FUTURE OF MANUFACTURING

How research & innovation are changing the game

THE MANY PROMISES OF ADVANCED MANUFACTURING TECHNOLOGIES

REAL TIME PERFORMANCE VISIBILITY
Allows faster response

ENGINEERED MATERIALS
Improves performance

ENERGY MANAGEMENT
optimizes consumptions

ADDITIVE MANUFACTURING
enhances functionalities

...

HUMAN-DEVICE INTEGRATION
improves productivity and safety

CLOSED LOOP AI-DRIVEN CONTROL
Improves yield & throughput

AUGMENTED OPERATOR
Augment competencies

INTELLIGENT AUTOMATION
Automates repetitive tasks

+20%
THROUGHPUT
with better visibility & availability of assets

+10%
PROCESS YIELD
with AI/ML enabled process control

+40%
LABOUR PRODUCTIVITY
with smart automation, guided operations & remote assistance

+20%
FULLFILMENT KPIs
with better demand visibility and more flexible production

AN AVALANCHE OF TECHNOLOGIES TO INVEST IN

Universal connectivity for fixed and mobile assets

Data capture, consolidation and analysis to improve performance

Mobile-based applications for augmented workers

Application integration for higher information management productivity

Nanomanufacturing

Reconfigurable Factories

Bio-manufacturing

ALM

Remanufacturing

New manufacturing technologies

Self-adaptive, self-controlled manufacturing operations

AI-controlled production planning and monitoring

Generative AI to discover and define new manufacturing processes

Compressed machine learning algorithms to run on the edge

Large Language Models to improve documentation creation and management

Generative AI to program flexible PLC

Generative AI for Work Preparation

New manufacturing technologies

Process Hydrogenation

Energy-autonomous factories

Environmental and HSE constraints and opportunities

Acceptance of technologies by factory workers

Regulatory frameworks for the use of AI

A COMBINATION OF 5 MEGATHEMES INFLUENCING THE FUTURE OF ENGINEERING

DIGITAL FABRIC

The availability of global computation, communication, and data aggregation at unprecedented scale catalyses disruption in all domains.

ORGANIC ENGINEERING

Organisations, markets, industry models and supply chains are becoming more dynamic and responsive to external stimuli & disruption, adopting (often bio-inspired) lifecycles.

BEYOND INTELLIGENCE

Technology now enables us to realise ideas beyond the imagination or conceptualisation of individuals or human teams

RESOURCE REVOLUTION

Environmental factors place primary resources back at the heart of innovation; Changes in the fundamental use and transformation of materials, and the capture, transmission and storage of energy are now disrupting products, systems, and supply chains

POSITIVE FUTURES

As technology evolves, is regulatory pressure constructive or restrictive? Does it evolve in the right direction at the right speed?

All types of technology are subject to legal and regulatory constraints: safety, environmental impact, ethical implications, social and psychological impacts.

THE REAL CHALLENGES OUR CLIENTS ARE FACING

Inexistent access to quick and affordable infrastructure to test technologies

Manufacturers usually do not have access or resources to test the applicability of new technologies, hindering their progress in the adoption

Insufficient knowledge of the more advanced technologies

Manufacturers cannot be fully expert or even competent in some of the more advanced technologies, and struggle to grasp the potential and the road to implementation of these technologies,

Difficulties in industrializing and scaling the new applications

Although some of the research projects might point in the right direction, many companies find it extremely difficult to industrialize their findings into workable, scaled solutions, preventing wide adoption

Lack of Operating R&I Model to foster implementation

Sometimes advanced manufacturing Initiatives are promoted in a siloed mode, pushed by technology, without proper business driven prioritization and outcome measurement, with parallel technology solutions, lacking stakeholders buy-in, synergy and creating technology debt.

OUR APPROACH TO HELPING YOU REALIZE BENEFITS FROM ADVANCED MANUFACTURING

Manufacturing leaders are struggling to materialize the promises of innovation into their production environment.

Practice matters more than theory when it comes to deliver measurable improvements in performance

We are running practical research & development programs to demonstrate attainable measurable efficiency in manufacturing in 4 areas

MANUFACTURING SYSTEMS

- Flexible configuration of factories
- MBSE fo rNature-inspired manufacturing systems
- Industrial Data platform infrastructure
- LLM GenAI applications

MANUFACTURING PROCESSES

- Additive Layer Manufacturing
- Biomanufacturing
- Nanotechnology
- Intelligence applied to the definition and control of processes

ROBOTICS & AUTOMATION

- Swarm Robotics configuration
- New generation of Industrial Information System
- AI driven Robotic programming

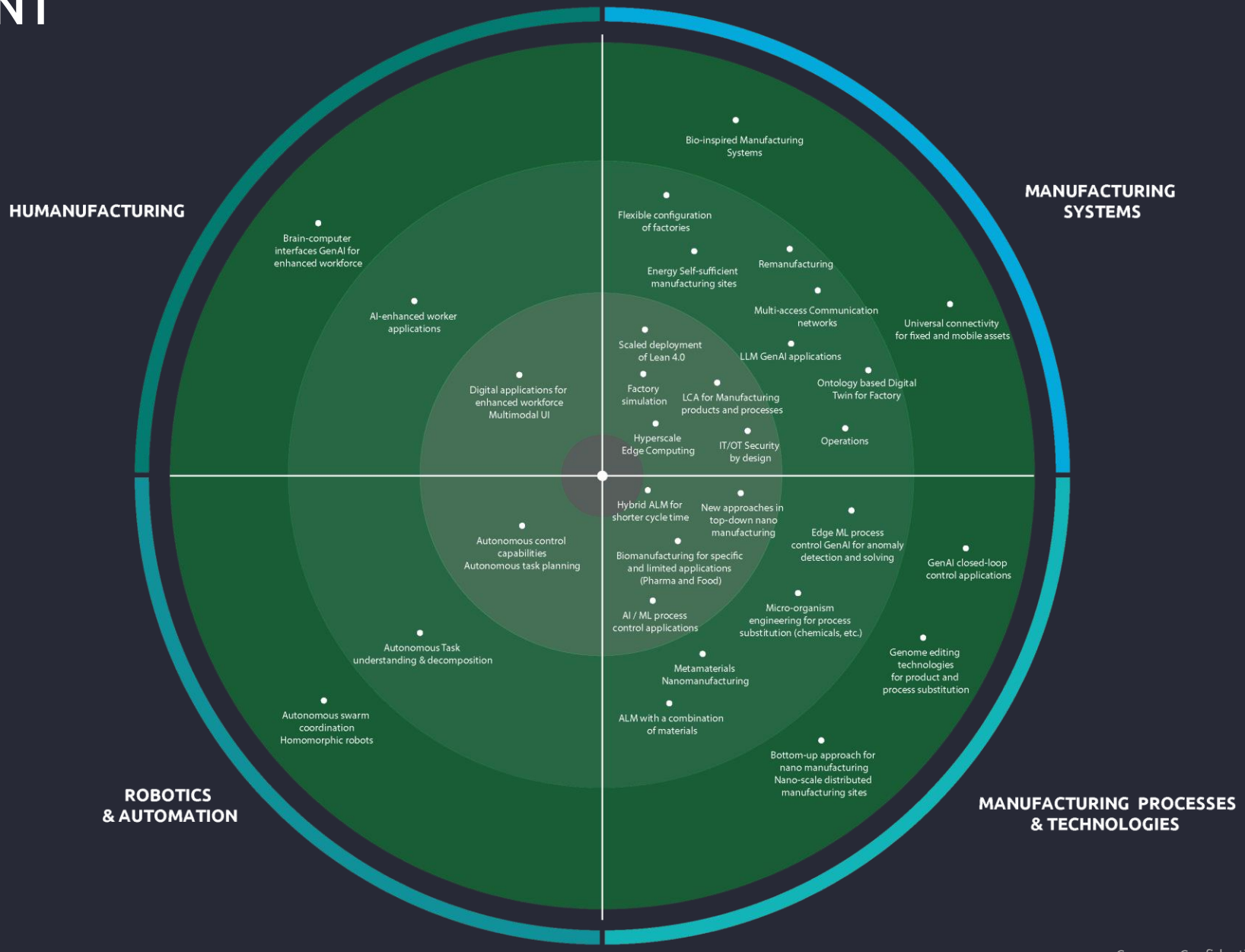
HUMANUFACTURING

- Applications for an augmented workforce
- New digital end user capability experience in an automated context.
- Human-device integration

SUMMARY OF MAIN TRENDS IN THE EVOLUTION OF THE MANUFACTURING ENVIRONMENT

TOPIC	HORIZON 3 *RESEARCH*	HORIZON 2 *INNOVATION*	HORIZON 1 *SCALING*
MANUFACTURING SYSTEMS	Bio-inspired Manufacturing Systems Universal connectivity for fixed and mobile assets	Flexible configuration of factories Energy Self-sufficient manufacturing sites Remanufacturing LLM GenAI applications Multi-access Communication networks Ontology based Digital Twin for Factory Operations	Scaled deployment of Lean 4.0 Factory simulation LCA for Manufacturing products and processes Hyperscale Edge Computing IT/OT Security by design
MANUFACTURING PROCESSES & TECHNOLOGIES	High-Speed ALM	ALM with a combination of materials	Hybrid ALM for shorter cycle time
	Bottom-up approach for nano manufacturing Nano-scale distributed manufacturing sites	Metamaterials Nanomanufacturing	New approaches in top-down nano manufacturing
	Genome editing technologies for product and process substitution	Micro-organism engineering for process substitution (chemicals, etc.)	Biomanufacturing for specific and limited applications (Pharma and Food)
	GenAI closed-loop control applications	Edge ML process control GenAI for anomaly detection and solving	AI / ML process control applications
ROBOTICS & AUTOMATION	Autonomous swarm coordination Homomorphic robots	Autonomous Task understanding & decomposition	Autonomous control capabilities Autonomous task planning
HUMANUFACTURING	Brain-computer interfaces GenAI for enhanced workforce	AI-enhanced worker applications	Digital applications for enhanced workforce Multimodal UI

SUMMARY OF MAIN TRENDS IN THE EVOLUTION OF THE MANUFACTURING ENVIRONMENT



H1 Scaling

H2 Innovation

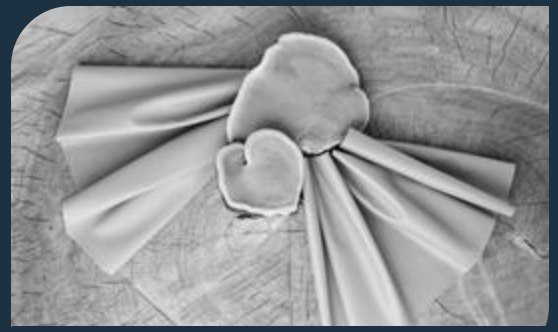
H3 Research

HOW OUR R&I PROJECTS - CAN HELP YOU REACH YOUR COMMITMENTS

#1 Manufacturing systems

MARS

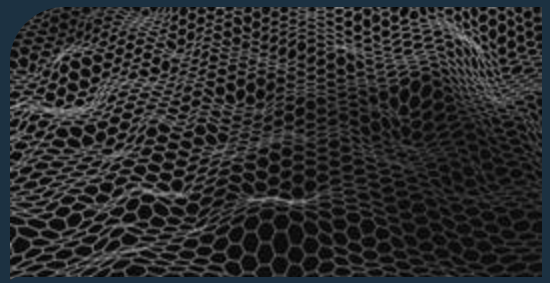
Build a generic tool-based methodology to support the reconfiguration of Reconfigurable Manufacturing Systems



MSD

Develop decision making tools focusing on biobased materials production compared to petroleum-based materials

#2 Manufacturing processes



UCB BERKELEY

Build methodologies and tools to discover material surface properties to meet needs for sustainable manufacturing & accelerate the time to market of new materials.

ETH ZURICH

Develop artificial intelligence solutions in the design of multi-material structures for Additive Layer Manufacturing (ALM)

#3 Automation & Robotics

ROBOTEC

Develop a set of technological blocks, methods and tools that can be used to accelerate the industrialization of automated tasks

TETRABOT

Many small and autonomously acting transport modules that are assembled into suitable teams depending on the type and requirements of the transport job

#4 Humanufacturing

CONAN

Symbiotic production system sharing cognitive and physical tasks between human and machine, in real time

FOHI4.0

Understanding and optimizing the interactions between people and the industry of the future

INTELLIGENT INDUSTRY LAB: DIGITAL PARTNER AT SCALE

The **Intelligent Industry Lab**, the place where **DIGITAL meets PHYSICAL** with the ambition to **innovate fast and at scale** and become your **digital partner to accelerate and de-risk large scale transformation projects**.

The Lab purpose can be summarized in the following detailed missions:

- **Emerging Technologies** early Adopter
- **Platform to Innovate Fast and at Scale**
- **Testing partner** to accelerate and de-risk large scale implementations

To achieve these missions, the core assets are:

- Multiskilled SQUADS
- Industrial Operations & Environment
- OT-IT-IoT Architecture
- Partners Eco system

IOT
Microsoft Azure
aws

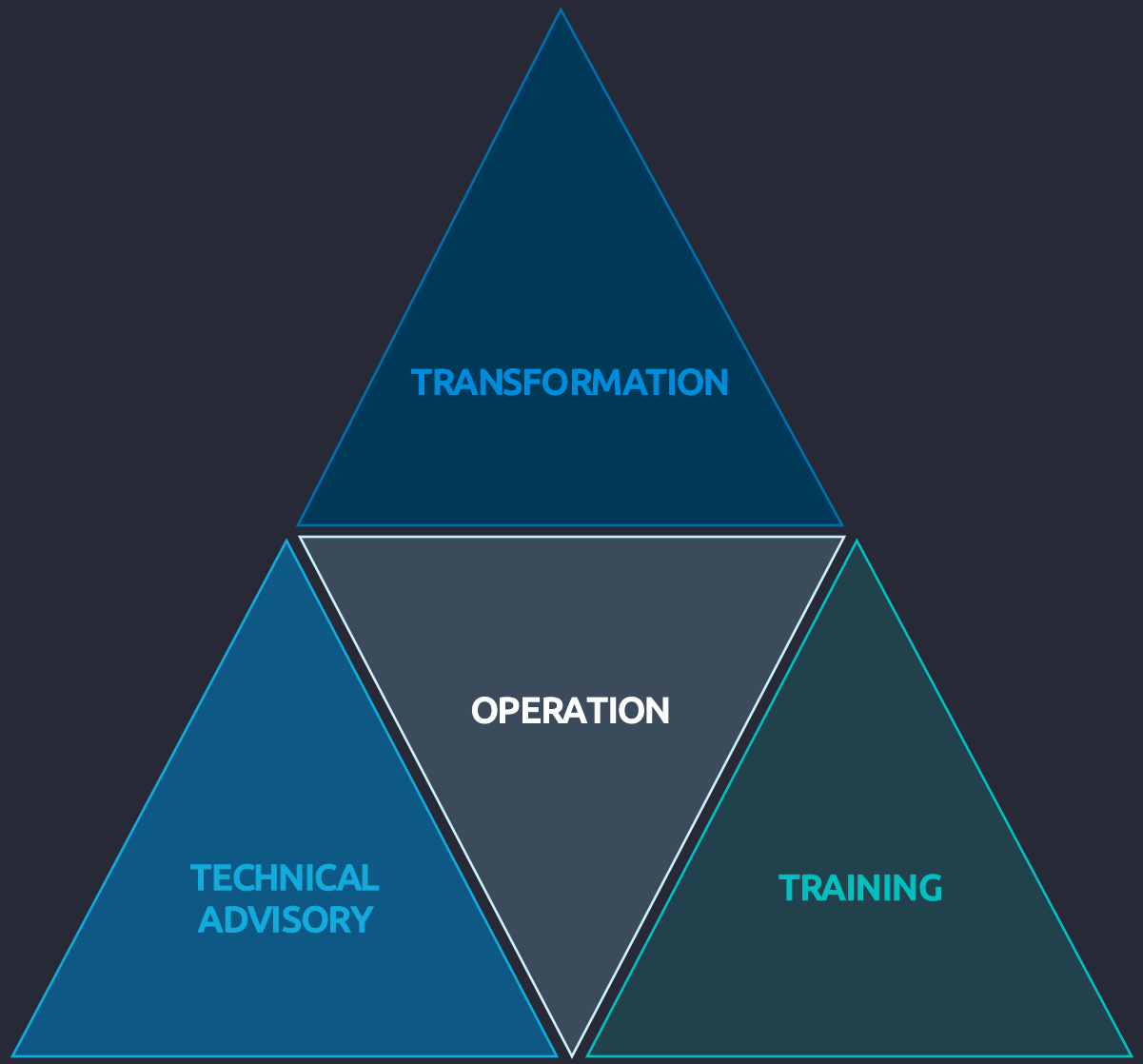
IT/OT
SAP
OPC
kafka
NATIONAL INSTRUMENTS
RabbitMQ

DEVELOPMENT
Unity
TensorFlow
docker
spring
ANGULAR
python

HARDWARE
KEYENCE
intel.
OMRON
NATIONAL INSTRUMENTS
SIEMENS

ROBOTICS
UNIVERSAL ROBOTS
FANUC ROBOTICS

WHAT IS OUR ROLE AS CAPGEMINI ENGINEERING?



TRANSFORMATION

DRIVING THE TRANSFORMATION JOURNEY

Support the manufacturing companies in planning and executing the transformation of their manufacturing systems

TECHNICAL ADVISORY

LEVERAGE TECHNOLOGY

Advice the manufacturing companies on the best use of emerging and existing technologies

TRAINING

BRING TEAMS TO THE NEXT LEVEL

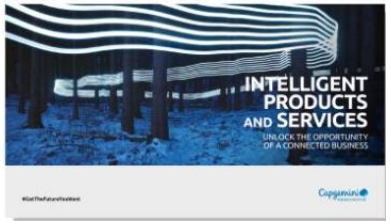
Reach a deep understanding of technologies, regulations, standards, methods and tools.

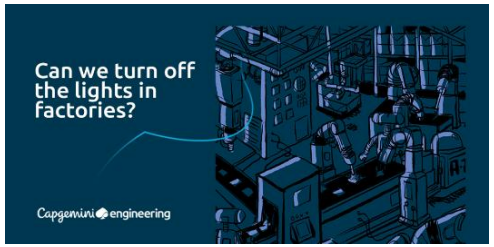
OPERATION

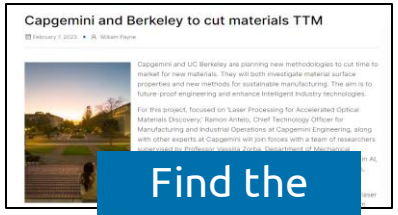
OPERATE WITH THE HIGHEST STANDARDS

Provide the right skills and systems to deliver at the best level: execute, monitor and report the manufacturing engineering activities.

THOUGHT LEADERSHIP







Find the right Berkeley scientific paper

…AND AN EXTENSIVE PARTNER ECOSYSTEM

We partner with the best companies in the world to deliver digital engineering & manufacturing services

Non-exhaustive

NW SOLUTIONS

End-to-end

ERICSSON

NOKIA

Core, Transport, Cloud, Storage

cisco

juniper networks

casa systems

Lanner

VERSA networks

CHIPSETS, MODULES

Qualcomm

NXP

MARVELL

BROADCOM

NVIDIA

QUECTEL

TECH / IT / SW PLATFORMS

Open Source

Red Hat

OSS, BSS, CRM, Data

MATRIXX SOFTWARE

OPENET

amdocs

DigitalRoute

Vlocity

COMARCH

Cloud, Edge

NUTANIX

FOGHORN

AKRAINO

Automation

UBiqube

ciena | blueplanet

Tech

intel

Hewlett Packard Enterprise

ORACLE

OEMs, ENGINEERING, MANUFACT.

FOXCONN

Lenovo

Inventec

PHOENIX CONTACT

Rockwell Automation

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SOFTWARE EDITORS

ptc

DASSAULT SYSTEMES

PLM Software SIEMENS NX

Schneider Electric

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INDUSTRIAL EQUIPMENT

SIEMENS

ABB

OMRON

Honeywell

Schneider Electric

PHOENIX CONTACT

Rockwell Automation

YOKOGAWA

COMMUNICATION SERVICE PROVIDERS

AT&T

T-Systems

Telefónica

verizon

vodafone

docomo

Business Services

kt

Singtel

BT

Cloud Hyperscalers

amazon web services

Azure

University Research Partnerships

Berkeley

ETH zürich

Georgia Tech

Standards & Research Organizations

O-RAN ALLIANCE

ONF

GSMA

Capgemini engineering

About Capgemini Engineering

Capgemini Engineering combines, under one brand, a unique set of strengths from across the Capgemini Group: the world leading engineering and R&D services of Altran – acquired by Capgemini in 2020 - and Capgemini's digital manufacturing expertise. With broad industry knowledge and cutting-edge technologies in digital and software, Capgemini Engineering supports the convergence of the physical and digital worlds. Combined with the capabilities of the rest of the Group, it helps clients to accelerate their journey towards Intelligent Industry. Capgemini Engineering has more than 52,000 engineer and scientist team members in over 30 countries across sectors including aeronautics, automotive, railways, communications, energy, life sciences, semiconductors, software & internet, space & defence, and consumer products.

Capgemini Engineering is an integral part of the Capgemini Group, a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided every day by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of 270,000 team members in nearly 50 countries. With its strong 50-year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms. The Group reported in 2020 global revenues of €16 billion.

Get the Future You Want | www.capgemini.com/capgemini-engineering

THERE IS A HUGE VALUE TO REALIZE FROM *ADVANCED TECHNOLOGIES* IN MANUFACTURING TO ENABLE *A MORE EFFICIENT AND SUSTAINABLE WORLD*

+20%
Increase in throughput due to better visibility and availability of assets

+10%
Increase in progress yield thanks to AI/ML enabled process control

+40%
Increase in labour productivity due to smart automation, guided operations and remote assistance

+20%
Increase in fuillfilment KPIs due to better demand visibility and more flexible production

Some examples of the application of Advanced Technologies in manufacturing are ..

REAL TIME PERFORMANCE VISIBILITY
Allows faster response

ENGINEERED MATERIALS
Improves performance

ENERGY MANAGEMENT
optimizes consumptions

ADDITIVE MANUFACTURING
enhances functionalities

...

HUMAN-DEVICE INTEGRATION
improves productivity and safety

CLOSED LOOP AI-DRIVEN CONTROL
Improves yield & throughput

AUGMENTED OPERATOR
Augment competencies

INTELLIGENT AUTOMATION
Automates repetitive tasks

MANUFACTURING COMPANIES HAVE TO TRANSFORM

wording

Invest in Key enabling technologies

Digital transformation and new business models

Master complexity of products, processes and systems

Resource efficiency and sustainable development

Resilient and adaptive manufacturing

Innovation ecosystem

THE POWER OF PARTNERSHIPS TO DRIVE SUSTAINABLE INNOVATION
EXAMPLES OF ONGOING DISCUSSIONS & STREAMS

Replaced by Ramon's partner slide

INDUSTRIAL PARTNE	OAIRSHIP	New air mobility powered by renewable energy
	EBHERR	Life cycle analysis & bio-sourced materials
	KYANOS	Industrial symbiosis for bio-production
ACADEMIC PARTNERS	ETH ZURICH	Sustainable advanced engineering designs based on metamaterials made with ALM
	GEORGIATECH	Next generation of PLM including sustainability
CONSORTIA	LIGHT TRAIN	Use of digital twin and design-to-X to design innovative light trains
	CLEAN AVIATION	HE-ART: Design and sizing of t thermal management system for future hybrid propulsion
TECHNOLOGY PARTNERS	IBM	AI-powered LCA chatbot
	DASSAULT SYSTEMS	Integrated Eco-design LCA

WHAT IS OUR CORE (SOURCE OF COMPETITIVE ADVANTAGE)?

Our discipline can contribute in different ways to the competitive position of Capgemini Engineering

- Demonstrating a technical leadership position in the Manufacturing part of the Intelligent Industry play
- Being the preferred partner for outsourcing mission critical context processes of our customers (fundamentally, in Production Engineering: transfer of work, continuous improvement, management of production activities).
- Based on practical and clear understanding of physical manufacturing operation and challenges, together with our mastery of digital technologies, designing and implementing the best solution in class to support physical and digital manufacturing operations.
- Supporting our client in scale up and roll-out of these solutions in our client worldwide industrial landscape

The key elements of our contribution to the competitive advantage would be:

- Leadership position in the Intelligent Industry play
  - Expertise in the physical and digital technologies – having a set of SMEs in the key technologies to position ourselves with top level customers
  - Leverage our worldwide labs network to provide our clients with clear position and Point of view on the way to take benefits of new digital solutions.
- Support the scale up and roll-out of manufacturing transformation, including outsourced manufacturing services
  - Industrialized way of working
  - Extensive leverage of Global Engineering Centers

OUR DEVELOPMENT PRIORITIES – EXPERTISE POSITIONING

Manufacturing Systems

Our focus will be in:

- Flexible configuration of factories
- MBSE fo rNature-inspired manufacturing systems
- New generation of Industrial Information System
- Industrial Data platform infrastructure
- LLM GenAI applications

Sustainable Manufacturing

Our focus will be in:

- Energy and waste optimization in Factories
- Sustainable real time control tower
- AI/ML for manufacturing of substitution materials

Manufacturing Technologies and Process Automation

Our focus will be in:

- Additive Layer Manufacturing
- Biomanufacturing
- Nanotechnology
- Robotics and process automation
- Intelligence applied to the definition and control of processes

Human-Centered Manufacturing

- **Our focus will be in:**
- Applications for an augmented workforce
- New digital end user capability experience in an automated context.
- Human-device integration

OUR DEVELOPMENT PRIORITIES – OUTSOURCED SERVICES

Automation

Our focus will be in:

- Developing of digital tools to increase productivity
- Leverage digital platform to ensure the continuity between engineering & manufacturing
- Use of GenAI for reducing the effort required from our engineers

Industrialization

Our focus will be in:

- Standardize the services provided, including the adequate on-shore/off-shore mix
- Implement IT/OT convergence best practices to improve the end to end digital platform
- Develop the on-shore teams in the priority Geos

These priorities should be addressed by a global reach transformation project, in combination with Turing, that should be led at Discipline level by the ETI.

It should start with a clear understanding of the market dynamics to better design our services.

MANUFACTURING & PROCESS ENGINEERING – HORIZONS MAP FOR EXPERTISE POSITIONING

Research

- Tool for Factory Reconfigurability (MARS Toulouse)
- Nature-insprired manufacturing systems
- Biomanufacturing for product substitution (through partnerships)
- Biosourcing decision tool (NEXTMAT)
- Multimaterial Multiobjective optimization for ALM (with ETH Zurich)
- ML for the use of lasers to change surface properties (with Berkeley)
- Autonomous self-planning robots
- Liquid Neural Networks applied to biomanufacturing closed-loop control
- Understand the impact of tech transformation on the workforce (FOHI4.0)
- Brain-Devica integration

Innovate

- Tool for Factory Reconfigurability Assessment (MARS Toulouse)
- Use of MBSE for Production Design
- AI-based Waste and energy reduction in manufacturing
- Adaptation of ALM to industrial production constraints (GOTAM)
- Simulation of AM processes (NEXTRUCTURES)
- Machine learning for robotics (thorugh partnerships)
- Accelerate the integration of collaborative robots (ROBOTEC)
- Co-pilot for Liquid Neural Networks in process control
- Methodology for Hybrid Manufacturing configuration
- Co-pilot of GenAI applied to Work Preparation
- Design of symbiotic systems (CONAN)

Scale

- Factory Physics methodology
- Organizational Readiness Level Assessment
- Carbon capture technology (already patented)
- Extrapolate the Energy Control Center to manufacturing environment
- Automatic Visual Inspection (IILab)
- Human Readiness Level Assessment

MANUFACTURING & PROCESS ENGINEERING – HORIZONS MAP (II) – DIGITAL TECHNOLOGIES

Research

- **AI Generated Composite solution** (Assembly of AI solution for operation – new LowCode NoCode approach)
- **Generative AI** (New features & services generated by the machine)
- **Digital Ethical** (impact on worker safety & user experience in factory, new best practices)
- **Smart Spaces** (extended/expanded shift and operation environment, Metaverse for industry)
- **New sustainable industrial System by design** (Industrial system definition based on sustainable new rules, use of quantum computing for industrial system)

Innovate

- **Graph technology & Collaboration production** (Metadata and Data fabrics : Vocabularies, Data Catalogues, multi level ontologies)
- **Synthetic Data for sensors** (Algorithmic digital sensors combined with physical one, self-adjustment of production line)
- **Data regression method** (Data classification, Data model for optimization)
- **Encryption & performance** (Compression & storage for Time series)
- **Digital Twin** (simple simulation based on real factory data. As Design, As Built as operate model, Virtual commissioning)
- **Impact on Net Zero** (sustainability in operations, impact on three scope of Net Zero objectives)

Scale

- **Hyperscale Edge computing** (Multi-tenant industrial platform, Edge-to-Cloud Continuum, Saas mode for Operation)
- **IT – OT security by design** (Available architectures for "good enough" autonomous & safe intelligence)
- **Multimodal UI** (AR/VR, Voice usage in surrounded environment, AI + Human augmentation collaboration in production line situations, Lowcode/Nocode for plants and operations)
- **Create the data & process** (Consistency between Data and Process using AI/ML)

Note: **Now**: Time span of 0 to 3 Years; **New**: Time span of 3 to 6 Years; **Next**: Time span of 6+ Years

CONAN

Program : Future of Industry

Topics

#UX | #Human monitoring | #Predictive maintenace | #Adaptative aid | #IA

Assets

- Human monitoring system
- Machine monitoring system
- Context monitoring system
- Adaptative aid in realtime
- Demonstrator on an assembly station

Project manager :
Alexandre.kostenko@altran.com

Research Project

How to improve the interaction between human and machine in the industrial field?

Objectives

Design a symbiotic production system capable of optimizing the interaction and sharing of cognitive and physical tasks between human and machine, in real time and according to their respective states.

Research paths

Human monitoring system
Expertise maturity : 3/5

Development of a model and dispositive of human monitoring able to detect the operator state in real time. This method take into account different types of data (physiological, behavioral, performance, etc.). This system is perfectly suitable to an operator on industrial assembly station.

Machine monitoring system
Expertise maturity : 2/5

Development of PHM methods that allow the diagnosis and prognosis of machine failure in real time situations. These methods are mainly addressed to machine tools of different kind (Lathe, milling machine, drilling machine, etc.)

Context monitoring system
Expertise maturity : 2/5

Perfectly reliable and robust learning systems capturing information from the working environment to classify the context (situation in which the activity is carried out) in real time.

Acceptability and ethics
Expertise maturity : 1/5

Create a system that is accepted by operators and aesthetics.

Official key partners

LGCO Laboratoire Gouvernance et Contrôle Organisationnel

ASYSTOM

MFJA Maison de la Formation Jacqueline Auriol

Key technologies used on this project

- Eye tracker, physiological sensor
- Connected tool
- Machine Learning
- HITL control system
- Industrial Internet of Things (IIOT)

MARS

Program : Future of Industry

Topics

#Flow Simulation | #Sustem reconfigurability | #Next Generation Manufacturing Systems | #Product/Process Qualification

Assets

- Reconfiguration tool-based decision method
- Modeling & optimization of RMS
- Workshop and flow simulation
- Qualification tool method

Scientific project manager :
adriana.pacheco@altran.com

Research Project

How to optimize the reconfiguration of a production plant?

Objectives

Develop a generic tool-based methodology to support the reconfiguration of Reconfigurable Manufacturing Systems (RMS). At first, the project aims to develop a tool method to measure the reconfigurability and optimize the reconfiguration process according to specific objectives. The second main objective of this project is developing a tool method to qualify the couple product/process as well as the operators for all reconfiguration levels in an RMS.

Research paths

RMS reconfigurability

Expertise maturity : 2/5

Development of a tool-based method to make any production line automatically and instantly reconfigurable to manufacture any new product line.

- Measure the system reconfigurability.
- Modeling, simulation and optimization.

Qualification of an RMS

Expertise maturity : 1/5

Development of a generic tool-based method for the instantaneous qualification of the product/process couple, the qualification of the operators and for the product/process/human safety regulation, for any level of reconfiguration in the environment (fluctuating and mobile) of an RMS.

Key technologies used on this project

- Workshop and flow simulation
- Model-based systems engineering (MBSE)
- Multi-criteria assessment
- Combinatorial optimization

Downloads & Media Kit

- https://altrangroup.sharepoint.com/sites/MARS

ROBOTEC

Program : Future of Industry

TOPICS

Autonomous Navigation | Automated Inspection | Drones & Robots

ASSETS

SOUL – Localization And Mapping (SLAM)

HUFII – Roller/Quadruped Conceptual Robot

Research Project

Program key contact :
Laurent.labracherie@capgemini.com

Project manager :
bilel.chenchana@capgemini.com

How to accelerate development of autonomous and collaborative robotic systems ?

Objectives

The project aims to develop a set of technological blocks, methods and tools that can be used to accelerate the industrialization of automated tasks using collaborative robotic systems.
The project results are integrated into a single use case of automated visual inspection of aircraft structures.

Research Paths

Autonomous Navigation
Expertise maturity : 4/5

Localization and mapping, visual and Lidar SLAM.
Even though autonomous navigation is a classical topic in robotics, doing it mutually for a moving base and a drone (or fleet of drones) is no trivial task. Due to the collaboration aspects of our robotic unit, it is essential to explore this research path.

Collaboration
Expertise maturity : 3/5

Robot with tethered drone or drone fleet.
Collaborative control is mandatory in case we want to increase the robot's performance by using several robots of similar or different types. Or by allowing the robots to perform the inspection task in close contact with a human operator.

Perception and Inspection
Expertise maturity : 3/5

Scene semantic analysis and target tracking.
An inspection task is based on the ability of the robot to detect the objects to inspect in an environment and to be able to estimate it's pose. This is possible using IA solutions, the challenge resides in the fact that data used to train these solutions are usually not available and replacing them with synthetic data has challenges.

Official Key Partners

Capgemini Benefits

- SITL/HITL environment to accelerate robotic functions development.
- Devops methodology.

Key technologies Used

- ROS/GAZEBO simulation platform.
- AI for perception.
- SLAM for autonomous navigation.
- Controllers.

Downloads & Media Kit

NEXTRUCTURES

Program : Future of Engineering

Topics

Structural Optimization	Design to Manufacturing	Damage simulation
Digital Twin	Process simulation	Machine Learning

Assets

- Physical simulation process *
- Topologic optimization
- Suspension patent *
- Crack analysis tool *
- Railwy inferface models
- Performance study – MBD approach *
- Optimisation through librairies *
- Monitoring and cost optimization of ALM*
- Intelligent 3D printing monitoring system*

Research Project

Project manager :
benoit.gely@capgemini.com

How to define the future of the physical and mechanical engineering towards a unified approach for design, manufacturing & monitoring?

SEC 2

Objective(s)

NEXTRUCTURES project aims at merging all modelling and simulation activities related to mechanical engineering and manufacturing offices through digital continuity in order to propose an integrated codesign solution.

Research paths

IDD.1 : Railway - Wheel/rail behavior modelling
Expertise maturity : 4/5
Multi-scale optimization of a railway system

IDD.1 : Multidisciplinary and multi-scale optimization
Expertise maturity : 2,5/5
Multi-scale optimization of a complex system

IDD.2 : Simulation of additive manufacturing process
Expertise maturity : 2,5/5
Methods to model additive manufacturing process and constraints for the optimization of parts

IDD.2 : Costing tool with smart database
Expertise maturity : 4/5
Estimate the cost of additive manufacturing from pre to after-treatment

IDD.3 : Simulation of crack propagation
Expertise maturity : 3/5
Predictive method for structural behavior in case of crack propagation

IDD.3 : Vibration digital twin
Expertise maturity : 2/5
Development of a structure monitoring method from real-time vibration analysis

IDD.4 : Machine learning optimization
Expertise maturity : 4/5
Design tool for parts using machine learning

IDD.4 : Reverse Engineering using Machine Learning
Expertise maturity : 3/5
CAD modeling tool of a part starting from a drawing

Official key partners

ISAE* | IRT | MIZAR*

Capgemini benefits

- Mechanical modeling expertise
- Optimization methodologies
- Dynamic simulation

Key technologies used on this project

- Additive Manufacturing
- Mechanical modeling & simulation
- Optimization, MDA-MDO
- IA, Machine Learning

Downloads & Media Kit

- Replay of last « Jeudi de la R&I »
- Linkedin Links of the team

NEXTMAT

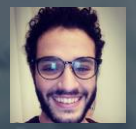
Program : Future of Energy

Topics

Bio-sourcing	Polymers	Composites
LCA	Simulation	CO_2

Assets

- Biosourcing Decision Tool
- Nanomaterials for CO_2 capture
- Finite Element Analysis
- Image post-processing
- Process simulation



Scientific Project Leader:
moncef.lehtihet@altran.com

Research Project

How can innovative & sustainable materials replace current materials and overcome various key industrial challenges ?

Objective(s)

Study and development of new smart and functional materials to build innovative solutions for different industrial sectors such as energy, aeronautics, building, etc. Alongside their conception and performances prediction, the project develops decision making tools focusing on biobased materials production compared to petroleum-based materials while ensuring a responsible and sustainable management of all these materials at the end of their life cycle.

Research paths

Materials & Sustainability | Expertise maturity : 3/5

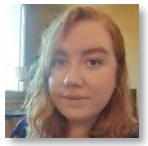
Study of materials/polymers originated from biomass platform molecules : Definition of relevant synthesis routes from agro-resources

Materials & Functionalities | Expertise maturity : 4/5

Nanomaterials for CO_2 capture, storage and utilization : modelization using Monte-Carlo of capture mechanism, process simulation of CO_2 transformation routes, ANR consortium with various partners

Globalized LCA of Studied Materials | Expertise maturity : 3/5

Innovative tools for impact assessment under 3 criteria : environmental, societal and economic. Reliable and robust simulation of biobased polymer synthesis processes for life cycle analysis



Materials & Aircrafts | Expertise maturity : 3/5

Sensing & optimization of composite materials for defect detection by IR thermography

Materials & Buildings | Expertise maturity : 3/5

Innovative & smart materials for walls (all-in-one brick) and responsive windows for heat management, under RE2020 reglementation

Official key partners

ICGM Institut Charles Gerhardt Montpellier — LSPC Laboratoire de sécurité des procédés chimiques — SIKÉMIA — IRT Saint Exupéry — Laboratoire Cobra — CIMV

Key technologies used on this project

- Finite – Element simulation
- Process simulation and Life-Cycle Analysis
- Monte-Carlo simulation

Downloads & Media Kit

- Promotional video of aeronautics activities (link here)
- NextMat project presentation slides (link here)

Capgemini engineering

FUTURE OF MANUFACTURING

OUR VISION FOR MANUFACTURING AND CAPGEMINI'S R&I ACTIVITIES

2024

5 MEGATHEMES INFLUENCING THE FUTURE OF MANUFACTURING ENGINEERING

The availability of global computation, communication, and data aggregation at unprecedented scale catalyses disruption in all domains.

- Universal connectivity for fixed and mobile assets
- Data capture, consolidation and analysis to improve performance
- Mobile-based applications for augmented workers
- Application integration for higher information management productivity

Organisations, markets, industry models and supply chains are becoming more dynamic and responsive to external stimuli & disruption, adopting (often bio-inspired) lifecycles.

- Reconfigurable Factories
- Remanufacturing
- Self-adaptive, self-controlled manufacturing operations
- New manufacturing technologies
- Bio-manufacturing
- ALM
- Nanomanufacturing

Technology now enables us to realise ideas beyond the imagination or conceptualisation of individuals or human teams

- AI-controlled production planning and monitoring
- Generative AI to discover and define new manufacturing processes
- Compressed machine learning algorithms to run on the edge
- Large Language Models to improve documentation creation and management
- Generative AI to program flexible PLC
- Generative AI for Work Preparation

Environmental factors place primary resources back at the heart of innovation; Changes in the fundamental use and transformation of materials, and the capture, transmission and storage of energy are now disrupting products, systems, and supply chains

- Energy-autonomous factories
- Process Hydrogenation
- New manufacturing technologies
- Bio-manufacturing
- ALM
- Nanomanufacturing

As technology evolves, is regulatory pressure constructive or restrictive? Does it evolve in the right direction at the right speed?

All types of technology are subject to legal and regulatory constraints: safety, environmental impact, ethical implications, social and psychological impacts.

- Acceptance of technologies by factory workers
- Regulatory frameworks for the use of AI
- Environmental and HSE constraints and opportunities

AN AVALANCHE OF TECHNOLOGIES TO INVEST IN

Universal connectivity for fixed and mobile assets

Data capture, consolidation and analysis to improve performance

Mobile-based applications for augmented workers

Application integration for higher information management productivity

Nanomanufacturing

Reconfigurable Factories

Bio-manufacturing

ALM

Remanufacturing

New manufacturing technologies

Self-adaptive, self-controlled manufacturing operations

AI-controlled production planning and monitoring

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New manufacturing technologies

Process Hydrogenation

Energy-autonomous factories

Environmental and HSE constraints and opportunities

Acceptance of technologies by factory workers

Regulatory frameworks for the use of AI

Technological

•Accelerated technological progress and adoption (digital technologies, new materials, new processes, robotics, sustainable energies, bio-inspired production, etc.)
•More complex products, processes and systems

Environmental

•Scarcity of natural resources (fossil fuels, rare earths, etc.)
•Climate change drive (de carbonization, circular economy, etc.)

Social

•Changes in demographics (older population, lack of local people, etc.)
•New consumer preferences (customization, environmentally friendly, etc.)
•New skills and employment patterns (more tech and less human labor)
•Global Access to knowledge (global sourcing for talent, etc.)

Economic

• Uncertain global political environment (re-location, supply chain complexity, etc.)
• Fierce competition from emerging countries (China, India, SE Asia, etc.)
• New Business models and global networks (sharing, etc.)

ORGANIC ENGINEERING

Organisations, markets, industry models and supply chains are becoming more dynamic and responsive to external stimuli & disruption, adopting (often bio-inspired) lifecycles.

Engineering becomes more sympathetic to environmental constraints, concerns and sustainability

Driven by: global disruption of resources & populations; environmental crises

ENGINEERING CHALLENGES

- Autonomy and resilience
- Simultaneous engineering; Systems of systems; systems of interest
- Bio-inspired engineering
- New manufacturing technologies
  - Bio-manufacturing
  - ALM
  - Nanomanufacturing
- Circularity

IMPACT ON MANUFACTURING

- Reconfigurable Factories
- Remanufacturing
- Self-adaptive, self-controlled manufacturing operations
- New manufacturing technologies
  - Bio-manufacturing
  - ALM
  - Nanomanufacturing

BEYOND INTELLIGENCE

Technology now enables us to realise ideas beyond the imagination or conceptualisation of individuals or human teams

Driven by: Market attention to Large Language Models;
Emergence of multi-modal models;
Opportunity for Generative design;
Continual demand for product novelty/time/cost/quality

ENGINEERING CHALLENGES

- Content is easy, value is hard – engineering flow
- Accuracy, robustness, predictability and adaptability
- Managed application in the cloud, on premises and the edge
- Combining multi-type AI with agents
- Pervasive AI as a systems engineering topic – solving specific, not general problems
- Explainable/ comprehensible/ defensible AI

IMPACT ON MANUFACTURING

- AI-controlled production planning and monitoring
- Generative AI to discover and define new manufacturing processes
- Compressed machine learning algorithms to run on the edge
- Large Language Models to improve documentation creation and management
- Generative AI to program flexible PLC
- Generative AI for Work Preparation

RESOURCE REVOLUTION

Industrial transformations are characterised materials and energy – which drive them.

Environmental factors place primary resources back at the heart of innovation; Changes in the fundamental use and transformation of materials, and the capture, transmission and storage of energy are now disrupting products, systems, and supply chains

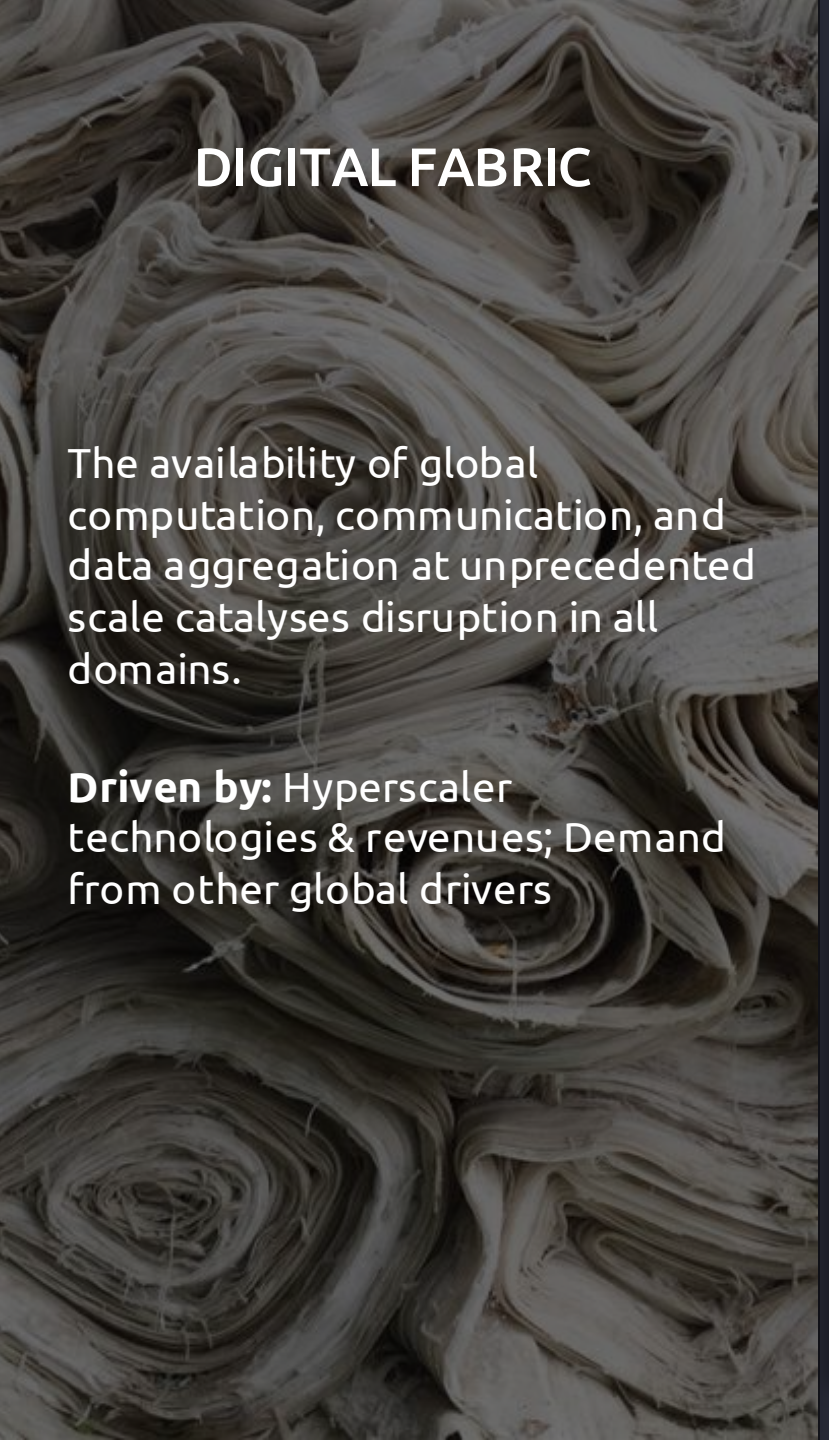
Driven by: Environmental crises; geopolitics

ENGINEERING CHALLENGES

- Means of energy production
- Process electrification & hydrogenation
- Flexible resource management with data
- Nanomaterials
- Multifunctional materials
- Geopolitics of new natural resources

IMPACT ON MANUFACTURING

- Energy-autonomous factories
- Process Hydrogenation
- New manufacturing technologies
  - Bio-manufacturing
  - ALM
  - Nanomanufacturing



DIGITAL FABRIC

The availability of global computation, communication, and data aggregation at unprecedented scale catalyses disruption in all domains.

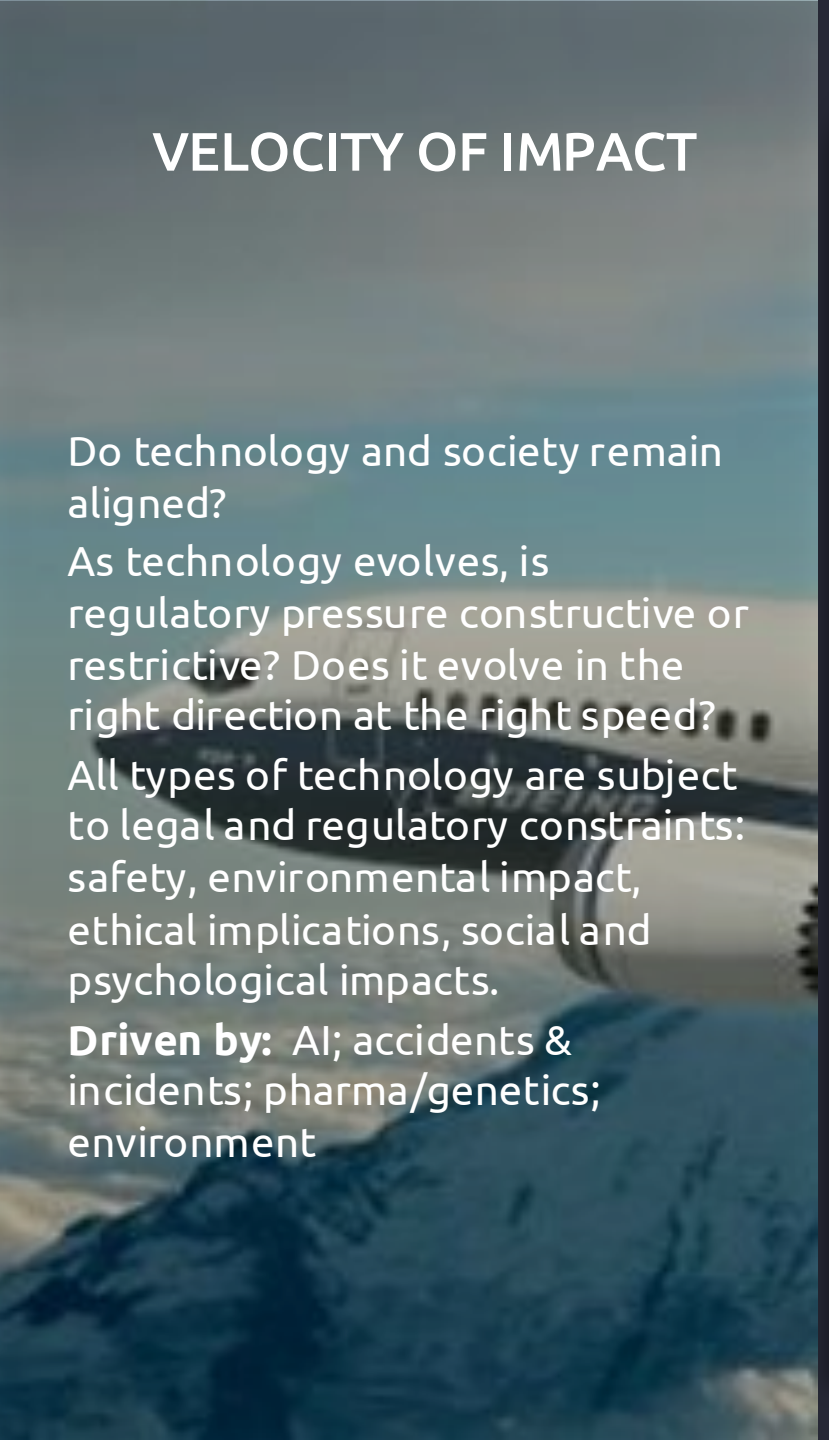
Driven by: Hyperscaler technologies & revenues; Demand from other global drivers

ENGINEERING CHALLENGES

- Universal pervasive connectivity
- Data architectures, ontologies & graphs
- Virtual environments
- Generative semiconductor design
- Chiplets
- Composable architectures
- Quantum computing

IMPACT ON MANUFACTURING

- Universal connectivity for fixed and mobile assets
- Data capture, consolidation and analysis to improve performance
- Mobile-based applications for augmented workers
- Application integration for higher information management productivity



VELOCITY OF IMPACT

Do technology and society remain aligned?

As technology evolves, is regulatory pressure constructive or restrictive? Does it evolve in the right direction at the right speed?

All types of technology are subject to legal and regulatory constraints: safety, environmental impact, ethical implications, social and psychological impacts.

Driven by: AI; accidents & incidents; pharma/genetics; environment

ENGINEERING CHALLENGES

- Trustworthy AI
- Responsible Innovation
- Data-driven regulation
- Digital certification
- Supply-chain impact
- Asymmetric competition

IMPACT ON MANUFACTURING

- Acceptance of technologies by factory workers
- Regulatory frameworks for the use of AI
- Environmental and HSE constraints and opportunities

KEY ENABLING TECHNOLOGIES FOR MANUFACTURING

- Robotics
- Artificial Intelligence
- Connectivity and Cybersecurity
- Nanomanufacturing
- Additive Layer Manufacturing
- Bio Manufacturing
- Industrial Data Driven Architecture
- Cloud/Edge
- Digital Applications for an augmented workforce

