

# ETSI GR CIM 052 V1.1.1 (2025-01)



## **Context Information Management (CIM); VR and AR for Smart Learning: Guidelines for using NGSI-LD to train personnel in Smart Industries**

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## Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) cross-cutting Context Information Management (CIM).

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## Modal verbs terminology

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# 1 Scope

The present document focuses on the selection of relevant and representative implementations, methodologies, and standards employed in the training of personnel within Smart Industries. It establishes guidelines for the effective use of the NGS-LD API in Smart Learning applications enhanced by VR/AR technologies. Additionally, it includes the mapping of at least one Smart Learning standard to NGS-LD to ensure compatibility and interoperability across various platforms.

## 2 References

### 2.1 Normative references

Normative references are not applicable in the present document.

### 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Milgram, Paul, H. Takemura, A. Utsumi, F. Kishino (1994), "Augmented Reality: A class of displays on the reality-virtuality continuum", Proceedings of SPIE - The International Society for Optical Engineering Vol. 2351. Retrieved 2021-06-01.
- [i.2] [Meta, Immersive Experiences: "Best Practices". \(2025-01\)](#)
- [i.3] Billy T.M. Wong, Kam Cheong Li: "[Research and Practice in Smart Learning: A Literature Review](#)", in IEEE<sup>TM</sup> Access, pp. 23-26, 2020.
- [i.4] [ISO/IEC TR 23844:2023](#): "Information technology for learning, education, and training — Immersive content and technology".
- [i.5] [ISO/IEC 5927:2024](#): "Computer graphics, image processing and environmental data representation — Augmented and virtual reality safety — Guidance on safe immersion, set up and usage".
- [i.6] [Experience API \(xAPI\) Standard](#).
- [i.7] ADL: "[Documentation about xAPI data model and features](#)".
- [i.8] ADL: "[Sharable Content Object Reference Model SCORM®](#)".
- [i.9] [IETF RFC 2046 \(November 1996\)](#): "Multipurpose Internet Mail Extensions (MIME) Part Two: Media Types".
- [i.10] [ETSI GS ARF 004-2 \(V1.1.1\) \(08/2021\)](#): "Augmented Reality Framework (ARF) Interoperability Requirements for AR components, systems and services Part 2: World Storage and AR Authoring functions".
- [i.11] "[Minerva project](#)", HT s.r.l, P.M.F. s.r.l, Sfera s.r.l, European Project F/190045/01-02-03/X44.
- [i.12] Khronos GROUP: "[OpenXR](#)".
- [i.13] W3C® Immersive Web Working and Community Groups: "[WebXR](#)".

- [i.14] [OGC 06-103r4 V1.2.1](#): "OpenGIS® Implementation Standard for Geographic information - Simple feature access - Part 1: Common architecture".
- [i.15] [IETF RFC 5646](#): "Tags for Identifying Languages".
- [i.16] ISO 8601 (2019): "Data elements and interchange formats — Information interchange — Representation of dates and times.
- [i.17] [IETF RFC 7946](#): "The GeoJSON Format".

## 3 Definition of terms, symbols and abbreviations

### 3.1 Terms

Void

### 3.2 Symbols

Void

### 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3D	three-Dimensional
ADL	Advanced Distributed Learning
API	Application Programming Interface
APP	Achievements, Progress and Position tracking software for LET
AR	Augmented Reality
ARF	Augmented Reality Framework
ETSI	European Telecommunications Standards Institute
GPS	Global Positioning System
GS	Group Specification
HMD	Head Mounted Display
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronic Engineers
IETF	International Engineering Task Force
IRI	Internationalized Resource Identifier
IRL	Internationalized Resource Locator
ISG	Industry Specification Group
ISO	International Standardization Organisation
JSON	JavaScript Object Notation
LBS	Location-Based Service
LET	Learning, Education and Training
LMS	Learning Management System
MR	Mixed Reality
OpenXR	Open standard for virtual and augmented reality
RFC	Request For Comments
s.r.l.	società a responsabilità limitata
SCORM®	Sharable Content Object Reference Model
SRS	Spatial Reference System
TR	Technical Report
UI/UX	User Interface/User eXperience
VR	Virtual Reality
W3C	World Wide Web Consortium
XAPI	eXperience API
XR	eXtended Reality

## 4 Immersive technologies used for Smart Learning based on 3D representation of real environments

### 4.1 Types of immersive technologies and their use

#### 4.1.0 Foreword

Based on the available literature [i.1], the realm of immersive technologies is characterized by the 'distance' between the 3D experiences developed and the reality on which they are based. The main category of immersive content is the eXtended Reality (XR), it is the full range of virtual content added to the real environment. This spectrum includes various technologies ranging from the simplest augmentation of reality of Augmented Reality (AR), to more complex and virtual experiences of Mixed Reality (MR) and Virtual Reality (VR) technologies. The usage of immersive technologies is growing, these enhance the quality and the efficiency of traditional Learning, Education and Training (LET) environments and make experiences more inclusive than ever.

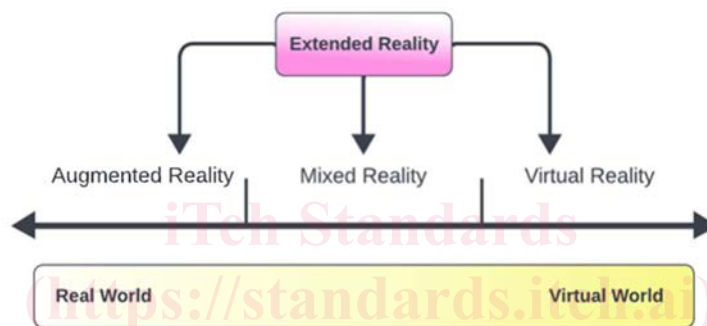


Figure 4.1.0-1: The reality-virtuality continuum diagram

#### 4.1.1 AR-based content

AR-based content [i.4] consists of overlaying the real world with virtual 3D objects. This type of content requires mobile devices or compatible see-through devices. These immersive experiences are the least computationally demanding among others and are consumed daily by millions of people around the world. In fact, AR face filters, popular mobile games, and many interior design customization applications use AR technology to create engaging and personalized experiences. AR-based content includes:

- **Location-Based Service (LBS) applications**, heavily use Global Positioning System (GPS), gyroscope sensor and can rely on images to gather information about user's position in the real world.
- **Image and object recognition applications**, make use of the device's camera module to recognize marker, images and objects and make possible to instantiate 3D objects on the plane of the scanned asset (museum or school applications and face filter used in social networks as reference).
- **Projection applications**, are limited to small projectors installed on a device that project images directly to the user's retinas or eyeglasses to display additional real-time information about the environment.

#### 4.1.2 VR-based content

Virtual Reality-based (VR-based) content [i.4] is played through a Head Mounted Display (HMD) device, which typically needs high computing and graphics rendering capabilities and is often used with a pair of controllers for hand gestures and input devices. There are two distinct types of experiences:

- **360° images applications**, use panoramic images of real environment that can be virtually visited by the user, it is possible to play even on mobile devices.

- **3D simulations applications**, place 3D objects in a virtual environment that can be manipulated and interactable, this type of content needs devices with high specification (heavily used in gaming, simulations and training).

### 4.1.3 MR-based content

The Mixed Reality (MR) merges the best of both Augmented Reality (AR) and VR technologies, this type of content is characterized by the fusion of 3D synthetic objects and real world environments. MR technology allows users to interact with digital objects that co-exists with the tangible physical world, they can be even anchored to real world locations to be viewed through devices that need cameras such as HMD devices, smartphones or glasses. This technology is growing rapidly and the rate of adoption of devices capable of these features will increase in the near future.

## 4.2 Smart Learning and Immersive experiences

### 4.2.1 Standards

#### 4.2.1.1 Overview

Clause 4.2.1 will present standards and de-facto standards about technical requirements, data models, implementation and User Interface/User eXperience (UI/UX).

At the moment, there are no available standards [i.4] for eXtended Reality (XR) experiences themselves or their implementations. However, there are standards related to peripherals, safety of HMD devices, image processing, 3D rendering, and audio; some of these are the same as those used in other software, such as video games or interactive experiences. XAPI and SCORM are the two standards in e-learning experiences data model, eXperience API (XAPI) in particular is the one used the most in interactive immersive learning experiences. The IEEE and Khronos group [i.4] are the main organizations that work on de-facto standards on VR and MR technologies, Khronos Group released OpenXR (open standard for virtual and augmented reality), that makes possible for developers to write code that runs everywhere, so it is a common interface for immersive applications.

#### 4.2.1.2 XAPI

xAPI is a specification for learning technologies developed by Advanced Distributed Learning (ADL) [i.6] that makes possible to collect data about the online and offline experiences that users may have. APIs (Application Programming Interfaces) capture data from different technologies in a consistent format. In this way, very different systems can communicate securely by collecting and sharing the flow of activities with the xAPI vocabulary. xAPI has a syntax based on basic statements: an **actor**, a **verb** and an **object**.

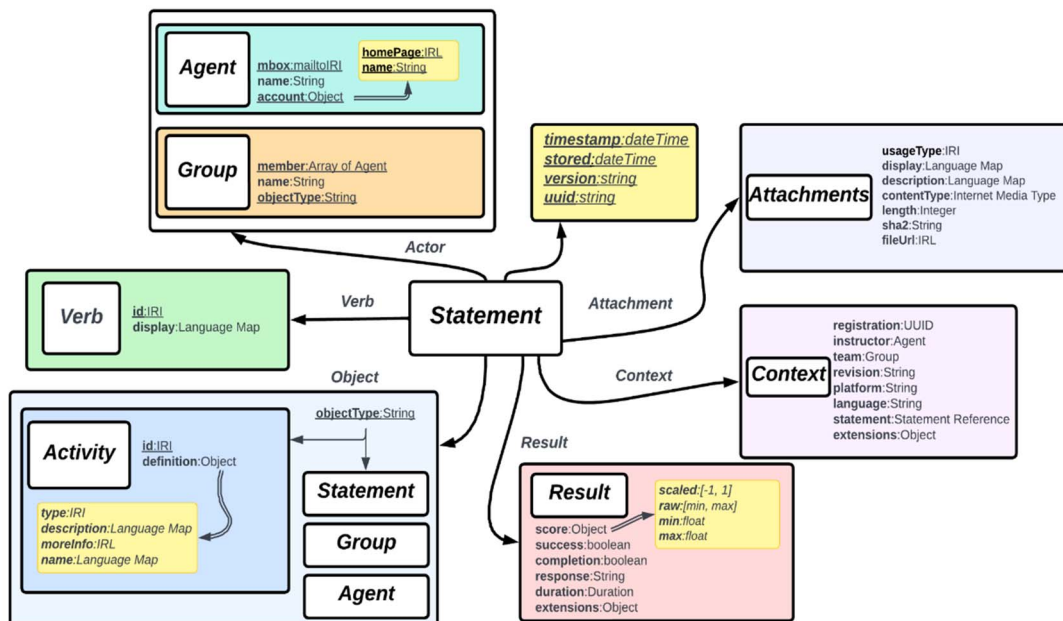


Figure 4.2.1.2-1: xAPI statement's diagram

The statement can also be expanded by adding more pieces of information; in Figure 4.2.1.2-1 on the left are represented the three basic main components of an xAPI statement, the optional components are on the right.

In the proposed statement are also present the result and context objects in addition to the actor, verb and object which are mandatory.

```
{
  "actor": {
    "name": "Sally",
    "mbox": "mailto:sally@example.com"
  },
  "verb": {
    "id": "http://adlnet.gov/expapi/verbs/completed",
    "display": { "en-US": "completed" }
  },
  "object": {
    "id": "http://example.com/activities/solo-hang-gliding",
    "definition": {
      "type": "http://adlnet.gov/expapi/activities/assessment",
      "name": { "en-US": "Solo Hang Gliding" },
      "extensions": {
        "http://example.com/gliderClubId": "test-435"
      }
    }
  },
  "result": {
    "completion": true,
    "success": true,
    "extensions": {
      "http://example.com/flight/averagePitch": 0.05
    }
  },
  "context": {
    "extensions": {
      "http://example.com/weatherConditions": "rainy"
    }
  }
}
```

The verb element allows the recording of the individual passages of which the student's interaction with a content is composed. From the tracking it emerges that the student has chosen a certain type of activity (attempted) and has begun to do it (accessed), has progressed and answered the questions provided by that activity (answered), has completed it (completed) and has successfully passed it (passed) up to the highest level of comprehension and competence (mastered). Below is a list of the main components of an xAPI statement:

- **Actor**, the subject of the action performed, can be an **Agent**, an Anonymous or Identified **Group** (of Agent) [i.7]:

Table 4.2.1.2-1

Agent property			
Attribute name	Type	Description	Required
name	String	The complete name of the user.	Optional.
objectType	String	The value of this attribute has to be "Agent".	Required only if Agent is used as object of a statement
An Inverse Functional Identifier at choice (Table 4.2.1.2-4)			Required

Table 4.2.1.2-2

Anonymous Group property			
Attribute name	Type	Description	Required
objectType	String	The value of this attribute has to be "Group".	Required
name	String	The name of the Group.	Optional
member	Array of Agent Objects	The member list of the Group.	Required

Table 4.2.1.2-3

Identified Group property			
Attribute name	Type	Description	Required
objectType	String	The value of this attribute has to be "Group".	Required
name	String	The name of the Group.	Optional
member	Array of Agent Objects	The member list of the Group.	Optional
An Inverse Functional Identifier at choice (Table 4.2.1.2-4)			Required

Table 4.2.1.2-4

Inverse Functional Identifiers		
Attribute name	Type	Description
openid	URI	An openID that uniquely identifies the Agent.
account	Object	Object that incapsulate information about a user existing account on e.g. LMS or intranet (Table 4.2.1.2-5).
mbox	mailtoIRI	The email address of the user.
mbox_sha1sum	String	The hex-encoded SHA1 hash of a mail to IRI (i.e. the value of an mbox property).

Table 4.2.1.2-5

Account Object			
Attribute name	Type	Description	Required
homePage	IRL	The canonical home page for the system the account is on.	Required
name	String	The unique id or name used to log in to this account. This is based on FOAF's accountName.	Required

- **Verb**, the action performed by the Actor [i.7]:

Table 4.2.1.2-6

Verb property			
Attribute name	Type	Description	Required
id	IRI	Corresponds to a Verb definition. Each Verb definition corresponds to the meaning of a Verb, not the word.	Required
display	LanguageProperty	The human readable representation of the Verb in one or more languages. It serves as a description.	Recommended

- **Object**, the object of the action performed can be a **Statement**, **Group**, **Agent** or an **Activity**. For example, "Ken pressed a button", "Marie interviewed Ken", "Marie commented on 'Ken pressed a button' " are all different actions that imply different object of the action itself [i.7]:

Table 4.2.1.2-7

Object of Activity type			
Attribute name	Type	Description	Required
objectType	String	HAS TO be Activity when present.	Optional
id	IRI	An identifier for a single unique Activity.	Required
definition	Object	Metadata of the activity (Table 4.2.1.2-8).	Optional

Table 4.2.1.2-8

Definition Object			
Attribute name	Type	Description	Required
name	LanguageProperty	The human readable/visual name of the Activity.	Recommended
description	LanguageProperty	A description of the Activity.	Recommended
type	IRI	The type of Activity.	Recommended
moreInfo	IRL	Resolves to a document with human-readable information about the Activity.	Optional
Interaction properties, more at [i.7].			
extensions	Object	A map of other properties as needed.	Optional

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Table 4.2.1.2-9

Object of StatementRef type			
Attribute name	Type	Description	Required
objectType	String	HAS TO be StatementRef.	Required
id	UUID	The UUID of the Statement used as Object.	Required

NOTE: In this case the Object is a pre-existing Statement referred by its UUID [i.7].

Table 4.2.1.2-10

Object of SubStatement type			
Attribute name	Type	Description	Required
objectType	String	HAS TO be SubStatement.	Required

NOTE: In this case the Object is a new Statement, called SubStatement, which is similar to a StatementRef but self contained into a Statement, it does not represent an event that has already occurred. The SubStatement has to be a valid Statement in addition to other SubStatement requirements like not containing "id", "stored", "version" or "authority" properties [i.7].