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,

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.

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

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
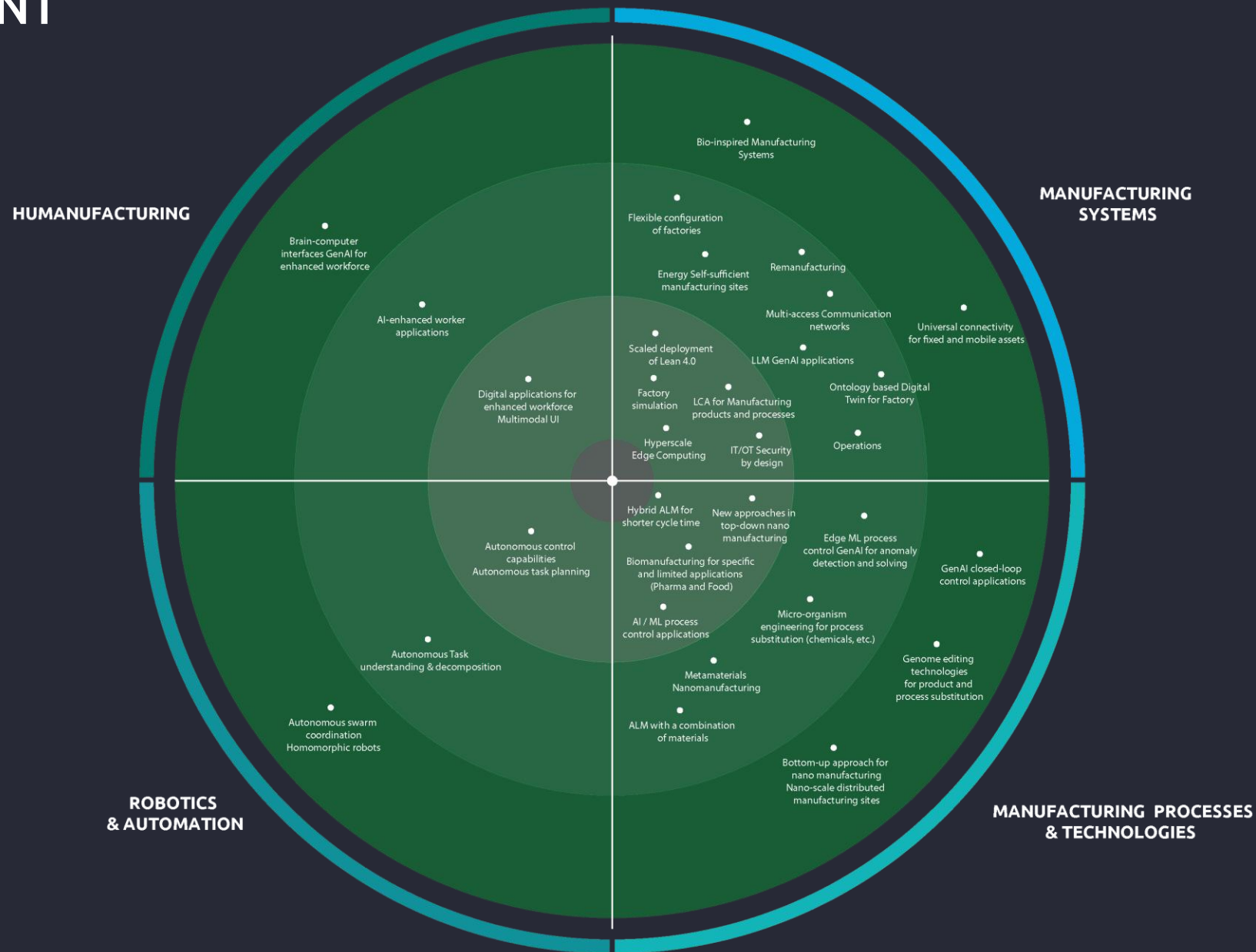- AI driven Robotic programming

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

HUMANUFACTURING

- Brain-computer interfaces GenAI for enhanced workforce
- AI-enhanced worker applications
- Digital applications for enhanced workforce Multimodal UI

MANUFACTURING SYSTEMS

- Bio-inspired Manufacturing Systems
- Flexible configuration of factories
- Energy Self-sufficient manufacturing sites
- Remanufacturing
- Multi-access Communication networks
- Universal connectivity for fixed and mobile assets
- Scaled deployment of Lean 4.0
- LLM GenAI applications
- Factory simulation
- LCA for Manufacturing products and processes
- Ontology based Digital Twin for Factory
- Hyperscale Edge Computing
- IT/OT Security by design
- Operations

ROBOTICS & AUTOMATION

- Autonomous control capabilities Autonomous task planning
- Autonomous Task understanding & decomposition
- Autonomous swarm coordination Homomorphic robots

MANUFACTURING PROCESSES & TECHNOLOGIES

- Hybrid ALM for shorter cycle time
- New approaches in top-down nano manufacturing
- Edge ML process control GenAI for anomaly detection and solving
- Biomanufacturing for specific and limited applications (Pharma and Food)
- GenAI closed-loop control applications
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H1 Scaling
H2 Innovation
H3 Research

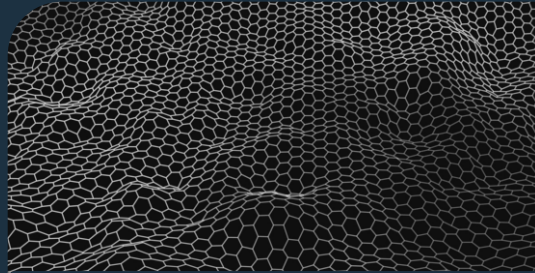# HOW OUR R&I PROJECTS - CAN HELP YOU REACH YOUR COMMITMENTS

#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.
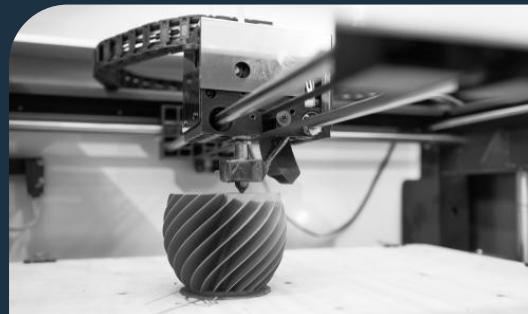

ETH ZURICH

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
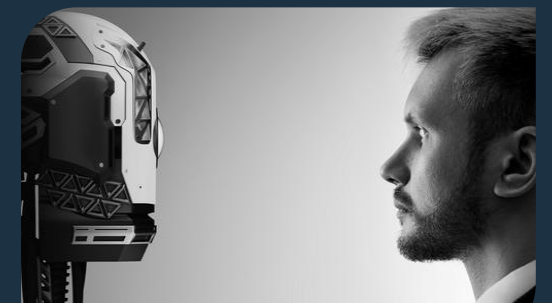
FOHI4.0

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

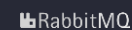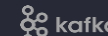To achieve these missions, the core assets are:

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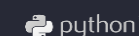- OT-IT-IoT Architecture
- Partners Eco system

Intelligent Industry Lab

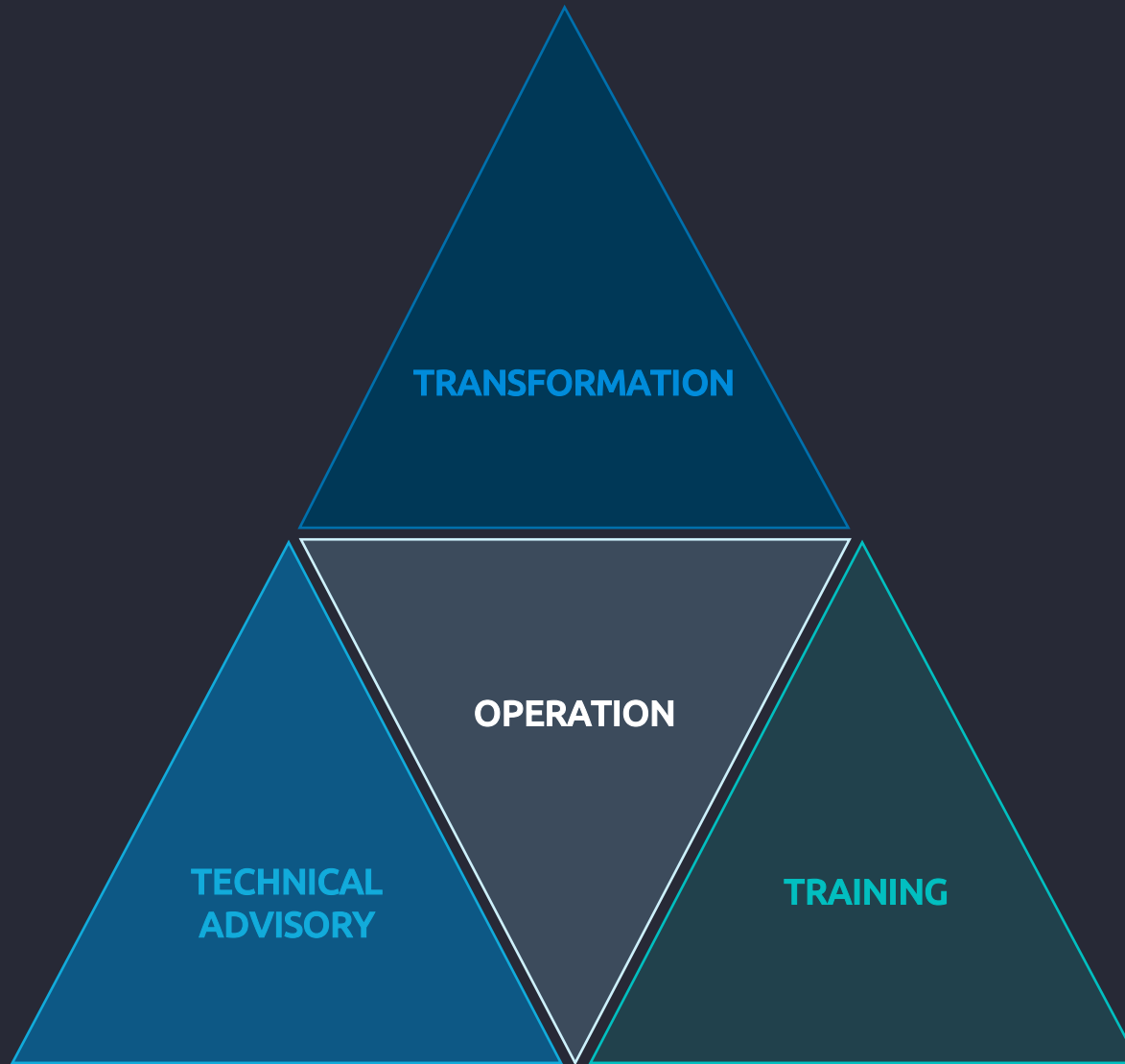| IOT	IT/OT	DEVELOPMENT	HARDWARE	ROBOTICS
Microsoft Azure	SAP	Unity	KEYENCE	UNIVERSAL ROBOTS
aws	OPC FOUNDATION	TensorFlow	intel	FANUC ROBOTICS
	kafka	docker	OMRON	
	NATIONAL INSTRUMENTS	spring	NATIONAL INSTRUMENTS	
	RabbitMQ	ANGULAR	SIEMENS	
		python		

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
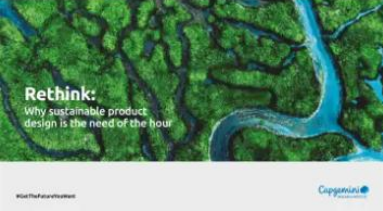
TRAINING

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

...AND AN EXTENSIVE PARTNER ECOSYSTEM

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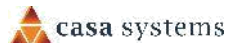
Non-exhaustive

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 INDUSTRY CLOUD APPS   COMARCH

Cloud, Edge

NUTANIX   DTI

FOGHORN   AKRAINO

Automation

UBiqube   ciena | blueplanet

Tech

intel   Hewlett Packard Enterprise   ORACLE

OEMs, ENGINEERING, MANUFACT.

FOXCONN

Lenovo

Inventec

PHOENIX CONTACT

Rockwell Automation

EMERSON

SOFTWARE EDITORS

ptc

DASSAULT SYSTEMES

PLM Software
SIEMENS NX

Schneider Electric

GE Digital

SIEMENS SIMATIC

INDUSTRIAL EQUIPMENT

SIEMENS

ABB

OMRON

Honeywell

Schneider Electric

PHOENIX CONTACT

GE

Rockwell Automation

YOKOGAWA

COMMUNICATION SERVICE PROVIDERS

AT&T

T··Systems·

Telefónica

Verizon

vodafone

NTT docomo

orange Business Services   kt

Singtel   BT

Cloud Hyperscalers

amazon web services   Azure

University Research Partnerships

Berkeley UNIVERSITY OF CALIFORNIA   ETHzürich   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.

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