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Augmented Reality Framework (ARF); Interoperability Requirements for AR components, systems and services; Part 4: World Analysis, World Storage and Scene Management functions

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Foreword

The present document is part 4 of a multi-part deliverable covering Interoperability Requirements for AR components, systems and services, as identified below:

Part 1: "Overview";

Part 2: "World Storage and AR Authoring functions";

Part 3: "World Capture, World Analysis and Scene Management";

Part 4: "World Analysis, World Storage and Scene Management functions";

Part 5: "External Communications".

The ISG ARF shares the following understanding for Augmented Reality: Augmented Reality (AR) is the ability to mix in real-time spatially-registered digital content with the real world.

Modal verbs terminology

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

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1 Scope

The present document specifies the high level Reference Point requirements between the World Analysis, the World Storage and the Scene Management functions as they are identified in ETSI GS ARF 003 [1]. It further defines the requirements of the Reference Points "Pose" (AR8), "3D Map" (AR10) and "Relocalization Information" (AR11).

2 References

2.1 Normative 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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

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The following referenced documents are necessary for the application of the present document.

[1] ETSI GS ARF 003 (V1.1.1): "Augmented Reality Framework (ARF) AR framework architecture".

[2] ETSI GS ARF 004-2 (V1.1.1): "Augmented Reality Framework (ARF) Interoperability Requirements for AR components, systems and services Part 2: World Storage and AR Authoring functions".

2.2 Informative references

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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.

Not applicable.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

AR Asset: any kind of content positioned and oriented in the real world to alter the user's experience

feature: characteristics of a real world element that can be searched, recognized or tracked

NOTE: Features can be of different nature without being limited to visual patterns, UWB, Wi-Fi®, infrared or sounds.

GeoTrackable: position and orientation on earth in a geodetic referential

Reference Point: point located at the interface of two non-overlapping functions and representing interrelated interactions between those functions

Trackable: element of the real world of which features are available and/or could be extracted

NOTE: Features can be made available from an analysis of the element itself (fiducial markers, natural images, 3D point cloud) or processed from a representation of the element (3D CAD model).

World Anchor: fixed position in relation to one or more elements of the real world

NOTE 1: A World Anchor has a Coordinate Reference System in which AR Assets stay spatially-registered.

NOTE 2: More than one World Anchor can be attached to a Trackable.

NOTE 3: As the AR system updates its knowledge of the environment, the World Anchor's pose adapts to the real world preventing the associated AR Asset attached to the World Anchor from drifting.

World Graph: graph of Trackables and World Anchors representing the real world knowledge in the World Representation sub-function

3.2 Symbols

Void.

3.3 Abbreviations

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

AR	Augmented Reality
GNSS	Global Navigation Satellite System
LiDAR	Light Detection And Ranging
SM	Scene Management
UUID	Universally Unique IDentifier
WA	World Analysis
Wi-Fi®	Wireless Fidelity
WS	World Storage

4 Interoperability requirements for AR8 and AR11

4.1 AR8 and AR11 Reference Points scope

AR8 "Pose" and AR11 "Relocalization Information", as specified in ETSI GS ARF 003 [1], define a subset of the dialog structure between the AR Scene Management (SM), the World Analysis (WA), and the World Storage (WS) functions. The SM function needs the poses of the AR device and/or of one or more World Anchors to update its AR scene representation at runtime. These poses are estimated by the WA function which will require relocalization information extracted from the World Graph stored in the WS function.

4.2 Pose

A pose defines the position and orientation in six degrees of freedom in the world of either an AR device in relation to a World Anchor or a Trackable (AR device pose), or conversely a Trackable or World Anchor in relation to the AR device (object pose).

RQ-AR8-001 The WA function shall provide the SM function with a pose of either an AR device in relation to a World Anchor or a Trackable, or conversely a Trackable or World Anchor in relation to the AR device.

NOTE: The pose can be estimated from data captured by various sensors (e.g. cameras, depth sensors, LiDAR, GNSS, accelerometers, or Wi-Fi®).The World Anchors and Trackables are referenced in the Scene Graph of the application by their UUID defined during the World Graph authoring.

RQ-AR8-002 The WA function shall provide the SM function with a pose defined either in a geodetic or Cartesian reference frame. In case of a geodetic reference frame, the geodetic system shall be specified.

NOTE: In case where poses are defined in different reference frames, a conversion of these poses in a common reference frame will be required.

RQ-AR8-003 The WA function shall provide the SM function with a time stamp for the specific captures used to estimate the pose.

NOTE: The pose estimation can require complex computation. This means that the time between the capture of the data used to estimate the pose and the moment when the SM function receives the corresponding pose, a non-negligible time may have elapsed. Providing the SM function with a time stamp corresponding to the time of the captures used to estimate the pose can be useful for example to notify the end-user of the latency, to limit the perceptive effect of this latency with pose prediction, or to fuse poses estimated by different sensors.

RQ-AR8-004 The SM function shall have the ability to request the pose for one or several World Anchors or Trackables from the WA function.

NOTE: A scene graph may include several references to World Anchors or Trackables requiring to request several poses. In that case, a policy for deriving the final pose from these several poses will be required.

RQ-AR8-005 The WA function shall have the ability to send a notification to the SM function in case of a pose estimation failure.

NOTE: For different reasons (e.g. textureless environment, overexposure of captured images, or no GNSS signal) the WA function may fail to estimate a pose. In that case, it could be relevant for the SM function to be informed of this failure for example to inform the end-user or to limit the perceptive effect of this failure with pose prediction mechanisms.

RQ-AR8-006 The WA function should allow the SM function to specify a minimum frame rate for pose estimation.

NOTE: Some AR use cases require to estimate the pose at a high frame rate (e.g. surgery or precision actions). Thus, this requirement allows the WA function to be configured to provide a pose at the requested frame rate if it can do so.

RQ-AR8-007 The WA function shall provide the pose at the minimum frame rate requested by the SM function, or shall notify the SM function if the requested minimum frame rate cannot be supported.

NOTE: Notifying the SM function if the requested pose estimation frame rate cannot be supported is mainly relevant if this frame rate is mandatory for specific use cases (e.g. surgery or precision actions).

RQ-AR8-008 The WA function should provide the SM function with a score corresponding to the confidence of the pose estimation.

NOTE: Many use cases require high accuracy 3D registration. By informing about the confidence concerning the accuracy of the pose estimated by the WA function, the SM function could inform in real-time the end-user who can act accordingly.

RQ-AR8-009 The WA function shall provide the SM function with information about its capabilities (e.g. frame rate, latency, accuracy or Trackable types supported for the pose estimation).

NOTE: The SM function can embed adaptation capabilities depending on the capabilities of the WA functions it accesses. Being informed of the capabilities of the accessible WA functions can thus be essential in order to adapt and offer the best service to end-users.

RQ-AR8-010 When access control is required by the WA function, the SM function shall provide the WA function with identification information to manage access rights.

NOTE: The relocalization information related to some Trackables or World Anchors may have restricted access for confidentiality purposes. In the same way, some features of the WA function could have restricted access. In these cases, it is essential to pass some user identification information to the WA function to let it decide if it returns the requested poses.

4.3 Relocalization Information

Relocalization information is the data required by the AR Device Relocalization or the Object Relocalization subfunctions of the WA function to estimate the AR device pose or object poses. This data can be extracted from World Graph handled by the WS function. If Trackables are used as references to estimate either object and/or AR device poses, the information consists of features extracted from these Trackables. If World Anchors are used as references to estimate either object and/or AR device poses, 3D transforms between the Trackables and the World Anchors are also required (in addition to the features).

NOTE: This Relocalization Information may be used by other subfunctions of the WA function, such as the mapping subfunction to initialize the map, or by the tracking subfunctions.

RQ-AR11-001 The WA function shall have the ability to request relocalization information from the WS function for estimating the pose of World Anchors or Trackables.

NOTE: In case the WA function receives a request to estimate one or several poses from one or several Trackables or World Anchors from the SM function, it will request the relocalization information for these requested Trackables and World Anchors from the WS function.

RQ-AR11-002 The WS function shall have the ability to provide the WA function with the relocalization information (if available in the world representation stored by the WS function) required to estimate the pose of either an AR device in relation to any World Anchors or Trackables, or converserly any Trackables or World Anchors in relation to an AR device.

NOTE: When receiving a request for relocalization information for given Trackables or World Anchors from the WA function, the WS function will analyse its World Graph. The WS function could find all Trackables handling the relocalization information required to estimate the pose related to the requested Trackables or World Anchors. For requests related to World Anchors, the WS function will find the Trackables connected to them, and will include the 3D transform between the requested World Anchors and the found Trackables in the relocalization information.

RQ-AR11-003 The WA function shall have the ability to request relocalization information compatible with the capabilities of the WA function from the WS function (e.g. Trackable types as well as encoding information and versions supported by the WA function).

NOTE: The WA function may not support all types, encodings, or versions of Trackables. In such cases, the WA function can request only the relocalization information related to Trackables it can support. This will avoid to transmit irrelevant information between the WS function and the WA function.

RQ-AR11-004 The WS function should provide the WA function with a score corresponding to the confidence of the relocalization information to estimate the pose.

NOTE: Some kind of Trackables can provide a more accurate pose estimation than others. Thus, a confidence score related to the relocalization information returned by the WS function can be taken into account by the WA function when returning back the confidence score of the estimated pose to the SM function.

RQ-AR11-005 When access control is required by the WS function, the WA function shall provide the WS function with identification information to manage access rights.

NOTE: The relocalization information related to some Trackables or World Anchors may have restricted access for confidentiality purposes. In these cases, it is essential to pass some user identification information to the WS function to let it decide if it could provide back the requested relocalization information for some Trackables or World Anchors.

5 Interoperability requirements for AR10

5.1 AR10 Reference Points scope

AR10 "3D Map" as specified in ETSI GS ARF 003 [1], called "World Representation Update" in the present document (as it can address any kind of Trackable types and not only map Trackables), defines part of the dialog structure between the World Analysis and the World Storage functions. The World Analysis function, through for example its 3D mapping subfunction, can create Trackables or update them when real world changed over time. This update can be sent to the World Storage function in order to keep up-to-date the World Graph it stores.

5.2 World Representation Update

A World Representation Update (referenced as the AR10 "3D Map" Reference Point in Figure 2 of the AR framework architecture [1]) consists of data used to create or update Trackables stored in the World Graph hosted by the World Storage function when elements of the real world recognized by the World Analysis function are appearing or changing over time.

RQ-AR10-001 The WA function should have the ability to provide the WS function with a new Trackable if the WA function detects a new Trackable not handled by WS function.

NOTE: The AR Authoring function can create and update a World Graph stored by the WS function. But the WA function can have the capability to detect or create at runtime new Trackables that was not added to the World Graph by the AR Authoring function (e.g. a fiducial or image Trackable, a map Trackable, or a Radio Trackable).

RQ-AR10-002 The WA function should have the ability to provide the WS function with updates of a Trackable if the WA function detects that one or more features of this Trackable have changed.

NOTE: The AR Authoring function can create an initial World Graph stored by the WS function. Additionally, the WA function can have the capability to update at runtime Trackables that already exist in the World Graph stored by the WS function (e.g. the pose of a Trackable or a map Trackable if the real world changes over time).

RQ-AR10-003 The WA function should have the ability to provide the WS function with information about the author of the creation or the update of a Trackable.

NOTE: When a Trackable is created or updated by the WA function, it can be relevant to trace who has modified the World Graph stored by the WS function. Thus, the WA function can inform the WS function about the author of the Trackable creation or update.

RQ-AR10-004 The WA function shall provide the WS function with the time stamp corresponding to the detection of a new Trackable or the detection of updates of an existing Trackable.

NOTE: When a Trackable is created or updated by the WA function, it can be relevant to trace the time when this modification or creation was applied to the World Graph stored by the WS function. This temporal information can be useful when merging several Trackable updates in the World Graph provided by different WA functions according to their age.

RQ-AR10-005 The WA function may provide the WS function with a score corresponding to the confidence about the features of a detected Trackable.

NOTE: When a Trackable is created or updated by the WA function, it can be relevant to provide the WS function with a score estimated by the WA function corresponding to the confidence about the detected features (e.g. based on outliers ratio, or a reprojection error). Thus, when this Trackable will be used by another WA function, this confidence score on the features can be used to compute the confidence score of the pose estimated by the WA function and returned to the SM function.

RQ-AR10-006 When access control is required by the WS function, the WA function shall provide the WS function with identification information to manage access rights.

NOTE: The WS function may have restricted access on the update or creation of Trackables for security purposes. For example, only authorized users may have the ability to modify the World Graph stored by the WS function. In these cases, it is essential to pass some user identification information to the WS function to let it decide if it accepts the update or the creation of Trackables.

Annex A (informative): Pose estimation overview

Augmented reality registers AR assets in 3D with the real world in real-time. To achieve this, the augmented reality system estimates the 3D transform of the AR device in relation to the AR assets, or conversely the 3D transforms of the AR assets in relation to the AR device. As shown in Figure A.1, these 3D transforms can be decomposed in the following way (the capital letter "T" represents the necessary transforms done by the involved functions):

- The 3D transform of the AR assets in relation to a World Anchor (defined by the AR Scene Graph).
- The 3D transform of the World Anchor in relation to one or several Trackables (defined by the World Graph [2]).
- The pose (position and orientation) of the Trackable in relation to the AR device or conversely the pose of the AR device in relation to the Trackables (estimated by the World Analysis function).

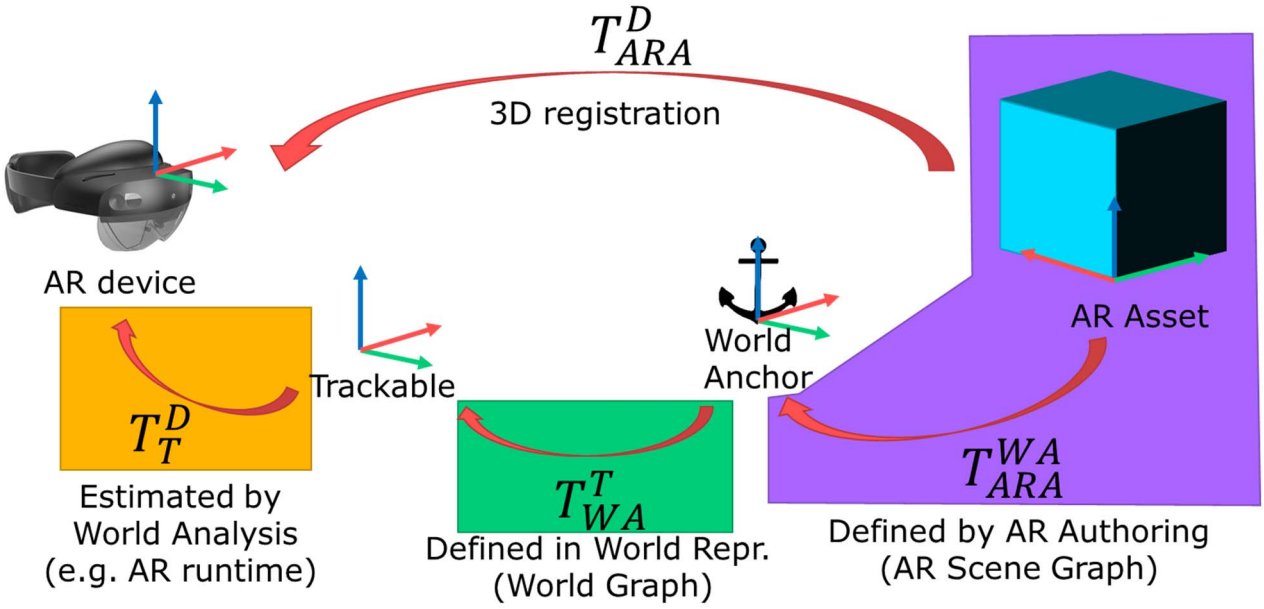

Figure A.1: Decomposition of the 3D transform between an AR Device and an AR asset

The 3D transforms between World Anchors and Trackables are stored in the World Graph hosted by the World Storage Function. Figure A.2 shows a simple World Graph representing the spatial structure of Trackables and World Anchors for a Museum use case. Here, two Trackables of type Marker are positioned on both sides of the pedestal of the statue. One or both of these Trackables can be tracked by vision sensors embedded in an AR device, and their poses in relation to the AR device, or conversely the pose of the AR device in relation to the Trackables can be estimated by the World Analysis function. Since the World Graph links Trackables and World Anchors with associated 3D transforms, the useful Trackables to estimate the pose of an AR device in relation to any World Anchors (or conversely the pose of any World Anchors in relation to an AR device) as well as the 3D transforms between useful Trackables and corresponding World Anchors can be provided to the World Analysis function. More examples of World Graphs are available in ETSI GS ARF 004-2 [2] specifying requirements for AR components, systems and services.

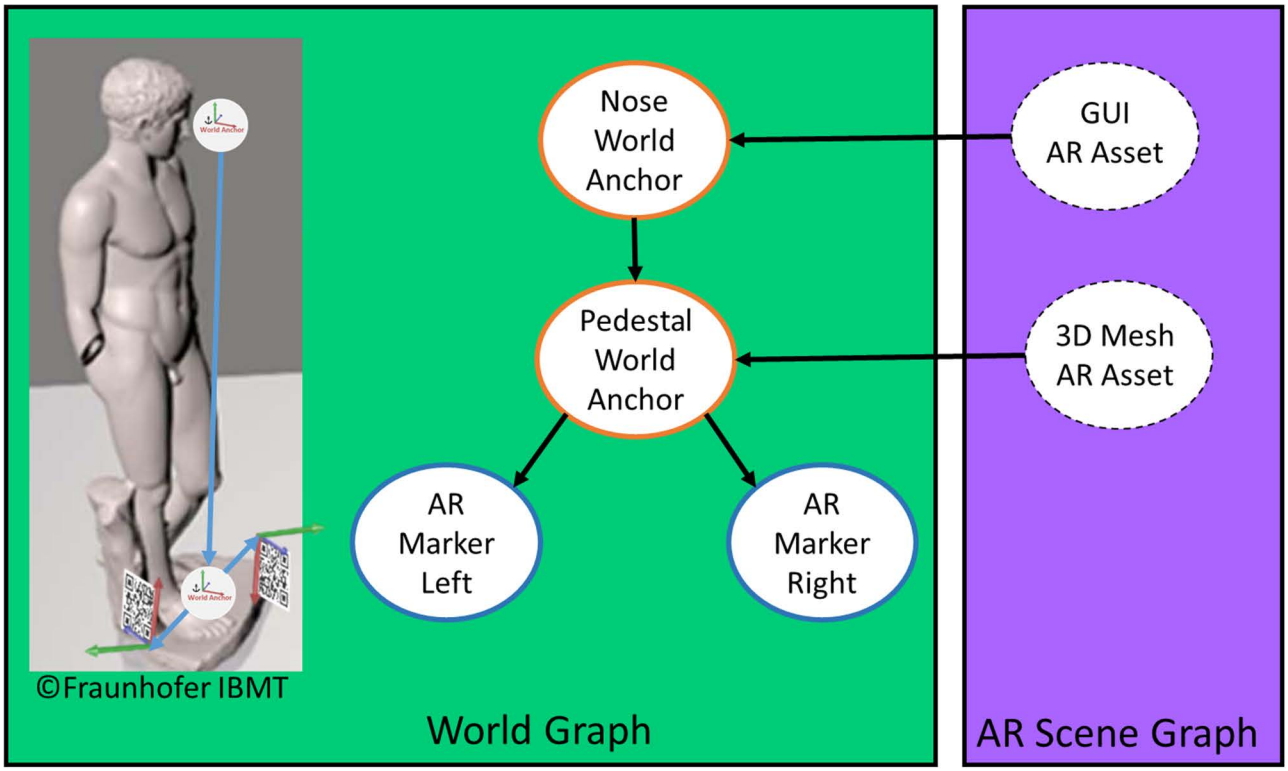

Figure A.2: Simple World Graph for a Museum use case

Figure A.3 shows the data flow required at runtime to estimate the pose of an AR device in relation to one or several AR assets, or controverely, the pose of AR assets in relation to an AR device:

1) The Scene Management function loads an AR scene including one or several World Anchor or Trackable references to which AR assets are attached.

2) The scene management requests the pose of the AR device in relation to a set of World Anchors or Trackables from the World Analysis function, and conversely the poses of a set of World Anchors or Trackables in relation to the AR device.

3) Due to the previous request, the World Analysis function requests the relocalization information required to estimate the poses of the World Anchors and the Trackables from the World Storage function.

4) The World Storage function answers the request by sending back the relocalization information needed to estimate the pose of the World Anchors and Trackables. The relocalization information being provided by the Trackables, the relocalization information required to estimate the pose in relation to a World Anchor consists of the Trackables linked to these World Anchor in the World Graph stored by the World Storage function, associated with the 3D transform between the World Anchor and the linked Trackables.

5) The World Analysis function receives sensor data from the World Capture function.

6) Knowing the relocalization information for each requested Trackable and World Anchor, the World Analysis function can continuously estimate the poses from the sensor data and return them to the Scene Management function.

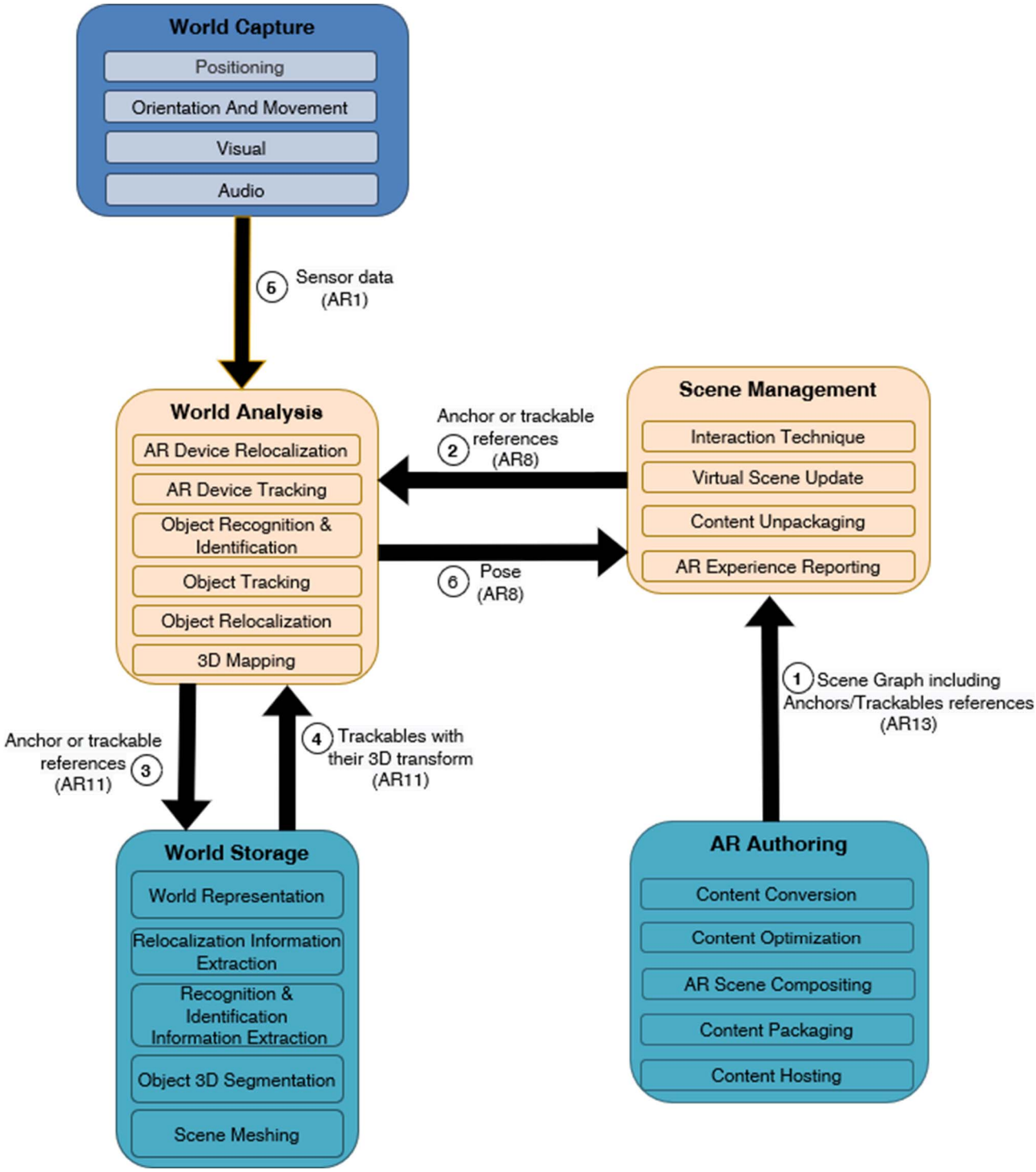

Figure A.3: Data flow at runtime to estimate the pose of an AR device in relation to one or several AR assets, or conversely, the pose of AR assets in relation to an AR device

History

Document history		
V1.1.1	January 2023	Publication