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OGC Augmented Reality Markup Language 2.0 (ARML 2.0)

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i. Abstract

This OGC™ Standard defines the Augmented Reality Markup Language 2.0 (ARML 2.0). ARML 2.0 allows users to describe virtual objects in an Augmented Reality (AR) scene, their appearances and their anchors (a broader concept of a *location*) in the real world. Additionally, ARML 2.0 defines ECMAScript bindings to dynamically modify the AR scene based on user behavior and user input.

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc ar augmented reality virtual objects arml virtual reality mixed reality 3d graphics model

iii. Preface

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium Inc. as a Request For Adoption:

a) Wikitude GmbH.
b) Georgia Tech
c) University of Alabama Huntsville - Information Technology & Systems Center
d) CACI International Inc.

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Contents

1 Scope

ARML 2.0 provides an interchange encoding for Augmented Reality (AR) applications to describe an AR scene, with a focus on vision-based AR (as opposed to AR relying on audio etc.). The encoding describes the virtual objects that are placed into an AR environment, as well as their registration in the real world. ARML 2.0 specifies an XML grammar.
Additionally, ARML 2.0 provides ECMAScript bindings to allow both dynamic modifications of the scene as well as interaction with the user. The ECMAScript bindings use the same core object models as the XML grammar and include event handling and animations.

The goal of ARML 2.0 is to provide an extensible standard and framework for AR applications. With AR, many different standards and computational areas developed in different domains come together. Therefore, ARML 2.0 needs to be flexible enough seamlessly integrate with other non-OGC standards, thus creating an AR-specific standard with connecting points to other widely used and AR-relevant standards.

A device running an AR implementation and supporting ARML 2.0 *must* have a component (screen, see-through display etc.) where the virtual objects are projected onto. The device *must* have sensors that provide real world observations. To fully support ARML 2.0, the following sensors are required:

For geospatial AR:

- Location Sensors (GPS or any alternative localization sensors)
- Direction Sensor (such as a magnetometer)
- Orientation Sensors (such as accelerometer or gyroscope)

For computer vision AR:

- Camera

Other types of sensors might be required for alternative tracking solutions, such as microphones, thermometers etc., see section 7.5.1.2 for details.

Users interact with the virtual scene by moving around in the real world. The movement of the user is tracked with onboard device sensors, the ARML 2.0 implementation is provided with the data delivered by the sensors. Based on the sensed data (representing the movement of the user), the scene on the screen is constantly updated. A user can also interact with the scene by selecting virtual objects, typically by touching them on the screen. However, how a user selects a virtual object is application and device-specific and out of scope for ARML 2.0.

The plan is to extend ARML in the future to also support non-visual virtual objects, such as sound and haptic feedback. The current specification of ARML 2.0, however, focusses on visual objects.

2 Normative References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

XML Schema Part 1: Structures Second Edition. W3C Recommendation (28 October 2004)
http://www.w3.org/TR/xmlschema-1/

ECMAScript Language Specification
http://www.ecma-international.org/ecma-262/5.1/ECMA-262.pdf

Web IDL Specification
http://www.w3.org/TR/WebIDL/

CSS Specification
http://www.w3.org/TR/CSS/

GML Specification
http://www.opengeospatial.org/standards/gml

COLLADA Specification
http://www.khronos.org/collada/

XML Path Language (XPath) 2.0
http://www.w3.org/TR/xpath20/

3 Terms and Definitions

Terms and definitions used in this document are reused form the AR Glossary developed by the International AR Standards Community *[AR Glossary]* where applicable. The glossary is a public document, and specific permission for usage was given by the community's chairperson.

The following definitions are used within the document:

An **(AR) Implementation** or **AR Application** is any service that provides *Augmentations* to an AR-ready device or system.

The **Device** is the hardware unit the *AR implementation* is running on.

An **Augmentation** is a relationship between the real world and a *digital asset*. The realization of an *augmentation* is a *composed scene*. An augmentation may be formalized through an authoring and publishing process where the relationship between real and virtual is defined and made discoverable.

A **Digital Asset** is data that is used to augment users' perception of reality and encompasses various kinds of digital content such as text, image, 3d models, video, audio and haptic surfaces. A digital asset is part of an *augmentation* and therefore is rendered in a *composed scene*. A digital asset can be scripted with behaviors. These scripts can be integral to the object (for example, a GIF animation) or separate code artifacts (for example, browser markup). A digital asset can have styling applied that changes its default appearance or presentation. **Visual Assets** are *digital assets* that are represented visually. As ARML in its current version focusses on visual representations of augmentations, only Visual Assets are allowed.

A **Composed Scene** is produced by a system of sensors, displays and interfaces that creates a perception of reality where *augmentations* are integrated into the real world. A composed scene in an augmented reality system is a manifestation of a real world environment and one or more rendered *digital assets*. It does not necessarily involve 3D objects or even visual rendering. The acquisition of the user (or device)'s current pose is required to align the composed scene to the user's perspective. Examples of composed scenes with visual rendering (AR in camera view) include a smartphone application that presents visualization through the handheld video display, or a webcam-based system where the real object and augmentation are displayed on a PC monitor.

The **Camera View** or **AR View** is the term used to describe the presentation of information to the user (the *augmentation*) as an overlay on the camera display.

4 Conventions

4.1 Abbreviated terms

ARML	Augmented Reality Markup Language
GML	Geography Markup Language
JSON	JavaScript Object Notation
CSS	Cascading Style Sheets
KML	Keyhole Markup Language
OGC	Open Geospatial Consortium
UML	Unified Modeling Language
XML	Extensible Markup Language
XSD	W3C XML Schema Definition Language

4.2 Schema language

The XML implementation specified in this Standard is described using the XML Schema language (XSD) [*XML Schema Part 1: Structures*].

4.3 Scripting Components

The Scripting components described are based on the ECMAScript language specification [ECMAScript Language Specification] and are defined using Web IDL [Web IDL Specification].

5 Introduction

Even though Augmented Reality has been researched for a couple of decades, no formal, agreed to definition of Augmented Reality exists. Below are two descriptions/definitions of Augmented Reality:

[Wikipedia AR Definition]: Augmented reality (AR) is a live, direct or indirect, view of a physical, real-world environment whose elements are *augmented* by computer-generated sensory input such as sound, video, graphics or GPS data. As a result, the technology functions by enhancing one's current perception of reality. AR is about augmenting the real world environment with virtual information by improving people's senses and skills. AR mixes virtual characters with the actual world.

[Ronald Azuma AR Definition]: Augmented Reality is a system that has the following three characteristics:

- Combines real and virtual
- Interactive in real time
- Registered in 3-D

5.1 History of ARML - ARML 1.0

ARML 2.0's predecessor ARML 1.0 [ARML 1.0 Specification] was developed in 2009 as a proprietary interchange format for the Wikitude World Browser. ARML 2.0 does not extend ARML 1.0, ARML 2.0 is a complete redesign of the encoding. ARML 1.0 documents are not expected to work with implementations based on ARML 2.0. ARML without a version number implicitly stands for ARML 2.0 in this document.

ARML 1.0 is a descriptive, XML based data encoding, specifically targeted for mobile Augmented Reality (AR) applications. ARML focuses on mapping geo-referenced Points of Interest (POIs) and their metadata, as well as mapping data for the POI content providers publishing the POIs to the AR application. ARML 1.0 was defined in late 2009 by the creators of the Wikitude World Browser to enable developers to create content for Augmented Reality Browsers. ARML 1.0 combines concepts and functionality typically shared by AR Browser, reuses concepts defined in OGC's KML standard and is already used by hundreds of AR content developers around the world.

ARML 1.0 is fairly restrictive and focuses on functionality Wikitude required back in 2009. Thus, ARML 2.0, while still using ideas coming from ARML 1.0, is targeted to be a complete redesign of the 1.0 format, taking the evolution of the AR industry, as well as other concepts and ideas into account.

6 Augmented Reality Markup Language (ARML) 2.0

6.1 Units

Units in ARML are given in meters. Whenever any virtual object in ARML has a size of x meters, the size of this object on the screen is equal to a real world object of the same size and the same distance in the camera view.
Remark: The actual size on the screen is dependent on certain camera parameters on the device.

6.2 Features, Anchors and VisualAssets

In ARML 2.0, a Feature represents a real world object that can be augmented. Using the Ferris Wheel example (below), the Feature to augment is the Ferris Wheel. A Feature consists of some metadata on the real world object, as well as one or more Augmentations that describe where a Feature is located in the composed scene. In ARML 2.0 terms, an Augmentation is called an Anchor.

Anchors define the link between the digital and the physical world (a broader concept of a *location*). An Anchor describes where a particular Feature is located in the real world. An Anchor can be either a spatial location that is tracked using location and motion sensors on the device, or a visual pattern (such as markers, QR codes or any sort of reference image) that can be detected and tracked in the camera stream using computer vision technology. In the Ferris Wheel example, the Anchor is the geospatial location of the Ferris Wheel in Vienna.

Finally, VisualAssets describe how a particular Anchor should be represented in the Composed Scene. VisualAssets can either be 2-dimensional (such as text or images) or 3-dimensional. The icon and the text in the example below represent VisualAssets that are attached to the Anchor of the Ferris Wheel, causing the Ferris Wheel to be augmented with the Visual Assets as soon as the Anchor is visible in the scene.

Examples:

Geospatial AR		
Feature		The physical object: The Riesenrad (Ferris Wheel) in Vienna, including Metadata
Anchor		Its location: 48.216581,16.395847
VisualAsset		The digital object that is used to represent the Feature in the scene.
Result		As soon as the location of the Ferris Wheel is detected to be in the field of vision (typically using GPS, motion sensors, magnetometers etc.), the VisualAsset is projected onto the corresponding position on the screen.

Computer Vision-based AR		
Feature	The security features of a 10-dollar-note	
Anchor		A US 10 Dollar-note (along with the location of the security features on the note).
VisualAsset		Some buttons that can be pressed to get more information on a particular security feature
Result		As soon as the 10 Dollar note is detected in the scene, the VisualAssets are projected onto the note in the correct positions.

6.3 Declarative and Scripting Specification

ARML 2.0 comes with a declarative specification describing the objects in the AR scene, as well as a scripting specification allowing dynamically modifying the scene and reacting on user-triggered events. This document describes the declarative specification first, followed by the ECMAScript bindings. The scripting spec uses ECMAScript for the scripting parts and the JSON serialization of the objects for accessing the objects' properties.

The scripting spec declares hooks to the descriptive spec, so both specs, while existing separately from another, work together for a dynamic experience. An implementation only supporting the declarative spec (for instance in case scripting parts cannot be implemented on the platform the implementation is running on) must clearly state this restriction and ignore any scripting components.

The scripting spec contains sections which are intended for advanced users only. These sections are clearly marked as *Advanced ARML* in the title and are intended for those already familiar with the basic concepts of ARML.

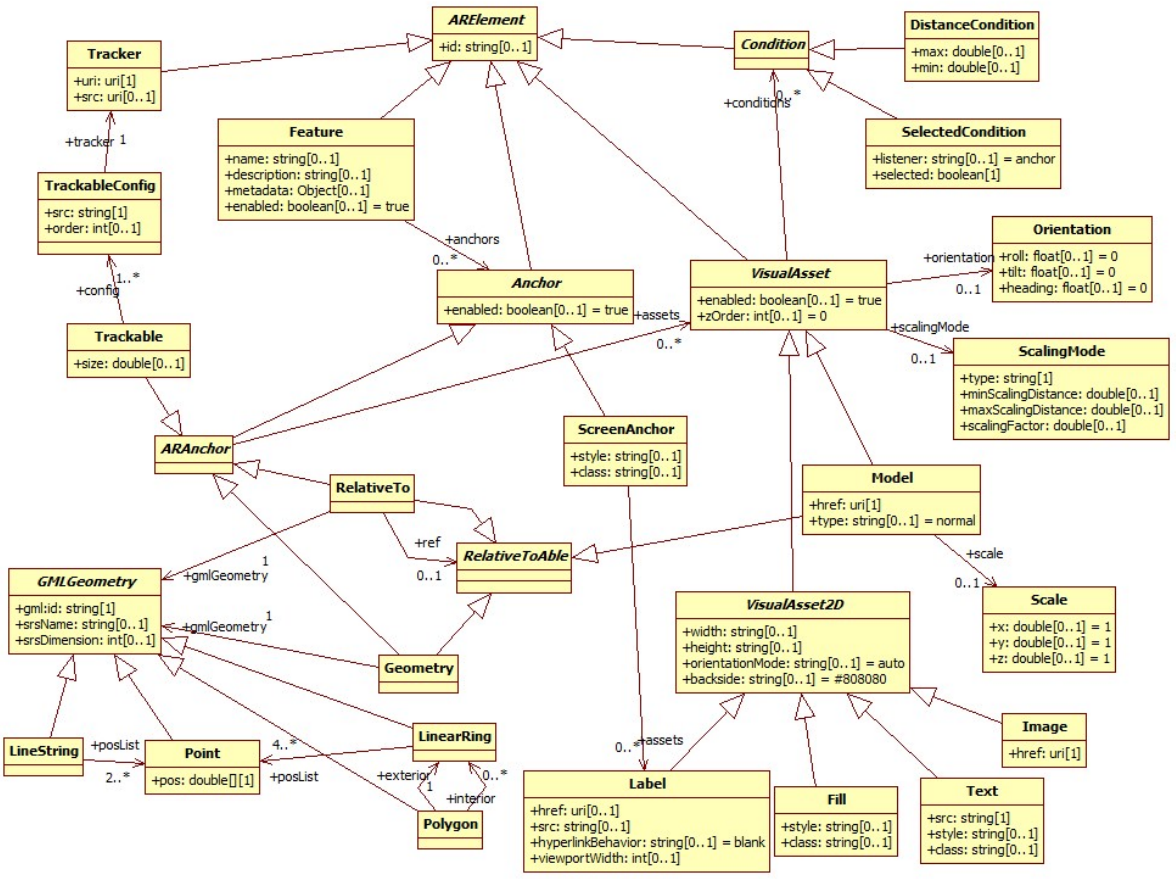
7 Object Model

ARML 2.0 is build based on a generic object model. The objects involved in ARML are specified and described in this chapter.

7.1 Object Model Representations

ARML 2.0 is based on a generic object model to allow serialization in different languages, as well as good extensibility for future needs.

The diagram below shows the generic object model in a UML diagram.



Section 7 of the document describes the descriptive elements of ARML 2.0. Throughout this section, an XSD translation of the UML model is introduced to define an XML serialization of the ARML 2.0 object model. The following XSD header, namespaces and imports are used in XSD snippets and XML examples:

```
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  targetNamespace="http://www.opengis.net/arml/2.0"
  xmlns="http://www.opengis.net/arml/2.0"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:gml=" http://www.opengis.net/gml/3.2"
  elementFormDefault="qualified"
  version="2.0">

  <!-- Xlink import -->
  <xsd:import namespace="http://www.w3.org/1999/xlink"
    schemaLocation="http://www.w3.org/1999/xlink.xsd" />
  <!-- GML import -->
  <xsd:import namespace="http://www.opengis.net/gml/3.2"
    schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd" />
```

Section 9 of the document describes the scripting part of ARML 2.0. Throughout this section, an WebIDL translation of the UML model is introduced to define ECMAScript bindings and a JSON serialization of the ARML 2.0 object model.

7.2 Document Structure

An ARML document is comprised of three parts: The declarative part (AR Elements), the styling part and the scripting part. The root element of the document is *<arml>*, which contains the following elements:

- The *ARElements* element contains a list of *ARElement* objects, as specified in the ARML specification below.
- An arbitrary number (0 or more) of *style* elements contain CSS styles used for styling the virtual objects in the scene. An optional *type*-attribute allows the specification of the style-mimetype (typically *text/css*), an optional *xlink:href* attribute loads a source from an external file. See CSS styling for details.
- An arbitrary number (0 or more) of *script* part contain scripting code (typically ECMAScript or JavaScript). An optional *type*-attribute allows the specification of the script-mimetype (typically *text/ecmascript* or *text/javascript*), an optional *xlink:href* attribute loads a source from an external file. The content of the script tags is executed after the ARElements have been created.
  Remark: Created means that the objects have been created in the memory and are accessible through scripting. It is not required that the objects' external resources have already been loaded etc.

XML Example (shortest possible ARML document):

```
<arml xmlns="http://opengis.net/arml/2.0">
  <ARElements>
  </ARElements>
</arml>
```

XML Example (with all namespaces loaded):

```
<arml xmlns="http://opengis.net/arml/2.0"
      xmlns:xlink="http://www.w3.org/1999/xlink"
      xmlns:gml="http://www.opengis.net/gml/3.2">
  <ARElements>
    <Feature id="myFeature">
      <name>My first Feature</name>
      <anchors>
        <gml:Point gml:id="myPoint">
          <gml:pos>48.123 13.456</gml:pos>
        </gml:Point>
      </anchors>
    </Feature>
  </ARElements>

  <style type="text/css">
    <![CDATA[
      ... CSS style definitions of any Visual Assets
    ]]>
  </style>

  <script type="text/ecmascript">  <!--might also be javascript and other
derivatives -->
    <![CDATA[
      ... ECMAScript goes here ...     ]]>
  </script>
```

```
  <script type="text/ecmascript" xlink:href="http://mySrc.com/script.js">
    <!—loaded from external resource-->
  </script>
</arml>
```

XSD:

```
<xsd:complexType name="ArmlType">
  <xsd:sequence>
    <xsd:element name="ARElements" maxOccurs="1" minOccurs="1">
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element ref="ARElement" minOccurs="0" maxOccurs="unbounded"
/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>
    <xsd:element name="style" maxOccurs="unbounded" minOccurs="0">
      <xsd:complexType>
        <xsd:simpleContent>
          <xsd:extension base="xsd:string">
            <xsd:attribute name="type" type="xsd:string" use="optional" />
            <xsd:attribute ref="xlink:href" use="optional" />
          </xsd:extension>
        </xsd:simpleContent>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="script" maxOccurs="unbounded" minOccurs="0">
      <xsd:complexType>
        <xsd:simpleContent>
          <xsd:extension base="xsd:string">
            <xsd:attribute name="type" type="xsd:string" use="optional" />
            <xsd:attribute ref="xlink:href" use="optional" />
          </xsd:extension>
        </xsd:simpleContent>
      </xsd:complexType>
    </xsd:element>
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="arml" type="ArmlType" />
```

7.3 interface ARElement

Most classes specified in ARML 2.0 are derived from *ARElement*. Only *ARElement*s are allowed as root nodes in the *ARElements* tag of the document. An *ARElement* has an optional *id* property which uniquely identifies the object. When set, the *id* must be unique in the document.

The id *user* is pre-assigned by the system and must not be used with objects. If *user* is used, the attribute must be ignored.

Properties:

Name	Description	Type	Multiplicity
id	The unique ID of the ARElement	string	0 or 1

id
The unique ID of the *ARElement* which makes it uniquely accessible and referenceable.

XSD:

```
<xsd:complexType name="ARElementType" abstract="true">
  <xsd:attribute name="id" type="xsd:ID" use="optional" />
</xsd:complexType>

<xsd:element name="ARElement" abstract="true" type="ARElementType" />
```

7.4 class Feature

Inherits From ARElement.

A *Feature* is an abstraction of a real world phenomenon *[GML Specification]*. In ARML, a Feature has one or more *Anchors*, which describe how the *Feature* is registered in the real world. Each of these *Anchors* have one or more *VisualAssets* attached to it, which visually represent the Feature('s Anchors) in the composed scene.

Example:

		The physical object: The Riesenrad (Ferris Wheel) in Vienna, including Metadata

Properties:

Name	Description	Type	Multiplicity
name	The name of the Feature	string	0 or 1
description	A description of the Feature	string	0 or 1
enabled	A boolean flag controlling the state of the Feature	boolean	0 or 1

Name	Description	Type	Multiplicity
metadata	Arbitrary metadata	Any XML	0or 1
anchors	A list of anchors the Feature is referenced with	Anchor[]	0 or 1

name
The optional name of the Feature. Can be reused in Label and Text VisualAssets by using $[name] in the Label or Text. Additionally, the name of the Feature is used as a Text-VisualAsset when an Anchor of the Feature has no VisualAsset attached to it. The property can be omitted.

description
The optional description of the Feature. Can be reused in Label and Text VisualAssets by using $[description] in the Label or Text.

metadata
Allows the storage of arbitrary metadata for the Feature. Any XML content can be used, the content may or may not conform with a custom scheme.

enabled
Setting the boolean flag to true (enabled) means that VisualAssets attached to the Anchors of the Feature are part of the composed scene, setting it to false (disabled) causes all Assets attached to the Feature to be ignored for the composed scene (i.e. they are never visible in the AR View). Defaults to true if not given.

anchors
contains a list of Anchors describing the Anchors of the Feature in the real world.
An Anchor can either be defined directly in the *anchors*-tag, or referenced using the *anchorRef* tag. Both ways can be mixed within one Feature, and a Feature can have an arbitrary number of Anchors. In an Anchor is referenced with *anchorRef*, the URI to the Anchor is specified in the xlink:href attribute.

XSD:

```
<xsd:complexType name="FeatureType">
  <xsd:complexContent>
    <xsd:extension base="ARElementType">
      <xsd:sequence>
        <xsd:element name="name" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="description" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="enabled" type="xsd:boolean" maxOccurs="1"
minOccurs="0" />
        <xsd:element processContents="lax" name="metadata" maxOccurs="1"
minOccurs="0">
          <xsd:complexType>
            <xsd:sequence>
              <xsd:any minOccurs="0" maxOccurs="unbounded"/>
            </xsd:sequence>
```

```
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="anchors" maxOccurs="1" minOccurs="0">
          <xsd:complexType>
            <xsd:sequence>
              <xsd:element ref="Anchor" minOccurs="0" maxOccurs="unbounded"
/>
              <xsd:element name="anchorRef" maxOccurs="unbounded"
minOccurs="0">
                <xsd:complexType>
                  <xsd:attribute ref="xlink:href" use="required" />
                </xsd:complexType>
              </xsd:element>
            </xsd:sequence>
          </xsd:complexType>
        </xsd:element>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Feature" type="FeatureType"
substitutionGroup="ARElement" />
```

XML Example:

```
<Feature id="ferrisWheel">
  <name>Ferris Wheel</name>
  <enabled>true</enabled>
  <metadata>
    <constructed>1896-1897</constructed>
    <height unit="meters">64,75</height>
  </metadata>
  <anchors>
    <!-- either defined directly in the tag -->
    <Geometry>
      ...
    </ Geometry>
    <!-- or referenced -->
    <anchorRef xlink:href="#myAnchor" />
  </anchors>
</Feature>
```

7.5 interface Anchor

Inherits From ARElement.

An *Anchor* describes the registration (location) of a *Feature* in the real world or on the screen. Two different types of Anchors are used in ARML:

- *ARAnchor* describes the location of a Feature in the real world. This Anchor is used for virtual objects that are registered in the real world and move around on the screen as the user moves around.

- *ScreenAnchor* describes a fixed location of a Feature on the screen. This Anchor is used for objects that have a fixed location on the screen (similar to HTML components inside a HTML page). The objects associated with a ScreenAnchor will not move when the user is moving around, but remains static on the screen. Typical use cases are game HUDs or static informational displays on certain Features.

Properties:

Name	Description	Type	Multiplicity
enabled	The state of the anchor	boolean	0 or 1

enabled
Setting the boolean flag to true (enabled) means that VisualAssets attached to the Anchor are part of the composed scene (if the Feature the Anchor is attached to is also enabled), setting it to false (disabled) causes all VisualAssets attached to the Anchor to be ignored in the composed scene (i.e. they are never visible in the AR View). Defaults to true if not given.

XSD:

```
<xsd:complexType name="AnchorType" abstract="true">
  <xsd:complexContent>
    <xsd:extension base="ARElementType">
      <xsd:sequence>
        <xsd:element name="enabled" type="xsd:boolean" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Anchor" type="AnchorType" abstract="true"
substitutionGroup="ARElement" />
```

Remark: Anchors are typically used within one or more Features, however, an Anchor can also exist outside a Feature. Regardless if the anchor is located within a Feature or was defined separately (immediately within the *ARElements* section), it is part of the composed scene.

7.5.1 interface ARAnchor

Inherits From Anchor.

An ARAnchor describes the registration (location) of a Feature in the real world. An ARAnchor might be declared using spatial coordinates, i.e. a *location* in a (geo-)spatial sense, or an image or marker that is recognized in the live camera video stream and even a sound that is recognized over the microphone.

ARAnchor is an abstract class which must not be instantiated directly. We define the following concrete types of ARAnchors in ARML:

Geometry		Either a Point, LineString or Polygon, described with spatial coordinate tuples
Trackable		A visual pattern that is detected in the camera stream
RelativeTo		An Anchor relative to other objects (e.g. another ARAnchor); useful to create large scenes relative to another Trackable

Properties:

Name	Description	Type	Multiplicity
assets	The assets representing the anchor in the live scene	Asset[]	1

assets

A list of VisualAssets attached to the ARAnchor. These VisualAssets will represent the ARAnchor.
A VisualAsset can either be defined directly in the *assets*-tag, or referenced using the *assetRef* tag. Both ways can be mixed within one ARAnchor, and an ARAnchor can have an arbitrary number of VisualAssets.
In case VisualAssets are referenced with *assetRef*, the URI to the VisualAsset is specified in the xlink:href attribute.
If no VisualAsset is supplied, a *Text* VisualAsset, with its text set to the *name* of Feature the ARAnchor is attached to, is used as the default VisualAsset. In case even the *name* property is omitted for the Feature, no VisualAsset is attached as default.

XSD:

```
<xsd:complexType name="ARAnchorType" abstract="true">
  <xsd:complexContent>
    <xsd:extension base="AnchorType">
      <xsd:sequence>
        <xsd:element name="assets" maxOccurs="1" minOccurs="1">
```

```
          <xsd:complexType>
            <xsd:sequence>
              <xsd:element ref="VisualAsset" maxOccurs="unbounded"
minOccurs="0" />
              <xsd:element name="assetRef" maxOccurs="unbounded"
minOccurs="0">
                <xsd:complexType>
                  <xsd:attribute ref="xlink:href" use="required" />
                </xsd:complexType>
              </xsd:element>
            </xsd:sequence>
          </xsd:complexType>
        </xsd:element>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="ARAnchor" type="ARAnchorType" abstract="true"
substitutionGroup="Anchor" />
```

7.5.1.1 Local Coordinate System and Dimensions

Any ARAnchor type specifies its own local coordinate system, with LineStrings being the only exception. This allows VisualAssets to be placed on top of any ARAnchor (see section 7.6.2 for details), and RelativeTo Anchors created relative to an underlying ARAnchor. For each ARAnchor type, it is explicitly stated how the coordinate system is defined for this particular type of ARAnchor. Additionally, each ARAnchor has a dimension associated with it. As VisualAssets take on different dimensions (a Text is 2D, while a 3D model is 3D), it is important to define the dimension of an ARAnchor as well, to allow a high level definition of how an n-dimensional Visual Asset will be rendered on top of an m-dimensional ARAnchor, without having to specifically consider each ARAnchor and VisualAsset combination.

Wherever a concrete ARAnchor is defined, the dimension and coordinate system is defined as well, except for ARAnchors with a dimension of 1 (Lines). Due to their nature, these ARAnchors do not define a local coordinate system.

class Geometry

Inherits from ARAnchor.

A Geometry Anchor is used when a Feature is registered in the real world using spatial coordinates (such as geolocations). The Geometry Anchor serves as a wrapper for GMLGeometries which eventually describe the spatial location of the Feature. A Geometry Anchor contains all properties inherited from ARAnchor, as well as an additional element which describes the wrapped GMLGeometry and the spatial coordinates.

The following GMLGeometries are allowed in ARML 2.0 and are described below:

- gml:Point (a single position)
- gml:LineString (a list of positions, connected to form a line)
- gml:Polygon (a list of positions, connected to form a planar area)

Remark: Geometry anchors can only be considered if an implementation is capable of detecting the user's current position and is thus capable of calculating spatial relationships between the user and the Geometry anchors.

XSD:

```
<xsd:complexType name="GeometryType">
  <xsd:complexContent>
    <xsd:extension base="ARAnchorType">
      <xsd:choice>
        <xsd:element ref="gml:Point" />
        <xsd:element ref="gml:LineString" />
        <xsd:element ref="gml:Polygon" />
      </xsd:choice>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Geometry" type="GeometryType"
substitutionGroup="ARAnchor" />
```

Example:

```
<Feature id="myFeature">
  <anchors>
    <Geometry>
      <enabled>true</enabled>
      <assets>
        ...
      </assets>
      <gml:Point gml:id="point1">
        <gml:pos>1 2</gml:pos>
      </gml:Point>
    </Geometry>
  </anchors>
</Feature>
```

7.5.1.1.1 interface GMLGeometries

The GMLGeometries Point, LineString and Polygon are borrowed from the GML specification *[GML Specification]*. They all share the following elements:

Complying with the GML specification, each GMLGeometry must have a *gml:id* property.

The default coordinate reference system (CRS) for Geometries is WGS84 (EPSG code 4326; "longitude latitude"; decimal numbers; no altitude). Alternative CRSes can be specified using *srsName*, either by supplying the EPSG code *[EPSG Codes]*, or by pointing to an OGC WKT CRS definition. Implementations are required to at least support WGS84. If a certain CRS used in ARML is unknown to an implementation, the entire Geometry Anchor must be gracefully ignored.

If custom altitude values should be used, the CRSes dimension must be set to 3 (see *srsDimension*), and values must be provided in "longitude latitude altitude" format (altitude in meters). If no altitude is supplied, the altitude of every position will be set to the ground level of the devices current altitude minus 1.6 meters. This altitude estimates the altitude of the ground the user stands at, taking the height of an average human being.

GML Geometries also allow other attributes, such as axis labels etc., which are not relevant in the context of ARML and can thus be safely omitted.

Properties:

Name	Description	Type	Multiplicity
gml:id	A unique ID for the geometry	string	1
gml:srsName	The link to a well-known CRS or an EPSG code	string	0 or 1
gml:srsDimension	The dimension of the CRS specified	positiveInteger	0 or 1

gml:id
A unique ID, required as per the GML specification.

srsName
optionally specifies either a link to an OGC WKT CRS, or an EPSG code. If *srsName* is omitted, WGS84 is implicitly assumed to be the default CRS.

srsDimension
The optional attribute srsDimension specifies the number of coordinate values in a position (i.e. the dimension of the underlying CRS). srsDimension should be used when srsName is specified. If both srsName and srsDimension are not given, srsDimension defaults to 2.

7.5.1.1.2 class Point

Derived from [GML Specification].

A Point specifies a position in the referenced coordinate reference system by a single coordinate tuple.

Properties:

Name	Description	Type	Multiplicity
pos	The list of doubles, specifying the position of the Point	list of double values	1

pos
Specifies the coordinate vector describing the position of the Point, in a blank-separated list.

Remark: GML allows the specification of a custom *srsName* and *srsDimension* also on the *pos*-level, but states that it is unlikely that this will be used in a useful way. The same applies for ARML 2.0.

XSD:

See [GML Specification].

XML Example:

```
<gml:Point gml:id="myPointWithAltitudeOfUser">
  <gml:pos>
```

```
    47.48 13.14
  </gml:pos>
</gml:Point>

<gml:Point gml:id="myPointWithExplicitAltitude" srsDimension="3">
  <gml:pos>
    47.48 13.14 520
  </gml:pos>
</gml:Point>
```

7.5.1.1.3 class LineString

Derived from [GML Specification].

A LineString is defined by two or more coordinate tuples, with linear interpolation between them. The number of direct positions in the list shall be at least two. The segments created by interpolation between the coordinate tuples are called *LineString segments*.

Properties:

Name	Description	Type	Multiplicity
posList	The list of doubles, specifying the vector of positions of the LineString	list of double values	1
or			
pointProperty	A List of gml:Point elements that make up the LineString	List of gml:Point element	2 .. *

posList

Specifies the list coordinate vectors describing the vertices of the LineString, in a blank-separated list.

Remark: GML allows the specification of a custom *srsName* and *srsDimension* also on the *posList*-level, but states that it is unlikely that this will be used in a useful way. The same applies for ARML 2.0.

pointProperty

Specifies the list of Points describing the vertices of the LineString. Must appear at least twice.

XSD:

See [GML Specification].

XML Example:

```
<gml:LineString gml:id="myLineString">
  <gml:posList>
    47.48 13.14 48.49 14.15
  </gml:posList>
</gml:LineString>
```

7.5.1.1.4 class Polygon

Derived from [GML Specification].

A Polygon is a planar object defined by an outer boundary and 0 or more inner boundaries. The boundaries are specified using the *exterior* and *interior* elements. The boundaries, in turn, are defined by LinearRings.

A LinearRing is a closed LineString (with at least 4 coordinates) that should not cross itself. It is defined in the exact same way as a LineString, except the element tag is called *LinearRing*. Simplified, a LinearRing is a LineString where the last position equals the first position.
As a convention, the vertices of the Polygon (especially the vertices of the exterior LinearRing) should be specified in counter-clockwise direction to correctly define the VisualAssets's front face. See Orienting VisualAssets for details.

Properties:

Name	Description	Type	Multiplicity
exterior	A LinearRing forming the outer boundary of the Polygon	LinearRing	1
interior	A LinearRing forming a hole in the interior of the Polygon	LinearRing	0 .. *

exterior
A LinearRing forming the outer boundary of the Polygon

interior
A LinearRing forming a hole in the Polygon

XSD:

See [GML Specification].

XML Example:

```
<gml:Polygon gml:id="myPolygon">
  <gml:exterior>
    <gml:LinearRing>
      <gml:posList>
        47.48 13.14 48.49 14.15 48.49 14.13 47.48 13.14
       </gml:posList>
    </gml:LinearRing>
  </gml:exterior>
  <gml:interior>
    <gml:LinearRing>
      <gml:posList>
        48.00 14.00 48.01 14.01 48.01 13.99 48.00 14.00
       </gml:posList>
    </gml:LinearRing>
  </gml:interior>
  <gml:interior>
    <gml:LinearRing>
```

```
      ...
    </gml:LinearRing>
  </gml:interior>
</gml:Polygon>
```

7.5.1.1.5 Advanced ARML: Coordinate Reference System and Dimensions

Dimensions:

The dimensions of Geometries are defined as specified in GML (Point: 0, LineString : 1, Polygon: 2). The coordinate systems defined below are all of cartesian type (i.e. orthogonal axes).

Local Coordinate Systems:

Point
The ground plane is defined by the projected earth's surface at the specified Point. In case the Point is used relative to a 2-dimensional Trackable, the ground plane is formed by the Trackable's surface. The x and y axes run within the ground plane.
Origin: The point itself
x-axis: pointing east (or right, parallel to the Trackable's lower and upper edges, when used relative to a Trackable, see RelativeTo Anchor for details)
y-axis: pointing north (or towards the top edge, running parallel to the left and right edges of the Trackable when used relative to a Trackable)
z-axis: pointing up, perpendicular to earth's (or Trackable's) surface
Unit: Meters

LineString
Due to their nature, LineStrings do not define their own local coordinate system. Refer to section 7.6.2 for details how to map VisualAssets onto LineStrings. Consequently, LineStrings cannot be used as an originating Anchor for RelativeTo-Geometries (see section 7.5.1.3).

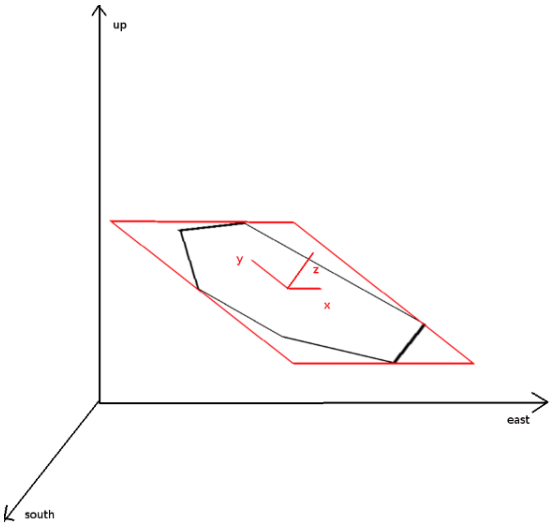
Polygon
A Polygon's local coordinate system is derived from the (uniquely defined) bounding rectangle (the smallest rectangle fully enclosing the Polygon) having two of the four edges parallel to the earth's surface (or Trackable's surface when used relative to a 2-dimensional Trackable, see RelativeTo Anchor for details).

To calculate the BoundingRectangle, take the lowest and highest point (with respect to altitude) of the Polygon and draw the two lines through these points in the polygon's plane, parallel to the earth's surface. Now, take the easternmost and westernmost point and draw the two lines through these points in the polygon's plane, perpendicular to the earth's surface. The resulting rectangle is the bounding rectangle of the Polygon.
If the Polygon is used relative to a Trackable, take the topmost, bottommost, rightmost and leftmost point relative to the Trackable, as well as the Trackable's surface for the ground plane instead.

This ensures that the bounding rectangle is aligned with the (earth's or Trackable's) surface. The bounding rectangle forms the ground plane of the coordinate system, x and y axis run within the ground plane.
Origin: The point marking the center of the bounding rectangle
x-axis runs parallel to the edges of the bounding rectangle which run parallel to the surface. When

the origin of the coordinate system is viewed from the center of the lower edge (the one edge parallel to the surface which is closer to the earth's or Trackable's surface) of the bounding rectangle, the x axis points right.
y-axis runs perpendicular to x and z axis, creating a right-handed coordinate system
z-axis is equal to the Polygon's normal vector
Unit: Meters

Illustration:



Special case:
In case the Polygon is placed parallel to the earth's (or Trackable's) surface (that means altitude is equal for each vertex), the bounding rectangle cannot be determined in the above definition. In this case, the bounding rectangle's edges are aligned with the vectors pointing north/south and east/west from the first vertex of the Polygon (or up/down and left/right when used relative to a Trackable), and the southern/down edge form the lower edge of the Bounding Rectangle (which is used to determine the x axis).

7.5.1.2 Trackable and Tracker

Trackables are a more general concept of a *location* of a Feature in the real world. Instead of specifying an exact, well known set of coordinates somewhere within a well-known coordinate reference system by using the geometry types specified in the previous section, a Trackable describes something that is tracked in the real world (typically by a camera) and serves as the Anchor of a Feature. As an example, a Trackable could be a 2D image, QR code or 3D model, however, Trackables are not restricted to visual objects, an application could also track Sounds coming in from the microphone. As Trackables are mostly visual in AR implementations, we will put a focus on those.

Two classes are required to specify a Trackable:

- *Trackable*: The Trackable describes the trigger (in whatever form) that should be tracked in the scene. A Trackable might be an artificial game marker, the reference image or reference 3D model, the description of a face, the referenced song etc.
- *Tracker:* A Trackable is always linked to one or more specific Trackers, which references the framework(s) that needs to be used to track the referenced Trackable. For instance, if the Trackable is a generic image, the Tracker needs to reference a generic image tracking

capability the implementation needs to be bundled with. If the implementation uses face tracking and the Trackable describes a specific face, the Tracker needs to reference an underlying face tracking functionality, which is exposed by the implementation.

7.5.1.2.1 class Tracker

Inherits From ARElement.

The Tracker describes the tracking framework to be used to track the Trackables associated with this Tracker.

A Tracker is uniquely and globally identified by a URI. It is not required that any meaningful content is accessible via the URI, however, a developer of a Tracker is encouraged to expose some descriptions about the Tracker when the URI is called from a standard web browser. A definition of the exposed content is beyond the scope of ARML 2.0.

Properties:

Name	Description	Type	Multiplicity
uri	The URI identifying the Tracker	string	1
src	The container the Tracker is operating in	string	0 or 1

uri

To reference the framework used to track the associated Trackables, a Tracker specifies a uri property that uniquely identifies the underlying tracking software. The URI might be registered in a Tracker dictionary that assigns a unique URI to any publicly used Tracker, so AR implementations using the standard can use this as a reference to what tracking framework should be used. The URI might also point to a custom tracker implementation that is used just within the specific implementation. If the URI cannot be resolved to any of the Trackers available on the implementation, the Tracker cannot be used and must be gracefully ignored along with any associated Trackables.
The uri to the tracker is specified in the xlink:href attribute.

src

Optionally specifies a URI which references the container the Tracker is operating in, and the associated Trackables can be found in. This mechanism allows a two-level location of the actual Trackable in case it is contained within a container. *src* must be set if the Trackable is not directly accessible via some sort of URI or any other identifier, but is located in any sort of container, such as a zip file or a proprietary binary container containing all targets.
The URI is specified in the xlink:href attribute.

XSD:

```
<xsd:complexType name="TrackerType">
  <xsd:complexContent>
    <xsd:extension base="ARElementType">
      <xsd:sequence>
        <xsd:element name="uri" maxOccurs="1" minOccurs="1">
```

```
          <xsd:complexType>
            <xsd:attribute ref="xlink:href" use="required" />
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="src" maxOccurs="1" minOccurs="0">
          <xsd:complexType>
            <xsd:attribute ref="xlink:href" use="required" />
          </xsd:complexType>
        </xsd:element>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Tracker" type="TrackerType"
substitutionGroup="ARElement" />
```

XML Example:

```
<!-- a generic image Tracker -->
<Tracker id="myGenericImageTracker">
  <uri
xlink:href="http://opengeospatial.org/arml/tracker/genericImageTracker" />
</Tracker>

<!-- a generic image Tracker operating on a set of image targets supplied
via a zip file -->
<Tracker id="myGenericImageTrackerWithZip">
  <uri
xlink:href="http://opengeospatial.org/arml/tracker/genericImageTracker" />
  <src xlink:href="http://www.myserver.com/myTargets/myTargets.zip" />
</Tracker>

<!-- a custom Tracker -->
<Tracker id="myCustomTracker">
  <uri xlink:href="http://www.myServer.com/myTracker" />
  <src xlink:href="http://www.myServer.com/myTrackables/binary.file" />
</Tracker>
```

The following generic tracker URI is defined for every implementation:

- http://opengeospatial.org/arml/tracker/genericImageTracker hosting a tracker which takes jpeg, png or gif images as image targets. The Trackables can be zipped, the src property must then point to the zip file containing the Trackables.

7.5.1.2.2 class Trackable

Inherits From ARAnchor.

A Trackable represents the object that will be tracked. It provides the actual Anchor of the Feature in the real world.

Conceptually, a Trackable consists of a digital file that describes the Trackable (marker, image etc.), and a Tracker that is used to track the particular Trackable. This linkage between a digital file and the

Tracker is defined in a TrackableConfig. Typically, only one TrackableConfig will be supplied per Trackable (one Trackable is attached to a particular Tracker which can read the digital file provided and track it in the camera), however, if a Trackable can be tracked in multiple ways with multiple Trackers (typically requiring a specific digital file to be provided per Tracker), multiple TrackableConfigs can be supplied.

Properties:

Name	Description	Type	Multiplicity
config	Linking the Trackable with the Tracker	TrackableConfig	1 .. *
size	The real world size of the Trackable, in meters	double	0 or 1

config
The config provides the mapping between the Tracker and the Trackable. Each Trackable must have at least on config, but might have more in case the Trackable can be tracked using different Trackers. See TrackableConfig below for details.

size
The size property allows to specify the size of the real world object that is tracked with the Trackable. If the Trackable is any sort of 2-dimensional object (such as images, face descriptions etc.), the size specifies the width of the Trackable in meters. For example, if a billboard advertisement sized 5 by 10 meters in the real world should be tracked, the image representing the Trackable should be in the same aspect ratio as the real object (1:2), and the size property needs to be set to 5. If the Trackable is a 3-dimensional object, the size property specifies the meters representing one unit in the 3D mesh. For example, if the model is using meters as the unit, set size to 1, if it is using feet, set it to 0.3048.

Certain Trackables might already contain information on the actual size of the Trackable within the referenced file. Examples include 3D models in COLLADA file format *[COLLADA Specification]*. In this case, the size property of the Trackable can be omitted. However, the usage of the *size* element is encouraged even in these cases. The size property overrules any size-properties implicitly set in the file format. A Trackable without any defined size (either in the file or with the *size* property) by the implementation must be ignored.

TrackableConfig

Name	Description	Type	Multiplicity
tracker	The URI of the Tracker that is used to track the Trackable	string	1
src	The identification of the Trackable	string	1
order	An order of the TrackableConfigs	int	0 .. 1

tracker
The tracker property holds the URI to the referenced Tracker the Trackable will be tracked with (format: #id).

src
The src property references the digital file that contains the description of the Trackable (a marker, an image etc.). Depending on the src property of the Tracker, the src property of the Trackable must be of different formats:

- If *src* of the referenced Tracker is not set, *src* of the Trackable must contain a URI pointing to the Trackable.
- If *src* of the referenced Tracker is set (e.g. pointing to a zip file), *src* of the Trackable must be set to a String that uniquely identifies the Trackable for the given Tracker (e.g. the path to the Trackable in a zip file, or any unique ID in another container)

order
An optional attribute that can be used to set a rank for the config in case multiple configs are available for a particular Trackable. The one with the lowest number is checked first, and only if the referenced Tracker is not available on the implementation, the next configs are considered. If two or more configs have the same order set, it is up to the implementation to decide on an order. If the attribute is not set, it defaults to the maximum integer on the platform, causing these configs to be considered last.

XSD:

```
<xsd:complexType name="TrackableType">
  <xsd:complexContent>
    <xsd:extension base="ARAnchorType">
      <xsd:sequence>
        <xsd:element name="config" maxOccurs="unbounded" minOccurs="1">
          <xsd:complexType>
            <xsd:sequence>
              <xsd:element name="tracker" maxOccurs="1" minOccurs="1">
                <xsd:complexType>
                  <xsd:attribute ref="xlink:href" use="required" />
                </xsd:complexType>
              </xsd:element>
              <xsd:element name="src" type="xsd:string" maxOccurs="1"
minOccurs="1" />
            </xsd:sequence>
            <xsd:attribute name="order" type="xsd:int" use="optional" />
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="size" type="xsd:double" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

```
<xsd:element name="Trackable" type="TrackableType"
substitutionGroup="ARAnchor" />
```

XML Example:

```
<!-- using the trackers specified above -->
<!-- a png image tracked with the generic image tracker -->
<Trackable id="myBirdTrackable">
  <config>
    <tracker xlink:href="#myGenericImageTracker" />
    <src>http://www.myserver.com/myTrackables/bird.png</src>
  </config>
  <size>0.2</size> <!-- in real word dimensions, the bird image is 20 cm
wide -->
</Trackable>

<!-- a jpg image tracked with the generic image tracker operating on a zip
file-->
<Trackable id="myBirdTrackableInZip">
  <config>
    <tracker xlink:href="#myGenericImageTrackerWithZip" />
    <src>/images/bird.png</src>
  </config>
  <size>0.2</size>
</Trackable>

<!-- a jpg image tracked with the generic image tracker operating on a zip
file-->
<Trackable id="myCustomBirdTrackable">
  <config>
    <tracker xlink:href="#myCustomTracker" />
    <src>bird</src> <!-- the custom tracker is supposed to understand the
ID "bird" in the Tracker's binary container -->
  </config>
  <size>0.2</size>
</Trackable>

<!—a Trackable that can be tracked in two different ways, preferably with a
custom implementation that takes a binary file, and if this configuration
is not available, a generic imagetracker should be used-->
<Trackable id="myTrackable">
  <config order="1">
    <tracker xlink:href="#myCustomSuperSpeedyTracker" />
    <src>http://www.myserver.com/myTrackables/bird.dat</src>
  </config>
  <!—fallback -->
  <config order="2">
    <tracker xlink:href="#myGenericImageTracker" />
    <src>http://www.myserver.com/myTrackables/bird.png</src>
  </config>
  <size>0.2</size>
</Trackable>
```

7.5.1.2.3 Advanced ARML: Coordinate Reference System and Dimension

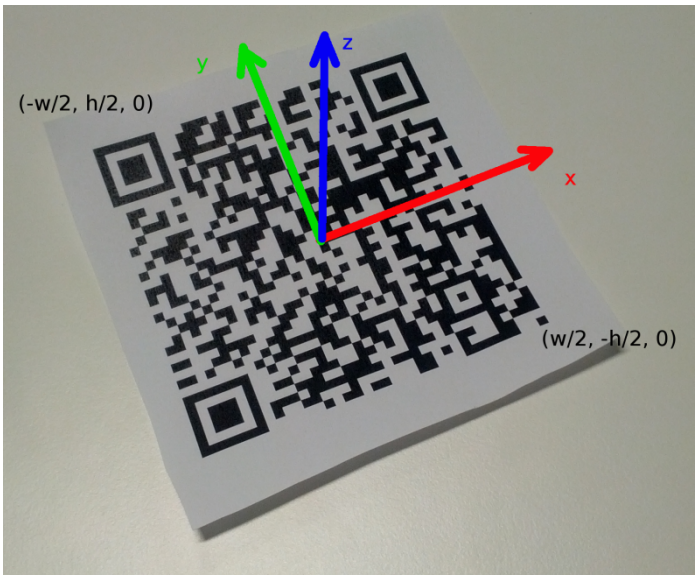
Dimensions:

The *center* (see Local Coordinate Systems below for details) of the Trackable will be tracked, resulting in a 0-dimensional ARAnchor (similar to a Geometry ARAnchor of type *Point*). Other areas of the Trackable (such as Outline etc.) can be tracked using RelativeTo locations, see *RelativeTo* section for details.

Local Coordinate Systems:

2D Trackables (QR Codes, Markers, Images etc.):

origin: the intersection of the diagonals of the bounding rectangle of the marker (for rectangular markers, this is the natural "center" of the image).
x-axis: pointing right with respect to the Trackable, running parallel to the top and bottom edge of the marker
y-axis: pointing up, parallel to the left and right edge of the marker
z-axis: perpendicular to x and y axis (i.e. the plane the Trackable is forming), pointing upwards (out of the marker)
Unit: Meters



w := width of Trackable
h := height of Trackable (calculated based on aspect ratio)

3D Trackables (tracked 3D models):

origin: the origin of the model.
x, y and z axis are reused from the model
Unit: As specified in the size property of the model (or any implicit size detected in the model file itself)

Other Trackables:

Trackables which do not fall into or cannot be mapped onto one of the above categories must specify their local coordinate system on their own.

7.5.1.3 Advanced ARML: class RelativeTo

Inherits From ARAnchor.

RelativeTo Anchors are defined relative to another ARAnchor (except LineStrings), to the user or relative to a Model. RelativeTo allows ARAnchors to be defined relative to other objects, regardless of where they are actually located. A Trackable, for example, defaults to a 0-dimensional ARAnchor. RelativeTo can be used to track the outline or any specific area in the Trackable without having to specify the Trackable again. The area can be specified using the local coordinate system of a Trackable.

RelativeTo are specified using GMLGeometryElements. The coordinate system is calculated according to the rules set forth in Local Coordinate Systems of GMLGeometryElements, based on the underlying ARAnchor or Model (in which case the model's x/y plane serves as the surface plane for coordinate system calculations).

While it is technically possible to define RelativeTo anchors relative to another RelativeTo anchor, usage of this construct is discouraged due to complex local coordinate system handling. It is advised to always base a RelativeTo-Anchor directly on a non-RelativeTo ARAnchor, a Model or the user.

Properties:

Name	Description	Type	Multiplicity
ref	The ARAnchor or Model the RelativeTo Anchor is referencing	string	1
GMLGeometry	The geometry describing the RelativeTo ARAnchor	GMLGeometryElement	1

ref

Specifies the URI to the object the Anchor is referencing, using the xlink:href attribute. Either another ARAnchor (except LineStrings) or Model, or #user is allowed as reference. If an ARAnchor is specified as *ref*, the ARAnchors's local coordinate system is used to calculate the relative location (based on the GMLGeometryElement of the RelativeTo Anchor). If a Model is used, the engineering coordinate system of the Model is used as coordinate system for the calculation of the relative location.
If #user is provided as reference, the current location of the user is considered a Point-Anchor (with its local coordinate system set accordingly).

GMLGeometry

The GMLGeometry describes the location relative to the object specified in *ref*. Thus, the resulting RelativeTo-Anchor can either be a gml:Point, gml:LineString or gml:Polygon, and the coordinates are given with respect to the underlying coordinate system of the ARAnchor or the coordinate system of the Model.
srsName and *srsDimension* for the GMLGeometryElement are ignored, *srsDimension* is implicitely set to 3. The local coordinate system of the underlying ARAnchor or Model will be used.

XSD:

```
<xsd:complexType name="RelativeToType">
  <xsd:complexContent>
    <xsd:extension base="ARAnchorType">
      <xsd:sequence>
        <xsd:element name="ref" maxOccurs="1" minOccurs="1">
          <xsd:complexType>
            <xsd:attribute ref="xlink:href" use="required" />
          </xsd:complexType>
        </xsd:element>
        <xsd:choice>
          <xsd:element ref="gml:Point" />
          <xsd:element ref="gml:LineString" />
          <xsd:element ref="gml:Polygon" />
        </xsd:choice>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="RelativeTo" type="RelativeToType"
substitutionGroup="ARAnchor" />
```

Example (to mark the outline of a Trackable):

```
<Trackable id="myTrackable">
   <size>5</size> <!-- assuming a square Trackable for this example-->
   ...
</Trackable>

<RelativeTo>
  <ref xlink:href="#myTrackable" />
  <gml:LineString gml:id="trackableOutline">
    <gml:posList dimension="3"> <!-- will describe the outline of the
square marker (2.5 meters from origin to top, bottom, left and right edge -
->
      2.5 2.5 0 2.5 -2.5 0 -2.5 -2.5 0 -2.5 2.5 0 2.5 2.5 0
    </gml:posList>
  </gml:LineString>
</ RelativeTo>
```

7.5.2 class ScreenAnchor

Inherits From Anchor.

A *ScreenAnchor* describes a fixed location on the screen which can be used to draw HTML components on the screen which are not registered in the real world and will not move on the screen as the user moves through the environment. A ScreenAnchor describes a rectangular area on the screen, aligned with the edges of the screen.

Properties:

Name	Description	Type	Multiplicity
style	inline styling for the element	String	0 or 1
class	References a CSS class	String	0 or 1
assets	The Labels representing the anchor in the live scene	Label[]	1

style and *class*
see CSS styling for details

CSS Styles are used to position the ScreenAnchor on the screen, similar to absolute positioning of an iframe in a HTML page. The following CSS properties are available for ScreenAnchor:

- *top* specifies how far the top edge of the ScreenAnchor is offset below the top edge of the screen
- *bottom* specifies how far the bottom edge of the ScreenAnchor is offset above the bottom edge of the screen
- *left* specifies how far the left edge of the ScreenAnchor is offset to the right of the left edge of the screen
- *right* specifies how far the right edge of the ScreenAnchor is offset to the left of the right edge of the screen
- *width* specifies the width of the ScreenAnchor
- *height* specifies the height of the ScreenAnchor

top, bottom, left, right, width and height can either be non-negative integer values (representing pixels on the screen) or percentage values (top, bottom and height in percentage of screen height, left, right and width in percentage of screen width). Only one value of top and bottom should be set. In case of conflicting top/bottom/height values, top takes precedence over height, which takes precedence over bottom. In case of conflicting left/right/width values, left takes precedence over width, which takes precedence over right. If neither top, not bottom is given, the ScreenAnchor will be placed as if top would be set to 0. If neither left, nor right is given, the ScreenAnchor will be placed as if left would be set to 0. width and height default to 100% if not given.

It is advised that out of top/bottom/height and left/right/width respectively, 2 out of the 3 values are always specified.

assets
A list of Labels attached to the ScreenAnchor which will be projected on the screen, see Anchor.assets for details.

When Labels are attached to a ScreenAnchor, the following properties of the Label will be ignored:

- width and height
- Orientation
- orientationMode

- ScalingMode
- any DistanceConditions

Additionally, the distance from the user to any ScreenAnchor is always 0, causing Labels attached to ScreenAnchors to occlude any other VisualAsset with a lesser or equal zOrder. Two overlapping ScreenAnchors should never have the same zOrder value set.

Absolute width and height values of a Label attached to a ScreenAnchor represent pixels on the screen. Percentage values represent the length in percent of the total screen width or height. If the content of the Label does not fit in the specified ScreenAnchor, the content should be made scrollable.

XSD:

```
<xsd:complexType name="ScreenAnchorType">
  <xsd:complexContent>
    <xsd:extension base="AnchorType">
      <xsd:sequence>
        <xsd:element name="style" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="class" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="assets" maxOccurs="1" minOccurs="1">
          <xsd:complexType>
            <xsd:sequence>
              <xsd:element ref="Label" maxOccurs="unbounded" minOccurs="0"
/>
              <xsd:element name="assetRef" maxOccurs="1" minOccurs="0">
                <xsd:complexType>
                  <xsd:attribute ref="xlink:href" use="required" />
                </xsd:complexType>
              </xsd:element>
            </xsd:sequence>
          </xsd:complexType>
        </xsd:element>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="ScreenAnchor" type="ScreenAnchorType"
substitutionGroup="Anchor" />
```

Example (a Placemark also contains a ScreenAnchor showing some information on the POI):

```
<Feature id="myPlacemark">
  <anchors>
    <ScreenAnchor>
      <style> bottom:0; left:0; width: 100%;</style>
      <!-- area spans the entire screen width, and is located at the bottom
of the screen; top is dynamic -->
      <assets>
```

```
        <Label>
          <src><![CDATA[<div><b>My Restaurant</b> is wonderful, come in and
have a seat!</div>]]></src>
        </Label>
      </assets>
    </ScreenAnchor>
  </anchors>
</Feature>
```

7.6 interface VisualAsset

Inherits From ARElement.

Visual Assets are the visual representations of the Features (and their Anchors) on the screen. The following VisualAssets are defined:

- 2-dimensional
  - Label: a VisualAsset specified through HTML elements
  - Fill: a colored area
  - Text: plain text
  - Image: an image
- 3-dimensional
  - Model: a 3D model

Properties:

Name	Description	Type	Multiplicity
enabled	The state of the VisualAsset	boolean	0 or 1
zOrder	Defines the Drawing order	int	0 or 1
conditions	Conditions in which the VisualAsset will be projected	Condition[]	0 or 1
Orientation	An Orientation object that describes how the VisualAsset is oriented in the Anchor's coordinate system	Orientation	0 or 1
ScalingMode	The scaling mode of the VisualAsset	ScalingMode	0 or 1

enabled

Setting the boolean flag to true (enabled) means that the VisualAsset is part of the composed scene (if the corresponding Anchor and Feature is enabled as well), setting it to false (disabled) causes the VisualAsset to be ignored in the composed scene. Defaults to true if not given.

zOrder

Visual Assets are projected onto the screen according to their distance, with Assets of closer Anchors occluding assets of Anchors further away. To customize the drawing order, any VisualAsset has a *zOrder* property. Assets with higher zOrder values will occlude assets with lower zOrder values, independent on their distance. Only if the zOrder values of two assets are equal, the distance is taken into account again. If not given, zOrder defaults to 0.

conditions
A list of conditions controlling when the VisualAsset will be drawn. This is particularly useful for a Level Of Detail (LOD) control over how an anchor is represented. From further away, an Anchor might have a Label representation, when the user gets closer, the representation might change to a 3D Model. Refer to Conditions for details.

Orientation
A VisualAsset's orientation can be manually configured using an Orientation object. See Orientation-class for details.

ScalingMode
Defines how the VisualAsset will be scaled, see *Scaling VisualAssets* for details.

XSD :

```
<xsd:complexType name="VisualAssetType" abstract="true">
  <xsd:complexContent>
    <xsd:extension base="ARElementType">
      <xsd:sequence>
        <xsd:element name="enabled" type="xsd:boolean" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="zOrder" type="xsd:int" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="conditions" maxOccurs="1" minOccurs="0">
          <xsd:complexType>
            <xsd:sequence>
              <xsd:element ref="Condition" maxOccurs="unbounded" />
            </xsd:sequence>
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="Orientation" type="OrientationType"
maxOccurs="1" minOccurs="0" />
        <xsd:element name="ScalingMode" type="ScalingModeType"
maxOccurs="1" minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="VisualAsset" type="VisualAssetType" abstract="true"
substitutionGroup="ARElement" />
```

Example:

```
<VisualAsset id="myVisualAsset">
  <enabled>true</enabled>
  <zOrder>0</zOrder>
  <Orientation>
    <roll>90</roll>
    <tilt>90</tilt>
    <heading>90</heading>
  </Orientation>
```

```
  <Conditions>
    ..
  </Conditions>
</VisualAsset>
```

7.6.1 VisualAsset Types

7.6.1.1 interface VisualAsset2D

Inherits From VisualAsset.

VisualAsset2D is an abstract class that provides common properties for every concrete instance of 2-dimensional VisualAssets.

Properties:

Name	Description	Type	Multiplicity
width	The width of the VisualAsset	string	0 or 1
height	The height of the VisualAsset	string	0 or 1
orientationMode	defines how VisualAssets are automatically aligned in the underlying Anchor	string	0 or 1
backside	Customization of the back side of the VisualAsset2D	string	0 or 1

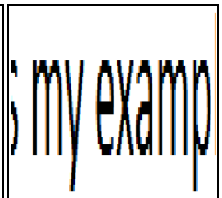
width and height

2-dimensional VisualAssets like Images do not have an implicit width and height in the composed scene. Thus, width and height can be explicitly set for 2-dimensional VisualAssets.

Both width and height can be set in absolute values (representing meters in the real world), as well as percentage values (the percentage of the total area of the underlying ARAnchor covered by the VisualAsset). If only one of width and height is set, the other value is implicitly calculated based on the aspect ratio of the VisualAsset (for Fill where an aspect ratio is not applicable, the unset value is always implicitly set to 100%). If neither width, nor height is set, width is implicitly set to 100%, and height is calculated based on the aspect ratio. If both width and height are set, the VisualAsset is stretched accordingly.

Examples:

The Anchor used in the examples below is a flat polygon with a real world width of 20 meters and height of 18 meters. The Visual Asset projected onto it is a simple Text saying "This is my example Text". The examples showcase different settings of width and height, the actual measures are only approximate to show the effects of different settings.

Image	This is my example Text				
Setting	-	<width> 100% </width> <height> 100% </height>	<height> 100% </height>	<width> 5 </width>	<width> 5 </width> <height> 2 </height>
Automatically Calculated	width = 100%; height according to aspect ratio		width according to aspect ratio	height according to aspect ratio	-

If the underlying Anchor does not have an extent in width and/or height direction (like a Point (no width and height) or a LineString (no height)), the Anchor's extent in the affected direction is set to 1 meter. For example, when an Image is projected onto a Point Anchor, and the Image's width is set to 100%, the Image is rendered 1 meter wide. Height is calculated according to the aspect ratio of the Image.

orientationMode

This property controls how the VisualAsset2D is initially oriented in the Anchor's coordinate system (before roll, tilt and heading are applied) and can take on three different values: *auto* (default)*, user* and *absolute*.

Setting the value to *user* orients the VisualAsset2D towards the user. *absolute* positions the VisualAsset2D according to the coordinate system specification of the VisualAsset and the Anchor. *auto* sets the orientationMode implicitly to *absolute* when the VisualAsset2D is attached to a Trackable (or a RelativeTo Anchor referencing a Trackable), and sets it to *user* for all other cases. See *Orienting VisualAssets* for details on how this affects the orientation of a VisualAsset.

backside

Backside defines how the back side of the VisualAsset should appear. Naturally, this is only relevant in case orientationMode is set to absolute.

The following values are possible for backside:

- any hex value: paints the back side of the VisualAsset2D in the color referenced by the hex value. The hex value start with # and must be given in a hex code of an RGB or RGBA value. If backside is not given, the value defaults to #808080.
- *mirrored*: the front face of the VisualAsset is mirrored onto the back face. This effect gives the impression of the front face shining through.
- *copied*: the front side is copied onto the back side.

XSD:

```
<xsd:complexType name="VisualAsset2DType" abstract="true">
  <xsd:complexContent>
    <xsd:extension base="VisualAssetType">
      <xsd:sequence>
        <xsd:element name="width" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="height" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="orientationMode" maxOccurs="1" minOccurs="0">
          <xsd:simpleType>
            <xsd:restriction base="xsd:string">
              <xsd:enumeration value="user" />
              <xsd:enumeration value="absolute" />
              <xsd:enumeration value="auto" />
            </xsd:restriction>
          </xsd:simpleType>
        </xsd:element>
        <xsd:element name="backside" type="xsd:string" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="VisualAsset2D" type="VisualAsset2DType" abstract="true"
substitutionGroup="VisualAsset" />
```

7.6.1.1.1 class Label

Inherits From VisualAsset2D .

A Label is a VisualAsset representing a HTML view, and its content is specified in HTML. The content can either be specified using a URI pointing to a HTML file, or specified with inline HTML. Any HTML5 content is allowed, and implementations are encouraged to support the full feature set of HTML5, ECMAScript and CSS.

In case ECMAScript, as well as ARML 2.0's ECMAScript bindings are supported (see section 9), ARML's *arml* root object is injected into each Label before it is constructed. From the *arml* object a Label can access any object in the scene.

Properties:

Name	Description	Type	Multiplicity
href	A link to a HTML page that describes the rendered content	String	0 or 1
src	Inline HTML that will be used to describe the content	String	0 or 1
hyperlinkBehavior	A flag indicating how the implementation should handle	String	0 or 1

Name	Description	Type	Multiplicity
	clicks on hyperlinks in the Label		
viewportWidth	An optional viewport setting	positive integer	0 or 1

href and *src*
href and src describe the content of the Label. href is a URI pointing to a HTML page that is rendered in the Label, src holds inline HTML content. If both properties are set, *src* takes precedence over *href*. At least one of the properties must be set, otherwise, the Label must be ignored. In case click through is enabled for the Label and a link is clicked, the *target* parameter of the link determines if the link should be opened in a full screen HTML view (target *_blank*) or if the content inside the Label should be updated in the Label itself (all other targets).

hyperlinkBehavior
hyperlinkBehavior allows to control how the implementation should handle clicks on hyperlinks in the Label, as well as any other location changes to the HTML document. The value can be set to either *block*, *blank* or *self*.

- *block*: Hyperlinks are not followed.
- *blank*: Hyperlinks are followed, the resulting page is opened full-screen in a new browser window. This is the default.
- *self*: Hyperlinks are followed, the resulting page is opened within the Label, replacing the original content of the Label.

The hyperlinkBehavior is independent from any onClick-event listeners set on the Label (see section 9.3.28), or the selected state of the Label (see section 7.6.4.2).

viewportWidth
An optional setting to control the viewport width of the Label, in pixels. This setting effectively controls the size of the content in the Label (contrary to width and height of the Label, which only describe the size of the Label itself), as well as how much space is available in the Label. If not set or set to a non-positive value, viewportWidth defaults to 256. The larger the value, the smaller the content is rendered. Implementations are allowed to set an implicit maximum threshold for viewportWidth.
Consider an image, 256 pixels wide. Setting the viewport to 256 pixels causes the Image to horizontally span across the entire Label. ViewportWidth set to 512 causes the Image to span across the first half of the Label, with the right half of the Label being blank.

Accessing metadata through src and href
The Feature element in ARML 2.0 allowed the definition of metadata (in the name, description and metadata tag, see section 7.4). In src and href of a Label, metadata can now be referenced by supplying special character sequences in the HTML. *$[name]* and *$[description]* will be replaced by the name and description of the Feature, or an empty string if not specified. To reference metadata in the metadata tag, XPath 2.0 expressions *[XML Path Language (XPath) 2.0]* enclosed in $[and] must be used (see examples below). The root node for the XPath evaluation is the metadata-tag in

the Feature section. The character sequence is only replaced with the resulting node's value if an XPath evaluation returns a single TextNode, and is replaced with an empty string otherwise.

XSD:

```
<xsd:complexType name="LabelType">
  <xsd:complexContent>
    <xsd:extension base="VisualAsset2DType">
      <xsd:sequence>
        <xsd:element name="href" maxOccurs="1" minOccurs="0">
          <xsd:complexType>
            <xsd:attribute ref="xlink:href" use="required" />
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="src" type="xsd:anyType" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="hyperlinkBehavior" maxOccurs="1" minOccurs="0">
          <xsd:simpleType>
            <xsd:restriction base="xsd:string">
              <xsd:enumeration value="block"></xsd:enumeration>
              <xsd:enumeration value="blank"></xsd:enumeration>
              <xsd:enumeration value="self"></xsd:enumeration>
            </xsd:restriction>
          </xsd:simpleType>
        </xsd:element>
        <xsd:element name="viewportWidth" type="xsd:positiveInteger"
maxOccurs="1" minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Label" type="LabelType"
substitutionGroup="VisualAsset2D" />
```

Example:

```
<Label id="mySrcLabel">
  <src>
    <div>Here's my Label in a div</div>
  </src>
</Label>

<Label id="myHrefLabel">
  <href xlink:href="http://www.myserver.com/myLabel.html" />
</Label>

<!-- Example of replacing name and metadata fields -->
<Feature id="empireStateBuilding">
  <name>The Empire State Building</name>
  <metadata>
    <constructed>1929-1931</constructed>
    <height>381m</height>
  </metadata>
```

```
  ...
</Feature>
<!-- The Label could be attached to multiple buildings conforming with the
same metadata-layout -->
<Label id="myBuildingLabel">
  <src>
    $[name]<br/>Constructed: $[/constructed]<br/>height: $[/height]
  </src>
</Label>
```

7.6.1.1.2 class Fill

Inherits From VisualAsset2D.

Fill is used when an Anchor should appear colored. It is most useful for coloring LineStrings and Polygons. Fill can be styled using CSS styles.

Properties:

Name	Description	Type	Multiplicity
style	inline styling for the element	String	0 or 1
class	References a CSS class	String	0 or 1

style and *class*
see CSS styling for details

The following CSS properties are available for Fill:

- *color* defines the fill color of the Fill, in #RGB or #RGBA; defaults to black

XSD:

```
<xsd:complexType name="FillType">
  <xsd:complexContent>
    <xsd:extension base="VisualAsset2DType">
      <xsd:sequence>
        <xsd:element name="style" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="class" type="xsd:string" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Fill" type="FillType" substitutionGroup="VisualAsset2D"
/>
```

Example:

```
<Fill id="myFill">
  <style>color:#FF0000;</style>
</Fill>

<!-- the same can be achieved with -->
<!-- style-section in arml document -->
<style type="text/css">
  Fill.redFill {
    color : #FF0000;
  }
</style>

<!-- ARElements section of arml document -->
<Fill id="myFill" class="redFill" />
```

7.6.1.1.3 class Text

Inherits From VisualAsset2D.

Text allows plain text to be rendered. Contrary to Label, where HTML styling can be used, Text only allows a limited set of styling options. Developers are encouraged to use Text when no HTML content is necessary, as Text does not need viewport settings to be correctly set. The size of the text is dependent on the *width* and *height* settings of the Text and will be automatically calculated.
Text can be styled using CSS styles.

Properties:

Name	Description	Type	Multiplicity
src	The text that will be rendered	String	1
style	Achieve inline styling for the element	String	0 or 1
class	References a CSS class	String	0 or 1

src
The text to be rendered. Implementations use the platform's primary font style to render the text. No control sequences such as \n or \t are available, use Label in these cases.
$[name] and *$[description]* in the text supplied to *src* will be replaced by the name and description of the Feature, or an empty string if not specified.

style and *class*
see CSS styling for details

The following CSS properties are available for Text:

- *font-color* defines the font color of the Text, in #RGB or #RGBA; defaults to black
- *background-color* defines the color of the background, in #RGB or #RGBA; defaults to transparent

XSD:

```
<xsd:complexType name="TextType">
  <xsd:complexContent>
    <xsd:extension base="VisualAsset2DType">
      <xsd:sequence>
        <xsd:element name="src" type="xsd:string" maxOccurs="1"
minOccurs="1" />
        <xsd:element name="style" type="xsd:string" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="class" type="xsd:string" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Text" type="TextType" substitutionGroup="VisualAsset2D"
/>
```

Example:

```
<Text id="myText">
  <src>This text will be displayed</src>
  <style>font-color:#FF0000;</style>
</Text>
```

7.6.1.1.4 class Image

Inherits From VisualAsset2D.

Image allows an image to be rendered. Developers are encouraged to use Image instead of Label when only an image should be displayed, as Image does not need viewport settings to be correctly set. The size of the image is dependent on the *width* and *height* settings of the Image and will be automatically calculated.

Properties:

Name	Description	Type	Multiplicity
href	A URI to an image	string	1

href

A URI to the image that will be displayed on the screen. Supported image formats are PNG, GIF and JPEG.

XSD:

```
<xsd:complexType name="ImageType">
  <xsd:complexContent>
    <xsd:extension base="VisualAsset2DType">
      <xsd:sequence>
        <xsd:element name="href" maxOccurs="1" minOccurs="1">
          <xsd:complexType>
            <xsd:attribute ref="xlink:href" use="required" />
```

```
          </xsd:complexType>
        </xsd:element>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Image" type="ImageType"
substitutionGroup="VisualAsset2D" />
```

Example:

```
<Image id="myImage">
  <href xlink:href="http://www.myserver.com/myImage.png" />
</Image>
```

7.6.1.2 class Model

Inherits From VisualAsset.

A Model is a Visual Asset representing a 3D Model. Model files are stored in the COLLADA format, using the COLLADA Common Profile. Implementations are encouraged to make sure that COLLADA Common Profile is fully supported as a minimum. If parts are not supported, it should be clearly stated. Implementations are also allowed to support additional file formats, however, these will not be standardized.

Properties:

Name	Description	Type	Multiplicity
href	A URI to a model file	string	1
type	The type of the Model, either normal or infrastructure	string	0 or 1
Scale	Setting the scale of the Model	Scale	0 or 1

href

The Model file itself is specified using a URI containing the source of the Model.

type

defines the role of the model in the augmented scene. Type can take on two different values, *normal* (default) and *infrastructure*.

Models with type *normal* are rendered in the composed scene. Infrastructure models are declared in the scene and used for occlusion detection, but are not visible in the scene (for example, a real world building might be modeled as an infrastructure model, so it's not rendered on the screen, but it is used to virtually occlude other VisualAssets behind the real world building).

Scale

allows scaling of the Model, see class Scale for details.

XSD:

```
<xsd:complexType name="ModelType">
  <xsd:complexContent>
    <xsd:extension base="VisualAssetType">
      <xsd:sequence>
        <xsd:element name="href" maxOccurs="1" minOccurs="1">
          <xsd:complexType>
            <xsd:attribute ref="xlink:href" use="required" />
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="type" maxOccurs="1" minOccurs="0">
          <xsd:simpleType>
            <xsd:restriction base="xsd:string">
              <xsd:enumeration value="normal" />
              <xsd:enumeration value="infrastructure" />
            </xsd:restriction>
          </xsd:simpleType>
        </xsd:element>
        <xsd:element name="Scale" type="ScaleType" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Model" type="ModelType" substitutionGroup="VisualAsset"
/>
```

Example:

```
<Model id="myModel">
   <href xlink:href="http://domain.com/myColladaFile.zip" /> <!-- a URI to
a zip file, containing the COLLADA dae file, textures and any other
ressources required -->
   <type>infrastructure</type> <!-- one of normal|infrastructure -->
   <Orientation>
      <roll>0</roll>
      <tilt>0</tilt>
      <heading>0</heading> <!-- Model is oriented towards north -->
   </Orientation>
   <Scale>
      <x>1</x>
      <y>1</y>
      <z>1</z>
   </Scale>
   <zOrder>0</zOrder> <!-- int value controlling the rendering order
(defaults to 0)-->
</Model>
```

7.6.1.2.1 class Scale

Scale allows scaling of the Model along the x, y and z axis. The values default to 1 if not specified. As with orientations, applying scales does not affect the axes of the Model itself, only the object is scaled.

XSD:

```
<xsd:complexType name="ScaleType">
  <xsd:sequence>
    <xsd:element name="x" type="xsd:double" maxOccurs="1" minOccurs="0" />
    <xsd:element name="y" type="xsd:double" maxOccurs="1" minOccurs="0" />
    <xsd:element name="z" type="xsd:double" maxOccurs="1" minOccurs="0" />
  </xsd:sequence>
</xsd:complexType>
```

7.6.2 Orienting VisualAssets

Depending on the dimension of the VisualAsset and dimension of the ARAnchor it is attached to, different rules apply how VisualAssets are rendered on ARAnchors. The orientation is also dependent on the properties *orientationMode* (VisualAsset2D only) and *Orientation*.

7.6.2.1 Orienting VisualAsset2Ds

VisualAsset2Ds come with an *orientationMode* property (see interface VisualAsset2D) which controls how the VisualAsset is oriented.

Case 1: Underlying ARAnchor is of Dimension 0, orientationMode = "user"

In this case, the center point of the VisualAsset2D is placed right onto the position of the ARAnchor in 3D space (either the geolocation for Point-Geometries, or the center point of the Trackable for Trackables). The upper face of the VisualAsset2D is always oriented towards the user's current location. The upper and lower edges of the VisualAsset2D run parallel to the earth's surface in case of a Point-Geometry, and parallel to the Trackable's surface in case of a Trackable.

Case 2: Underlying ARAnchor is of Dimension 1, orientationMode = "user"

The VisualAsset2D runs along the defined LineString. The horizontal center line of the Asset (the line being equidistant from the top and bottom of the VisualAsset) is placed onto the defined LineString. The horizontal center of the 2-dimensional VisualAsset (the point being equidistant from the center point of the left and right edge of the VisualAsset) is placed on the point being equidistant from the left and right end of the LineString (the origin of the coordinate system of the Anchor). This ensures that the VisualAsset expands from the center of the LineString, equally in both directions.

For each line segment of the LineString (the lines between the positions that form the LineString), the VisualAsset is directly facing the user. For each segment, the shortest distance from the LineString segment to the user’s viewing point is calculated, the resulting vector forms the normal vector of the plane the VisualAsset will be drawn into for this particular LineString segment (see figure below).

Remark: In case a LineString consists of more than one segment, the tie points of the segments might cause issues when the VisualAsset is rendered onto them. It is up to the implementation to smooth these artifacts.

Case 3: Underlying ARAnchor is of Dimension 2, orientationMode = "user"

The center of the VisualAsset2D is placed in the center of the BoundingRectangle of the ARAnchor, which can be considered the center of the Polygon forming the ARAnchor (see Local Coordinate System of a Polygon for details). The lower and upper edges and the left and right edges of the VisualAsset respectively are parallel to the lower and upper edges and the left and right edges of the BoundingRectangle of the Polygon respectively. The front face of the VisualAsset2D faces the user.

In case the Polygon and the VisualAsset are not of the same shape, the Polygon's boundaries will cut off any areas of the VisualAsset that do not lie within the Polygon's boundaries. This also applies to any holes in the Polygon defined by *interior LinearRings*.

Case 4: Underlying ARAnchor is of Dimension 0, orientationMode = "absolute"

Same as case 1, with the exception that the VisualAsset is placed into the x/y plane of the coordinate system of the Anchor, regardless of the user's position. The top and bottom edges of the VisualAsset are parallel to the x-axis, the left and right edges of the VisualAsset are parallel to the y axis of the ARAnchor's coordinate system. The top edge of the VisualAsset is located in the positive y-half, the right edge of the VisualAsset is located in the positive x-half.

Case 5: Underlying ARAnchor is of Dimension 1, orientationMode = "absolute"

The basic setup is equal to case 2. However, instead of calculating the plane as facing the user, the VisualAsset's left and right edges are placed parallel to the earth's surface for LineStrings associated with a Geometry, and parallel to the Trackable's surface for LineStrings associated with Trackables. This ensures the VisualAsset appears to be *lying flat on top of the LineString* when viewed from above.

The VisualAsset's front face is always facing up, whereat up is defined as out of the earth when attached to a Geometry, and out of the Trackable when attached to a Trackable.

Case 6: Underlying ARAnchor is of Dimension 2, orientationMode = "absolute"

The same as case 3, with the exception that the VisualAsset's front face is always facing up (depending on the order the vertices of the Polygon were specified).

7.6.2.2 Orienting 3D VisualAssets

Case 1: Underlying ARAnchor is of Dimension 0

3-dimensional assets are projected into the coordinate system of a 0-dimensional location. Both the Model and the ARAnchor use the same coordinate system origin and the same axis alignment.

Case 2: Underlying ARAnchor is of Dimension 1 or 2

3-dimensional assets cannot be attached to 1- or 2-dimensional Anchors and must be ignored in these cases.

7.6.2.3 class Orientation - Manual Orientation of VisualAssets

The Orientation class allows to manually adjust the orientation of a VisualAsset in 3D space after it was automatically oriented according to the above rules.

Properties:

Name	Description	Type	Multiplicity
roll	rotation around a certain rotation axis, see below for details	double	0 or 1
tilt	rotation around a certain rotation axis, see below for details	double	0 or 1
heading	rotation around a certain rotation axis, see below for details	double	0 or 1

The orientation object has 3 properties, *roll*, *tilt* and *heading*, which define rotations of the VisualAsset in 3 directions. The following rules apply:

- The rotation is applied using static axes (meaning that the axes are not transformed, only the object inside the coordinate system is rotated)
- The rotation steps are executed in the following order: roll - tilt - heading
- roll, tilt and heading are specified in degrees from -180 to 180.

Depending on the orientationMode and the type of the Anchor, the rotations are applied slightly different:

case 1: 0-dimensional Anchor and orientationMode absolute, or VisualAsset is 3-dimensional

- roll rotates the VisualAsset about the y axis. A positive rotation is clockwise around the y axis when viewed from the origin of the coordinate system looking along the positive axis.
- tilt rotates the VisualAsset about the *x* axis. A positive rotation is clockwise around the *x* axis when viewed from the origin of the coordinate system looking along the positive axis.
- heading rotates the VisualAsset about the *z* axis. A positive rotation is clockwise around the *z* axis when viewed from the origin of the coordinate system looking along the positive axis.

case 2: 0-dimensional Anchor, orientationMode user

- tilt rotates the VisualAsset about the line parallel to the (earth's or Trackable's) surface, running through the center of the VisualAsset (the user will see the VisualAsset flipping towards or away from him). A positive rotation moves the top towards the user at first.
- heading rotates the VisualAsset about the line connecting the center of the screen with the center of the VisualAsset (the user will see the VisualAsset rotating in the plane that is facing

him). A positive rotation is clockwise when viewed from the user looking towards the VisualAsset.

- roll rotates the VisualAsset about the axis that is perpendicular to the other two axes specified above, pointing away from the surface. A positive rotation moves the right edge of the VisualAsset towards the user first.

case 3: 1-dimensional Anchor

- roll does not apply
- tilt rotates the VisualAsset about each LineSegment of the LineString. A positive rotation is to the right when viewed from the start of each LineSegment towards the end of the LineSegment.
- heading does not apply

case 4: 2-dimensional Anchor

- roll does not apply
- tilt does not apply
- heading rotates the VisualAsset inside the plane the Polygon is forming around the center of the VisualAsset (and the coordinate system of the Anchor). A positive rotation is clockwise when viewed from above the Polygon.

XSD:

```
<xsd:complexType name="OrientationType">
  <xsd:sequence>
    <xsd:element name="roll" type="xsd:double" maxOccurs="1" minOccurs="0"
/>
    <xsd:element name="tilt" type="xsd:double" maxOccurs="1" minOccurs="0"
/>
    <xsd:element name="heading" type="xsd:double" maxOccurs="1"
minOccurs="0" />
  </xsd:sequence>
</xsd:complexType>
```

7.6.3 class ScalingMode - Scaling VisualAssets

VisualAssets appear smaller when their attached Anchors are further away, and appear bigger when the user moves towards the Anchor.

Consider, for example, a Polygon geometry representing a billboard on the street, with measures 20x10 meters, where a Label is attached to it (with width set to 100%). As the Anchor (and thus the Label) is scaled naturally, the further away the user, the smaller the Label is rendered, so it always fits the billboard. This is called *natural scaling*.

However, as the user walks away from the billboard, pretty soon the Label will become almost invisible, as a width of 20 meters, seen from a distance of 1000 meters, will appear very tiny.

Contrary, if standing right in front of the billboard, the Label will obstruct the entire screen, occluding any other objects.

To overcome this, a Visual Asset can be scaled in *custom* mode. In custom scaling mode, a *minScalingDistance* and *maxScalingDistance* are supplied along with a scalingFactor. *min*- and *maxScalingDistance* specify the distance of the user to the anchor of the VisualAsset (precisely: the distance of the origin of the coordinate system of the anchor) where custom scaling should start and stop. Outside of those boundaries, no scaling will apply. *scalingFactor* controls how quickly VisualAssets are scaled between those two boundaries.

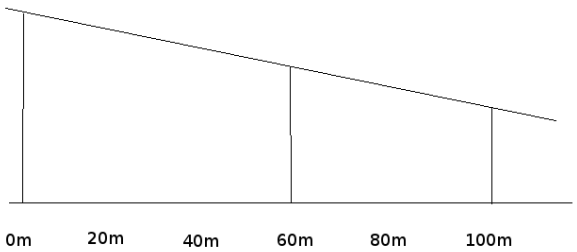
For example, setting a minScalingDistance to 10 meters causes the Label to be rendered as if the billboard would be 10 meters away, even if the user is standing closer. Similarly, setting a maxScalingDistance to 100 meters causes the Label to be rendered as if the billboard would be 100 meters away, even if the user is standing a lot further away. Between 10 and 100 meters, natural scaling is applied if no scalingFactor is set.

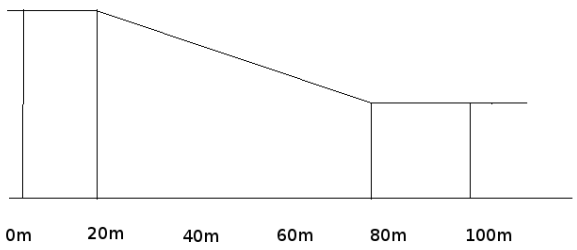
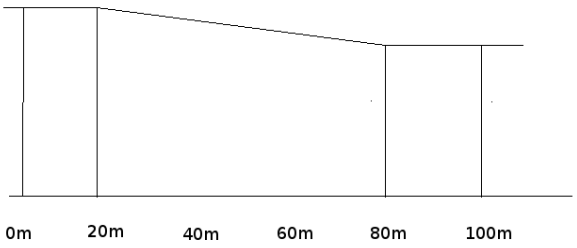
The amount of scaling between min and maxScalingDistance can be controlled using a scaling factor. scalingFactor specifies the size of the VisualAsset at maxScalingDistance in percentage of the size of the VisualAsset at minScalingDistance. Setting scalingFactor to 0.5, minScalingDistance to 10 meters and maxScalingDistance to 100 meters causes the VisualAsset to lose 50% of its size (on the screen) between 10 and 100 meters distance.

If both *minScalingDistance* and *maxScalingDistance* are set to the same value and *scalingFactor* is omitted, the VisualAsset will appear at the same size on the screen, regardless of the distance. If *scalingFactor* is set to 50%, the VisualAsset has a constant size until *maxScalingDistance* is reached, then drops to 50% of the size and keeps this size for any distances further than *maxScalingDistance*.

Illustration:

The following three diagrams show the effect of applying different settings to the size of a VisualAsset on the screen. The horizontal axis of the diagram shows the distance from the user to the Visual Asset, the vertical axes shows the size of the VisualAsset on the screen.

	Natural Scaling: The Visual Asset has a certain natural size at distance 0 and is scaled according to natural scaling.

	Custom Scaling: minScalingDistance: 20 maxScalingDistance: 80 scalingFactor: not set The VisualAsset is not scaled between 0 and 20 meters distance (at 20 meters, it is at its natural size), then naturally scaled between 20 and 80 meters. At 80 meters distance, it takes on its natural size. Beyond 80 meters distance, the VisualAsset does not change its screen size.
	Custom Scaling: minScalingDistance: 20 maxScalingDistance: 80 scalingFactor: 0.75 Scaling behaves similar to the previous example. The main difference is that at 80 meters distance, the VisualAsset is now at 75% of its size at 20 meters.

Example:

Natural scaling of a Label, with viewing distances 10 meters, 20 meters, 30 meters and 40 meters	
Custom scaling of a Label, with viewing distances 10 meters, 20 meters, 30 meters and 40 meters, minScalingDistance set to 20, maxScalingDistance set to 30 and scalingFactor omitted.	

In the second example, natural scaling applies between 20 and 30 meters distance. If the user is closer than 20 meters, the Label is rendered on the screen as if the Anchor would be 20 meters away (minScalingDistance set to 20 meters). Similarly, if the user is further than 30 meters away, the Label is rendered on the screen as if the Anchor would be 30 meters away (maxScalingDistance set to 30).

The scaling mode calculations are applied after the VisualAsset was positioned, scaled (according to width and height for VisualAsset2D, and Scaling for Model) and aligned according to the orientation settings.

Properties:

Name	Description	Type	Multiplicity
type	The type of the scaling mode, either "natural" or "custom"	string	1
minScalingDistance	The distance the natural scaling effect should start	double	0 or 1
maxScalingDistance	The distance the natural scaling effect should stop	double	0 or 1
scalingFactor	The size of the VisualAsset at maxScalingDistance in percentage of the size of the VisualAsset at minScalingDistance	double	0 or 1

type
Either *natural* or *custom*

minScalingDistance
The distance the natural scaling effect should start. Should only be specified when type is set to custom and is ignored for natural. If not specified or set to a negative value, custom scaling acts as if the value would be set to 0. Must be less than or equal to *maxScalingDistance*.

maxScalingDistance
The distance the natural scaling effect should stop. Should only be specified when type is set to custom and is ignored for natural. If not specified or set to a non-positive value, custom scaling acts as if the value would be set to Infinity. Must be greater than or equal to *minScalingDistance*.

scalingFactor
scalingFactor is a percentage value (0 <= scalingFactor <= 1) that defines how rapidly the VisualAssets should be scaled between min and maxScalingDistance. It specifies the size of the VisualAsset at maxScalingDistance in percentage of the size of the VisualAsset at minScalingDistance. If minScalingDistance is not supplied, it must be temporarily set to 1 meter for the purpose of the scalingFactor calculations. scalingFactor should only be specified when type is set to custom and maxScalingDistance is set, and is ignored otherwise.

XSD:

```
<xsd:complexType name="ScalingModeType">
  <xsd:complexContent>
    <xsd:extension base="ARElementType">
```

```
      <xsd:sequence>
        <xsd:element name="minScalingDistance" type="xsd:double"
maxOccurs="1" minOccurs="0" />
        <xsd:element name="maxScalingDistance" type="xsd:double"
maxOccurs="1" minOccurs="0" />
        <xsd:element name="scalingFactor" type="xsd:double" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
      <xsd:attribute name="type" use="required">
        <xsd:simpleType>
          <xsd:restriction base="xsd:string">
            <xsd:enumeration value="natural" />
            <xsd:enumeration value="custom" />
          </xsd:restriction>
        </xsd:simpleType>
      </xsd:attribute>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

Example:

```
<VisualAsset id="myVisualAsset">
  ... <!-- visual asset definition -->
  <ScalingMode type="custom">
    <minScalingDistance>50</minScalingDistance>
    <maxScalingDistance>5000</maxScalingDistance>
    <scalingFactor>0.75</scalingFactor>
  </ScalingMode>
</VisualAsset>

<VisualAsset id="myVisualAsset2">
  ... <!-- visual asset definition -->
  <ScalingMode type="natural" /> <!-- this is the default behavior -->
</VisualAsset>
```

7.6.4 interface Condition

Inherits from ARElement.

Depending on the situation, certain VisualAssets might be visible on the screen at different times. Consider a mountain with a mountain hut on its summit which should be remodeled. The mountain hut has a representation as a 3D model, showing the shape of the mountain hut in the future. However, from further away, the 3D model is not visible at all. Hikers starting at the valley ground, however, want to see a big Label indicating where the Mountain hut is actually located.

The following conditions are available:

- *distance* (min and max distance)
- *selected* (true/false)

If multiple conditions are supplied for a particular VisualAsset, all these conditions must yield true for the VisualAsset to be visible.

Remark: To achieve a "condition1 or condition2" situation, the VisualAsset must be duplicated (asset1 and asset2), where asset1 is tied to condition1, and asset2 is tied to condition2.

XSD:

```
<xsd:complexType name="ConditionType" abstract="true">
  <xsd:complexContent>
    <xsd:extension base="ARElementType" />
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="Condition" type="ConditionType" abstract="true"
substitutionGroup="ARElement" />
```

7.6.4.1 class DistanceCondition

Inherits from Condition.

DistanceCondition allows VisualAssets to be activated and deactivated based on the distance of the user to the anchor (precisely: the origin of the coordinate system of the anchor).

Properties:

Name	Description	Type	Multiplicity
max	The maximum distance the VisualAsset will be visible for	double	0 or 1
min	The minimum distance the VisualAsset will be visible for	double	0 or 1

max

denotes the maximum distance the VisualAsset will be visible for, in meters. For example, if it is set to 100, VisualAssets attached to Anchors with a distance of more than 100 meters are not visible.

min

denotes the minimum distance the VisualAsset will be visible for, in meters. For example, if it is set to 100, VisualAssets attached to Anchors with a distance of less than 100 meters are not visible.

If both min and max are set, both conditions must yield true for the visual asset to be rendered

XSD :

```
<xsd:complexType name="DistanceConditionType">
  <xsd:complexContent>
    <xsd:extension base="ConditionType">
      <xsd:sequence>
        <xsd:element name="max" type="xsd:double" maxOccurs="1"
minOccurs="0" />
        <xsd:element name="min" type="xsd:double" maxOccurs="1"
minOccurs="0" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

```
<xsd:element name="DistanceCondition" type="DistanceConditionType"
substitutionGroup="Condition" />
```

Example:

```
<Model id="myModel">
  ... <!-- representation of the mountain hut as a 3D model
  <conditions>
    <DistanceCondition>
      <min>200</min> <!-- only visible when distance is more than 200
meters -->
    </DistanceCondition>
  </conditions>
</Model>

<Label id="myLabel">
  ... <!-- representation of the mountain hut as a Label
  <conditions>
    <DistanceCondition>
      <max>500</max>
      <min>200</min> <!-- only visible when distance more than 200 meters,
but less than 500 meters -->
    </DistanceCondition>
  </conditions>
</Label>
```

7.6.4.2 class SelectedCondition

Inherits from Condition.

The selected condition allows VisualAssets to be activated and deactivated based on the selected-status of the Feature or Anchor.

An Anchor is considered *selected* if one of its VisualAssets has been selected. It is expected that for most implementations, a click or touch on a VisualAsset will be considered a selection of that VisualAsset, however, the definition is implementation- and platform-specific. In turn, a Feature is considered selected if one of its Anchors is selected.

Properties:

Name	Description	Type	Multiplicity
listener	The element type the selected-condition is listening for, either "feature" or "anchor"	String	0 or 1
selected	The selected state the VisualAsset should be visible	boolean	1

listener

One of *feature* or *anchor*, defaults to *anchor*.

If set to *feature*, the selected-condition listens on the selected state of the Feature the VisualAsset is attached to (if either one of the VisualAssets the Feature is associated with is clicked, the Feature is

considered selected). If set to *anchor*, the selected-condition listens on the selected state of the Anchor the VisualAsset is attached to.

selected
If set to true, the VisualAsset is only visible when the Anchor or Feature (see *listener*) is currently selected. If set to false, it is only visible when the Anchor or Feature is not currently selected.

XSD:

```
<xsd:complexType name="SelectedConditionType">
  <xsd:complexContent>
    <xsd:extension base="ConditionType">
      <xsd:sequence>
        <xsd:element name="listener" maxOccurs="1" minOccurs="0">
          <xsd:simpleType>
            <xsd:restriction base="xsd:string">
              <xsd:enumeration value="feature" />
              <xsd:enumeration value="anchor" />
            </xsd:restriction>
          </xsd:simpleType>
        </xsd:element>
        <xsd:element name="selected" type="xsd:boolean" maxOccurs="1"
minOccurs="1" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="SelectedCondition" type="SelectedConditionType"
substitutionGroup="Condition" />
```

Example:

```
<Model id="myModel">
  <conditions>
    <SelectedCondition>
      <listener>feature</listener>
      <selected>true</selected> <!-- only visible when the Feature the
VisualAsset is attached to is selected -->
    <SelectedCondition>
  </conditions>
  <href xlink:href="http://myserver.com/myModel.dae" />
</Model>
```

7.7 CSS Styling

Several ARML 2.0 objects can be styled using CSS, following the definitions set forth in the CSS Specification (either using inline *style* elements or the *class* attribute, as used in HTML. Whenever the CSS . selector is used, it refers to the class-attribute (i.e. *E.myClass* is short-hand for *E[class~=myClass]*).

8 Examples

The following section provides some examples of ARML snippets in common use cases. All usecases assume the following:

- A valid COLLADA 3D Model (including correctly referenced texture images) exists at the following location: http://www.myserver.com/myModel.dae
- A 512x512 (arbitrary) image exists at the following location: http://www.myserver.com/myImage.jpg
- A 512px wide and 1024px high artificial marker exists at the following location: http://www.myserver.com/myMarker.jpg. When printed, the marker is 20cm wide and 40cm high.

8.1 Typical geospatial AR Browser

A typical geospatial AR Browser shows placemarks, referenced by latitude and longitude values, as icons on the camera screen. When the user clicks on a placemark, a static info window is shown at the bottom of the screen, displaying some textual information.

Remark: Descriptions of the Placemarks are taken from the Wikipedia pages of the Golden Gate Bridge and Coit Tower.

```
<arml>
  <ARElements>

   <!-- define the placemark marker; we use custom scaling mode to allow
markers to be visible from further away markers will appear 20 meters wide
as a maximum in the composed scene. The Image will be used by each
Placemark in the scene. -->

   <Image id="placemarkMarker">
     <ScalingMode type="custom">
       <minScalingDistance>10</minScalingDistance>
       <maxScalingDistance>1000</maxScalingDistance>
       <scalingFactor>0.4</scalingFactor>
     </ScalingMode>
     <width>20</width>
     <href xlink:href="http://www.myserver.com/myImage.jpg" />
   </Image>

   <!-- define the info window. The info window is located at the bottom of
the screen and displays the name and description of the Feature it is
attached to. It will only be visible when the particular Feature
(placemark) was selected, and will disappear as soon as the Feature is
unselected. The Anchor will be used by each Placemark in the scene. -->

   <ScreenAnchor id="infoWindow">
     <style>left: 0; width: 100%; bottom: 0; height: 25%</style>
     <assets>
       <Label>
         <conditions>
           <SelectedCondition>
             <listener>feature</listener>
             <selected>true</selected>
```

```
          </SelectedCondition>
        </conditions>
        <src><b>$[name]</b><br />$[description]</src>
      </Label>
    </assets>
  </ScreenAnchor>

  <!-- Golden Gate Placemark -->

  <Feature id="goldenGateBridge">
   <name>Golden Gate Bridge</name>
   <description>The Golden Gate Bridge is a suspension bridge spanning the
Golden Gate, the opening of the San Francisco Bay into the Pacific
Ocean.</description>
    <anchors>
     <anchorRef xlink:href="#infoWindow" />
      <Geometry>
       <assets><assetRef xlink:href="#placemarkMarker" /></assets>
        <gml:Point gml:id="myPoint">
          <gml:pos>37.818599 -122.478511</gml:pos>
        </gml:Point>
      </Geometry>
    </anchors>
  </Feature>

  <!-- Coit Tower Placemark -->

  <Feature id="coitTower">
   <name>Coit Tower</name>
   <description>Coit Tower, also known as the Lillian Coit Memorial Tower,
is a 210-foot (64 m) tower in the Telegraph Hill neighborhood of San
Francisco, California.</description>
    <anchors>
     <anchorRef xlink:href="#infoWindow" />
     <Geometry>
      <assets><assetRef xlink:href="#placemarkMarker" /></assets>
        <gml:Point gml:id="myPoint">
          <gml:pos>37.802494 -122.405727</gml:pos>
        </gml:Point>
     </Geometry>
   </anchors>
  </Feature>

 </ARElements>
</arml>
```

8.2 Different Representations based on Distance

The Golden Gate Bridge example from above will be reused, but this time, the Golden Gate Bridge should appear as a (scaled) icon when viewed from more than 5 kilometers away, as a red colored line when viewed from between 1 and 5 kilometers away, and as a 3D model showing the bridge just after its completion when viewed from less than 1 kilometer away.

```
<arml>
  <ARElements>
```

```
    <Image id="placemarkMarker">
      <conditions>
        <DistanceCondition>
          <min>5000</min>
        </DistanceCondition>
      </conditions>
      <ScalingMode type="custom">
        <minScalingDistance>10</minScalingDistance>
        <maxScalingDistance>1000</maxScalingDistance>
        <scalingFactor>0.4</scalingFactor>
      </ScalingMode>
      <width>20</width>
      <href xlink:href="http://www.myserver.com/myImage.jpg" />
    </Image>

    <Fill id="myRedFill">
      <!-- only visible when 1km <= distance <= 5km -->
      <conditions>
        <DistanceCondition>
          <max>5000</max>
          <min>1000</min>
        </DistanceCondition>
      </conditions>

      <!-- the Golden Gate Bridge is 27.4 meters wide, thus the height of
the Fill (which represents the width of the Bridge) is set to 27.4 meters -
->
      <height>27.4</height>
      <!--  red color -->
      <style>color:#FF0000;</style>
    </Fill>

    <Model id="3dModel">
      <!-- only visible when distance <= 1km -->
      <conditions>
        <DistanceCondition>
          <max>1000</max>
        </DistanceCondition>
      </conditions>
      <href xlink:href="http://www.myserver.com/myModel.dae" />
    </Model>

    <!-- Golden Gate Placemark -->

    <Feature id="goldenGateBridge">
      <name>Golden Gate Bridge</name>
      <anchors>
        <Geometry>
          <assets>
            <!-- the model and the icon are mapped onto the same point, but
shown at different distances (see the VisualAssets declaration on top for
details) -->
            <assetRef xlink:href="#placemarkMarker" />
            <assetRef xlink:href="#3dModel" />
          </assets>
```

```
          <gml:Point gml:id="myPoint">
            <gml:pos>37.818599 -122.478511</gml:pos>
          </gml:Point>
        </Geometry>

        <Geometry>
          <!-- the line-representation must be mapped as a LineString
Geometry -->
          <assets><assetRef xlink:href="#filledLine" /></assets>
          <gml:LineString gml:id="myLineString">
            <gml:posList>
              37.827752 -122.479541 37.811005 -122.477739
            </gml:posList>
          </gml:LineString>
        </Geometry>
      </anchors>
    </Feature>

  </ARElements>
<arml>
```

8.3 3D Model on a Trackable

The 3D Model should appear on top of the referenced marker to play a game etc.

```
<arml>
  <ARElements>
    <!-- register the Tracker to track a generic image -->
    <Tracker id="defaultImageTracker">
      <uri
xlink:href="http://opengeospatial.org/arml/tracker/genericImageTracker" />
    </Tracker>

    <!-- define the artificial marker the Model will be placed on top of --
>
    <Trackable>
      <assets>
        <!-- define the 3D Model that should be visible on top of the
marker -->
        <Model>
          <href xlink:href="http://www.myserver.com/myModel.dae" />
        </Model>
      </assets>
      <config>
        <tracker xlink:href="#defaultImageTracker" />
        <src>http://www.myserver.com/myMarker.jpg</src>
      </config>
      <size>0.20</size>
    </Trackable>

  </ARElements>
</arml>
```

8.4 Color the Outline of the artificial marker

Use case: When the marker is detected in the camera screen, a red line, 1 centimeter wide, should be drawn around the marker (the marker outline).

```
<arml>

  <ARElements>

    <!-- define the VisualAsset for the outline - the LineString will be
filled with red color -->
    <Fill id="myRedFill">
      <!-- height set to 0.01 causes the LineString to be drawn 1cm thick -
->
      <height>0.01</height>
      <!-- define red color for the fill -->
      <style>color:#FF0000;</style>
    </Fill>

    <!-- define the Tracker and the Marker (see previous example) -->
    <Tracker id="defaultImageTracker">
      <uri
xlink:href="http://opengeospatial.org/arml/tracker/genericImageTracker" />
    </Tracker>
    <Trackable id="myTrackable">
      <config>
        <tracker xlink:href="#defaultImageTracker" />
        <src>http://www.myserver.com/myMarker.jpg</src>
      </config>
      <size>0.20</size>
    </Trackable>

    <!-- defines the location of the outline of the marker as a LineString
which has to be defined relative to the Trackable's center point -->
    <RelativeTo id="markerOutline">
      <assets>
        <!-- use the Fill-VisualAsset defined above to draw the LineString
-->
        <assetRef xlink:href="#myRedFill" />
      </assets>
      <!-- reference the Trackable the RelativeTo-geometry will be using --
>
      <ref xlink:href="#myTrackable" />
      <!-- define the Outline as LineString, from the top right corner of
the marker, moving clockwise. The top right point is 10 centimeters to the
right, 20 centimeters to the top and 0 centimeters above the Trackable's
center (0.01, 0.02 and 0 meters). -->
      <gml:LineString gml:id="myLineString">
        <gml:posList>0.01 0.02 0 0.01 -0.02 0 -0.01 -0.02 0 -0.01 0.02 0
0.01 0.02 0</gml:posList>
      </gml:LineString>
    </RelativeTo>

  </ARElements>
</arml>
```

8.5 Color the entire area of a marker

The use case above can be slightly altered to color the entire marker area instead of just the outline, only the LineString-element must be significantly changed, while the Fill-element is implicitly set back to 100% width and height, causing the entire marker area to be filled.

```
<arml>

  <ARElements>

    <!-- define the VisualAsset for the colored area -->
    <Fill id="myRedFill">
      <!-- define red color for the fill -->
      <style>color:#FF0000;</style>
    </Fill>

    <!-- define the Tracker and the Marker (see previous example) -->
    <Tracker id="defaultImageTracker">
      <uri
xlink:href="http://opengeospatial.org/arml/tracker/genericImageTracker" />
    </Tracker>
    <Trackable id="myTrackable">
      <config>
        <tracker xlink:href="#defaultImageTracker" />
        <src>http://www.myserver.com/myMarker.jpg</src>
      </config>
      <size>0.20</size>
    </Trackable>

    <!-- defines the location of the area of the marker as a Polygon which
has to be defined relative to the Trackable's center point -->
    <RelativeTo id="markerOutline">
      <assets>
        <!-- use the Fill-VisualAsset defined above to draw the LineString
-->
        <assetRef xlink:href="#myRedFill" />
      </assets>
      <!-- reference the Trackable the RelativeTo-geometry will be using --
>
      <ref xlink:href="#myTrackable" />
      <!-- define the Outline as LineString, from the top right corner of
the marker, moving clockwise. The top right point is 10 centimeters to the
right, 20 centimeters to the top and 0 centimeters above the Trackable's
center (0.01, 0.02 and 0 meters). -->
      <gml:Polygon gml:id="myPolygon">
        <gml:exterior>
          <gml:LinearRing>
            <gml:posList>0.01 0.02 0 0.01 -0.02 0 -0.01 -0.02 0 -0.01 0.02
0 0.01 0.02 0</gml:posList>
          </gml:LinearRing>
        </gml:exterior>
      </gml:Polygon>
    </RelativeTo>
```

```
  </ARElements>
</arml>
```

9 ECMAScript Bindings

ARML provides ECMAScript (the standardized version of JavaScript) bindings to allow the dynamic access and modification of objects in the AR scene, as well as event handlers to react on user input. In addition to the XML serialization, each class defined in ARML also has a JSON serialization, which is used to access and modify the properties of the objects in the scene.

Implementations are encouraged to support ARML's ECMAScript bindings to allow the developer dynamic access to the scene. However, if ECMAScript bindings cannot be provided for whatever reason, the implementation must clearly state that only the descriptive ARML specification is supported.

9.1 Accessing ARElements and Modifying the Scene

Implementations must ensure that an *arml* object is injected into the ECMAScript runtime context on startup. This object is the root node for any scripting operations on the AR scene and serves as the namespace for the objects defined in ARML 2.0.

In addition to serving as the namespace, *arml* has the following properties and methods:

```
module arml {
  readonly attribute ARElement[] arElements;

  ARElement getARElementById(String id);
  void addToScene(ARElement element);
  void removeFromScene(ARElement element);

  void addEventListener(String type, EventListener listener);
  void removeEventListener(String type, EventListener listener);

  ... all interface objects from below
}
```

getARElementById(String id)
returns the object having its *id* property set to the passed String. In case no such object exists, or *id* is empty, the call returns *null*.

addToScene(ARElement element)
adds the given element to the AR scene

removeFromScene(ARElement element)
removes the given element from the AR scene

9.2 Object Creation and Property Access

Each concrete subclass of *ARElement* has its own constructor. To make an object accessible in the scene, *ar.addToScene(element)* must be invoked first, only then is the element accessible via *ar.getARElementById(element.id)*.

An implementation must ensure that properties set in the descriptive spec are always in sync with the matching properties in the scripting spec. For example, if the following feature is defined in the declarative spec,

```
<Feature id="empireStateBuilding">
  <name>The Empire State Building</name>
  <enabled>true</enabled>
  <anchors>
    ...
  </anchors/>
</Tracker>
```

the implementation must ensure that the following object is accessible

```
var empireState = arml.getARElementById("empireStateBuilding");
```

and the object stored in empireState has its properties set to the following values:

```
empireState = {
  "id" : "empireStateBuilding",
  "name" : "The Empire State Building",
  "enabled" : true,
  anchors : [
    ... //the array of Anchors defined for the Feature
  ]
}
```

The properties of empireState can now be accessed and modified using *empireState.name* etc.

9.3 Object and Constructor Definitions

The ECMAScript bindings of the objects specified in ARML follow some simple principles.

1. Only concrete classes of ARML can be constructed in a valid way.
2. Constructor parameters consist of all mandatory attributes of the class, plus an optional dictionary (key/value JSON object) parameter allowing the population of all optional parameters.
3. Read-only parameters can only be populated at construction time of the object and must not be altered later.

Any misuse of constructors, methods or properties (e.g. wrong number of parameters or illegal values) provided must result in an Exception.

Remark: All objects defined below are accessible through the *arml* namespace and, in WebIDL terms, belong to the `arml` module. For example, a new Feature can be created with `new arml.Feature();`

```
interface ARElement {
  readonly attribute string id;
};
```

```
dictionary ARElementDict {
  string id;
};
```

9.3.1 Feature

```
[Constructor(optional FeatureDict initDict)]
interface Feature : ARElement {
  attribute string name;
  attribute string description;
  attribute boolean enabled;
  attribute object metadata;
  attribute Anchor[] anchors;
};

dictionary FeatureDict : ARElementDict {
  string name;
  string description;
  boolean enabled;
  object metadata;
  Anchor[] anchors;
};
```

9.3.2 Anchor

```
interface Anchor : ARElement {
  attribute boolean enabled;
};

dictionary AnchorDict : ARElementDict {
  boolean enabled;
};
```

9.3.3 ARAnchor

```
interface ARAnchor : Anchor {
  attribute VisualAsset[] assets;

  void addEventListener(string type, EventListener listener);
  void removeEventListener(string type, EventListener listener);
};

dictionary ARAnchorDict : AnchorDict {
  VisualAsset[] assets;
};
```

9.3.4 ScreenAnchor

```
[Constructor(Label[] assets, optional ScreenAnchorDict initDict)]
interface ScreenAnchor : Anchor {
  attribute string class;
  attribute ScreenAnchorStyleDict style;
  attribute Label[] assets;
};

dictionary ScreenAnchorDict : AnchorDict {
  string class;
```

```
  ScreenAnchorStyleDict style;
};

dictionary ScreenAnchorStyleDict {
  string top;
  string bottom;
  string left;
  string right;
  string width;
  string height;
};
```

9.3.5 Geometry

```
interface Geometry : ARAnchor {
  readonly attribute GMLGeometry gmlGeometry;
};

dictionary GeometryDict : ARAnchorDict {
  GMLGeometry gmlGeometry;
};
```

9.3.6 GMLGeometry

```
interface GMLGeometry {
  readonly attribute string id;
};
```

9.3.7 Point

```
[Constructor(string id, double[] pos, optional PointDict initDict)]
interface Point : GMLGeometry {
  attribute double[] pos;
  readonly attribute string srsName;
  readonly attribute string srsDimension;
};

dictionary PointDict {
  string srsName;
  string srsDimension;
};
```

9.3.8 LineString

```
[Constructor(string id, Point[] posList)]
interface LineString : GMLGeometry {
  readonly attribute string id;
  attribute Point[] posList;
};
```

Remark: The descriptive specification allows setting the srsName and srsDimension for the entire LineString, as well as single Points separately. The scripting specification only supports setting the srsName for each single Point. In case the srsName and srsDimension should be set for the entire LineString, the implementation needs to make sure it runs through the entire list of Points and sets the srsName and srsDimension accordingly.

9.3.9 Polygon

```
[Constructor(string id, LineString exterior, optional PolygonDict
initDict)]
interface Polygon : GMLGeometry {
  readonly attribute string id;
  attribute LineString[] interior;
  attribute LineString exterior;
};

dictionary PolygonDict {
  LineString[] interior;
};
```

Remark 1: As *LinearRing*s are closed *LineString*s from a technical perspective, ARML's ECMAScript bindings avoid an additional *LinearRing* type and use *LineString* instead.

Remark 2: The descriptive specification allows setting the srsName and srsDimension for the entire Polygon, as well as single LinearRings and Points separately. The scripting specification only supports setting the srsName for each single Point. In case the srsName and srsDimension should be set for the entire Polygon or LinearRing, the implementation needs to make sure it runs through the entire list of Points and sets the srsName and srsDimension accordingly.

9.3.10 RelativeTo

```
[Constructor(object ref, GMLGeometry gmlGeometry)]
interface RelativeTo : ARAnchor {
  readonly attribute object ref;
  attribute GMLGeometry gmlGeometry;
};
```

ref can either be a RelativeToAble or a String with its value set to *"#user"*, thus the type has to be a general object.

9.3.11 Tracker

```
[Constructor(string uri, optional TrackerDict initDict)]
interface Tracker : ARElement {
  readonly attribute string uri;
  attribute string src;
};

dictionary TrackerDict : ARElementDict {
  string src;
};
```

9.3.12 Trackable

```
[Constructor(TrackableConfig[] configs, optional TrackableDict initDict)]
interface Trackable : ARAnchor {
  readonly attribute TrackableConfig[] configs;
  attribute double size;

  void addEventListener(string type, EventListener listener);
  void removeEventListener(string type, EventListener listener);
};
```

```
dictionary TrackableDict : ARAnchorDict {
  double size;
};


[Constructor(Tracker tracker, string src, optional int order)]
interface TrackableConfig {
  readonly attribute Tracker tracker;
  readonly attribute string src;
  readonly attribute int order;
};
```

9.3.13 VisualAsset

```
interface VisualAsset : ARElement {
  attribute boolean enabled;
  attribute int zOrder;
  attribute Condition[] conditions;
  attribute Orientation orientation
  attribute ScalingMode scalingMode;

  void addEventListener(string type, EventListener listener);
  void removeEventListener(string type, EventListener listener);
};

dictionary VisualAssetDict : ARElementDict {
  boolean enabled;
  int zOrder;
  Condition[] conditions;
  Orientation orientation;
  ScalingMode ScalingMode;
};
```

9.3.14 Orientation

```
[Constructor(OrientationDict initDict)]
interface Orientation {
  attribute double roll;
  attribute double tilt;
  attribute double heading;
}

dictionary OrientationDict {
  double roll;
  double tilt;
  double heading;
};
```

9.3.15 ScalingMode

```
[Constructor(string type, optional ScalingModeDict initDict)]
interface ScalingMode {
  readonly attribute string type;
  attribute double minScalingDistance;
  attribute double maxScalingDistance;
```

```
  attribute double scalingFactor;
};

dictionary ScalingModeDict {
  double minScalingDistance;
  double maxScalingDistance;
  double scalingFactor;
};
```

9.3.16 VisualAsset2D

```
interface VisualAsset2D : VisualAsset {
  attribute string width;
  attribute string height;
  attribute string orientationMode;
  attribute string backside;
};

dictionary VisualAsset2DDict : VisualAssetDict {
  string width;
  string height;
  string orientationMode;
  string backside;
};
```

9.3.17 Label

```
[Constructor(LabelDict initDict)]
interface Label : VisualAsset2D {
  attribute string href;
  attribute string src;
  attribute string hyperlinkBehavior;
  attribute int viewportWidth;
};

dictionary LabelDict : VisualAsset2DDict {
  string href;
  string src;
  string hyperlinkBehavior;
  int viewportWidth;
};
```

9.3.18 Fill

```
[Constructor(FillDict initDict)]
interface Fill : VisualAsset2D {
  attribute FillStyleDict style;
  attribute string class;
};

dictionary FillDict : VisualAsset2DDict {
  FillStyleDict style;
  string class;
};
```

```
dictionary FillStyleDict {
  string color;
};
```

9.3.19 Text

```
[Constructor(string src, TextDict initDict)]
interface Text : VisualAsset2D {
  attribute string src;
  attribute TextStyleDict style;
  attribute string class;
};

dictionary TextDict : VisualAsset2DDict {
  TextStyleDict style;
  string class;
};

dictionary TextStyleDict {
  string fontColor;
  string backgroundColor;
};
```

9.3.20 Image

```
[Constructor(string href)]
interface Image : VisualAsset2D {
  attribute string href;
};
```

9.3.21 Model

```
[Constructor(string href, ModelDict initDict)]
interface Model : VisualAsset {
  attribute string href;
  attribute string type;
  attribute Scale scale;

  string start3DAnimation(string id, int loopCount, EventListener
callback);
  void stop3DAnimation(string animationId);
  void pause3DAnimation(string animationId);
  void resume3DAnimation(string animationId);
};

dictionary ModelDict : VisualAssetDict {
  string href;
  string type;
  Scale scale;
};
```

start3DAnimation starts an animation that was declared in the Model's file.

Parameters:

id: The animation to start is referenced by an id with which the animation can be identified in the Model file. In case the animations in the Model file are not referenceable with IDs, the position of the Animation in the file (starting with 1) can be used as a reference. In case no such animation exists, an

Exception must be thrown.
loopCount: An optional parameter specifying how often the animation should loop. If set to -1, the animation will loop infinitively often. Defaults to 1.
callback: An optional callback function can be supplied which will be executed right after the animation finished with all the loops provided. The callback will not be executed when the animation was manually stopped (see stop3DAnimation). For more details on EventListeners, see *Event Handling*.
Returns:
a string identifying the 3DAnimation. This String can be used to stop the Animation.

stop3DAnimation stops an animation before it regularily finishes.
Parameters:
animationId: The id returned when the animation was started
Returns:
void

pause3DAnimation pauses a currently running animation. Has no effect if the Animation is not running.
Parameters:
animationId: The id returned when the animation was started
Returns:
void

resume3DAnimation resumes a currently paused animation. Has no effect if the Animation is not paused.
Parameters:
animationId: The id returned when the animation was started
Returns:
void

9.3.22 Scale

```
[Constructor(ScaleDict initDict)]
interface Scale {
  attribute double x;
  attribute double y;
  attribute double z;
};

dictionary ScaleDict {
  double x;
  double y;
  double z;
};
```

9.3.23 DistanceCondition

```
[Constructor(DistanceConditionDict initDict)]
interface DistanceCondition : ARElement {
  attribute double max;
  attribute double min;
};
```

```
dictionary DistanceConditionDict : ARElementDict {
  double max;
  double min;
};
```

9.3.24 SelectedCondition

```
[Constructor(boolean selected, SelectedConditionDict initDict)]
interface SelectedCondition : ARElement {
  attribute string listener;
  attribute boolean selected;
};

dictionary SelectedConditionDict : ARElementDict {
  string listener;
  boolean selected;
};
```

9.3.25 Animation

```
interface Animation {
  void addEventListener(string type, EventListener listener);
  void removeEventListener(string type, EventListener listener);

  void start(int loopCount, int delay);
  void stop();
  boolean isRunning();
};
```

Animations cannot be defined in the declarative part of ARML, they can only be declared and controlled in the scripting part. Animations constantly modify the value of a property over a certain time period.
2 different types of Animations are supported in the ECMAScript bindings of ARML, NumberAnimations and GroupAnimations, they all inherit from Animation.

start starts an animation.
Parameters:
loopCount: An optional parameter specifying how often the animation should loop. If set to -1, the animation will loop infinitively often. Defaults to 1.
delay: The number of milliseconds the start of the animation will be delayed. Defaults to 0 (immediate start).
Returns:
void

stop stops an animation before it regularly finished.
Parameters:
-
Returns:
void

isRunning returns if an animation is currently running.
Parameters:
-

Returns:
true if the Animation is currently running, false otherwise.

9.3.26 NumberAnimation

```
[Constructor(ARElement target, string property, float start, float end,
float duration)]
interface NumberAnimation : Animation {
  readonly attribute ARElement target;
  readonly attribute string property;
  readonly attribute float start;
  readonly attribute float end;
  readonly attribute int duration;
};
```

NumberAnimations constantly modify a numeric value over a certain period of time from a given start value to a specified end value. Between start and end, the value is linearly interpolated.

Properties:
target specifies the ARElement that holds the property that will be animated. Must not be null.
property holds the name of the property that will be animated. The property must hold a numeric value.
start holds the start value of the Animation. If null, the current value of the property is used as start value.
end holds the end value of the Animation. The property will take on this value after the Animation completed.
duration, supplied in miliseconds, specifies the duration of one loop of the Animation.

9.3.27 GroupAnimation

```
[Constructor(string type, Animation[] animations)]

interface GroupAniimation : Animation {
  readonly attribute string type;
  readonly attribute Animation[] animations;
};
```

A GroupAnimation groups multiple Animations and runs them depending on the type of the GroupAnimation. Type can either be parallel, causing all Animations in the GroupAnimation to start at the same time, or sequential, causing the Animations to run one after another.

Properties:
type specifies the type of the GroupAnimation, either *parallel* or *sequential*.
animations holds the array of Animations contained in the GroupAnimation.

A parallel GroupAnimation loop has finished when the longest Animation in the group has finished. A sequential GroupAnimation loop has finished when the last Animation in the group has finished.

9.3.28 Event Handling

EventHandling in ARML is based on concepts of event handling in HTML, see http://www.w3.org/TR/2000/REC-DOM-Level-2-Events-20001113/events.html for details.

Developers can react on certain events by registering *EventListener*s listening on the occurance of a certain *Event type* on specific *event targets*.

The following ARML classes serve as event targets, with their corresponding Events.

EventTarget	Event Type	Description
arml	locationChanged	fires when the implementation receives a new geolocation representing the user's current position. The position will be passed as a parameter to the event listener, of type Point.
VisualAsset	enterFieldOfVision	fires when at least one pixel of the VisualAsset becomes visible on the screen
	exitFieldOfVision	fires when the last pixel of the VisualAsset moves out of the screen
	click	fires when the VisualAsset was clicked
ARAnchor	enterFieldOfVision	fires when at least a part of the area the ARAnchor covers becomes visible on the screen
	exitFieldOfVision	fires when the ARAnchor becomes invisible on the screen
Trackable	tracked	fires when the Trackable was detected in the scene
	trackingLost	fires when the Trackable cannot be tracked anymore
Animation	start	fires just before the animation starts
	finish	fires just after the animation finished

Event Listeners are registered in the event targets using

```
eventTarget.addEventListener(string type, EventListener listener);
```

and removed using

```
eventTarget.removeEventListener(string type, EventListener listener);
```

9.3.28.1 EventListener

```
interface EventListener {
  void handleEvent(Event evt);
};
```

handleEvent is called whenever an event occurs of the type for which the EventListener interface was registered. The *evt* parameter holds the Event object containing contextual information about the event.

9.3.28.2 Event

```
interface Event {
  readonly attribute EventTarget target;
};
```

target is used to indicate the Event Target to which the event was originally dispatched.

Example:

```
var clickFunction = function(event){
  var t = event.eventTarget.src;
  //do something
};

var text = new arml.Text("This is my text");
text.addEventListener("click", clickFunction);
```

Annex A: Revision history

Date	Release	Author	Paragraph modified	Description
2012-10-31	1.0.0	Martin Lechner	All	Copy from TWiki to this document for RFC
2012-11-02	1.0.1	Martin Lechner	1,2,4,5,7	Fixed some broken Links, added historical information on ARML 1.0
2013-02-11	1.0.2	Martin Lechner	6,7,8,9	Incorporated comments received during the public commenting phase

Annex B: Bibliography

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