

ETSI GR ARF 010 V2.1.1 (2025-10)



GROUP REPORT

Augmented Reality Framework (ARF); Virtual World Standards Landscape Report (<https://standards.iteh.ai>) Document Preview

[ETSI GR ARF 010 V2.1.1 \(2025-10\)](https://standards.iteh.ai/catalog/standards/etsi/b8b4b914-882f-4b84-81e1-491eda6f3e5e/etsi-gr-arf-010-v2-1-1-2025-10)

<https://standards.iteh.ai/catalog/standards/etsi/b8b4b914-882f-4b84-81e1-491eda6f3e5e/etsi-gr-arf-010-v2-1-1-2025-10>

Disclaimer

The present document has been produced and approved by the Augmented Reality Framework (ARF) 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.



ReferenceRGR/ARF-0010v211

Keywordsaugmented reality, metaverse,
standards landscape

ETSI650 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 the
[ETSI Search & Browse Standards](#) application.

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 on [ETSI deliver](#) repository.

Users should be aware that the present document may be revised or have its status changed, this information is available in the [Milestones listing](#).

If you find errors in the present document, please send your comments to the relevant service listed under [Committee Support Staff](#).

If you find a security vulnerability in the present document, please report it through our [Coordinated Vulnerability Disclosure \(CVD\)](#) program.

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 2025.
All rights reserved.

Contents

Intellectual Property Rights	7
Foreword.....	7
Modal verbs terminology.....	7
Executive summary	7
Introduction	8
1 Scope	9
2 References	9
2.1 Normative references	9
2.2 Informative references.....	9
3 Definition of terms, symbols and abbreviations.....	10
3.1 Terms.....	10
3.2 Symbols.....	11
3.3 Abbreviations	12
4 Emerging Virtual Worlds	15
4.1 Enabling technologies are maturing	15
4.2 Virtual world standardization efforts follow	16
4.2.1 Introduction.....	16
4.2.2 Low collaboration.....	17
4.2.3 Low industry participation.....	18
4.2.4 Notable exceptions.....	18
4.3 Contrasting standardization approaches	19
4.3.1 Introduction.....	19
4.3.2 Timing is important	20
4.3.3 Supporting documentation.....	21
4.4 Trends in standards and technical reports.....	23
4.4.1 Introduction.....	23
4.4.2 Domain focus.....	23
4.4.3 Specialization.....	25
4.4.4 Technical Reports support standardization activities.....	27
4.5 Standards adoption	29
4.6 Conclusions	30
5 Eight virtual world domains	31
6 Infrastructure	32
6.1 Domain Scope	32
6.1.1 Introduction.....	32
6.1.2 Networks and Connectivity	33
6.1.3 Computational resources.....	34
6.1.4 Content delivery and optimization.....	34
6.2 Standards Development Organizations	34
6.3 Standards Working Groups	34
6.4 Standards	34
6.5 Technical Reports.....	35
6.6 Conclusions	35
7 Data Management	36
7.1 Scope	36
7.1.1 Introduction.....	36
7.1.2 Data protection.....	36
7.1.3 Data collection and processing	37
7.1.4 Data compression, resilience and optimization.....	37
7.1.5 Data integration and interoperability	37
7.2 Standards Development Organizations	38

7.3	Standards Working Groups	38
7.4	Standards	38
7.5	Technical Reports	38
7.6	Conclusions	39
8	Artificial Intelligence	39
8.1	Scope	39
8.1.1	Introduction	39
8.1.2	AI-powered content generation and design	40
8.1.3	AI-powered interaction and recognition	40
8.1.4	AI-powered intelligent virtual entities	41
8.1.5	AI-assisted environment and experience optimization	41
8.1.6	Real-time AI-assisted adaptation	41
8.2	Standards Development Organizations	41
8.3	Standards Working Groups	42
8.4	Standards	42
8.5	Technical Reports	42
8.6	Conclusions	43
9	Reality Capture	43
9.1	Scope	43
9.1.1	Introduction	43
9.1.2	Environmental data acquisition and mapping	44
9.1.3	Human capture, recognition and interaction	45
9.1.4	Digital Twins and Internet of Things integration	45
9.2	Standards Development Organizations	45
9.3	Standards Working Groups	45
9.4	Standards	46
9.5	Technical Reports	46
9.6	Conclusions	46
10	Human Interface Systems and Devices	47
10.1	Scope	47
10.1.1	Introduction	47
10.1.2	Immersive experience form factors	48
10.1.3	General purpose components	49
10.1.4	Selection, control and interaction components	49
10.1.5	Feedback mechanisms	50
10.1.6	Metrology for systems and displays	50
10.2	Standards Development Organizations	50
10.3	Standards Working Groups	50
10.4	Standards	50
10.5	Technical Reports	51
10.6	Conclusions	51
11	Immersive Experiences	52
11.1	Scope	52
11.1.1	Introduction	52
11.1.2	Delivery, recording and communication	53
11.1.3	Realism and immersion	54
11.1.4	Authoring and design	54
11.1.5	Distributed architectures	54
11.1.6	User interaction design and usability	55
11.2	Standards Development Organizations	55
11.3	Standards Working Groups	55
11.4	Standards	55
11.5	Technical Reports	56
11.6	Conclusions	56
12	Virtual Society	57
12.1	Scope	57
12.1.1	Introduction	57
12.1.2	Governance and frameworks for civil society	58
12.1.3	Ethics and accessibility	58

12.1.4	Open social structures and interactions.....	58
12.2	Standards Development Organizations	59
12.3	Standards Working Groups	59
12.4	Standards	59
12.5	Technical Reports.....	59
12.6	Conclusions	60
13	Virtual Economy	60
13.1	Scope.....	60
13.1.1	Introduction.....	60
13.1.2	Identity and representation of entities	61
13.1.3	Verification of authenticity, ownership, provenance and traceability.....	62
13.1.4	Digital Goods and Services.....	62
13.1.5	Transactions and Business Models	62
13.1.6	Governance and Regulations	63
13.2	Standards Development Organizations	63
13.3	Standards Working Groups	63
13.4	Standards	63
13.5	Technical Reports.....	64
13.6	Conclusions	64
14	Cross-Domain Standards.....	65
14.1	Scope.....	65
14.1.1	Introduction.....	65
14.1.2	Benefits of cross-domain standards	65
14.2	Standards	65
14.3	Conclusions	66
15	Industry-Specific Standards	66
15.1	Scope	66
15.2	Manufacturing industry	67
15.2.1	Introduction.....	67
15.2.2	Standards	67
15.3	Architecture and Construction.....	67
15.3.1	Introduction.....	67
15.3.2	Standards	68
15.4	Healthcare.....	68
15.4.1	Introduction.....	68
15.4.2	Standards	68
15.5	Conclusions	68
16	Conclusions	69
16.1	Introduction	69
16.2	High number and diversity	70
16.3	Collaboration.....	70
16.4	Lack of standards for standardization information.....	70
16.5	Standards adoption	71
Annex A:	Methodology	72
A.1	Introduction	72
A.2	Definition of eight virtual world domains	72
A.3	Data collection.....	72
A.4	Data processing	74
A.5	Data analysis	75
A.6	Data presentation.....	75
Annex B:	Standards Development Organizations	78
B.1	Introduction	78

B.2	Radar charts for top 20 standards development organizations	78
B.3	Standards Development Organizations in the Data Set.....	98
Annex C:	Bibliography	120
History		124

i T h S t a n d a r d s
 (h t t p s : / / s t a n d a r d s . i t
 D o c u m e n t i e P w r

E T S I R G V R D . 1 1 0 . 1 (2 0 2 5 - 1 0)
 h t t p s : / / s t a n d a r d s . i t e h . a i / c a t a l - a g f s 0 a r 0

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 IPR online database](#).

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™**, **LTE™** and **5G™** logo 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 Report (GR) has been produced by ETSI Industry Specification Group (ISG) Augmented Reality Framework (ARF).

The present document provides a deep analysis of standards and standardization activities conducted in various Standards Development Organizations (SDOs) and other fora, as available at the time of publishing. The analysis is performed on all public information about standardization activities that impact development of virtual world technologies and the creation of value using these technologies, including enabling technologies, components, services and human interface systems and devices. It also examines standards that address challenges common across all types of virtual worlds including transactions, governance, cybersecurity and privacy.

Modal verbs terminology

In the present document "**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.

Executive summary

The present document aims at providing a landscape of standardization activities in the field of Virtual Worlds. Providing the current status of virtual world standardization activities in a public resource such as the present document and its supporting materials can increase general understanding of virtual world technologies in the context of the general technology lifecycle where innovation often proceeds in tandem with standardization and through collaborations between diverse stakeholders of an ecosystem, as defined in [i.9] and [i.10]. It also serves as input to the EC's 2026 Rolling Plan for ICT standardisation [i.11].