

ETSI GS F5G 013 V1.1.1 (2023-04)



Fifth Generation Fixed Network (F5G); F5G Technology Landscape Release 2

[ETSI GS F5G 013 V1.1.1 \(2023-04\)](https://standards.iteh.ai/catalog/standards/sist/cff3a441-90db-4d58-b8d6-26c84d44e8bd/etsi-gs-f5g-013-v1-1-1-2023-04)

<https://standards.iteh.ai/catalog/standards/sist/cff3a441-90db-4d58-b8d6-26c84d44e8bd/etsi-gs-f5g-013-v1-1-1-2023-04>

Disclaimer

The present document has been produced and approved by the Fifth Generation Fixed Network (F5G) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG. It does not necessarily represent the views of the entire ETSI membership.

Reference

DGS/F5G-0013_Techno Land R2

Keywords

F5G, next generation protocol, requirements

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:

<https://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://standards.etsi.org/People/CommitteeSupportStaff.aspx>

If you find a security vulnerability in the present document, please report it through our

Coordinated Vulnerability Disclosure Program:

<https://www.etsi.org/standards/coordinated-vulnerability-disclosure>

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2023.
All rights reserved.

Contents

Intellectual Property Rights	15
Foreword.....	15
Modal verbs terminology.....	15
1 Scope	16
2 References	16
2.1 Normative references	16
2.2 Informative references.....	16
3 Definition of terms, symbols and abbreviations.....	24
3.1 Terms.....	24
3.2 Symbols.....	24
3.3 Abbreviations	24
4 Technology requirements and landscape.....	30
4.1 Overview	30
4.1.1 Introduction.....	30
4.1.2 Document structure overview	31
4.2 Cloud Virtual Reality	31
4.2.1 Use case briefing.....	31
4.2.2 Technical requirements	31
4.2.2.1 Cloud VR network performance requirements.....	31
4.2.2.2 High performance channel requirements	32
4.2.2.2.1 Home network performance	32
4.2.2.2.2 Access network performance.....	33
4.2.2.2.3 OLT Enhancement.....	33
4.2.2.2.4 Aggregation network performance	34
4.2.2.3 Dynamic channel requirements	34
4.2.2.4 Efficient transport of cloud VR services	35
4.2.3 Current related standard specifications	35
4.2.4 Gap analysis.....	35
4.2.4.1 Gap Context	35
4.2.4.2 Cloud VR network performance	35
4.2.4.3 High performance channel requirements	35
4.2.4.3.1 Home network performance	35
4.2.4.3.2 Access network performance.....	36
4.2.4.3.3 OLT Enhancement.....	36
4.2.4.3.4 Metro network performance	36
4.2.4.4 Dynamic channel setup and release	37
4.2.4.5 Efficient transport of Cloud VR services	37
4.3 High Quality Private Line	37
4.3.1 Use Case briefing.....	37
4.3.2 Technology Requirements	38
4.3.2.1 General introduction.....	38
4.3.2.2 Connection Overview.....	38
4.3.2.3 Flexible Bandwidth	39
4.3.2.4 Private line User Isolation.....	39
4.3.2.5 On Demand Ordering.....	39
4.3.2.6 Guaranteed Reliability	39
4.3.2.7 Low latency.....	39
4.3.2.8 Private DC and Cloud access	40
4.3.2.9 Scalability.....	40
4.3.3 Current related standard specifications	40
4.3.4 Gap analysis.....	41
4.3.4.1 Gap Context	41
4.3.4.2 Flexible Bandwidth	41
4.3.4.3 Private line User Isolation.....	41

4.3.4.4	On Demand Ordering	41
4.3.4.5	Guaranteed Reliability	41
4.3.4.6	Low and deterministic Latency	41
4.3.4.7	Private DC and Cloud access	41
4.3.4.8	Scalability.....	42
4.4	High Quality Low Cost private lines for SMEs.....	42
4.4.1	Use Cases briefing	42
4.4.2	Technology Requirements	42
4.4.2.1	General introduction.....	42
4.4.2.2	CPN to support a large number of terminals.....	42
4.4.2.3	Quality assurance (bandwidth, latency, reliability)	43
4.4.2.4	Quality of Experience for cloud based services	43
4.4.2.5	Low cost based on reusing residential Access Network.....	43
4.4.2.6	High availability and reliability.....	44
4.4.2.7	Fast provisioning and highly efficient management and operation.....	44
4.4.3	Current related standard specifications	44
4.4.4	Gap analysis.....	44
4.4.4.1	Gap Context	44
4.4.4.2	CPN to support a large number of terminals.....	44
4.4.4.3	Quality assurance (bandwidth, latency, reliability)	45
4.4.4.4	Quality of Experience for cloud based services	45
4.4.4.5	Low cost based on reusing residential Access Network.....	45
4.4.4.6	High availability and reliability.....	46
4.4.4.7	Fast provisioning and high efficient management and operation.....	46
4.5	Fibre on-premises networking: Fibre-to-The-Room (FTTR)	46
4.5.1	Use case briefing	46
4.5.2	Technical requirements.....	46
4.5.2.1	General introduction.....	46
4.5.2.2	Variety of data rate profile	46
4.5.2.3	Lower optical link budget	47
4.5.2.4	Seamless roaming support for Wi-Fi® connection	47
4.5.2.5	Support of diversified transceiver	47
4.5.2.6	Network security	48
4.5.2.7	Fibre infrastructure.....	48
4.5.2.8	Power saving and management.....	48
4.5.2.9	Support of network QoS.....	49
4.5.2.10	Support of East-to-West data streaming.....	49
4.5.3	Current related standard specifications	49
4.5.3.1	IEEE	49
4.5.3.2	ITU-T	49
4.5.3.3	Broadband Forum (BBF)	50
4.5.3.4	Wi-Fi® alliance (WFA)	51
4.5.4	Gap analysis.....	51
4.5.4.1	Gap Context	51
4.5.4.2	General	51
4.5.4.3	Variety of data rate profile	51
4.5.4.4	Lower optical link budget	51
4.5.4.5	Seamless roaming support for Wi-Fi® connection	51
4.5.4.6	Diversified transceiver and fibre types.....	52
4.5.4.7	Network security	52
4.5.4.8	Fibre infrastructure.....	52
4.5.4.9	Power saving and management.....	52
4.5.4.10	Support of network QoS.....	53
4.5.4.11	Support of East-to-West data streaming.....	53
4.6	Passive optical LAN.....	53
4.6.1	Use case briefing.....	53
4.6.2	Technical requirements.....	53
4.6.2.1	General introduction.....	53
4.6.2.2	Network slicing	54
4.6.2.3	Network security and reliability	54
4.6.2.4	Centralized access control.....	54
4.6.2.5	Power over Ethernet (PoE).....	55

4.6.3	Current related standard specifications	55
4.6.3.1	ITU-T PON standards	55
4.6.3.2	Broadband Forum	55
4.6.4	Gap analysis.....	55
4.6.4.1	Gap Context	55
4.6.4.2	Network slicing	55
4.6.4.3	Network security and reliability	55
4.6.4.4	Centralized access control	55
4.6.4.5	Power over Ethernet (PoE).....	56
4.7	PON for Industrial Manufacturing	56
4.7.1	Use Cases briefing	56
4.7.2	Technology Requirements	56
4.7.2.1	Unified multi-service support.....	56
4.7.2.2	Deterministic network performance.....	57
4.7.2.3	Industrial interface and protocol support.....	57
4.7.2.4	Stronger network resilience.....	58
4.7.2.5	Higher network security	58
4.7.2.6	Smart management.....	58
4.7.2.7	Harsh environment adaptation	59
4.7.2.8	Edge computing	59
4.7.3	Current related standards	59
4.7.3.1	IEEE.....	59
4.7.3.2	ITU-T	60
4.7.3.3	ETSI	60
4.7.3.4	IEC	60
4.7.4	Gap analysis.....	60
4.7.4.1	Gap Context	60
4.7.4.2	Unified multi-service support.....	60
4.7.4.3	Deterministic network performance.....	60
4.7.4.4	Industrial interface and protocol support.....	61
4.7.4.5	Stronger network resilience.....	61
4.7.4.6	Higher network security	61
4.7.4.7	Smart management.....	61
4.7.4.8	Harsh environment adaption	61
4.7.4.9	Edge computing	62
4.8	Multiple Access Aggregation over PON (MAAP)	62
4.8.1	Use Cases briefing	62
4.8.2	Technology requirements	62
4.8.2.1	General introduction.....	62
4.8.2.2	Bandwidth	63
4.8.2.3	Protection	65
4.8.2.4	Latency	65
4.8.2.5	Timing & Synchronization.....	66
4.8.2.6	Slicing	68
4.8.2.7	Protocol transparency	68
4.8.3	Current related standard specifications	68
4.8.3.1	ITU-T	68
4.8.3.2	3GPP	69
4.8.3.3	IEEE	69
4.8.3.4	ETSI	69
4.8.3.5	MEF	70
4.8.3.6	BBF	70
4.8.4	Gap analysis.....	70
4.8.4.1	Gap Context	70
4.8.4.2	Overall gap analysis	70
4.8.4.3	Bandwidth	70
4.8.4.4	Protection	70
4.8.4.5	Latency	71
4.8.4.6	Timing & Synchronization.....	71
4.8.4.7	Slicing	71
4.8.4.8	Protocol Transparency	71
4.9	Scenario Based Broadband.....	71

4.9.1	Use Cases briefing	71
4.9.2	Technology Requirements	72
4.9.2.1	General introduction.....	72
4.9.2.2	Application identification.....	72
4.9.2.3	Broadband application feature database establishment and updates	72
4.9.2.4	Network slicing and application acceleration.	72
4.9.2.5	QoE evaluation.....	72
4.9.2.6	Potential application and user discovery	73
4.9.2.7	The network capacity monitoring and expansion prediction.....	73
4.9.3	Current related standards	73
4.9.3.1	ITU-T	73
4.9.3.2	BBF	73
4.9.3.3	ETSI	73
4.9.3.4	Artificial Intelligence	74
4.9.4	Gap analysis.....	74
4.9.4.1	Gap Context	74
4.9.4.2	Traffic or application classification.....	74
4.9.4.3	Application list or database setup.....	74
4.9.4.4	Network slicing and SLA.....	75
4.9.4.5	QoE improvement effect automatic evaluation.....	75
4.9.4.6	Potential application and subscriber discovery	75
4.9.4.7	Network status monitoring.....	76
4.10	Telemetry-based Enhanced Performance Monitoring in Intelligent Access Network.....	76
4.10.1	Use Case briefing.....	76
4.10.2	Technology Requirements	76
4.10.2.1	Telemetry based network performance monitoring	76
4.10.2.2	Network abstraction and configuration schemes for telemetry	77
4.10.3	Current related standards	77
4.10.3.1	BBF	77
4.10.3.2	IETF	78
4.10.3.3	Related open-source project.....	78
4.10.4	Gap analysis.....	78
4.10.4.1	Gap Context	78
4.10.4.2	Telemetry technology supporting and evolution in Access Network.....	78
4.10.4.3	Data model supporting network quality monitoring	78
4.11	Remote Attestation	79
4.11.1	Use Cases briefing	79
4.11.2	Technology Requirements	79
4.11.2.1	General introduction.....	79
4.11.2.2	Secure measurement data generating, storing and reporting	79
4.11.2.3	Remote attestation support for network elements with multiple hardware architectures	79
4.11.2.4	Remote attestation support for network element booting and running.....	80
4.11.3	Current related standards	80
4.11.3.1	IETF	80
4.11.3.2	Global Platform.....	80
4.11.4	Gap analysis.....	81
4.11.4.1	Gap Context	81
4.11.4.2	Secured measurement data generating, storing and reporting	81
4.11.4.3	Remote attestation support for devices with multiple hardware architectures	81
4.11.4.4	Remote attestation support for network element booting and running.....	81
4.12	Digitalized ODN/FTTX	82
4.12.1	Use case briefing.....	82
4.12.2	Technology Requirements	82
4.12.2.1	General introduction.....	82
4.12.2.2	ODN digital management	82
4.12.2.3	Digitized ODN construction based on pre-connection.....	83
4.12.3	Current related standards	83
4.12.3.1	IEC	83
4.12.3.2	ITU-T	83
4.12.3.3	ETSI	83
4.12.4	Gap analysis.....	83
4.12.4.1	Gap Context	83

4.12.4.2	Introduction	84
4.12.4.3	ODN digital management	84
4.12.4.4	Digitized ODN construction based on pre-connection	84
4.13	Virtual Presence	84
4.13.1	Use Case briefing	84
4.13.2	Technology Requirements	85
4.13.2.1	General introduction	85
4.13.2.2	High performance bi-directional channel requirements	85
4.13.2.3	Virtual Presence slices	85
4.13.2.4	Edge computing and compute offloading	87
4.13.2.5	Privacy and security	87
4.13.3	Current related standard specifications	88
4.13.3.1	ITU-T	88
4.13.3.2	BBF	88
4.13.3.3	ETSI	88
4.13.3.4	3GPP	89
4.13.3.5	ISO/IEC	89
4.13.3.6	CTA WAVE	89
4.13.3.7	IETF	89
4.13.4	Gap analysis	89
4.13.4.1	Gap Context	89
4.13.4.2	High performance bi-directional channel requirements	89
4.13.4.3	Virtual Presence slices	89
4.13.4.4	Edge computing and compute offloading	90
4.13.4.5	Privacy and security	91
4.14	Enterprise private line connectivity to multiple Clouds	91
4.14.1	Use Case briefing	91
4.14.2	Technology Requirements	92
4.14.2.1	General introduction	92
4.14.2.2	Single-point/Multi-point access to multiple Clouds	92
4.14.2.3	Service driven	92
4.14.2.4	Flexible bandwidth	92
4.14.2.5	Slicing	93
4.14.2.6	Service scalability	93
4.14.2.7	Deterministic protection and restoration	93
4.14.3	Current related standard specifications	94
4.14.3.1	ITU-T	94
4.14.3.2	IETF	94
4.14.4	Gap analysis	95
4.14.4.1	Gap Context	95
4.14.4.2	Single-point/Multi-point access to multiple Clouds	95
4.14.4.3	Service driven	95
4.14.4.4	Flexible bandwidth	95
4.14.4.5	Slicing	96
4.14.4.6	Service scalability	96
4.14.4.7	Deterministic protection and restoration	96
4.15	Premium home broadband connectivity to multiple Clouds	97
4.15.1	Use Case briefing	97
4.15.2	Technology Requirements	97
4.15.2.1	General introduction	97
4.15.2.2	Single-point/Multi-point access to multiple Cloud DCs	97
4.15.2.3	Service-driven optical network	97
4.15.2.4	Flexible bandwidth adjustments for DC connections	98
4.15.2.5	Slicing	98
4.15.2.6	Service scalability	99
4.15.2.7	Deterministic protection and restoration	99
4.15.3	Current related standard specifications	99
4.15.3.1	ITU-T	99
4.15.3.2	IETF	99
4.15.4	Gap Analysis	99
4.15.4.1	Gap Context	99
4.15.4.2	Single-point/Multi-point access to multiple Clouds	100

4.15.4.3	Service-driven optical network	100
4.15.4.4	Flexible bandwidth.....	100
4.15.4.5	Slicing	100
4.15.4.6	Service scalability	101
4.15.4.7	Deterministic protection and restoration	101
4.16	Virtual Music.....	102
4.16.1	Use Case briefing.....	102
4.16.2	Technology Requirements	102
4.16.2.1	General introduction.....	102
4.16.2.2	Ultra-low latency and jitter for increased distance between musicians.....	102
4.16.2.3	Dynamic set up of audio channel	103
4.16.2.4	Guaranteed bandwidth	104
4.16.2.5	Edge computing capability.....	104
4.16.3	Current related standard specifications	104
4.16.3.1	General introduction.....	104
4.16.3.2	ETSI	104
4.16.3.3	3GPP	104
4.16.4	Gap analysis.....	105
4.16.4.1	Gap Context	105
4.16.4.2	Ultra-low latency and jitter for increased distance between musicians.....	105
4.16.4.3	Dynamic set up of audio channel	105
4.16.4.4	Guaranteed bandwidth	105
4.16.4.5	Edge computing capability.....	105
4.17	Next Generation Digital Twin.....	106
4.17.1	Use Case Briefing.....	106
4.17.2	Technology Requirements	106
4.17.2.1	Next generation digital twin technology for industrial automation.....	106
4.17.2.2	Interworking with Ethernet/TSN networks	107
4.17.2.3	Deterministic network performance and mix of traffic	108
4.17.2.4	Stronger network resilience.....	108
4.17.2.5	Time synchronization.....	108
4.17.3	Current related standard specifications	108
4.17.3.1	ITU-T	108
4.17.3.1.1	GPON	108
4.17.3.1.2	OTN.....	109
4.17.3.2	IEEE.....	109
4.17.3.2.1	Time Sensitive Networks.....	109
4.17.3.2.2	Precise Timing Protocol	109
4.17.3.3	3GPP	110
4.17.3.3.1	Industrial Automation: 5G and Industry 4.0.....	110
4.17.3.3.2	5G and Time Sensitive Communications	110
4.17.3.4	IEC	110
4.17.3.5	5G-ACIA.....	110
4.17.4	Gap analysis.....	111
4.17.4.1	Gap Context	111
4.17.4.2	Interworking with Ethernet/TSN networks	111
4.17.4.3	Deterministic network performance and mix of traffic	111
4.17.4.4	Stronger network resilience.....	111
4.17.4.5	Time synchronization.....	112
4.18	Media transport	112
4.18.1	Use case briefing.....	112
4.18.2	Technical requirements	113
4.18.2.1	General introduction.....	113
4.18.2.2	Flexible media interface	113
4.18.2.3	Guaranteed high bandwidth	113
4.18.2.4	Deterministic and low latency.....	113
4.18.2.5	Ultra-low packet loss.....	114
4.18.2.6	Service Security	114
4.18.2.7	High Reliability.....	114
4.18.3	Current related standard specifications	115
4.18.3.1	Society of Motion Picture and Television Engineers (SMPTE).....	115
4.18.3.2	ITU-T	115

4.18.4	Gap analysis.....	115
4.18.4.1	Gap Context	115
4.18.4.2	General	115
4.18.4.3	Flexible media interface	115
4.18.4.4	Guaranteed Bandwidth.....	115
4.18.4.5	Deterministic and low latency.....	116
4.18.4.6	Ultra-low packet loss.....	116
4.18.4.7	Service security	116
4.18.4.8	High reliability	116
4.19	Edge/Cloud-based visual inspection for automatic quality assessment in production	116
4.19.1	Use Case briefing.....	116
4.19.2	Technology Requirements	116
4.19.2.1	General introduction.....	116
4.19.2.2	Deterministic network performance.....	117
4.19.2.3	Time Synchronization	117
4.19.2.4	Industrial interface and protocol support.....	117
4.19.2.5	Upstream bandwidth	117
4.19.2.6	Network resilience	117
4.19.2.7	Network security	118
4.19.2.8	Harsh environment adaptation	118
4.19.3	Current related standards	118
4.19.3.1	GiGE Vision® and USB3 Vision™	118
4.19.3.2	IEC/IEEE	118
4.19.3.3	Industrial Ethernet.....	118
4.19.3.4	ETSI	118
4.19.4	Gap analysis.....	118
4.19.4.1	Gap Context	118
4.19.4.2	Deterministic network performance.....	118
4.19.4.3	Time Synchronization	119
4.19.4.4	Industrial interface and protocol support.....	119
4.19.4.5	Upstream bandwidth	119
4.19.4.6	Network resilience	119
4.19.4.7	Network security	119
4.19.4.8	Harsh environment adaptation	119
4.20	Edge/Cloud-based control of Automated Guided Vehicles (AGV)	120
4.20.1	Use Case briefing.....	120
4.20.2	Technology Requirements	120
4.20.2.1	General introduction.....	120
4.20.2.2	Interworking with wireless networks	120
4.20.2.3	Deterministic network performance.....	120
4.20.2.4	Network availability	120
4.20.2.5	Network resilience	121
4.20.2.6	Network security	121
4.20.3	Current related standards	121
4.20.3.1	3GPP	121
4.20.3.2	Wi-Fi® 6 (IEEE 802.11ax) and Wi-Fi® 7 (IEEE 802.11be).....	121
4.20.4	Gap Analysis.....	121
4.20.4.1	Gap Context	121
4.20.4.2	Interworking with wireless networks	121
4.20.4.3	Deterministic network performance.....	121
4.20.4.4	Network availability	122
4.20.4.5	Network resilience	122
4.20.4.6	Network security	122
4.21	Cloudification of Medical Imaging	122
4.21.1	Use Case Briefing	122
4.21.2	Technology Requirements	123
4.21.2.1	General introduction.....	123
4.21.2.2	Flexible Bandwidth	124
4.21.2.3	Hard isolation based on service flows.....	125
4.21.2.4	On-demand Network Management	125
4.21.2.5	Reliability.....	125
4.21.2.6	Latency.....	125

4.21.2.7	Private Data Centre and Cloud access.....	125
4.21.3	Current related standard specifications	126
4.21.4	Gap analysis.....	126
4.21.4.1	Gap Context	126
4.21.4.2	Flexible Bandwidth	126
4.21.4.3	Implements hard isolation based on service flows	127
4.21.4.4	On-Demand network management.....	127
4.21.4.5	Reliability.....	127
4.21.4.6	Latency.....	127
4.21.4.7	Private Data Centre and Cloud access.....	127
4.22	F5G for Intelligent Mining	127
4.22.1	Use Case Briefing.....	127
4.22.2	Technology Requirements	128
4.22.2.1	General introduction.....	128
4.22.2.2	High-reliability networking.....	128
4.22.2.3	Industrial grade equipment.....	128
4.22.2.4	Fast fibre connection.....	128
4.22.2.5	Intelligent optical O&M management.....	129
4.22.3	Current standard.....	129
4.22.3.1	ITU-T.....	129
4.22.3.2	IEC.....	129
4.22.4	Gap analysis.....	129
4.22.4.1	Gap Context	129
4.22.4.2	General	129
4.22.4.3	Networking reliability	129
4.22.4.4	Electrical safety.....	130
4.22.4.5	Fast fibre connect.....	130
4.22.4.6	Intelligent optical O&M management.....	130
4.23	Enhanced optical transport network for Data Centre Interconnections	130
4.23.1	Use case briefing.....	130
4.23.2	Typical scenarios and services of DCI.....	131
4.23.2.1	Scenarios introduction.....	131
4.23.2.2	DCI Service functionality	131
4.23.3	Technical requirements	132
4.23.3.1	Network bandwidth.....	132
4.23.3.2	Fibre infrastructure and distance for intra-city DCI.....	132
4.23.3.3	Ultra-long-haul transmission distance for intercity DCI.....	132
4.23.3.4	Optical-layer wavelength grooming.....	132
4.23.3.5	High reliability	133
4.23.3.6	High flexibility.....	133
4.23.3.7	Latency measurement and control.....	133
4.23.4	Current related standard specifications	133
4.23.4.1	General	133
4.23.4.2	ITU-T.....	133
4.23.4.3	IEEE.....	133
4.23.4.4	OIF.....	133
4.23.5	Gap analysis.....	133
4.23.5.1	Gap Context	133
4.23.5.2	Network bandwidth.....	134
4.23.5.3	Fibre infrastructure and distance for intra-city DCI.....	134
4.23.5.4	Ultra-long-haul transmission distance for intercity DCI.....	134
4.23.5.5	Optical-layer wavelength-level grooming.....	134
4.23.5.6	High Reliability.....	134
4.23.5.7	High flexibility.....	135
4.23.5.8	Latency measurement and control.....	135
4.24	Enhanced Point to Point optical access	135
4.24.1	Use case briefing.....	135
4.24.2	Technical requirements.....	135
4.24.2.1	General introduction.....	135
4.24.2.2	Network Supervision.....	135
4.24.2.3	Point to point link performance.....	136
4.24.3	Current related standard specifications	136

4.24.3.1	ITU-T	136
4.24.3.2	IEEE	136
4.24.4	Gap analysis	136
4.24.4.1	Gap Context	136
4.24.4.2	General	136
4.24.4.3	Network Supervision	136
4.24.4.4	Point to point link performance	137
4.25	High-speed Passive P2MP Network Traffic Aggregation	137
4.25.1	Use Case briefing	137
4.25.2	Technology Requirements	138
4.25.2.1	Technology Description	138
4.25.3	Current related standards	139
4.25.4	Gap analysis	140
4.25.4.1	Gap Context	140
4.25.4.2	Gap Description	140
4.26	Bandwidth on demand	141
4.26.1	Use Case briefing	141
4.26.2	Technology Requirements	141
4.26.2.1	General introduction	141
4.26.2.2	Relation to scenario-based broadband	141
4.26.2.3	User-based Bandwidth change requests	142
4.26.2.4	Network-based Bandwidth change requests	142
4.26.2.5	Allocation of bandwidth changes	142
4.26.2.6	Privacy	142
4.26.3	Current related standard specifications	142
4.26.3.1	ITU-T	142
4.26.3.2	BBF	143
4.26.3.3	ETSI	143
4.26.3.4	Artificial Intelligence	143
4.26.4	Gap analysis	143
4.26.4.1	Gap Context	143
4.26.4.2	User-based Bandwidth change requests	143
4.26.4.3	Network-based Bandwidth change requests	143
4.26.4.4	Allocation of bandwidth changes	143
4.26.4.5	Privacy	143
4.27	Intelligent Optical Cable Management	144
4.27.1	Use case briefing	144
4.27.2	Technology Requirements	144
4.27.2.1	Automatic identification of shared-route	144
4.27.2.2	GIS-based optical cable management	144
4.27.2.3	Real-time fibre quality monitoring and health prediction	144
4.27.3	Current related standard specifications	145
4.27.3.1	Overview	145
4.27.3.2	IETF	145
4.27.4	Gap analysis	145
4.27.4.1	Gap Context	145
4.27.4.2	Automatic identification of shared-route	145
4.27.4.3	GIS-based optical cable management	145
4.27.4.4	Real-time fibre quality monitoring and health prediction	146
4.28	AI-based PON optical path diagnosis	146
4.28.1	Use case briefing	146
4.28.2	Technical requirements	146
4.28.2.1	General introduction	146
4.28.2.2	Visualization of optical power in the PON network	146
4.28.2.3	Data collection	147
4.28.2.4	Path fault identification and strategy generation	147
4.28.3	Current related standard specifications	147
4.28.3.1	Broadband Forum (BBF)	147
4.28.3.2	ITU-T framework standards	148
4.28.3.3	ISO/IEC JTC1 SC42	148
4.28.3.4	ETSI	148
4.28.4	Gap analysis	148

4.28.4.1	Gap Context	148
4.28.4.2	General	149
4.28.4.3	Visualization of optical power in the PON network	149
4.28.4.4	Data collection	149
4.28.4.5	Path fault identification and strategy generation	149
5	Status Quo of Major Related Technologies.....	149
5.1	Wi-Fi® 6 (802.11ax).....	149
5.2	Ten gigabit passive optical network: XG(S)-PON	150
5.3	Optical Transport Network (OTN).....	152
5.4	Slicing technologies	153
5.4.1	Slicing in Access Networks	153
5.4.2	Packet-based Aggregation Network.....	153
5.4.3	OTN based Aggregation Network	154
5.4.4	Wi-Fi® for CPN	154
5.5	F5G Network Management and Control	155
5.5.1	General.....	155
5.5.2	F5G network automation and autonomy.....	155
5.5.3	Modelling language and protocols.....	156
5.5.4	Modelling language and protocols.....	156
5.5.5	Management and control of Optical Transport Network	156
5.6	Artificial Intelligence	157
5.6.1	Introduction.....	157
5.6.2	TM Forum.....	157
5.6.3	ITU-T.....	158
5.6.4	ETSI.....	158
5.6.4.1	General description	158
5.6.4.2	ISG ZSM	159
5.6.4.3	ISG ENI	160
6	Technology Landscape Summary	162
Annex A (informative): Bibliography.....		178
History		179

Table of figures

Figure 1: OTN Aggregation Equipment in the CO	39
Figure 2: CWMP remote management in E2E architecture	50
Figure 3: The architecture of the industrial interfaces and protocols carried by a PON system.....	58
Figure 4: The comparison of vendor-specific management system and standard protocols based management system ..	59
Figure 5: Maximum average bit rate per access and Forecast of PON average traffic per access	64
Figure 6: Protection schemes	65
Figure 7: Example of phase discrimination measured in a GPON solution	67
Figure 8: Example of PDV for downlink (Tp1) and uplink (Tp2) measured in a GPON solution.....	67
Figure 9: Example of an Access Network slicing model	68
Figure 10: Telemetry based network monitoring scheme	77
Figure 11: A schematic impression of a resource space allocation	86
Figure 12: Example of OTN dual-homing protection	96
Figure 13: Example of OTN dual-homing protection (Source: Figure 70 of ETSI GR F5G 008 [i.75])	101
Figure 14: End to end latency caused at various points between the musicians.....	103
Figure 15: Industrial- PON network, with and without integration with TSN networks.....	107
Figure 16: Example of video transmission flow in OTN	114
Figure 17: Example of a medical image Cloud network	124
Figure 18: Example of regional DC with remote DCs and city DC clusters.....	131
Figure 19: The visualization of the optical power in PON network.....	147
Figure 20: PON protocol framework (Source: Recommendation ITU-T G.984.3 [i.94]).....	148
Figure 21: Triple coexistence in the ITU-T PON framework	151

Table of tables

Table 1: Expected Network requirements of Cloud VR in each phase	32
Table 2: Data rate of Wi-Fi® standards depending on the antenna configuration	32
Table 3: PON data rate and split ratio requirements.....	33
Table 4: F5G Aggregation Network rate requirements	34
Table 5: Optical power budget and wavelength allocation requirement of 10G-EPON.....	49
Table 6: Different optical path loss classes for XG(S) PON	50
Table 7: Different Slicing Granularities	54
Table 8: Different Slicing Granularities	57
Table 9: Different Network Performance characteristics	57
Table 10: Default bandwidth allocation on current xPON technologies	63
Table 11: Typical bandwidth requirements for cell site types.....	64
Table 12: Latency measures in current GPON/XGS-PON implementations	66
Table 13: KPI Targets for latency in future XGS-PON or Next-PON implementations.....	66
Table 14: Telemetry related RFC	78
Table 15: Telemetry related IETF working drafts.....	78
Table 16: IETF RATS draft briefing	80
Table 17: Trusted Execution Environment specifications briefing	81
Table 18: Virtual Presence Phases and network performance requirements.....	85
Table 19: Latency, jitter and bandwidth requirements for different types of user experience	103
Table 20: Example of different traffic types and service requirements in industrial automation.....	106
Table 21: The latency comparison of OSI layer network model.....	114
Table 22: SDI interfaces and their relevant standards	115
Table 23: OTN recommendation in ITU-T SG15	115
Table 24: Example of experimental data for uploading time for different delays on the cloud access network	122
Table 25: Example of experimental data for uploading time for different packet loss rates on the cloud access network	123
Table 26: Throughput Rates	150
Table 27: Comparison of AI related activities within ETSI ISG ENI and ISG ZSM.....	162
Table 28: Summary of Requirements and Gaps	162
Table 29: Suggested actions for identified gaps	174

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Fifth Generation Fixed Network (F5G). <https://standards.iteh.ai/catalog/standards/sist/eff3a441-90db-4d58-b8d6-26c84d44e8bd/etsi-gs-f5g-013-v1-1-1-2023-04>

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.