Capgemini invent

CXO INSIGHTS

CXO TECH BRIEFS FOR MANUFACTURING

1.SECTORIAL EXEC SUMMARY

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SECTORIAL OVERVIEW WITH RETROSPECTIVE ON 2020 AND 2021 PROJECTION

COVID-19 and Environmental issues are disrupting Manufacturers' value chain and creating an longing to develop **Resilience and Sustainability** capabilities. These transformations should be carried out in line with the ongoing initiatives to **improve Productivity** and to **develop service-based** capabilities

CORNERSTONE	RETROSPECTIVE		2020 TURNING POINT AND WHAT'S NEXT	
	PRODUCTIVITY	**SERVITIZATION**	**RESILIENCE**	**SUSTAINABILITY**
STAKES	Over the past years, Manufacturers have been focused on **improving productivity**: • **Reducing costs** • **Improving throughput** • **Improving Quality**	Digitalization has driven the **transformation towards Product as a service** to diversify revenue streams: • **Developing added value services above product** • **Adapting business model and organization**	The Covid Crisis created the need to develop **reactivity to change** capabilities. **Adaptability will become the new normal:** • **Value stream steering and optimization** • **Customer centricity & agility** • **Reduced R&D cycle and TTM**	**Eco-responsibility** became a major **societal issue** and needs to be embodied by companies: • **Ecological standards compliance** • **Brand Image improvement**
TECH LEVERS	**4.0 Factory Transformation** launch: • Go beyond computerization and **blur Physical and Digital Worlds** • **Bring intelligence** through smart technologies • **Automate everything** physical and digital	Implement an **extended digital ecosystem** to design and provide end-to-end services: • Develop **Smart and connected products** • Make **Software and IT as an integral part of products** • **Capitalize on the data** generated by connected products	**4.0 Factory improvement** – leverage tech to react to changes: • Make **R&D fully Digital** • Install **multimodal sourcing & sales** channel • Foreseen changes with **Big Data & Analytics** • Rely on an **Open and connected IS**	**Leverage mature technologies** such as IoT and Analytics to ensure sustainable & compliant solutions, energy efficiency and carbon footprint reduction
FACTS	**2019** **75% of manufacturers have ongoing smart factory initiatives***	**2019** **72% of manufacturers plan to develop Services-based capabilities**	**2020** **55% of Supply chain leaders seek to improve resilience in next years**	**2019** **62% of automotive companies developed a sustainability strategy**

Technologies have become a must have to drive these transformations. Through this Tech Radar we will share with you our convictions on **how emerging Technologies will help you thrive**.

TO GO FURTHER

Digital and Smart Manufacturing relies on Information Systems transformation. **Capgemini's Smart MOM solutions and architectures** are targeted at the challenges faced by Manufacturers by connecting industrial objects and people with business processes. **Capgemini supports your transformation** toward an architecture:
- Wide and Scalable, based on Cloud platforms
- Interoperable, by connecting in real time enterprise applications (ERP, CRM…), engineering solutions (PLM/ALM) and machines & industrial infrastructure

1.SECTORIAL EXEC SUMMARY

MAJOR MOVES OF KEY SECTORIAL STAKEHOLDERS REGARDING TECHNOLOGIES IMPACTS ON VALUE CHAIN

MANUFACTURERS PLAYERS X BIG TECH

LARGE MANUFACTURERS HAVE BEEN LOOKING TO PARTNER WITH KEY DIGITAL ACTORS TO LEVERAGE THEIR EMERGING TECHNOLOGIES' EXPERIENCES

Microsoft	**BMW**	2019: **Open Manufacturing Platform** to support smart factory development – Capgemini joined in 2020
Microsoft	**Airbus**	2019: **Mixed Reality cases** for production, maintenance and training
Google Cloud	**Renault**	2020: **Digitization of production** facilities and supply chain, both in terms of technologies and skills
AWS	**Volkswagen**	2020: **Cloud industrial platform** – open marketplace for Smart factory solutions

PRODUCTS AND SERVICES PROVIDERS

PRODUCTS AND SERVICES PROVIDERS ARE CREATING PARTNERSHIPs TO STRENGTHEN MANUFACTURERS TRANSFORMATION OFFERS

Siemens	**SAP**	2020 : **develop integrated end-to-end software solutions** across product lifecycle, supply chain and asset management
ABB	**Ericsson**	2019 : **accelerate wireless automation for flexible factories** and bring 5G and Industry 4.0 into the industrial ecosystem

CONVICTIONS ON THE SECTORIAL MAIN TRENDS BASED ON TECH AND SECTOR MATURITY ANALYSIS

The **digital transformation of your organization will have to rely on must have technologies** already adopted by the manufacturing players to fully unleash the potential of the upcoming new technologies. Here is **our conviction regarding the key tech levers** to keep an eye on for the next few years :

BUSINESS ADOPTION

TECHNOLOGY MATURITY		ADOPT NOW	READY TO SCALE	IDENTIFYING USE CASES
	MATURE	**Big data and Analytics** **Internet of Things (IoT)** **Robotics** **Standard AI**	**Virtual Reality:** Enable a friction-less monitoring of the operations **Augmented Reality:** Reinvent the manufacturing and maintenance phases	**Blockchain:** Ensure traceability and security along the value chain and strengthen the operational excellence thanks to "smart contracts"
	MATURING		**5G Network:** Unlock a massive use of digital tools and technologies **3D printing:** Standardize the prototypes, components & spare parts production and allows generative design	**New AI tech:** Strengthen existing tools & technologies with deep learning & sharpened smart models
	EXPLORATORY			**Quantum Computing:** Enhance intelligent systems thanks to a large computing power **Tiny ML:** Bring machine learning at the scale of the device and reduce ML running costs **Light-based manufacturing:** Replace the traditional robotics to manufacture tiny electronic components faster and cheaper

2.1 HOW VALUE CHAIN IS DISRUPTED BY TECH

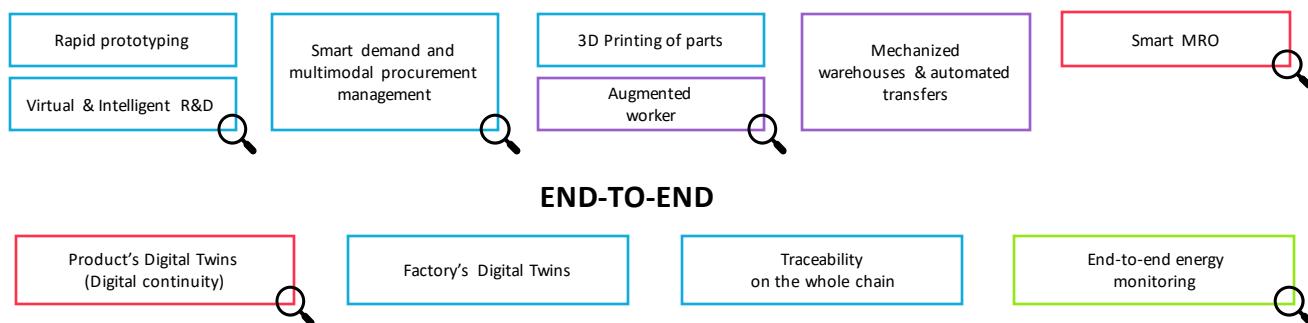| Research & development	Planning & sourcing	Production	Logistics	Maintenance

CHALLENGES

Research & development	Planning & sourcing	Production	Logistics	Maintenance
• Accelerate time to market • Include customers at the earliest stage in the development process	• Sharpen the existing analytical tools • Ensure resilience to unpredictable events for procurement	• Strengthen production operations (processes, productivity, quality) • Monitor the entire assembly line	• Optimize transport routes & monitor conditions externally (to clients) and internally (within the factory/ the warehouse)	• Ensure a continuous & resilient value chain • Reduce the risks faced by the workers to a minimum

Rapid prototyping	Smart demand and multimodal procurement management	3D Printing of parts	Mechanized warehouses & automated transfers	Smart MRO
Virtual & Intelligent R&D		Augmented worker		

END-TO-END

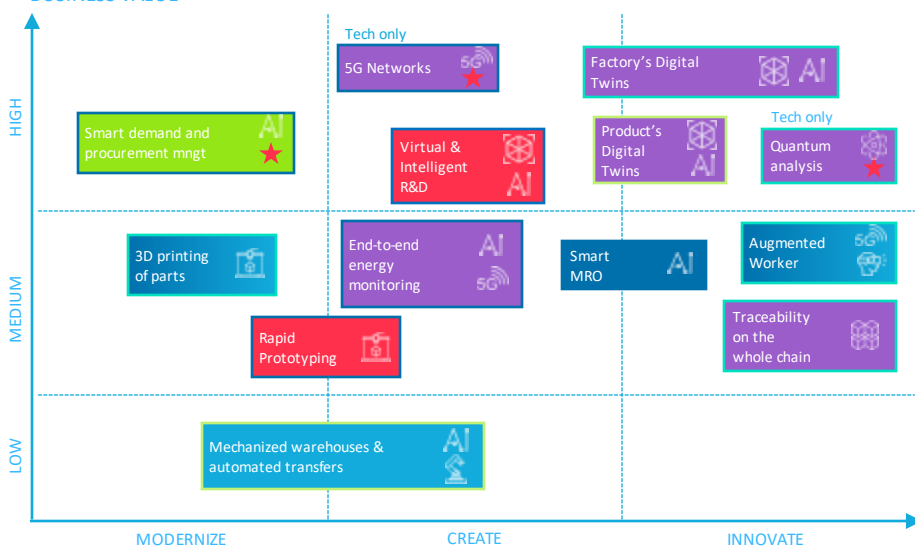| Product's Digital Twins (Digital continuity)	Factory's Digital Twins	Traceability on the whole chain	End-to-end energy monitoring

For most of the presented use case, they can only be deployed based on IoT, Big Data & Cloud solutions enablers

— Productivity   — Servitization   — Resilience   — Eco-efficiency   🔍 Use case detailed below

2.2 FOCUS ON TECH DELIVERY MATURITY & BUSINESS VALUE

BUSINESS VALUE

Tech only
- 5G Networks ★
- Smart demand and procurement mngt ★
- Virtual & Intelligent R&D
- Factory's Digital Twins
- Product's Digital Twins
- *Tech only* Quantum analysis ★
- 3D printing of parts
- End-to-end energy monitoring
- Smart MRO
- Augmented Worker
- Rapid Prototyping
- Traceability on the whole chain
- Mechanized warehouses & automated transfers

HIGH / MEDIUM / LOW

MODERNIZE   CREATE   INNOVATE

Value chain positioning :

End-to-end	Production and Logistics	Product development	Planning & Sourcing	Maintenance	★ Must have

Horizon

— < 2 years	— 2-3 years	— > 3 years

- 5G Network
- Quantum
- Blockchain
- 3D Printing
- Virtual reality
- Augmented reality
- Robotics
- AI

TECHNOLOGIES ROADMAP TAKEAWAYS

We identified essential techs to drive future transformations:

- **Must have Techs. :** IoT, Big Data & Analytics, Robotics and AI are at the core of the Value Chain, especially to address **Productivity** and **Sustainability** issues

- **Future Must have Techs. :** 5G and over the long-term Quantum, will improve the mass of data transferred and the computing power mainly to improve **Productivity**. AI will bring intelligence into the whole value chain to improve **Resilience** capabilities

3. FOCUS ON VALUE CHAIN BLOCKS FED WITH USE CASES

RESEARCH & DEVELOPMENT

- Up to -40% TTM
- Customer centricity
- Mature and proven techs.
- 3D Printing & AR/VR

- **Stakes and why now:**. In the coming years, manufacturers should develop capabilities around customer centricity and faster time-to-market to respond to increasing levels of uncertainty & a high demand volatility
- **How tech can help:** Develop new ways of prototyping and testing products through smart 3D printing with AI and Virtual Testing
- **Emerging Uses cases examples :**
  - **Short term:** Rapid and cost-efficient prototyping through 3D printing enabling more frequent iterations, intelligent & generative design process and faster convergence on product development; **Maturing & ready to scale technology**
  - **Mid term:** Virtual testing of products relying on Augmented or Virtual reality solutions to strengthen collaboration and accelerate decision making processes; **Technology mature & ready to scale**

PLANNING & SOURCING

- Up to -60% in lost sales
- Vulnerability to change
- Mature and proven techs.
- AI & Big Data

- **Stakes and why now:** The Covid Crisis pointed out a new issue faced by manufacturers : Resilience. Covering the unveiled vulnerabilities regarding the companies' resilience to change (drop in orders, shift towards 100% online services) has therefore become the new major challenge
- **How tech can help:** Reinforce planning and sourcing accuracy by leveraging the diversity of data from sales, operations and eventually external sources
- **Emerging Uses cases examples :**
  - **Short term:** Advanced Sales & Operations and demand planning tools supported by AI & Big data analytics to increase accuracy and flexibility. In addition, AI can be used to support multimodal procurement implementation and optimization ; **both techs are mature enough to create a competitive edge rapidly**

PRODUCTION

- Up to 99.99% quality
- Productivity & Resilience
- 5G to accelerate transformation
- IoT, 5G, AR & 3D printing

- **Stakes and why now:**
  - **Productivity** : Continue the trend towards Operational Excellence (quality, cost, energy …) as production is the heart of manufacturers' value chain and therefore remain competitive
  - **Resilience** : Following the Covid Crisis, manufacturers should develop new practices to increase reactivity to change of their factory (parts shortage, …)
- **How tech can help:** Optimization of production through 5G deployment and AI bringing intelligence into production monitoring; Developing new resilient production methods thanks to 3D printing
- **Emerging Uses cases examples :**
  - **Productivity use case**: IoT installed on the machinery and use of AR smart glasses and other tools supported by a potent 5G network and a cloud-based data management system to Increase reliability of operational activities performed by workers; **Technology mature & ready to scale**
  - **Resilience Use case:** Implement 3D printing capabilities into factories to address parts shortage and replicate virtually the product to monitor its life cycle thanks to Digital Twins; **Maturing technology almost ready to scale**

3. FOCUS ON VALUE CHAIN BLOCKS FED WITH USE CASES

LOGISTICS

- Productivity and Agility
- Mature techs..
- IoT, Big Data and Robotics

- **Stakes and why now:** Productivity improvement required to optimize transport routes externally (to clients) and internally (within the factory/ the warehouse). In addition, customer centricity should be addressed by reshaping the logistics from a big risk & cost center to a competitive advantage by enabling transparency and client delivery monitoring.

- **How tech can help:** Bring intelligence to transportation and improve monitoring capabilities to ensure "0 default" due to transportation and develop new services toward customers

- **Emerging Uses cases examples :**
  - **Short term**: Big Data can be used to optimize transport routes & reduce energy consumption; **Mature technology**
  - **Mid term** : The use of IoT within the containers can monitor the product conditions at an extreme precision; **5G deployment to support use case adoption**
  - **Mid term**: Robots can be used to mechanize the warehouses and to automate inhouse transfers; **5G deployment to support use case adoption**

MAINTENANCE

- Up to -12% manuf. Costs
- Productivity & compliance
- AI mature solutions
- IoT & AI, AR, 3D Printing

- **Stakes and why now:** Continue the trend towards Operational Excellence by reducing maintenance costs of both manufacture products and production tools and machines

- **How tech can help:** Bring intelligence to maintenance processes to better anticipate operations and support worker

- **Emerging Uses cases examples :**
  - **Short term**: 3D printing of spare parts reduces emergency reaction time & related costs; **Highly mature technology**

  - **Mid term** : Maintenance operation optimization through "Augmented worker" thanks to AR devices coupled with PLM tools; **Technology ready to scale with 5G deployment**

  - **Long Term :** Predict defaults and/or needs for inspection and access machine learning potential at the device's scale by leveraging IoT and Tiny ML; **Exploratory technology**

END-TO-END

- Energ. Mgmt: up to -25% energy costs
- Resilience
- 5G to accelerate IoT and AI transformation
- IoT, AI, 5G, Blockchain

- **Stakes and why now:** Improve resilience and develop sustainability on the whole value chain are now key stakes faced by Manufacturer. On one hand, manufacturers should develop reactivity to change capabilities to anticipate future crisis and on the other they should improve energy efficiency & reduce carbon footprint to meet regulations and improve brand image

- **How tech can help:** Bring intelligence to the value chain management to simulate change and reinforce capability to adapt. Develop Energy monitoring capabilities to optimize eco efficiency

- **Emerging Uses cases examples :**
  - **Short term:** Smart Energy Management based on End-to-end IoT and power monitoring tools

  - **Mid term** : Set and monitor a Digital Twin of the product and ensure digital continuity on the value chain through IoT and digital simulation in order to reinforce resilience

  - **Long Term:** Increased traceability and transparency thought the implementation of a secured and non-alterable ledger (Blockchain) coupled with IoT

4. FOCUS ON USE CASES AND ASSOCIATED TECHNOLOGIES

PRODUCT'S DIGITAL TWIN

END-TO-END

- **Goals:** Increased operational efficiency and set a foothold towards the product-as-a-service transition
- **Means:** Digital continuity along the life cycle of a product, from conceptualization to maintenance
  - Digital representation of a product coupling the two models ("Digital Twins"):
    - The "Concept" model referring to the product as an extensive list of parameters & configurations defining its characteristics
    - The "Real-life" model representing the product as manufactured and its status in operation
  - IoT field allowing to monitor the product's condition from its manufacturing process to its maintainability and to virtually simulate specific events & related outcomes (regulatory requirements, quality assurance, functional safety, ...)
  - ERP, MES (Manufacturing Execution system), CRM & PLM softwares communicating in real time to facilitate access to any data linked to every stage of the product's life cycle
  - 5G as a key enabler to unleash the full potential of virtualization thanks to a more stable, more powerful and faster network

MARKET TECHNO IMPACT

Market and techno rationales:
The technologies are ready to be used but in order to optimize the outcomes of duplicating virtually, manufacturers will need to develop their activity & process mapping capacity (through an extensive use of IoT, for instance)

TECHNOLOGIES — VIRTUAL REALITY

IOT   5G

AI

Why now

- Incoming transition towards 5G, enabling an extensive usage of IoT and connected virtual reality solutions

Key success factors:

- Digitization of the entire value chain & constant updates to keep the virtual twins consistent

VIRTUAL & INTELLIGENT R&D

RESEARCH & DEVELOPMENT

- **Goals:** Time-to-market acceleration
- **Means:**
  - **Step 1 : Virtual design and testing of parts & prototypes on computers**
    - Computer-aided design (CAD) generated prototypes manipulated remotely by the product development team, allowing more flexible workflows & faster decision making
    - Enhanced CAD method to support a virtual, iterative and massive creation of AI-generated designs, satisfying specifics criteria with the perspective of printing it in 3D
    - Virtual recreation of environments almost identical to real-life to test a variety of parameters (heat/pressure/choc resistance, design, weight) and to simulate specific conditions (space, deep waters, extreme heat, etc.)
  - **Potential next turning points**
    a) Immersive rooms creating a complex virtual environment to free the technicians, workers, researchers from physical restraints
    b) Computational threshold reached by the current computers pushed by quantum computing for more complex simulations

MARKET TECHNO IMPACT

Market and techno rationales:
- Pioneer companies already implementing such solutions (GM, Airbus, Ford, ...) but most are still at the POC phase
- Product development acceleration & prototyping cost reduction supported by an ever-perfecting technology

TECHNOLOGIES — VIRTUAL REALITY   AI   AI

AUGMENTED REALITY

3D PRINTING

Why now :

- Need to transition towards a more agile product development process
- Increasing demand for flexible work life from stakeholders (i.e remote) accelerated by the Covid-19 crisis

4. FOCUS ON USE CASES AND ASSOCIATED TECHNOLOGIES

SMART DEMAND AND MULTIMODAL PROCUREMENT MANAGEMENT

 PLANNING

- **Goals:** More accurate forecasts reducing inventory & potential shortfalls

- **Means:**

  - **Step 1 : Machine learning-based with multi modal tool implementation**

    - Predictive analysis model coupled with the use of Artificial Intelligence (Feed Forward, Recurrent and/or Convolutional neural network)

    - Connection between internal & external data linked to real-time information (prices, regulations, weather condition, etc.) allowing a smart replenishment strategy & reduction in inventory

    - Multi-modal routing method unlocking global agility to monitor the procurement activities (suppliers, routes, means of transports) & increasing resilience to unpredicted events

  - **Step 2 : Quantum computing for enhanced accuracy**

    - Possibility to free the existing computers from their existing computational threshold (even if supported by AI tools) to perform much more accurate analysis

- **Benefits*:**
  - -40% forecasting errors on average
  - Up to -60% in lost sales
  - Between -20% and -50% of inventory levels

MARKET TECHNO IMPACT

Market and techno rationales:
Technology not yet entirely adopted in the manufacturing sector vs Consumer Goods/Retail where it is more mature and where it demonstrated great added value

TECHNOLOGIES
BIG DATA
QUANTUM
AI

Why now

- Mature technology
- "just-in-time" production settings democratization

SMART MRO

 MAINTENANCE

- **Goals:** Anticipated maintenance & updates for optimal performance & improved customer experience

- **Means:** IoT field deployed on the tools & machines gathering heavy data flows

  - **Current use case**

    - Captors, sensors & camera installed in & around the machinery, monitoring performance & other information (use rate, environmental data, unit flow, etc.)

    - Powerful data processing tools based on Machine learning allowing to predict defaults and/or needs for inspection

  - **Potential next turning points**

    a) Replacing the current IoT field and develop a Tiny ML devices network to reduce complexity within the IS infrastructure (lighter data flows), the hardware's interconnectivity (smaller devices) and the energy consumption (low-powered devices)

    b) Unlocking the necessary computing power to develop much stronger predictive analysis and capitalize on the data generated by the IoT fields thanks to Quantum Computing

MARKET TECHNO IMPACT

Market and techno rationales:

Predictive maintenance already well implemented in the industry but can be mutualized with AI tools to strengthen & multiply its impacts

TECHNOLOGIES
BIG DATA
QUANTUM
AI
IOT

Why now :

- Ability to maintain continuous operations becoming a key success factor in the industry

4. FOCUS ON USE CASES AND ASSOCIATED TECHNOLOGIES

THE AUGMENTED WORKER

PRODUCTION

- **Goals :** Increased reliability of operational activities (assembly, picking, maintenance), reduced risks and stronger productivity at every manufacturing stage
- **Means :** IoT installed on the machinery and use of AR smart glasses and other tools supported by a potent 5G network and a cloud-based data management system
  - Massive deployment of IoT objects at every stage of the manufacturing process, transferring data through a 5G network : Higher-speed traffic enabling real-time monitoring without latency while reducing transmission & energy cost (adjustable network flow based on actual & planned bandwidth requirements)
  - Use of Smart glasses displaying information captured by the captors & camera installed, helping the technician to monitor specific elements such as heat, pressure, resistance, weight, etc. with possible integration inside a collaboration system such as Microsoft Teams to streamline communications throughout the organization (i.e to a remote expert for support)
  - Maintenance application : remote collaboration & "just-in-time" mentoring for maintenance operations optimized for challenging environments leading to faster resolution time, increased productivity & worker safety, and higher uptime for customers

MARKET   TECHNO   IMPACT

Market and techno rationales:
AR technology becoming more impactful for the manufacturing sector, especially with the upcoming 5G network (higher fluidity, better image quality, more information displayed, large pool of IoT supporting the usage…)

TECHNOLOGIES   IOT

          5G

          AUGMENTED REALITY

Why now :

- Incoming transition towards 5G, enabling an extensive usage of IoT and AR solutions
- Data usage limited in the current LPWAN IoT fields

Key success factors :

- Interconnected & open IS structure

END-TO-END ENERGY MONITORING

END-TO-END

- Cost and CO_2 footprint reduction
- **Means:** End to end IoT and power monitoring tool implementations
  - **Step 1 : Global watch of the energy grid**
    - IoT captors are installed within the electric grid to monitor the consumption & the activity, and to capture data on a global scale
    - Real time monitoring through high-granularity energy consumption analysis made possible by the application of a 5G network
    - Advanced cloud-based data analytics models allowing to predict energy consumption for a better procurement management
  - **Step 2 : Develop a smart monitoring grid**
    - Deploying new generation of IoT objects with embedded machine learning potential (tiny ML) for reduced energy consumption, better monitoring and a smart management of the energy grid
  - **Benefits examples**
    - +26% energy cost reduction
    - +78% CO^2 reduction
    - +20% accuracy for energy demand forecast

MARKET   TECHNO   IMPACT

Market and techno rationales:
- Large corporations already implementing such solutions (Siemens, Airbus …)
- A vast number of start-ups supporting its spread (GreenFlex, Lition, STEM, …) with differentiated solutions

TECHNOLOGIES   IOT   BIG DATA

          5G   CLOUD

          AI

Why now :

- Mature technologies & upcoming transition towards 5G
- Strong regulatory requirements on CO^2 footprint
- Customer expectation shift

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