



BSI Standards Publication

Industrial networks — 5G communication technology — General considerations

National foreword

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Industrial networks - 5G communication technology - General considerations



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**Industrial networks - 5G communication technology -
General considerations**

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Draft	Report on voting
65C/1354/DPAS	65C/1362/RVDPAS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Publicly Available Specification is English.

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INTRODUCTION

The overall market for wireless communication solutions spans a range of diverse applications, with differing performance and functional requirements. Within this overall market, the industrial automation domain can include:

- process automation, covering for example the following industry branches:
 - oil and gas, refining,
 - chemical,
 - pharmaceutical,
 - mining,
 - pulp & paper,
 - water & wastewater,
 - steel,
- electric power such as:
 - power generation (for example wind turbine),
 - power transmission and distribution (grid),
- factory automation, covering for example the following industry branches:
 - food and beverage,
 - automotive,
 - machinery,
 - semiconductor.

Application communication requirements for industrial wireless communication systems are different from those of, for example, the telecommunications, and commercial and consumer markets. These industrial application requirements are identified and provided in 5G-ACIA white papers that are referenced by this document.

This document provides general requirements for industrial automation and spectrum considerations that are the basis for industrial communication solutions.

Industrial premises can contain a variety of wireless communication technologies and other sources of radio emissions.

In industrial automation, many different wireless communication solutions can operate in the same premises. Different to wired fieldbuses, the wireless communication devices can interfere with others on the same premises or environment, disturbing each other.

This document is intended to provide considerations on cellular wireless communication systems according to the specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020) for being applicable in wireless communication system of industrial automation plants (see ITU-R M.2150-1:02/2022).

In Figure 1, a UML class diagram is used to categorize the term Industrial 5G, along with other examples of standards for industrial wireless communications. Accordingly, Industrial 5G refers to a set of functions for wireless data transmission using 5G in industrial automation applications. In this context, only the 3rd Generation Partnership Project (3GPP) 5G radio interface technologies (RIT) according to the detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020) are considered 3GPP TR22.832.

The 3GPP is a collaborative project that brings together standardization organizations from around the world to create globally acceptable specifications for mobile networks. As its name implies, it was first created to establish such specifications for the third generation (3G) of mobile systems. It has continued its work for subsequent generations, including the one considered here, the fifth generation (5G).

As an application of cellular networks in industrial automation, the class "Industrial 5G" inherits from both class "3GPP 5G – RIT" and class "wireless industrial communication".

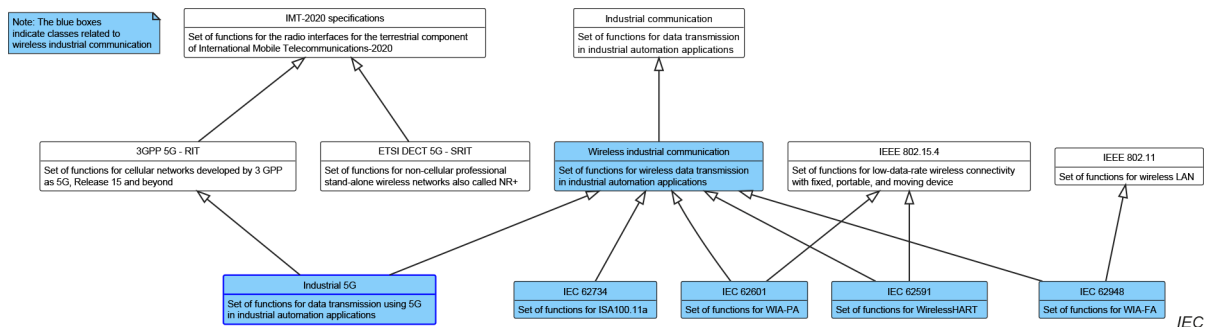


Figure 1 – 5G in the context of industrial communication

1 Scope

This document defines wireless communication systems based on 5G and beyond technologies applicable for industrial process measurement and control applications. Based on common terminology, generic descriptions, and use cases, this document provides requirements for related users, designers, and device manufacturers.

This document considers cellular wireless communication systems according to the specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020) developed by 3GPP as 5G Release 15 and beyond (see ITU-R M.2150-1:02/2022).

NOTE 1 Non-cellular professional stand-alone wireless communication systems, also called NR+, are not considered.

NOTE 2 The PAS is a pre-standard and can be converted into a series of documents for users, designers, and device manufacturers.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, abbreviated terms and conventions

For the purposes of this document, the following terms and definitions apply.

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- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

5G device

user equipment that is part of a 5G system

3.1.2

5G functions

set of functions standardized by 3GPP for 5G communication and implemented in 5G devices or 5G network equipment

3.1.3

5G network equipment

equipment that implements radio access network functions and core network functions

3.1.4

5G system

5G network

cellular network of the 5th generation and beyond

3.1.5

application adaption unit

set of functions of a 5G system that obtain QoS parameters of the application, compare them with QoS parameters of the 5G system, negotiate QoS parameters between application and 5G system and adjust QoS parameters

3.1.6

application communication requirements

quantitative requirements specifying the required conditions and the required characteristics of wireless communication solutions at the communication interface that is met in order to achieve the purpose of the automation application

[SOURCE: IEC 62657-2, 3.1.7]

3.1.7

availability (performance)

ability to be in a state to perform as required under given conditions

[SOURCE: IEC 60050-192:2015, 192-01-23, modified – Figure 1 and the pertaining notes have been deleted, Notes to entry 1 to 5 have been deleted.]

3.1.8

best effort traffic

<communication system> data transmission with no constant or guaranteed delivery time

Note 1 to entry: This happens for example if admission control mechanisms like priority are not present or where the effective bandwidth is shared among stations operating at different speeds, all varying on short timescales and with that no deterministic behavior of the data transmission.

3.1.9

cellular network

mobile network

telecommunications network in which the connection to and from the end nodes is wireless and the network is distributed over land areas known as cells, each served by at least one fixed transceiver called base station

3.1.10

communication

act of conveying intended meanings from one entity or group to another through the use of mutually understood signs and semiotic rules

3.1.11

communication cycle

closed sequence of functions for the realization of periodic data transmission determined by the communication system

3.1.12

communication relationship

set of connections between communication endpoints for data transmission determined by the communication system

3.1.13

communication system resilience

ability to maintain the intended communication application in the face of errors

3.1.14

communication technology

<Physical Layer of a communication system> physical media usable in a communication system

3.1.15

concern

factor arise from system needs and requirements, from design choices and from implementation and operating considerations throughout the life cycle

3.1.16

delivery time

<communication system> time to convey a message containing data that has to be delivered in real-time from one node (source) to another node (destination) plus the redundancy recovery time

3.1.17

distributed automation system

set of interconnected automation devices that implement the functions of a spatially distributed industrial automation application

3.1.18

down time

time interval for which the item is in a down state

[SOURCE: IEC 60050-192:2015, 192-02-21]

3.1.19

high availability

significantly increased availability of communication systems by using topologies and protocols that introduce redundancy and automatically reconfigure redundant communication elements in case of failure

3.1.20

industrial 5G functions

functions of a 5G system complemented by functions required to make use in distributed automation systems

3.1.21

industrial 5G communication functions

subset of industrial 5G functions that directly serve data communication

3.1.22

industrial 5G communication management functions

subset of industrial 5G functions that serve the management of data communication

3.1.23

industrial 5G network

part of an industrial 5G system that implements radio access network functions and core network functions

3.1.24

local automation function

sub-function that is assigned to a defined location in a distributed automation system

3.1.25

logical link

directed relationship between one end point of a reference interface of a source device and one end point of a reference interface of a target device, which is determined by the application

3.1.26

network architecture

communication network architecture

set of layers and layer protocols that constitute the communication system

3.1.27

radio cell

range in which the signal transmitted by a base station of a cellular network can be received and decoded without errors

3.1.28

radio environment

surroundings for the radio signal propagation with its passive environmental influences and active environmental influences

[SOURCE: IEC 62657-2, 3.1.94]

3.1.29

recovery

event when the network regains the ability to perform its required communication function after a disruption

Note 1 to entry: Examples of disruptions could be a fault or removal and reinsertion of a component.

[SOURCE: IEC 62439-1:2010, 3.1.40]

3.1.30

recovery time

time period between disruption and recovery

[SOURCE: IEC 62439-1:2010, 3.1.41]

3.1.31

redundancy

<in a system> provision of more than one means for performing a function

Note 1 to entry: The additional means of performing the function can be intentionally different (diverse) to reduce the potential for common mode failures

[SOURCE: IEC 60050-192:2015, 192-10-02]

3.1.32

redundancy recovery time

<communication system> maximum time from failure to become fully operational again in case of a single permanent failure

Note 1 to entry: If a permanent failure occurs, then the delivery time of a message is equal to the redundancy recovery time. In a seamless redundancy network, where the redundancy recovery time is 0 s, then the delivery time is independent of the recovery time.

3.1.33

response time

time interval between the instant delivery of the first user data bit, or octet, of a message to the reference interface of a transmitter, and the instant when the last bit, or octet, of the confirmation message is delivered at the reference interface of the same transmitter, which can be assigned to the request

[SOURCE: IEC 62657-2, 3.1.105]

3.1.34

spatial dimension

reach

<communication system> physical size in any direction

Note 1 to entry: Not limited to length, height or width.

Note 2 to entry: The average length of links times the number of hops is the special dimension in a bridged network.

3.1.35

time synchronization accuracy

time difference between clock signals provided at the reference interfaces of any of two wireless devices

3.1.36

transmission time

interval from starting the delivery of the first application data octet of a message to the reference communication interface of a producer until the delivery of the last application data octet of the same message from the reference communication interface of a consumer

[SOURCE: IEC 62657-2, 3.1.122]

3.1.37

update time

interval from the delivery of the last user data octet of the message of a producer, from the reference interface of a consumer to the automation application, until the delivery of the last user data byte of the following message of the same producer

[SOURCE: IEC 62657-2, 3.1.126]

3.1.38

up time

time interval for which the item is in an up state

[SOURCE: IEC 60050-191:2015, 192-02-02]

3.1.39

user data

data which represent the states or events of a user process, without any additional data

Note 1 to entry: In the case of communication between safety-related equipment, the user data contain safety-related data.

[SOURCE: IEC 821-11-57]

3.1.40

data throughput

ratio between the number of user data transferred to the application at the target reference interface and the observation time

[SOURCE: IEC 62657-2, 3.1.29]

3.1.41

user equipment

end device of a cellular network

3.1.42**wireless device**

wireless automation device

equipment of wireless communication applications that uses radio waves for wireless communication with other equipment of wireless communication applications

[SOURCE: IEC 62657-2, 3.1.134]

3.1.43**wireless solution**

wireless communication solution

specific implementation or instance of a wireless communication system

Note 1 to entry: A wireless solution can be composed of products of one or more producers.

[SOURCE: IEC 62657-2, 3.1.142]

3.1.44**wireless system**

wireless communication system

set of interrelated elements providing wireless communication

Note 1 to entry: A wireless system is a high-level representation of a system, while a wireless solution is a practical instance of a system.

[SOURCE: IEC 62657-2, 3.1.143]

3.2 Abbreviated terms

(g)PTP	gPTP in a 5G system
(R)AN	(Radio) Access Network
3G	Third Generation Mobile Networks
3GPP	3 rd Generation Partnership Project
4G	Fourth Generation Mobile Networks
5G	Fifth Generation Mobile Networks
5G-ACIA	5G Alliance for Connected Industries and Automation
AF	Application function
AFH	Adaptive frequency hopping
AGV	Automated guided vehicle
AKA	Authentication and key agreement
AMF	Access and mobility management function
APN	Access point name
CEPT	European conference of postal and telecommunications administrations
CNC	Centralized network configuration
CP	Communication profile according to IEC 61784-2
CSMA	Carrier sense multiple access
DAA	Detect and avoid
DAR	Detect and reduce
DAS	Detect and suppress
DECT	Digital enhanced cordless telecommunications
DN	Data network
DS-TT	Device-side TSN translator

EAP	Extensible authentication protocol
ECO	European communications office (the electronic communications committee of CEPT)
EIF	Extensible authentication protocol identity function
EIRP	Equivalent isotropic radiated power
eMBB	Enhanced mobile broadband
eSIM	Embedded subscriber identity module
FRER	Frame replication and elimination for reliability
gPTP	generalized Precision Time Protocol
GSM	Global system for mobile communications
HMI	Human machine interface
ICT	information and communication technology
IF	Intermediate frequency
IIoT	Industrial Internet of things
IMT	International mobile telecommunications
IP	Internet protocol
IPv6	Internet protocol version 6
ISM	Industrial, scientific and medical
IT	Information technology
ITU	International telecommunication union
ITU-R	ITU Radiocommunication Sector
LAA	License assisted access
LAN	Local area network
LOS	Line of sight
MAC	Medium access control
ME	Mobile equipment
MES	Manufacturing execution system
MLR	Message loss ratio
mMTC	Massive machine-type communications
MT	Mobile termination
N/A	Not applicable
NAA	Network authentication application
NEF	Network Exposure Function
NF	Network Functions
NLOS	Non line of sight
NPN	Non-public network
NR	New radio
OFDM	Orthogonal frequency division multiplex
OAM&P	Operation, administration, maintenance, and provisioning
OSI	Open systems interconnection
OT	Operational technology
PCB	Printed circuit board
PCF	Policy Control Function

PCI	Peripheral Component Interconnect
PCIe	Peripheral Component Interconnect express
PCP	Priority code points
PDU	Protocol data unit
PHY	Physical layer
PLC	Programmable logic controller
PLMNID	Public land mobile network identifier
PMIC	Power management integrated circuit
PNI/NPN	Public Network Integrated Non-Public Network
PSD	Power spectral density
PTP	Precision time protocol
QoS	Quality of service
RAN	Radio access network
RF	Radio frequency
RFID	Radio frequency identification
RIT	Radio interface technologies
RSSI	Received signal strength indication
SCADA	Supervisory Control and Data Acquisition
SIR	Signal-to-interference ratio
SLA	Service-level agreement
SLS	Service-level specification
SMF	Session Management Function
SNPN	Standalone Non-Public Networks
SP	Service provider
SPI	Serial peripheral interface
TCP	Transmission control protocol
TDMA	Time division multiple access
TR	Technical report
TRP	Total radiated power
TS	Technical Specification
TSi	ingress TimeStamp
TSN	Time Sensitive Networking
UART	Universal asynchronous receiver/transmitter
UDR	unified data repository
UE	User equipment
UHD	Ultra high definition
UICC	universal integrated circuit card
UMIC	User-managed integrity protection control
UML	Unified modeling language
UMTS	Universal mobile telecommunications system
UPF	User plane Function
URLLC	Ultra-reliable and low latency communications
USB	Universal serial bus

USIM	Universal subscriber identity module
UTC	Coordinated universal time
V2X	Vehicle to anything
VLAN	Virtual LAN
WD	Wireless device
WIA-PA	Wireless network for industrial automation – process automation
WLAN	Wireless local area network

3.3 Conventions

Capitalization of the term Bridge means a device type according to IEEE Std 802.1Q.

The terms Ethernet and Internet are capitalized.

This document refers to the latest 3GPP release unless otherwise specified.

The term wired does not only refer to metallic wire but also includes glass fiber and polymer optical fiber.

The graphical representations of flow charts in figures (e.g. Figure 8) are based on ISO 5807.

4 Considerations on 5th Generation mobile networking

4.1 Overview

5G is the 5th generation Mobile Network Technology specified by 3GPP organization. While previous mobile network generations (up to 4G) were mainly focused on consumer applications with phone, messaging and data transfer services, 3GPP 5G promises to provide new types of communication services that are of relevance for industrial applications and adjacent verticals.

5G system network architecture is shown in Figure 2. In general, 5G system consists of three planes to handle various network requirements.

- User plane: responsible for the transfer of user data, which includes all the data that is not related to control signaling. This includes services such as voice calls, video streaming, web browsing, and file transfers. It involves protocols and functions that handle the actual data transmission from the user equipment (UE) to the network and vice versa. In 5G, user plane includes UE, the Radio Access Network (RAN) and user plane function (UPF) from 5G core network.
- Control plane: manages the signalling and control information that are necessary for the establishment, maintenance, and release of data connections. This plane is responsible for functions such as mobility management, session management, and radio resource control, including core network functions such as access and mobility management function (AMF), session management function (SMF) policy control function (PCF), network exposure function (NEF), application function (AF), etc.
- Management plane: focus on the operation, administration, maintenance, and provisioning (OAM&P) of the network. This plane includes network management systems and protocols that are used for configuration, fault management, performance management, and security management. It allows network administrators to monitor the health of the network, configure network elements, and troubleshoot any issues. Management plane ensures that the network can be running efficiently and that any network issues can be detected and resolved promptly.

All relevant network functions (NF), interfaces and procedures are specified in 3GPP TS 23.501. The major core network functionalities are selected and explained as below.

- Access and mobility management function (AMF) includes the functionality of registration management, connection management, reachability management and mobility management, etc. This function provides a control plane interface toward the user equipment (UE).
- Session management function (SMF) includes the functionality of session management, UE IP address allocation and management, etc.
- User plane function (UPF) includes for example the functionality of anchor point for mobility, allocation of UE IP address and prefix (if supported) in response to SMF request, packet routing and forwarding and QoS handling for user plane.
- Policy control function (PCF) includes the functionality of supporting unified policy framework to govern network behavior, providing policy rules to control plane function(s) to enforce them, access subscription information relevant for policy decisions in a unified data repository (UDR).
- Network exposure function (NEF) supports exposure of capabilities of 5G network capabilities toward entities external to 5G systems. The exposed capabilities can be categorized as monitoring capability, provisioning capability, policy and charging capability and analytics reporting capability.
- Application function (AF) interacts with the 3GPP core network in order to provide services, for example to support the following: application influence on traffic routing, accessing network exposure function, interacting with the policy framework for policy control, time synchronization service, etc. The AF represents a server or an application which makes use of 5G system capabilities to provide services to the end devices. The AF cannot interact directly with the 5G system NF, but it shall use the exposure framework provided by NEF to interact with relevant NF.
- Data network (DN) function, for example operator services, Internet access or 3rd party services.

The 5G network architecture provides two ways to enable the interaction between network functions:

- N1, N2, N3, N4, etc. are point-to-point reference points that show the interaction between the NF services in the network functions.
- Nnef, Npcf, Naf, etc. are the service-based interface exhibited by the corresponding NF.

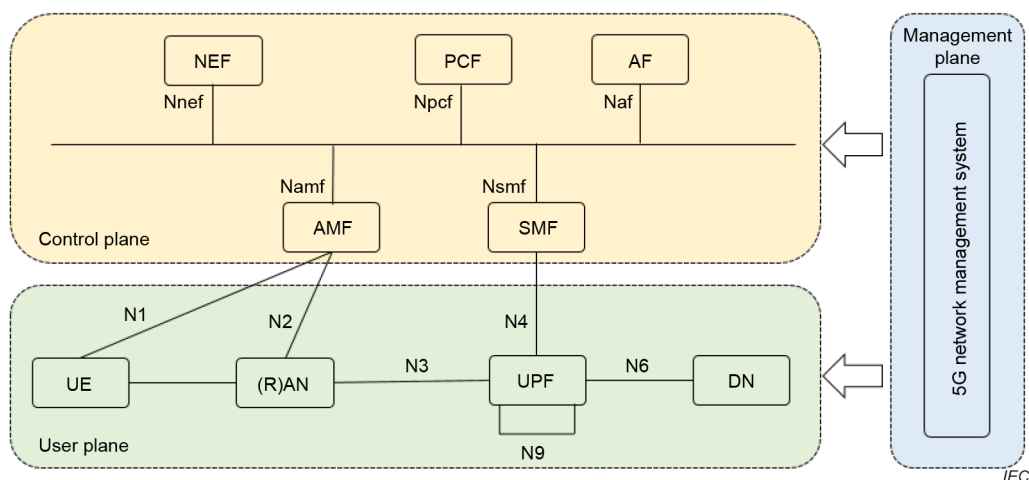


Figure 2 – 5G system network architecture

The general directions of these services and the targeted use case have been defined by ITU-R in their definition of International Mobile Telecommunications IMT for 2020 (IMT-2020) and shown in Usage scenarios of IMT for 2020 and beyond, see ITU-R Recommendation M.2083.

Enhanced mobile broadband (eMBB) is slated to provide both high data rates and low-latency communication in some areas, and reliable broadband access over large coverage areas.

Massive machine-type communications (mMTC) are slated to provide wireless connectivity for up to tens of billions of network-enabled devices worldwide. Here, scalable connectivity for an increasing number of devices, wide area coverage, and deep indoor penetration are key priorities.

Ultra-reliable and low latency communications (URLLC) shall provide ultra-reliable low-latency using resilient communication links for, e.g. vehicle to anything (V2X) communication, mission critical and industrial control applications.

They are the base for the 5G development. Minimum requirements for IMT-2020 radio interfaces were defined in ITU-R Report M.2410-0, see also ITU-R Recommendation M.2083 that describes the IMT 2020 key capabilities. These requirements are rather generic and high level, and specific requirements are defined as part of the 3GPP 5G standardization process.

The first feasibility study of 3GPP on New Services and Markets Technology Enablers for 5G, see 3GPP TR22.891, identified use cases in the following five service dimensions:

- 1) enhanced mobile broadband (for example UHD or Hologram, Virtual Presence);
- 2) critical communications (for example interactive games, industrial control);
- 3) massive machine type communications (for example Subway, eHealth);
- 4) network operation (for example network slicing, routing);
- 5) enhancement of vehicle-to-everything (for example autonomous Driving).

This study covered use cases in industrial areas relevant for IEC, for instance automation and control, robotics, railways, and healthcare. The study contributed to 3GPP TS22.261, "Service requirements for the 5G system" for Release 15, see 3GPP TS22.261. This specification is updated for each new release.

5G service dimensions are shown in 3GPP TR22.891.

4.2 Radio access technology and spectrum

For 5G new radio (NR), an orthogonal frequency division multiplex (OFDM)-based unified air interface is deployed. The interface shall deliver high performance at low complexity. It shall support diverse spectrum bands and deployment models and cover efficiently all the different service scenarios from eMBB to mMTC and URLLC.

The assignment of significant spectrum in different bands is necessary for 5G in order to support the various services. This includes the sub 1 GHz range for wide coverage; the 1 to 6 GHz range for a good mixture of coverage and bandwidth; and spectrum above 6 GHz for high-bandwidth applications. Besides spectrum licensed exclusively for 5G, the use of unlicensed spectrum is supported. For the latter, besides license assisted access (LAA), which combines unlicensed 5G access aggregation with a licensed 5G carrier, standalone unlicensed access is studied, see Draft 3GPP TR38.889.

Countries worldwide have already allocated or targeted specific spectrum bands for 5G usage, see study on NR to support non-terrestrial networks, see Draft 3GPP TR38.811. Further spectrum can be allocated over time by national regulators evaluating the demand for 5G services.

5 Considerations of 5G in industrial automation applications

5.1 General

Clause 5 provides an overview on considerations of 5G in industrial automation applications, which have been completed in the consortium 5G-ACIA, is the central global forum for shaping 5G in the industrial domain. On one platform, various industries from all over the world jointly create a new ICT and OT ecosystem and set the frameworks for a highly attractive emerging market. Clause 5 is referring to some of the publicly available white papers of the consortium 5G-ACIA.

NOTE Annex A provides a list of 5G-ACIA White Papers of interest.

5.2 5G background and challenges

The capabilities of 5G extend far beyond mobile broadband with ever increasing data rates. 5G supports communication with unprecedented reliability and very low latencies.

The 5G-ACIA white paper "5G for Connected Industries and Automation", provides an overview of 5G's basic potential for manufacturing industry, and outlines relevant use cases and requirements. Furthermore, it introduces some of the main building blocks of 5G and certain major challenges that have not yet been resolved. Finally, the aforementioned 5G-ACIA is presented in more detail as an important initiative to ensure that 5G for the industrial domain is ultimately successful.

NOTE Annex A provides a list of 5G-ACIA White Papers of interest.

5.3 Use cases and requirements

5.3.1 Key 5G use cases and requirements

3GPP's 5G specifications include multiple manufacturing and control use cases and requirements. Requirements with regard to 5G services and 5G performance are defined by the 3GPP SA1 working group in corresponding 3GPP Technical Specifications (TS) 3GPP TS22.104 and 3GPP TS22.261 and are summarized in 3GPP technical reports (TR) 3GPP TR22.804 and 3GPP TR22.832 describe use cases and requirements in more detail and are informative in character.

The 5G-ACIA white paper "Key 5G Use Cases and Requirements", summarizes the industrial automation key 5G use cases and requirements.

NOTE Annex A provides a list of 5G-ACIA White Papers of interest.

5.3.2 A 5G traffic model for industrial use cases

Applications in industrial automation systems have stringent requirements regarding latency and reliability. These requirements are already met by current communication systems, mostly based on wired technologies. To determine whether a wired system can be replaced by a wireless 5G system or not, it is necessary to analyze the actual data volumes and traffic types of industrial use cases. To accurately predict network load, a realistic traffic model is required to enable performance evaluation and design of the corresponding communications systems. The communication requirements of selected use cases should therefore be analyzed, modelled and validated. The 5G-ACIA white paper "A 5G Traffic Model for Industrial Use Cases", describes a 5G user data traffic model for industrial use cases employing a 3GPP-compliant radio network.

NOTE Annex A provides a list of 5G-ACIA White Papers of interest.

The traffic is modelled by a set of parameters relevant to the design and spatial dimensioning of 5G networks. These traffic model parameters give both network service providers (SPs) and network service users (e.g. OT companies) to a common method of describing the projected 5G traffic. Based on these mutually agreed parameters, SPs can assess and install necessary spectrum and network resources for the 5G networks offered to OT companies. The traffic model will focus on use case categories of high priority for industrial automation, process automation and inbound (production) logistics.

5.3.3 5G for automation in industry

The 5G-ACIA white paper "5G for Automation in Industry", examines how the 3GPP-defined 5G network architecture will impact industry, in particular process and factory automation. It describes the most relevant use cases, and the corresponding 5G functions and service requirements. It is consciously an overview, and does not aspire to be fully comprehensive, for instance spectrum aspects are out of scope. Spectrum aspects are discussed in 5G-ACIA white paper "5G for Connected Industries and Automation" and in 4.2.

NOTE Annex A provides a list of 5G-ACIA White Papers of interest.

Consideration is primarily given to the requirements of automation and robotics. This paper is intended to give ICT professionals a high-level overview of relevant 3GPP supported OT use cases. Furthermore, it is designed to give OT companies (i.e. those companies in industry who will deploy 5G) high-level guidance on what is supported by the 3GPP-defined network architecture, and to provide references where they can find more detailed information. The main 3GPP TR related to industrial use cases are as follows:

- Study on Communication for Automation in Vertical Domains (FS_CAV) in Draft 3GPP TR 22.804,
- Feasibility Study on Business Role Models for Network Slicing (FS_BMNS) in Draft 3GPP TR 22.830, and
- Feasibility Study on LAN Support in 5G (FS_5GLAN) in Draft 3GPP TR 22.821.

These TRs are not normative (that means, they are not prescriptive, and they are non-binding). They cannot be used as the basis for implementation, and they cannot be referred to by 3GPP TS. It should be noted that 3GPP often employs the term "vertical domain", that means, a particular industry or group of enterprises in which similar products or services are developed, produced, and provided. The TRs were primarily written by 3GPP to understand and summarize the high-level communication requirements of the industrial community, which have since been described in the following normative and binding TS:

- Service requirements for cyber-physical control applications in vertical domains, 3GPP TS22.104, and
- Service requirements for the 5G system, 3GPP TS22.261.

Once finalized ("frozen"), the TRs given above are not updated. However, TSs are updated as the requirement arises. As a result, it is possible for the content of a TS to diverge increasingly from that of a TR over time. This should be taken into account when making references to any 3GPP TR or TS. The functionality described in this white paper is proposed for implementation in 3GPP Rel-16 specifications, that was published in 2020.

5.4 5G system network architecture and capabilities

5.4.1 Security aspects of 5G for industrial networks

5G security is an integral part of secure industrial operations. 5G is an enabler of both telecommunications and industrial use cases. The security requirements of telecommunications networks are well defined and have been widely published. The 5G-ACIA white paper "Security Aspects of 5G for Industrial Networks", concentrates on the security requirements of industrial networks.

NOTE Annex A provides a list of 5G-ACIA White Papers of interest.