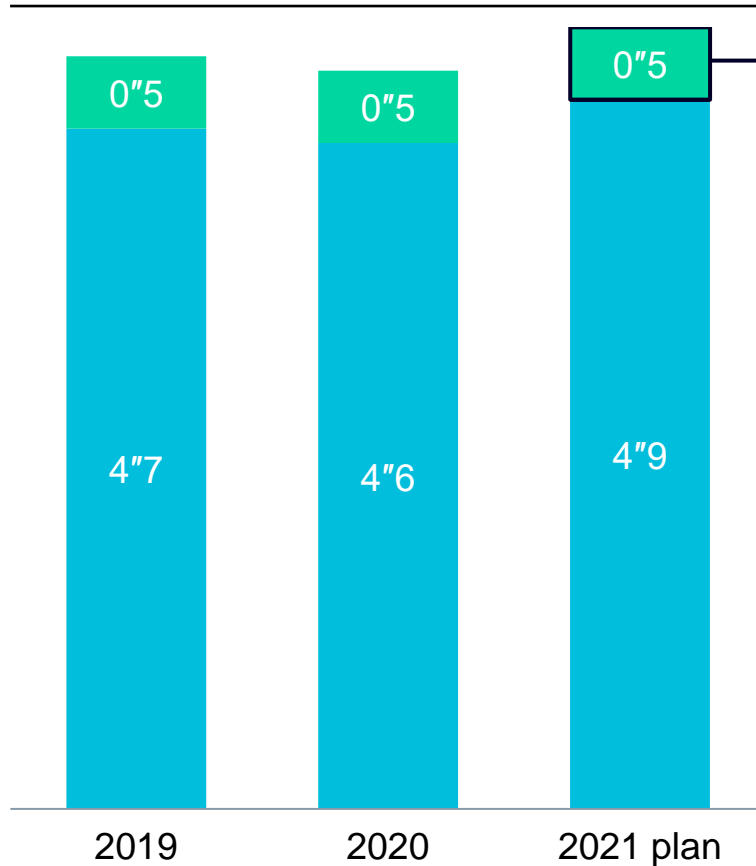# Company Core Technologies

Overview, February 2021

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Improving speed and focus with "Company Core Technologies"
Leverage cross-company synergies in research and (pre)development

R&D spending [1] (in billions EUR)

Year	
2019	0"5 / 4"7
2020	0"5 / 4"6
2021 plan	0"5 / 4"9

Data analytics, artificial intelligence
Software systems and processes
Distributed energy systems
Materials & Manufacturing
Simulation and digital twin
Connectivity and edge
Connected (e)mobility
Additive manufacturing
Autonomous robotics
Future of automation
Storage Applications
Power electronics
Cybersecurity
Blockchain

~500 million EUR focused investments in innovation fields with high relevance for our business

1) W/o SE and SHS

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Company Core Technologies (CCT)
The Siemens approach to Technology & Innovation
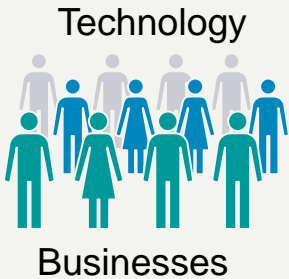
Business-driven, end-to-end

Research (Universities) > Applied Research > Pre-Development, prototyping > Biz model innovation / Product innovation > (New) Business

Transparent spending

~500' EUR in FY20

Clear leadership

One manager per CCT

Cooperation across units

Technology

Businesses

Co-location of cross-functional teams

Co-creation

Customers | next **47**
CCT
Universities
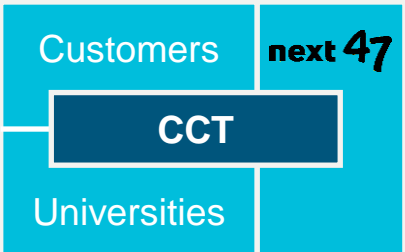
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Each CCT is led by a CCT-manager

- Appointed by Siemens CTO

- Diverse background, e.g.,

  - Technology field head at Corporate Technology

  - Business segment head

  - Business unit CTO

- Leads a cross-unit team

  - To define a CCT strategy and program plan

  - To set up und drive a CCT program across organizations

  - To manage funds and drive program execution

Company Core Technologies

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CCT Software Systems & Processes
Mastering the digital transformation at scale

Research, pre-development and transfer of **Innovative software technology and methodology** to **enable, scale and speed up digitalization** at Siemens

Architecture and Paradigms for Future Systems: building blocks and technologies for the next generation digital offering

Strategic Architecture Management: strategic direction for a high-performing and sustainable digital portfolio

Software Ecosystems, Digital Offerings & Co-Creation: methods to realize partnering opportunities and boost Siemens' SW eco system
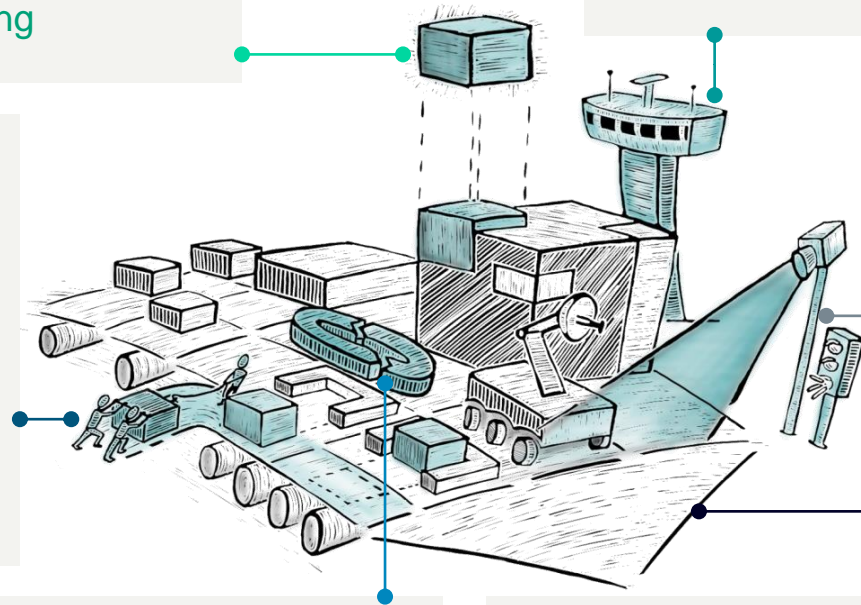
Engineering & Validation of Intelligent Systems: methods and approaches to secure the behavior of intelligent, self-aware systems

Development efficiency & industrial-grade DevOps: development agility, fast product delivery, feedback cycle for product innovation

Holistic and Seamless Cross Federation of Independent Platforms: research and pre-dev. for the Siemens IoT Platform Architecture

CCT Simulation and Digital Twin
Design products and systems better and faster, and optimize their usage

The Digital Twin...

… **links models and data** related to products or systems, production or construction, and operations across tools and applications

… **provides insights** to designers, engineers, operators and service technicians through data and simulations
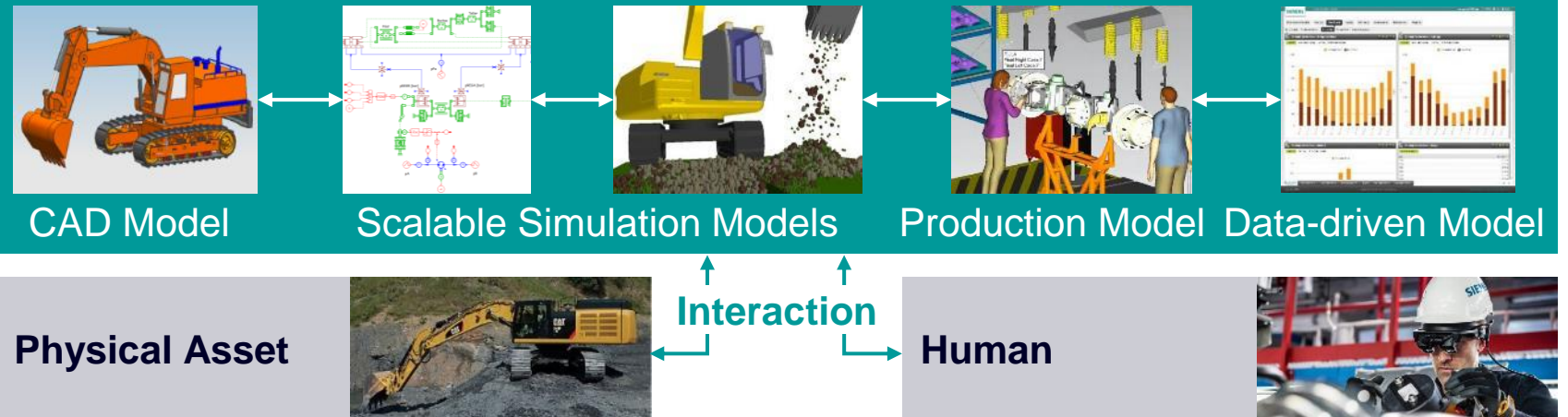
… stays in sync along lifecycle

- Design better and faster
- Commission virtually
- Master variety, complexity
- Optimize operations

Applications: generative and probabilistic design, simulation during operation

Digital Twin Management & Intelligence: infrastructure, semantics, AR & VR [1]

Digital Twin Models & Simulation: sys. simulation, fast simulation, simulation + ML [2]

Digital Twin

CAD Model   Scalable Simulation Models   Production Model   Data-driven Model

Physical Asset   **Interaction**   **Human**

1) AR = Augmented Reality, VR = Virtual Reality
2) ML = machine learning

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CCT Data Analytics and Artificial Intelligence
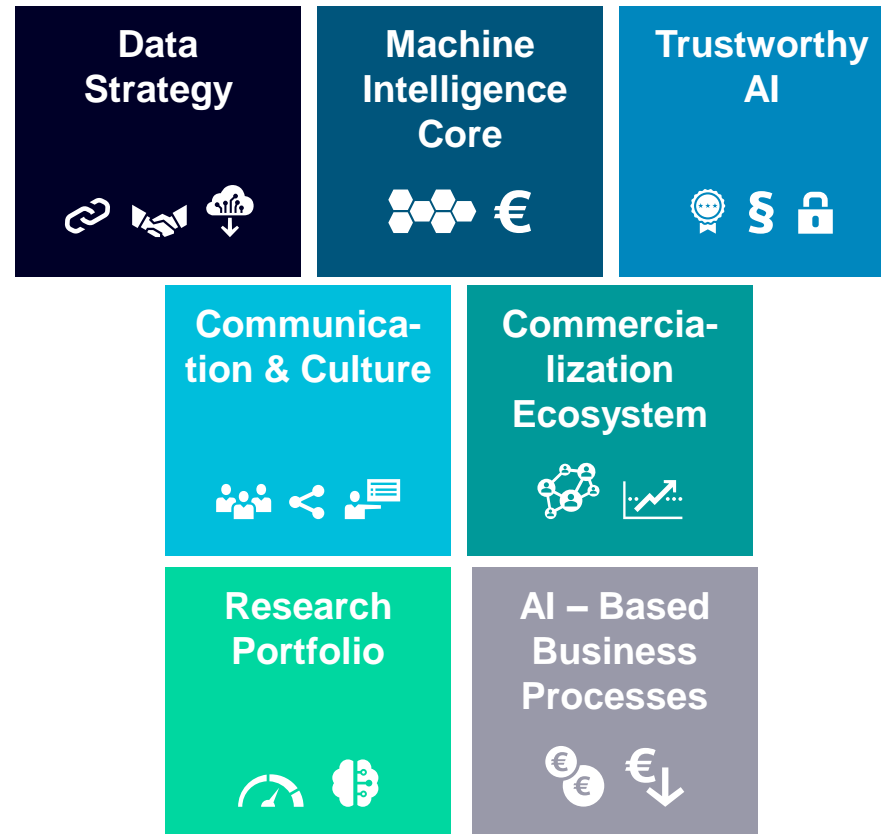## Applying artificial intelligence to industrial use cases

External dynamics

- Increasing revenue expectations
- Accommodate upcoming AI regulation
- Expanding AI computation from cloud to edge

Internal dynamics

- Innovation Ecosystem in the new Siemens setup
- Focus on AI monetization
- Next generation IoT architecture

CCT focus

Data Strategy	Machine Intelligence Core	Trustworthy AI

Communication & Culture	Commercialization Ecosystem

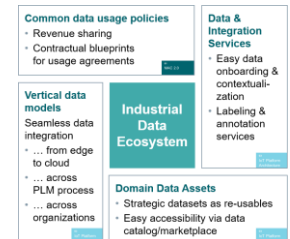| Research Portfolio	AI – Based Business Processes

Example use cases

Advanced Diagnostics System (ADS) identifies solutions for technical problems and scales in the dimensions Industry, Execution &Technology
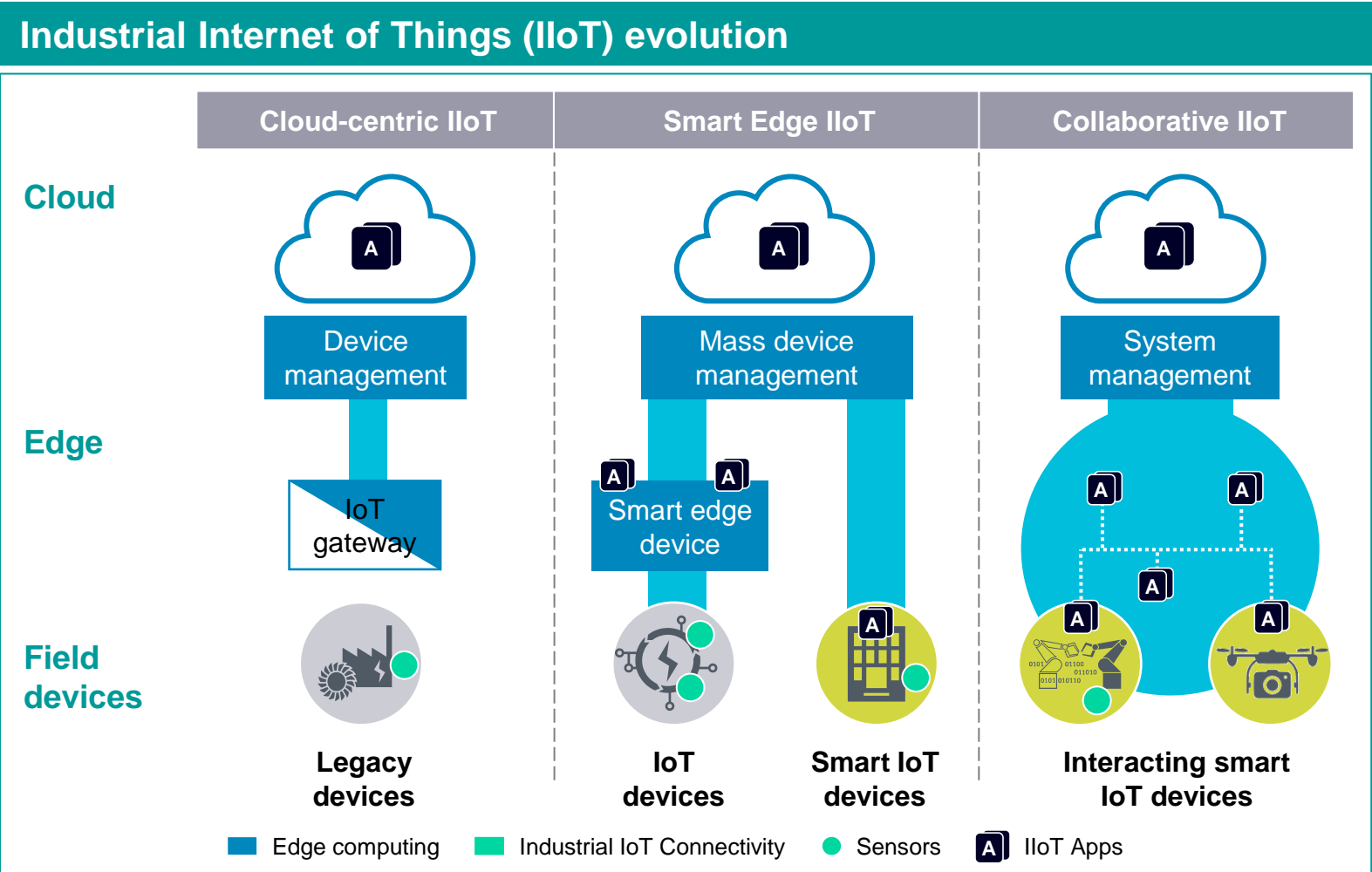
Data Axxelerator enables development of x-functional data assets and provides common data services out-of-the-box

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CCT Connectivity and Edge
Building the technology foundation for the "Industrial Internet of Things"

Industrial Internet of Things (IIoT) evolution

Cloud-centric IIoT	Smart Edge IIoT	Collaborative IIoT
Cloud		
Device management	Mass device management	System management
Edge		
IoT gateway	Smart edge device	
Field devices		
Legacy devices	**IoT devices** / **Smart IoT devices**	**Interacting smart IoT devices**

Legend: Edge computing | Industrial IoT Connectivity | Sensors | IIoT Apps

Siemens research focus

- High-performance as well as constrained edge computing
- Flexible app runtime and app deployment solutions
- Scalable device and systems management for the industrial IoT
- IIoT connectivity, industrial grade communication services, future wireless technologies
- Distributed real-time computing and collaborative systems
- Smart devices, smart sensing and perception

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CCT Future of Automation
Increased automation of engineering, planning and optimization tasks

Business demand in all domains

Less effort in engineering, set-up & commissioning

Simplified operations and automation equipment

Assisted optimization along lifecycle

Supporting technology trends

Autonomy

HW/SW decomposition

Modularization

Future of Automation

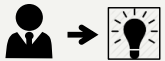Autonomous systems are aware of environment and execute **high-level tasks without detailed programming**

Automation and control functions can be seamlessly **deployed locally, in the edge, or in the cloud**
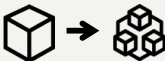
Integrated & modular engineering and runtime environments allow for an **effortless "plug & operate" automation**
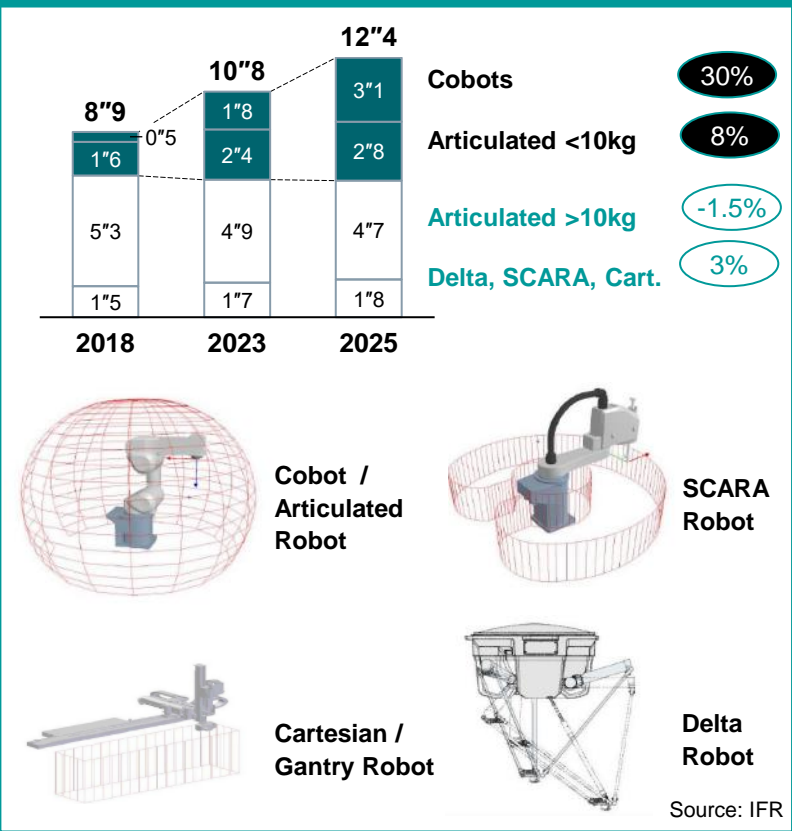
Vision: automation of engineering, planning, and optimization tasks ("automation of automation")

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CCT Autonomous Robotics (ARO)
Make advanced robotics easy to use in manufacturing

Advanced robotics market growing

• Industrial robots: small co-/robots driving growth

	8″9	10″8	12″4	
Cobots	1″6	1″8	3″1	30%
Articulated <10kg		2″4	2″8	8%
Articulated >10kg	5″3	4″9	4″7	-1.5%
Delta, SCARA, Cart.	1″5	1″7	1″8	3%
	2018	2023	2025	

0″5

Cobot / Articulated Robot

SCARA Robot

Cartesian / Gantry Robot

Delta Robot

Source: IFR

Siemens research focus

Requirements for using advanced robots
- Easy to program for non experts
- Flexibility for frequent changes
- Flexibility for using different devices
- Integration into automation systems

Key focus: Engineering and autonomy
- Intuitive engineering using low code
- Cloud-native co-engineering platform for robotics and beyond
- Ease of use and integrated autonomy functions

Example: Graphical low-code engineering tool

Example use cases

Production cell with three different robot makes, parallel execution and task handover

**PCB test machine tending** using robot arm, vision, AGV and torque sensor

Quick programming and configuration for vision based pick&place

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CCT Blockchain – Drive research and development of reusable building blocks for industrial blockchain solutions

Automated Ecosystems

- **Digitalization** connects physical products and systems with business transactions, financial services, and analytics

- **Automated ecosystems,** across company boundaries, are enabled by trust technologies and unlock a new level of productivity potential

- Blockchain with smart contracts will play a key role as underlying **trust technology** in enabling such cross-company integration

- Siemens' blockchain strategy focuses on **industrial blockchain integration** to facilitate participation in automated ecosystems, for instance with factories, energy systems, mobility and healthcare infrastructures

Automated ecosystem
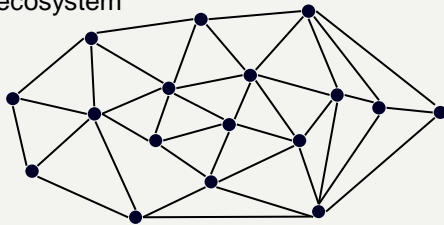
Industrial Blockchain Integration

With **industrial blockchain integration** services, Siemens enables customers to participate in automated industry ecosystems and open **further productivity potential** from digitalization.

Industrial Blockchain Integration
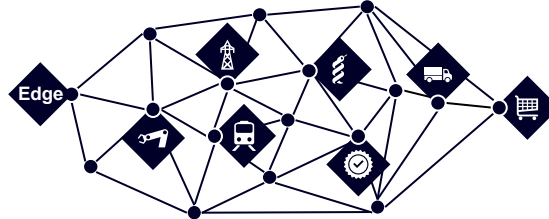
Decentral Architectures

Software Engineering Lifecycle

Confidentiality & Integrity

Edge & Field Integration

CCT Blockchain Deliverables

Identification and development of reusable building blocks to enable fast deployment of industrial blockchain integration.

- **Decentral Architectures**
  Design blueprints for distributed and decentralized architectures and industrial blockchain systems

- **Software Engineering Lifecycle**
  Increase quality and efficiency in the development cycle of blockchain systems through automation

- **Confidentiality & Integrity**
  Balance transparency and confidentiality in blockchain systems with privacy-preserving techniques

- **Edge & Field Integration**
  Integrate existing blockchain stacks into edge and field technologies & environments and apply root-of-trust techniques

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CCT Power Electronics
Exploring new application fields, shaping market & technology trends

PE application fields

Power-to-Power (P2P)

Power Generation

Wind	Photovoltaics

Transmission, Distribution, Storage

Transmission	Distribution	Stationary battery storage	Charger

Power-to-Motion (P2M)

Industrial Drives

Pumps, Fans, HVAC	Discrete	Tooling Machines	Process

e-Mobility

e-Car	e-Train	Marine	e-Aircraft

Market trends

- Electr(on)ification
- Distribution, decentralization
- DC infrastructures
- Functional integration
- Individualization
- Short innovation cycles

Power Electronics

Technology trends

- Semiconductor materials
- Multi core & cloud computing
- Hybrid switches, solid state transform.
- Vertical integration
- SW-defined functionality
- Virtual prototyping & digital twin

Siemens research and development focus (examples)

- Power Electronic systems with SW-defined, customized functionalities
- Data-driven services based on Power Electronic systems as sensors and actors
- Modular, scalable HW/SW architecture; networked Power Electronic building blocks
- Vertical integration: new materials, planar joining technologies

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CCT Storage Applications – Optimization of battery production & system development for mobile and stationary applications

Battery Storage: Mobile systems, stationary applications, models

- Optimized battery design and production
- Battery powered full-electric trains and ferries
- Commercial and industrial stationary systems for microgrids, grid stability, flexibility services and energy trading
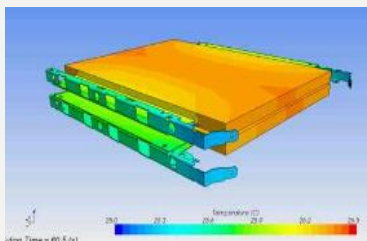
Design Tools
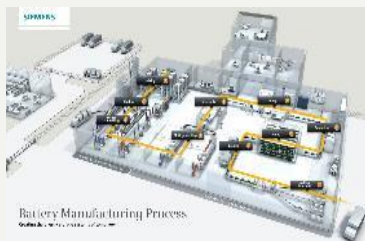
Battery Production

Battery inverters

Microgrids and Buildings

Marine & Offshore

Trains (Mireo Plus B)

Technology Focus

- Models
- State of Health
- State of Charge
- Degradation
- Lifetime
- Operation optimization
- Digital applications
- Integration
- Tech. scouting

Fuel Cells: industrial systems

- System integration
- Fuel cell & hybrid solutions for ships and trains
- Solutions for stationary applications

FC system for underwater application

H2-train (Mireo Plus H)

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CCT Distributed Energy Systems
Digitalization expertise and technical domain know-how along the lifecycle

Trends shaping the energy system

Decarbonization

Decentralization

Digitalization

Future Energy
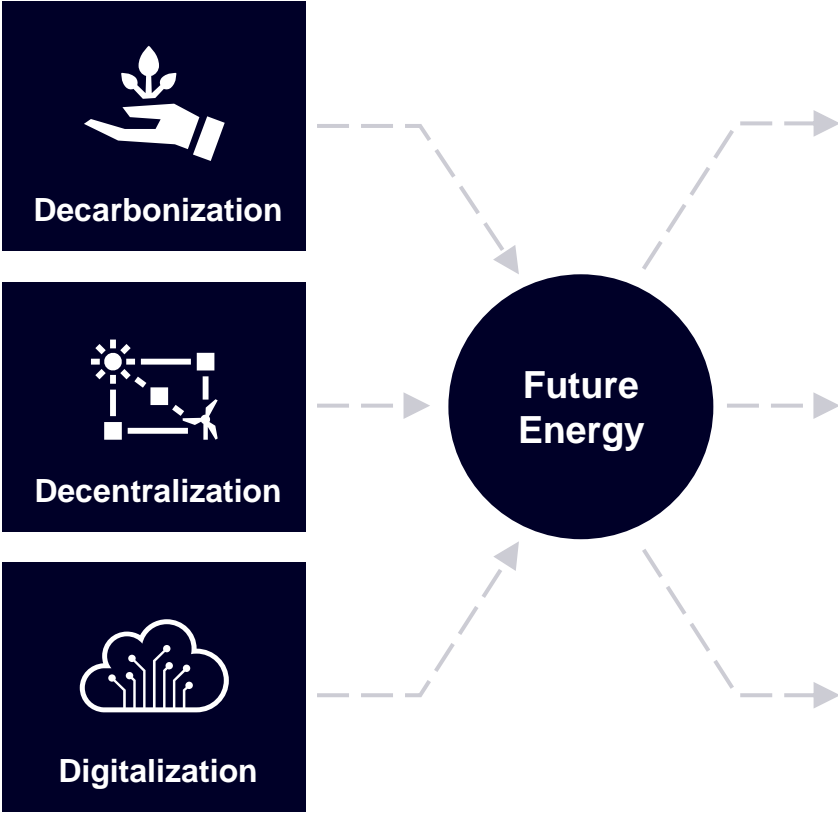
Siemens research focus

System under-standing & integration competence
- Energy system design know-how and tools
- Advanced automation & control
- Plug & operate concepts
- Protection and safety

Integrated digital tool chain
- Seamless toolchain: Design, monitoring, optimization, analysis & optimization, maintenance management
- Data & collaboration platform

Standardization in products and solutions
- Standardized applications
- Prepackaged solution modules for generation, storage, energy efficiency and automation
- Seamless toolchain integration

Example use case

Hybrid Power Plant based on 100% renewables

Galapagos Islands, Ecuador

THE smarter E award 2019 WINNER

- Designed to run carbon-neutral
- Smart control system incl. short-term PV forecast
- Remote monitoring and services
- 99% availability
- Guaranteed renewable plant performance
- Avg. monthly reduction of 79.5 tons CO_2

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CCT Connected (e)Mobility
Innovating an autonomous, connected, electric & shared mobility future

Today

- Driver
- Stand-alone
- Combustion
- Owned

Tomorrow

- **A**utonomous
- **C**onnected
- **E**lectric
- **S**hared

Charging Infrastructure
Automated charging solutions for cars and trucks

Charging Connectivity
Service innovations to optimize availability

Artificial Intelligence
Applications of AI for USP development

Road Space Management
Dynamic models for coding city curbsides

Autonomous vehicles
Certification suite for AV deployments in Cities

Urban Mobility
Operational digital twins for cities

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CCT Materials and Manufacturing
Digital value chain from material to components

Bring materials into the digital world

- Light-weight construction (e.g., for trains)
- Field grading materials with wide range of sheet resistance (e.g., for high voltage machines)
- Advanced electric and electronic gear (e.g., generators, motors, transformers, switches)
- End-to-end digital engineering from materials to component manufacturing
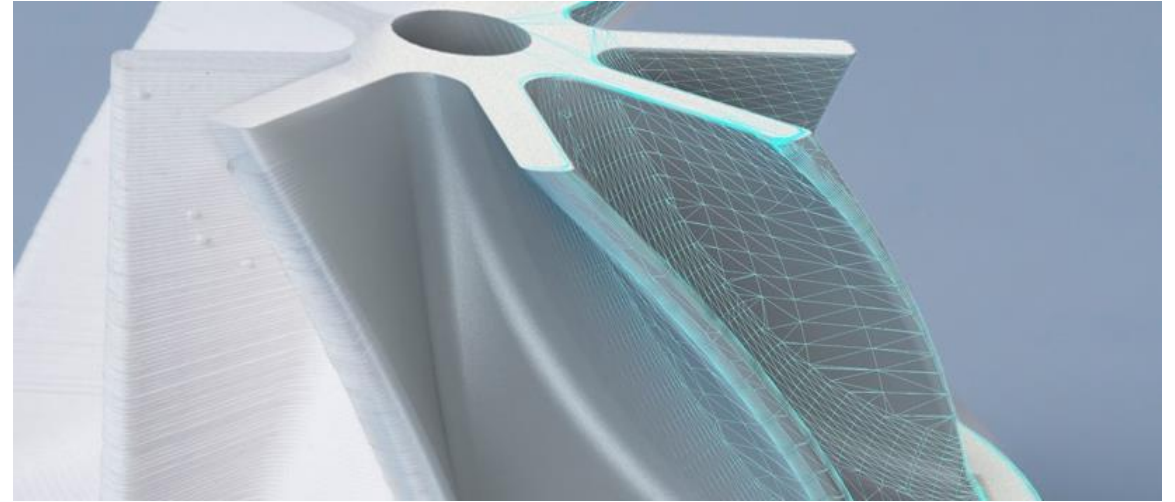
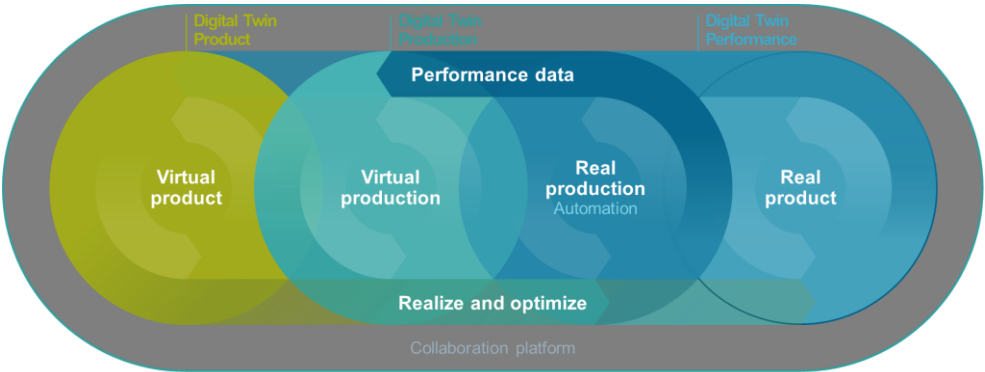| Hybrid & Polymer Composite Materials	Conducting & Insulating Polymers	Metals, Ceramics & Coatings

Emerging Material Technologies

Overarching Manufacturing/Processing

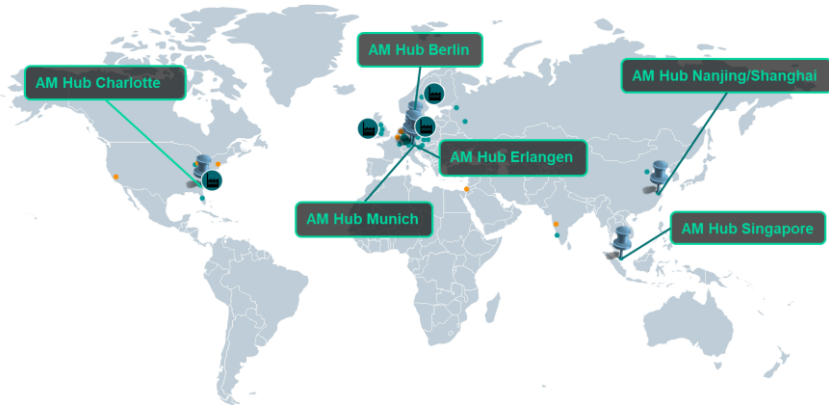Material Characterization and Qualification

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CCT Additive Manufacturing (AM)
Leading the industrialization of AM, as a supplier and user

Supplier of a holistic portfolio for industrial AM

Digital Twin Product
Digital Twin Production
Digital Twin Performance

Performance data

Virtual product

Virtual production

Real production
Automation

Real product

Realize and optimize

Collaboration platform

User and developer of industrial AM technologies

AM Hub Charlotte
AM Hub Berlin
AM Hub Nanjing/Shanghai
AM Hub Erlangen
AM Hub Munich
AM Hub Singapore

Siemens Focus

|	
PLM Software	• End 2 end digital thread for industrial AM • Equipment automation • Seamless digital AM chain
Leadership in factory automation	• TIA portfolio • Equipment automation • AM eco system and AM network
Next generation AM technology	• New and high-impact technologies • Identification, Prototyping, co-creation

Industrial application highlights

Shoe midsole
Complexity and high variance
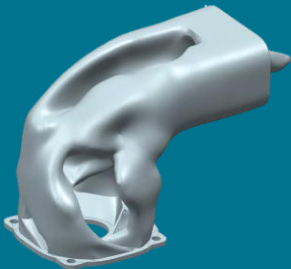
Hewlett Packard - Air duct
Performance optimization through simulation

Siemens Energy - IBuMa burner
High complexity, function driven design & H_2 capability

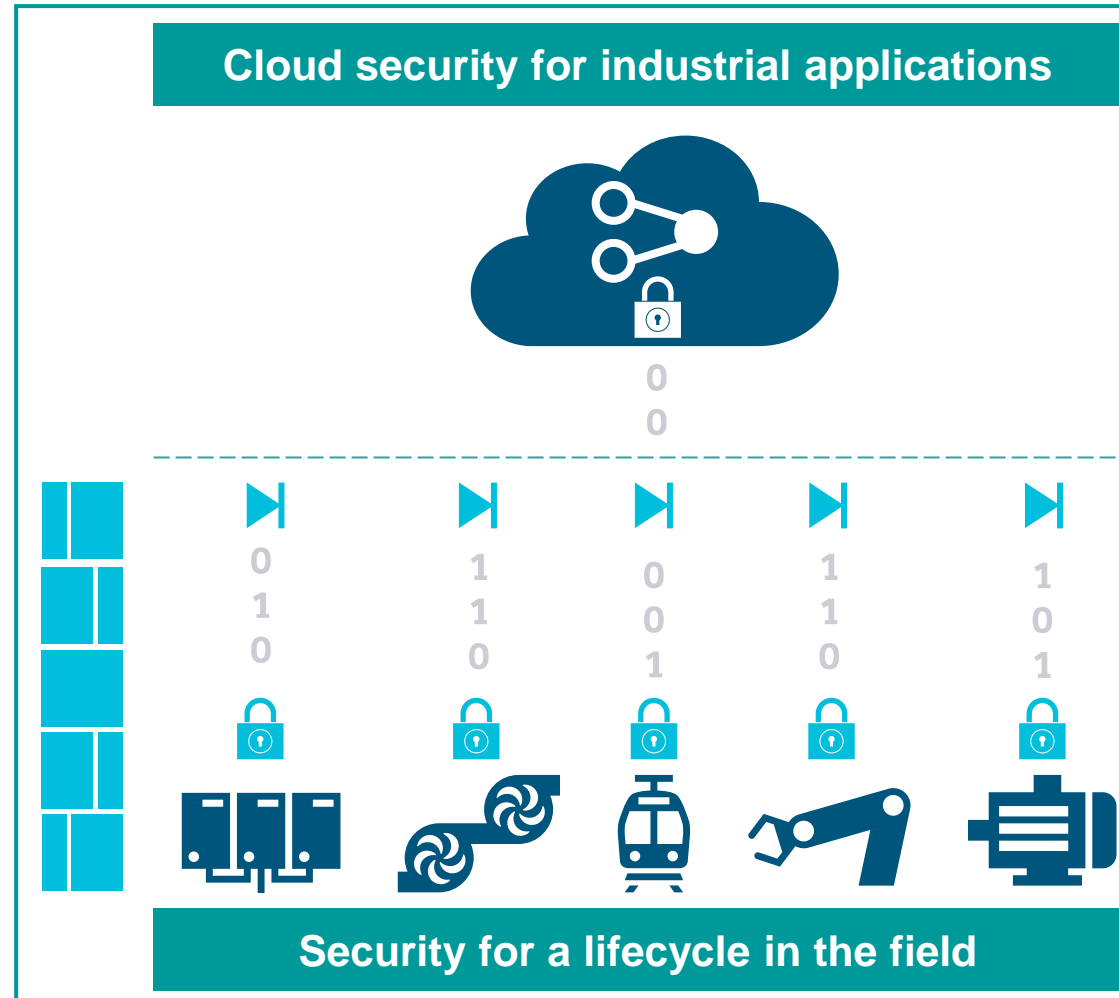**SIEMENS**

CCT Cyber Security
Protecting industrial infrastructure along their entire lifecycle

Security Components, e.g.,

- One-way gateway

- IoT public key infra-structure, identity and access management

- Small footprint IoT cryptography

Security automation in R&D, e.g.,

- Automated penetration testing

- Automated hardening and secure configuration

Cloud security for industrial applications

0
0

0 1 0

1 1 0

0 0 1

1 1 0

1 0 1

Security for a lifecycle in the field

Technologies for security services in operations, e.g.,

- Security analytics platform

- Artificial intelligence for security

- Automatic response – malware containment

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Siemens is a technology leader in industrial Cyber Security
Security functionalities delivered the last 3 years

Data Capture Unit (one-way-gateway) enhanced version publicly released in 2018

Product PKI service for customer solutions available since 2019

Systematic and certification-ready secure OT solution delivery framework offered and implemented 2020

2018 ———— **2019** ———— **2020** ⟶

PROFINET security based on Identity Access Management system defined and standardized in 2018

Security Analytics within Cyber Security Services Portfolio as of 2019

Automated security hardening and testing of product and solution development in 2020

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