Projekt

INSPIRER

(PartizipatIoN in StadtPlanungsprozessen In viRtuEllen und Realen Räumen)

Arbeitspaket 06 *„AR App“*
Arbeitspaket 07 *„VR App“*
Arbeitspaket 10 *„Kommunikation Living Lab“*

V/AR für Stadtplanungsanwendungen: Betrachtung von Normen, Standards, Richtlinien

Vorgelegt durch:
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Stand: v02. 06.10.2021

VIRTUAL DIMENSION CENTER

Förderhinweis:
Das Projekt wird vom Bundesministerium für Bildung und Forschung unter dem Förderkennzeichen 16SV8746 gefördert.

Bundesministerium für Bildung und Forschung

Inhalt

Abbildungsverzeichnis

1. Standardisierung im V/AR-Kontext

Die Standardisierung ist allgemein die Vereinheitlichung von Produkten, Bauteilen oder Verfahren auf eine oder wenige Varianten (Normung). Es ist eine Vereinheitlichung von Objekten nach gewissen Vorlagen. Die Vorgehensweisen zur Standardisierung sind Normung und Typisierung. Der Begriff kann auf verschiedene Gebiete angewandt werden. In den wirtschaftlichen Bereichen: Fertigungsbereich Normung und Typisierung von Teilen, Zwischen- oder Endprodukten. Rechnungsbereich: Standardisierung der Kosten (Standardkosten).

Virtual Reality (VR) lässt sich definieren als eine Computer-generierte, echtzeitfähige 3D-Umgebung, in die eine oder mehrere Personen eintauchen, indem sie per Positionserfassung in das räumliche Koordinatensystem der 3D-Szene eindeutig verortet werden. VR ist damit eine räumliche Benutzungsschnittstelle für 3D-Daten. Nur damit reagiert die Wahrnehmung der 3D-Inhalte (Perspektivwechsel, richtungsabhängiges Hören, Abtasten, etc.) so, wie wir es aus der natürlichen Realität gewohnt sind. Dadurch kann der Mensch die präsentierten 3D-Inhalte besser erfassen und in ihrer Räumlichkeit verstehen. Mit Hilfe von VR lassen sich 3D-Umgebungen also besser wahrnehmen als mit einfachen Desktop-Rechnersystemen. Gleichzeitig unterstützt VR die räumliche Interaktion mit den präsentierten 3D-Daten. Grundvoraussetzung für den sinnvollen VR-Einsatz sind räumlich-geometrisch komplexe 3D-Daten. Augmented Reality (AR) ist die Überlagerung der natürlichen Sichtperspektive mit (3D-) Computergraphik. AR verschmilzt damit also eine Virtuelle Umgebung mit der Realität. Dieses kann sinnvoll sein für Assistenzsysteme oder Soll-Ist-Abgleiche (digitaler Plan versus physische Realität). Mixed Reality (MR) ist die gleichzeitige Präsentation natürlicher und künstlicher Sinnesreize, zumeist digitaler Visualisierung in Kombination mit physisch-haptischen Schnittstellen.

Virtuelle Realität und Erweiterte Realität sind keine neuen Methoden: die ersten Umsetzungen von VR begannen spätestens in den 1960er Jahren, die der AR spätestens in den 1970er Jahren. VR und AR (auch V/AR oder XR) sind Querschnittstechnologien und -methoden, die eine riesige Anzahl von Wissensdomänen umfassen können. Dazu zählen die Wahrnehmungs-/ Kognitionspsychologie, Arbeitswissenschaften, Computergraphik, Akustik, Haptik, User Interface Design, Hardware-Entwicklung, Software-Entwicklung, etc. Dazu kommt für die praktische Nutzung häufig noch geballtes Wissen aus dem Anwendungsfeld (etwa Design, Wartung, Ergonomie, Industrial Engineering, Marketingkommunikation, etc.) und aus der Branche.

Diese Vielfalt an Themengebieten schlägt sich auch unmittelbar bei der Betrachtung der Standardisierungsfelder nieder. Letztlich lassen sich die in Abbildung 1 gezeigten sechs Themenfelder identifizieren.

Mögliche Gliederung der Normen und Standards im V/AR-Kontext

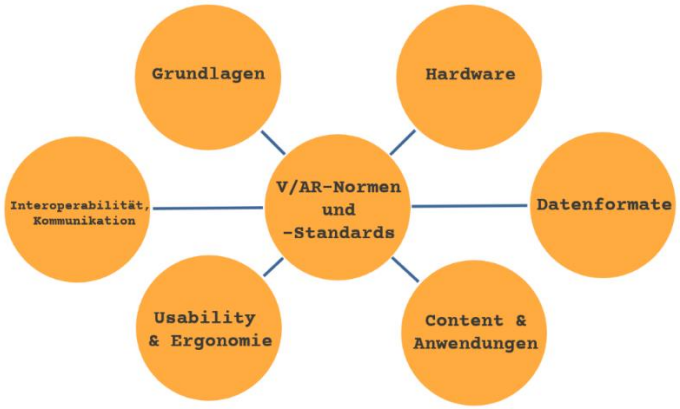

Abbildung 1: Mögliche Gliederung der Gruppen an Normen und Standards im V/AR-Kontext

2. Aktive Organisationen in der V/AR-Standardisierung

Korrespondierend zu der enormen Bandbreite der im vorherigen Kapitel bereits angerissenen Themen ist auch die Anzahl und der Hintergrund aktiver Organisationen in der V/AR-Normierung und -Standardisierung entsprechend vielfältig. Nach Sichtung beteiligen sich aktuell mindestens folgende Organisationen:

- Verbände der V/AR-Anwenderbranchen
- Verbände der V/AR-Hersteller
- einzelne V/AR-Hersteller
- User Communities und Individuen
- Normungsorganisationen

Da die Interessen dieser Gruppen durchaus unterschiedlich gelagert sind, engagieren diese sich auch sichtbar unterschiedlich in den einzelnen in Abbildung 1 gezeigten Themengebieten, siehe u.a. Abbildung 2.

Schwerpunkte der Stakeholder-Gruppen

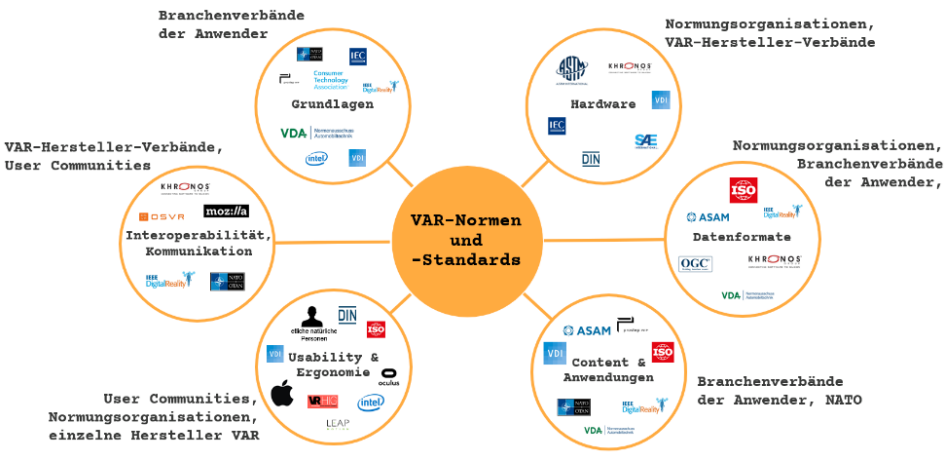

Abbildung 2: Stakeholder-Gruppen in V/AR-Normierungs- und Standardisierungsaktivitäten

Die Branchenverbände der Anwender kümmern sich um die Grundlagen, um ihre Mitglieder auf einen gemeinsamen Verständnisstand und eine gemeinsame Begrifflichkeit zu heben. Die Interoperabilität und die Kommunikationstechnik sind Arbeitspunkte der V/AR-Herstellerverbände und von User Communities. User Communities, einzelne V/AR-Hersteller und Normungsorganisationen engagieren sich heute weiterhin in Fragestellungen der V/AR-Usability und -Ergonomie. Die Normierung von V/AR-Content und von Anwendungen fällt in den Arbeitsbereich der Branchenverbände und (als Exot) der NATO. Normungsorganisationen kümmern sich weiterhin um Hardware und Datenformate. Datenformate werden ebenfalls von den Branchenverbänden der V/AR-Anwender festgelegt, wohingegen die Branchenverbände der V/AR-Hersteller auch die V/AR-Hardware schauen.

Folgende Abbildung gibt einen aktuellen Überblick über die im Rahmen dieser Arbeit identifizierten Organisationen, die im Umfeld der V/AR-Normierung und Standardisierung aktiv sind. Angegeben sind der Organisationsname, eine eventuelle Fachgruppe, in der V/AR-Spezifika erarbeitet werden sowie ein Hyperlink zur Gesamtorganisation oder eben zur Fachgruppe, falls gegeben.

Auflistung der V/AR-Normierungs- und -Standardisierungsorganisationen

Kürzel	Voller Name der Organisation	Fachgruppe (falls gegeben)	URL
BSI	British Standards Institution	The BSI Standards Catalogue	https://shop.bsigroup.com/?_ga=2.124424589.605947943.1543325451-701466709.1543325446
CEA	Consumer Technology Association	Arbeitsgruppe in VR/AR Standards	https://www.cta.tech
CEN	European Committee for Standardization	Übersicht aller Technical Bodies	https://standards.cen.eu/dyn/www/f?p=CENWEB:6:::NO:::
CEN	European Committee for Standardization	Building Information Modelling (BIM)	https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:1991542&cs=16AAC0F2C377A541DCA571910561FC17F
CEN	European Committee for Standardization	Materials modelling terminology, classification and metadata	https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:2301711&cs=1E88728758F1460484FE6AD7406F13C76
DIN	Deutsches Institut für Normung	Übersicht Normenausschüsse	https://www.din.de/de/mitwirken/normenausschuesse
DIN	Deutsches Institut für Normung	Informationstechnik und Anwendungen (NIA)	https://www.din.de/de/mitwirken/normenausschuesse/nia
DIN	Deutsches Institut für Normung	Arbeitsgestaltung in der Industrie 4.0	https://www.din.de/de/forschung-und-innovation/themen/innovative-arbeitswelt
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE	AK 742.0.6 "Display und Projektion“	https://www.dke.de/de/ueber-uns/dke-organisation-auftrag/dke-fachbereiche/dke-gremium?id=2000298&type=dke%7Cgremium
DVB	Digital Video Broadcasting	CM-VR; published its Virtual Reality Study Mission Report in October 2016	https://www.dvb.org
GS1 US	Global Standards, US branch	not-for-profit information standards organization. GS1 US has 300,000-plus members, and GS1 Standards are the most widely-used supply chain standards in the world	https://www.gs1us.org
IEC	International Electrotechnical Commission	TC 110: Electronic Displays	https://www.iec.ch/dyn/www/f?p=103:29:0::::FSP_ORG_ID:1313
IEC	International Electrotechnical Commission	TC 110 / WG 6: 3D Display Devices (3DDD)	https://www.iec.ch/dyn/www/f?p=103:14:2372783507877:::FSP_ORG_ID,FSP_LANG_ID:7362,25
IEC	International Electrotechnical Commission	TC 110 / WG 9: Touch and interactive displays	https://www.iec.ch/dyn/www/f?p=103:14:2372783507877:::FSP_ORG_ID,FSP_LANG_ID:10594,25
IEC	International Electrotechnical Commission	JTC 1/SC 24/WG 9 - Augmented Reality Continuum Concepts and Reference Model	https://standards.iteh.ai/catalog/tc/iso/ffd00520-a70c-4565-8cfa-4037db25795c/iso-iec-jtc-1-sc-24-wg-9
IEC	International Electrotechnical Commission	TC 110 / WG 12: Eyewear display	https://www.iec.ch/dyn/www/f?p=103:14:2372783507877:::FSP_ORG_ID,FSP_LANG_ID:21030,25
IEC	International Electrotechnical Commission	TC 124 Wearable electronic devices and technologies	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:20537,25
IEC	International Electrotechnical Commission	SC24 Computer Graphics	https://www.iso.org/committee/45252/x/catalogue/p/1/u/1/w/0/d/0
IEEE	Institute of Electrical and Electronics Engineers	AR-LEM - Augmented Reality Learning Experience Model	http://standards.ieee.org/develop/wg/AR-LEM.html
IEEE	Institute of Electrical and Electronics Engineers	IEEE 2048 VR/AR Working Group (VRARWG)	https://sagroups.ieee.org/2048wg
IEEE	Institute of Electrical and Electronics Engineers	Digital Reality	https://digitalreality.ieee.org/standards
IETF	Internet Engineering Task Force	Internet Standards Group	https://www.ietf.org/standards
ISO	International Organization for Standardization	Coding of audio, picture, multimedia and hypermedia information - SC 29 Working Group 11	https://www.iso.org/committee/45316.html
ISO	International Organization for Standardization	common Web3D working Group on X3D, VRML	http://www.web3d.org/working-groups/x3d

Kürzel	Voller Name der Organisation	Fachgruppe (falls gegeben)	URL
ITU	International Telecommunication Union	Standardization Sector	https://www.itu.int/en/ITU-T/Pages/default.aspx
Khronos	Khronos Group	-	https://www.khronos.org/about
mipi alliance	Mobile Industry Processor Interface Alliance	Application Area A/VR	https://www.mipi.org/augmented-virtual-reality
MIMOSA	Open Standards for Operations and Maintenance	-	https://www.mimosa.org/specifications/ccom-4-0-0
Mozilla	Mozilla	Mixed-Reality-Entwicklergemeinschaft	https://mixedreality.mozilla.org
MPEG	Moving Pictures Expert Group	OMAF	https://mpeg.chiariglione.org
NATO	North Atlantic Treaty Organization	Science & Technology Organisation (STO), Modelling & Simulation Group	https://www.sto.nato.int/Pages/activitieslisting.aspx?FilterField1=Panel&FilterValue1=NATO%20Modelling%20and%20Simulation%20Group
NATO	North Atlantic Treaty Organization	NATO Modelling and Simulation Group	https://www.sto.nato.int/Pages/technical-team.aspx?k=%28%2A%29&s=Search%20MSG%20Activities
NATO	North Atlantic Treaty Organization	NATO M&S Resources/Standards Support Team MSG-157	https://www.sto.nato.int/Lists/test1/activitydetails.aspx?ID=16330
OGC	Open Geospatial Consortium	Übersicht der OGC Standards	http://www.opengeospatial.org/standards
OSVR	Open Source Virtual Reality Movement	-	http://www.osvr.org/what-is-osvr.html
PROFIBUS	PROFIBUS Nutzerorganisation e.V.	omlox open locating standard	https://omlox.com/home
ProSTEP	ProSETP iViP e.V.	-	https://www.prostep.org/mediathek/veroeffentlichungen
QUALINET	WG2 - Standardization	IMEX Immersive Media Experiences Taskforce	http://www.qualinet.eu
SAE	Society of Automobile Engineers	SAE Standards	https://www.sae.org/standards
SISO	Simulation Interoperability Standards Organization	-	https://www.sisostds.org
TIFCA	International Future Computing Association (früher: Immersive Technology Alliance)	Immersive Technology Alliance	https://tifca.com/divisions
TIFCA	International Future Computing Association (früher: Immersive Technology Alliance)	Alliance of Content Creators	https://tifca.com/divisions
VDA	Verband der Automobilindustrie e. V.	Publikationen	https://www.vda.de/de/services/Publikationen.html
VDI	Verein Deutscher Ingenieure	Richtlinienkatalog	https://www.vdi.de/technik/richtlinien
VESA	Video Electronics Standards Association	Special Interest Group Focused on Emergent Virtual and Augmented Reality Markets	https://vesa.org/featured-articles/vesa-forms-special-interest-group-focused-on-emergent-virtual-and-augmented-reality-markets
VESA	Video Electronics Standards Association	DisplayPort	https://vesa.org/standards-specifications
VRARA	Virtual Reality and Augmented Reality Association	3D Working Group within the Retail Committee	https://www.thevrara.com/industry-committees
vrhig	Virtual Reality Human Interface Guidelines Community	-	http://vrhig.com
VRIF	Virtual Reality Industry Forum	VRIF Guidelines Working Group	https://www.vr-if.org/guidelines
W3C	World Wide Web Consortium (W3C)	Immersive Web Community Group	https://www.w3.org/community/immersive-web

Abbildung 3: Auflistung der aktiven V/AR-Normierungs- und -Standardisierungsorganisationen

3. Relevante Normen im Kontext Geo und AR

Die relevanten Normen, Standards und Richtlinien in den Kontexten Augmented Reality und Geographie sind im Folgenden zunächst nach den maßgeblich treibenden Organisationen (OGC, 3GPP, MPEG) gegliedert. Danach werden weitere, verstreute Aktivitäten aufgeführt.

3.1 Aktivitäten des OGC

Das Open Geospatial Consortium (OGC) ist eine 1994 als Open GIS Consortium gegründete gemeinnützige Organisation, die sich zum Ziel gesetzt hat, die Entwicklung von raumbezogener Informationsverarbeitung (insbesondere Geodaten) auf Basis allgemeingültiger Standards zum Zweck der Interoperabilität festzulegen. Dabei baut sich das OGC aus Mitgliedern von Regierungsorganisationen, privater Industrie und Universitäten auf, deren Mitgliedschaft im OGC kostenpflichtig ist. Das OGC seinerseits ist seit Januar 2007 Mitglied des World Wide Web Consortiums (W3C).

fertiggestellt				
Status	**Jahr**	**Organisation**	**Nummer**	**Bezeichnung**
✓	2012	OGC	CityGML	**City Geography Markup Language (CityGML) Encoding Standard** The CityGML standard defines a conceptual model and exchange format for the representation, storage and exchange of virtual 3D city models. It facilitates the integration of urban geodata for a variety of applications for Smart Cities and Urban Digital Twins, including urban and landscape planning; Building Information Modeling (BIM); mobile telecommunication; disaster management; 3D cadastre; tourism; vehicle & pedestrian navigation; autonomous driving and driving assistance; facility management, and; energy, traffic and environmental simulations. CityGML 3.0 is an evolution of the previous versions 1.0 and 2.0 of CityGML. While the previous versions standardised a GML exchange format, CityGML 3.0 standardises the underlying information model, and can be implemented in a variety of technologies including GML. The CityGML 3.0 Conceptual Model Standard describes a common semantic information model for the representation of 3D urban objects. The primary function of the model is to define the human interpretation of modelled data objects as well as their geometric representation and relationships. As such the CityGML 3.0 Conceptual Model provides a framework for integrating, storing, and exchanging 3D geospatial data. CityGML 3.0 allows data to be encoded in GML/XML, but also in JSON or database schemas. Additional benefits compared to previous versions include much better integration with BIM, the ability to represent indoor spaces in different Levels of Detail (LOD), support for dynamic data provided by sensors and simulations, and the capability to extend the information model into Application Domain Extensions using Model Driven Architecture tools.
✓	2007	OGC	GML	**OpenGIS Geography Markup Language (GML) Encoding standard** The OpenGIS® Geography Markup Language Encoding Standard (GML) The Geography Markup Language (GML) is an XML grammar for expressing geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet. As with most XML based grammars, there are two parts to the grammar – the schema that describes the document and the instance document that contains the actual data. A GML document is described using a GML Schema. This allows users and developers to describe generic geographic data sets that contain points, lines and polygons. However, the developers of GML envision communities working to define community-specific application schemas [en.wikipedia.org/wiki/GML_Application_Schemas] that are specialized extensions of GML. Using application schemas, users can refer to roads, highways, and bridges instead of points, lines and polygons. If everyone in a community agrees to use the same schemas they can exchange data easily and be sure that a road is still a road when they view it. Clients and servers with interfaces that implement the OpenGIS® Web Feature Service Interface Standard [http://www.opengeospatial.org/standards/wfs] read and write GML data. GML is

				also an ISO standard (ISO 19136:2007) [www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32554].
✓	2018	OGC	Indoor-GML	**IndoorGML Encoding Standard** This OGC® IndoorGML standard specifies an open data model and XML schema for indoor spatial information. IndoorGML is an application schema of OGC® GML 3.2.1. While there are several 3D building modelling standards such as CityGML, KML, and IFC, which deal with interior space of buildings from geometric, cartographic, and semantic viewpoints, IndoorGML intentionally focuses on modelling indoor spaces for navigation purposes.
✓	2015	OGC	KML 2.3	**Keyhole Markup Language (KML)** Google submitted KML (formerly Keyhole Markup Language) to the Open Geospatial Consortium (OGC) to be evolved within the OGC consensus process with the following goal: KML Version 2.2 has been adopted as an OGC implementation standard. Future versions may be harmonized with relevant OGC standards that comprise the OGC standards baseline. There are four objectives for this standards work: ▪ That there be one international standard language for expressing geographic annotation and visualization on existing or future web-based online and mobile maps (2d) and earth browsers (3d). ▪ That KML be aligned with international best practices and standards, thereby enabling greater uptake and interoperability of earth browser implementations. ▪ That the OGC and Google will work collaboratively to ensure that the KML implementer community is properly engaged in the process and that the KML community is kept informed of progress and issues. ▪ That the OGC process will be used to ensure proper life-cycle management of the KML Standard, including such issues as backwards compatibility. The OGC has developed a broad Standards Baseline. Google and the OGC believe that having KML fit within that family will encourage broader implementation and greater interoperability and sharing of earth browser content and context. KML is an XML language focused on geographic visualization, including annotation of maps and images. Geographic visualization includes not only the presentation of graphical data on the globe, but also the control of the user's navigation in the sense of where to go and where to look. From this perspective, KML is complementary to most of the key existing OGC standards including GML (Geography Markup Language), WFS (Web Feature Service) and WMS (Web Map Service). Currently, KML 2.2 utilizes certain geometry elements derived from GML 2.1.2. These elements include point, line string, linear ring, and polygon. The OGC and Google have agreed that there can be additional harmonization of KML with GML (e.g. to use the same geometry representation) in the future. The Mass Market Geo Working Group (MMWG) in the OGC will establish such additional harmonization activities. OGC specifications such as Context and Styled Layer Descriptor (SLD) may be considered.
✓	2006	OGC	WMS	**OpenGIS Web Map Server Implementation Specification** The OpenGIS® Web Map Service Interface Standard (WMS) provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc) that can be displayed in a browser application. The interface also supports the ability to specify whether the returned images should be transparent so that layers from multiple servers can be combined or not.

in Arbeit / geplant

Status	Jahr	Organisation	Nummer	Bezeichnung
⚠	Das OGC hat eine eigene Entwicklungsroadmap seiner Standardisierungsaktivitäten vorgelegt (siehe Abbildung 13).			

Abbildung 4: Vergangene, aktuelle und geplante Normierungs-/Standardisierungsaktivitäten des OGC

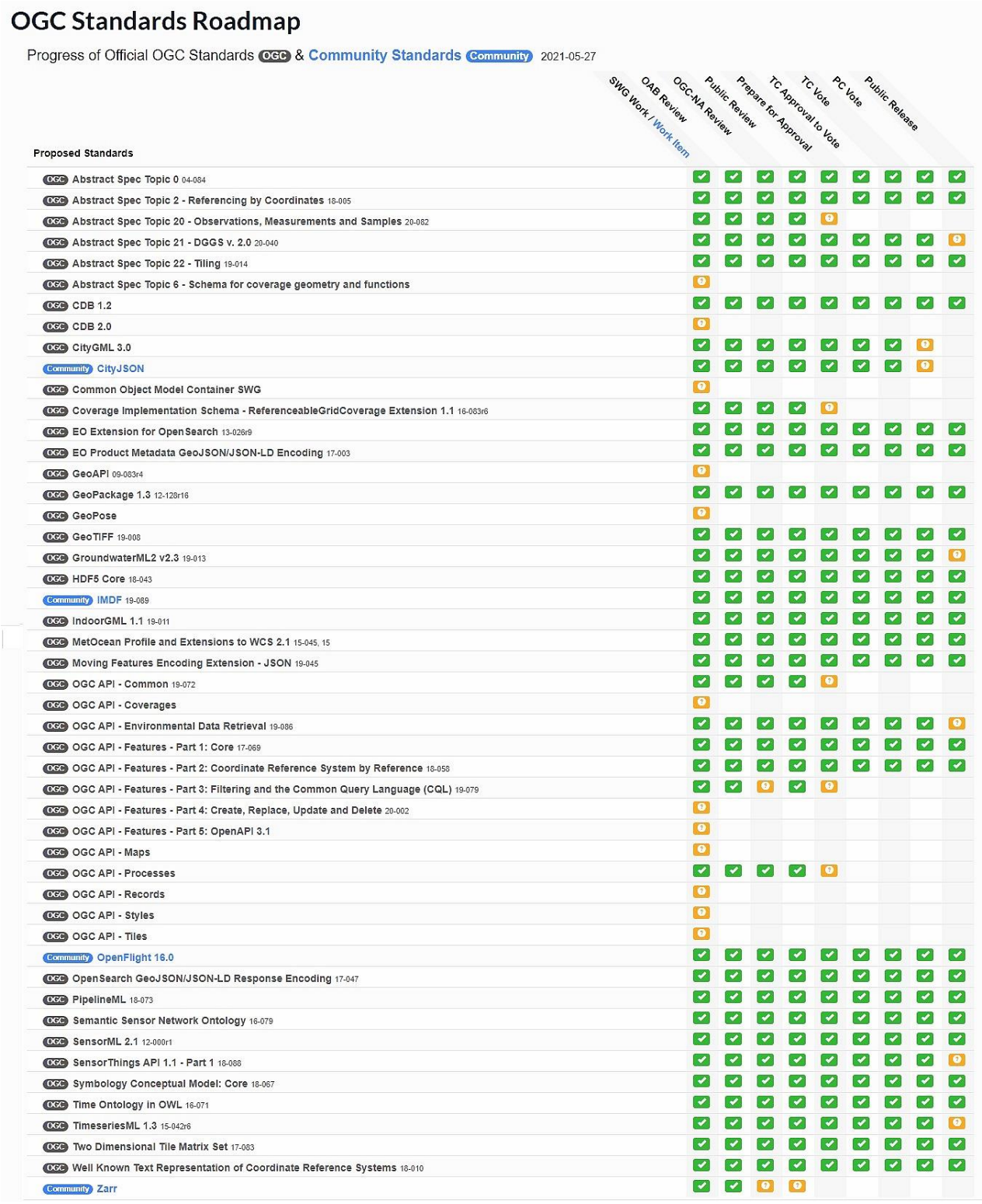

Abbildung 5: Standardisierungs-Roadmap des OGC

3.2 Aktivitäten des 3GPP

Das 3rd Generation Partnership Project (3GPP) ist eine weltweite Kooperation von Standardisierungsgremien für die Standardisierung im Mobilfunk; konkret für UMTS, GSM, LTE und 5G/NR. Die 3GPP wurde am 4. Dezember 1998 von fünf Organizational Partners gegründet. Die Partner des Projekts sind die ARIB (Association of Radio Industries and Businesses, Japan), das ETSI (European Telecommunication Standards Institute), die ATIS (ehem. T1) (Alliance for Telecommunications Industry Solutions, USA), die TTA (Telecommunications Technology Association, Korea) und dasTTC (Telecommunications Technology Committee, Japan).

Die Arbeiten des 3GPP sind insbesondere für mobile V/AR-Anwendungen interessant, bei denen es um Aspekte des Streamings, oder um Telekooperation und Telepräsenz geht.

fertiggestellt

Status	Jahr	Organisation	Nummer	Bezeichnung
✓	**2020**	**3GPP**	**TR 26.905**	**Mobile stereoscopic 3D video** This Technical Report provides a study on mobile 3D stereoscopic video in 3GPP. Use cases and technical solutions are investigated regarding a variety of setups using 3GPP's streaming, multicast/broadcast, download and progressive download as well as conversational services. Clause 5 provides a definition of the stereoscopic 3D video technologies and terminology as well as a video codecs performance comparison. Clauses 6 and 7 focus on use cases for which the working assumptions and the operation points are defined before providing a technical analysis, whereas clause 8 provides a set of use cases in which further study is required so as to identify the gaps. Clause 9 introduces subjective tests conducted on a 3D capable mobile terminal and clause 10 presents a generic approach for 3D content adaptation depending on the client terminal charasteristics. The conclusion summarizes the recommended way forward for the introduction of 3D stereoscopic video support in 3GPP specifications.
✓	**2018**	**3GPP**	**TR 26.918**	**Virtual Reality (VR) media services over 3GPP** The scope of the present document is to investigate the relevance of Virtual Reality in the context of 3GPP. Virtual Reality is the ability to be virtually present in a non-physical world created by the rendering of natural and/or synthetic image and sound correlated by the movements of the immersed user allowing to interact with that world. With recent progress made in rendering devices, such as Head mounted displays (HMD), a significant quality of experience can be offered. By collecting comprehensive information on VR use cases, existing technologies and subjective quality, the report attempts to identify potential gaps and relevant interoperability points that may require further work and potential standardization in 3GPP in order to support VR use cases and experiences in 3GPP user services. The report primarily focuses on 360 degrees video and associated audio, which support three degrees of freedom (3DOF).
✓	**2021**	**3GPP**	**TR 26.926**	**Feasibility Study on Typical Traffic Characteristics for XR Services and other Media** The present document provides traffic models and quality evaluation methods for different media and eXtended Reality (XR) Services. In order to address this, generic modelling considerations are introduced and for different services reference designs, simulation models and suitable quality metrics are reported. This information permits to obtain accurate information on exact bitrate and delay requirements in uplink and downlink, develop detailed traffic traces, develop suitable statistical models for media and XR traffic and to evaluate the expected media quality of such services. The information may be used by other 3GPP groups in order to assess media quality for different configuration of 5G System parameters, as well as for evaluating the requirements in terms of QoS for XR and media services.
✓	**2020**	**3GPP**	**TR 26.928**	**Extended Reality (XR) in 5G** The present document collects information on eXtended Reality (XR) in the context of 5G radio and network services. The primary scope of the present document is the documentation of the following aspects:

				▪ Introducing Extended Reality by providing definitions, core technology enablers, a summary of devices and form factors, as well as ongoing related work in 3GPP and elsewhere, ▪ Collecting and documenting core use cases in the context of Extended Reality, ▪ Identifying relevant client and network architectures, APIs and media processing functions that support XR use cases, ▪ Analysing and identifying the media formats (including audio and video), metadata, accessibility features, interfaces and delivery procedures between client and network required to offer such an experience, ▪ Collecting key performance indicators and Quality-of-Experience metrics for relevant XR services and the applied technology components, ▪ Drawing conclusions on the potential needs for standardisation in 3GPP.
✅	**2019**	**3GPP**	**TR 26.929**	**QoE parameters and metrics relevant to the Virtual Reality (VR) user experience** The present document provides a study on the QoE metrics relevant to VR service. The study focuses on: ▪ Defining a device reference model for VR QoE measurement points. ▪ Studying key performance indicators that may impact the experience of VR service. ▪ Identifying the existing QoE parameters and metrics defined in SA4 standards such as TS 26.247, TS 26.114 which are relevant to Virtual Reality user experience; ▪ Identifying and defining new QoE parameters and metrics relevant to Virtual Reality user experience, taking into consideration the use cases listed in TR 26.918, and any sources that show the relevance of new metrics, e.g. scientific literature, specifications/solutions from other standard organizations. ▪ Analysing potential improvements to the existing QoE reporting so as to better accommodate VR services. ▪ Providing recommendations to future standards work in SA4 on the QoE parameters and metrics and, as necessary, coordinate with other 3GPP groups and external SDOs, e.g. MPEG, ITU-T.
✅	**2021**	**3GPP**	**TR 26.998**	**Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices** The present document collects information on glass-type AR/MR devices in the context of 5G radio and network services. The primary scope of this Technical Report is the documentation of the following aspects: ▪ Providing formal definitions for the functional structures of AR glasses, including their capabilities and constraints ▪ Documenting core use cases for AR services over 5G and defining relevant processing functions and reference architectures ▪ Identifying media exchange formats and profiles relevant to the core use cases ▪ Identifying necessary content delivery transport protocols and capability exchange mechanisms, as well as suitable 5G system functionalities (including device, edge, and network) and required QoS (including radio access and core network technologies) ▪ Identifying key performance indicators and quality of experience factors ▪ Identifying relevant radio and system parameters (required bitrates, latencies, loss rates, range, etc.) to support the identified AR use cases and the required QoE ▪ Providing a detailed overall power analysis for media AR related processing and communication
✅	**2021**	**3GPP**	**TR 26.999**	**Virtual Reality (VR) streaming interoperability and characterization** The present document provides content generation guidelines, performance and bit rate characteristics, as well as reference test material and test results for improved usability of technologies based on a set of usage scenarios. The specification includes several VR media profiles for video and a single media profile for audio with different configuration options. The specification focuses primarily on interoperability requirements for VR360 applications, but does neither address content generation guidelines nor performance characterization of the solutions. In order for content providers and the rest of the ecosystem to be able to select and configure the technologies defined in [2] and to generate content for streaming applications, collecting such information would be most valuable. In addition, VR client implementers would benefit from conformance bit streams and media presentations that fulfil the requirements of the specification and are generated

				using the content generation guidelines. Bit streams and media presentations generated through these guidelines would be most useful.
	2021	**3GPP**	**TR 26.118**	**Virtual Reality (VR) profiles for streaming applications** The present document defines interoperable formats for Virtual Reality for streaming services. Specifically, the present document defines operation points, media profiles and presentation profiles for Virtual Reality. The present document builds on the findings and conclusions in TR 26.918.
	2018	**3GPP**	**TR 26818**	**Virtual Reality (VR) streaming audio; Characterization test results** The present document is a collection of test results on candidate audio media profiles for VR streaming services over 3GPP. A brief description of the 3 tests characterizing the audio media profile performances is presented under clause 4. The following clauses provide the test results from the audio media profile proponent as well as those from the crosscheck labs. The four documented solutions are (in alphabetical order): ▪ DTS-UHD ▪ Metadata Assisted EVS Codec (MAEC) ▪ OMAF 3D Audio Baseline Profile ▪ Spatial AAC extension (spAACe)

in Arbeit / geplant

Status	Jahr	Organisation	Nummer	Bezeichnung
	folgt	**3GPP**	**TR 26.962**	**Immersive Teleconferencing and Telepresence for Remote Terminals (ITT4RT) Operation and Usage Guidelines** N/A

Abbildung 6: Vergangene, aktuelle und geplante Normierungs-/Standardisierungsaktivitäten des 3GPP

3.3 Aktivitäten der MPEG Group

Die Moving Picture Experts Group (MPEG, dt. „*Expertengruppe für bewegte Bilder*“) ist eine Gruppe von Experten, die sich mit der Standardisierung von Videokompression und den dazugehörenden Bereichen, wie Audiodatenkompression oder Containerformaten, beschäftigt. Umgangssprachlich wird mit „MPEG“ meistens nicht die Expertengruppe, sondern ein spezieller MPEG-Standard bezeichnet. Drei- oder viermal jährlich kommt die MPEG in fünftägigen Treffen zusammen. Etwa 350 Experten aus 200 Unternehmen und Organisationen aus 20 Ländern nehmen an diesen Treffen, den MPEG-Meetings, teil. Die MPEG ist ein Teil des ISO/IEC JTC1/SC29 (International Organization for Standardization/International Electrotechnical Commission, Joint Technical Committee 1, Subcommittee 29) und dort seit Juni 2020 in verschiedene Arbeitsgruppen aufgeteilt (vormals "Working Group 11"). Die Standards werden mit der Internationalen Fernmeldeunion (ITU) abgeglichen und größtenteils in gemeinsamen Arbeitsgruppen entwickelt. Prominentestes Beispiel ist der MPEG-4 AVC Standard, der im Wortlaut identisch als ITU-T H.264 verabschiedet wurde.

Boyce [01][02], Stockhammer [07], Timmerer [14] und Wien [16] skizzieren die Pläne der ISO IEC MPEG Group für die nächsten Jahre. Insbesondere gibt es dort eine MPEG-Immersive-Media-Subgruppe [07], die V/AR-relevante Themenstellungen bearbeitet. Aktuelle Arbeitsgebiete können der EG Immersive Media Standardization Roadmap entnommen werden. Diese beinhaltet:

- AR/VR Audio Extension
- Audio Wavefield coding, Immersive Sound
- Point Cloud Compression
- Light Field Coding
- VR360, On-Demand and Live (3 DoF)
- Immersive Media with 6 DoF, combining natural and synthetic Environment
- MPEG project: ISO/IEC 23090: coded representation of immersive Media

Die aktuellen Aktivitäten im MPEG-Projekt ISO/IEC 23090 (Blatt 2 veröffentlicht; Blatt 1 und 9 ausstehend) „Coded Representation of immersive Media“ beinhaltet folgende Unterpunkte:

- Architectures
- Omnidirectional Media Format (OMAF)
- New & Immersive Video Coding
- New & Immersive Audio Coding
- Point Cloud Coding
- Metadata for Immersive Services and Applications
- Metrics for Immersive Services and Applications
- Network-Based Media Processing

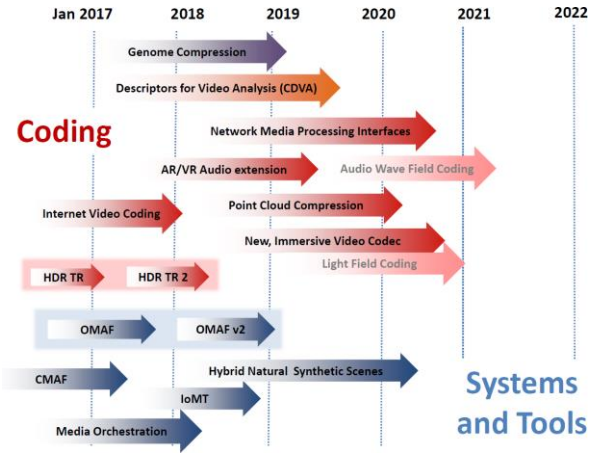

Abbildung 7: Aktuelle Roadmap der MPEG-I(MPEG Immersive)-Subgruppe

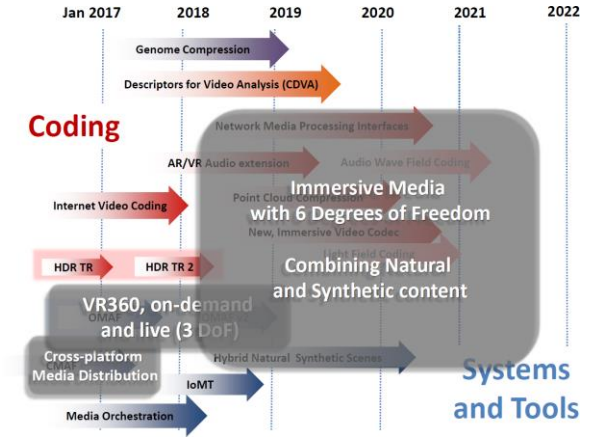

Abbildung 8: Einordnung der Aktitiväten der MPEG-I(MPEG Immersive)-Subgruppe in die Themenfelder Cross Plattform Media Distribution, VR360, on demand and live sowie Immersive Media with 6 Degrees of Freedom

Die V/AR-bezogenen Standardisierungsaktivitäten der MPEG Group stellen sich aktuell wie folgt dar:

fertiggestellt

Status	Jahr	Organisation	Nummer	Bezeichnung
✓	**2004**	**ISO/IEC**	**14496-2**	**Coding of audio-visual objects -- Part 2: Visual** ISO/IEC 14496-2:2004 provides the following elements related to the encoded representation of visual information: ▪ Specification of video coding tools, object types and profiles, including capability to encode rectangular-based and arbitrary-shaped video objects, capability to define scalable bitstreams and error-resilient encoding tools; ▪ Specification of coding tools, object types and profiles for mapping of still textures into visual scenes; ▪ Specification of coding tools, object types and profiles for human face and body animation based on face/body models and additional semantic parameters; and ▪ Specification of coding tools, object types and profiles for animation of 2D warping grids with uniform and irregular topology. The Visual specification contains definitions of the bitstream syntax, bitstream semantics and the related decoding process. It does not specify the encoders, which can be optimized in different implementations.
✓	**2008**	**ISO/IEC**	**23000-9**	**Multimedia application format (MPEG-A) — Part 9: Digital Multimedia Broadcasting application format — Amendment 1: Conformance and reference software.** ISO/IEC 23000-9 can be used for multimedia file format transmission. ISO/IEC 23000-9:2008 specifies a file format that pertains to both terrestrial digital multimedia broadcasting (T-DMB) and satellite digital multimedia broadcasting (S-DMB) contents and services. It integrates the existing DMB contents with appropriate additional information to facilitate storage, interchange, management, editing, and presentation of the contents in protected, governed, and interoperable ways. ISO/IEC 23000-9:2008 is applicable both to storage and playback of DMB contents and to acquisition and consumption through communication networks and removable storages. Application examples of this specification include but are not limited to ▪ scheduled storage and time-shifted playback of DMB contents, ▪ file casting through DMB data channel, ▪ IP media service such as DMB content portal, ▪ rightful interchange of DMB contents between terminals, and ▪ user editing or creation from DMB contents.
✓	**2009**	**ISO/IEC**	**14496-3**	**Coding of audio-visual objects -- Part 3: Audio (AAC)** This document integrates many different types of audio coding: natural sound with synthetic sound, low bitrate delivery with high-quality delivery, speech with music, complex soundtracks with simple ones, and traditional content with interactive and virtual-reality content. This document standardizes individually sophisticated coding tools to provide a novel, flexible framework for audio synchronization, mixing, and downloaded post-production. This document does not target a single application such as real-time telephony or high-quality audio compression. Rather, it applies to every application requiring the use of advanced sound compression, synthesis, manipulation, or playback. This document specifies the state-of-the-art coding tools in several domains. As the tools it defines are integrated with the rest of the ISO/IEC 14496 series, exciting new possibilities for object-based audio coding, interactive presentation, dynamic soundtracks, and other sorts of new media, are enabled.
✓	**2011**	**ISO/IEC**	**14496-16**	**Coding of audio-visual objects -- Part 16: Animation Framework eXtension (AFX)** ***Deleted***
✓	**2016**	**ISO/IEC**	**23005-5**	**Media context and control (MPEG-V)** This document specifies syntax and semantics of the data formats for interaction devices by providing a standardized format for interfacing actuators and sensors by defining XML schema-based language named Interaction Information Description Language (IIDL). IIDL provides a basic structure with common information for com-

				munication with various actuators and sensors in consistency. Device Command Vocabulary (DCV) is defined to provide a standardized format for commanding individual actuator, and Sensed Information Vocabulary (SIV) is defined to provide a standardized format for holding information from individual sensors either to get environmental information from real world or to influence virtual world objects using the acquired information on the basis of IIDL.
✓	**2010**	**ISO/IEC**	**23000-12**	**Multimedia application format (MPEG-A) — Part 12: Interactive music application format** ISO/IEC 23000-12:2010 specifies a file format designed for interactive music services. It integrates the multiple audio tracks with appropriate additional information for enabling users to experience various preset mixes and to make their own mixes complying with interactivity rules imposed by the producer. It specifies ▪ a file type brand regarding relevant application area, and ▪ a file structure, which is capable of storage with multiple audio tracks with the following: ▪ group information on hierarchical structure of audio tracks; ▪ preset which is predefined mixing information on multiple audio tracks; ▪ rule which introduces specific data related to user's interaction; ▪ timed text, image and metadata.
✓	**2017**	**ISO/IEC**	**23000-13**	**Multimedia application format (MPEG-A) -- Part 13: Augmented reality application format (ARAF)** ISO/IEC 23000-13:2017 specifies the following: ▪ scene description elements for representing AR content; ▪ mechanisms to connect to local and remote sensors and actuators; ▪ mechanisms to integrated compressed media (image, audio, video, graphics); mechanisms to connect to remote resources such as maps and compressed media
✓	**2018**	**ISO/IEC**	**23003**	**MPEG audio technologies -- Part 2: Spatial Audio Object Coding (SAOC)** This document specifies the reference model of the spatial audio object coding (SAOC) technology that is capable of recreating, modifying and rendering a number of audio objects based on a smaller number of transmitted channels and additional parametric data.
✓	**2019**	**ISO/IEC**	**23090-2**	**Coded representation of immersive media** This document specifies the omnidirectional media format for coding, storage, delivery, and rendering of omnidirectional media, including video, images, audio, and timed text. In an OMAF player the user's viewing perspective is from the centre of the sphere looking outward towards the inside surface of the sphere. NOTE 1 In this document, only 3 degrees of freedom (3DOF) is supported. In other words, purely translational movement of the user does not result in different omnidirectional media being rendered to the user. For 3DOF support with stereoscopic video, when the user rolls his/her head, there could be a stereoscopic rendering issue. NOTE 2 Omnidirectional video could contain graphics elements generated by computer graphics but encoded as video.

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Status	Jahr	Organisation	Nummer	Bezeichnung
⚠	***offen***	**ISO/IEC**	**23090-1**	**Coded representation of immersive media - Part 1: Immersive media** ***Under development***
⚠	***offen***	**ISO/IEC**	**23090-9**	**Coded representation of immersive media - Part 5: Graphics-based Point Cloud Compression** ***Under development***

Abbildung 9: Vergangene, aktuelle und geplante Normierungs-/Standardisierungsaktivitäten der MPEG Group

3.4 Weitere Standards im Kontext AR und Geo-Information

Interessante Arbeiten in den Kontexten Lokalisierung, Punktewolken und Mapping Real-Virtuell kommen von der IETF (Internet Engineering Task Force), dem IEEE, dem W3C, ISO/IEC, Microsoft und Profibus e.V.

fertiggestellt

Status	Jahr	Organisation	Nummer	Bezeichnung
✓	**2010**	**IETF**	**RFC 5870**	**A Uniform Resource Identifier for Geographic Locations ('geo' URI)** This document specifies a Uniform Resource Identifier (URI) for geographic locations using the 'geo' scheme name. A 'geo' URI identifies a physical location in a two- or three-dimensional coordinate reference system in a compact, simple, human-readable, and protocol-independent way. The default coordinate reference system used is the World Geodetic System 1984 (WGS-84).
✓	**2016**	**IETF**	**RFC 7946**	**The GeoJSON Format** GeoJSON is a format for encoding a variety of geographic data structures. GeoJSON is a geospatial data interchange format based on JavaScript Object Notation (JSON). It defines several types of JSON objects and the manner in which they are combined to represent data about geographic features, their properties, and their spatial extents. GeoJSON uses a geographic coordinate reference system, World Geodetic System 1984, and units of decimal degrees. In 2015, the Internet Engineering Task Force (IETF), in conjunction with the original specification authors, formed a GeoJSON WG to standardize GeoJSON. RFC 7946 was published in August 2016 and is the new standard specification of the GeoJSON format, replacing the 2008 GeoJSON specification.
✓	**2021**	**W3C**	**WMS**	**Geolocation API Specification 2nd Edition** The Geolocation API defines a high-level interface to location information associated only with the device hosting the implementation, such as latitude and longitude. The API itself is agnostic of the underlying location information sources. Common sources of location information include Global Positioning System (GPS) and location inferred from network signals such as IP address, RFID, WiFi and Bluetooth MAC addresses, and GSM/CDMA cell IDs, as well as user input. No guarantee is given that the API returns the device's actual location. The API is designed to enable both "one-shot" position requests and repeated position updates, as well as the ability to explicitly query the cached positions. Location information is represented by latitude and longitude coordinates. The Geolocation API in this specification builds upon earlier work in the industry, including [AZALOC] , [GEARSLOC] , and [LOCATIONAWARE] .
✓	**1998**	**W3C**	**GeoVRML 2.0**	**GeoVRML** GeoVRML is an official Working Group of the Web3D Consortium. It was formed on 27 Feb 1998 with the goal of developing tools and recommended practice for the representation of geographical data using the Virtual Reality Modeling Language (VRML). The desire is to enable geo-referenced data, such as maps and 3-D terrain models, to be viewed over the web by a user with a standard VRML plugin for their web browser. The GeoVRML Working Group has a mailing list where discussions and developments are posted. Currently, this list consists of members drawn from a wide gamut of backgrounds and nationalities, including members from industry, government, and academia; geographers, geologists, computer graphics developers, and of course interested hobbyists.

				The group has recently produced the GeoVRML 1.1 specification, providing a number of extensions to VRML for supporting geographic applications. There is also an accompanying Open Source Java sample implementation of these nodes. Finally, these nodes are part of Amendment 1 to the VRML97 ISO standard. VRML has been succeeded by X3D.
✅	**2020**	**PROFIBUS Nutzerorganisation e.V.**	**omlox**	**omlox open locating standard** Omlox is an open standard for precise real-time indoor localization system. It specifies open interfaces for an interoperable localization system that enable industry to use a single infrastructure with different applications from different providers. As the same infrastructure is used, it lowers the Total Cost of Ownership (TCO) enabling easy integration of different applications. One key trait of omlox is that it allows for cyber-physical facilitation, combining the integration of industrial software and hardware solutionsin one common ecosystem. omlox specifies an open ultra-wideband system, that ensures complete hardware interoperability, and which enables multi-purpose infrastructures, e.g., for multi-site asset tracking and AGV navigation. By means of lightweight APIs and flexible operation setups, omlox can be integrated into existing software and hardware scenarios.
✅	**2020**	**Microsoft**	**AZURE Spatial Anchors**	**Microsoft AZURE Spatial Anchors** Azure Spatial Anchors enables developers to work with mixed reality platforms to perceive spaces, designate precise points of interest, and to recall those points of interest from supported devices. These precise points of interest are referred to as Spatial Anchors. Across augmented reality (AR) platforms, "anchors" are a common frame of reference for enabling multiple users to place digital content in the same physical location, where it can be seen on different devices in the same position and orientation relative to the environment. With Spatial Anchors, you can add anchor persistence and permissions, and then connect anchors in your application so that your users can find nearby content. Spatial Anchors offers platform support for Unity, ARKit, ARCore, and UWP. Create your first app using quickstart templates for HoloLens, Unity, iOS, and Android.
✅	**2019**	**IEEE**	**P2048.07**	**P2048.7 - Standard for Virtual Reality and Augmented Reality: Map for Virtual Objects in the Real World** This standard specifies the requirements, systems, methods, testing and verification for Augmented Reality (AR) and Mixed Reality (MR) applications to create and use a map for virtual objects in the real world.
✅	**2019**	**IEEE**	**P2048.08**	**Standard for VR and AR: Interoperability between Virtual Objects and the Real World** This standard specifies the requirements, systems, methods, testing and verification for the interoperability between virtual objects and the real world in Augmented Reality (AR) and Mixed Reality (MR) applications.
✅	**2022**	**IEEE**	**IC16-004-02 [closed]**	**Augmented Reality in the Oil/Gas/Electric Industry** IEEE hosted a workshop in October 2015, exploring the application of augmented reality (AR) solutions in the oil and gas industry. Coupled with interest within the electric power industry, workshop participants expressed an interest in forming an ongoing interest group to facilitate collaboration in identifying requirements, standards needs and other issues, to help enable AR solutions, as well as potentially mixed and virtual reality solutions, that can benefit these industries. Existing augmented reality devices have not yet achieved a state of readiness for widespread application in the oil, gas, and electric industries. “Heads up Display” type devices are of particular interest, however a variety of issues need to be overcome including ruggedness, wireless connectivity, use case viability and human factors considerations. While each of the represented industries have some industry-specific interests, there are sufficient commonalities

				such that aggregating efforts is anticipated to provide a beneficial approach to achieving efficient solutions. Both hardware and software issues can be largely influenced by standards. Participants in this activity will identify existing standards, and standards in progress that are relevant and valuable to supporting AR in the electric/oil/gas industries, as well as identifying gaps where new standards efforts are recommended – analysis will include not only IEEE standards, but standards and specification available via other SDOs, alliances, etc. Use Cases will also be an area of work activity – development of a collection of use cases that are 1) of mutual interest across electric/oil/gas, 2) of segment specific interest. Prioritize use cases and identify applicable standards and gaps in existing standards.
✅	**2020**	**ISO/IEC**	**86012**	**JPEG Pleno Point Cloud Use Cases and Requirements v1.3** This document is intended to describe a number of use cases for the coding of (3D) point clouds. For each use case, a description is given and requirements outlined. From the requirements specific to each use case, a general set of requirements is derived and divided into systems and coding requirements. These requirements can then drive coding proposals and subjective testing. Point clouds are instrumental to support the display of 3D content in virtual, augmented and mixed reality (VR/AR/MR) environments and 2D or 3D computer graphics and gaming scenarios.
✅	**2020**	**ISO/IEC**	**88014**	**Final CfE JPEG Pleno PCC (Point Cloud)** This document contains the Final Call for Evidence (CfE) on JPEG Pleno Point Cloud Coding issued in the context of the JPEG Pleno standardization project, which aims at developing a next generation visual information coding standard that moves beyond coding of 2D planar content by taking advantage of plenoptic representations. The scope of this Call for Evidence is the identification of efficient coding solutions for static point clouds supporting advanced flexible data access functionalities. The JPEG Committee has identified scalability and random access as crucial requirements for point cloud codecs to facilitate many of the emerging applications of plenoptic content collection, processing and visualisation. Therefore, this Final Call for Evidence on JPEG Pleno Point Cloud Coding focuses on efficient point cloud codecs for static point cloud content supporting scalability and random access.
✅	**2021**	**ISO/IEC**	**90022**	**Report on JPEG Pleno PCC Call for Evidence Results (Point Cloud)** The submission to the Call for Evidence displays random access and both quality and rate scalability for point cloud geometry using a Deep Learning paradigm. An extension of the submission was made to include colour information to allow for subjective testing. The subjective and objective results show the potential for scalable codecs to provide effective solutions to use-cases currently not well addressed by existing solutions. Results of Call for Evidence highlight key issues to be addressed by the AhG in the future ▪ How should geometry-only use-cases and solutions be addressed by JPEG? ▪ What is the role of Deep Learning in point cloud coding representation and processing? ▪ How should the scope of the activity change as a result of the results from this Call for Evidence?
✅	2021	ISO/IEC	91041	**JPEG Pleno Point Cloud Scope and Timeline** The scope of the JPEG Pleno Point Cloud activity is the creation of a learning-based coding standard for point clouds and associated attributes, offering a single-stream, compact compressed domain representation, supporting advanced flexible data access functionalities. This standard targets both interactive human visualization, with significant compression efficiency over state of the art point cloud coding solutions in common use at equivalent subjective quality, and

				effective performance for 3D processing and computer vision tasks, and has the goal of supporting a royalty-free baseline. This standard is envisioned to provide a number of unique benefits, including a single efficient point cloud representation for both humans and machines. The intent is to provide humans with the ability to visualise and interact with the point cloud geometry and attributes while providing machines the ability to perform 3D processing and computer vision tasks in the compressed domain enabling lower complexity and higher accuracy through the use of compressed domain features extracted from the original instead of the lossy decoded point cloud.
	**2021**	**ISO/IEC**	**91058**	**JPEG Pleno Point Cloud Common Test Conditions** This document describes the Common Test Conditions for the JPEG Pleno Point Cloud Coding experiments. The JPEG Pleno Point Cloud Coding Data Test Set is diverse in terms of ▪ Content type ▪ Number of points ▪ Spatial density of points ▪ Additional attributes such as colour

in Arbeit / geplant

Status	Jahr	Organisation	Nummer	Bezeichnung
	-	**ISO/IEC**	**23090-5**	**Coded representation of immersive media -- Part 5: Video-based Point Cloud Compression** This document specifies the syntax, semantics and decoding for visual volumetric media using video-based coding methods. This document also specifies processes that can be needed for reconstruction of visual volumetric media, which can also include additional processes such as post-decoding, pre-reconstruction, post-reconstruction and adaptation.
	-	**ARTwin (EU-Horizon-2020-Projekt**	**AR Cloud**	**ARCloud** Die AR Cloud ist eine persistente digitale 3D-Repräsentation der realen Welt. Als allgegenwärtige Datenplattform dient sie zum Speichern und Austauschen von Informationen und soll so gemeinsame AR-Erlebnisse durch mehrere Benutzer und Geräte ermöglichen. Eine Initiative, die an der Realisierung dieses Konzepts arbeitet, ist die Open AR Cloud. Darüber hinaus gibt es auch geschlossene Systeme einzel-ner Hersteller wie PTC, 8th Wall, Niantic, Microsoft, Google, Apple und Facebook. Derzeit erfüllen diese ersten AR-Cloud-Implementierungen allerdings die Anforderungen der Industrie und des Baugewerbes 4.0 nicht. Vor allem europäische Akteure könnten mit ihren sensiblen Daten ins Hintertreffen geraten, wenn ihnen keine akzeptable Lösung bereitgestellt wird. Das EU 2020 Horizon ARTwin-Projekt zielt darauf ab, dem europäischen Industrie- und Bausektor eine AR-Cloud-Plattform zur Verfügung zu stellen, die ihren Anforderungen an Dateninhalten und -sicherheit entspricht. Technisch betrachtet, ist die AR Cloud dabei ein maschinenlesbares Modell der Welt im Maßstab 1:1, das kontinuierlich in Echtzeit aktualisiert wird. Sie ist eine Sammlung von Milliarden maschinenlesbarer Datensätze, Point Clouds und Deskriptoren, die mit den Koordinaten der realen Welt abgeglichen sind. Ähnlich einem digitalen Zwilling der Welt sollen Informationen so abgebildet und dokumentiert werden, dass sie von AR- oder auch VR-Anwendungen für ein besseres und umfangreicheres Erlebnis verwendet werden können. Um diese Erlebnisse performant zu ermöglichen, spielt entsprechend auch das Streaming von 3D-Daten eine große Rolle.

Abbildung 10: Weitere, vergangene, aktuelle und geplante Normierungs-/Standardisierungsaktivitäten im Kontext

4. Argumente für und wider die Normierung und Standardisierung

4.1 Pro Normierung und Standardisierung

Der Hauptzweck der Standardisierung ist in der Kostenersparnis und der Arbeitsvereinfachung zu sehen. Die Standardisierung führt zur Erhöhung der Markttransparenz und zur Kostensenkung (bei Herstellungskosten, Informationskosten, Transaktionskosten, Versandkosten, Vertriebskosten, Wechselkosten).

Auf Seiten der Käufer standardisierter Produkte, Services und Dienstleistungen sind besonders die reduzierten Wechselkosten sowie die Kompatibilität interessant: eingekaufte Produkte und Services werden deutlich leichter austauschbar und technisch anschlussfähig, damit integrierbar. Damit intensiviert sich der Wettbewerb, was zu Preisdegression und Leistungssteigerung führen muss.

4.2 Contra Normierung und Standardisierung

Den positiven Aspekten der Normierung und Standardisierung stehen allerdings auch mögliche Nachteile gegenüber.

Für den Erfolg eines Produktes, einer Dienstleistung und somit des Gesamtunternehmens sollte eine USP („unique selling proposition“), also ein Alleinstellungsmerkmal, gegeben sein. Damit kann es problematisch erscheinen, dass eine Standardlösung Basis einer guten USP sein kann, da sie sich von der Masse absetzen muss. Das heißt zwangsläufig, dass der besondere Mehrwert des Produktes, statt durch eine standardisierte Wertschöpfungskette, nur durch eine Abweichung vom Standard entstehen kann.

Analysiert man bestehende Standards, so wird deutlich, dass es sich bei den formulierten Kriterien immer um Minimalanforderungen handelt (also das, was der Kunde sowieso erwarten können sollte). Das konsequente Verfolgen von Standards kann also dazu führen, dass Unternehmen sich immer am untersten Rand der Möglichkeiten befinden und ihre Alleinstellungsmerkmale sogar aufgeben.

Blue Ocean Strategien beinhalten – etwas verkürzt gesagt – insbesondere das Weglassen erlernter Features eines Produkts oder einer Leistung, wenn dadurch möglich wird, dem Kunden an anderer Stelle einen erheblichen Mehrwert zu schaffen. Hier ist in sinnvoll, Standards nicht zu erfüllen, wenn dies dem Alleinstellungsmerkmal und dem Erfolg des Produktes dient.

Standardisierung begründet die Gefahren der Schematisierung und des Flexibilitätsverlustes. Es kann vorkommen, dass Aspekte, die nicht standardisiert werden können, vernachlässigt werden. Standardisierung ist ein abstimmungsintensiver Prozess, der hohe Kosten verursacht und im Normalfall eine Dauer von einigen Jahren benötigt. Daraus ergibt sich ein zu statischer Rahmen. Standardisierung kann dazu führen, dass der kreative Freiraum eingeschränkt wird. Dieses Abwürgen von Innovationsfeldern ist insbesondere im Umfeld der Entwicklung innovativer Technologien nicht erwünscht.

5. Abkürzungen

3D	dreidimensional
5G	Mobilfunkstandard der fünften Generation
AR	Augmented Reality (dt. Erweiterte Realität): Überlagerung der natürlichen Sicht mit Computer-generierten Informationen
bsi	British Standards Institution
CEA	Consumer Technology Association
CEN	European Committee for Standardization
DIN	Deutsches Institut für Normung e.V.
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE
DSGVO	Datenschutz-Grundverordnung
DOF	Freiheitsgrade (Degrees of Freedom)
DVB	Digital Video Broadcasting
GS1 US	Global Standards, US branch
HMD	Head-Mounted Display (dt. Datenhelm)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISO	International Organization for Standardization
ITU	International Telecommunication Union
Khronos	Khronos Group
LED	Light Emitting Diode (dt. Leuchtdiode)
LET	Lernen, Bildung, Training – learning/education/training
mipi alliance	Mobile Industry Processor Interface Alliance
MIMOSA	Open Standards for Operations and Maintenance
Mozilla	Mozilla
MPEG	Moving Pictures Expert Group
MR	Mixed Reality, gleichzeitige Präsentation künstlicher und natürlicher Sinnesreize
NATO	North Atlantic Treaty Organization
OGC	Open Geospatial Consortium
OLED	organische Leuchtdiode
OMAF	Omnidirectional MediA Format
OSVR	Open Source Virtual Reality Movement
ProSTEP	ProSETP iViP e.V.
QUALINET	WG2 - Standardization

SAE	Society of Automobile Engineers
SISO	Simulation Interoperability Standards Organization
TIFCA	International Future Computing Association (früher: Immersive Technology Alliance)
USP	Unique Selling Proposition
UX	User Experience
VDA	Verband der Automobilindustrie e. V.
VDI	Verein Deutscher Ingenieure e.V.
VESA	Video Electronics Standards Association
VR	Virtual Reality (dt. Virtuelle Realität): interaktive Integration eines Benutzers in eine Computer-generierte 3D-Umgebung
VRARA	Virtual Reality and Augmented Reality Association
vrhig	Virtual Reality Human Interface Guidelines Community
VRIF	Virtual Reality Industry Forum
W3C	World Wide Web Consortium (W3C)
XR	eXtended Reality; Sammelbegriff für AR, MR, VR

6. Literatur und Verweise

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7. Impressum

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