Digital Twins: a European perspective

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EU-MATHS-IN president

4TU.AMI Company Event

Utrecht, June 14, 2019

Some statements about Digital Twins (from DT meeting, Heidelberg 20190507)

- Digital Twins are the next wave in simulation technologies.
- Digital Twins accumulate all digital knowledge, models, and data during the complete lifetime of products and systems – from their ideation to their end of life.
- They thus integrate model-based approaches on which classical simulation and optimization paradigms are built on as well as data analytics based approaches.
- Digital twins are powerful masterminds for innovation and performance. Combining engineering knowledge with available data novel services such as simulation-based monitoring and diagnosis or predictive maintenance will open new business opportunities.

We (=EU-MATHS-IN) fully agree with these statements! In this talk, the European perspective will be discussed.

EMS and ECMI created EU-MATHS-IN end of 2013

Umbrella for all industrial mathematics activities in Europe

EU-MATHS-IN: a unique network

EU-MATHS-IN is a **network of national networks** that represent the entire community in their respective countries with respect to mathematics for industry – started November 2013

National networks currently on board:

- *IMNA (Austria)*
- *Bulgarian network*
- *BE-MATHS-IN (Belgium)*
- *CNMI (Czech Republic)*
- *FI-MATHS-IN (Finland)*
- *AMIES (France)*
- *KoMSO (Germany)*
- *HSNMII (Hungary)*
- *MACSI (Ireland)*
- *Sportello (Italy)*
- *NNMII (Norway)*
- *PL-MATHS-IN (Poland)*
- *PT-MATHS-IN (Portugal)*
- *RO-MATHS-IN (Romania)*
- *math-in (Spain)*
- *EU-MATHS-IN.se (Sweden)*
- ***PWN committee Innovation (The Netherlands) – including 4TU.AMI***
- *UK network (→ report Philip Bond)*

Mission: EU-MATHS-IN aims to leverage the impact of mathematics on innovations in key technologies by enhanced communication and information exchange between and among the involved stakeholders on a European level.

Contact us at

www.eu-maths-in.eu

EU-MATHS-IN and Europe

Only a **combined effort at the European level** will be able to convince politicians, policy makers and funding institutions of the importance of mathematics

Many groups have **organised themselves** (examples: BDVA, ETP4HPC, EOS) to lobby for their cause; it is essential that the **voice of mathematics** is also heard in Brussels, as well as in the ministries in the various countries

Success stories, **convincing arguments** and **strategic research agendas** are the way to receive the desired attention

- PR for mathematics is extremely important…..
- …..but this is not in the genes of mathematicians
- So we need to work on this! **Together!**

Towards a European Technology Platform for Modelling, Simulation, Optimisation

ETP4MSO

Towards ETP4MSO

Two workshops in Amsterdam (July and October 2017) with industrial partners to define the scope of ETP4MSO and gather support

- **Industry must be in the driving seat**

Combined research/innovation workshop in Lorentz Centre, Leiden, December 2017

Vision document was presented at French Embassy in Berlin, April 2018

Working on **Strategic Research Agenda**, essential to convince policy makers and funding institutions

Exemplary for us: SRA of ETP4HPC

*"The ETP4HPC Strategic Research Agenda (SRA) is our key deliverable. It is a document that outlines a **roadmap** for the achievement of exascale capabilities by the European High-Performance Computing (HPC) ecosystem. The **milestones** set in the SRA are used to **define the contents** of the HPC Technology R&D Work Programmes managed by the European Commission. Any project submitted within the HPC part of the EC work programme should reflect the milestones identified in the current SRA."*

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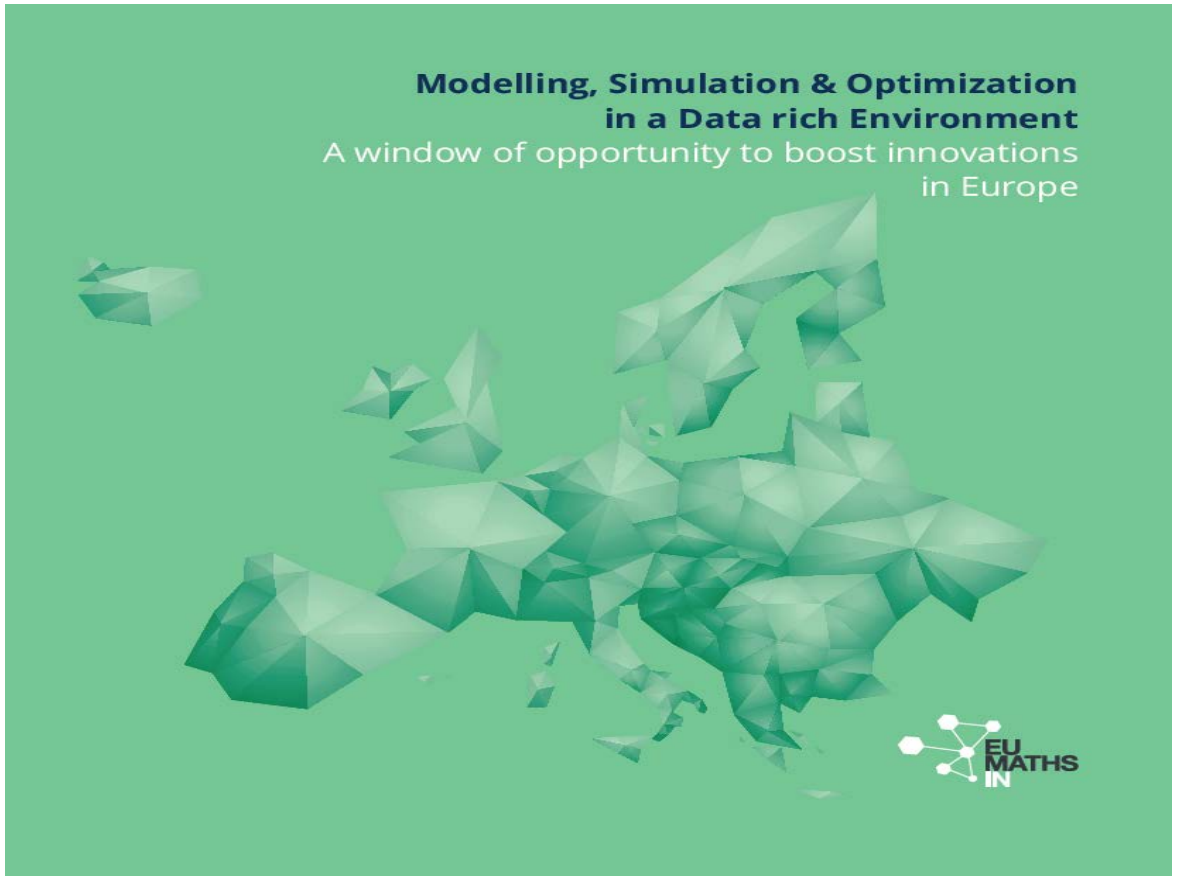
Vision document



Presented at French Embassy in Berlin on April 18, 2018

Available on www.eu-maths-in.eu

EU MATHS IN

Modelling, Simulation & Optimization in a Data rich Environment

A window of opportunity to boost innovations in Europe

Berlin, French Embassy, April 18, 2018

Participating industry: Atos, ESI, Michelin, Shell, Siemens, Akselos, ECOMT, FEDEM, MAGWEL, SmartSample, VORtech

Executive Summary of the Initiative

- Accelerating the development and optimization of industrial processes and devices
- Extending current MBSE concepts to model-based assistance along the complete lifecycle

Needed:

- High powered multi-disciplinary effort to bring mathematical MSO methods together with techniques for the treatment of big data and AI methods
- To make these methods efficient on modern hardware envirionments

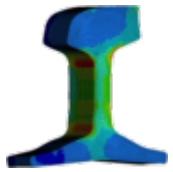
- Europe is traditionally very strong in mathematics (initially, more than in HPC & Exascale)
- MSO industry is focussing more and more in Europe (Siemens, ESI, Dassault Systemes, SAP)

Opportunities:

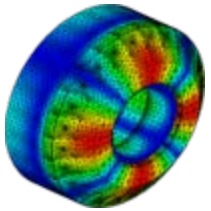
- Much more is possible when a major and concerted effort is developed to truly bridge the gap, and unite the strengths of European mathematicians with Industry 4.0 (…) to bring European Industry to the forefront
- Develop new business interactions

Modeling, Simulation and Optimization is evolving from a trouble shooting tool to key business drivers in the form of digital twins

Model Pioneers



CAx Sunrise



PLM Pervasion

Digital Twin Era

Timeline **~1985** **~2000** **~2015**

Scientific experts use models

- Understanding of phenomena
- Failure Analysis

Computer aid in product design and engineering

- Design Validation and Design
- Decision Support

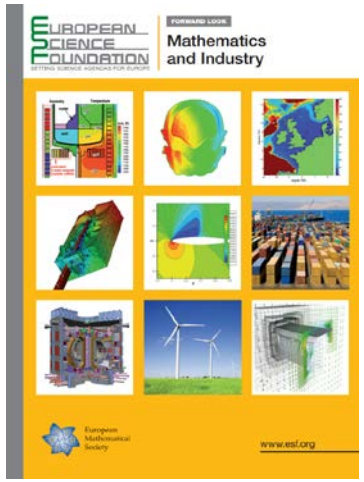
Key for communication in across departments & companies

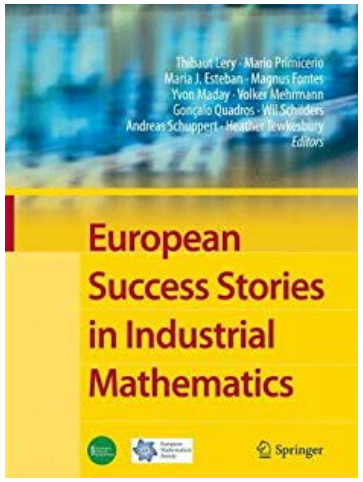
- Design Driver
- Model-based Systems engineering

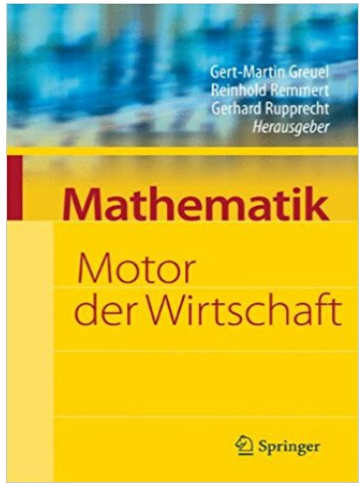
Nexus of data and executable models accessible to everyone

- Business Driver bridging different value chains
- Generative Design

Modeling, Simulation and Optimization is a Key Enabling Technology for Europe







The Value of MSO in Europe

Automotive industry: **1000 bn €/year**
- Ecological and digital challenges

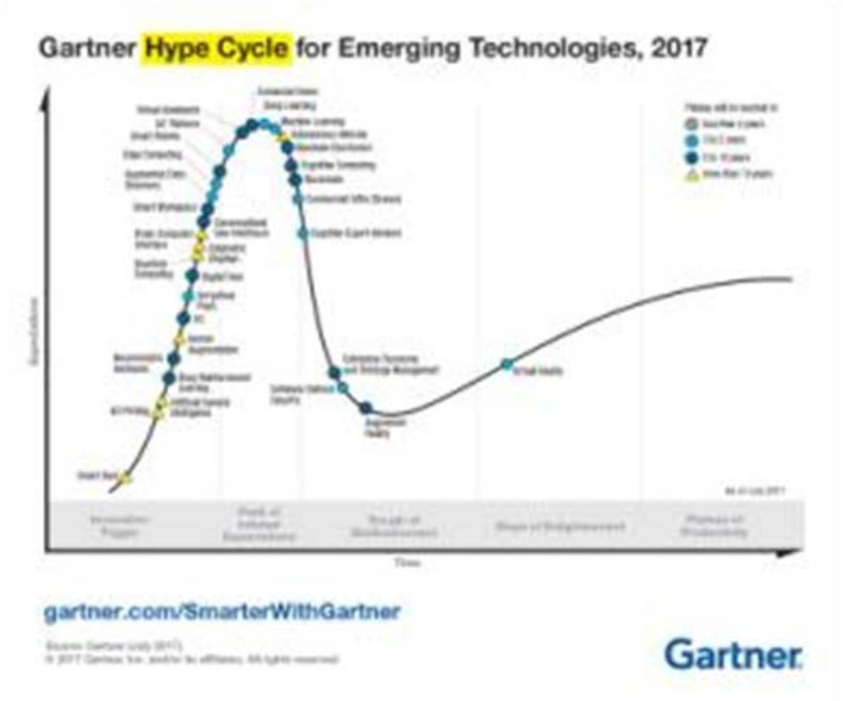
Aeronautics: **200 bn €/year**
- Test saving

Energy **priceless**
- Green transition

Impact studies of Mathematics in Europe

France	15% GNP,	9% of employments
Netherlands	30% GNP*,	11% of employments
UK	16% GNP,	10% of employments
Germany	“Mathematik: Motor der Wirtschaft”	

The digital twin concept has developed from a NASA[1] concept to one of the hottest technical trends in 2018 [2,3,4]



Digital Twins [2,3]

A digital twin is a digital representation of a real-world entity or system. Digital twins are linked to real-world objects and offer information on the state of the counterparts, respond to changes, improve operations and add value.

The concept of digital twins is not new.

Several factors have now converged to bring the concept of the digital twin to the forefront as a disruptive trend.

1) E. Glaessgen, D. Stargel(2012): *The digital twin paradigm for future NASA and U.S. air force vehicles*. 53rd AIAA/ASME/ASCE/AHS/ASC
2) L. Panetta (2017): Gartner Top 10 Strategic Technology Trends for 2018, Gartner
3) K. Panetta (2017): *Top Trends in the Gartner Hype Cycle for Emerging Technologies 2017*, Gartner
4) C. Pettey (2017): *Prepare for the Impact of Digital Twins*, Gartner

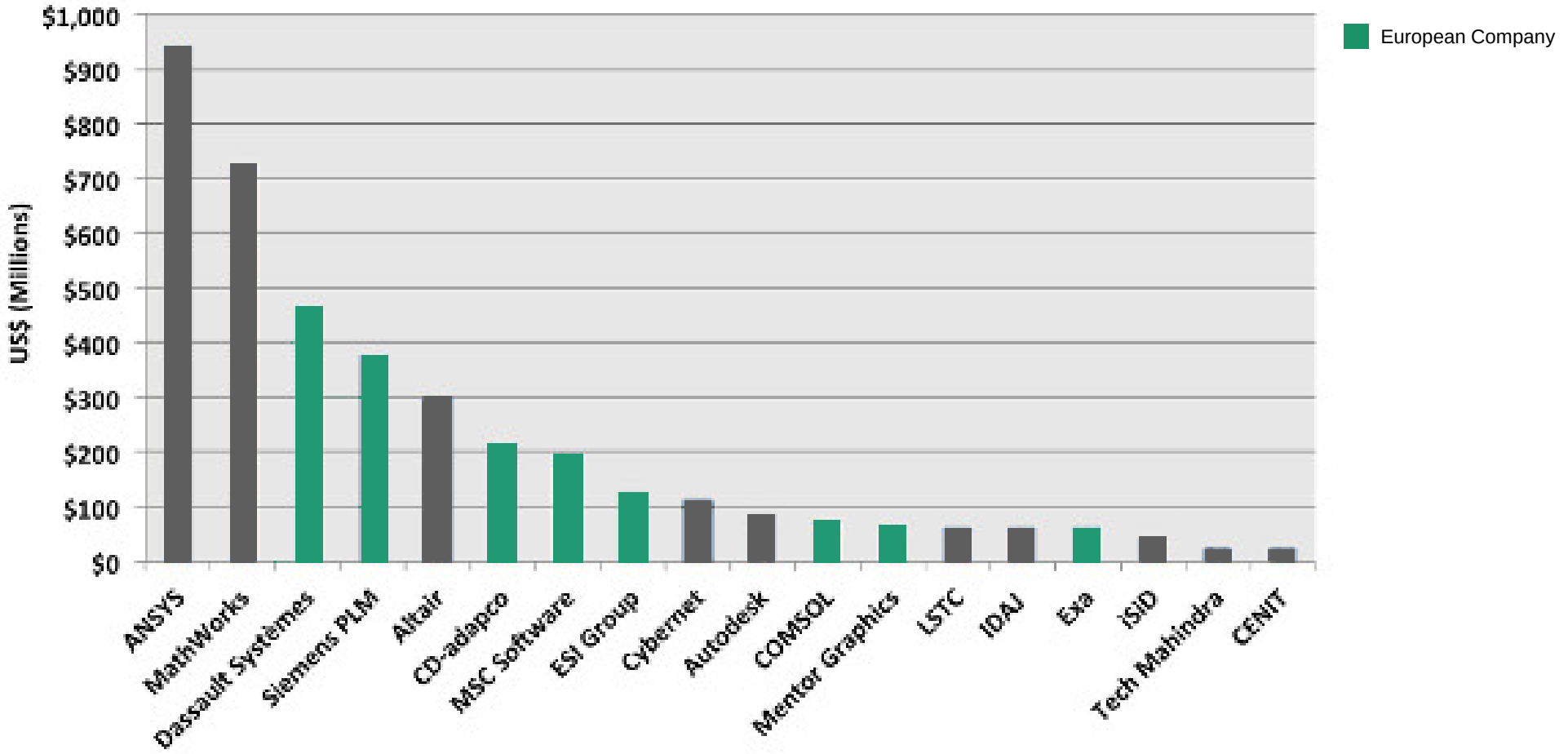
Digital Twins will have a major impact

Digital Twins will make **Modeling, Simulation and Optimization widely available** & appropriate to drive **improved decision making** to a level not seen before throughout the **entire life-cycle** of engineered products and processes

- The **“**Digital Twin” approach will dramatically increase the **demand, amount, breadth, and complexity of Engineering Simulation**
- Digital Twins will generate a **significant amount of data** in addition to sensor data
- **Machine Learning** can play a role in managing the data and **working with Systems Engineering** to determine what simulations are needed

ASSESS
ANALYSIS, SIMULATION AND SYSTEMS ENGINEERING SOFTWARE STRATEGIES

Europe possesses a worldwide asset as it concentrates major simulation companies



1) CIMdata (2017) 2017 Simulation & Analysis Market Analysis Report

SIEMENS

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Digital Twin Community Hub & Knowledge Base

Visit our community hub for in-depth knowledge on digital twin technology and applications.

Join the community discussion, or watch videos and read articles about digital twins and the digital thread from experts in the PLM industry.

Learn more about digital twins ›

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› Products, Domains and Frameworks

Your Success

› Advantedge Services
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Our Story

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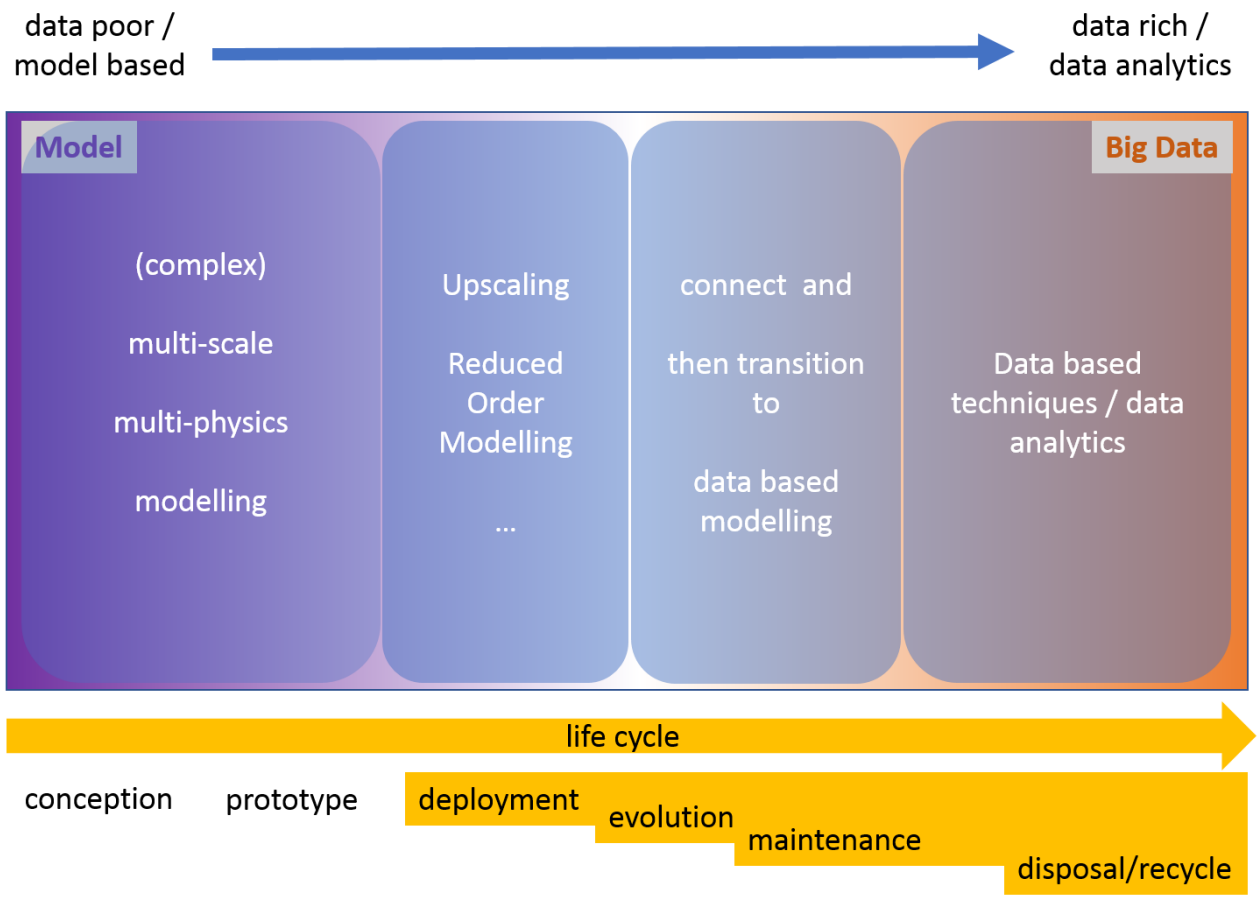
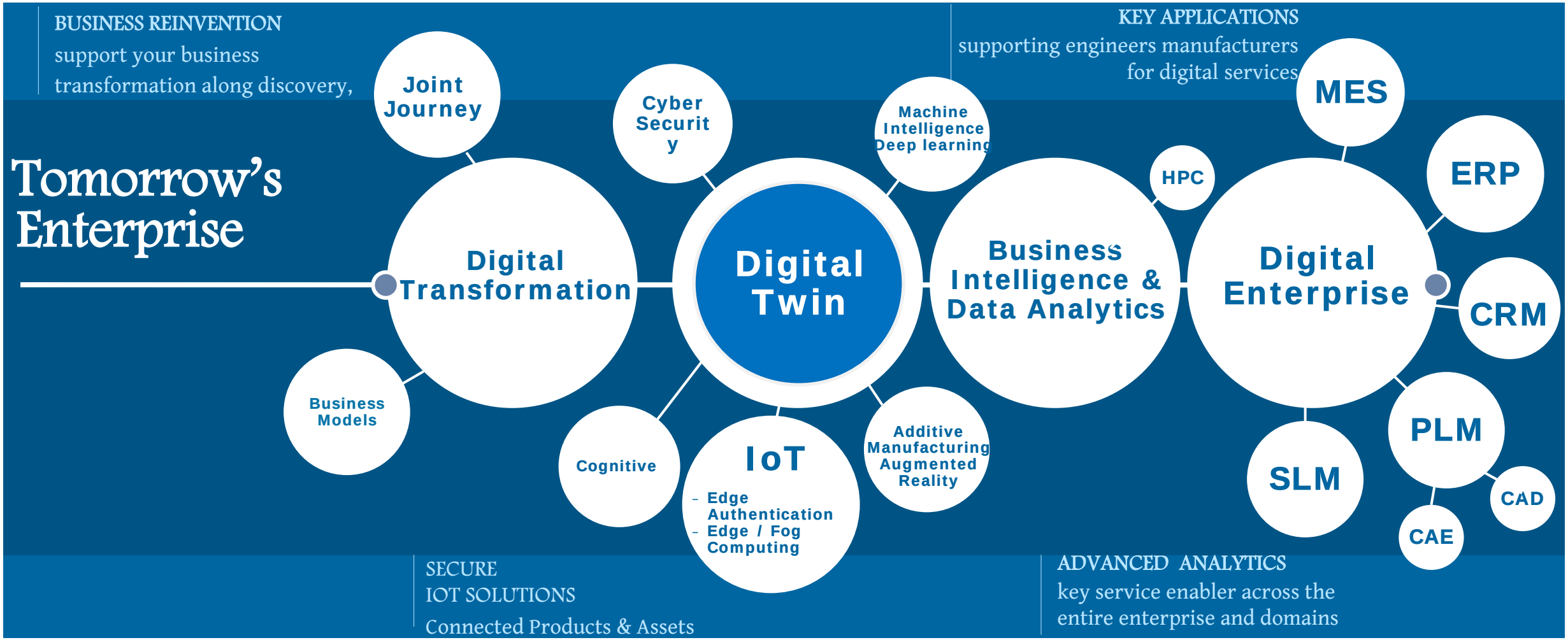
Intelligent Computing – the key to Accelerated Innovation

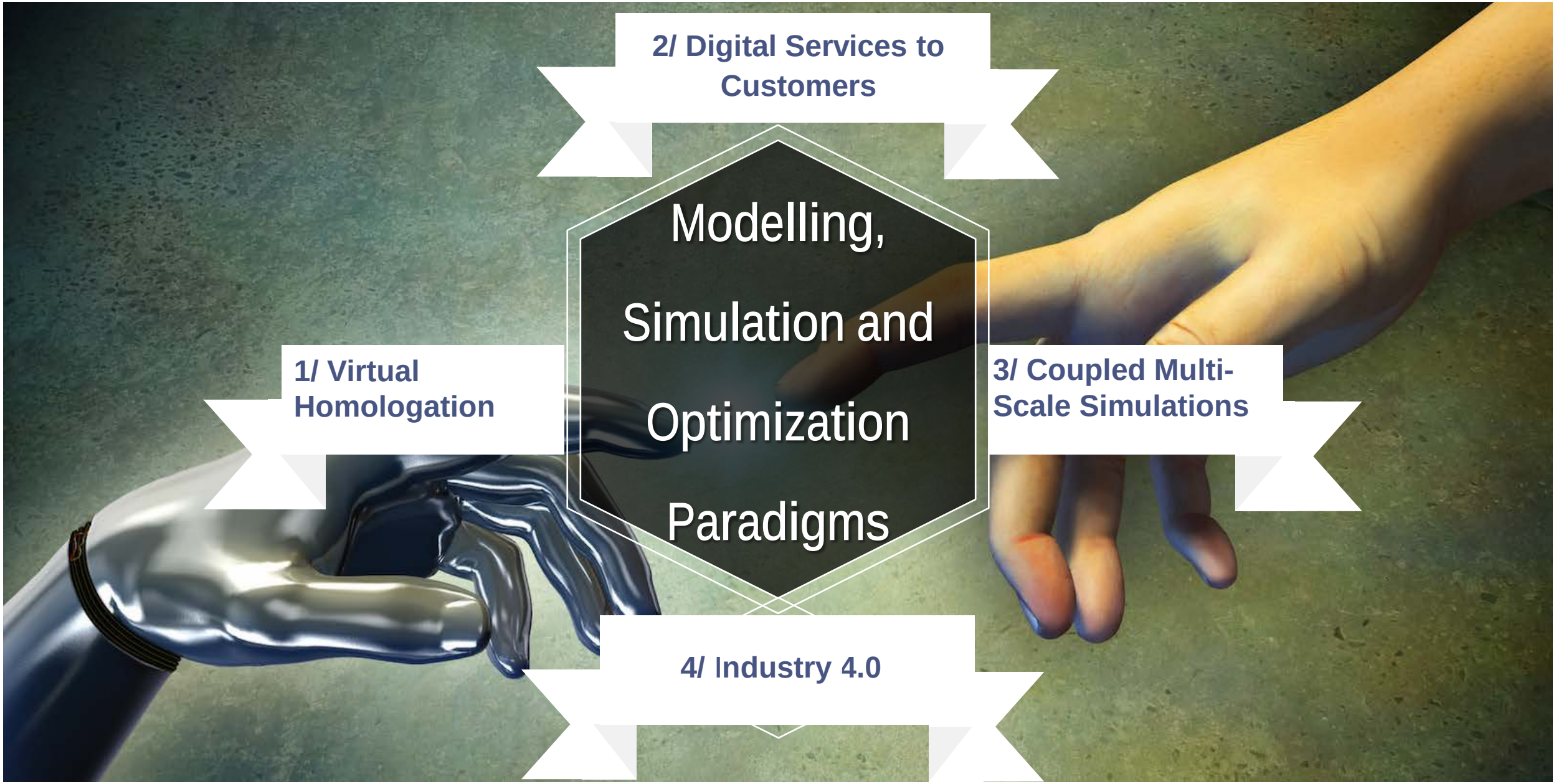


Digital Twins


Digital Twin
True closed-loop
asset management
Atos

Digital Twin to be the next big thing





MICHELIN
A BETTER WAY FORWARD

We foster Europe to be at the forefront of digital twins and digitalization

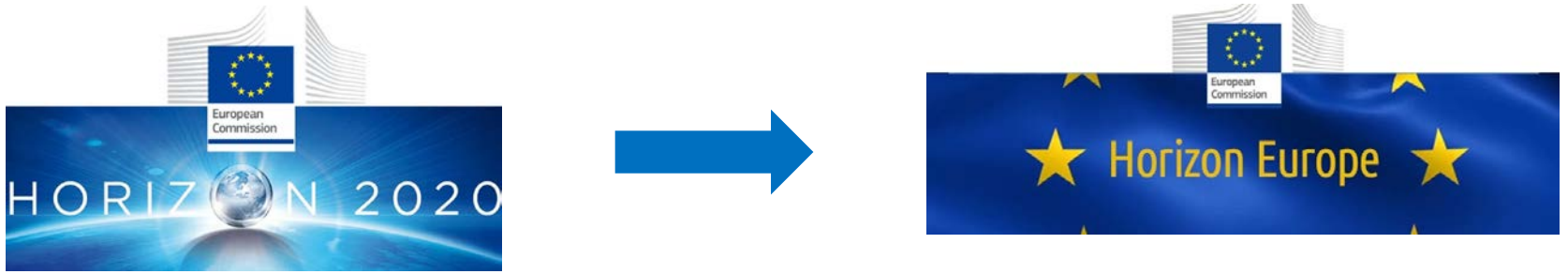
EU-MATHS-IN
Industrial Core Team

- Diederik Fokkema, **ING**, THE NETHERLANDS
- Dirk Hartmann, **Siemens**, GERMANY
- Patrice Hauret, **Michelin**, FRANCE
- Cor van Kruijsdijk, **Shell**, THE NETHERLANDS
- Michel Mallet, **Dassault Aviation**, FRANCE
- Margarida Pina, **Nors Group**, PORTUGAL
- José Francisco Rodriguez, **Repsol**, SPAIN
- Hubert Tardieu, **ATOS**, FRANCE

http://www.eu-maths-in.eu/EUMATHSIN/industrial-core-team

The next steps

- Many things are happening in Europe, especially around 2020 when the “Horizon 2020” programme ends, and Europe is lining up for the new 7-year period with “Horizon Europe”



- Important is the emphasis on High Performance Computing in the Joint Undertaking EuroHPC
- All activities (and funding) of ETP4HPC have been transferred to EuroHPC

EuroHPC - Europe's journey to exascale HPC

- The European High-Perfomance Computing Joint Undertaking (EuroHPC JU) will pool European resources to develop top-of-the-range **exascale** supercomputers for processing **big data**, based on competitive European technology.
- The EuroHPC Joint Undertaking (JU) is a legal and funding entity which will enable pooling of EU and national resources in High Performance Computing (HPC) with the aim of:
  - Developing a pan-European supercomputing infrastructure
  - Supporting research and innovation activities
- MSO is an important part of the second bullet, but it needs quite some convincing as we need to compete with Artificial Intelligence, Machine Learning, Deep Learning, Big Data (in which MSO plays a crucial role, but is often invisible)
- The Industrial Core Team of EU-MATHS-IN is having discussions in Brussels (DG Connect)
  - Max Lemke – Head of unit for “Technologies and systems for digitising industry”
  - Khalil Rouhana – Deputy director-general
  - Roberto Viola – Director-general
- We are discussing a meeting between the aforementioned persons and CEOs/CTOs of our industrial core team partners

From the EuroHPC event in Sofia, April 19, 2018: keynote speech by Thierry Breton, CEO of ATOS

Let me share with you 4 main messages that will show you why exascale has rightly be chosen as a key priority for Europe :

1/ Industry 4.0 calls for ever more Computing Power

2/ Modelling, Simulation & Optimization will simultaneously rely on Computing Power and will structure new business opportunities

3/ High Performance Computing, Digital Twins, Big Data and sovereignty are closely interlinked and will be the basis for EuroHPC

4/ EuroHPC requires the success of the European Processor Initiative (EPI).

MATHWARE

A complicating issue is that people always speak about hardware and software, where software is a mixture of mathematics and computer science.

To distinguish clearly between mathematical work and implementation activities, more and more we have started to use the terminology MATHWARE

MATHWARE ⟷ SOFTWARE ⟷ HARDWARE

Conclusion: how to act on the European level

- First and foremost: the mathematical community should act together
- Join forces with industry:
  - they need mathematics to master the complexity, and are willing to invest
  - Policy makers are often more inclined to listen to industry than to scientists
- Improve the PR of mathematics
  - Tell all policy makers about the advances in algorithms (and, important: organize annual reports about improvements in algorithms!)
  - Start using “Mathematics Inside” stickers
  - Make a clear distinction between the work done in the MSO area, and use the terminology “Mathware” to make this evident
- More specifically about Digital Twins:
  - This will require a major investment and a solid cooperation between mathematicians and industry partners
  - True digital twinning will need new ways of MSO (example: using data and machine learning to improve models)