation

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 materials
for a sustainable & competitive economy
with a culture in lifelong (digital) skills training

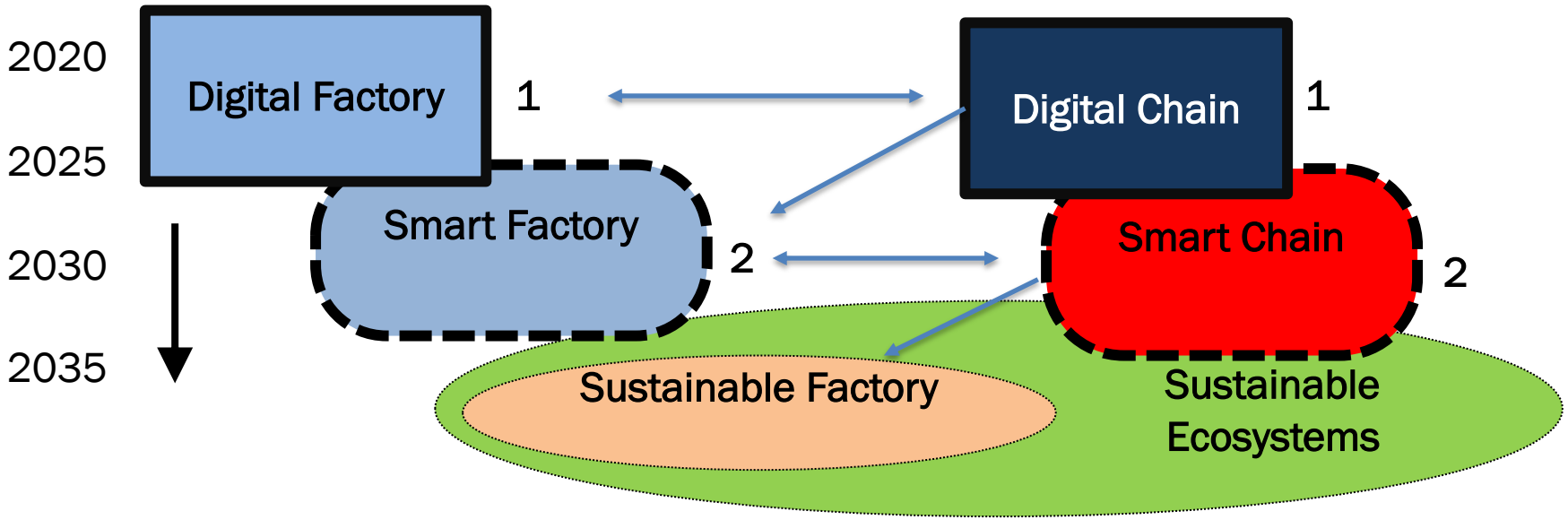


8 Industry transformations and
45 Smart Industry Fieldlabs
are the core of the program → now 5 EDIH in spe
(North, East, South, West, and Northwest (A'dam)

Vision: from digital via smart to sustainable

Roadmap (inside) Factories

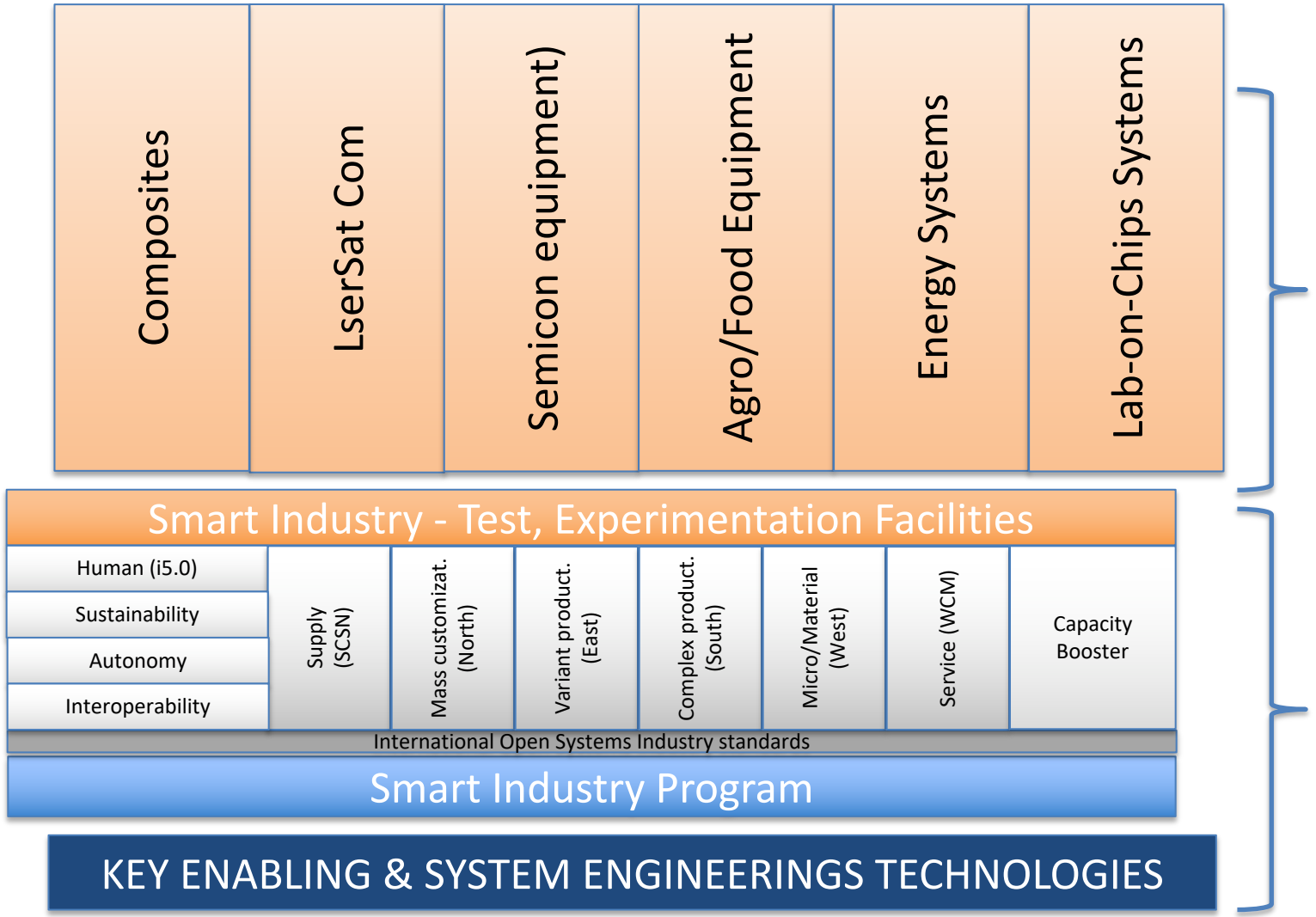
Roadmap (inside) Value Chains



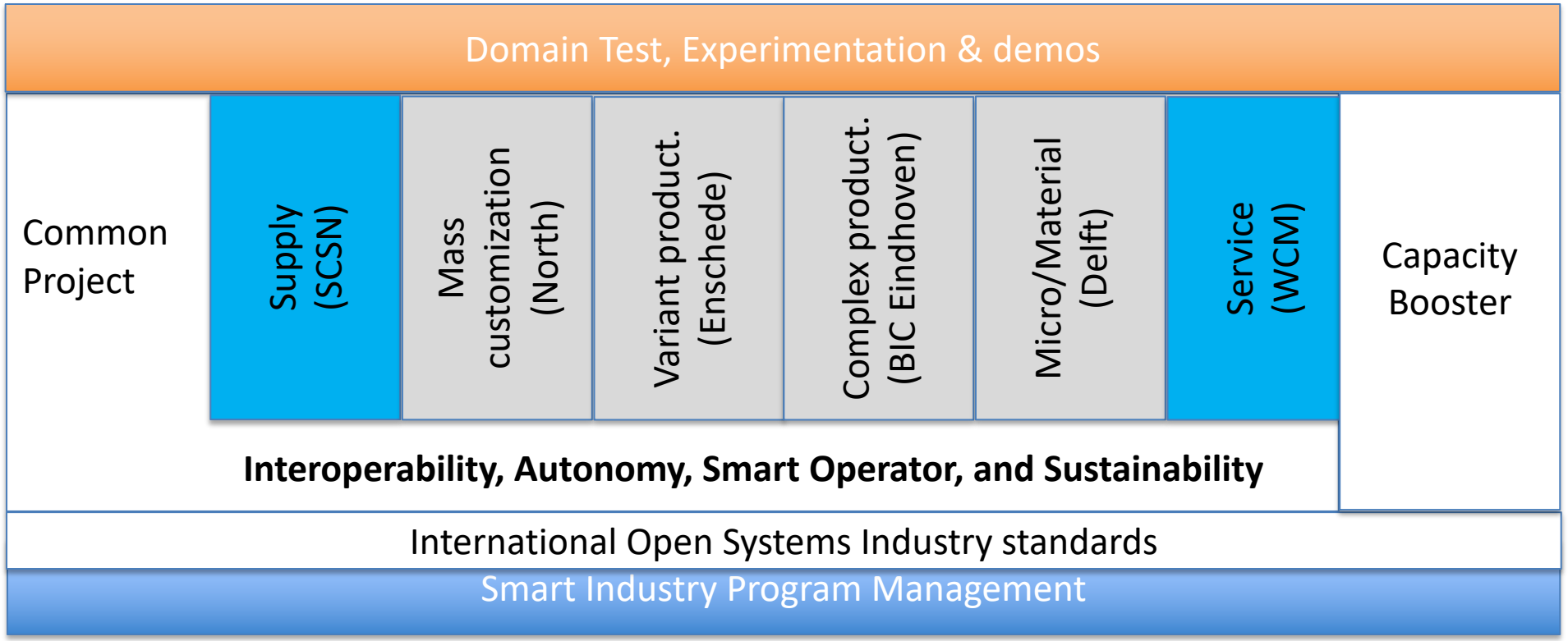
NXT GEN HIGH TECH growth fund (2023-2029):

Autonomous Factory and Smart (Supply/Service) Networks

NXT GEN High Tech program



NXT GEN High Tech - Smart Industry projects

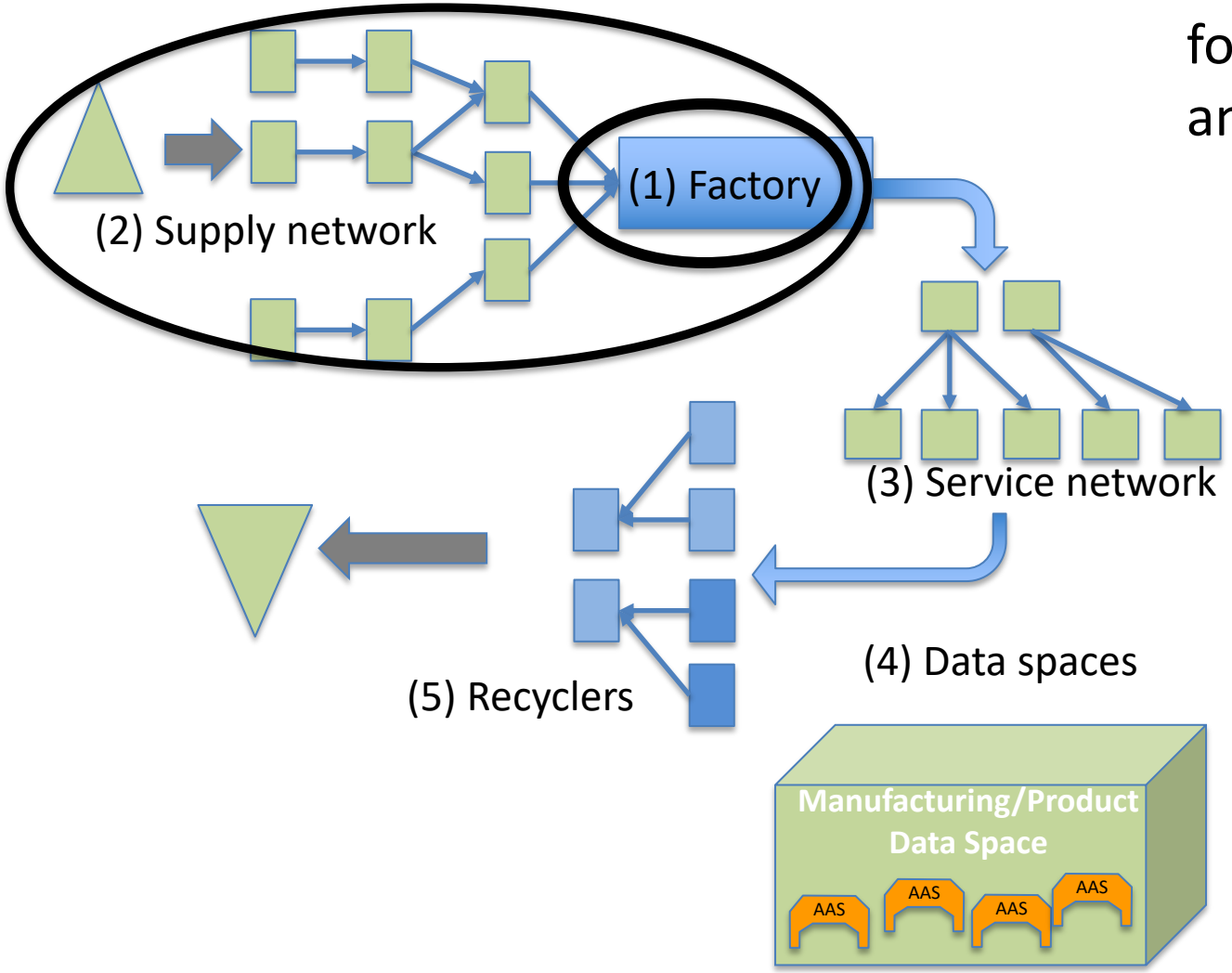


Autonomous Factory cluster (North, Enschede, Eindhoven, Delft)

Smart Networks (Supply and Services)

Support projects (prg mgt, standards, common & capacity booster=training)

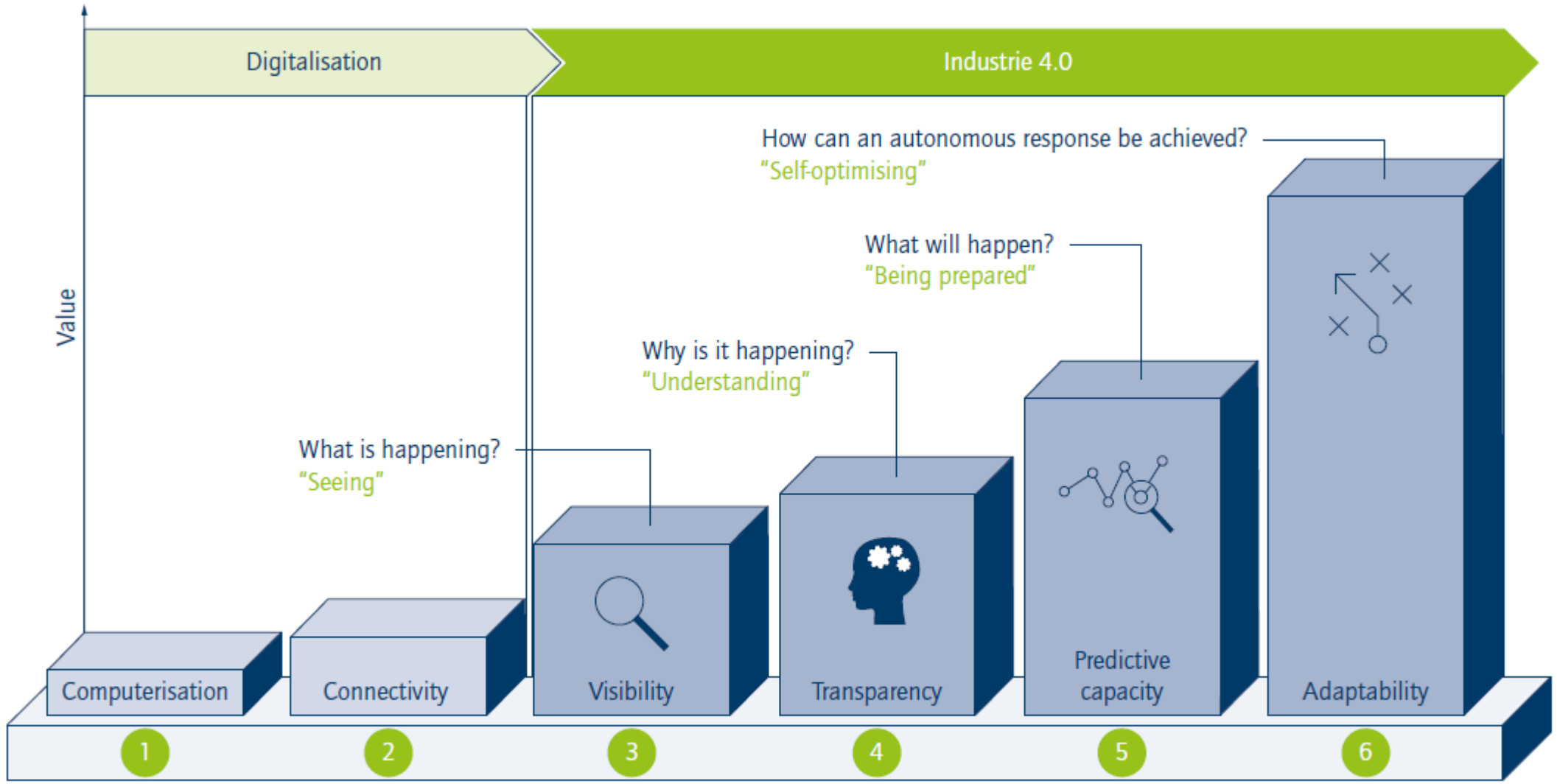
Digitalization is crucial for sustainability



The fourth industrial revolution
for the (1) factory
and with smart industry including
(2) the supply and
(3) service chains (servitisation)

we **prepare for a full sustainability and the use of digital product passports**
a digital twin of each product stored in
(4) manufacturing data spaces

and a new ecosystem of
(5) recyclers, a new role of suppliers as a kind of inverse factories



Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

Content:

Introduction – setting the scene

"Voordat we de Industrie boom in het AI bos groot laten groeien, moet eerst het wortel stelsel worden ontwikkeld vergelijkbaar met de ijsberg metafoor waarbij eerst de data collective op orde moet zijn"

Trends in Industry (Industrie 4.0/Smart Industry)

Digitalization and Sustainability

interoperability, autonomous operations and smart networks (supply/service)

How to digitalize

– drive towards common (open systems) standards in the industry

- standard digital connector, DTI or I4.0 stack and apps

And then gradually create and grow the AI apps on top of a standard I4.0 stack

You ain’t seen nothing yet

“Every, everything in manufacturing will be digitized”

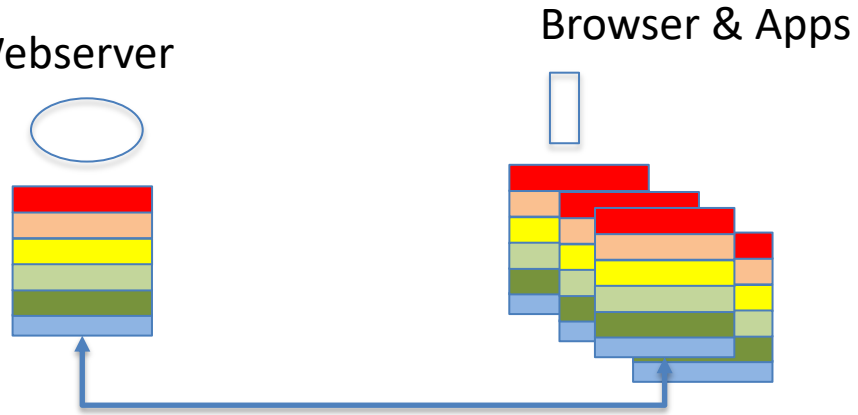
Like it or not, if you don’t, you will be out of business

The analogy with the rain radar apps:

Is there an I4.0 stack of standards/digital connector enabling a similar evolution?

Yes, next slide. ……

Internet rain radar app lesson:
use a standard stack (IP) and a standard interface/connector (HTML)



HTTP/HTML	Web ‘90 between computers and in ‘00 mobiles/handhelds controlling pixels on a screen
HTTPS & XML	Next to writing pixels, also more execution tasks (Java)
HTTP3, OPC-UA	Computers, mobiles, IoT devices from WhatsApp to Rain Radar usage

since the ‘90-ties, it led to web apps by 2000 and after 2010 an explosion of all kinds of mobile apps

The IP/HTML standards made it affordable, reliable and everywhere enabling you could 20 years ago, not think off or image.

The Manufuture – DTI vision & challenge EU Made-In-Europe R&D calls 2025-2027

2025-2030: Digital Technical Intelligence (basic requirement)

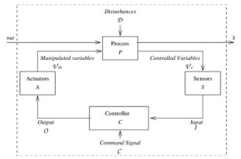
2030-beyond: Decentralised Tech. Intell. (autonomy apps)

Decentralised Technical Intelligence (DTI)

Next evolutionary step to boost industry performance

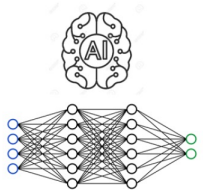
Control Theory & (Systems) Engineering

Feedback loops with sensors, actuators & controllers



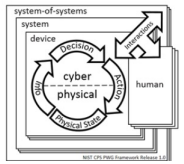
Artificial Intelligence

Simulation of some human intelligence processes by computer systems



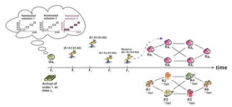
Cyber Physical Systems

Interconnection of 'cyber' (informatic, software) components with 'physical' (mechanical and electronic) parts that communicate via a data infrastructure, e.g. Internet-of-Things



agent-based/holonic manufacturing

Autonomous & cooperative agents provide manufacturing systems with flexibility, adaptability, agility, and dynamic reconfigurability ...



Decentralised Technical Intelligence

Next evolutionary step to revolutionise industry performance – going beyond the limits of today in an interdisciplinary approach.

⇒ self-x in real time

⇒ distributed, knowledge-based intelligence

⇒ process optimization in manufacturing systems

Digital Technical Intelligence (or Digital Connector)

From Research & Development to Innovation & Education:

Prerequisite for Deployment

- Business transformation

DTI Core Action Fields

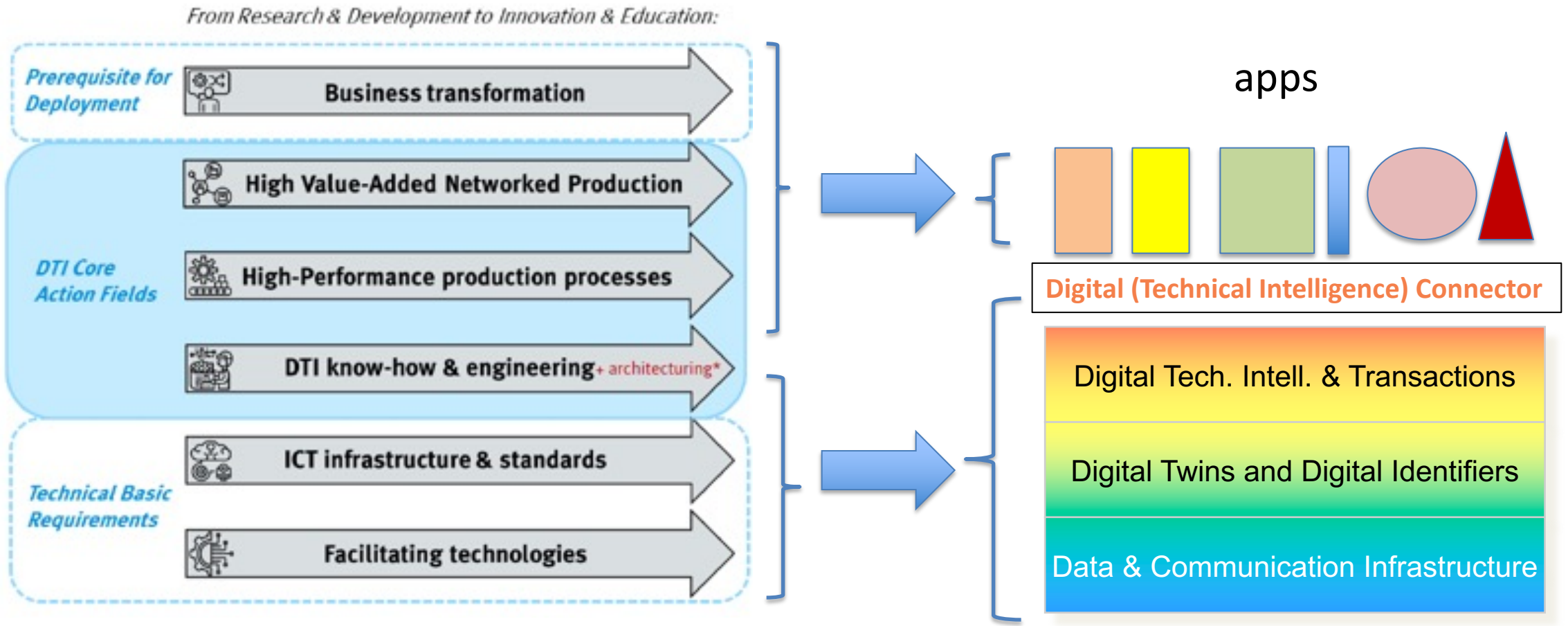
- High Value-Added Networked Production
- High-Performance production processes
- DTI know-how & engineering + architecturing*

Technical Basic Requirements

- ICT infrastructure & standards
- Facilitating technologies

The Manufuture – vision

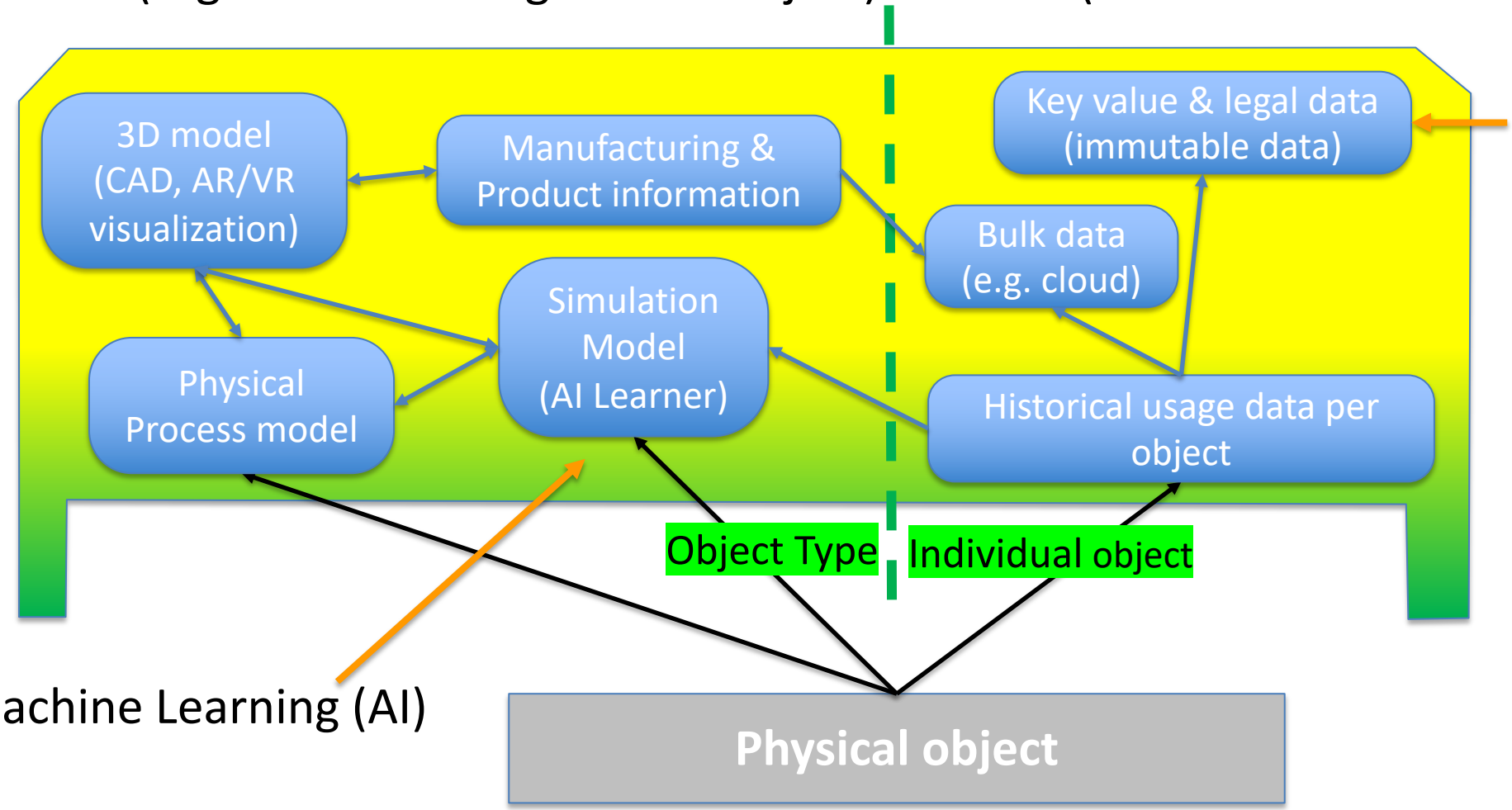
2025-2030: Digital Technical Intelligence (basic requirement)



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)



Blockchain (DLT)

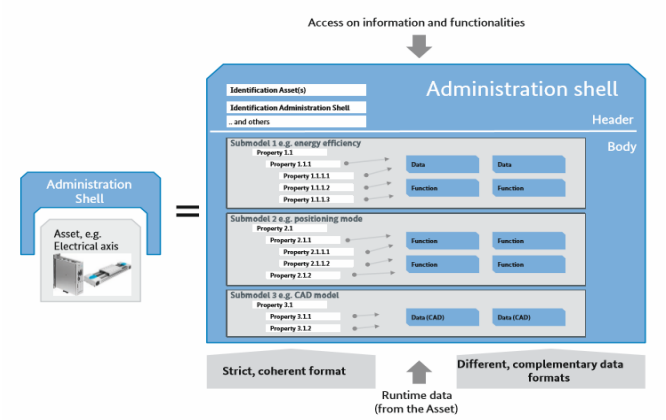
e.g. of DT;s:
- a product
- a machine
- a sensor
- a factory

Machine Learning (AI)

Digital Twin = AAS (Asset Admin Shell)

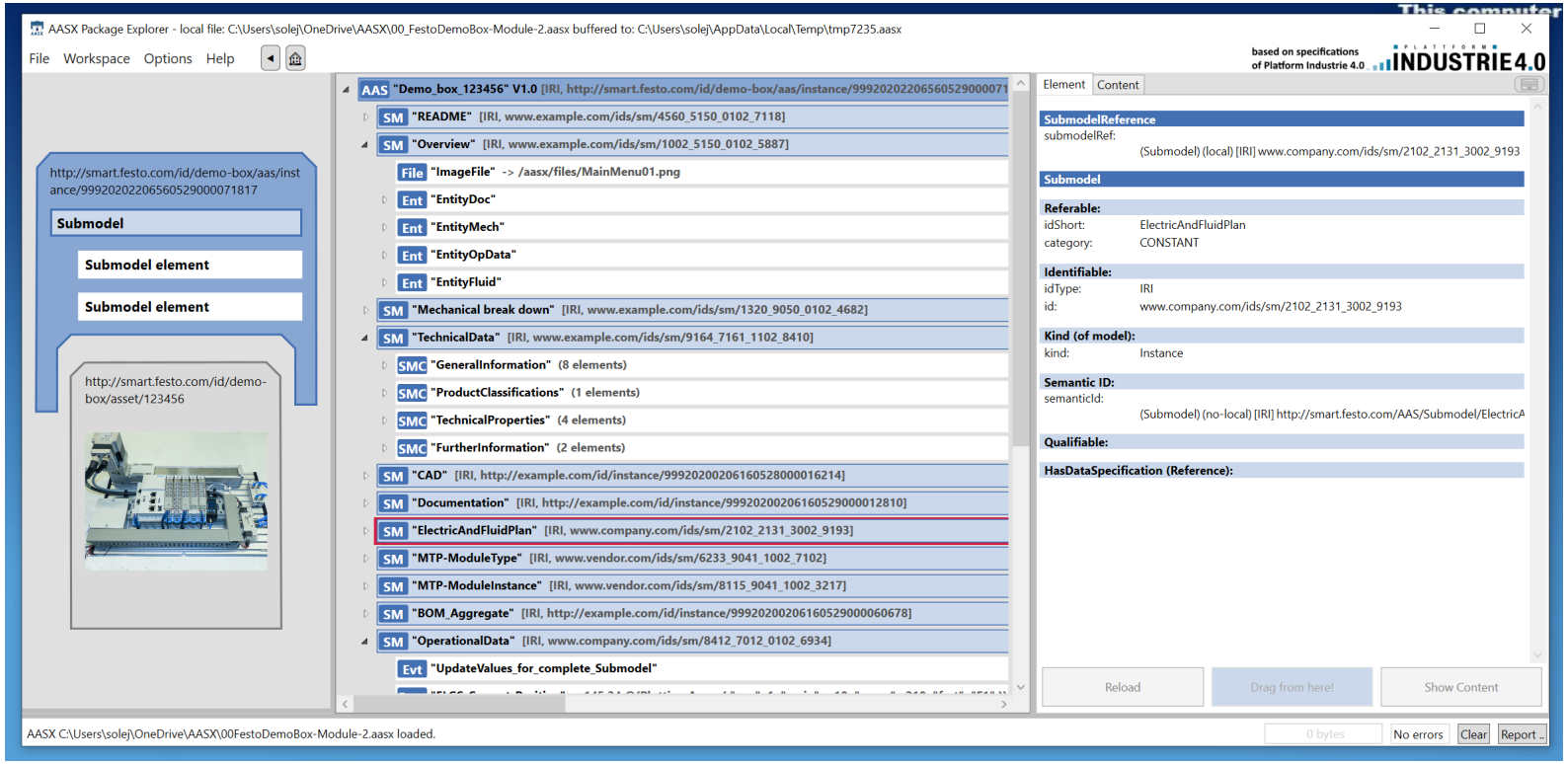
Product data: Digital Twin (DT) of Product Passport Data

A Digital Twin (DT) is a “living” virtual/digital representation of a physical (or virtual) product containing the information as: identifier (e.g. barcode nr), the history and status (and sometimes the planning/future) of a product and the references to locations where more information is stored (e.g. manufacturing and design data).



Digital Twin standard with AAS

(header / body similar to IP & HTML message header/body)



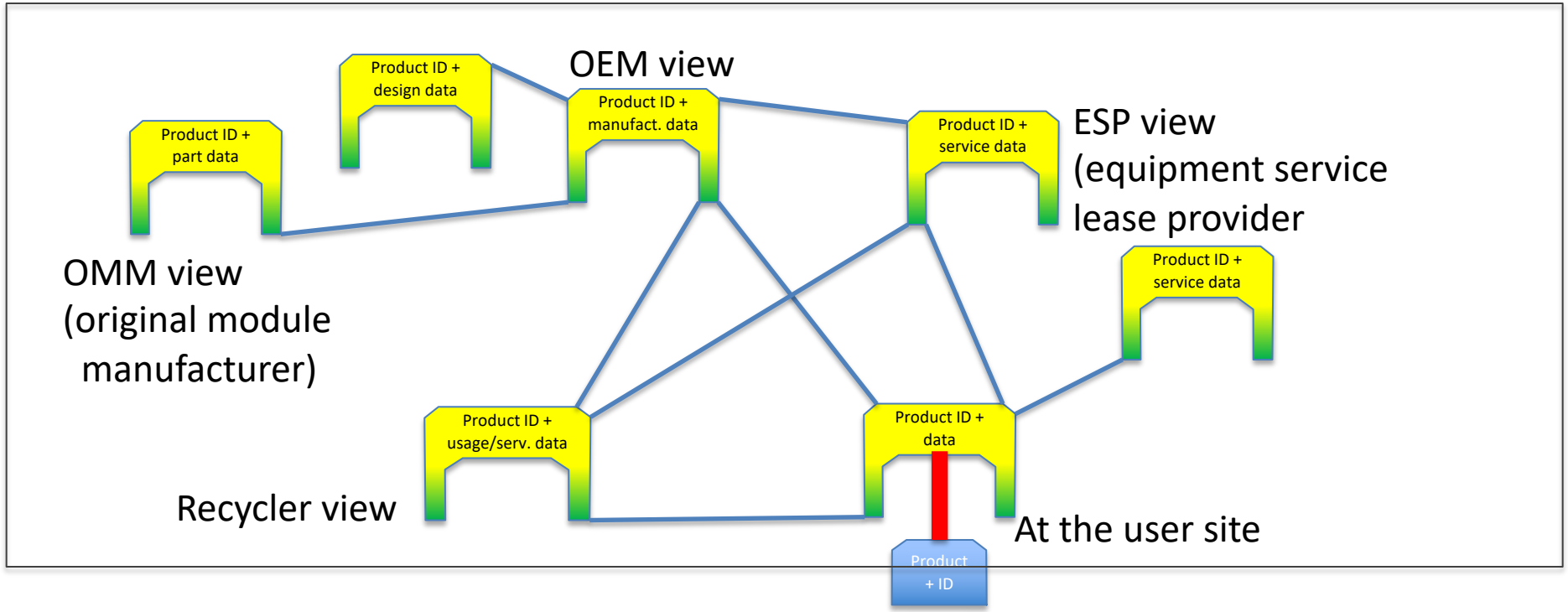
https://github.com/admin-shell-io/aasx-package-explorer/releases

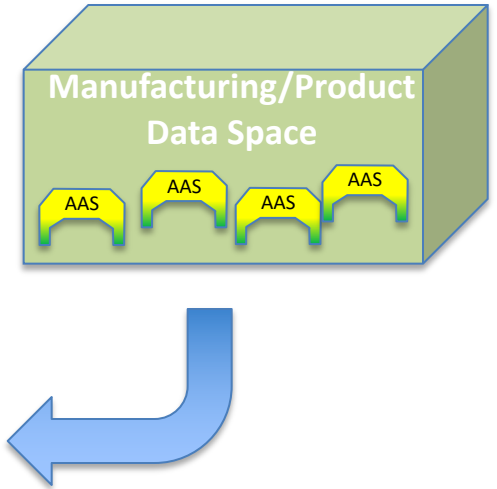
Relation Product and DT data stored a multiple locations/database/clouds

This is an more impactful slide then you might realize

Digital Twin data is a hypertext linked list with a hierarchy (product and its parts)
where product, part, usage and status data is stored at different places in a manufacturing data space.

To avoid data doubling (and inconsistency) data is updated and stored at only one place but can be by others

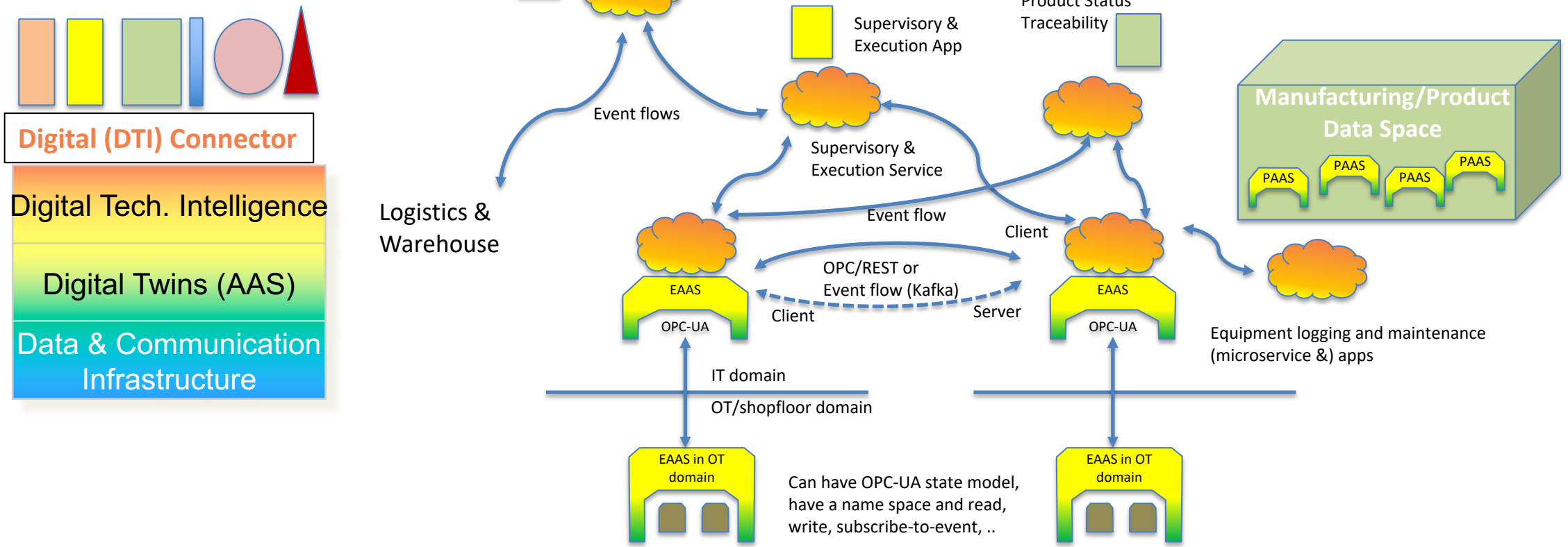




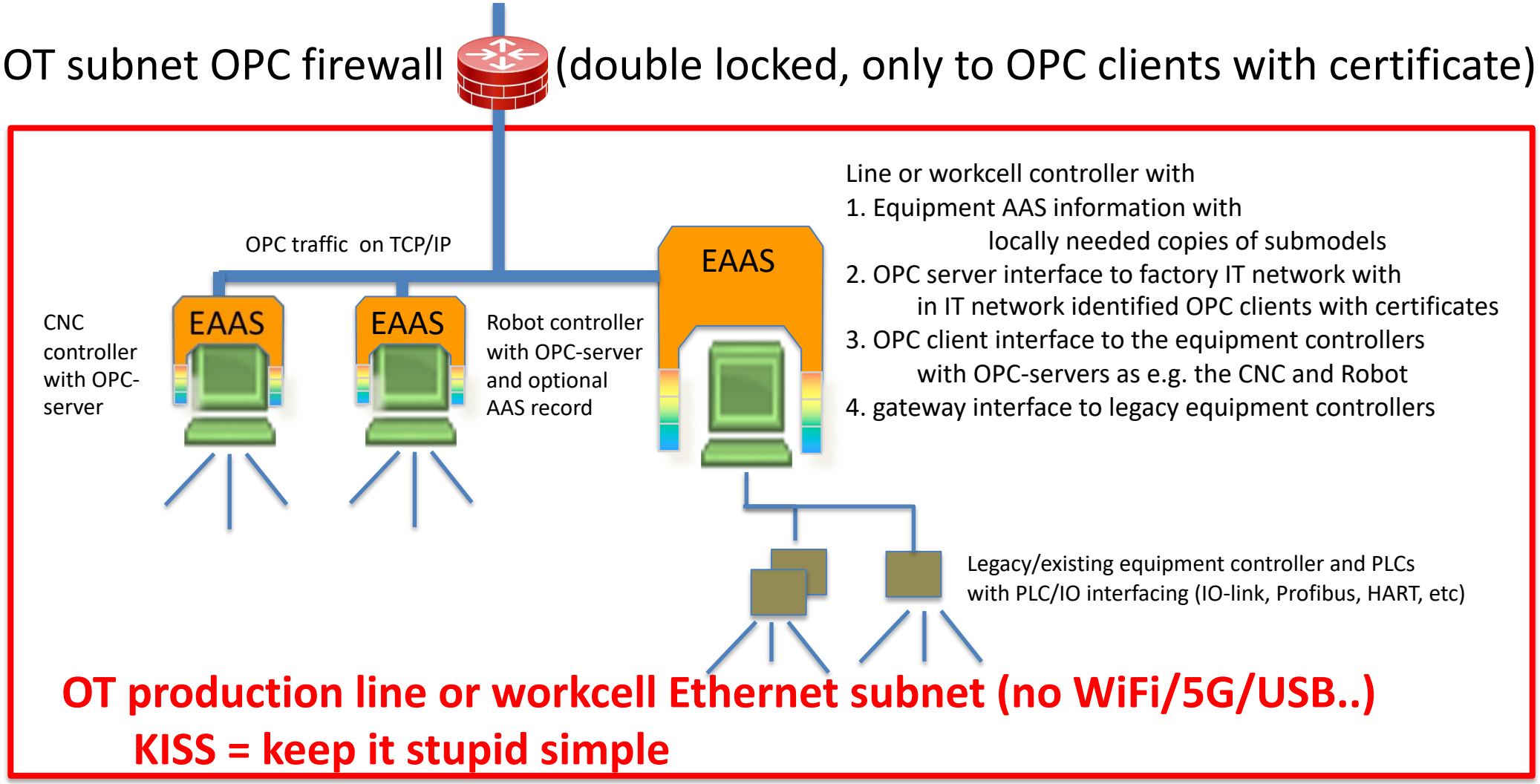
The link ▮ between product + ID and the product data + ID is critical and should not be modified

DT (Digital Twin) layer and active DTI (Digital Technical Intelligence) layer:

Product AAS (PAAS) in MDS (manufacturing data space) and Equipment-AAS (EAAS)+microservices as DTI's communicating with other DTI's, and I40 apps using event flows (=logs) and databases



OT OPC equipment subnet with OT cybersecurity and legacy



DTI (Digital Technical Intelligence) Connector

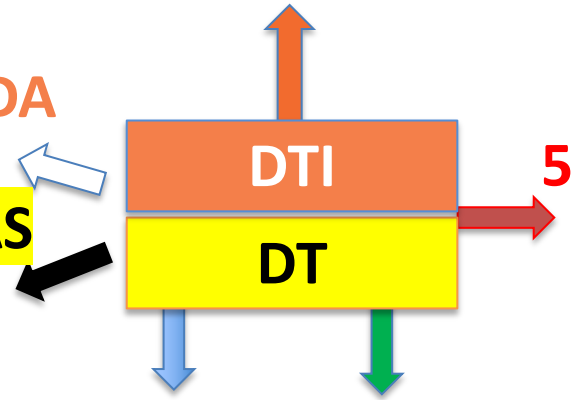
A Digital Technical Intelligence (DTI) connector has six standard interfaces:

Company logging
Event-Driven Architecture with event streams towards (micro)services, e.g. Kafka and business apps

6: Apps and app library

4: EDA

3: AAS



5: IDS **Towards customers, suppliers, and service providers,**
Industrial/international Data Space(s)

Company Product Data space
(Asset Administration Shell)

1: OPC-UA

2: REST/HTTP

IT

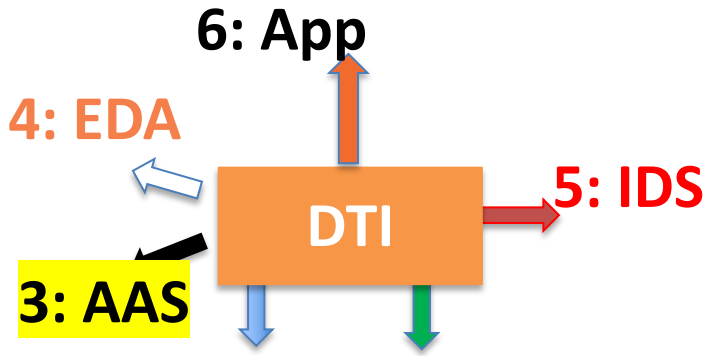
OT

OPC-UA between **equipment** in OT and DT in IT
(Open Platform Communication – Unified Archi.)

Human operator monitoring & control apps
(Representational State Transfer/HTTP/1.1)

OT-world (Operational Technology) with physical products, production equipment, and operators

Pre-DT/DTI I40 Digital Connector



Planning & Preparation

Control & Execution

Monitoring & Logging

Design & Descriptions

1000+ dedicated special programs

creating an intimidating legacy mess

100+ monolithically ERP, MRP, MES software packagers

10+ different fieldbus protocols

Modbus, Profibus, etc.

1-3 major CAD/Design environments

Industrial revolutions (0, 1, 2, 3)

Propritary software, vendor protocol/interfaces

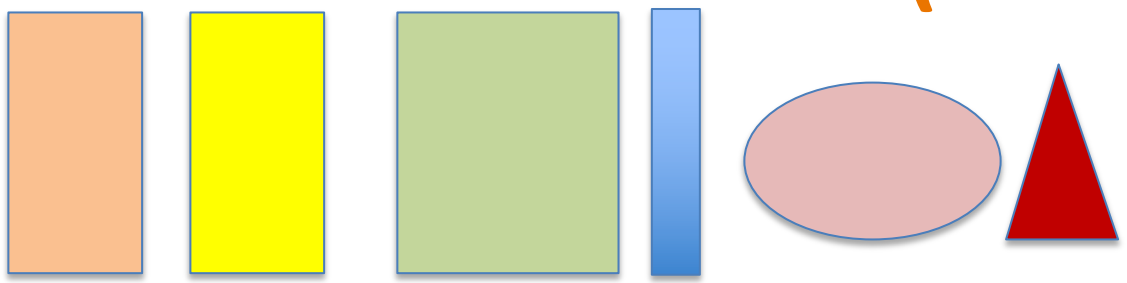
Interactive Digital Twins with digital (DTI) connectors (Digital Technical Intelligence) using OPC/REST/EDA/IDS

Digital Twinning with AAS (Asset Admininstration Shell)

Industrie 4.0/Smart Industry

Open Systems, International Standards

(DTI or I4.0) Digital Connector



DTI or I4.0 App Interface

New software:
Low-code when you can,
And for system software: Rust,
not in cyber unreliable C/C++ anymore

DTI
REST (and in OT network OPC) web interfaces with active virtual processors (OPC state/REST stateless) and web (inter)action & secure transactions (distribute ledger tech)

Plattform Industrie 4.0
OI4A, IDTA, tbd ISO/IEC
And UID, UUID standards

DT
Digital Twins AAS asset admin (sub)models and Digital Identifiers, Authentication and Authorization (IAA)

IT/OT
Information Technology Layer
(SQL) AAS Datastore, Gaia-X, IDS connector, OPC-UA/TCP/IP/Ethernet/IO Comm. & Cyber Security /Firewall Infrastructure

ISO/IETF/OPC/IEC
Common IT/OT standards

Content:

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And then gradually create and grow the AI apps on top of a standard I4.0 stack

Building an AIM system

AI requires data sets with good/bad classification to train your application.

Separate in train/validate/test data sets (eventually augment data set)

To train the model, start with input layer and create the CNN layers, (convolutional neural network) and process/improve them if needed.

Then **build an industrial system** with

1. the input (e.g. camera, sensors, physical model/Digital Twin info),
2. load the AI model parameters in the control algorithm
3. and connect the output (robot, agv, operator screen)

Industriële AI – Wat is er al?

Gereedschapskist voor AI in de industrie:

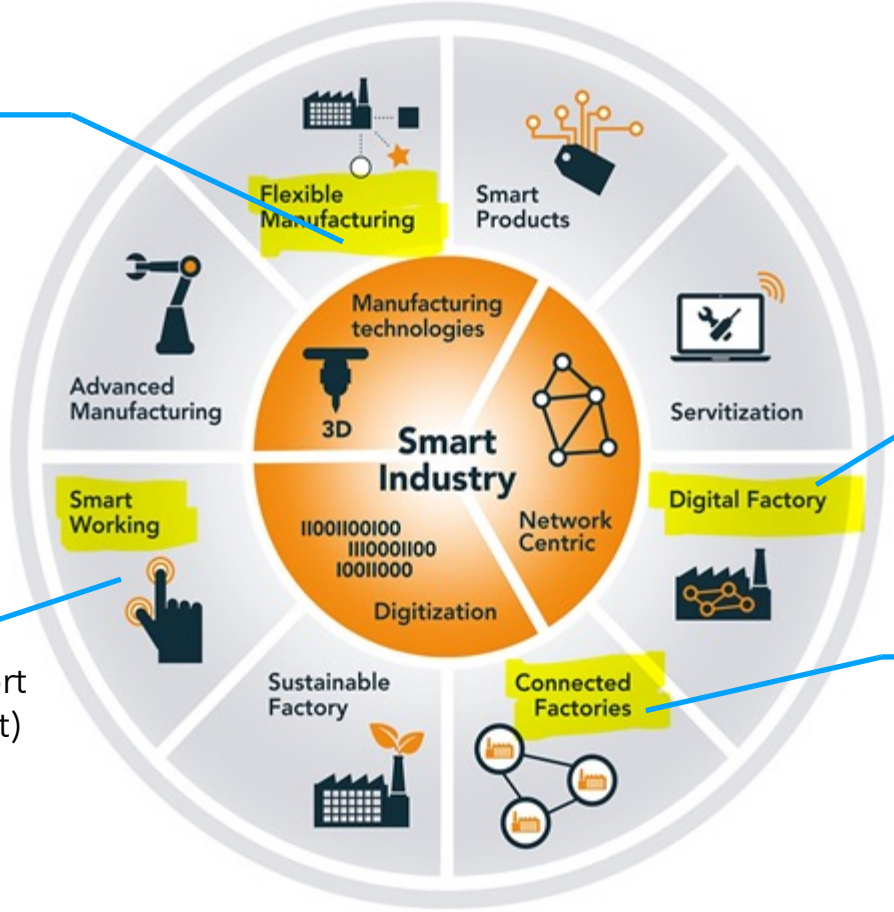
- Formats en infrastructuur voor data delen
- IoT, wireless connectivity
- Cloud services: AWS, Azure, Google
- Rekenkracht: centraal en decentraal, IIoT/edge computing
- Data analytics, machine learning tools (neural network) en libraries:

  Tensorflow, (Py)Torch, Numpy/Theano, Scikit-learn, Keras …
- Sensortechnologie, camerasystemen, beeldherkenning
- Digital twin, cyber physical systems, fysica modellen
- Robots, cobots, AGV's, Robot Operating System
- Operator support systemen, AR/VR tools
- AI experts : kennis van theorie en ervaring met toepassing

Voorbeeldprojecten om eerste oplossingen te ontwikkelen en demonstreren in Fieldlab setting, bv. BIC en SMITZH

4. Wat doen de eerste bedrijven nu al?

- Offline programmeren van robottaken voor geautomatiseerde productie
- Plannen van eenvoudige AGV logistiek
- Beeldherkenning van onderdelen in voorraadbakken



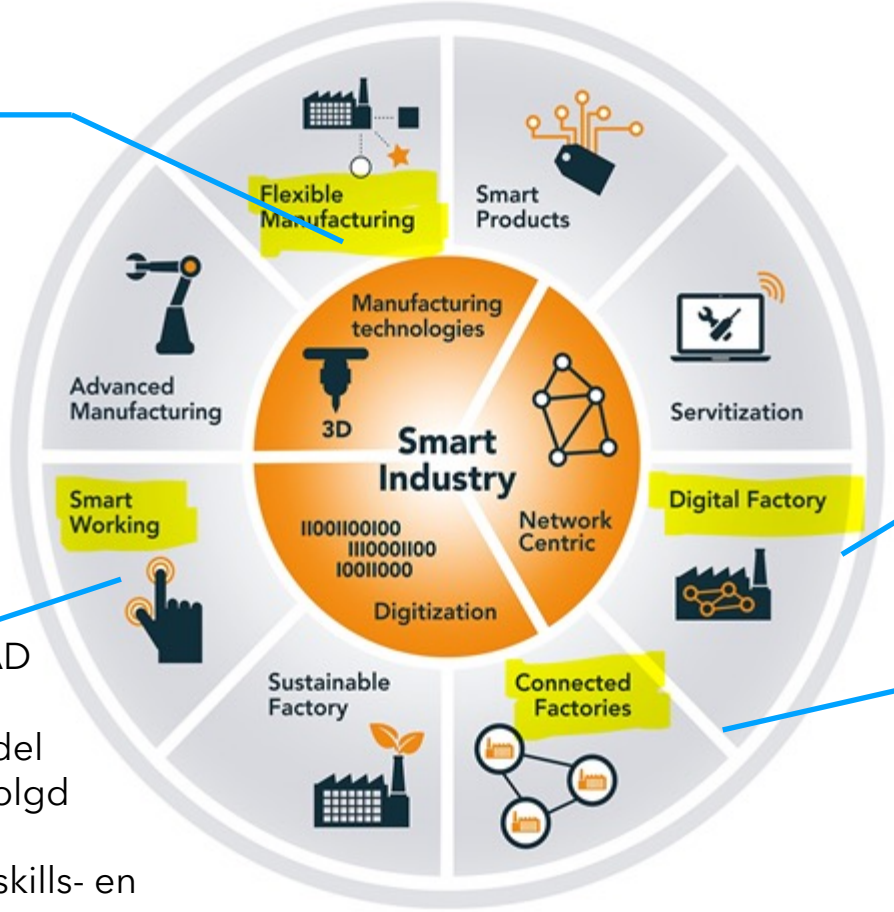
- Data gebaseerde condition monitoring (AI detecteert afwijkingen in performance)
- Decision support door analyse en statistiek van productiedata

- Geavanceerde interactieve operator support (projectietechniek, foutdetectie, pick to light)
- Veilige cobots in samenwerking met mens

- Data delen in de keten
- Data veiligheid en soevereiniteit

5. Wat kan de praktijk morgen met versnelling?

- AI genereert robotpaden voor geautomatiseerde productie
- AI leert omgeving inzichtelijk te maken voor robots en AGV's
- AI verdeelt mens-robot samenwerking
- AI herkent en onderdelen uit beelden van ongeordende stapels en pakt ze



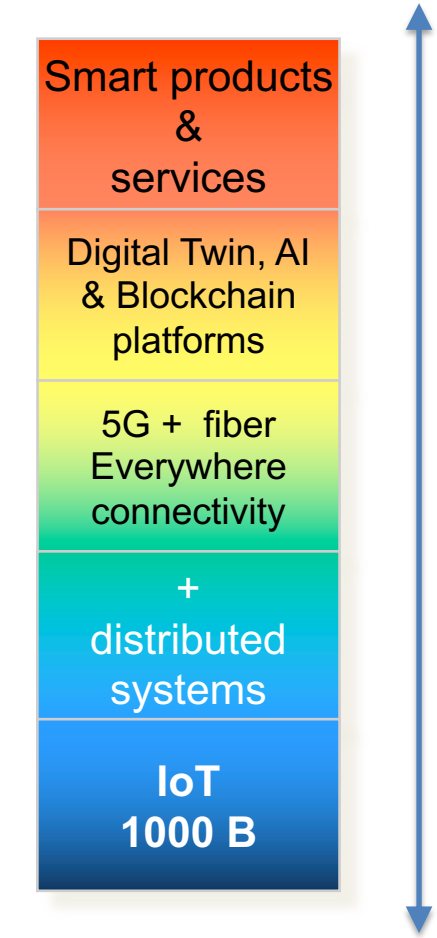
- AI leert gedrag van apparaten
- AI leert ondanks uniek gemaakte producten
- AI genereert mogelijke oplossingen gebaseerd op root-cause analyse

- AI genereert assemblagestappen uit CAD model
- AI genereert werkinstructie uit CAD model
- AI detecteert of assemblageproces gevolgd wordt
- AI past instructies aan aan de hand van skills- en ervaringsniveau operator

- AI leert semantische structuur van data
- AI leert welke fabrieksdata relevant is

AI apps will come, but first, we need to structure the stack below

Internet of Services IoS:



Internet of Things IoT

Control – smart AI

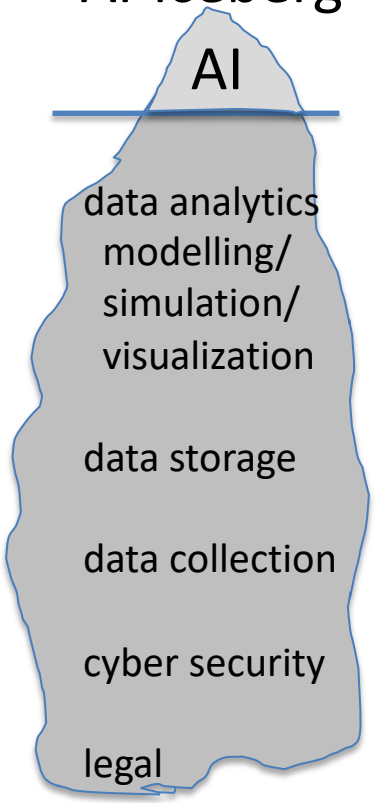
Control – direct

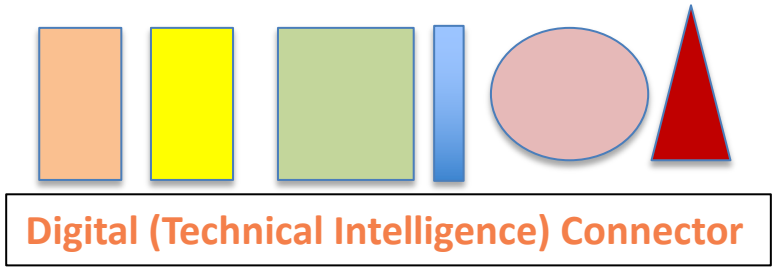
Data visualization & monitoring

Data collection & storage

Sensor data & communication

Top of AI-iceberg





Summary:

why After decades of vendor lock-in interfaces and monolithic software systems manufacturing should evolve, similar to Internet and web/mobile apps, towards

what the usage of apps on top of a digital technical intelligence with a standard, affordable, and reliable digital connector.

to enable autonomous data collection and exchange to improve productivity and sustainability using all kinds of apps, from simple up to advanced AI apps.

how But to turn this vision into projects, test and training facilities, and ultimate into real-life systems in factories are needed it has huge consequences for (re)training our workforce in digital skills.

Smart Makers Academy – 1-day training modules as stations in a regional metro transport model for individual trip planning