

5G-Next Generation Networks Programme Repository of use cases

The Impact of 5G: Creating New Value across Industries and Society

November 2019

Overview

This repository of use cases across vertical industries is organized by use case category. The results of the collective analysis of 40 use cases, 35 of which are included in this document, are provided at the end. These results have been incorporated into the World Economic Forum White Paper titled “The Impact of 5G: Creating New Value Across Industries and Society”.

The framework used includes a mapping of 5G functional drivers, key industry advancement areas and the impact on other industry verticals and on society, using the United Nations Sustainable Development Goals as a reference and applying an impact pathway methodology to arrive at key tangible measures. A simple maturity roadmap of 5G functional drivers indicates potential enhancements.

Primary vertical	No. of use cases in this document
Manufacturing	14
Transportation	10
Public services (govt.)	2
Health and social work	3
Agriculture	1
Energy	1
Logistics	1
Media & entertainment	1
Mining & quarrying	1
Professional services	1

Use case category	No. of use cases in this document
Internet of Things	6
Mixed reality	6
Autonomous driving	5
Drones	3
Robotics	3
Artificial Intelligence	3
Advanced communication systems	3
Cloud	2
3D Printing	1
Digital twin	1
Simulation / Imaging	1
Gamification	1

Secondary vertical	No. of use cases in this document
Machinery & equipment	11
Automotive	8
Logistics	3
Railways	3
Education	2
Info & communications	2
Semiconductors	2
Urban infrastructure	2
Consumer	1
Sports	1

Use case category:
Advanced Communication systems/ networks (3)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- KT is taking the lead in providing new technologies and services based on 5G's ultra high speed, ultra low latency and hyperconnectivity, thereby creating socio-economic value for the general public.
 - **2015:** Announcement of the Vision for the World's First 5G Commercialization
 - **2015:** World's first 5G SIG (Special Interest Group) Common Specifications
 - **2016:** First successful 5G call
 - **2018:** World's first 5G Olympic Games



Key Players

Use case ecosystem:

Suseo–Pyeongtaek high-speed railway or Super Rapid Train (SRT), AR/VR equipment provider, cloud service provider, skilled workforce, content creators

Use case impact on the other sectors

Business intelligence, analytics solutions	Engineering	Insurance and finance	Logistics
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Key Facts

- Augmented reality by KT:
- KT, South Korea's biggest telecom company, worked with Disney to promote its first 5G network with an AR game based on the movie "Avengers: Endgame".
 - The "Catch Heroes" mobile game challenged players to collect 140 types of virtual cards in their surroundings, similar to the gameplay of Niantic's "Pokémon Go".
 - KT also uses the AR tech to carry out remote maintenance activities for railways.



Commercial Impact

- Expected to reach US\$ 85.0 billion by 2025, at a CAGR of 33.7% from 2018 to 2025 (<https://www.marketsandmarkets.com/PressReleases/augmented-reality.asp>)
- Reduced execution time and breakdowns
- Benefits due to increased productivity and operation speed
- Increased bottom line revenue
- Overall impact on GDP of an economy due to efficient logistics



Uniqueness

- Object detection- Visual analysis technology
- Voice control- Hands-free control with voice recognition technology
- AR remote supporter- AR-based remote support service between an expert and a field staff based on 5G videoconferencing
- GiGA storage overview- Fast storage service with integrated access to multiple devices storing AR content
- AR drawing- AR-based marking and indicating service for a field staff by an expert



Potential Societal Value

- Reduced emissions owing to remote maintenance support
- Increased digital skill set for the local workforce
- Reduced maintenance times, resulting in increased capacities
- Safer working environments for majority of the operations and maintenance staff

SDG impact



Decent work and Economic Growth



Sustainable Consumption and Production



Improvement areas/business benefits: Maintenance

Faster and effective inspections with predictive intelligence

Improved worker safety/ reduced fatalities

Managing carbon footprints/CO2 emission per unit of value added

Value added as a proportion of GDP and per capita due to reduced operating costs

Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency



5G Features Mapping

Illustrative impact pathway- AR for express railway maintenance

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Network and cloud infrastructure AR equipment Software applications Opex for: <ul style="list-style-type: none"> Training for operations and maintenance staff 	<ul style="list-style-type: none"> Visual analysis technology Hands-free control with voice recognition technology AR remote supporter GiGA storage overview AR drawing 	<ul style="list-style-type: none"> Improved object/collision detection capabilities Fast storage service with integrated access to multiple devices storing AR content AR-based indicating service for a field staff by an expert 	<ul style="list-style-type: none"> Enhanced sectoral performance [SDG 8: Decent Work and Economic Growth] Reduced usage on resources due to remote monitoring, maintenance [SDG 12: Responsible Consumption and Production] 	<ul style="list-style-type: none"> % reduction in operations and maintenance expenses % capacity enhancement Economic growth % increase in skilled job creation



Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



5G Maturity Timeline



Current State

- Cloud infrastructure backbone
- Faster image/video processing



Short Term (1-3 yrs)

- Enhanced real-time data gathering and alerts



Long Term (3+ yrs)

- Real-time machine learning and AI



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Nokia has declared >2,000 5G standard essential patent families to ETSI, reflecting its leadership in R&D and standardization.
- As of Oct. 2019, Nokia had >100 customer engagements and 48 commercial 5G deals on 6 continents. Nokia is the only player present in all 10 of the tier-1 cloud service providers (CSPs) in 3 of the 5G early adopter markets (US, South Korea and Japan).
- Nokia is the only vendor with expertise and global leadership across all 5G network elements. It has a track record supplying GSM-R, making it ready to handle the interworking of new 5G and existing GSM-R networks, crucial during the network migration phase.



Key Facts

- 5G offers a major opportunity for rail operators to transform their operations for the better.
- Its high-speed and extreme traffic handling capacity, together with ultra-low response times, highest reliability and support for massive machine type communication (IoT), will allow rail networks to improve safety, optimize costs and make their services more attractive to passengers in many ways.
- Such capabilities will make the telecommunication network the cornerstone of railways' ambitions for further digitization.



Uniqueness

The Nokia Bell Labs Future X architecture:

- An increase in freight and passenger miles on existing infrastructure demands implementation of new signalling and control systems, such as the European Train Control System (ETCS) and communications-based train control (CBTC).
- It is built with a dynamic mesh fabric around a high-performing IP/optical/microwave core; railways use wired or wireless access to connect with people, sensors, trains, video monitors and automated train control, all securely and with the highest reliability.



Key Players

Use case ecosystem:

Rail operator, regulatory agencies, Communications systems provider, analytics platform provider, European Train Control System (ETCS)

Use case impact on the other sectors



- Lower costs but also less human error and greater safety
- Lower maintenance and operational costs through the efficient operation of rolling stock, based on real-time information and improved communication between moving trains, maintenance staff and track-side systems
- Consolidation of fragmented legacy networks with a unified 5G network capable of running multiple services



Commercial Impact

- Lower operating costs due to faster and effective inspections
- Reduced number of incidents
- Safer rail operations



Potential Societal Value

SDG impact



Decent Work and Economic Growth



Sustainable Consumption and Production



Improvement areas/business benefits: Railways

Bridging digital divide/ proportion of population covered by a network, technology

Faster and effective inspections with predictive intelligence

Improved worker safety/ reduced fatalities

Managing carbon footprints/CO2 emission per unit of value added

Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency

Illustrative impact pathway for Régie Autonome des Transports Parisiens (RATP)

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Transmission and IP routing infrastructure Ultra broadband network Video surveillance cameras 	<ul style="list-style-type: none"> Wi-Fi access at the stations Communications-based train control (CBTC/ ETCS) In-train and on platform video surveillance system Passenger information system 	<ul style="list-style-type: none"> Reduction in overall maintenance schedules and downtime Increased customer satisfaction owing to ubiquitous connectivity Increased security intelligence 	<ul style="list-style-type: none"> Economic productivity [SDG 8: Decent Work and Economic Growth] Sustainable and efficient use of resources [SDG 12: Sustainable Consumption and Production] 	<ul style="list-style-type: none"> Increased bottom line Material footprint, material footprint per capita % increase in employment of specialized jobs Tourism direct GDP

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- High-definition entertainment on board
- The digital passenger

Short Term (1-3 yrs)

- Predictive maintenance and operations intelligence

Long Term (3+ yrs)

- Automatic train operations



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3. Exclusive 5G use case



Company Background

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- As of Oct. 2019, Nokia had >100 customer engagements and 48 commercial 5G deals on 6 continents. Nokia is the only player present in all 10 of the tier-1 cloud service providers (CSPs) in 3 of the 5G early adopter markets (US, South Korea and Japan).
- Nokia is the only vendor with expertise and global leadership across all 5G network elements. Its end-to-end portfolio offers the technology and services for a tailored, seamless, pre-integrated path to 5G, supporting all 66 3GPP frequency bands.



5G Ecosystem

Use case ecosystem:

Hospital, solution partner, network provider



Neusoft



Use case impact on the other sectors

Cities/urban infrastructure	Public sector (government)	Insurance and finance	Transportation (mobility)
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Key Facts

- Hospitals have rigid demands to improve patient healthcare services.
- AI and big data solutions are to be implemented as innovative solutions.
- New solutions for both in-hospital and pre-hospital services are expected.
- Providing care to patients in rural areas is also a hot topic.
- Data security must be assured.
- Nokia is working with the First Affiliated Hospital of Zhengzhou University on the use of 5G for healthcare and partnering with Neusoft Medical Systems.



Commercial Impact

- The telemedicine market was valued at over US\$ 38.3 billion in 2018 and is expected to grow more than 19% CAGR from 2019 to 2025.
- 5G will support the convergence of vertical applications onto a single common wireless network. This is expected to be accomplished through advances in network function virtualization and software-defined networking, allowing the flexible usage and configuration of network functions to enable use cases with very diverse requirements by means of network slices.



Uniqueness

- 5G coverage in hospital wards with remotely controlled robots for ward inspection
- 5G-enabled enhanced remote diagnosis
- 5G-enabled enhanced ambulance service
- AI and big data solutions implemented as innovative solutions



Potential Societal Value

- Medical coverage in rural and remote areas is available with the help of 5G networks.
- The transport of patients is reduced due to the availability of 5G-enabled healthcare services from experts at local centres.
- Medical personnel and specialists in serious diseases are available, ensuring immediate care to patients.

SDG impact



Good Health and Well-being



Industry, Innovation and Infrastructure



Improvement areas/business benefits: Healthcare

Bridging digital divide/
proportion of
population covered by
a network, technology

Effective
and
speedy
recovery

Value added as a
proportion of GDP
and per capita due to
reduced operating
costs

Scalability of
solutions/faster
proof of
concepts

Functional drivers of 5G facilitating the use case's deployment

Enhanced
mobile
broadband

Ultra-reliable
low latency
comms.

Massive
machine-
type comms.

Security
critical

Power
efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> 5G backbone connectivity AI and big data solutions Data analytics application Robotics Wearables 	<ul style="list-style-type: none"> Faster internet access Remote visual monitoring of patients Connected hospital wards 5G-enabled ambulance services 	<ul style="list-style-type: none"> Easier access to healthcare services for patients in rural areas Availability of global expertise in remote locations Enhanced operational efficiencies for doctors 	<ul style="list-style-type: none"> Increased citizen awareness and well-being [SDG 3: Good Health and Well-being] Research and innovation [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> % revenue growth through new business opportunities due to enhanced connectivity % of lives saved due to remote monitoring % reduction in healthcare costs for users

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Faster image/video processing for enhanced remote patient monitoring

Short Term
(1-3 yrs)

- AR/VR-based healthcare using cloud edge computing

- Internet of medical skills: machine learning, real-time health systems

Long Term
(3+ yrs)

5G Features Mapping



Impact Pathway



5G Maturity Timeline

Use case category:
Artificial Intelligence (3)

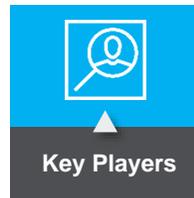


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Company Background

- Established in 2018, Bright Machines was born out of the desire to help manufacturers effortlessly and autonomously build the next generation of products.
- Bright Machine is reimagining what manufacturing will be in the future, grounded in the reality that exists on today's factory floors.
- Bright Machine digitizes factory operations, making them more transparent and accessible.



Key Players

Use case ecosystem:

Regulatory agencies, risk and legal partners, city governments, action teams (disaster response), original equipment manufacturers, network provider, software developers

Use case impact on the other sectors

Engineering	Education	Gaming	Healthcare	Artificial intelligence	Robotics
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Key Facts

- Application development for artificial intelligence (AI)
- Microfactories comprised of integrated elements that together provide a modern, AI-powered approach to automating the assembly stage on a production line
- **Brightware™** cloud-based software for design, simulation and deployment of the configuration and instructions used to set up, reconfigure and run any number of physical production lines for assembly
- **Bright Robotic Cells**



Commercial Impact

- The AI in manufacturing market is expected to grow from US\$ 1.0 billion in 2018 to US\$ 17.2 billion by 2025, at a CAGR of 49.5%.

North American factory increases production, lowers defect rates

- Unit production increased 33% per hour.
- The new micro factory required only 25% of the human touches compared to the previous, manual process.
- Defect rates reduced parts per million (PPM) by 88%.
- Assembly-line staff could be reduced by 50%.

Case study: Infotainment Electronics Console

- The existing assembly and inspection line was manual and labour-intensive, with 58 touch points that limited units produced per hour and made it difficult to reduce defect rates.
- The manufacturer replaced the assembly process with an automated, software-defined Bright Machines Microfactory to produce infotainment electronics consoles faster, with better yield and reduced defect.



Uniqueness



Potential Societal Value

- Reduced emissions due to environmental data monitoring
- Reduced number of workplace accidents
- Economic value added due to reduced operational costs
- Negative impact: less opportunity for unskilled workers

SDG impact



Good Health and Well-being



Industry, Innovation and Infrastructure



Improvement areas/business benefits: Automation in manufacturing

Customized and personalized products	Faster and effective inspections with predictive intelligence	Increasing volatility from business cycles and product life cycles, resulting in economic value addition	Scalability of solutions/ faster proof of concepts
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Bright robotic cells Brightware™ cloud-based software Machine learning and adaptive robotics Bright Machines Microfactories 	<ul style="list-style-type: none"> Higher level of intelligence to manufacturing through self-learning algorithms Digitization of factory operations, making them more transparent and accessible 	<ul style="list-style-type: none"> Reduce initial deployment and changeover time Improve return on capital investment by repurposing equipment Efficient space utilization on the factory floor 	<ul style="list-style-type: none"> Increased safety of the workforce and reduced accidents [SDG 3: Good Health and Well-being] Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> % reduction in emissions Reduced number of workplace accidents % economic value added due to reduction in operational costs Negative impact: reduction in unskilled staff

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Massive system capabilities
- Data analytics based on connected machines

Short Term
(1-3 yrs)

- Real-time and remote control of the machines

Long Term
(3+ yrs)

- Real-time machine learning and AI



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- DataProphet is a global leader in AI for manufacturing.
- The technology embeds unique adaptations and advancements of deep learning, enabling AI to have a significant and practical impact on the factory floor.
- DataProphet's solutions are built to be adapted and integrated into existing environments, making it possible for the digital transformation teams to take customers' operations from zero to AI.



Key Players

Use case ecosystem:

Cloud service provider, network providers, original equipment manufacturers, software development companies

Use case impact on the other sectors

Engineering	Education	Gaming	Healthcare	Artificial intelligence	Robotics
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Key Facts

- DataProphet's technology embeds unique adaptations and advancements of deep learning, enabling AI to have a significant and practical impact on the factory floor.
- DataProphet steers the manufacturing process into an operating region that:
 - Lowers the cost of non-quality
 - Increases efficiency
 - Provides higher yield



Commercial Impact

Predicting engine block defects and identifying high-yield operating regions

- Achievement of a 0% external scrap rate using the DataProphet solution, resulting in cost savings and an overall increase in customer satisfaction
- Monthly cost savings of between US\$ 120,000 and US\$ 140,000 due to stud weld quality in automotive assembly lines
- Savings of millions of rands per month every month, meaning a significant improvement in the bottom line



Uniqueness

- **DataProphet PRESCRIBE** accurately predicts the presence of defects. It does so by recognizing patterns that have previously been associated with one or more known defects.
- DataProphet can detect defects that the user would not otherwise be directly aware of, such as:
 - Subsurface defects
 - Latent defects (particularly important where warranty claims could be significant)
 - Uncaught quality violations
 - Hidden scrap



Potential Societal Value

- Reduction in manual intervention, resulting in overall efficiency improvements
- Client satisfaction in the quality, safety and reliability of their vehicles
- Job creation and contribution to local economy

SDG impact



Good Health and Well-being



Industry, Innovation and Infrastructure



Improvement areas/business benefits: AI in manufacturing

- Customized and personalized products
- Faster and effective inspections with predictive intelligence
- Increasing volatility from business cycles and product life cycles, resulting in economic value addition
- Scalability of solutions/ faster proof of concepts

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable low latency comms.
- Massive machine-type comms.
- Security critical
- Power efficiency

Illustrative impact pathway- Predicting engine block defects and identifying high-yield operating regions

Input	Output	Outcome	Impact	Measure
<ul style="list-style-type: none"> Capex for: <ul style="list-style-type: none"> DataProphet PRESCRIBE platform DataProphet INSPECT platform Data warehousing and cloud solutions Manpower cost 	<ul style="list-style-type: none"> Predictive model to identify defective engine blocks in advance Prescriptive model to identify high-yield operation region Improved QC inspection on subsurface defects 	<ul style="list-style-type: none"> Halved scrap rate in the first month of deployment 0% external scrap rate within three months (first time ever) 	<ul style="list-style-type: none"> Increased health monitoring of shop floor employees [SDG 3: Good Health and Well-being] Increased manufacturing output [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> % bottom line growth due to efficient ops % reduction in shop floor accidents Job creation and contribution to local economy

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Massive system capabilities
- Data analytics based on connected machines

Short Term
(1-3 yrs)

- Real-time and remote control of the machines

Long Term
(3+ yrs)

- Real-time machine learning and AI

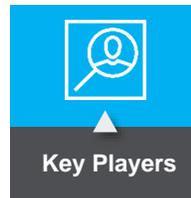


1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Dorobot, founded in 2014, develops automated warehouse solutions using cutting-edge AI and robotics, including computer vision, motion planning, mobility and deep learning.
- It covers induction, sorting, transportation and loading, and provides end-to-end solutions for logistics, express, e-commerce, seaports, airports, manufacturing and other scenarios.
- Dorobot's products include pick-and-place robots for sorting and loading, collaborative mobile robots, and planning and scheduling software for streamlining warehouse operations.



Key Players

Use case ecosystem:

Industrial robot original equipment manufacturers, industrial network provider, AI application developer, insurance, logistics, data analytics and cloud service provider

Use case impact on the other sectors

Artificial intelligence	Industries/factories	Logistics	Robotics	Security
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Key Facts

- Service offerings: pick-and-place system, mobile robots, software and services
- MARS: Multi Agent Robotic Sorting | MOMA: Mobile Manipulator
- **MARS** mobile robots leverage obstacle avoidance methods derived from simulation-trained neural networks, making them highly scalable and simple to implement; work in tandem with robot arms and forklifts
- **MOMA**: customizable wheeled robot with a programmable arm



Commercial Impact

- Robotics market valued at US\$ 31.78 billion in 2018, expected to register a CAGR of 25% over the forecast period of 2019-2024
- Implementation of AI in the supply chain, allowing companies to gain from US\$ 1.3-2.0 trillion per year
- Shorter cycle times
- Better space utilization
- Cost reduction with 24/7 AI powered robots



Uniqueness

- **MARS functionalities:**
 - Dynamic obstacle avoidance
 - Collision avoidance
 - Hot-swappable batteries
 - Auto docking and charging
 - Dynamic path planning and task allocation
- **MOMA functionalities:**
 - Multidirectional mobility
 - 3D vision to identify targets and obstacles
 - Collision-free movement
 - Tactile gripper



Potential Societal Value

- Increased safety of workers
- Reduced waste due to accurate sorting, palletizing and loading
- Enhanced employee skills with expertise in multiple applications
- Improved response times to the customers

SDG impact

3

GOOD HEALTH AND WELL-BEING

+

12

RESPONSIBLE CONSUMPTION AND PRODUCTION

Good Health and Well-being

Responsible Consumption



Improvement areas/business benefits: Robotics in logistics

Functional drivers of 5G facilitating the use case's deployment



- Customized and personalized products
- Improved product quality
- Increasing volatility from business cycles and product life cycles, resulting in economic value addition
- Scalability of solutions/faster proof of concepts

- Enhanced mobile broadband
- Ultra-reliable low latency comms.
- Massive machine-type comms.
- Security critical
- Power efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Building MARS and MOMA mobile robots Load planning software Facility design Pick-and-place systems 3D vision sensors 	<ul style="list-style-type: none"> Multidirectional mobility 3D vision identifies targets and obstacles Collision-free movement Tactile gripper Dynamic obstacle avoidance 	<ul style="list-style-type: none"> Vision sensors detection of incoming packages while monitoring load stability Accurate routing of particular boxes out of mixed singulated inflow using barcode data 	<ul style="list-style-type: none"> Increased workplace safety [SDG 3: Good Health and Well-being] Reduced recycling rate, tons of material recycled [SDG 12: Responsible Consumption and Production] 	<ul style="list-style-type: none"> % increase in capacities of sorting, palletizing and loading Enhancement of workforce skills % improvement in motion planning efficiency

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



Current State

- Massive system capacity, enabling connection of more mobile robots on the network

Short Term
(1-3 yrs)

- Network slicing: enhance service differentiation including isolation of critical traffic from other service types

Long Term
(3+ yrs)

- Real-time machine learning and AI

Use case category:
Autonomous driving (5)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Apple- Drive.ai uses AI to create self-driving transportation solutions that improve the state of mobility today.
- Apple bought Drive.ai in June 2019.
- From cars that communicate with the world around them to educational community programmes, drive.ai believes in putting people and safety first with everything they do.
- Apple- Drive.ai can scale to new cities and different use cases quickly and successfully, making self-driving a reality for more locations faster.



Key Players

Use case ecosystem:

Network provider, equipment manufacturers, automotive original equipment manufacturers, citizens, local administration, regulatory agencies, traffic control authority, mobile application developer

Use case impact on the other sectors

Cities/urban infrastructure	Public sector (government)	Insurance and finance	Logistics	Security
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Key Facts

- Apple- Drive.ai offers turnkey mobility solutions with self-driving cars for partners and communities, solving for their unique and everyday transportation needs.
- Apple- Drive.ai has partnered with the city of Arlington, Texas to offer one of the nation's first self-driving on-demand services open to the general public. Through a convenient, on-demand ride hailing system, Arlington residents and visitors can connect to office parks, restaurants, convention centres, entertainment venues and public recreational spaces throughout the area.



Commercial Impact

- The market for advanced driver-assistance systems could double by 2021, reaching US\$ 35 billion in revenue.
- €1 billion additional income can be created in the EU if half of all driving time can be utilized productively (*Bosch*).
- By eliminating the most common mistakes that cause accidents, self-driving cars would save up to 86 lives in the US every day (*Lyft*).
- Before acquisition, Drive.ai was providing shuttle service in Arlington, Texas at no cost to users.



Uniqueness

- Uses AI to create self-driving transportation solutions
- Offers turnkey mobility solutions with self-driving cars for partners and communities
- Promotes people-centric safety
- Scales to new cities and different use cases quickly and successfully, making self-driving a reality for more locations faster



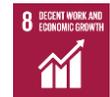
Potential Societal Value

- Reduced congestion, leading to lower transit times and reduced pollution levels
- Reduced number of road accidents
- Savings enabled by lower fuel consumption
- Reduced inequalities

SDG impact



Sustainable Cities and Communities



Decent Work and Economic Growth



5G Features Mapping

Improvement areas/business benefits: platooning

City infrastructure improvement	Faster and effective inspections with predictive intelligence	Value added as a proportion of GDP and per capita due to reduced operating costs	Ratio of land consumption rate to population growth rate
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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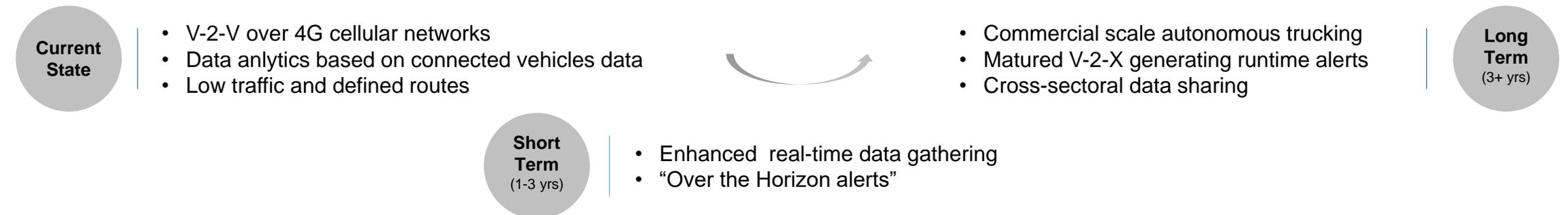
Impact Pathway

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> AV platform Network operations cloud Cloud infrastructure security LED screens on the vehicle Lidar camera 	<ul style="list-style-type: none"> Self-driving on-demand services Collision mitigation systems Connected braking Driver awareness video and info display 	<ul style="list-style-type: none"> Autonomous breaking, ensuring no attention lag, reducing collisions Appropriate level of driver engagement, ensuring the driver's focus on the driving task at all times 	<ul style="list-style-type: none"> Reduction in traffic congestions [SDG11: Sustainable Cities and Communities] Growth in GDP due to improved logistics [SDG 8: Decent Work and Economic Growth] 	<ul style="list-style-type: none"> Reduced congestion, leading to reduced pollution levels Reduced number of road accidents Savings enabled by lower fuel consumption Reduced inequalities

Speed: 1-5 Gbps Latency: <20 ms	Reliability: 99.99% Latency: <5ms	Reliability: 99.999% Latency: <1ms
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5G Maturity Timeline





1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- OTTO designs, manufactures and operates self-driving vehicles for industry, with the ultimate goal of making human driving obsolete.
- OTTO Motors is a division of Clearpath Robotics, which provides self-driving vehicles designed for indoor material transport.
- The vehicles operate with infrastructure-free navigation, offering intelligent, safe, efficient and reliable transportation within industrial centres. Proprietary hardware, software and services are delivered to provide customer excellence.



Key Players

Use case ecosystem:

Clearpath robotics, sensor manufacturers, customers (manufacturing, warehousing companies), network and cloud service providers

Use case impact on the other sectors

Business intelligence, analytics solutions	Engineering	Internet of things (IoT)	Security
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Key Facts

- A self-driving vehicle uses laser-based perception and AI to dynamically move through facilities, infrastructure-free. These vehicles combine the benefits of manual labour, conveyors and automated guided vehicles to provide the most advanced method of material transport available today.
- The OTTO platform is built on the principles of freedom and flexibility to modify automation as frequently as the changes on the floor.



Commercial Impact

- Recovery of wasted floor space for commercial purposes
- Ability to overcome labour shortages through proven use of carts and fork trucks
- Safe alternative for transportation of goods/materials, ensuring waste reduction
- Uptime with little interruption
- Data-driven decision-making, ensuring bottom line revenue growth



Uniqueness

- More than a self-driving vehicle
- Vehicles, chargers, software and services working together as an integrated inventory movement platform
- Use of onboard sensors and software to adapt to needs
- Ability to perform live operations in human-dense areas
- Centralized control system with real-time notification to operators
- Availability of tablet interface with workstation editor



Potential Societal Value

- Increase in digital skill set for the local workforce
- Reduced maintenance times, resulting in increased capacities
- Safer working environments for workforce
- Reduced material flows within the factory, resulting in lower environmental impacts

SDG impact



Industry, Innovation and Infrastructure



Good Health and Well-being



Improvement areas/business benefits: Autonomous vehicles/logistics

Functional drivers of 5G facilitating the use case's deployment

Factory infrastructure improvement	Improved passenger safety/reduced fatalities	Passenger and freight volumes, by mode of transport	Efficient logistics (inventory and dispatch management)	Managing carbon footprints/CO2 emission per unit of value added	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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5G Features Mapping

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> OTTO inventory movement platform Sensors OTTO robots Network infrastructure Cloud computing 	<ul style="list-style-type: none"> Virtual conveyance Collision mitigation systems Object and event detection and response Improved real-time inventory positioning 	<ul style="list-style-type: none"> Efficient time to market Floor space saving Reduced maintenance times Increased uptime for materials handling Increased throughput 	<ul style="list-style-type: none"> Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] Reduced number of accidents involving humans [SDG 3: Good Health and Well-being] 	<ul style="list-style-type: none"> % floor space savings % cost saving in logistics supply chain % worker compensation incidents Job creation for skilled workforce

Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Connected units for enhanced data analysis

Short Term
(1-3 yrs)

- Enhanced real-time data gathering and alerts

- Autonomous, matured V-2-X with runtime alerts
- Cross-sectoral data sharing

Long Term
(3+ yrs)

5G Maturity Timeline



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Peloton Technology is an automated and connected vehicle technology company established in 2011 and headquartered in Mountain View, California.
- It is developing a vehicle platooning system that enables pairs of trucks to operate at close following distances to improve safety and fuel efficiency. Peloton Technology was the first company to test a non-research commercial truck platooning system on public roads in the United States.



5G Ecosystem

Use case ecosystem:

Regulatory agencies, risk and legal partners, city governments, action teams (disaster response), original equipment manufacturers, network provider, software developers

Use case impact on the other sectors

Logistics and supply chain	Insurance and finance	Healthcare	Mobility	Retail and entertainment
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Key Facts

- Peloton's truck platooning system uses vehicle-to-vehicle communication to connect the braking and acceleration between the two trucks. The vehicle-to-vehicle link allows the lead truck to control the acceleration and braking of both trucks virtually simultaneously, reacting faster than a human or even radar sensors could.
- Every truck is connected to the Network Operations Cloud, which provides eligibility for being "always aware", to pair trucks or dissolve platoons at any time in response to changing weather, traffic, truck or other conditions.



Commercial Impact

- Trucking innovation opportunities in an industry with over US\$ 700 billion in annual revenue and 80% of all transported cargo
- Connected braking and acceleration, reducing collision chances and severity through automatic and immediate braking
- Cost savings due to average fuel savings of 7.25%
- Enhanced communication between drivers through an exclusive audio channel, fostering teamwork and improved driving experience



Uniqueness

- Trucks (individual or paired) can be alerted to safety conditions they may soon face, including accidents, traffic, construction and changing weather.
- To ensure safe platooning at all times, Peloton dynamically manages the geographic areas and conditions in which platooning can occur – on divided multilane highways under lower traffic conditions.
- The Network Operations Cloud intelligently commands the trucks to ensure they can drive and brake together safely.



Potential Societal Value

- Average fuel savings of 7.25% (10% for the follow truck and 4.5% for the lead truck), resulting in lesser emissions
- Safety by ensuring fewer crashes: almost instantaneous breaking of the two trucks – faster than the following truck driver would have had time to react to the brake lights

SDG impact



Good Health and Well-being



Industry, Innovation and Infrastructure



Improvement areas/business benefits: Trucking/logistics

Functional drivers of 5G facilitating the use case's deployment

5G Features Mapping

City infrastructure improvement	Improved worker safety/reduced fatalities	Passenger and freight volumes, by mode of transport	Efficient logistics (inventory and dispatch management)	Managing carbon footprints/CO2 emission per unit of value added	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Truck components Peloton Electronic Control Unit PlatoonPro system Network operations cloud Cloud infrastructure security 	<ul style="list-style-type: none"> Collision mitigation systems Connected braking Driver awareness video and info display 	<ul style="list-style-type: none"> Appropriate level of driver engagement, ensuring the driver's focus on the driving task at all times Autonomous breaking, ensuring no attention lag, reducing collisions 	<ul style="list-style-type: none"> Increased driver health and reduced accidents [SDG 3: Good Health and Well-being] Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> Increased bottom line Reduced number of accidents/crashes # of lives saved % reduction in fuel consumption % increase in capacities

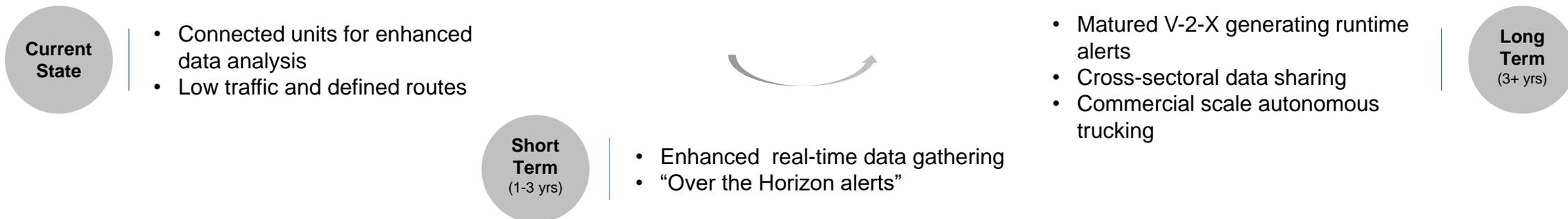
Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

5G Maturity Timeline





1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- After almost 150 years of pioneering exploration, expansion, diversification and innovation, Rio Tinto stands today as one of the world's largest producers of a range of essential materials, and a major force driving human progress.
- The company has pioneered technological innovations, such as the Mine of the Future™ programme and low-CO2 aluminium from hydropower.
- Rio Tinto's strategy focuses on the "four Ps" – portfolio, performance, people and partners – underpinned by disciplined capital allocation.

Key Facts

- Rio Tinto has successfully deployed AutoHaul™, establishing the world's largest robot and first automated heavy-haul, long distance rail network.
- At the remote control centre in Perth, Rio Tinto staff can now remotely control unmanned trucks, trains, drills and the like at the Pilbara iron mining site, a two-hour flight away in western Australia.
- Yurra Pty Ltd, which is the appointed representative of the Yindjibarndi people, provides civil maintenance services on and around Rio Tinto's Pilbara rail network in western Australia.

Uniqueness

- The \$940 million AutoHaul™ programme is focused on automating trains transporting iron ore to Rio Tinto's port facilities in the Pilbara region of western Australia.
- The network is the world's first heavy-haul, long-distance autonomous rail operation.
- Rio Tinto operates about 200 locomotives on more than 1,700 km of track in the Pilbara region, transporting ore from 16 mines to four port terminals.

Key Players

Use case ecosystem:

In collaboration with Hitachi Rail, Calibre, New York Air Brake, Wabtec, network service provider, national rail safety regulator, closed-circuit television original equipment manufacturers, analytics and cloud solution providers

Use case impact on the other sectors

Cloud solutions	Engineering	Insurance and finance	Internet of things (IoT)	Logistics
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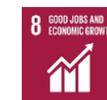
Commercial Impact

- Significant safety and productivity benefits as a result of reduced variability and increased speed across the network, helping to reduce average cycle times
- Increased logistical capacity, resulting in greater GDP contribution
- Increased top line revenue
- Reduction in operational costs due to logistical efficiencies
- An autonomous train market, in terms of volume, projected to grow at a CAGR of 4.87% from 2018 to 2030 (*MarketsandMarkets*)

Potential Societal Value

- Improved work conditions for the workforce
- Job creation to manage the digital portfolio of operation
- Increased skill set for the currently employed workforce
- Reduced number of accidents, resulting in reduced wastage

SDG impact



8 GOOD JOBS AND ECONOMIC GROWTH
Decent Work and Economic Growth



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
Industry, Innovation and Infrastructure



5G Features Mapping

Improvement areas/business benefits: Railways/logistics

- Faster and effective inspections with predictive intelligence
- Passenger and freight volumes, by mode of transport
- Managing carbon footprints/CO2 emission per unit of value added
- Value added as a proportion of GDP due to reduced operating costs

Functional drivers of 5G facilitating the use case's deployment

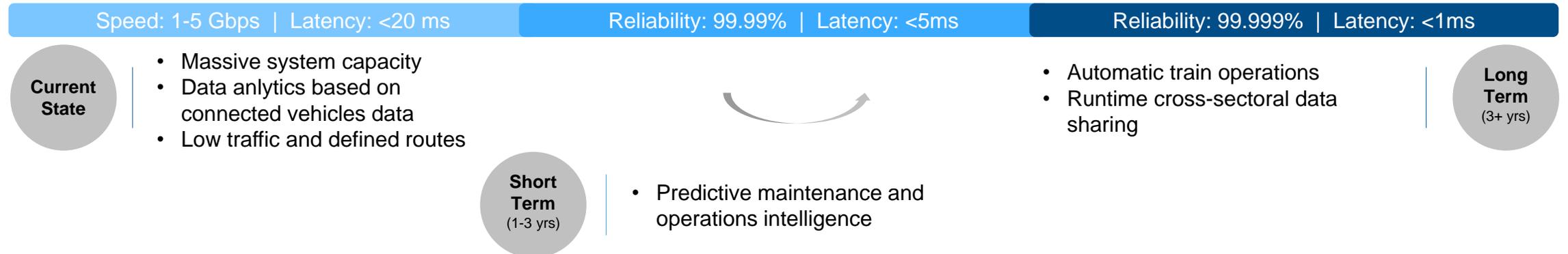
- Enhanced mobile broadband
- Ultra-reliable low latency comms.
- Massive machine-type comms.
- Security critical
- Power efficiency

Impact Pathway

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<ul style="list-style-type: none"> Capex for: <ul style="list-style-type: none"> Railway carriages Regulatory approvals Closed-circuit television infrastructure Network operations Cloud infrastructure 	<ul style="list-style-type: none"> Collision mitigation systems Connected braking Fully autonomous logistics 	<ul style="list-style-type: none"> Reduced performance variability Increased speed across the network, helping to reduce average cycle times 	<ul style="list-style-type: none"> Greater contribution to economy [SDG 8: Decent Work and Economic Growth] Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> % increase in top line and bottom line revenue Reduced number of accidents/crashes % reduction in fuel consumption Increase in skills and capacity of the workforce

5G Maturity Timeline





Starsky Robotics

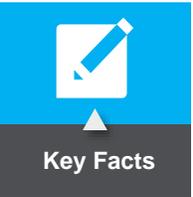
Bringing driverless trucks to market



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



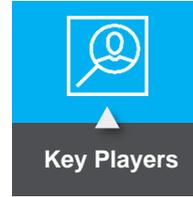
- Starsky Robotics, a San Francisco start-up trying to commercialize automated truck technology, has built a 36-truck regular trucking company to serve as a beachhead for their autonomous trucks.
- Starsky is shaping the future of the trucking industry by developing self-driving trucks with remote driving capabilities.
- Its approach to autonomous technology, coupled with remote driving capabilities, will provide Starsky drivers with a better work-life balance, fair wages and rewarding promotional opportunities.



- Starsky Robotics reports it is the first company to test an unmanned 18-wheeler on a stretch of US highway, doing so by combining an onboard self-driving system with a remote operator standing by to guide the vehicle when necessary.
- It uses teleoperation to remotely drive the truck between freight depots and the freeway where a highway-only automated driving system takes over.



- Vehicle cybersecurity
- Human machine interface: teleoperators
- Post-crash automated driving systems behaviour
- Data recording
- Object and event detection and response
- Compliance with all federal, state and local laws



Use case ecosystem:

Regulatory agencies, risk and legal partners, city governments, action teams (disaster response), original equipment manufacturers, network provider, software developers

Use case impact on the other sectors			
Public sector (government)	Insurance and finance	Logistics	Retail and entertainment



- Trucking innovation opportunities in an industry with over US\$ 700 billion in annual revenue and 80% of all transported cargo
- Reduced costs for customers while addressing the unavailability or shortage of skilled drivers
- Reduced crashes involving large trucks, which claimed 4,761 lives in the United States in 2017, 9% more than in 2016
- In partnership with governments, the realization of the employment and economic benefits offered by the automated commercial motor vehicles industry



- Solving the issue of driver shortages by allowing human drivers to work in office environments while making trucks autonomous on the highways
- Reducing the number of driver fatalities during long-haul journeys by using well-trained, well-rested teleoperators and exit-to-exit highway automation



Good Health and Well-being



Industry, Innovation and Infrastructure



Improvement areas/business benefits: Trucking/logistics

Functional drivers of 5G facilitating the use case's deployment



City infrastructure improvement	Improved worker safety/reduced fatalities	Passenger and freight volumes, by mode of transport	Efficient logistics (inventory and dispatch management)	Managing carbon footprints/CO2 emission per unit of value added
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Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Application design as per Operational design domain LTE/5G network GPS equipment Teleoperation system 	<ul style="list-style-type: none"> Object and event detection and response Deterministic automation system Connected braking Driver awareness video and info display 	<ul style="list-style-type: none"> Appropriate level of driver engagement, ensuring the driver's focus on the driving task at all times Autonomous breaking ensuring no attention lag, reducing collisions 	<ul style="list-style-type: none"> Increased driver health and reduced accidents [SDG 3: Good Health and Well-being] Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> Increased bottom line Reduced number of accidents/crashes # of lives saved % reduction in fuel consumption % increase in capacities



Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



- Connected units for enhanced data analysis
- Low traffic and defined routes



- Enhanced real-time data gathering and alerts

- Autonomous, matured V-2-X with runtime alerts
- Cross-sectoral data sharing



Long Term (3+ yrs)

Use case category:
Cloud (2)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Ericsson is driving 5G standardization and was the largest contributor to the standardization body in 3GPP during 2018.
- Ericsson has publicly announced commercial 5G deals with more than 20 named operator customers.
- Ericsson has over 40 operator memorandums of understanding worldwide and is collaborating with more than 40 universities and technology institutes as well as 30 industry partners.



Key Players

Use case ecosystem:

In collaboration with the BioRobotics Institute, Zucchetti Centro Sistemi original equipment manufacturers for industrial robots, network/spectrum provider, cloud service provider, software application provider

Use case impact on the other sectors

Public sector (government)	Healthcare	Internet of things (IoT)	Transportation (mobility)	Robotics
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Key Facts

- At present, the four types of industrial robots are:
 - Heavy single-armed robots (HEAVY)
 - Collaborative one-armed or two-armed robots (COOP)
 - Limited capability robots for dedicated use cases (LIMITED)
 - Exotic robots (EXOTIC).
- Within mobile, radio technologies will provide the wanted level of performance; thus the capabilities of 4G and 5G radio systems will enable 5G cloud robotics and facilitate the uptake of robotics in new applications.



Commercial Impact

- Smarter robots can carry out a greater number of tasks in the manufacturing process, allowing their human counterparts to be employed in other areas. This enhances safety – particularly where dangerous chemicals are involved.
- Smarter robots enable increased industrial automation, both in manufacturing and agriculture, minimizing the need for plant infrastructure and dramatically reducing costs.
- Tractica forecasts global revenue for cloud robotics will increase from US\$ 5.3 billion in 2018 to US\$ 170.4 billion in 2025 (*Roboticsbusinessreview*).



Uniqueness

- Usage of more powerful computing resources in the cloud (e.g. for AI tasks)
- Data from the internet for decision-making and learning (including digital twins)
- Lower cost per robot as functionalities are offloaded to a central cloud
- Possibility to perform a failover in case one robot physically breaks from an up-to-date backup in the cloud
- Easier operation and maintenance (software updates, configuration change, monitoring, etc.)



Potential Societal Value

- More efficient use of water in agriculture and reduced energy consumption
- Harnessed solar power by industries to power automated processes
- Reduction in carbon footprint
- Increased skills capital among the workforce

SDG impact



Decent Work and Economic Growth



Sustainable Consumption and Production



Improvement areas/business benefits: Cloud robotics

Functional drivers of 5G facilitating the use case's deployment



5G Features Mapping

Faster and effective inspections with predictive intelligence	Improved worker safety/ reduced fatalities	Value added as a proportion of GDP and per capita due to reduced operating costs	Scalability of solutions/ faster proof of concepts	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Shop floor robots Edge cloud platform Network connectivity Software PLC platform AI solution 	<ul style="list-style-type: none"> Connected robots on the shop floor Improved response time and precision of trajectory execution 	<ul style="list-style-type: none"> Increased capabilities for AI Quick decision-making and learning Runtime failover in case any robot physically breaks 	<ul style="list-style-type: none"> Increased throughput of the manufacturing process [SDG 8: Decent Work and Economic Growth] Waste reduction and use of unconventional energy sources [SDG 12: Sustainable Consumption and Production] 	<ul style="list-style-type: none"> Increased bottom line % reduction in fuel consumption % increase in economic value added % increase in skills capital

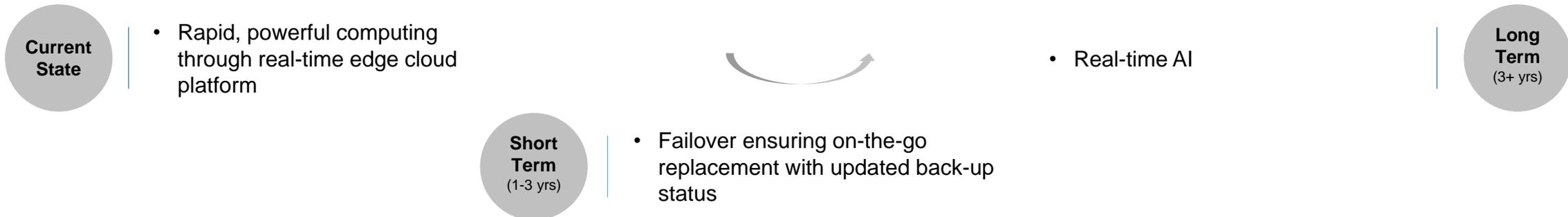
Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



5G Maturity Timeline





1. Already using 5G ●
2. Use of 5G will significantly enhance the outcome ●
3. Exclusive 5G use case ●



Company Background

- Schneider Electric develops connected technologies and solutions to manage energy and process in ways that are safe, reliable, efficient and sustainable.
- The company invests in R&D to sustain innovation and differentiation, with a strong commitment to sustainable development.
- It combines world-leading energy technologies, real-time automation, software and services into integrated solutions for homes, buildings, data centres, infrastructure and industries.



Key Players

Use case ecosystem:

Carriers, cable companies, telco equipment manufacturers, internet giants, colocation centres, IT vendors, integrators and real estate “owners”

Use case impact on the other sectors

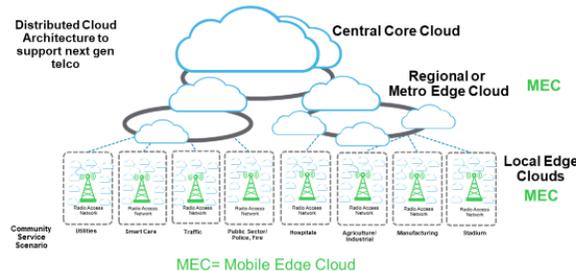
Energy	Public sector (government)	Healthcare	Mining and quarrying	Transportation (mobility)
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Key Facts

- Ecosystem players who are driving 5G – carriers, cable companies, telco equipment manufacturers, internet giants, colocation centres, IT vendors, integrators and real estate “owners” – will need to deploy an architecture of data centres that includes core, regional/metro mobile edge cloud and local mobile edge cloud.

We see Telco and IT data center worlds merging with 4.5/5G deployment – short term Regional/Metro Edge, long term Local Edge starting in 2021



Commercial Impact

- There are around 150,000 central offices in the world. Extrapolating to 300,000 regional/metro MECs by 2020, there will be 5 million telco towers in the world¹, each with a MEC data centre.
- Schneider Electric estimates that in standalone 5G clusters (without 3G or 4G), there will be a 3:1 ratio of telco towers with base stations including MEC data centres for every existing 4G tower today. However, standalone 5G will only be cost effective in about 50% of the existing coverage map, so in the future there will be 7.5 million standalone 5G towers with base stations and 2.5 million 3/4G towers with base stations.



Uniqueness

- Mobile edge cloud (MEC) technology brings activities (content delivery and computations or processing) with telecom functions (call routing, automation, analytics) closer to the user.
- MEC disaggregates hardware and software and will roll out with LTE Advanced (4.5G) that is upgradeable to 5G.



Potential Societal Value

- Increased number of jobs related to the infrastructure buildout and management
- Increased speed and quality of communications, leading to fewer in-person meetings, benefitting the environment
- Enabler to realize the promise of several “essential” and “quality-of-life” services (healthcare, mobility, government) that were constrained due to reliability, bandwidth, cost of connectivity at the edge

SDG impact



Decent Work and Economic Growth



Responsible Consumption

¹ Global Telecom Towers Market 2018 - Segmented by Tower Type, Fuel Type, Installation, Ownership, Region-Growth, Trends, and Forecast to 2023, Orbis Research



Improvement areas/business benefits: Edge cloud

Functional drivers of 5G facilitating the use case's deployment

5G Features Mapping

Faster and effective inspections with predictive intelligence	Value added as a proportion of GDP and per capita due to reduced operating costs	Scalability of solutions/faster proof of concepts	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Impact Pathway

Illustrative impact pathway

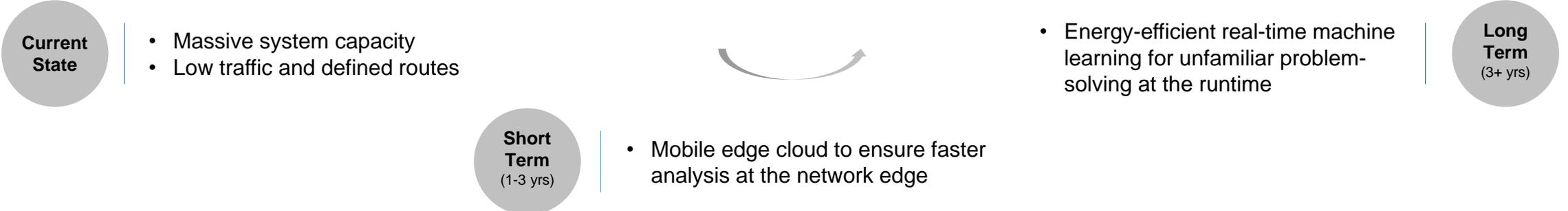
Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Data centre Edge computing <p>Opex for:</p> <ul style="list-style-type: none"> Skilled manpower for solution deployment 	<ul style="list-style-type: none"> Battery energy storage systems Distributed energy resource systems Micro data centres Cloud-based data centre infrastructure management 	<ul style="list-style-type: none"> Enhanced operational efficiency of field maintenance Reduced time lag in applications, cloud services Real-time data, alarm from edge computing sites 	<ul style="list-style-type: none"> Increased number of skilled jobs [SDG 8: Decent Work and Economic Growth] Efficiency in computing, resulting in reduced consumption [SDG 12: Responsible Consumption and Production] 	<ul style="list-style-type: none"> Increased number of jobs related to the infrastructure buildout and management % reduction in carbon emissions % increase in number of critical services

Speed: 1-5 Gbps | Latency: <20 ms

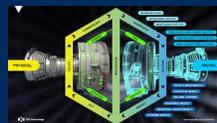
Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

5G Maturity Timeline



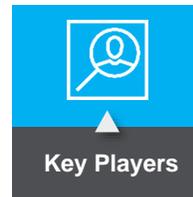
Use case category:
Digital twins (1)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



- DXC Technology is a global IT services company that leads digital transformations for clients by managing and modernizing mission-critical systems, integrating them with new digital solutions to produce better business outcomes.
- The company was created by the merger of CSC and the Enterprise Services business of Hewlett Packard Enterprise.



Use case ecosystem:

Original equipment manufacturers, supply chain operations, network provider, machine learning application, cognitive software application

Use case impact on the other sectors				
Artificial intelligence	Augmented and virtual reality	Engineering	Industries/factories	Internet of things (IoT)



- Digital twin is a path to resolve the costly challenge of providing intelligence on system performance before the occurrence of physical impacts by replicating a physical asset's performance via digital simulation.
- System performance deficiencies are highlighted before physical processes and products are completed.
- Models and simulations can optimize operations, manufacturing, inspections and sustainability, and are applied during the entire life cycle.
- Creating a digital twin starts with establishing new pipelines of manufacturing data.
- The process uses stochastic simulation to generate what-if scenarios that can help manufacturers avoid costly product quality issues, while speeding time to market and increasing throughput.
- Creating a digital twin requires developing rules that map from design to performance and add randomness to simulate risk.
- The prescriptive data from the simulations shows how new products will work.
- Connectivity such as 5G will allow fewer delays and hence effective operations.



- A market anticipated to witness a CAGR of 35.0% over the forecast period of 2019-2024 (<https://www.globenewswire.com>)
- Increased manufacturing output due to reduction in quality issues
- Savings due to lower power and fuel consumption
- Increased bottom line due to productivity around asset utilization, downtime reduction, also lowering overall maintenance costs



- Increased workplace safety
- Reduction in quality issues resulting in waste reduction
- Effective use of manpower capacities
- Competency building in creating and deploying digital twins

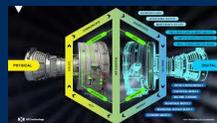
SDG impact



Industry, Innovation and Infrastructure



Responsible Consumption and Production



Improvement areas/business benefits: Digital twins

Customized and personalized products	Faster and effective inspections with predictive intelligence	Improved worker safety/ reduced fatalities	Managing carbon footprints/CO2 emission per unit of value added	Value added as a proportion of GDP due to reduced operating costs
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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5G Features Mapping

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Digital twin Machine learning solution Cognitive computing Analytics solution 	<ul style="list-style-type: none"> Stochastic simulations or prescriptive models Data-driven simulations 	<ul style="list-style-type: none"> Early detection of design flaws Cost prediction and minimization Capacity building of the workforce Increased innovations in the field of manufacturing 	<ul style="list-style-type: none"> Improved predictive intelligence [SDG 9: Industry, Innovation and Infrastructure] Reduction in supply chain wastes [SDG 12: Responsible Consumption and Production] 	<ul style="list-style-type: none"> Increased bottom line Reduced number of accidents/crashes % increase in machine utilization % increase in economic value added

Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Connected units for enhanced data analysis

Short Term
(1-3 yrs)

- Predictive maintenance and operations intelligence

- Real-time machine learning and AI

Long Term
(3+ yrs)

5G Maturity Timeline

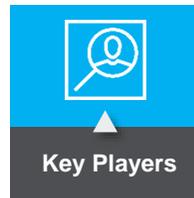
Use case category:
Drones (3)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



- Airobotics is one of the 10 hottest start-ups in Israel and 100 hottest start-ups in Europe, according to WIRED UK.
- CNBC featured Airobotics as one of 10 Israeli High-Tech Areas Making Waves. “Airobotics, for example, has just received the country’s first permission to operate a fully automated payload carrying drone.”
- Frost & Sullivan recognized Airobotics by awarding it the Global New Product Innovation Award for its completely autonomous drone platform.



Use case ecosystem:

Vertical industries, network provider, original equipment manufacturer for drones, regulatory agencies, risk and legal partners, governments, action teams (disaster response)

Use case impact on the other sectors			
Public sector (government)	Construction	Industries/factories	Mining and quarrying



- Airobotics has developed an unmanned drone solution, the first of its kind in the global market.
- Airobotics provides an end-to-end, fully automatic solution for collecting aerial data and gaining invaluable insights. The industrial grade platform is available on-site and on-demand, enabling industrial facilities to access premium aerial data in a faster, safer, more efficient way.



- Commercial unmanned aerial vehicles (UAVs) expected to reach some US\$ 13 billion by 2025
- Identifying and analysing data for haul road optimization, directly impacting the bottom line
- Surveying and mapping solution: Collecting and analysing data to produce invaluable insights for informed decision-making, risk management and planning, increasing the bottom line
- Inspecting chemical plants, refineries and manufacturing sites, resulting in reducing budgets for disaster management



- Fully automatic, programmable, self-deploying landing and servicing
- Robotic swapping of payloads and batteries enabling multipurpose applications
- Accurate measurements through aerial data capture, powering stockpile management essential to mining operations



- **Reduction in disasters:** Immediate aerial information of leaks and spills and safety procedures and evacuation monitoring
- **Reduction in number of workplace accidents:** Routine system inspections to ensure consistent operational integrity and access to hard-to-reach areas
- **Situational awareness** beyond the rig and intrusion alerts

[Airobotics Partners with Shapir-Ashtrom to Innovate and Automate Surveying and Mapping for the Construction of Israel’s New “Gulf Port” in Haifa]

SDG impact



Industry, Innovation and Infrastructure



Sustainable Cities and Communities



Improvement areas/business benefits: Industrial drones

Faster and effective inspections with predictive intelligence	Improved worker safety/ reduced fatalities	Efficient logistics (inventory and dispatch management)	Managing carbon footprints	Value added as a proportion of GDP and per capita due to reduced operating costs
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Functional drivers of 5G facilitating the use case's deployment

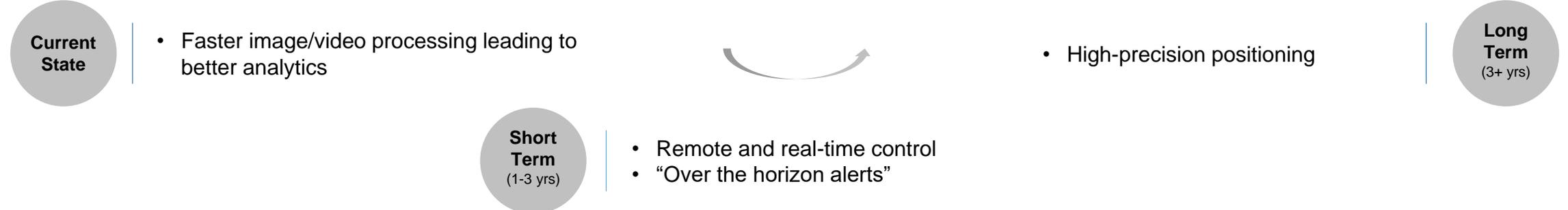
Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Network connectivity through mast AiRobotics "Airbase" AiRobotics "Optimus" AI software 	<ul style="list-style-type: none"> Surveillance and mapping Stockpile management Reduced number of workplace accidents 	<ul style="list-style-type: none"> Improved security and emergency response Remote monitoring of facilities with the use of fully automatic drone operations Increased situational awareness 	<ul style="list-style-type: none"> Increased operational efficiencies [SDG 9: Industry, Innovation and Infrastructure] Increased situational awareness and safety [SDG 11: Sustainable Cities and Communities] 	<ul style="list-style-type: none"> % improvement in safety and health of workforce % bottom line improvement due to remote location monitoring Reduced number of thefts and security breaches

Speed: 1-5 Gbps Latency: <20 ms	Reliability: 99.99% Latency: <5ms	Reliability: 99.999% Latency: <1ms
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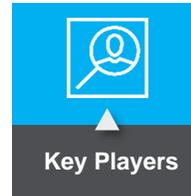




1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



- Delair.ai stands for **Delair Aerial Intelligence**.
- Delair.ai is the leading reality modelling platform for physical asset management, addressing the business requirements found in mining & aggregates, construction, agriculture & forestry, infrastructures, power & utilities.
- Delair.ai harnesses the computing power of the cloud to turn aerial and ground imagery data into key actionable insights for operational and corporate asset management.



Use case ecosystem:

Network providers, regulators (flying regulations), original equipment manufacturers, software security, map owners, insurance, analytics solution, government (surveillance monitoring)

Use case impact on the other sectors				
Business intelligence, analytics	Cities/urban infrastructure	Public sector (government)	Security	Industries/factories

- Delair is a trusted partner for enterprise customers who want to capture up-to-date, high resolution, geolocalized sky images and transform them into actionable aerial data.
- The solution adapts to specific imagery needs of heavy industrial users in geospatial, agriculture & forestry, power & utilities, security & defence, mines & quarries, oil & gas, railways & roads as well as emergency.
- Delair signed an agreement with Geoforma to open its first commercial drone service operation in Latin America.



- Global smart commercial drones market size, share and industry expected to reach US\$ 179,600 million by 2025, with a CAGR of 83.3% during 2018-2025 (*Reuters*)
- Productivity enhancement and immediate return on investment
- Savings for the clients due to reduced operating expenses to undertake surveys (eliminating the need to send workers to high altitudes or hire expensive airplanes for flyovers)

- **Business model:** Delair Takeoff - a cost-effective subscription programme for accessing the company's high performance Delair UX11 family of UAVs and delair.ai, cloud-based data management solution
- **Digital twin** of utilities
- Drone solutions success stories:
 - a. Inspection of anomalies around underground pipelines
 - b. Large-scale surveying of mines with a fixed-wing drone
 - c. 9,000-acre pipeline drone survey project in <45 days



- Maximized staff safety in sensitive areas with real-time video surveillance
- Airborne environmental surveys in remote and dangerous locations, reducing number of fatalities
- Automatic hazard detection from above, reducing accidents

SDG impact

3 GOOD HEALTH AND WELL-BEING

Good Health and Well-being

15 LIFE ON LAND

Life on Land



Improvement areas/business benefits: commercial drones

Faster and effective inspections with predictive intelligence

Improved worker safety/reduced fatalities

Value added as a proportion of GDP and per capita due to reduced operating costs

Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency



Illustrative impact pathway- Large-scale surveying of mines with a fixed-wing drone

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Fixed-wing UAV platform Delair UX11 Skilled manpower for drone operations 	<ul style="list-style-type: none"> Long-range capacity Reduced number of ground control points Accurate material quantification and data collection in real time Easy workflow and operations 	<ul style="list-style-type: none"> Coverage of wider facilities in short span of time Photogrammetry data of the route, development of necessary computer aided design files and delivery of alignment sheets Reduced field time and costs 	<ul style="list-style-type: none"> Automatic hazard detection from above, helping to reduce accidents [SDG 3: Good Health and Well-being] Aerial surveys to identify green covers [SDG 15: Life on Land] 	<ul style="list-style-type: none"> Increased bottom line due to faster analytics # of accidents averted for inspection of difficult areas Progress towards sustainable forest management (effective monitoring)



Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



- Faster image/video processing resulting in data analysis at the runtime



- Remote and real-time control
- "Over the Horizon alerts"

- High-precision positioning: sub-meter position accuracy delivered with low latency below 1 millisecond



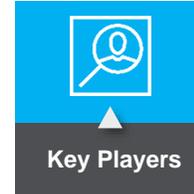


1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Volocopter provides urban air mobility in addition to existing transport options. It enables a wide range of users to reach urban destinations fast and comfortably.
- Volocopter GmbH (formerly called E-Volo GmbH) is a German aircraft manufacturer.
- The company specializes in the design of electric multirotor helicopters in the form of ready-to-fly aircraft, designed for air taxi use.



Key Players

Use case ecosystem:

Network providers, original equipment manufacturers, safety regulators, aviation companies, airport authorities, software development companies, governments

Use case impact on the other sectors

Transportation (mobility)	Insurance and finance	Healthcare	Cities/urban infrastructure
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Key Facts

- The Volocopter was the world's first multicopter to be granted a certification for manned flights (as early as 2016). It fulfils stringent German and international safety standards
- Its key features include remote control, GPS point tracking, possible sense and avoid integration, possible autonomous sub-feature integration, additional battery capacity to extend range and flight time, air traffic management (including unmanned traffic management) to coordinate autonomous Volocopter fleets.



Commercial Impact

- The Volocopter can fly a complete mission with less than 50 kWh of energy. Battery cost is managed by maximizing useful battery life. A direct consequence is that Volocopter does not apply fast-charging to its batteries. Instead, it swaps the batteries after every flight. This allows the batteries to be charged at optimal (low) C-rates, while being properly balanced and reducing thermal stress by using efficient, ground-based cooling systems.
- It is specifically designed to exclude high-maintenance systems that drive the maintenance cost of legacy helicopters.



Uniqueness

- Volocopter complies with specific airworthiness requirements for intra-city commercial air transport and serves as an industry benchmark for low noise emissions.
- A cruise speed of 80-100 km/h enables the Volocopter to offer significant time savings compared to ground transport, without the practical drawbacks of higher-speed aircraft.
- Volocopter will be able to service the vast majority of urban air taxi missions with its two-seat design.



Potential Societal Value

- Volocopter is implementing an airport shuttle in New York between John F. Kennedy International Airport (JFK) and Midtown Manhattan, which is a cumbersome route to travel by road or rail. The distance through the air is less than 30 km and can be covered by an air taxi in 20-25 minutes while, according to cellphone data, 90% of ground trips take longer than 60 minutes and roughly 50% of trips take longer than 90 minutes. This represents a huge potential for time saving.

SDG impact



Good Health and Well-being



Sustainable Cities and Communities



Improvement areas/business benefits: Urban mobility

City infrastructure improvement	Passenger and freight volumes, by mode of transport	Managing carbon footprints/CO2 emission per unit of value added	Ratio of land consumption rate to population growth rate
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway- Voloport

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Power supply and batteries Motors Network infrastructure Cloud infrastructure security Safety, emission certifications 	<ul style="list-style-type: none"> Electric-powered and noise regulated aircraft Collision mitigation systems 	<ul style="list-style-type: none"> Real-life testing of the full customer journey Planned customer services, including preflight checks, passenger lounges and boarding procedures 	<ul style="list-style-type: none"> Increased driver health and reduced accidents [SDG 3: Good Health and Well-being] Increased land availability in cities [SDG 11: Sustainable Cities and Communities] 	<ul style="list-style-type: none"> Reduced number of accidents/crashes % reduction in fuel consumption % increase in logistical capacity, resulting in GDP contribution

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



Current State

- Massive system capacity: increased efficiencies and capacity of the network
- Faster image/video processing for threat detection

Short Term
(1-3 yrs)

- Remote and real-time control: improved virtual drones flight control

Long Term
(3+ yrs)

- High-precision positioning: accurate position awareness

Use case category:
Gamification (1)

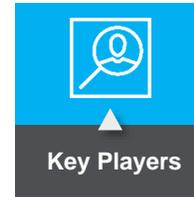


1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Pymetrics' gamified assessments and video interviews collect objective behavioural data that is unbiased, unlike résumé data or self-report data.
- They maximize predictions and increase efficiency through customized but automated machine learning algorithms.
- Rejected candidates can use Pymetrics to automatically match to other opportunities across other clients, improving the candidate experience.



Key Players

Use case ecosystem:

Corporates, network provider at the client, software development agencies, neuroscience experts, cloud service provider (CSP)

Use case impact on the other sectors

Cloud solutions	Gaming	Healthcare	Education	Retail and entertainment
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Key Facts

- Pymetrics recommends the right person for the job, while levelling the playing field for everyone.
- Proven benefits:
 - Time: 250 hours of recruiter time saved
 - Money: US\$ 20,000 saved in the recruiting process
 - Hire yield: twofold improvement in ratio of candidates to hires
 - Diversity: 20-100% increase in gender, ethnic and socio-economic diversity of hires



Commercial Impact

- Example: **UNILEVER**- Pymetrics assessed 280,000 applicants in 68 countries and 15 languages, replacing the résumé as a first-pass filter:
 - 100% increase in hire yield
 - 75% reduction in time to hire
 - 25% decrease in recruiting costs
 - Record diversity across gender, ethnicity and socio-economic status



Uniqueness

- Two science-based improvements to help companies hire more intelligently and help job seekers find career paths that capitalize on their strengths: 1) neuroscience assessment; and 2) data science analytics and algorithms.
- Innovations:
 - Neuroscience games
 - Customized AI
 - Bias-free algorithm
 - Common application



Potential Societal Value

- Record diversity across gender, ethnicity and socio-economic status:
- 30%: increase in the percentage of women matched to financial services position
 - 20-50%: percentage of women hired into an investment analyst role
 - 44%: percentage of offers extended to women after an interview with a professional services company

SDG impact



Quality Education



Reduced Inequalities



Improvement areas/business benefits: Gaming and education

Functional drivers of 5G facilitating the use case's deployment



5G Features Mapping

Faster and effective inspections with predictive intelligence	Multimedia experience helping to reduce inequalities	Facial expressions and body tracking	Promotion of gender equality	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway



Impact Pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Manpower to build the talent-matching platform Cloud platform Analytics solution 	<ul style="list-style-type: none"> Neuroscience games Behavioural insights Custom AI trained top performers Ethical AI: de-biased algorithms 	<ul style="list-style-type: none"> AI-driven talent-matching platform Candidate selection through the platform Sorting of profiles and marketplace of resources Talent insights 	<ul style="list-style-type: none"> Opportunities to scale the platform for immersive educational purpose [SDG4: Quality Education] Equal employment opportunities for all [SDG 10: Reduced Inequalities] 	<ul style="list-style-type: none"> % increase in new skills among employee % increase in women hires in the workforce % increase in the economy's skills index

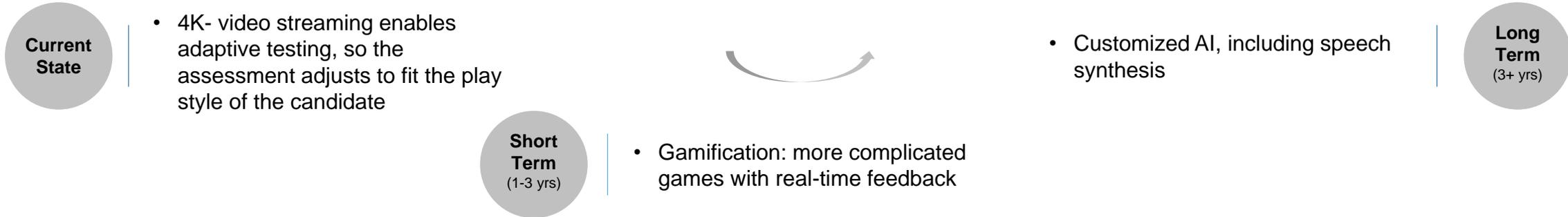
Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



5G Maturity Timeline



Use case category:
Internet of Things (6)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Ericsson is driving 5G standardization and was the largest contributor to the standardization body in 3GPP during 2018.
- Ericsson has publicly announced commercial 5G deals with more than 20 named operator customers.
- Ericsson has over 40 operator memorandums of understanding worldwide and is collaborating with more than 40 universities and technology institutes as well as 30 industry partners.



Key Players

Use case ecosystem:

In collaboration with Aitik mine, VR device original equipment manufacturer, data analytics and cloud service provider, network/spectrum provider, regulator, insurers, software and AI

Use case impact on the other sectors

Business intelligence, analytics solutions	Engineering	Internet of things (IoT)	Security
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Key Facts

- Key features and benefits of mobile communications in the mine are coverage, reliability, low latency, better accuracy in positioning, high bandwidth and the ability to run many devices, sensors or remotely controlled machines.
- With a number of partners, including Ericsson, Boliden has taken part in a research project to co-create the mine of the future.
- Example: Boliden is one of the most successful mining companies in the world; Aitik, located in the north of Sweden, is the largest open pit in Europe.



Commercial Impact

- The **Boliden Aitik** mine use case reduces costs by 1 percentage point through the application of automation, with communications being the key enabler.
- Carrying out drilling and blasting using automation shows an annual €2.5 million net saving for the Aitik mine alone.
- 7,000 hours per year of drill rig operation could be achieved through automation, an increase of 2,000 hours or 40%.
- The savings in fuel consumption is estimated at 10%.



Uniqueness

- Automated drill rigs ("pit vipers") can move from one drill hole to the next along a predefined path and perform repetitive tasks autonomously, in contrast to having a drill rig operator on-site carrying them out manually.
- Automation eliminated the need for additional staff, service stations, parking areas, transport on busy access roads and dangerous staff transportation within the mine.
- Applications (such as fully remote-controlled machines) need the capabilities and capacity offered through mobile communications, such as 4G and especially 5G.



Potential Societal Value

- Elimination of the need for additional staff, service stations, parking areas, transport on busy access roads and dangerous staff transportation within the mine
- Better working conditions for the mining staff
- Efficiency improvement, reducing Aitik's annual emissions by approximately 9,400 metric tons of carbon dioxide

SDG impact



Good Health and Well-being



Decent Work and Economic Growth



Improvement areas/business benefits: Mining automation

Faster and effective inspections with predictive intelligence

Improved worker safety/reduced fatalities

Managing carbon footprints/CO2 emission per unit of value added

Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Connected sensors and devices Pit viper (automated drill rigs) Data analytics solution Cloud platform 	<ul style="list-style-type: none"> Fully remote monitoring of mining operations Autonomous and remotely controlled machines Tracking and coordination of mobile equipment fleets 	<ul style="list-style-type: none"> Effective work planning due to autonomous operations Capacity to handle an ever-changing production environment and geography 	<ul style="list-style-type: none"> Better working conditions for the mining staff [SDG 3: Good Health and Well-being] Sectoral contribution to GDP [SDG 8: Decent Work and Economic Growth] 	<ul style="list-style-type: none"> Reduced number of accidents/crashes # of lives saved % reduction in fuel consumption % reduction in carbon footprint

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Connected units for enhanced data analysis

Short Term
(1-3 yrs)

- Enhanced real-time data gathering and alerts

- Real-time edge AI

Long Term
(3+ yrs)



5G Features Mapping



Impact Pathway



5G Maturity Timeline



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Ericsson is driving 5G standardization and was the largest contributor to the standardization body in 3GPP during 2018.
- Ericsson has publicly announced commercial 5G deals with more than 20 named operator customers.
- Ericsson has over 40 operator memorandums of understanding worldwide and is collaborating with more than 40 universities and technology institutes as well as 30 industry partners.



Key Players

Use case ecosystem:

In collaboration with Telefonica, Germany, physical and digital security service providers, software (analytics, enterprise resource planning, asset management), manufacturing robot original equipment manufacturers, regulators

Use case impact on the other sectors

Cities/urban infrastructure	Engineering	Public sector (government)	Industries/factories	Robotics
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Key Facts

- Ericsson and Telefónica Germany are building the network in a 20,000sq m complex, comprising solutions from Ericsson's Private Networks offerings, and will hand over to Mercedes-Benz upon completion for operation.
- Mercedes-Benz says the experiences gained from Factory 56 will be incorporated into plans for future 5G implementation in other plants.
- The 5G network will enable Mercedes-Benz to boost flexibility, production precision and efficiency as industry digitalization and internet of things becomes a reality in car production.



Commercial Impact

- The time to market is minimized, resulting in commercial roll out of new products.
- The global factory automation market size is expected to reach US\$ 368,372.4 million in 2025, from US\$ 190,882.2 million in 2017, growing at a CAGR of 8.8% from 2018-2025 (*Alliedmarketresearch.com*).
- The private Long-term Evolution (LTE - mobile communications standard) market size is expected to grow from US\$ 2.4 billion in 2018 to US\$ 4.5 billion by 2023, at a CAGR of 13% (*Research and Markets*).
- Communities: lesser environmental impacts as efficient operation will ensure lowered emissions, use of natural resources
- Safe, convenient, efficient workplace at cheaper costs
- Increased job opportunities for the skilled workforce
- Increase in skills capital of the existing workforce



Uniqueness

- The 5G network will facilitate data linking or product tracking on the assembly line. All processes will be optimized and made more robust and, if necessary, will be able to be adapted at short notice to fit market requirements.
- As a private 5G network, the intelligent connecting of production systems and machines in Factory 56 will be conducted securely.
- Solutions enable the integration of sensors, machines, in-vehicle and hand-held devices across a wide range of applications for industry enterprises.



Potential Societal Value

SDG impact



Industry, Innovation and Infrastructure



Responsible Consumption



Improvement areas/business benefits: Manufacturing processes

Functional drivers of 5G facilitating the use case's deployment

Customized and personalized products	Improved worker safety/reduced fatalities	Managing carbon footprints/ CO2 emission per unit of value added	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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5G Features Mapping

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Regulatory costs Local private network Cloud, analytics solutions <p>Opex for:</p> <ul style="list-style-type: none"> Managed services 	<ul style="list-style-type: none"> Secured critical broadband performance Connected robots Network slicing Connected intelligence 	<ul style="list-style-type: none"> Business scalability Operational efficiency Increased throughput Improved service-level agreement management Safer working environment 	<ul style="list-style-type: none"> Increased manufacturing throughput and logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] Efficient use of resources and reduced waste [SDG 12: Responsible Consumption and Production] 	<ul style="list-style-type: none"> % increase in manufacturing capacity % increase in bottom line % contribution to GDP % reduction in carbon footprints % increase in local job creation

Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



5G Maturity Timeline



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- KT is taking the lead in providing new technologies and services based on 5G's ultra high speed, ultra low latency and hyperconnectivity, thereby creating socio-economic value for the general public.
 - **2015:** Announcement of the Vision for the World's First 5G Commercialization
 - **2015:** World's first 5G SIG (Special Interest Group) Common Specifications
 - **2016:** First successful 5G call
 - **2018:** World's first 5G Olympic Games



Key Players

Use case ecosystem:

Skyship manufacturer, regulatory agencies, risk and legal partners, city governments, action teams (disaster response), original equipment manufacturers, network provider, software developers, healthcare provider

Use case impact on the other sectors

Connectivity /networks (telecom.)	Public sector (government)	Healthcare	Transportation (mobility)	Logistics
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Key Facts

- An innovative solution to showcase the capabilities of LTE and 5G networks – an airborne platform for disaster management and search and rescue scenarios
- Skyship: a bespoke airship and a mobile communication centre to remotely control drones and robots that carry out search and rescue operations for disaster survivors
- Comprises airship, drones, robots and ground control centre
- Third advanced version of aircraft with 5G network to be completed by 2020



Commercial Impact

- The South Korean government is investing in a US\$ 1.5 billion nationwide public safety network, based on LTE.
- Work on the PS-LTE network began in 2018 and will be finished by 2020.
- During Q1 of 2019, KT focused on access network investment for 5G worth US\$ 0.35 billion.



Uniqueness

- Cloud infrastructure backbone
- Visual scanning- machine vision to scan the components
- 5G connection camera- to send the image data to edge cloud server for examination
- Edge-cloud-based visual inspection- for the cloud server to find the faulty components
- Collision avoidance- for the 5G connected robot to stop automatically when detecting the collision



Potential Societal Value

- Assistance during disaster search and rescue operations, deployment of remotely controlled drones and robots from an aircraft
- Rescuers on the ground equipped with AR glasses to assist in the delivery of emergency treatment
- Integration with national registration and medical databases to expedite first-aid treatment

SDG impact



Good Health and Well-being



Responsible Consumption and Production



Improvement areas/business benefits: Disaster management

Bridging digital divide/
proportion of
population covered by
a network, technology

Effective and
speedy
recovery

Faster and effective
inspections with
predictive
intelligence

Improved worker
safety/reduced
fatalities

Functional drivers of 5G facilitating the use case's deployment

Enhanced
mobile
broadband

Ultra-reliable
low latency
comms.

Massive
machine-
type comms.

Security
critical

Power
efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Skyship aircraft equipment Network backbone Skyship drones Onboard cameras Opex for: <ul style="list-style-type: none"> Skyship operations and support staff 	<ul style="list-style-type: none"> Connected and advanced disaster management services Safer mechanism to conduct the rescue operations 	<ul style="list-style-type: none"> Increased situational awareness Fewer injuries/fatalities owing to robotic and drone-based disaster response 	<ul style="list-style-type: none"> Increased societal and rescue team well-being [SDG 3: Good Health and Well-being] Increase in efficiency of emergency healthcare services (lives saved) [SDG 12: Responsible Consumption and Production] 	<ul style="list-style-type: none"> # of lives saved % reduction in expenses for emergency healthcare services % reduction in expenses for disaster management Economic growth

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Faster image/video processing
- Visual scanning- Machine vision scans the components

Short Term
(1-3 yrs)

- Edge-cloud-based visual inspection
- Enhanced version of the Skyship
- Commercial production of Skyship

- Fully autonomous disaster management platform

Long Term
(3+ yrs)





1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Nokia has declared >2,000 5G standard essential patent families to ETSI, reflecting its leadership in R&D and standardization.
- As of Oct. 2019, Nokia had >100 customer engagements and 48 commercial 5G deals on 6 continents. Nokia is the only player present in all 10 of the tier-1 cloud service providers (CSPs) in 3 of the 5G early adopter markets (US, South Korea and Japan).
- Nokia is the only vendor with expertise and global leadership across all 5G network elements. Its end-to-end portfolio offers the technology and services for a tailored, seamless, pre-integrated path to 5G, supporting all 66 3GPP frequency bands.



Key Players

Use case ecosystem:

Wireless routers, IoT devices and sensors, video cameras, cloud and smart agriculture platform providers

Use case impact on the other sectors

Connectivity /networks (telecom)	Education	Government /social sector	Mobility	Construction
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Key Facts

- Limited connectivity in rural locations with farming areas covering large areas
- Variety of complex machinery requiring additional maintenance
- Challenging climatic environment and shortage of labour
- Bridging the digital divide by providing broadband access to the internet



Commercial Impact

- Improved crop production
- Optimal use of pesticides/fertilizers
- Reduced maintenance costs of large farming machinery
- Estimated 5G-enabled output through agriculture, forestry and fishing by 2035 of US\$ 510 billion (*IHS Markit*)



Uniqueness

- Uses fixed wireless access to deliver connectivity to the farm
- Supports both low and high bandwidth connectivity without the need for large satcom receivers
- Uses high bandwidth connectivity across multiple sites to support video surveillance
- Uses connectivity of IoT sensors for doors and gates to ensure security, temperature and humidity to monitor crops, real-time telemetry data from farm machinery for preventive maintenance



Potential Societal Value

- Greater crop yields
- Reduced pesticides and fertilizers
- Increased overall agricultural produce in the economy, resulting in increased per capita availability of food

SDG impact



Zero Hunger



Good Health and Well-being



Improvement areas/business benefits: Agriculture

Functional drivers of 5G facilitating the use case's deployment

Bridging digital divide/ proportion of population covered by a network, technology

Faster and effective inspections with predictive intelligence

Improved product quality

Managing carbon footprints/CO2 emission per unit of value added

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> 5G customer-premises equipment (CPE) Edge computing Data analytics application IoT devices 	<ul style="list-style-type: none"> Remote visual monitoring of sites Detailed information status of farming machinery Broadband internet access 	<ul style="list-style-type: none"> Improved security Provision of preventive maintenance for high-value assets Access to educational, government services and other business opportunities 	<ul style="list-style-type: none"> Sustainable and efficient use of resources [SDG 12: Sustainable Consumption and Production] Increased citizen awareness and well-being [SDG 3: Good Health and Well-being] 	<ul style="list-style-type: none"> % revenue growth from new business opportunities % savings through smart agriculture applications

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Connected units for enhanced data analysis

Short Term (1-3 yrs)

- Network slicing allowing the usage of 5G network for different IoT applications in rural areas

- Autonomous machine learning
- Satellite, content-based analytics

Long Term (3+ yrs)

5G Features Mapping

Impact Pathway

5G Maturity Timeline



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- A new age digital technology solutions company focused on being the intelligence behind every city, addressing the global smart cities' and communities' market
- AI powered smart and predictive solutions for the increasing challenges of the cities
- Ready-made end-to-end smart city solutions covering all the stages of implementation: integration of devices through IoT, data collection, Intelligence (analytics), automation and managed services

Key Players

Use case ecosystem:

City governments, original equipment manufacturers, environmental scientists, academic institutions, transport agencies, NGOs, citizens, tech companies, funding agencies

Use case impact on the other sectors				
Connectivity /network (telecom.)	Construction	Energy	Transportation (mobility)	Public sector (government)

Key Facts

- Quantela's Atlantis is a platform encompassing the digital life cycle of urban infrastructure implementations from data acquisition, automation and cross-domain AI analytics.
- The platform provides a powerful set of services to ingest and process data from a wide range of data sources.
- These data and events can be analysed and visualized in the Atlantis dashboard, and can also be used to automate city operations.

Commercial Impact

- According to Navigant Research, the global market for smart city solutions and services is expected to grow from US\$ 40.1 billion in 2017 to US\$ 97.9 billion in 2026.
- Environment investments in smart grid technology generate annual per capita savings of US\$ 229.86 and reduce CO2 emissions by 223 pounds per person.
- Data monetization opportunities exist across the private sector and smart cities.

Uniqueness

- Open data
- Machine-learning algorithms by accessing data in real time
- Offering of pre-packaged solutions
- Real-time computing and visualization
- Remote monitoring of a city's infrastructure, leveraging advanced machine learning capabilities to enable automated policies
- Analytics based on policies: connect, manage, control and create policies around their smart assets

Potential Societal Value

- Better disaster response by providing AI-based insights for real-time decision-making
- Effective savings in overall time taken for commute
- Real-time environmental monitoring, facilitating short- and long-term response plans
- Promotion of safety and inclusion

SDG impact

	Sustainable Cities and Communities		Good Health and Well-being
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Improvement areas/business benefits: Urbanization

City infrastructure improvement	Faster and effective inspections with predictive intelligence	Passenger and freight volumes, by mode of transport	Managing carbon footprints/CO2 emission per unit of value added
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Quantela's Atlantis platform Data analytics solution Cloud computing platform AI solution <p>Opex for:</p> <ul style="list-style-type: none"> Manpower for platform installation 	<ul style="list-style-type: none"> Open data Machine-learning algorithms by accessing data in real time Remote monitoring of a city's infrastructure Real-time computing and visualization 	<ul style="list-style-type: none"> Increased situational awareness Connected infrastructure across the city, making it proactive vs reactive Cross-domain and predictive models 	<ul style="list-style-type: none"> Increased situational awareness and safety [SDG 11: Sustainable Cities and Communities] Increased citizen awareness and well-being [SDG 3: Good Health and Well-being] 	<ul style="list-style-type: none"> Citizen safety, inclusion Timely disaster response by providing AI-based insights % time saving in commute at a city level % carbon footprint reduction

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



Current State

- Massive system capacity to connect thousands of sensors to the platform

Short Term
(1-3 yrs)

- AR/VR applications using cloud edge computing
- Urban analytics (natural language processing and video analytics)

- Ethical AI
- Satellite, content-based analytics

Long Term
(3+ yrs)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



- Founded in 2011, Vayyar started with the vision to develop a new modality for breast cancer detection, using radio frequency (RF) to quickly and affordably look into human tissue and detect malignant growths.
- Vayyar facilitates long-term partnerships with leading corporations to develop tailored solutions, meeting a wide range of specific needs. It also offers off-the-shelf development kits to provide companies with a hands-on experience and the ability to develop their own applications in-house.



Use case ecosystem:

Industry verticals, software development companies, hardware original equipment manufacturers, chipset manufacturers

Use case impact on the other sectors				
Public sector (government)	Healthcare	Transportation (mobility)	Retail and entertainment	Robotics



- Vayyar's powerful and unique chip creates high-resolution images in real time based on advanced RF technology.
- The chip covers imaging and radar bands from 3GHz to 81GHz with 72 transmitters and 72 receivers.
- The company's sensors can see through walls and objects and can track and map everything happening in an environment in real time, all while maintaining privacy.
- With a multitude of signals sent, received and analysed, Vayyar technology creates high-resolution 4D images.



Statistics for different industry verticals:

- The smart home market will be worth US\$ 151.4 billion by 2024.
- The global 3D sensor market is projected to reach US\$ 5.49 billion by 2023, growing at a CAGR of 27.69% from 2017 to 2023 (forecast period), according to a new report by Market Research Future.



- Generate a 4D image of components behind the walls
- Detect over 150,000 points of interest per second via Vayyar's automotive sensors
- Detect obstacles and monitor people's location, movement, height, posture and vital signs wirelessly and camera-free
- Monitor real-time activity, with a high degree of privacy
- Work in all lighting and weather conditions
- Detect objects accurately and within a wide range



- Elderly care through continuous monitoring, faster response time
- Early stage breast cancer detection: tumor identification in under five seconds with 4D imaging of breast tissue
- Collision avoidance with breakthrough trajectory mapping, classification and object-detection technology
- In manufacturing, robotic appendage protection and obstacle avoidance

SDG impact

3
GOOD HEALTH AND WELL-BEING

Good Health and Well-being

13
CLIMATE ACTION

Climate Action



Improvement areas/business benefits: Imaging sensors

Bridging digital divide/proportion of population covered by a network, technology	Effective and speedy recovery	Faster and effective inspections with predictive intelligence	Value added as a proportion of GDP and per capita due to reduced operating costs
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway- Smart home sensors

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Advanced, customizable hardware solution: off-the-shelf or specially tailored for specific needs Multifunctional software – people location, obstacles map, breathing: graphical user interface + application programme interface 	<ul style="list-style-type: none"> Monitoring real-time activity around the house Detecting and tracking location, movement, presence, position and vital signs Monitoring a range of motions from a baby's breathing to the intruder's presence 	<ul style="list-style-type: none"> Activity-based automation for energy-efficient operations Monitoring and detection of the location of occupants and their condition in case of fire or disaster 	<ul style="list-style-type: none"> Increased driver health and reduced accidents [SDG 3: Good Health and Well-being] Logistical efficiencies leading to lower carbon emissions [SDG 13: Climate Action] 	<ul style="list-style-type: none"> Increased bottom line due to increased intelligence Reduced number of accidents/crashes # of lives saved % reduction in fuel consumption

Speed: 1-5 Gbps Latency: <20 ms	Reliability: 99.99% Latency: <5ms	Reliability: 99.999% Latency: <1ms
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<p>Current State</p> <ul style="list-style-type: none"> Faster image/video processing, resulting in intelligence for decision-making 	<p>Short Term (1-3 yrs)</p> <ul style="list-style-type: none"> 3D holograms 	<p>Long Term (3+ yrs)</p> <ul style="list-style-type: none"> Volumetric video Cross-sectoral data sharing
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Use case category:
Mixed reality (6)



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3. Exclusive 5G use case



Company Background

- Ericsson is driving 5G standardization and was the largest contributor to the standardization body in 3GPP during 2018.
- Ericsson has publicly announced commercial 5G deals with more than 20 named operator customers.
- Ericsson has over 40 operator memorandums of understanding worldwide and is collaborating with more than 40 universities and technology institutes as well as 30 industry partners.



Key Players

Use case ecosystem:

In collaboration with AT&T, FOX Sports, Fox Innovation Lab, Intel original equipment manufacturer for network equipment, software and data analytics platform

Use case impact on the other sectors

Cities/urban infrastructure	Cloud solutions	Education	Gaming	Retail and entertainment
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Key Facts

- In June 2018, Ericsson partnered with AT&T, FOX Sports, Fox Innovation Lab and Intel in a 5G trial at the 118th US Open at Shinnecock Hills Golf Club on Long Island, New York, to bring ultra-high-definition (UHD) images of the event to FOX Sports viewers.



Commercial Impact

- According to Ericsson's 5G Consumer Potential study, 80% of consumer respondents said they will start watching YouTube and OTT content in 4K and will increase downloading of HD videos once 5G becomes easily available.
- The volumetric video market is expected to grow from US\$ 578.3 million in 2018 to US\$ 2,780.0 million by 2023 (*MarketsandMarkets*).
- The global media industry stands to gain US\$ 765 billion in cumulative revenues from new services and applications enabled by 5G (US\$ 260 billion in the US and US\$ 167 billion in China) (*Intel*).



Uniqueness

- Ericsson's 5G network equipment (radios, baseband and simulated network core), 4K video encoder and decoder, the spectrum provided by AT&T to optimize the 5G performance, and Intel's Mobile Trial Platform working as the 5G modem, were able to give FOX Sports viewers UHD views from two 4K cameras on the seventh green and tee box, where the trial network was deployed.
- Throughout the event, the 5G network demonstrated sustained uplink speeds of over 300 Mbps, easily meeting 60-80 Mbps encoded video transmission requirements.



Potential Societal Value

- Meeting increasing consumer demand for better picture quality and higher resolution to make the experience lifelike even in the viewer's living room
- More viewership for sports, leading to awareness and interest in playing the sport
- Increased job opportunities in the tech sector

SDG impact



Reduced Inequalities



Responsible Consumption



Improvement areas/business benefits: Immersive media

Functional drivers of 5G facilitating the use case's deployment



5G Features Mapping

Bridging digital divide/proportion of population covered by a network, technology	Faster and effective inspections with predictive intelligence	Improved product quality	Multimedia experience helping to reduce inequalities	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> 5G network equipment, including radios, baseband, simulated network core and 4K video encoder and decoder; Intel supplied the Intel® Mobile Trial Platform 	<ul style="list-style-type: none"> Compressed video - raw UHD live broadcast camera quality video Broadcast quality video at the on-site production compound without detectible loss in quality 	<ul style="list-style-type: none"> VR 360-video camera deployments for both in-venue and at-home viewers, creating a more immersive fan experience Live sports broadcasts and immersive entertainment 	<ul style="list-style-type: none"> Equal rights of immersive entertainment to everyone [SDG 10: <i>Reduced Inequalities</i>] Sustainable practices [SDG 12: <i>Responsible Consumption and Production</i>] 	<ul style="list-style-type: none"> Removing fibre from the course Reducing the footprint of assets needed at the event site Improving backhaul transmission costs to the distribution centre

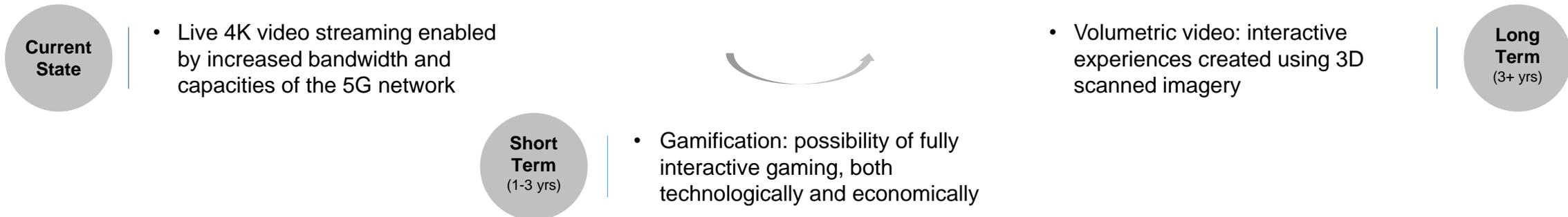
Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



5G Maturity Timeline





Ford

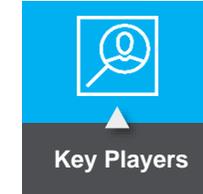
VR in manufacturing processes- FIVE



1. Already using 5G
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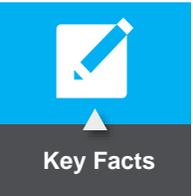


- Ford Motor Company was incorporated in Delaware in 1919 and is a global company based in Dearborn, Michigan.
- With about 199,000 employees worldwide, the company designs, manufactures, markets and services a full line of Ford cars, trucks, sport utility vehicles (SUVs), electrified vehicles and Lincoln luxury vehicles, provides financial services through Ford Motor Credit Company LLC (Ford Credit), and is pursuing leadership positions in electrification, autonomous vehicles and mobility solutions.



Use case ecosystem:

In collaboration with Gravity Sketch VR device original equipment manufacturers, network service providers, cloud, analytics and software (3D modelling, computer aided design) service providers



- Ford's VR lab is located at its product development centre in Michigan.
- Employees at Ford use a 3D virtual-reality tool that enables them to work on designs with colleagues remotely in real time.
- Headsets and controllers provide the tools for the designers to draw the outlines of a new vehicle. The designers can change any aspect of the vehicles, adjusting lines as they go. Every detail is considered, giving the designers ultimate control over the final product.



- Fast rollout of new designs, enabling less time to markets across different geographies
- Immersive training for the workforce, ensuring accuracy and effectiveness in design operations
- Global augmented and virtual reality market valued at around US\$ 26.7 billion in 2018, expected to reach approximately US\$ 814.7 billion by 2025, at a CAGR of 63.01% between 2019 and 2025 (*Zion market research*).



- The technology was developed by Gravity Sketch, in collaboration with Ford. Workers wear headsets and use controllers to “draw, rotate, expand and compress a 3D sketch”.
- Gravity Sketch is a London-based company that created a virtual-reality world where designers in a variety of industries could develop ideas in three dimensions. Gravity Sketch brings the idea to life by allowing the designer, architect or engineer to be inside a vehicle, building or product as it is evolving through the design process.



- Increased skill capacity of the workforce
- Reduction in carbon emissions due to reduction in travel requirements for training programmes
- Consumer satisfaction
- Innovative learning mode, increasing job satisfaction and retention



Industry, Innovation and Infrastructure



Sustainable Cities and Communities



Ford

VR in manufacturing processes- FIVE



5G- Landscape

Improvement areas/business benefits: VR in manufacturing

- Bridging digital divide/proportion of population covered by a network, technology
- Faster and effective inspections with predictive intelligence
- Multimedia experience helping to reduce inequalities
- Value added as a proportion of GDP and per capita due to reduced operating costs

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable low latency comms.
- Massive machine-type comms.
- Security critical
- Power efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> VR equipment Network service providers Cloud, analytics and software (3D modelling, computer aided design) service providers 	<ul style="list-style-type: none"> Ford Immersive Vehicle Environment High-resolution models and textures 3D models 	<ul style="list-style-type: none"> Faster rollout of new designs Immersive training for the workforce, ensuring accuracy and effectiveness in design operations 	<ul style="list-style-type: none"> Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] Increased driver health and reduced accidents [SDG 12: Reduced Consumption and Production] 	<ul style="list-style-type: none"> # new prototypes rolled out # of new product launches across geographies Job creation for skilled labour % contribution of auto manufacturing to GDP

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- 4K video streaming

Short Term
(1-3 yrs)

- Gamification

Long Term
(3+ yrs)

- Real-time machine learning and AI



5G Features Mapping



Impact Pathway



5G Maturity Timeline



Johnson & Johnson

VR-based training programme for doctors



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- The Johnson & Johnson company is committed to helping ensure that patients get excellent care, and the Johnson & Johnson Institute is one key way it is delivering on that commitment. It is providing professional education to healthcare providers worldwide, using speed on the latest techniques and procedures for the safe and effective use of its products.
- The Johnson & Johnson Institute VR training programme was launched at the company's facility in Germany in 2017 and has since expanded globally, with Johnson & Johnson Institutes in the US, Brazil, China and Japan.



Key Players

Use case ecosystem:

Oculus VR headsets, motion control devices, surgical training tool original equipment manufacturers, digital infrastructure providers, regulators

Use case impact on the other sectors

Mixed reality (augmented and virtual reality)	Construction	Education	Insurance and finance	Retail and entertainment
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Key Facts

- The Johnson & Johnson Institute, a world leader in professional education, has launched a new global VR training programme for surgeons and nurses.
- The programme currently includes three unique VR training modules for orthopedic surgery - Total Knee Replacement, Total Hip Replacement with Direct Anterior Approach and Hip Fracture Treatment with a Proximal Femoral Nail - to help improve surgical techniques and drive greater patient outcomes.



Commercial Impact

- Simulation of a real-world experience in the operating room, including anatomical accuracy, via all the instruments and implants featured in the VR training
- Acquisition of new professional skills, resulting in increased revenue opportunities
- Reduction in potential errors, leading to more accuracy while performing surgeries, resulting in effective care
- Cost saving for patients due to local availability of skills



Uniqueness

- A study conducted in 2017 with the first Johnson & Johnson VR education module found that 80% of 107 interviewed orthopaedic surgeons would like to use VR frequently for training, and 90% would recommend VR training to their peers.
- The Johnson & Johnson Institute has more than 50 sets of VR equipment worldwide, and several hundred surgeons have used it successfully.



Potential Societal Value

- Advanced skill enhancement for doctors across the globe
- Reduction in environmental impacts due to reduced logistical requirements
- Enhancement in national health indicators
- Scalability of the VR-based trainings to the support staff, ensuring care for all

SDG impact



Reduced Inequalities



Good Health and Well-being



Improvement areas/business benefits: VR for trainings

Bridging digital divide/proportion of population covered by a network, technology

Faster and effective inspections with predictive intelligence

Improved worker safety/reduced fatalities

Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency

Illustrative impact pathway- VR-based training programmes for doctors

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Oculus VR headsets Motion control devices, Surgical training tool Digital infrastructure Opex for: <ul style="list-style-type: none"> Trainers 	<ul style="list-style-type: none"> Walkthrough of procedural steps and physical motions of performing hip or knee replacement surgery Use of standardized terminologies for medical care 	<ul style="list-style-type: none"> Acquisition of new professional skills Accurate diagnosis and surgical knowledge among the experts Less travelling requirements for patients with chronic illness 	<ul style="list-style-type: none"> Increased emphasis on patient well-being [SDG 3: <i>Good Health and Well-being</i>] Equal healthcare facilities for people of all genders and races [SDG 10: <i>Reduced Inequalities</i>] 	<ul style="list-style-type: none"> % reduction in patient deaths due to non availability of facilities % increase in skills and capacities % reduction in fuel consumption Reduced carbon emissions

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- 4K streaming, ensuring faster delivery of training programmes

Short Term (1-3 yrs)

- Gamification, leading to immersive surgery techniques

- Internet of medical skills for connected surgery equipment

Long Term (3+ yrs)





1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Blue vision labs was acquired by Lyft in October 2018.
- Lyft- Blue Vision Labs is a collaborative augmented reality (AR) company that is enabling the next generation of AR and robotics.
- Lyft- Blue Vision has developed technology that provides both street-level mapping and interactive AR that lets two people see the same virtual objects.
- Lyft- Blue Vision’s “**collaborative**” **virtual reality (VR)** lets people look at the same spot in space and both see and create interactive, virtual figures in it.



Key Players

Use case ecosystem:

Lyft, cloud service provider, satellite image provider, automobile fleet agencies, network providers, original equipment manufacturers, software development companies

Use case impact on the other sectors

Engineering	Education	Gaming	Healthcare	Robotics
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Key Facts

- Blue Vision works closely with Lyft's Level 5 autonomous car division.
- The Lyft- Blue Vision AR Cloud SDK enables building city-scale collaborative AR experiences in the areas covered by 3D AR maps.
- Current AR engines like Apple ARKit or Android ARCore restrict developers to building only small-scale and single-use smartphone experiences that do not persist over time.
- Its mission is to empower developers to revolutionize how people interact with technology, their environment and each other.



Commercial Impact

- The global autonomous vehicle market size is estimated at US\$ 54.23 billion in 2019 and is projected to garner US\$ 556.67 billion by 2026, registering a compound annual growth rate (CAGR) of 39.47% from 2019 to 2026.
- Studies by Bain & Company also predict that AR adoption will increase 3 times more than the present adoption rate of 13%.
- Combined studies by McKinsey, the World Economic Forum and Goldman Sachs forecast that AR and VR will grow incrementally, attaining 50% in 2025.



Uniqueness

- The cloud works by combining the **global position of the camera** with the position of the stored AR content.
- The phone shows the physical world as seen by the camera; AR content is then rendered as an overlay, creating the illusion of digital objects being present in the physical world.
- The Lyft- Blue Vision AR Cloud provides a scalable and precise platform for creating immersive and seamless AR experiences.
- **AR Cloud Anchor** represents a fixed position in physical space that persists over time and can be accessed by different users.



Potential Societal Value

- Crowdsource mapping data from smartphones
- Accurate tracking of individuals/service providers on the street, which can be used for other aspects, such as disaster management
- Efficient tracking resulting in reduction of congestion on the streets, thus reducing carbon emissions

SDG impact



Good Health and Well-being



Sustainable Cities and Communities



Improvement areas/business benefits: Augmented reality in transport

Faster and effective inspections with predictive intelligence

Facial expressions and body tracking

Multimedia experience

Promotion of gender equality

Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> Network operations cloud Cloud infrastructure security Machine learning Repository of 3D maps 	<ul style="list-style-type: none"> Detailed interactive maps Street-level mapping and interactive AR 	<ul style="list-style-type: none"> Lyft's autonomous vehicle (AV) platform Localization of solutions for fully autonomous vehicles 	<ul style="list-style-type: none"> Increased situational awareness and safety [SDG 11: Sustainable Cities and Communities] Increased driver health and reduced accidents [SDG 3: Good Health and Well-being] 	<ul style="list-style-type: none"> % reduction in fuel consumption % reduction in carbon footprints Reduced number of accidents/crashes Health index of the city

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Higher bandwidth of 5G networks ensuring powerful computing

Short Term (1-3 yrs)

- Mobile edge cloud: enables cloud computing capabilities and an IT service environment at the edge of the cellular network

- Real-time machine learning (RTML) operation with energy efficiency

Long Term (3+ yrs)

5G Maturity Timeline



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



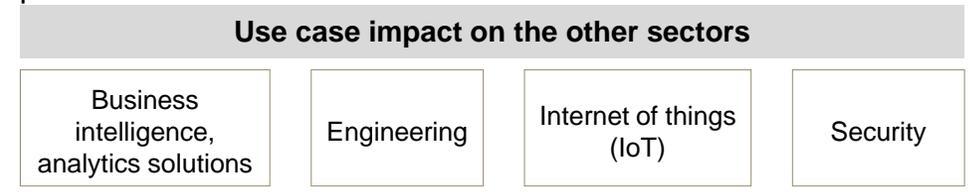
Company Background

- Phoenix Contact, headquartered in Blomberg, Germany, is a manufacturer of industrial automation, interconnection and interface solutions. It offers products and solutions for all aspects of electrical engineering and automation. Key product areas:
 1. Control cabinet: comprehensive range of components and systems
 2. Field installation: innovative I/O wiring systems and industrial connectors, ensuring efficient power and data transmission
 3. Device and connection technology
 4. Systems and solutions

Key Players

Use case ecosystem:

Original equipment manufacturer for network equipment, software and data analytics platform, radio-frequency identification (RFID) tags, wireless connectivity providers, AR equipment provider, cloud service providers



Key Facts

- AR puts an overlay on existing assets, so it can be used in many legacy and retrofit applications to get data out of file cabinets and off hard drives.
- Phoenix Contact uses a tablet and appropriate software to guide maintenance technicians for all inspections.
- Maintenance software on an individual handheld device guides employees and enables them to access documentation on-site quickly and without error. Further, the employee can use gestures to open a maintenance sheet or an exploded diagram to view in 3D.

Commercial Impact

- Real-time visualization of control assets, helping to reduce maintenance times and increase throughput
- Increased situation awareness of maintenance staff, resulting in increased uptime of machines
- Global augmented and virtual reality market valued at around US\$ 26.7 billion in 2018, expected to reach approximately US\$ 814.7 billion by 2025, at a CAGR of 63.01% between 2019 and 2025 (*Zion market research*)

Uniqueness

- Phoenix Contact innovated a new business model based on an in-house additive manufacturing start-up, which serves both internal and external customers:
- Digital replicas of physical assets, digitized production performance tools, mixed reality maintenance, energy management, additive manufacturing (3D printing) (Forum *Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing* report)
 - Use of Microsoft HoloLens to demonstrate an AR-aided pilot project for compressor controls; AR to view indicators like machine cycles, performance history and energy use much faster

Potential Societal Value

- Reduced emissions owing to remote maintenance support
- Increase in digital skill set for the local workforce
- Optimized capacity utilization of staff
- Safer working environments for a majority of operations and maintenance staff

SDG impact		Good Health and Well-being		Industry, Innovation and Infrastructure
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5G Features Mapping

Improvement areas/business benefits: Mixed reality

Bridging digital divide/ proportion of population covered by a network, technology	Faster and effective inspections with predictive intelligence	Improved worker safety/ reduced fatalities	Multimedia experience helping to reduce inequalities
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Functional drivers of 5G facilitating the use case's deployment

Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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Impact Pathway

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> • Network equipment • Data analytics platform • RFID tags • AR equipment • Cloud infrastructure 	<ul style="list-style-type: none"> • Availability of maintenance documentation on the go • Visualization of control assets at point of installation • AR-based trainings 	<ul style="list-style-type: none"> • Effective maintenance schedules • Reduced machine downtime • Increased situation awareness for decision-making 	<ul style="list-style-type: none"> • Safe working and maintenance environment for the staff <i>[SDG 3: Good Health and Well-being]</i> • Operational efficiencies <i>[SDG 9: Industry, Innovation and Infrastructure]</i> 	<ul style="list-style-type: none"> • Reduced number of accidents/crashes • % reduction in fuel consumption • % reduction in emission • % freed-up capacity for maintenance workers

Speed: 1-5 Gbps Latency: <20 ms	Reliability: 99.99% Latency: <5ms	Reliability: 99.999% Latency: <1ms
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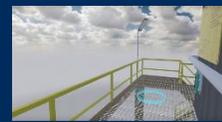
5G Maturity Timeline





Saudi Aramco

Virtual reality for operators



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Saudi Aramco is the state-owned oil company of the Kingdom of Saudi Arabia and a fully integrated, global petroleum and chemicals enterprise.
- Over the past 80 years, Aramco has become the world's largest integrated oil and gas company.
- Saudi Aramco's scale of production, operational reliability and technical advances make it the world's largest producer of crude oil and condensate.



Key Player

Use case ecosystem:

In collaboration with visual experience Oculus Rift VR headset, content creators, knowledge management platform, network provider

Use case impact on the other sectors

Education	Gaming	Mining and quarrying	Retail and entertainment
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Key Facts

- At Aramco's premises in Dhahran, a remodelled and vastly expanded office wing has been converted into a Fourth Industrial Revolution centre, where technological and digital innovation is, in turn, transforming the way in which the company runs its operations
- "VR Zone", at the Fourth Industrial Revolution centre, is used to develop, prototype and train for augmented and virtual reality, among other capabilities. This hub can be used to visualize plant assets and to get a live sense of the plant experience from a simulation booth.



Commercial Impact

- Reduction in training budgets, helping to increase the bottom line
- Provision of conducting the trainings on a larger scale, ensuring time savings and reduced logistical requirements
- Easy scalability of the solution, which can be extended to other organizations as a service, as a new business model
- Immersive training for the workforce, ensuring accuracy and effectiveness in routine operations



Uniqueness

- Saudi Aramco's Southern Area Oil Operations management inaugurated a new 3D Operator System Training Centre with a unique form of training that provides real-world incident training in a safe and engaging environment.
- The system uses the latest Oculus Rift VR headsets and standard computer game controls, giving outside operators an opportunity to virtually "walk" through a generic gas-oil separation plant, a gas and condensate processing plant and a water injection plant. In a typical training scenario, operators encounter a number of process disruptions.



Potential Societal Value

- Increased skill capacity of the workforce
- Elimination of risk and safety concerns
- Reduced carbon emissions due to reduced travel requirements for training programmes
- Innovative learning mode, helping to uphold job satisfaction and retention

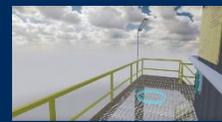
SDG impact



Good Health and Well-being



Decent Work and Economic Growth



Improvement areas/business benefits: VR in production

Functional drivers of 5G facilitating the use case's deployment

Bridging digital divide/
proportion of
population covered by
a network, technology

Faster and effective
inspections with
predictive
intelligence

Improved
worker safety/
reduced
fatalities

Multimedia
experience
helping to
reduce
inequalities

Enhanced
mobile
broadband

Ultra-reliable
low latency
comms.

Massive
machine-
type comms.

Security
critical

Power
efficiency



5G Features
Mapping

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Oculus Rift VR headsets Knowledge management platform Network, cloud infrastructure Opex for: <ul style="list-style-type: none"> Content creators, trainers 	<ul style="list-style-type: none"> 3D operator system Immersive training programme for the staff 	<ul style="list-style-type: none"> Increased understanding of the process among staff Reduced downtime due to improved operational knowledge Content enrichment for continuous improvement 	<ul style="list-style-type: none"> Safe and secure training/working environment [SDG 3: Good Health and Well-being] Increased job satisfaction and sectoral growth [SDG 8: Decent Work and Economic Growth] 	<ul style="list-style-type: none"> Increased bottom line Top line revenue growth % decrease in accidents at workplace % increase in employee retention

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- 4K- video streaming for effective training experience

Short Term
(1-3 yrs)

- Gamification

- Volumetric video

Long Term
(3+ yrs)



5G Maturity
Timeline

Use case category:
Robotics (3)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Energy-efficient technologies empower smart communities and industries to create healthier and more comfortable climates in our buildings and homes and to supply more food with less waste.
- Danfoss celebrated the company's 20-Year Manufacturing in China at its Wuqing Campus, the first manufacturing facility of Danfoss in China.
- Danfoss global Application Development Centers work towards improving solutions with customers and business partners in a live testing environment.



Key Players

Use case ecosystem:

Regulatory agencies, risk and legal partners, sensor manufacturers, original equipment manufacturers, network provider, data analytics solution providers

Use case impact on the other sectors				
Engineering	Education	Gaming	Healthcare	Robotics



Key Facts

Industrial internet of things platform combined with 3D factory visualization: Connects people, processes and devices

- Fully smart-connected enterprise
- Real-time generation and visualization of facts
- Real-time control of all processes in supply chain
- New cyber-physical systems and relations
- Fast response time
- Improvement in productivity and reliability of production lines



Commercial Impact

- Operational efficiencies through scrap reduction
- Reduction in customer complaints
- Reduction in machine cycle time
- Greater labour productivity
- Increased top line due to digital R&D and engineering



Uniqueness

Testing methods during manufacturing processes include:

- Reliability testing: temperature and humidity analysis
- Functional testing: use of test benches, automated software tests
- Comprehensive approval testing: includes highly accelerated life testing and omni-axial (6-axis) random vibration combined with thermal cycling testing
- 100% factory load testing: ensures high reliability
- Electromagnetic compatibility testing



Potential Societal Value

- Environmental data monitoring
- Lower carbon footprints due to efficient operations
- Increased labour morale and productivity
- Increased employment opportunities to the skilled manpower
- Reduction in waste and hence reduced consumptions

SDG impact



Good Health and Well-being



Industry, Innovation and Infrastructure



Improvement areas/business benefits: Industrial automation

Functional drivers of 5G facilitating the use case's deployment

5G Features Mapping

- Value added as a proportion of GDP and per capita due to reduced operating costs
- Faster and effective inspections with predictive intelligence
- Scalability of the solutions/use cases

- Enhanced mobile broadband
- Ultra-reliable low latency comms.
- Massive machine-type comms.
- Security critical
- Power efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<ul style="list-style-type: none"> Capex for: <ul style="list-style-type: none"> Network infrastructure (gateways, devices) Cloud computing and security Analytics and machine learning platforms Application programme interfaces 	<ul style="list-style-type: none"> Digital operator assistant system AI-enabled quality management system Real-time machining quality control Flexible automation assembly line 	<ul style="list-style-type: none"> Operational efficiencies through scrap reduction Reduction in customer complaints Machine cycle time reduction Labour productivity 	<ul style="list-style-type: none"> Increased manufacturing output [SDG 9: Industry, Innovation and Infrastructure] Increased workforce safety [SDG 3: Good Health and Well-being] 	<ul style="list-style-type: none"> % economic value added through increased manufacturing capacity % increased in skilled manpower % reduction in workplace accidents and fatalities

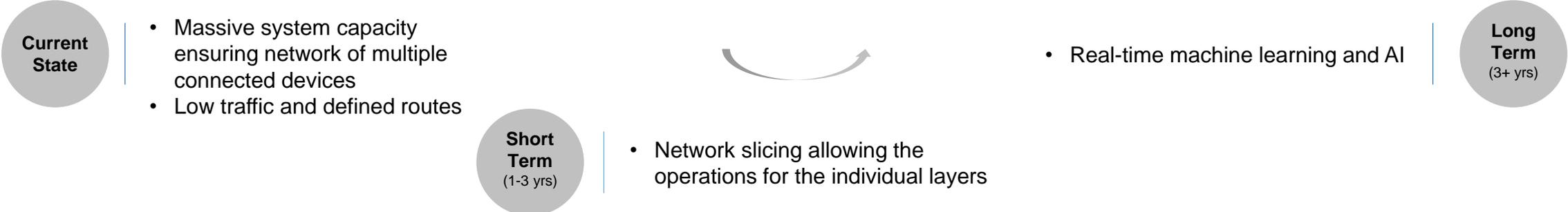
Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

5G Maturity Timeline





1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Ericsson is driving 5G standardization and was the largest contributor to the standardization body in 3GPP during 2018.
- Ericsson has publicly announced commercial 5G deals with more than 20 named operator customers.
- Ericsson has over 40 operator memorandums of understanding worldwide and is collaborating with more than 40 universities and technology institutes as well as 30 industry partners.



Key Players

Use case ecosystem:

AR/VR device original equipment manufacturer, data analytics and cloud service provider, network/spectrum provider, regulator, insurers, software providers including AI solutions

Use case impact on the other sectors

Business intelligence, analytics solutions	Cloud solutions	Connectivity/networks (telecom.)	Education	Energy
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Key Facts

- Ericsson Mobile Health (EMH) is a mobile health platform used for the delivery of personal or enterprise health and well-being services.
- Deployment of EMH opens up business opportunities in the healthcare and well-being market for telecom operators, healthcare service providers and health insurances.
- EMH enables healthcare professionals to objectively monitor patients' physiological parameters in near real time and provide feedback to them by using mobile communications.



Commercial Impact

Telecom operator revenue potential in addressing healthcare industry digitalization with 5G (US\$ 2,026 billion):

- Patient applications: 49.2
- Hospital applications: 19.8
- Healthcare other: 5.2
- Medical data management: 1.6
- **Total: US\$ 75.7 billion**



Uniqueness

- Supported measurements: ECG, spirometry, blood pressure, pulse rate, oxygen saturation, blood glucose, weight, etc.
- Health record, measurements viewer, feedback to patient, videoconferencing possibility, patient access to record, e-booking
- Medically certified solution – CE, Class IIA
- For the transformation of patient applications, central storage of patient data (effectively turning hospitals into data centres and doctors into data scientists)



Potential Societal Value

- Decentralized care ensuring access to healthcare for all
- Increased levels of education in rural areas
- Capacity building and skill enhancement in urban as well as rural areas

SDG impact



Good Health and Well-being



Gender Equality



Improvement areas/business benefits: Healthcare

Bridging digital divide/
proportion of
population covered by
a network, technology

Effective
and speedy
recovery

Value added as a
proportion of GDP and
per capita due to
reduced operating costs

Scalability of
solutions/
faster proof of
concepts

Functional drivers of 5G facilitating the use case's deployment

Enhanced
mobile
broadband

Ultra-reliable
low latency
comms.

Massive
machine-
type comms.

Security
critical

Power
efficiency

Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
<p>Capex for:</p> <ul style="list-style-type: none"> AR/VR devices Wearables Data analytics RAN virtualization and distributed cloud Network/spectrum 	<ul style="list-style-type: none"> Patients in homecare settings Patients discharged from hospital or after medical emergency Preventive check-ups Well-being programmes Support for clinical trials 	<ul style="list-style-type: none"> Information exchange among all stakeholders in healthcare system on national, regional or metropolitan level Increased quality of patient care "Self-help" care 	<ul style="list-style-type: none"> Increased emphasis on personal care [SDG 3: Good Health and Well-being] Healthcare agnostic of gender, location [SDG 5: Gender Equality] 	<ul style="list-style-type: none"> # of lives saved % reduction in fuel consumption % increase in GDP contribution Reduction in deaths due to non-availability of medical care

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Faster image/video processing resulting in effective remote healthcare monitoring

Short Term
(1-3 yrs)

- Mixed reality (AR/VR) inducing robotic surgeries

- Internet of medical things and skills through enhanced machine-to-machine communications

Long Term
(3+ yrs)

5G Features Mapping



Impact Pathway



5G Maturity Timeline



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Nokia has declared >2,000 5G standard essential patent families to ETSI, reflecting its leadership in R&D and standardization.
- As of Oct. 2019, Nokia had >100 customer engagements and 48 commercial 5G deals on 6 continents. Nokia is the only player present in all 10 of the tier-1 cloud service providers (CSPs) in 3 of the 5G early adopter markets (US, South Korea and Japan).
- Nokia is the only vendor with expertise and global leadership across all 5G network elements. Its end-to-end portfolio, including private wireless solutions, offers the technology and services for a tailored, seamless, pre-integrated path to 5G, supporting all 66 3GPP frequency bands.
- Traditionally, Oulu Factory has managed machine and device telecommunications through Ethernet cables, adding significant costs in rewiring work.
- Increasing the level of automation was thus a key objective - in production as well as in the material feed, which had been manual until now.
- Automation of the material flow is done via the Omron LD Autonomous Intelligent Vehicle (AIV), which delivers material from the storage to the production line, without any human interference.



Key Players

Use case ecosystem:

Omron (LD mobile robots), network equipment providers (Ethernet cables, wiring, hotspots and other equipment), cloud and business intelligence platform service provider

Use case impact on the other sectors

Business intelligence, analytics solutions	Artificial intelligence	Cloud solutions	Logistics	Robotics
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Key Facts

Unique use cases demonstrated in the Smart Factory:

- Virtualization of new product introduction (NPI)
- Flexible robotics to ensure high-productivity and agility for continuous new ramp-ups
- 4.9G/LTE private wireless network to speed up NPI line re-layout
- Cloud-based digital data control, enabling real-time process management
- No-touch internal logistics automation via connected mobile robots



Commercial Impact

- Material flow automation results following the deployment of the Omron mobile robot solution with the Nokia Digital Automation Cloud platform:
 - Usability (overall equipment effectiveness): increased by 40%
 - Efficiency of material feed operation: increased by 30%
 - System maintenance work (engineering support need) from daily basis to monthly; several hours to few minutes: reduced by 98%



Uniqueness



Potential Societal Value

- Fewer emissions, reduced carbon footprints
- Reduced number of workplace accidents
- Upskilling for the factory workers
- Negative impact: Less opportunity for unskilled workers

SDG impact



Industry, Innovation and Infrastructure



Sustainable Consumption and Production



Improvement areas/business benefits: Manufacturing

Functional drivers of 5G facilitating the use case's deployment

Customized and personalized products	Increasing volatility from business cycles and product life cycles, resulting in economic value addition	Efficient logistics (inventory and dispatch management)	Scalability of solutions/faster proof of concepts	Enhanced mobile broadband	Ultra-reliable low latency comms.	Massive machine-type comms.	Security critical	Power efficiency
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5G Features Mapping

Illustrative impact pathway

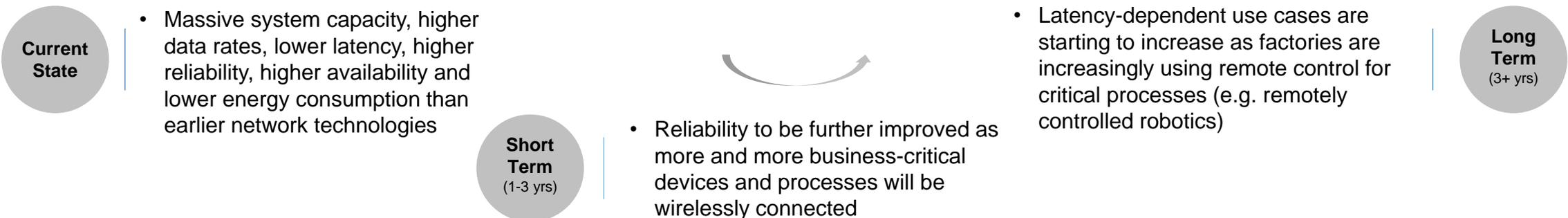
Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Omron LD Autonomous Intelligent vehicle Spectrum for private wireless network Other network instruments Automation Cloud Platform 	<ul style="list-style-type: none"> Ubiquitous reliable connectivity across the factory Collision mitigation systems Seamless, ever connected AIVs 	<ul style="list-style-type: none"> Efficient material feed operations Reduction in overall maintenance schedules Timely and error-free materials movement within the factory 	<ul style="list-style-type: none"> Sustainable industrialization [SDG 9: Industry, Innovation and Infrastructure] Sustainable and efficient use of resources [SDG 12: Sustainable Consumption and Production] 	<ul style="list-style-type: none"> Increased bottom line Reduced number of accidents/crashes % reduction in net carbon emission due to supply chain activities % increase in skills capital and available capacities

Impact Pathway

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



5G Maturity Timeline

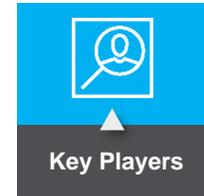
Use case category:
Simulation / Imaging (1)



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



- Siemens is a global powerhouse that focuses on electrification, automation and digitalization.
- One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of systems for power generation and transmission as well as medical diagnosis.
- Key inclusions of Vision 2020+ include three "operating companies" – "Gas and Power", "Smart Infrastructure" and "Digital Industries" – and the targeted expansion of the digitalization business and new growth field: "Internet of Things (IoT) Integration Services".



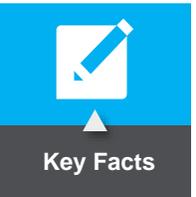
Key Players

Use case ecosystem:

Original equipment manufacturer for network equipment, Product Lifecycle Management software, data analytics platform, cloud service provider, original equipment manufacturer for manufacturing equipment

Use case impact on the other sectors

Artificial intelligence	Education	Gaming	Mining and quarrying	Retail and entertainment
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- Tecnomatix Plant Simulation software provides discrete event simulation and statistical analysis capabilities to optimize material handling, logistics, machine utilization and labour requirements.
- Powerful graphical visualization, charting and reporting features, genetic algorithms and experimentation tools evaluate the behaviour of production systems.
- The use of stochastic tools with object-oriented and 3D modelling capabilities increases manufacturing accuracy and efficiency while improving throughput and overall system performance.



Commercial Impact

- Eliminates bottlenecks and streamlines throughput, ensuring uninterrupted operations
- Assists in introducing lean manufacturing principles, in planning and building new sustainable production facilities, and in managing global production networks, ultimately resulting in operational efficiency
- Minimizes the investment cost of production lines
- Optimizes energy usage



Key features of Tecnomatix Plant Simulation:

- Object-oriented, hierarchical modelling based on dedicated object libraries for fast and efficient modelling of discrete and continuous processes
- Energy analysis tools for calculating and optimizing energy usage
- 3D online visualization and animation based on the ISO standard JT visualization format
- Graphical outputs for analysis of throughput, resource utilization, automatic bottleneck detection, Sankey diagrams and Gantt charts



Potential Societal Value

- Reduced carbon footprint
- Maximized manufacturing resources
- Increased job creation opportunities
- Enhanced skills capital of the workforce

SDG impact



Industry, Innovation and Infrastructure



Responsible Consumption



Improvement areas/business benefits: Simulation in production

- Customized and personalized products
- Increasing volatility from business cycles and product life cycles, resulting in economic value addition
- Multimedia experience helping to reduce inequalities

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable low latency comms.
- Massive machine-type comms.
- Security critical
- Power efficiency



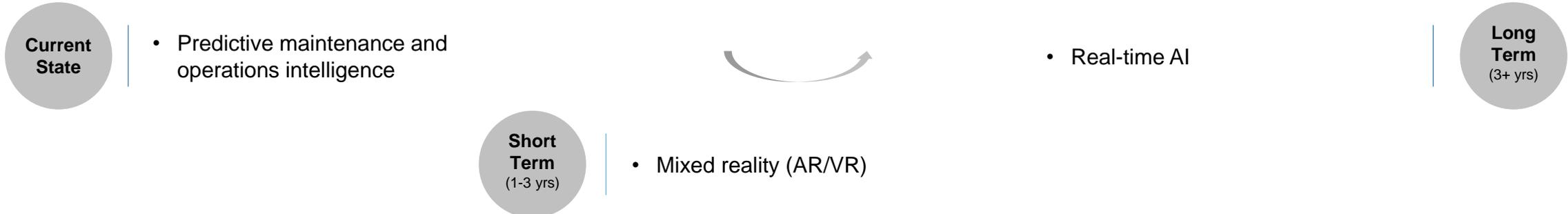
Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Product Lifecycle Management software 3D simulation tool Data analytics platform Cloud infrastructure Manufacturing equipment 	<ul style="list-style-type: none"> Energy analysis tools 3D online visualization and animation Automatic bottleneck detection 	<ul style="list-style-type: none"> Lowered investment risks through early proof of concept Maximized use of manufacturing resources Reduced inventory and throughput time 	<ul style="list-style-type: none"> Optimal use of available source and waste reduction [SDG 12: Responsible Consumption and Production] Logistical efficiencies [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> % reduction in carbon footprint % increase in bottom line revenue % contribution of manufacturing to GDP Job creation

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



Use case category:
3D Printing (1)



Fast Radius

Additive manufacturing- From “not possible” to “now possible”



1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case



Company Background

- Fast Radius, an additive manufacturing company based in Chicago, IL, understands how important agility is to the future of manufacturing.
- This is especially true for the additive manufacturing industry, where evolving environments and disruptive technologies necessitate the need for teams to become more adaptive.
- To that end, Fast Radius set out to enact an agile working mode that would enable its team to constantly iterate and optimize for efficiency.



Key Players

Use case ecosystem:

In collaboration with UPS, Curtiss motorcycles network service provider, regulators, designers, 3D printing original equipment manufacturers, retailers

Use case impact on the other sectors

Mixed reality (augmented and virtual reality)	Engineering	Industries/ factories	Internet of things (IoT)
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Key Facts

- Last year, Fast Radius was recognized as one of the nine companies best “implementing technologies of the Fourth Industrial Revolution” by the World Economic Forum – the only company honoured that is based in North America.
- With its sweeping chromoly frame and eight banks of sleek, visible battery cylinders, the Zeus 8 electric motorcycle from Curtiss would be unlike anything the market had ever seen.
- Curtiss faced challenges in the manufacturing of large parts, such as longer lead times and meeting quality requirements.



Commercial Impact

- Supply-chain-on-the-cloud approach resulting in cost reductions
- Reduced cost of prototyping, promoting innovation in designing and manufacturing
- Innovative and customized product, resulting in increased revenue opportunities
- Increased yield and faster time to market due to efficient, on-demand manufacturing (Fast Radius and Curtiss are already in production on the first 100 Zeus 8 bikes, available to the public in 2020)

Making a game-changing electric motorcycle with hybrid manufacturing



Uniqueness

- Fast Radius in partnership with Curtiss Motorcycles used hybrid manufacturing processes to create the highly-acclaimed Zeus 8 motorcycle.
- Using three separate legacy and additive manufacturing processes, Fast Radius produced more than 60 parts and components for the bike at more than 95% yield.



Potential Societal Value

- Reduction in environmental impacts due to supply and demand matching of the complex parts
- Skill enhancement for the workforce
- Promotion of industry innovations, resulting in job satisfaction



Industry, Innovation and Infrastructure



Responsible Consumption



Fast Radius

Additive manufacturing- From “not possible” to “now possible”



5G- Landscape

Improvement areas/business benefits: Digital twins- factories

Functional drivers of 5G facilitating the use case’s deployment



Customized and personalized products

Faster and effective inspections with predictive intelligence

Improved worker safety/reduced fatalities

Enhanced mobile broadband

Ultra-reliable low latency comms.

Massive machine-type comms.

Security critical

Power efficiency



Illustrative impact pathway

Input	Output	Outcome	Impact	Measure
Capex for: <ul style="list-style-type: none"> Curtiss motorcycle parts Network and cloud infrastructure security 3D printing equipment Opex for: <ul style="list-style-type: none"> Implementation SMEs 	<ul style="list-style-type: none"> Innovative prototypes Detection of wear and tear Lower downtime Hybrid manufacturing processes 	<ul style="list-style-type: none"> Enabled new part geometries Improved functional performance Cost-efficient operations 	<ul style="list-style-type: none"> Use of limited sources in manufacturing [SDG 12: Responsible Consumption and Production] Increased innovation in product designing [SDG 9: Industry, Innovation and Infrastructure] 	<ul style="list-style-type: none"> % increase in yield % time to market % increase in manufacturing capacities # of prototypes/proof of concepts rolled out

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms



Current State

- Connected bandwidth for connected units for enhanced data analysis

Short Term
(1-3 yrs)

- Predictive maintenance and operations intelligence

Long Term
(3+ yrs)

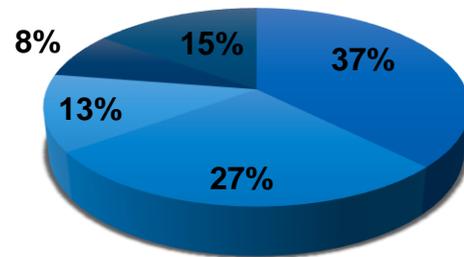
- Real-time machine learning and AI

Analysis results

Analysis #1: 5G use cases

Primary vertical	Total No. of use cases analysed*
Manufacturing	15
Transportation	11
Public services (govt.)	5
Health and social work	3
Agriculture	1
Energy	1
Logistics	1
Media & entertainment	1
Mining & quarrying	1
Professional services	1

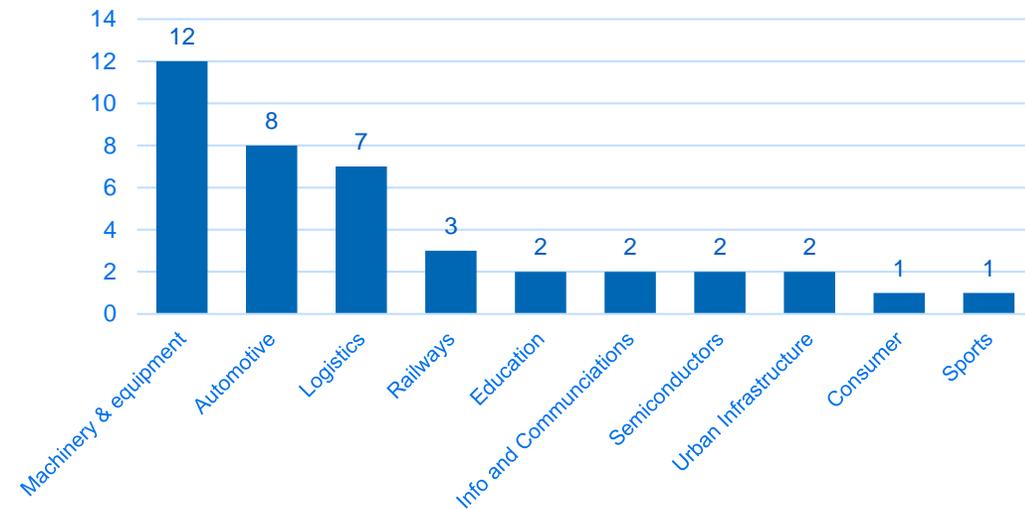
Classification of use cases - Primary industry vertical



- Manufacturing
- Transportation
- Public Services (Govt.)
- Health and social work
- Others (Agriculture, Energy, Logistics, Media & Entertainment, Mining, Professional services)

Secondary vertical	Total No. of use cases analysed*
Machinery & equipment	12
Automotive	8
Logistics	7
Railways	3
Education	2
Info & communications	2
Semiconductors	2
Urban infrastructure	2
Consumer	1
Sports	1

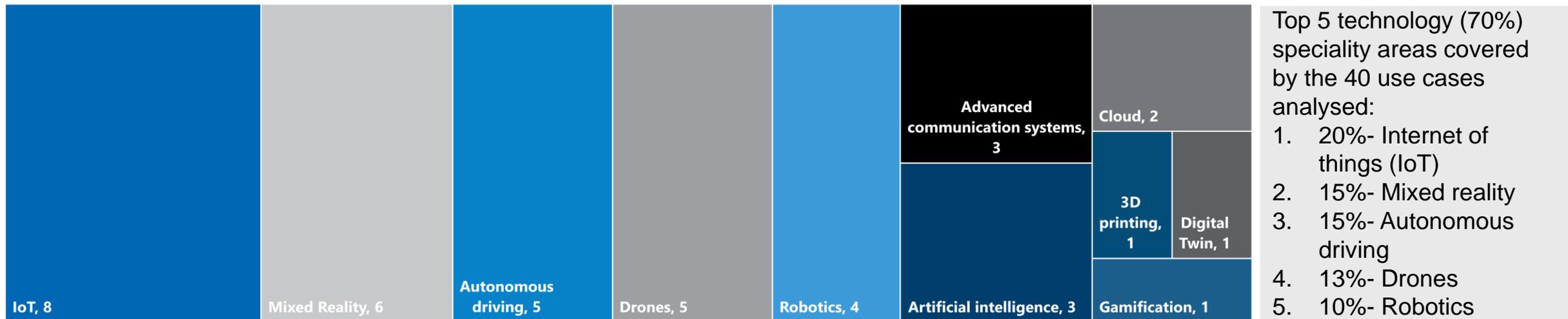
Classification of use cases - Secondary industry vertical



*A total of 40 use cases have been analysed. 35 have been included in this document

Analysis #2: 5G use cases

Technology specialty area for the 40 use cases analysed*

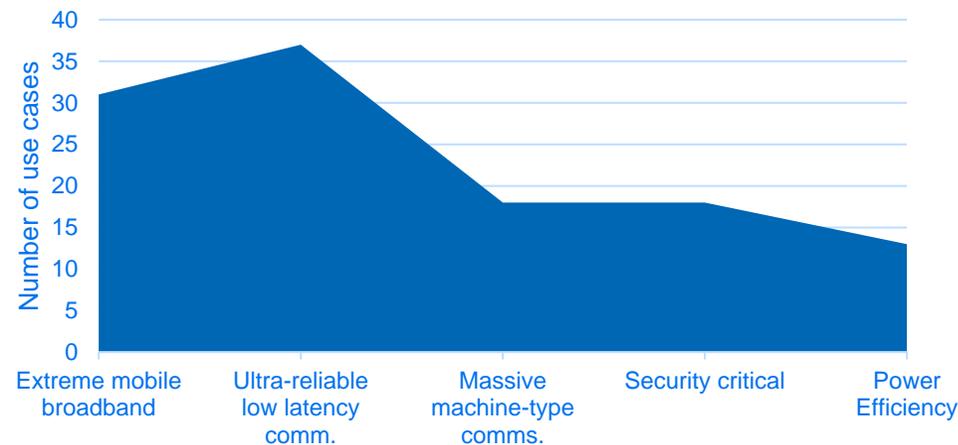


- Top 5 technology (70%) speciality areas covered by the 40 use cases analysed:
1. 20%- Internet of things (IoT)
 2. 15%- Mixed reality
 3. 15%- Autonomous driving
 4. 13%- Drones
 5. 10%- Robotics

Functional drivers of 5G	#
Enhanced mobile broadband	31
Ultra-reliable low latency comms.	37
Massive machine-type comms.	18
Security critical	18
Power efficiency	13

- 93% Ultra-reliable low latency communications
- 78% Enhanced mobile broadband
- 45% Massive machine-type communications
- 45% Security critical
- 33% Power efficiency

Functional drivers of 5G enabling number of use cases



*A total of 40 use cases have been analysed. 35 have been included in this document

Analysis #3: 5G use cases

Top 5

Impact on SDGs	No. of use cases	% of total use cases
SDG 3: Good health and well-being	22	55
SDG 9: Industry, innovation and infrastructure	16	40
SDG 12: Responsible consumption and production	12	30
SDG 11: Sustainable cities and communities	11	28
SDG 8: Decent work and economic growth	10	25
SDG 10: Reduced inequalities	4	10
SDG 2: Zero hunger	1	3
SDG 4: Quality education	1	3
SDG 5: Gender equality	1	3
SDG 13: Climate action	1	3
SDG 15: Life on land	1	3
SDG 1: No poverty	0	0
SDG 6: Clean water and sanitation	0	0
SDG 7: Affordable and clean energy	0	0
SDG 14: Life below water	0	0
SDG 16: Peace, justice and strong institutions	0	0
SDG 17: Partnership for goals	0	0

Improvement areas/business benefits for use cases	No. of use cases	% of total use cases
Faster and effective inspections with predictive intelligence	25	63
Improved worker safety/reduced fatalities	20	50
Value added as a proportion of GDP and per capita due to reduced operating costs	18	45
Managing carbon footprints/CO2 emission per unit of value added	13	33
Bridging digital divide/proportion of population covered by a network, technology	12	30
Customized and personalized products	8	20
Scalability of solutions/faster proof of concepts	8	20
Passenger and freight volumes, by mode of transport	7	18
Multimedia experience helping to reduce inequalities	7	18
City infrastructure improvement	6	15
Effective and speedy recovery	6	15
Increasing volatility from business cycles and product life cycles, resulting in economic value addition	5	13
Efficient logistics (inventory and dispatch management)	5	13
Ratio of land consumption rate to population growth rate	5	13
Improved product quality	4	10
Reduction in direct disaster economic loss/national and local disaster risk reduction strategies	2	5
Promotion of gender equality	2	5

*A total of 40 use cases have been analysed. 35 have been included in this document

Analysis #4: 5G use cases

Top 3

Functional drivers to be rolled out with 5G maturity- short term	No. of use cases
Connected units for enhanced data analysis	11
Faster image/video processing	10
Massive system capacity	9
4K video streaming	6
Powerful computing	2
High-definition entertainment on board	1
Predictive maintenance and operations intelligence	1

Functional drivers to be rolled out with 5G maturity- mid term	No. of use cases
Remote and real-time control	7
Enhanced real-time data gathering and alerts	7
Gamification	6
Network slicing	5
Predictive maintenance and operations intelligence	4
Mixed reality (AR/VR)	4
Mobile edge cloud	2
Failover	1
Edge cloud- visual inspections	1
3D holograms	1
Mixed reality using edge computing	1
Humanoid robots	1

Functional drivers to be rolled out with 5G maturity- long term	No. of use cases
Real-time machine learning and AI	10
High-precision positioning	5
Autonomous, matured V-2-X with runtime alerts	5
Real-time AI	4
Volumetric video	3
Internet of medical skills	3
Real-time machine learning	2
Automatic train operations	2
Autonomous machine learning	2
Ethical AI	2
Fully autonomous disaster management platform	1
Customized AI	1

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