socialXR

SPRING SCHOOL

Social XR Spring School

April 7-10, 2025
Amsterdam

Interoperability

Towards a human-Centered and Ethical Development of Immersive Technologies Checklist

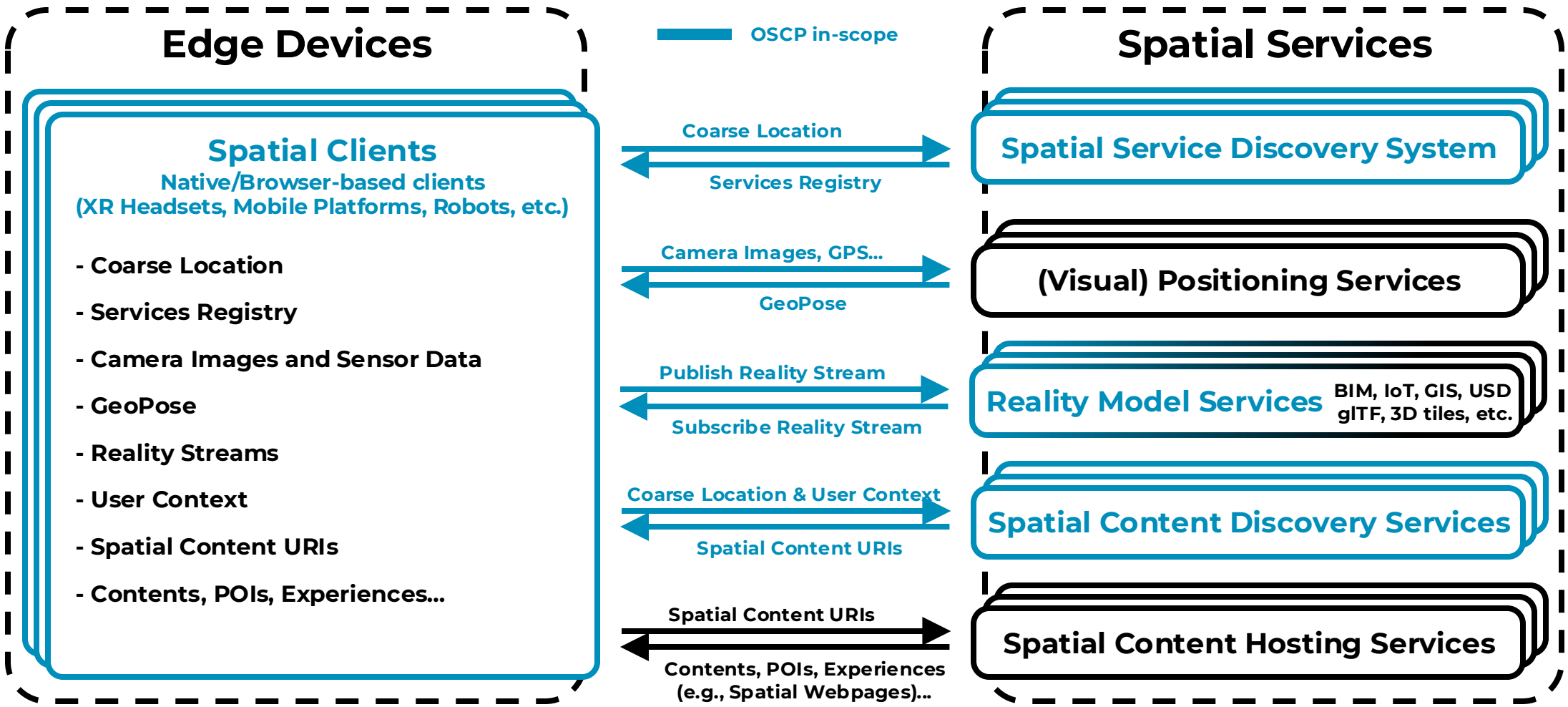
OPEN AR CLOUD EUROPE

OPEN AR CLOUD EUROPE

To support interaction with the European tech industry and institutions, a branch of the Open AR Cloud Association, "**Open AR Cloud Europe**" has been established in Munich, Germany, in July 2020: Our Official European presence will enable us to collaborate closely with government or academic organizations and companies throughout the EU.

OPEN AR CLOUD EUROPE

Topic


Edge Devices
Spatial Clients
Native/Browser-based clients
(XR Headsets, Mobile Platforms, Robots, etc.)
- Coarse Location
- Services Registry
- Camera Images and Sensor Data
- GeoPose
- Reality Streams
- User Context
- Spatial Content URIs
- Contents, POIs, Experiences...
OSCP in-scope
Coarse Location
Services Registry
Camera Images, GPS...
GeoPose
Publish Reality Stream
Subscribe Reality Stream
Coarse Location & User Context
Spatial Content URIs
Spatial Content URIs
Contents, POIs, Experiences
(e.g., Spatial Webpages)...
Spatial Services
Spatial Service Discovery System
(Visual) Positioning Services
Reality Model Services
BIM, IoT, GIS, USD
glTF, 3D tiles, etc.
Spatial Content Discovery Services
Spatial Content Hosting Services

Mapps, GPS, VPS

The technology of positioning ourselves on the planet began centuries ago with traditional navigational tools like maps and compasses.

There was a big leap forward with the development of the Global Positioning System (GPS) in the 1970s, which introduced satellite-based navigation, transforming how people and machines determine their exact position on Earth.

A Visual Positioning System (VPS) is a further revolutionary approach to navigation and mapping. It uses computer vision and artificial intelligence to determine precise location based on visual cues from the environment.

WHAT IS A VISIAL POSITIONING SYSTEM (VPS)

VPS is a technology that enables a device, such as a smartphone or a drone, to determine its location and orientation in the physical world using visual cues.

VPS systems use computer vision algorithms to analyze images from a camera or other optical sensor and match them against a database of known locations or features.

HOW DOES A VISIAL POSITIONING SYSTEM (VPS) WORK

VPS determines a device's location based on imagery rather than GPS signals. VPS first creates a map by taking a series of images that have a known location and analyzing them for key visual features, such as the outline of buildings or bridges, to create a large-scale and fast searchable index of those visual features. To localize the device, VPS compares the features in imagery from the phone to those in the VPS index. However, the accuracy of localization through VPS is greatly affected by the quality of both the imagery and the location associated with it.

Topic

VPS determines a device's location based on imagery rather than GPS signals. VPS first creates a map by taking a series of images that have a known location and analyzing them for key visual features, such as the outline of buildings or bridges, to create a large-scale and fast searchable index of those visual features. To localize the device, VPS compares the features in imagery from the phone to those in the VPS index. However, the accuracy of localization through VPS is greatly affected by the quality of both the imagery and the location associated with it.

GOOGLE’s ARCORE GEOSPATIAL API (GOOGLE’S VPS

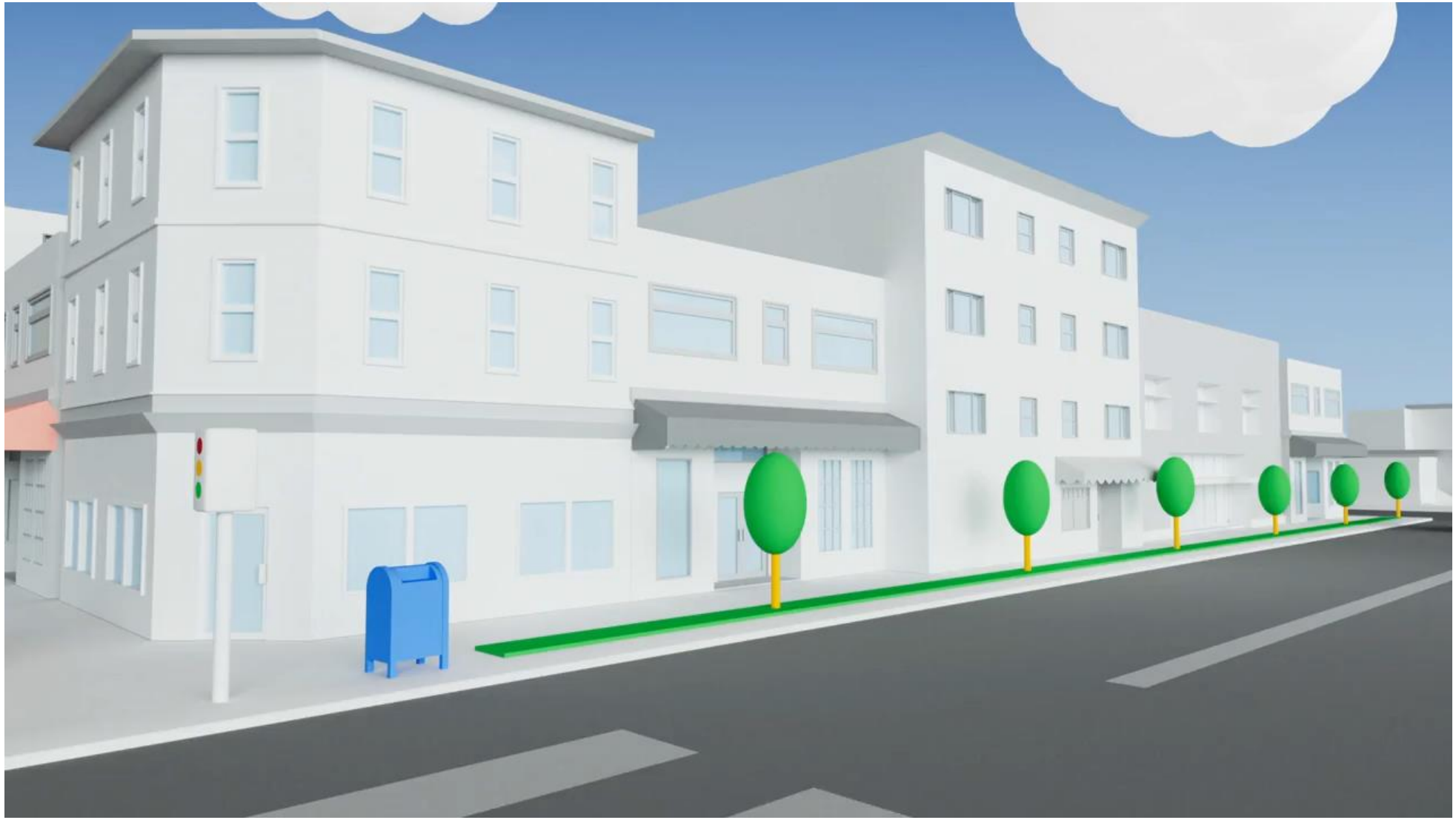
How Does AR CORE GeoSpatial API work?

The ARCore Geospatial API enables you to remotely attach content to any area covered by Google Street View and create AR experiences on a global scale.

It uses device sensor and GPS data to detect the device's environment, then matches the recognizable parts of that environment to a localization model provided by Google’s Visual Positioning System (VPS) to determine the precise location of a user’s device.

The API also takes care of merging the user’s local coordinates with the geographic coordinates from VPS so that you can work within a single coordinate system.

GOOGLE’s ARCORE GEOSPATIAL API (GOOGLE’S VPS

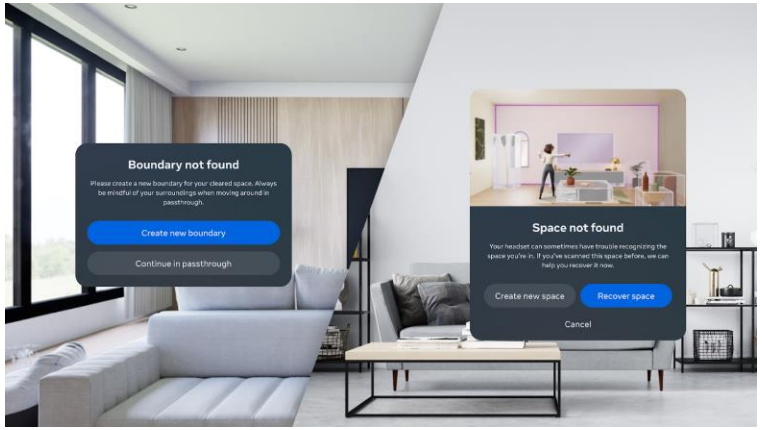


METAs VPS

How Does Metas VPS Work?

- VPS uses visual cues from your space to determine the position of your Quest with respect to its surroundings. This is important because it allows for more accurate and immersive experiences in virtual and mixed reality, like being able to place a virtual Chess board on a table and have it stay there day after day.

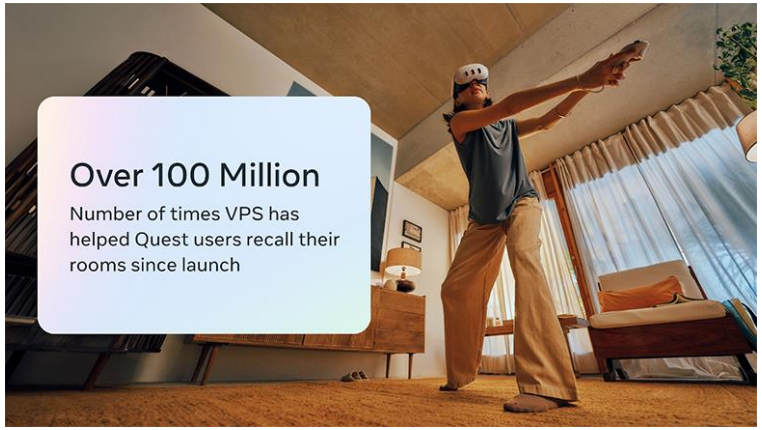
- VPS enhances your headset's ability to understand its position within a space by extending your Quest's inside-out tracking with cloud storage and computing power. VPS creates more accurate and more robust spatial maps, making it more resilient to changes like lighting variations between day and night, changing clutter, and more. VPS also lets you save content in more rooms without losing it between sessions.



METAs VPS

The Benefits of Metas VPS

- **More Robust Mixed Reality Content:** With VPS, your headset can better recognize your space and find your MR content right where you left it in your last session.
- **Improved Boundary Persistence:** VPS helps your headset remember your space and its boundaries. That means you won't have to redraw boundaries and can jump into your virtual or mixed reality experience faster.
- **Improved Space Setup Persistence:** VPS also helps your headset remember your room layout. That means you're less likely to see a "Scene Not Found" message and won't need to rescan your space.
- **Use Quest in More Places:** VPS lets you use your Quest in more places than before. You can enjoy VR and MR at home, at work, or on the go



METAs VPS

NIANTIC VPS

How Does Niantic's Lightship VPS work?

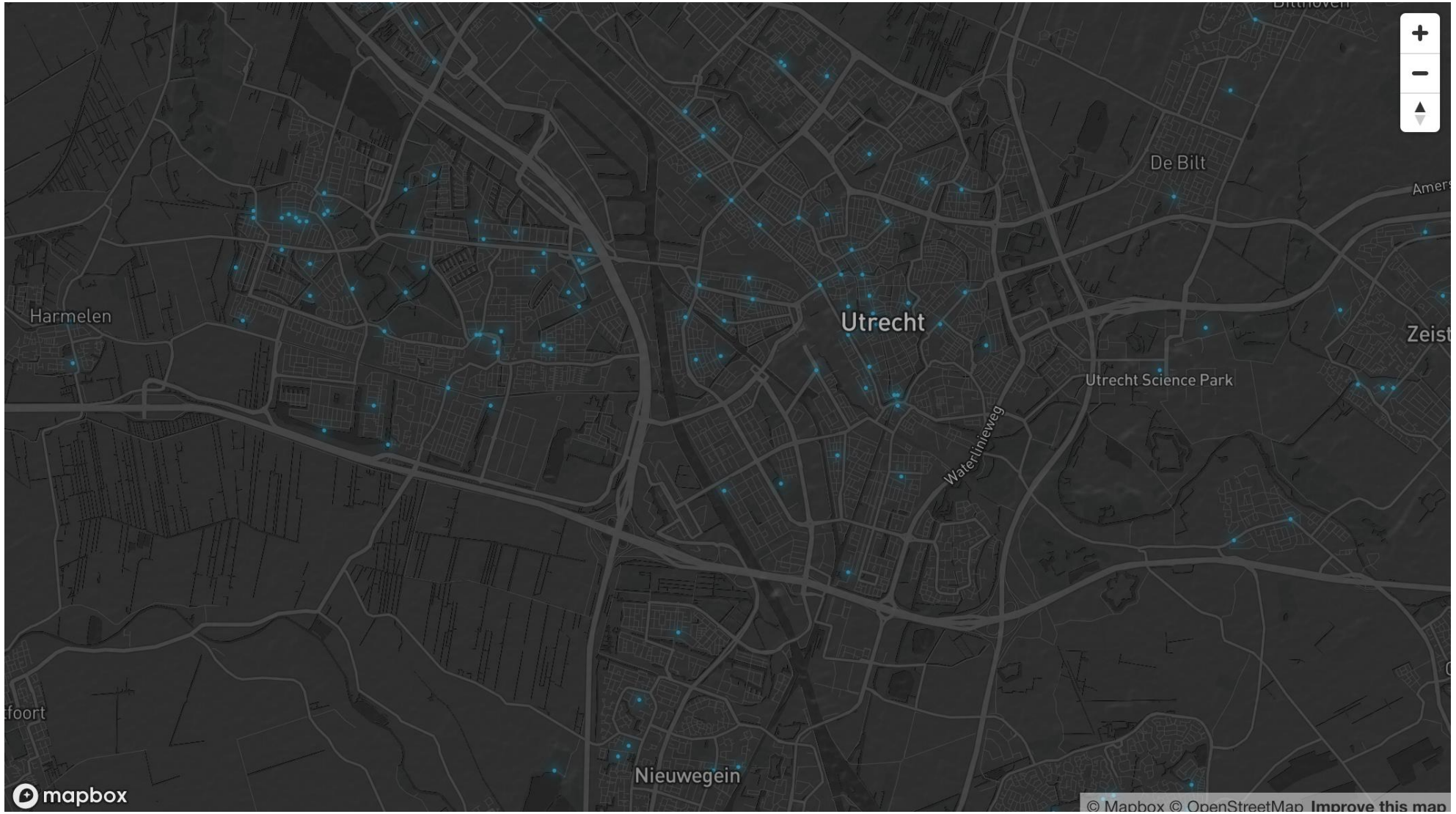
When a device makes a call to the VPS service, the service receives a query image from the user's device along with their rough location (from GPS) as inputs and attempts to localize them using the map(s) that exist at that location on Niantic Map. If localization is successful, then the service returns the device's position and orientation (pose) corresponding with the timestamp of the image that was transmitted.

Because there is a time delay between when a VPS query image is captured and when a response is received from the VPS service, the device needs to have a motion tracking system in order to stay accurately localized while moving. When the VPS service returns a pose estimate to the device, the difference in pose from the device's tracking system is added to the localization response so that VPS can "keep up" with how the device moved while waiting for the server's response to the VPS query.

NIANTIC VPS

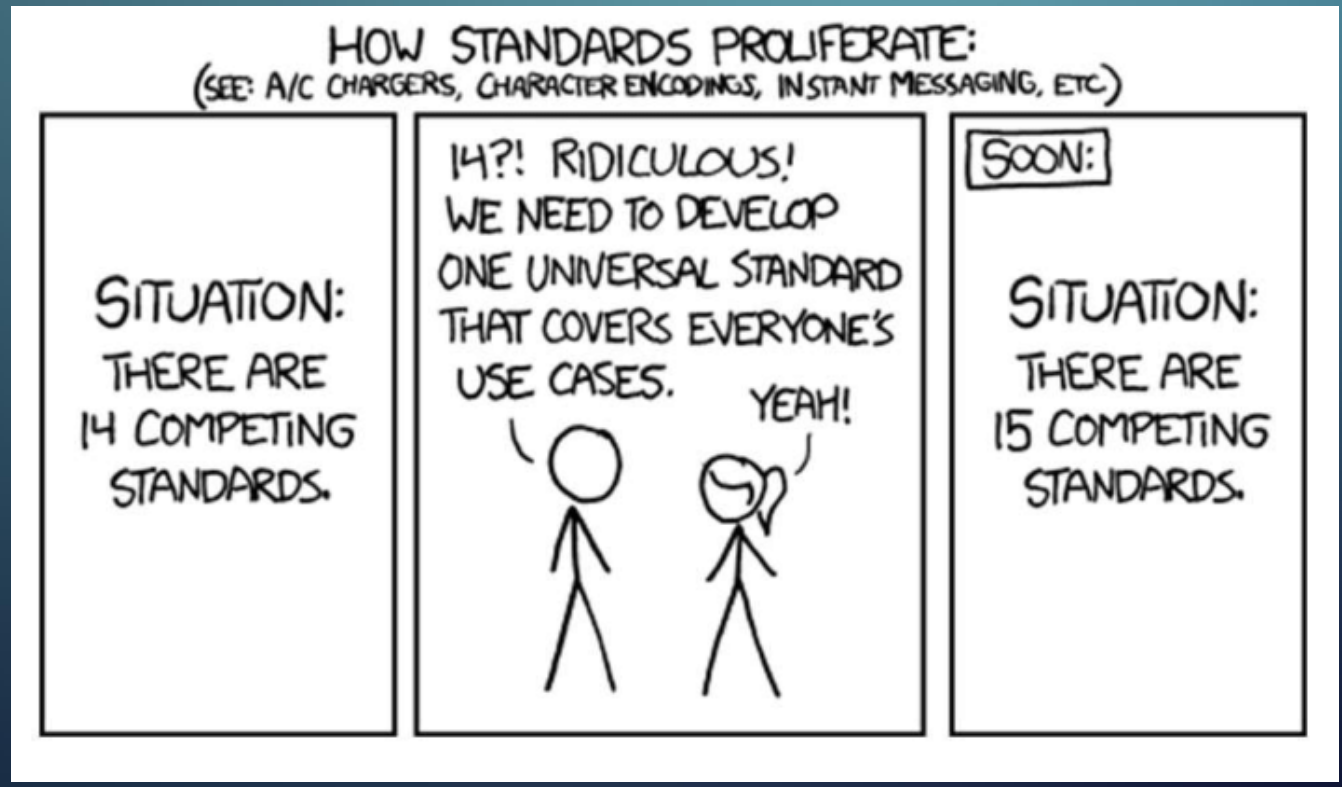
IMMERSAL's VPS

OPEN STREET MAPS



WHY AN OPEN SOURCE VISIAL POSITIONING SYSTEM (VPS) IS REQUIRED

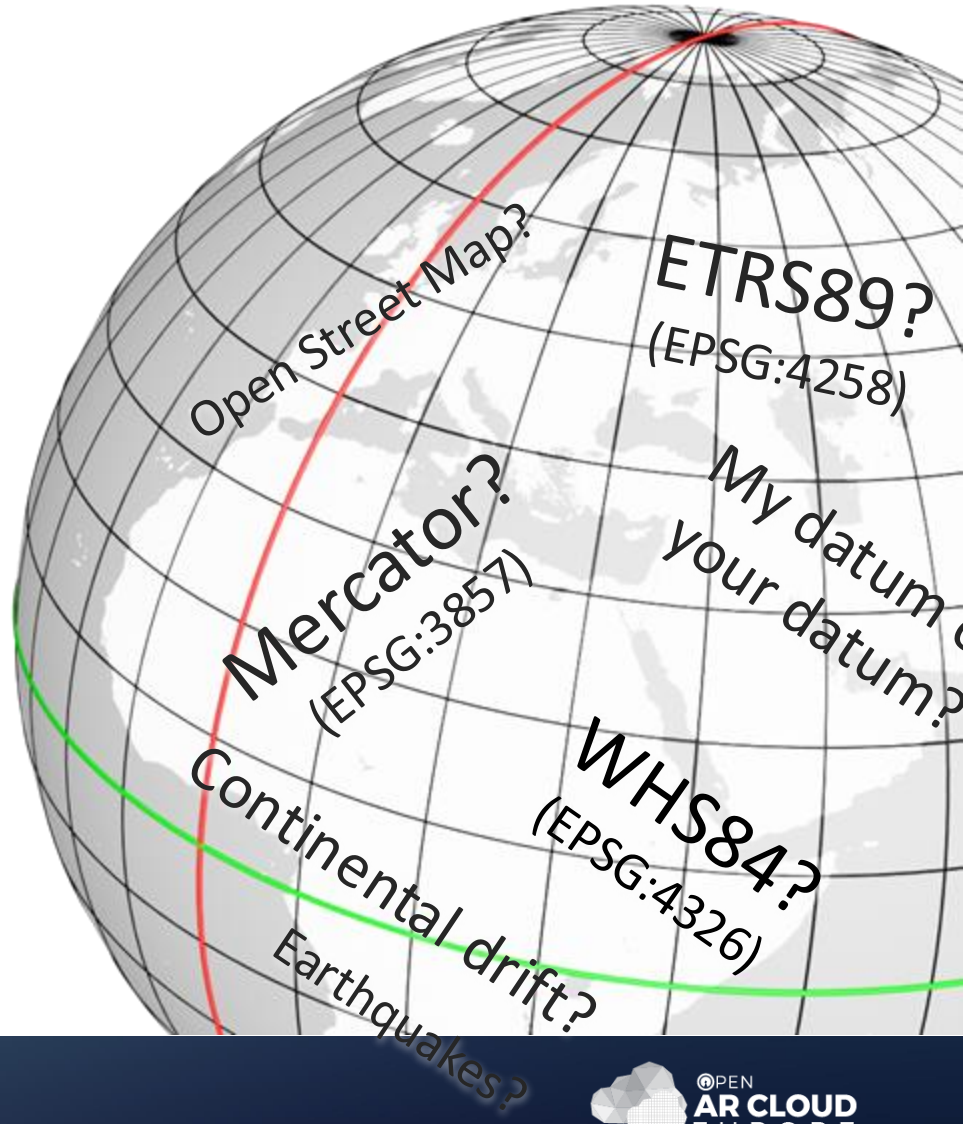
OPEN AR CLOUD EUROPE



OPEN AR CLOUD EUROPE

WORKING WITH GEOSPATIAL DATA

While often a confusing mess of formats and Coordinate Reference Systems (CRS) due to conflicting political views**, geospatial data** can be **extremely valuable** for **many use cases** and might be the missing piece for XR technologies to, at long last, gain widespread adoption.



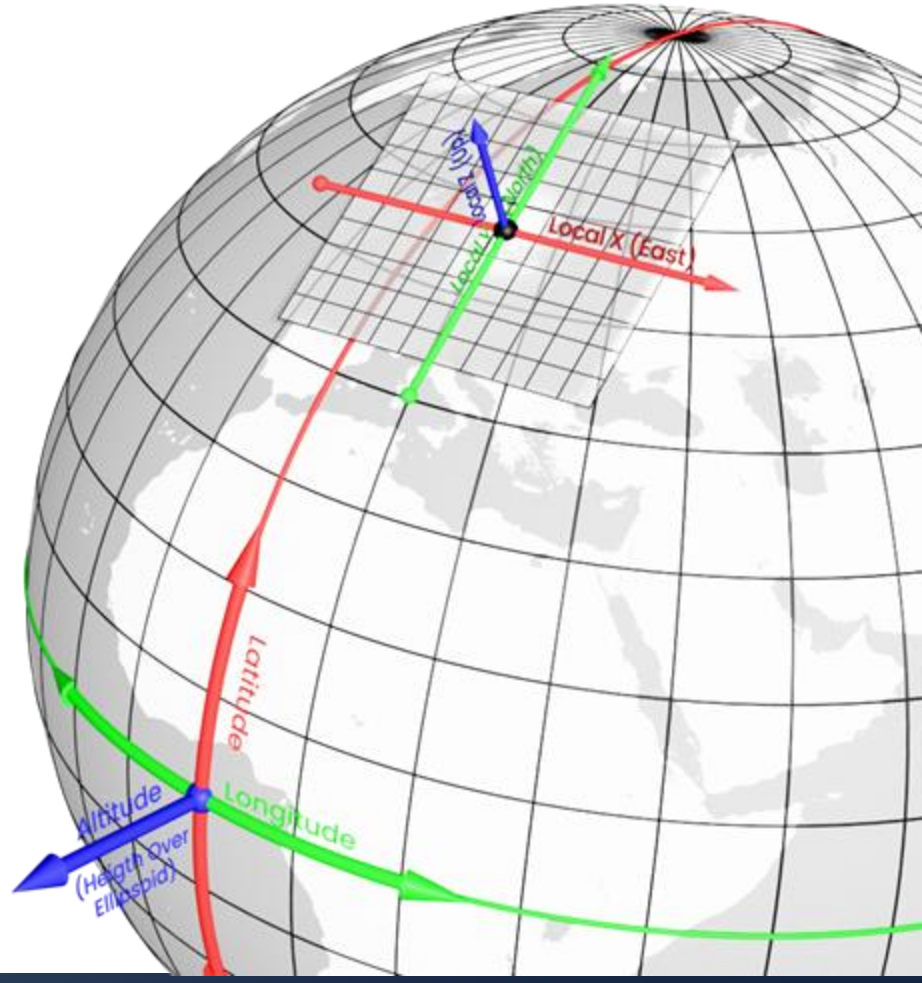
COORDINATE REFERENCE SYSTEMS (CRS)

LIMITED INTERACTION in IMMERSIVE AR

Currently, WebXR user interaction spaces are relatively limited because **all XRReferenceSpace types operate** with an **Euclidean ("flat-earth") CRS**.

As **Digital Twins grow larger and more complex** (with many users across the planet often communicating via satellite), it is necessary to start thinking in **geospatial terms** (latitude, longitude and altitude/height, instead of X, Y and Z).

But... how to enable WebXR developers to work with this new spatial reference system?



BENEFITS OF THIS APPROACH

Enhanced User Interaction: Having a **common reference frame** for the entire planet allows the creation of **larger** and **more advanced experiences** and contents, that can be discovered as the users go about their daily lives.

Massively Multiuser Experiences: Since all participants in this space employ the same CRS, they can more easily communicate with each other and collaborate to achieve common goals (or at least share their intended paths to avoid collisions

Geospatial Ecosystems: Many organizations are taking advantage of existing OGC standards to create digital ecosystems where developers can work with otherwise inaccessible Geospatial data (3D maps, sensor data, etc.).

CHALLENGES YET TO OVERCOME

Nevertheless, there are several issues that have yet to be solved:

Low Accuracy: Currently, built-in sensor **have rather poor accuracy** (GPS only offers accuracy within 1-5 meters under open sky, and indoor location systems are still under development). To achieve the millimetric level accuracy would **require the use of extra devices** or **external services like Visual Positioning Systems (VPSs**).

Cybersecurity Risks: Sharing your physical position with third parties poses **significant privacy and security risks**. Sharing photos with a VPS system might also **expose others** to **similar risks**.

Additional Computation: Translating geospatial coordinates into the transform matrices that 3D hardware operates with requires the use of **trigonometric functions** that are **computationally expensive**.

GEOPOSE OPEN GEOSPATIAL CONSORTIUM

WHAT IS GEOPOSE?

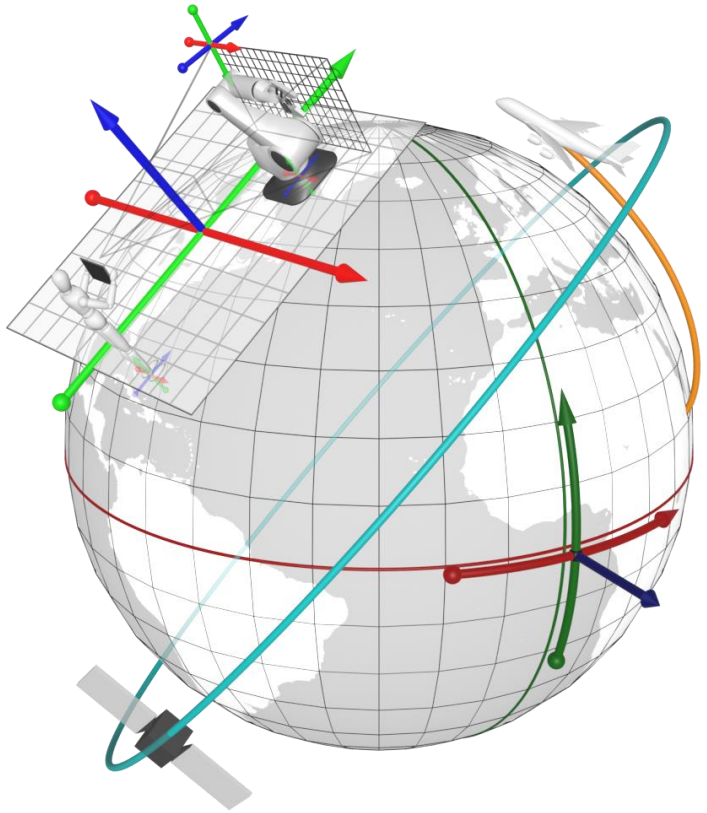
- When a real or digital object's pose is defined relative to a geographical frame of reference, it will be called a geographically-anchored pose, or "GeoPose" for short.

- All physical world objects have a geographically-anchored pose. Digital objects may be assigned/attributed a GeoPose.

WHY STANDARDISE GEOPOSE?

- OGC GeoPose Standard defines the encodings for the real world position and orientation of a real or a digital object in a machine-readable form.

- Using GeoPose enables the easy integration of digital elements on and in relation to the surface of the planet.



HOW TO IMPLEMENT THE BASIC GEOPOSE

To give you a better idea of how much computation is required to work with OGC GeoPose, here is a small JavaScript implementation:

```
// A Basic Euler Geopose is a simple JSON structure
let geopose = {
    "position": {"lat": 47.7, "lon": -122.3, "h": 11.5},
    "angles": {"yaw": 40, "pitch": -3, "roll": 0.0}
}


// Grab the values of the World Geodetic System (WGS84) ellipsoid
// @see https://en.wikipedia.org/wiki/World_Geodetic_System#WGS84
const equatorialRadius = 6378137.0;
const polarRadius = 6356752.314245;
const flatteningFactor = equatorialRadius / polarRadius;


// Use trigonometry to calculate the position of the
// space on the WGS84 Ellipsoid
let lng = geopose.position.lng  * (Math.PI/180),
    lat = geopose.position.lat * (Math.PI/180),
    alt = geopose.position.h,
    radius = equatorRadius + alt,
    lngSin = Math.sin(lng), lngCos = Math.cos(lng),
    latSin = Math.sin(lat), latCos = Math.cos(lat),
    geoX = lngCos * latCos,      geoY = latSin,
    geoZ = lngSin * latCos;

let position = new Vector(geoX * radius,
    geoY * radius * flatteningFactor, geoZ * radius);
```

```
// It is recommended to create the vertical vector for the
camera
// lookat() function, and, once negated, for the gravity vector
let verticalVector = new Vector(geoX, geoY, geoZ);
verticalVector.normalize();
let gravity = verticalvector.clone().negate();
// Then, we can use a small hack to calculate the initial
// rotation of the entity/space in Euler angles
let x0 = latSin * equatorialRadius ,
            x1 = latSin * (equatorialRadius  + 1);
    y0 = latCos * polaRadius;
    y1 = latCos * (equatorialRadius  + 1) * equatorialRadius ;
    dx = x1 - x0, dy = y1 - y0;
    l = Math.sqrt((dx * dx) + (dy * dy));

let rotation = new Euler(-Math.PI/2 + Math.acos(dx / l),
          Math.PI/2 - lng, 0);  // The Z component is not
necessary


 // From this point, one can rely on the built-in functions of
 the
 // 3D engine to do the hard work, but the intermediate variables
 // might be useful for other purposes (lighting, simulation...)
```

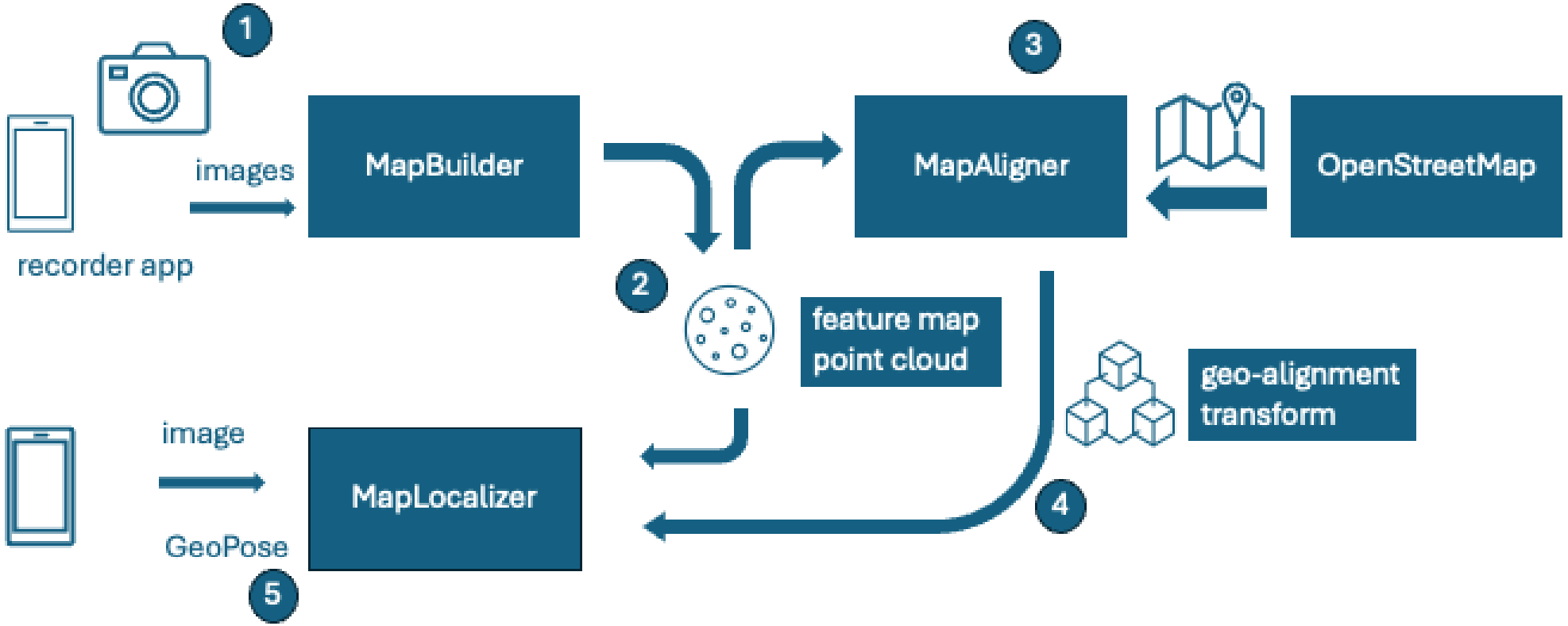
End-to-end open-source location-based augmented reality in 5G

Gábor Sörös, John Nilsson, Nan Wu,
Jennifer Shane, Alina Kadlubsky

ISMAR 2022

OPEN AR CLOUD EUROPE

OPEN SOURCE VPS OVERVIEW



OSCAR4US

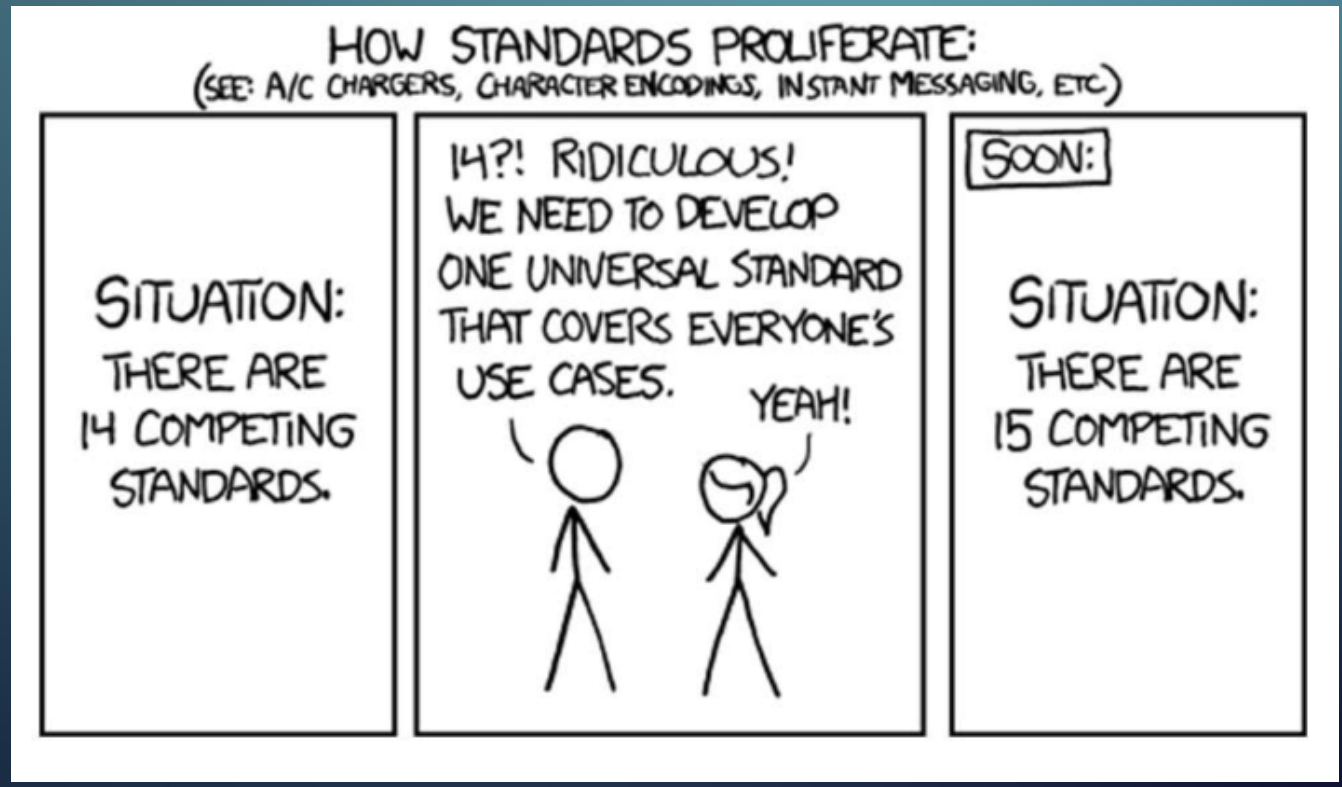

14:44
Press button to find your exact position
A teljes képernyős megjelenítésből való kilépéshez húzza le felülről, majd koppintson a vissza gombra.

OSCAR4US

LINKS AND RESOURCES

Spatial Data on the Web - Best Practices: https://www.w3.org/2021/sdw/bp/

OGC GeoPose Website: https://geopose.org /

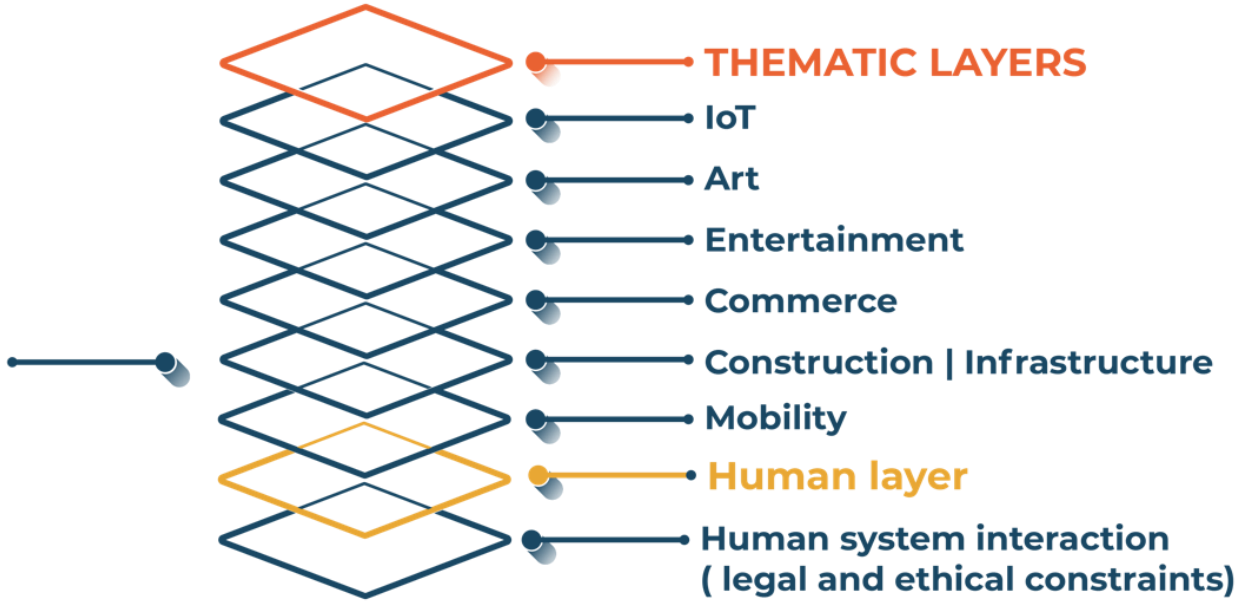


OPEN AR CLOUD EUROPE

Standards– COORDINATED EFFORTS

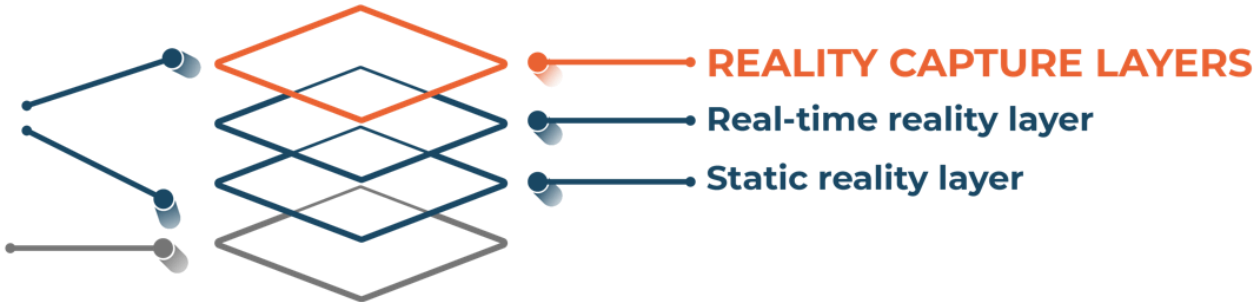
LAYERS OF THE SPATIAL WEB

A layer can contain experiences, static content, live datasteams, services, applications/solutions etc. There needs to be a shared way of registering all such things to one or more layers.

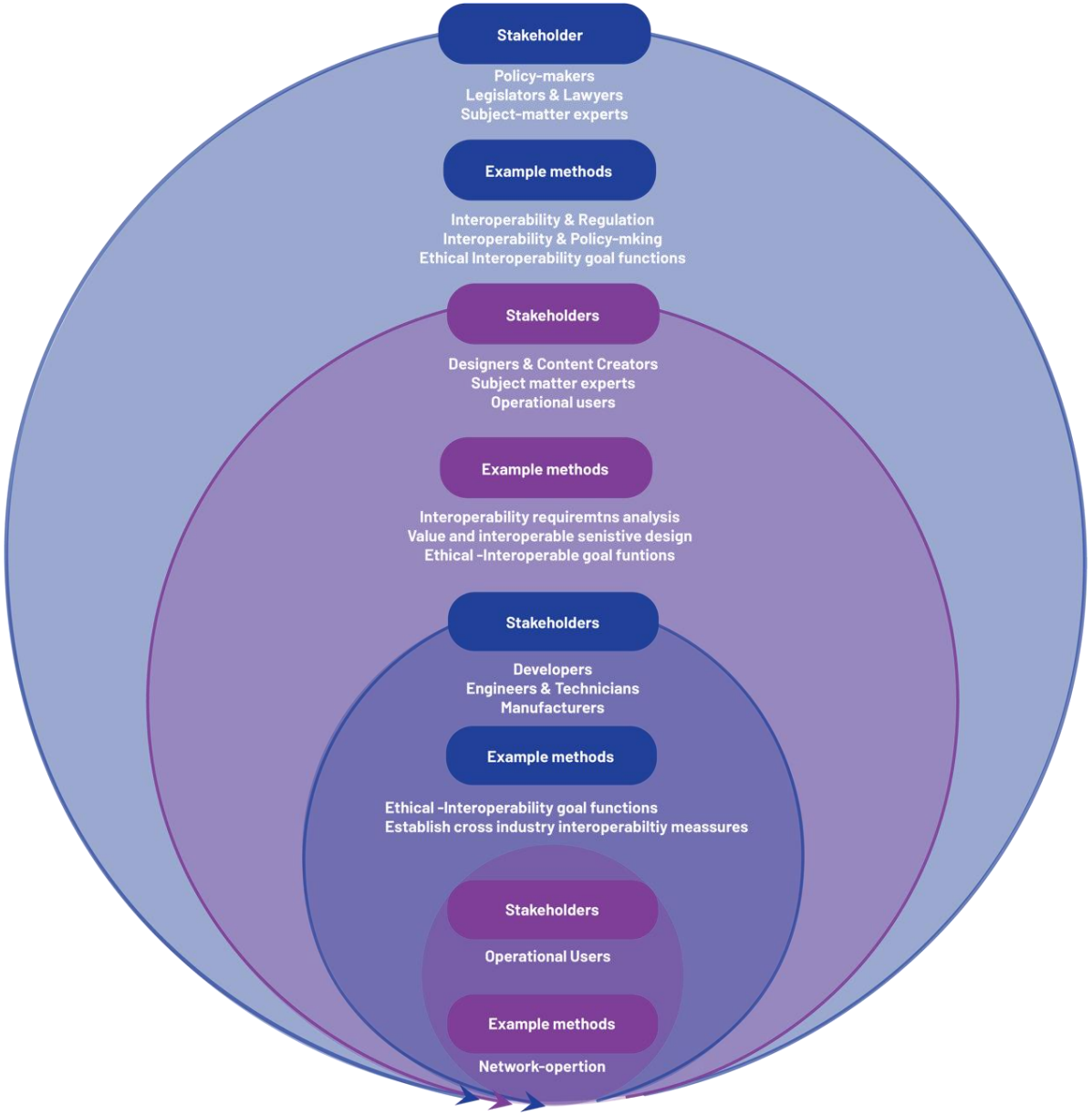


BITS: Digital representations of the real world

ATOMS: Real world



LIFECYCLE OF A **HUMAN-CENTERED INTEROPERABLE XR SYSTEM**



XR4HUMAN

Funded by the European Union

INTEROPERABILITY THE 3 PILLARS
TOWARD HUMAN CENTERED INTEROPERABILITY

Experience management layer

Guardrails | Collaboration

Stakeholder participation layer

Access | Movement | Transactions | Creation

Data and infrastructure layer

Computing | Networks

Considerations

Interoperability **guidance, standards, best practices,** etc. at each level should consider three key areas:

- **Technical** interoperability
- **Usage** interoperability
- **Jurisdictional** interoperability

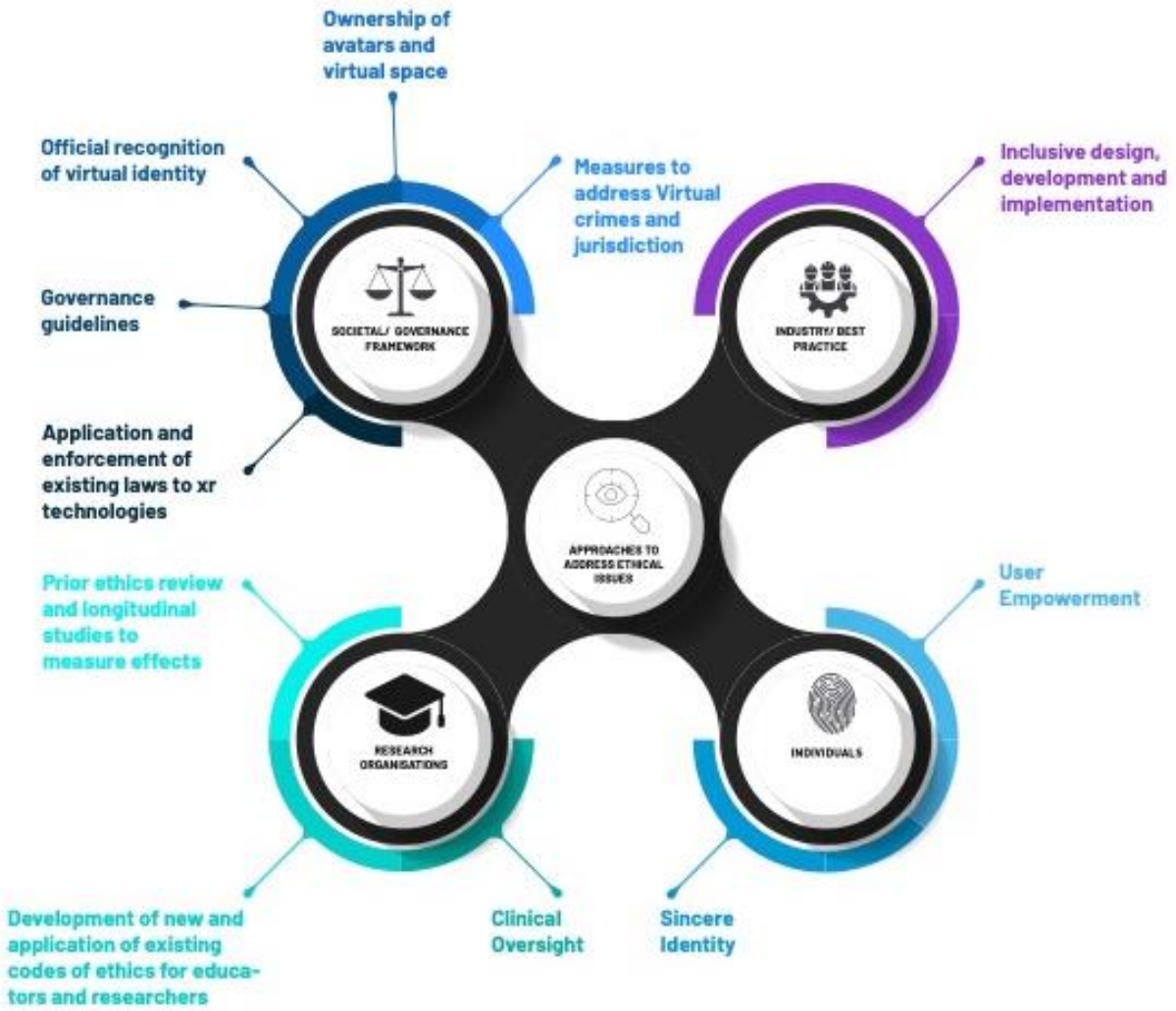
These apply to **places** within the metaverse and stakeholders' **assets, data and identity(s).**

Funded by the European Union

A scoping review of the ethics frameworks describing issues related to the use of extended reality

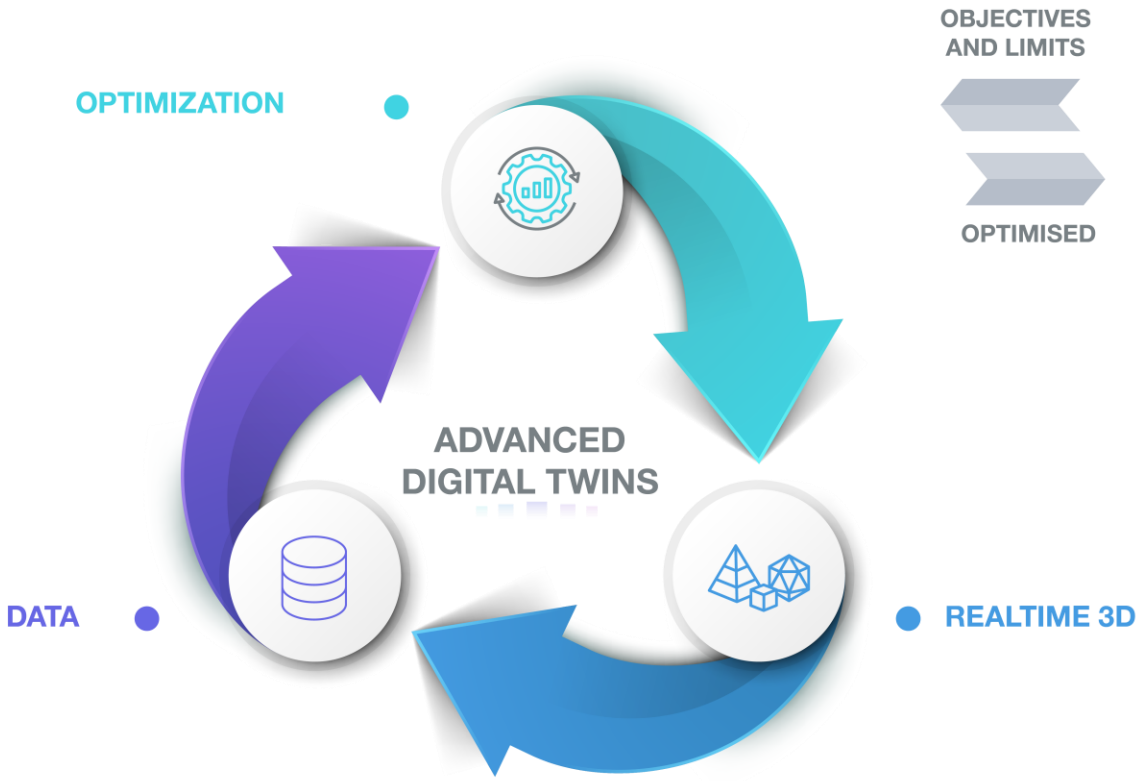
Funded by
the European Union

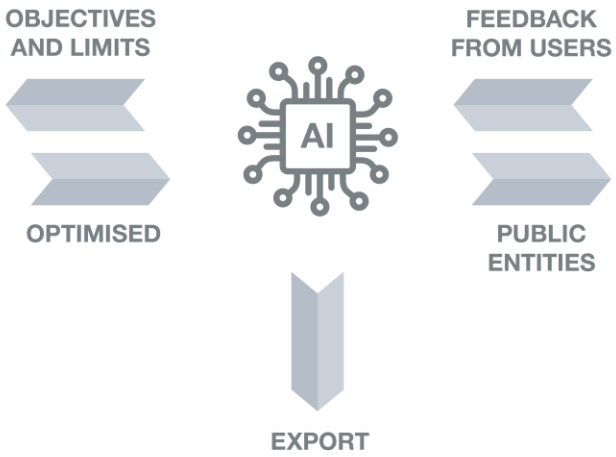
APPROACHES TO ADDRESS ETHICAL ISSUES WITH THE USE OF IMMERSIVE TECHNOLOGIES

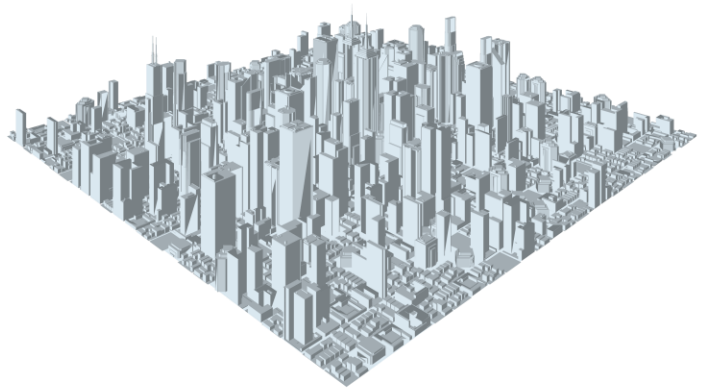


Funded by the European Union

EMERGING INTEROPERABILITY ISSUES





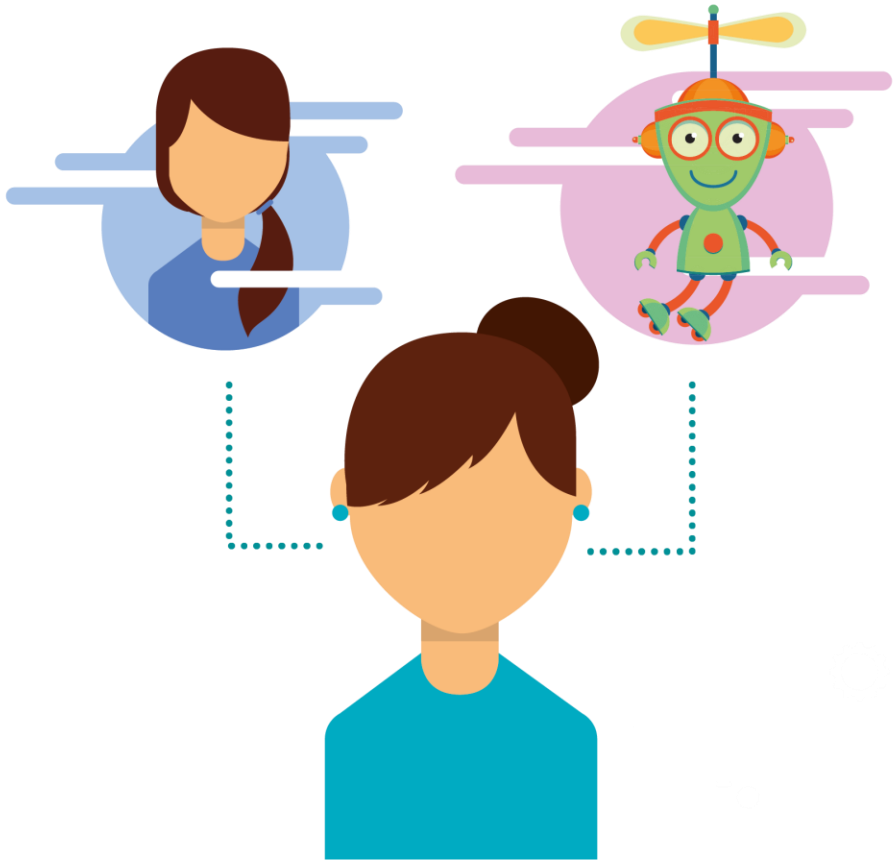


FROM REALTIME DATA TO
AI POWERED OPTIMIZED
URBAN PLANNING

Funded by
the European Union

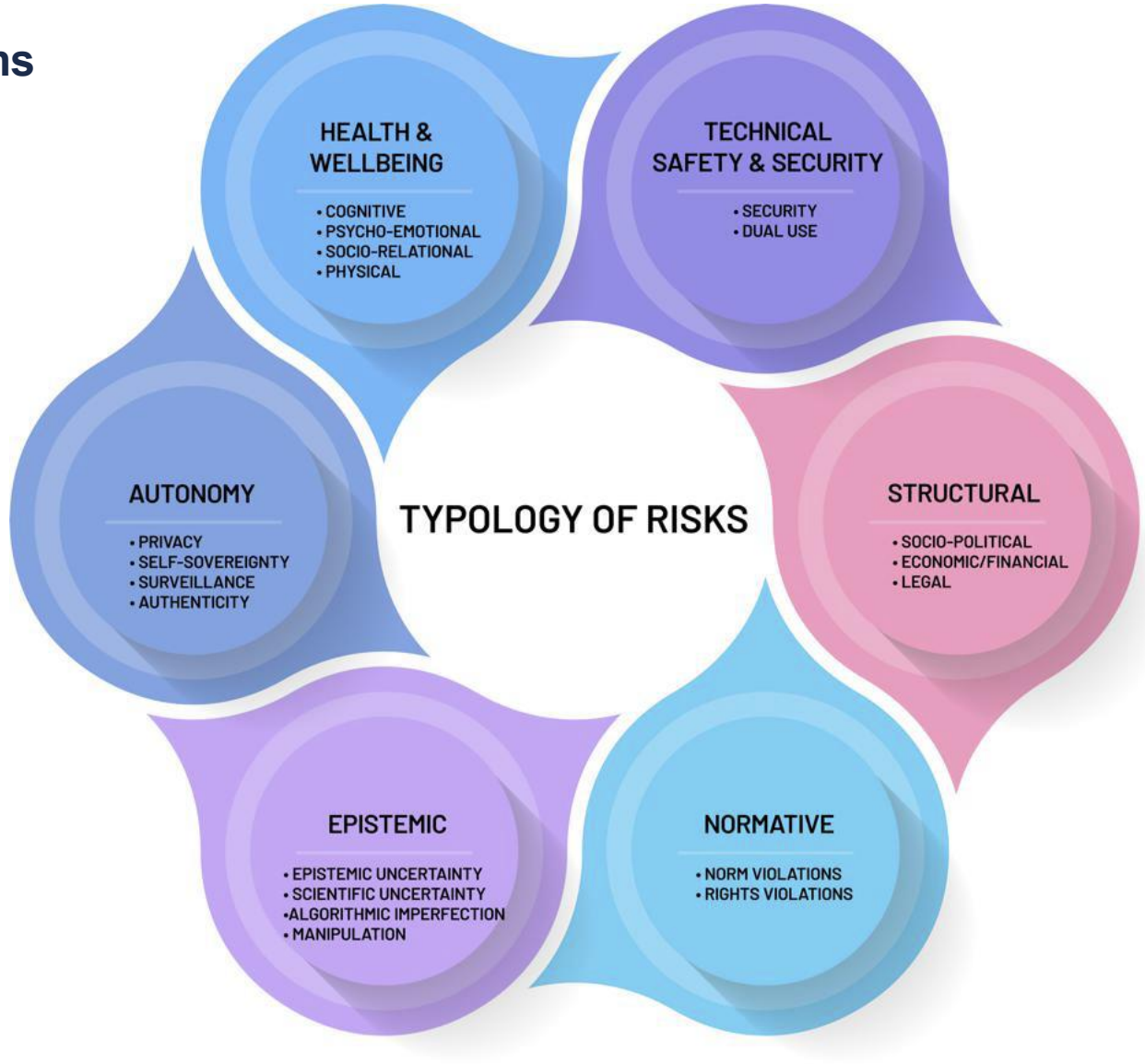
EMERGING INTEROPERABILITY ISSUES

IDENTITY & TRANSFER OF ASSETS



Funded by
the European Union

Mapping of risks and harms of XR
Typology of risks and corresponding harms



Funded by the European Union

Regulatory gab analysis Topics

- **Privacy and Data**
- **Intellectual property**
- **Consumer and Competition law**
- **Media and online services**
- **Cyber Security**
- **Accessibility and non Discrimination**
- **Artificial Intelligence Act**
- **Health law and finance law**

Funded by
the European Union

Regulatory gap analysis GDPR and XR challenges

- XR devices can collect biometric and sensitive data (e.g., iris scans, gait, eye movement) which may reveal ethnicity, beliefs, or health.
- Developers must prove their devices don’t and can’t collect such data, though this is difficult with standard XR tech.
- GDPR allows processing of special data under specific conditions (e.g., consent, vital interest, legal claims, public data).
- Consent is often bundled in XR terms, but its validity under GDPR's data minimization principle can be disputed.
- Most XR apps shouldn't gather sensitive data intentionally, but unintentional collection is still a risk.

Funded by the European Union

Regulatory gap analysis AI Act and applicability to XR

- XR apps using AI (e.g. object/gesture recognition, spatial mapping) may fall under the EU AI Act
- Risk-based approach could label some XR uses (e.g. real-time biometric ID) as “unacceptable”
- XR providers must ensure transparency, safety, and accountability
- Deep learning models pose explainability challenges
- Complex risk categories may confuse developers and slow innovation
- Compliance may burden SMEs but could position EU XR as ethical and trustworthy globally

Funded by the European Union

Workshop

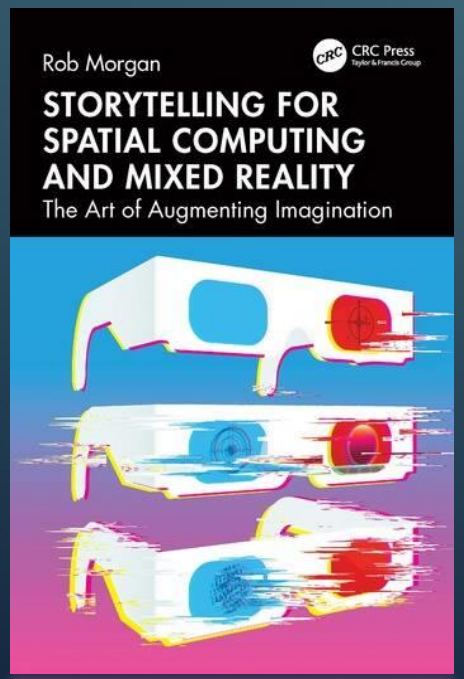
PLEASE SCAN AND SIGN UP FOR MURAL

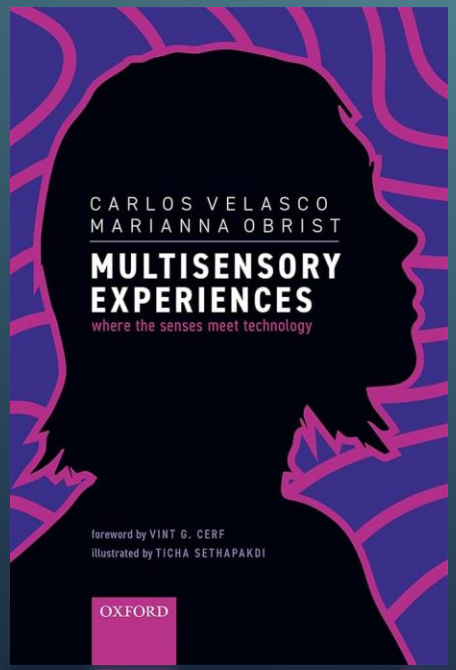
XR4 HUMAN

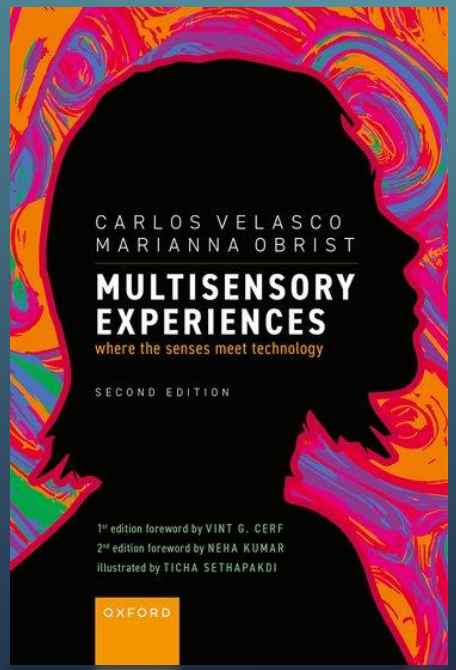
Scan to access draft Code of Conduct and provide your feedback

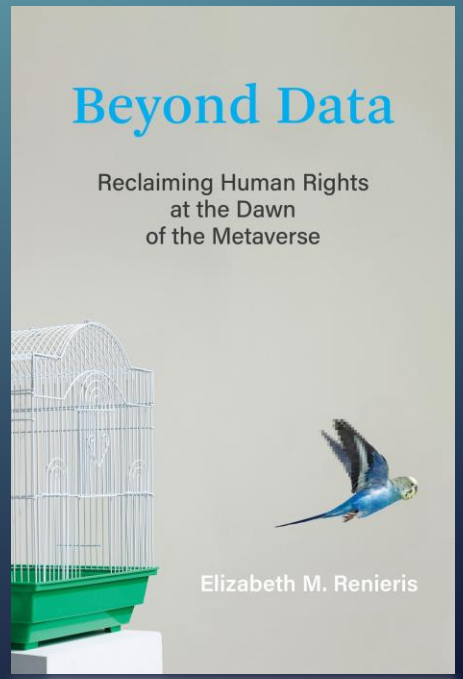
Funded by the European Union

LITERATURE RECOMMENDATION









OPEN AR CLOUD EUROPE

Submit your poster to national XRDAY
Rotterdam July 2nd deadline **Sunday**

Reach out
communicaton@openarcloud.org

Or connect via Social.

OPEN AR CLOUD EUROPE

THANK YOU!

OPEN AR CLOUD EUROPE

QUESTIONS?

OPEN AR CLOUD EUROPE