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Document for IEC TC100 AGS

# Draft TR: Conceptual Model for Multimedia XR Systems

25 September 2017

System Architecture Research Dept.
Hitachi, LTD.
Tadayoshi Kosaka, Takayuki Fujiwara

* XR is a term which unifies augmented reality (AR), virtual reality (VR), mixed reality (MR), substitutional reality(SR).

# 1. Contents of Draft TR

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Introduction

1. Scope

2. Normative references

3. Terms and definitions

4. Conceptual model for multimedia XR systems

5. Issues to be standardized

6. Standardization strategy and priority

Annex A Use cases
Annex B Examples of existing XR systems

# Introduction

# 0. Introduction

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XR systems include a number of technologies and cover wide range of technical fields. As the first step to discussion and standardization of the technologies, a conceptual model for multimedia XR systems should be established and standardization issues should be clarified.

# 1. Scope

# 1. Scope

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This document (Technical Report) describes a conceptual model for multimedia XR systems. The conceptual model is specified from the TC 100 standardization point of view in order to clarify the functionality and services of multimedia XR systems and/or subsystems.

The model provides the key technologies to be standardized in the XR system environment. The modelling is expected to be used as a reference for discussing and developing new standardization work on multimedia XR systems and related equipment and, therefore, to contribute to the expansion of the international and domestic markets for multimedia XR systems.

# 2. Normative References

# 2. Normative Reference: ISO/IEC 18039

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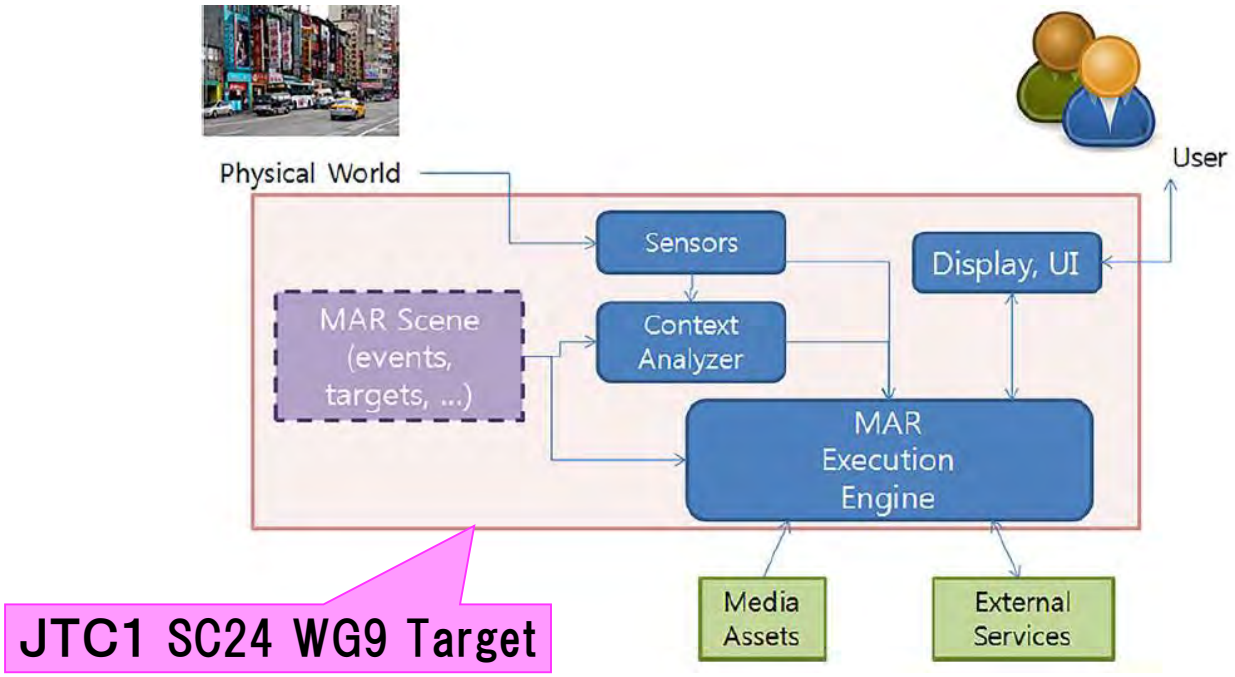
ISO/IEC JTC1 SC24 focuses on "Computer graphics, image processing and environmental data representation".

SC24 WG9 is now preparing "ISO/IEC 18039" a standard for Mixed and augmented reality (MAR) reference model.




Reference: ISO/IEC DIS 18039 --- Mixed and augmented reality (MAR) reference model

# 3. Terms and Definitions

# 3. Terms and definitions

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In this chapter, terms and definitions to be related to multimedia XR systems standards in TC100 are described.

AR is an abbreviated term for "Augmented Reality". AR means augmented perception or technology with computer operation.

VR is ...

MR is ...

SR is ...

XR is a term which unifies AR, VR, MR, and SR.

XR engine means a library or a middleware or a framework for generating XR perception.

XR object means computer generated object to make user perceive. For example a computer generated image or a text data object which is indicated at a display device.

The descriptions will be defined, and the terms will be added in the DTR document.

# 4. Conceptual Model for Multimedia XR Systems

# 4-1. Conceptual Model for Multimedia XR Systems

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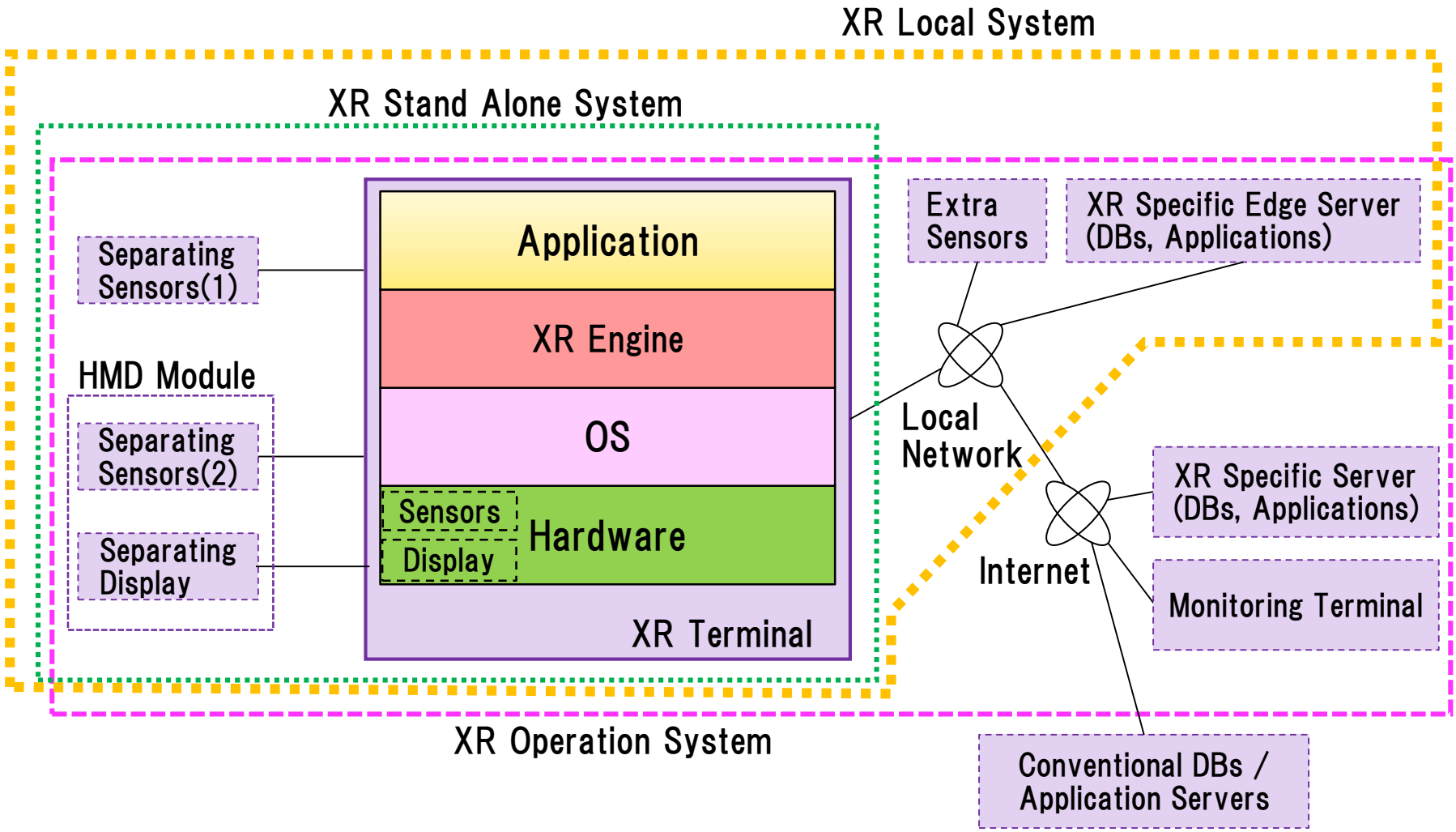


* HMD(Head Mounted Display)

# 4-2. System Architectures of Existing XR Terminals

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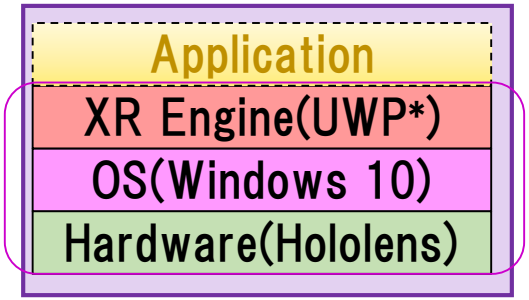
Microsoft "Hololens"

MR

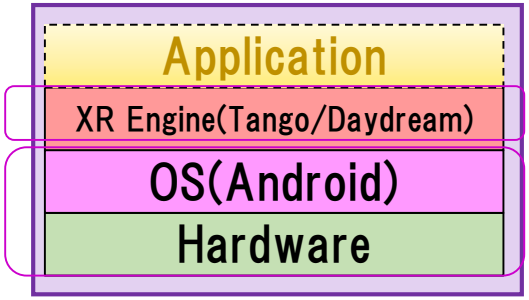



Microsoft Products

Reference: Microsoft Homepage
"https://www.microsoft.com/en-us/hololens"

Lenovo "Phab 2 Pro",
ASUS "ZenFone AR", etc.

AR/VR

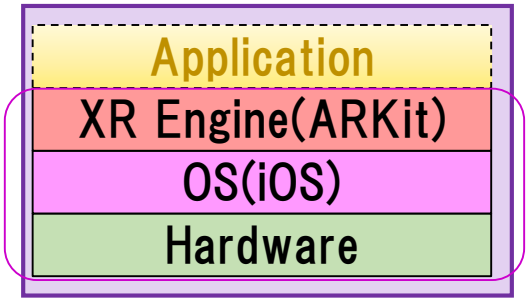



Google Products // collaboration
Lenovo or ASUS Products

Reference: Lenovo Homepage
"http://www3.lenovo.com/us/en/arvr/"

Apple "iPhone", "iPad"

AR




Apple Products

Reference: Apple Computer Homepage
"https://www.apple.com/iphone/"

* XR Engine means software libraries to handle XR information.
* UWP(Universal Windows Platform)

# 4-3. System Architectures of Existing VR HMD

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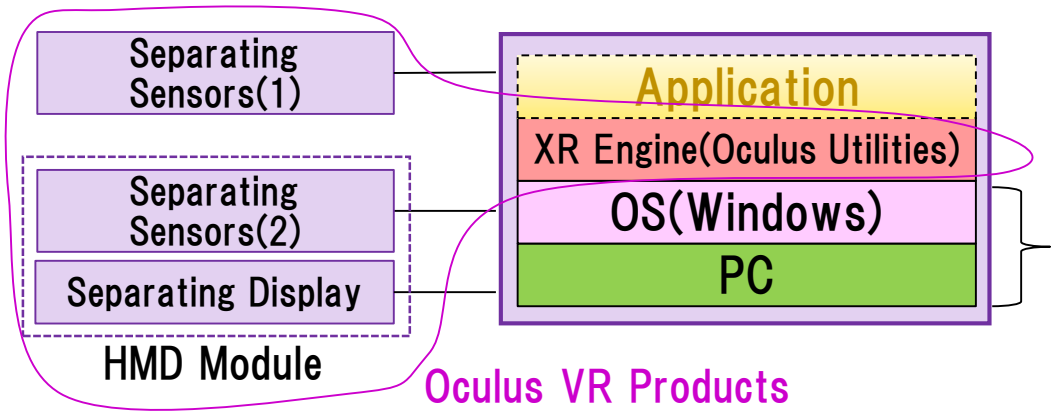
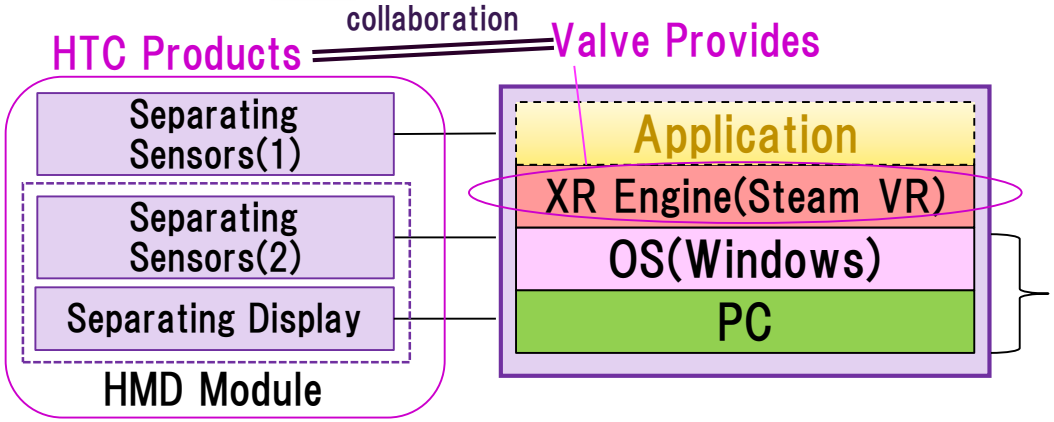
Oculus VR "Oculus Rift" VR

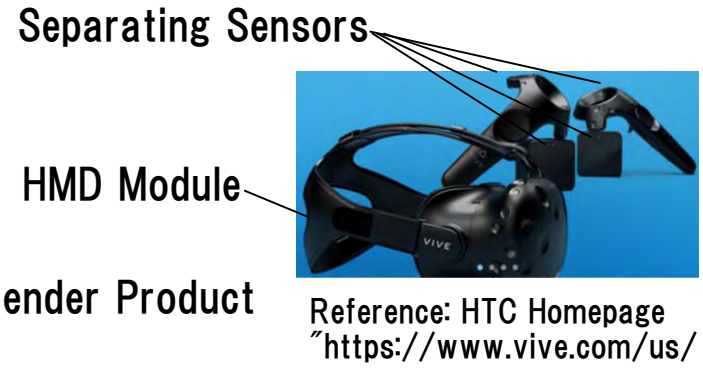




Reference: Oculus VR Homepage
"https://www.oculus.com/rift/

HTC "Vive" VR




Reference: HTC Homepage
"https://www.vive.com/us/

Many XR products consists of hardware and XR engine. An application is divided from hardware and XR Engine maker's responsibility.

# 4-4. System Architectures of Existing XR Engines

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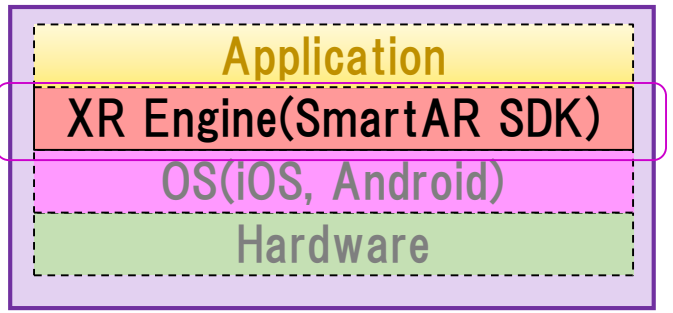
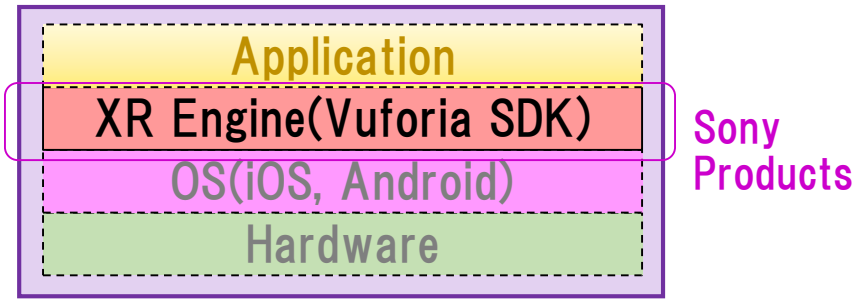
## Some company produce XR Engines

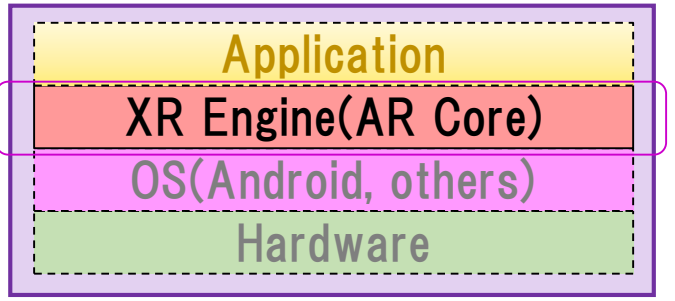
Sony "SmartAR SDK" AR



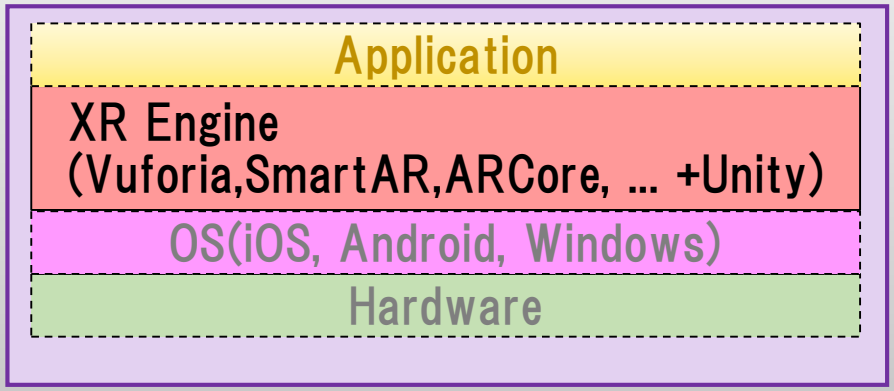

Vuforia "Vuforia SDK" AR




Google "AR Core" AR




Some XR Engine works with Game Engine "Unity"




"Unity" is a cross-platform game engine which can run on many kinds of OSs.

# 4-5. System Architectures of Existing XR Operation System

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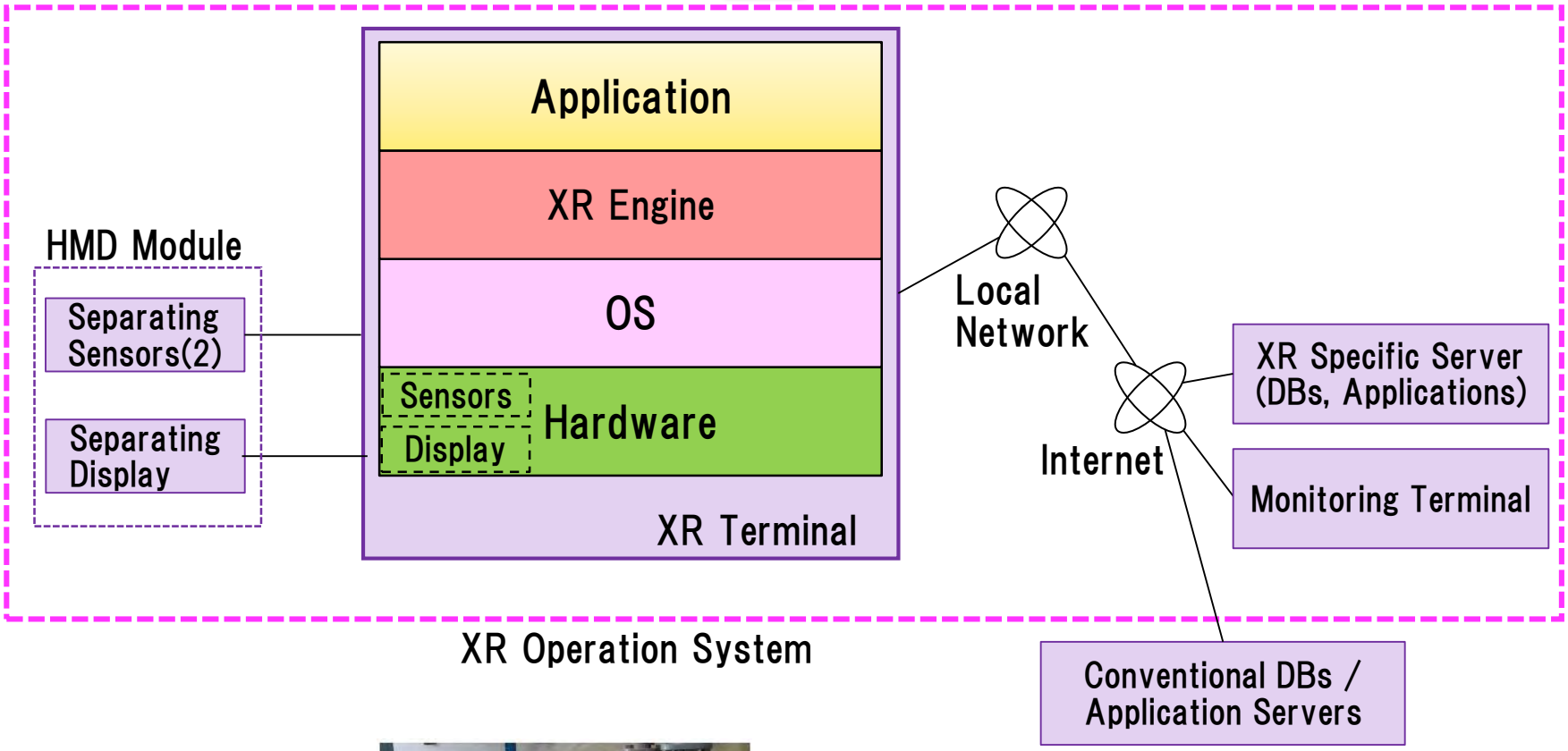
Hitachi "AR Inspection Work Support System" AR




Reference: Press Release from Hitachi, LTD. ,
http://www.hitachi.co.jp/New/cnews/month/2015/09/0902b.html

# 5. Issues to be standardized

# 5-1. Possible Standards for evaluation Methods

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XR stand alone system evaluation methods with application:
- XR Application performance
- Battery Maintain Time

XR engines evaluation methods:
- XR Algorithm performance

ISO/IEC JTC1 SC21 WG9 cares

XR local system evaluation methods with application:
- XR performance with edge server and extra sensors

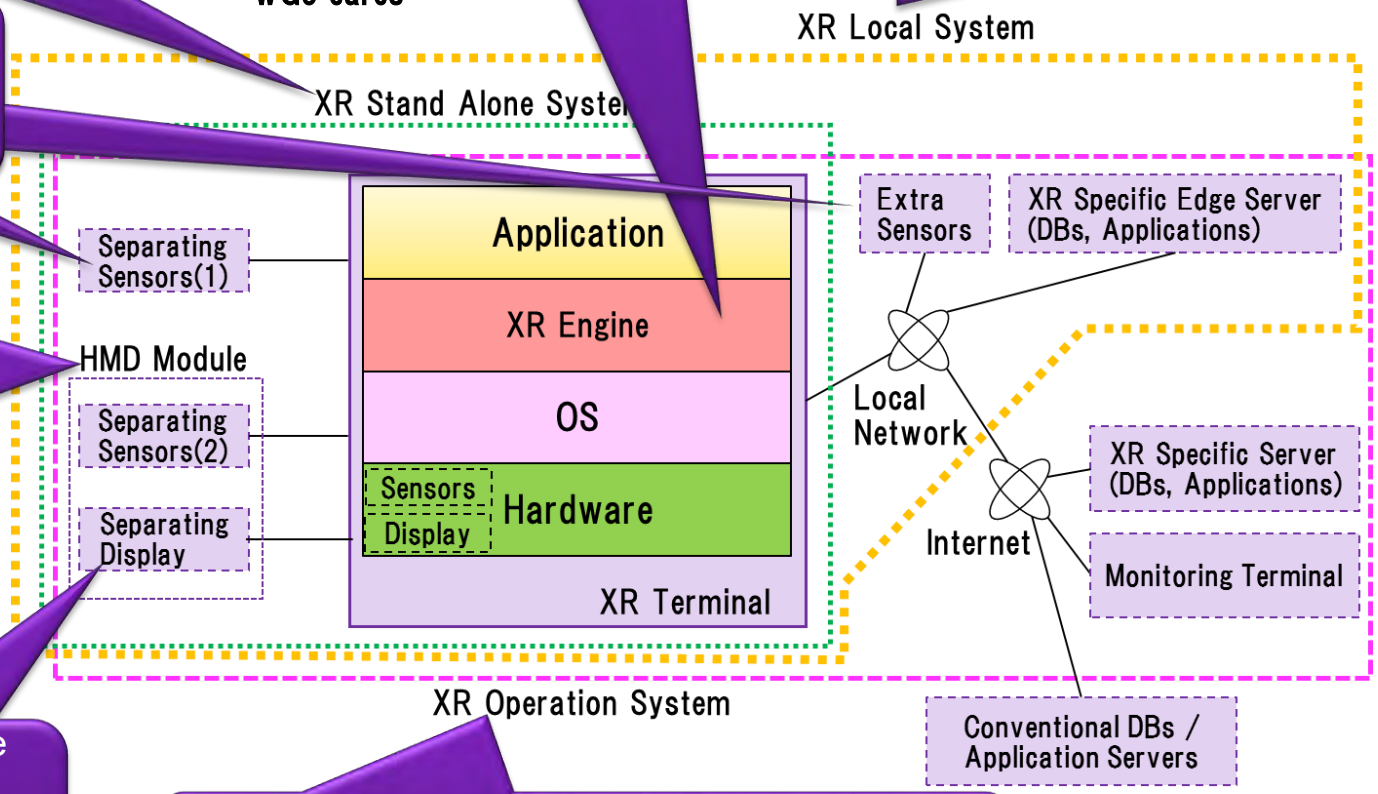
Sensor performance evaluation methods:
- Accuracy
- Battery maintain time

HMD performance evaluation methods:
- Battery maintain time with sensors
- Wearing stability
- Comfortability

Display performance evaluation methods:
- View field
- Luminance
- Energy efficiency

IEC TC110 cares for specifications as a display

XR operation systems evaluation methods:
- XR performance with outside servers and monitoring terminals



# 5-2. Possible Standards for Interfaces

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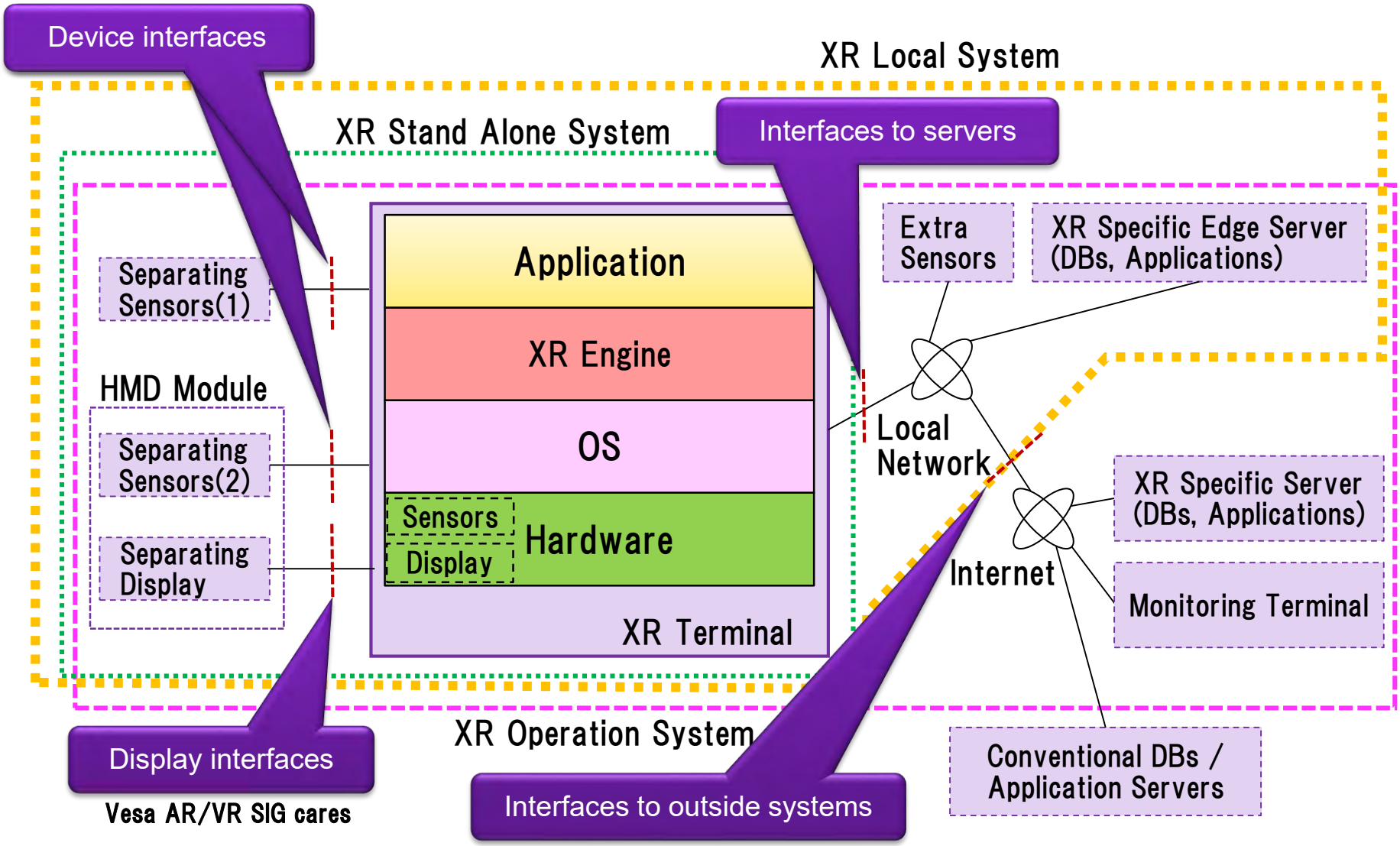

# 5-3. Possible Standards for Software Interfaces

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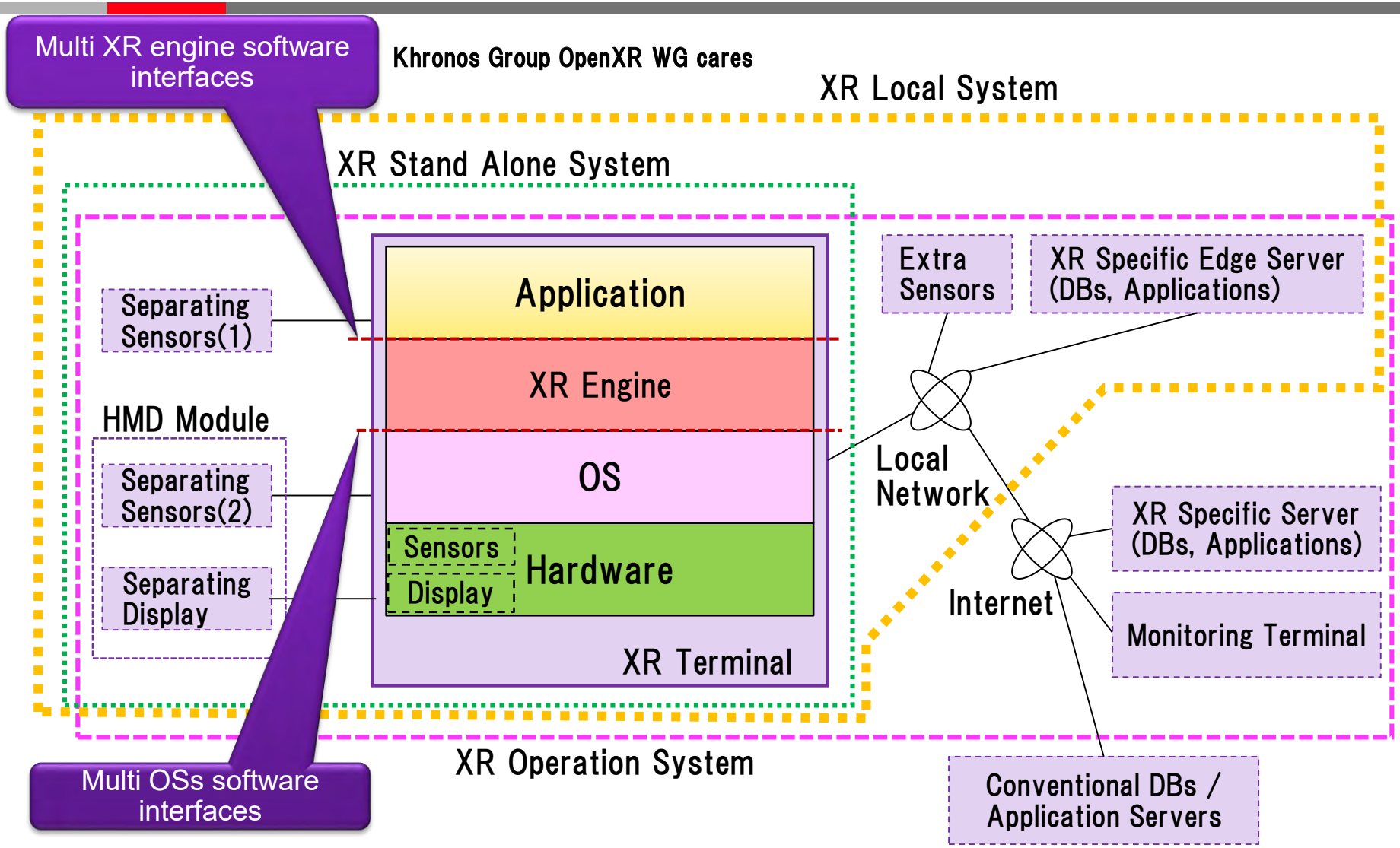

# 6. Standardization Strategy and Priority

# 6-1. Standardization Strategy and Priority

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Standard Candidates for Multimedia XR Systems:

1. Evaluation methods for XR systems
2. System interfaces between servers and terminals
3. Energy efficiency evaluation methods
4. Input methods and user interface
5. Network security and requirements
6. System interfaces to external conventional servers
7. System interfaces between sensors and controllers

⋮

- Strategy and priority will be discussed in this TR.
- At this moment, Hitachi wanted to make the standard of evaluation methods for XR systems as a next step.

# 6-2. First Target: Evaluation Methods for XR Systems

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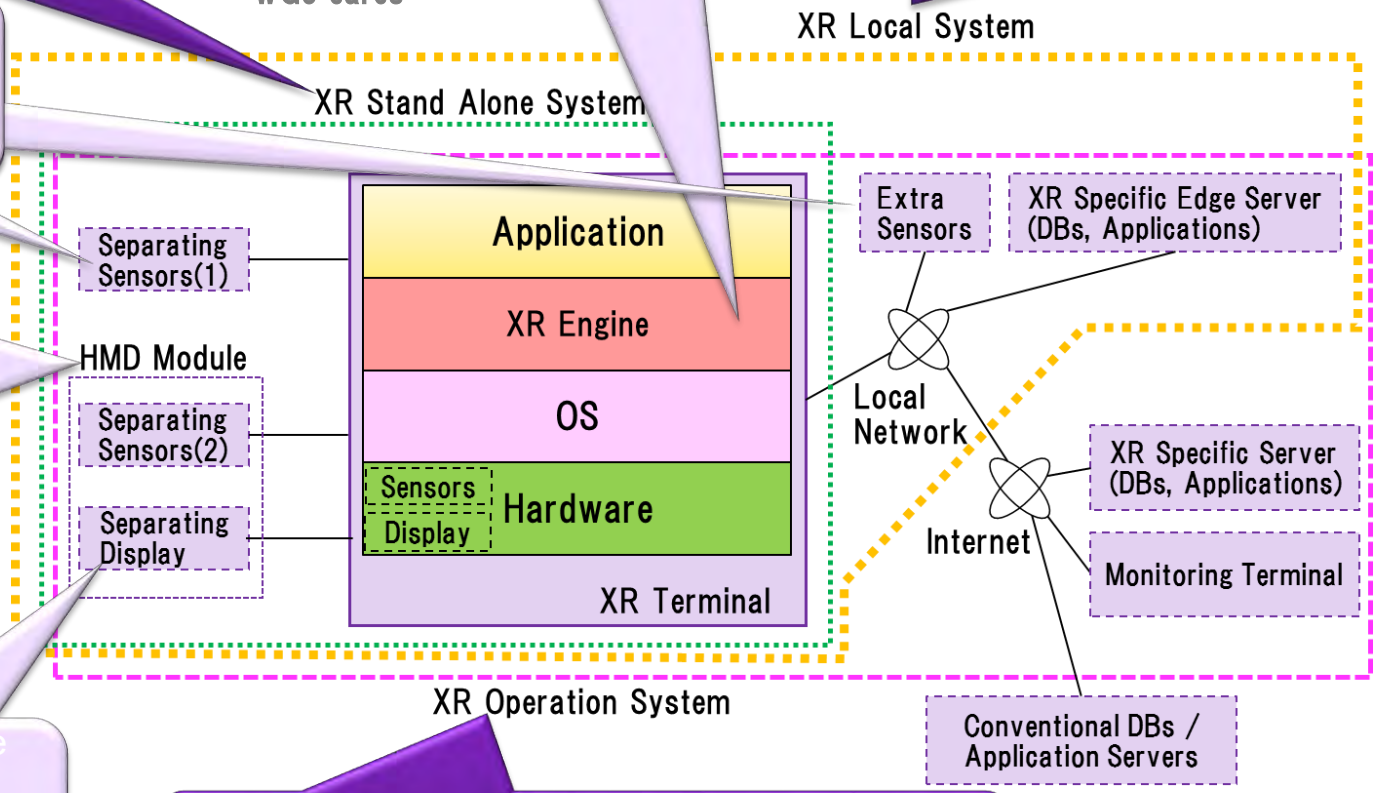
XR stand alone system evaluation methods with application:
- XR Application performance
- Battery Maintain Time

XR engines evaluation methods:
- XR Algorithm performance

ISO/IEC JTC1 SC21 WG9 cares

XR local system evaluation methods with application:
- XR performance with edge server and extra sensors

Sensor performance evaluation methods:
- Accuracy
- Battery maintain time




HMD performance evaluation methods:
- Battery maintain time with sensors
- Wearing stability
- Comfortability

Display performance evaluation methods:
- View field
- Luminance
- Energy efficiency

IEC TC110 cares for specifications as a display

XR operation systems evaluation methods:
- XR performance with outside servers and monitoring terminals

# 6-3. Needs of First Target "Evaluation Methods"

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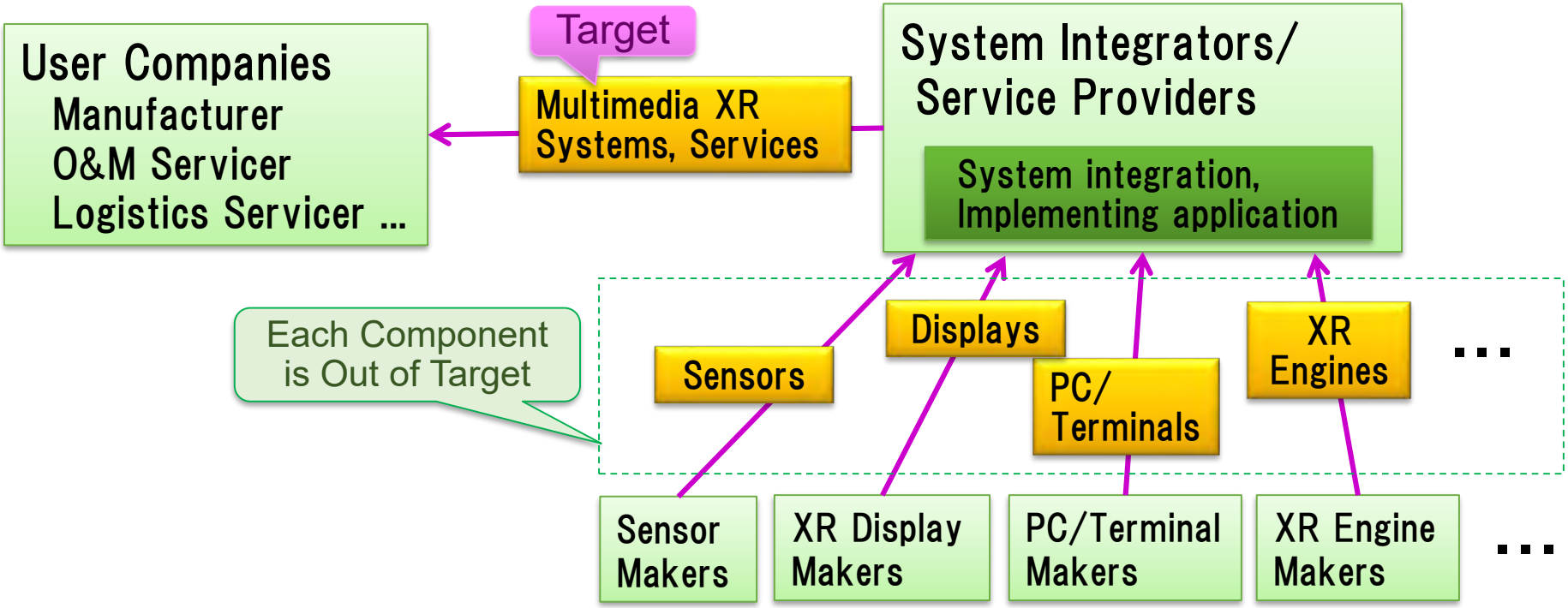
## Business model of System Integrators




User companies just want to know whether the multimedia XR system with application can satisfy with their requirements or not.

For examples: XR application performances, battery maintain time

The purpose is to qualify specification of multimedia XR systems

# Annex A : Use Cases

# A-1. Examples of Use cases

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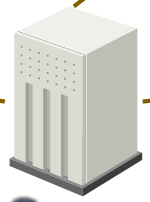
## (1) AR Remote Support System


External Server for Conventional System



Server

Supervisors

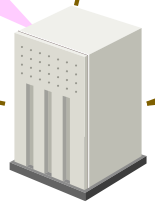
Workers and supervisors can communicates each other.

## (2) VR Instruction System

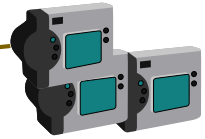

External Server for Conventional System


VR Terminals

Cameras



Server



Extra Sensors

Workers can move in virtual space.

# A-2. Example of Functional Arrangement(1)

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## AR Remote Support System





### AR Terminal

[Functions]
- Sending information such as video, audio, sensing data to the remote management terminal.
- Receiving the instructions from the remote management terminal.
- Indicating instructions.

Information

Instructions

### Remote Management Terminal

[Functions]
- Receiving the information.
- Indicating the information.
- Getting instructions from manager.
- Sending instructions to the AR Terminal.

(In some cases)
- Indicates 3D image at VR head set or VR cave.

The AR terminal can be used with external devices such as scanners, cameras, switches, positioning beacons.

The remote management system and the AR terminal can be connected via a communication server.

# A-3. Example of Functional Arrangement(2)

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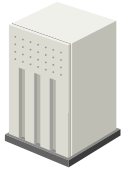
## VR Instruction System





### VR Terminal

[Functions]
- Receiving 3D virtual world information from the management system.
- Displaying 3D virtual world.
- Receiving the instructions from the management system.
- Recognizing triggers such as markers, real world objects, positions, actions, times.
- Recognizing user's direction.
- Sending the recognized data to the management system.
- Indicating the instructions by the triggers.

(In some cases)
- Recognizing user's position.
- Recording markers, real world objects, positions, actions, times.
- Sending the records to the management system.

3D virtual world information

Instructions

Recognized Data

Records

User's Positioning Data

### Management System

[Functions]
- Sending 3D virtual world information.
- Receiving user's position
- Receiving the recognized data from the VR terminal.
- Sending instructions.

(In some cases)
- Receiving the records.

3D Map DB | Instructions DB | Records DB

### Positioning Sensors

[Functions]
- Detecting user's position.
- Sending user's position to the management system

# Annex B : Examples of Existing XR Systems

# B-1. AR System Examples

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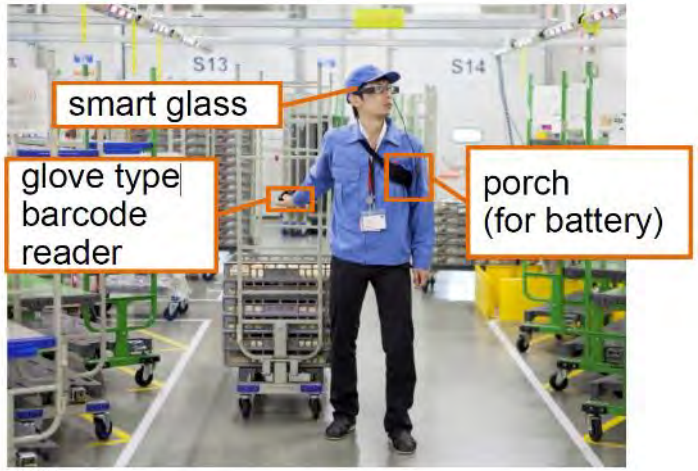
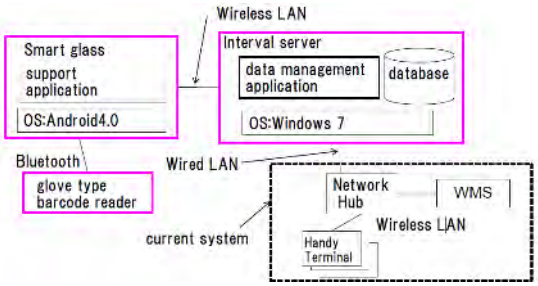
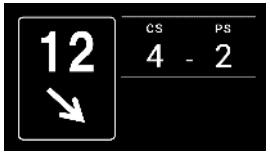
## Business application systems using AR wearable eye glasses, tablets, smart phones have been developed.

### AR Assortment Work Support System in Logistics




Schematic Diagram of the System




[Image on smart glass]
(Black is transparent)

Reference: "An Applied Method for Wearable Device with Assortment Work in Logistics", IDW 2015 (International Display Workshops)

### AR Inspection Work Support System


Schematic Diagram of the System

Reference: Press Release from Hitachi, LTD. , http://www.hitachi.co.jp/New/cnews/month/2015/09/0902b.html

# B-2. VR Systems Examples

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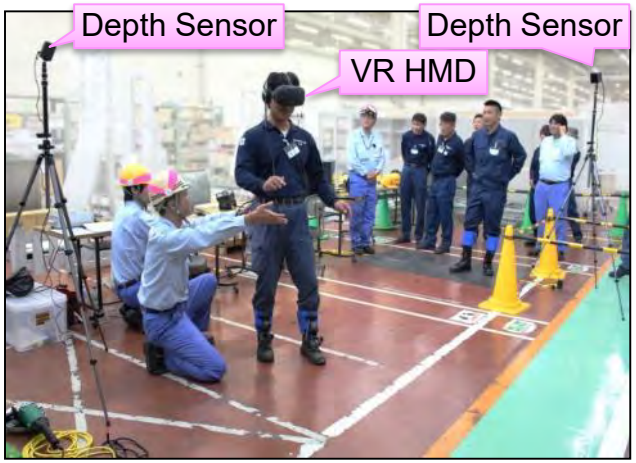
## The business application systems with VR technology is also developed.

### VR High-place Work Training System




Position of worker is detected by depth sensors

Reference: Homepage of Meidensha Corporation
http://www.meidensha.co.jp/products/plant/prod_01/prod_01_01/index.html#ancFree01

### Cave Type VR System for Displaying 3D Data

Using 6 Projectors to Display 3D Around Image

Reference: Homepage of Christie Digital Systems USA, Inc. Japan Branch
http://www.christiedigital.jp/casestady/story/entry_201112080000.php
(Japanese article only)

# Thank you for attention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# Extra Slides:
# Draft document of the first target "Evaluation Methods for XR Systems".

# E-1. Contents of Evaluation Methods for XR Systems

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Introduction

1. Scope
2. Normative References
3. Categorizing of use cases' system models
4. Requirements for each use case
5. Evaluation Methods for each use case

# E-2. Target and scope

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The purpose of the part 2 document is to specify the evaluation method for the XR operation support systems which comprise XR Terminal and operation management server.

There are many AR operation support solutions and systems on the market. And many software houses advertise that they can build AR operation support system.

But user companies can not know whether the system or the solution satisfies their requirements or not because there is no criteria to evaluate the functions of AR operation support systems. On the other hand, AR operation support system makers can not assert the superiority of their productions, because of same reason.

The specific specifications for XR operation support systems are listed below.

1. Delay response on indicating XR objects
2. Space perception and tracking performance
3. Marker recognition ability

# 6-2. First Target: Evaluation Methods for XR Systems

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XR stand alone system evaluation methods with application:
- XR Application performance
- Battery Maintain Time

XR engines evaluation methods:
- XR Algorithm performance

ISO/IEC JTC1 SC21 WG9 cares

XR local system evaluation methods with application:
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Sensor performance evaluation methods:
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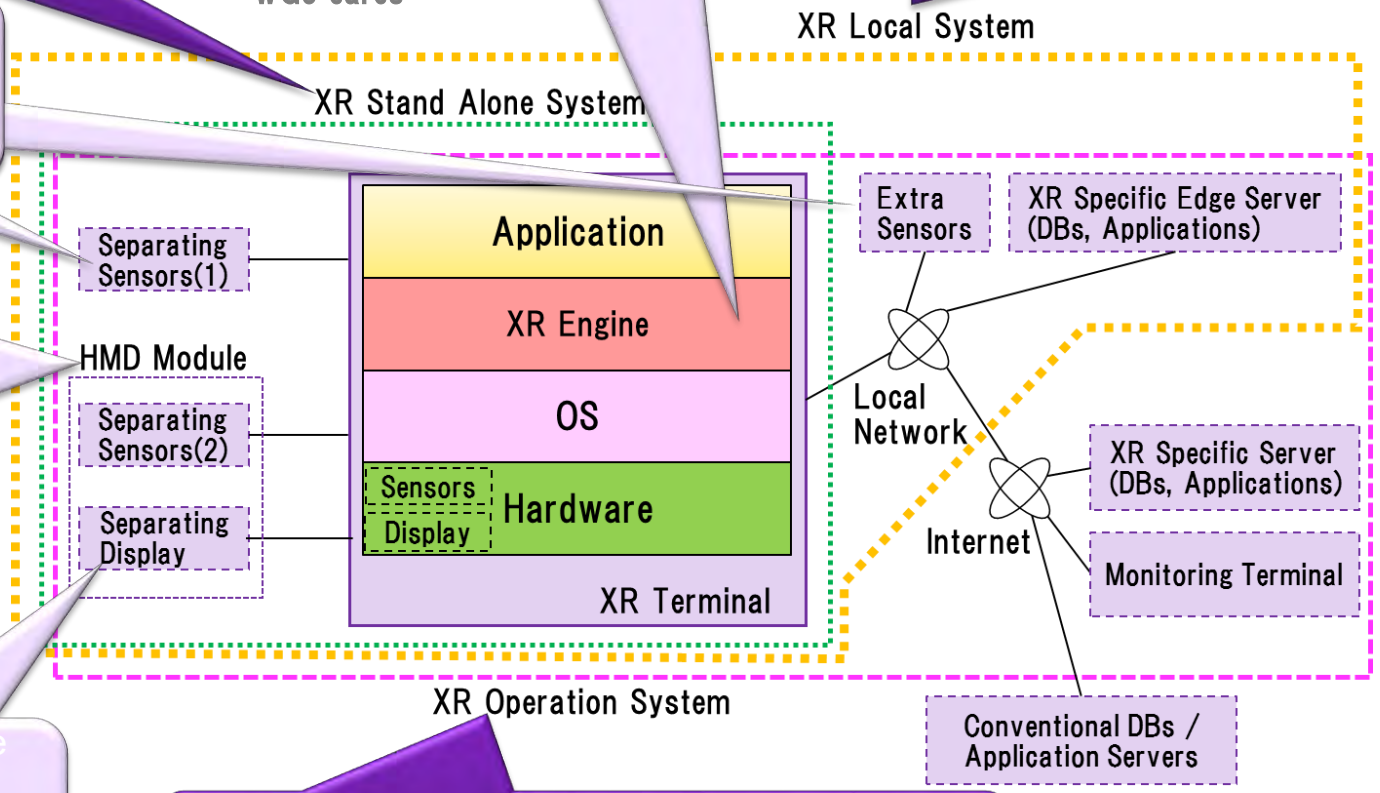
- Battery maintain time




HMD performance evaluation methods:
- Battery maintain time with sensors
- Wearing stability
- Comfortability

Display performance evaluation methods:
- View field
- Luminance
- Energy efficiency

IEC TC110 cares for specifications as a display

XR operation systems evaluation methods:
- XR performance with outside servers and monitoring terminals

# 6-3. Needs of First Target "Evaluation Methods"

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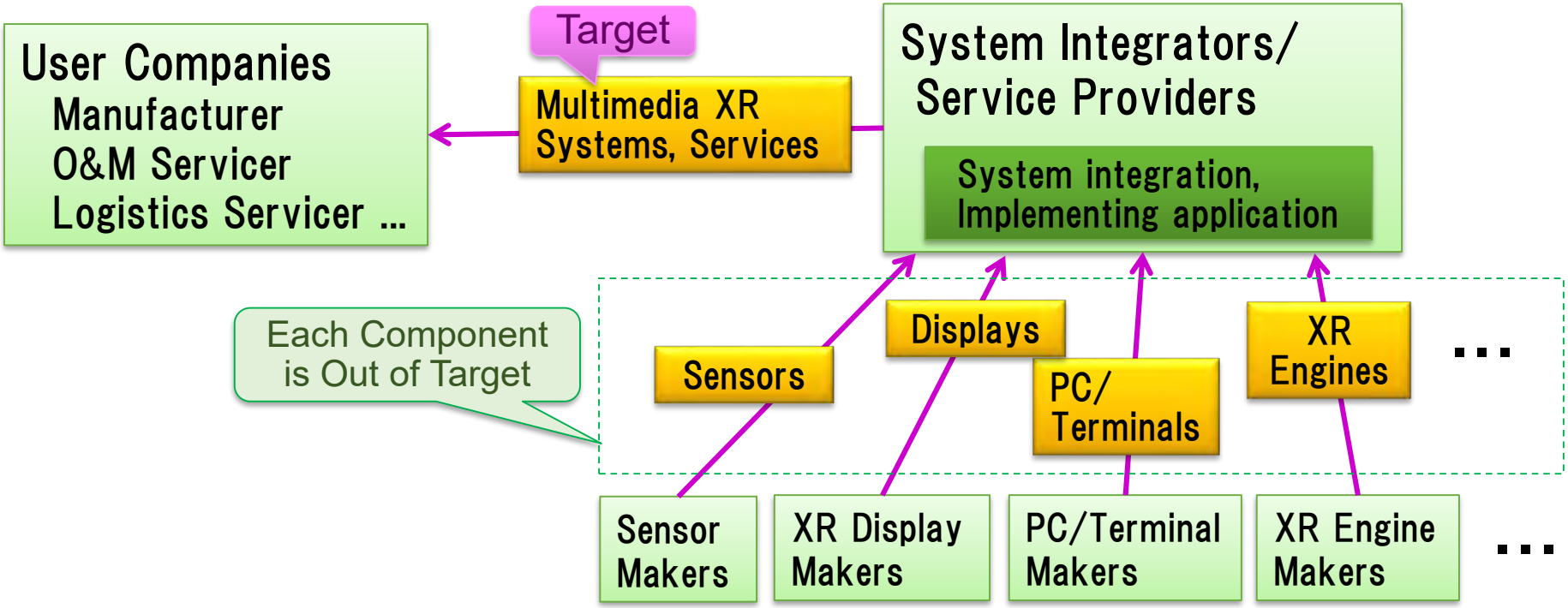
## Business model of System Integrators




User companies just want to know whether the multimedia XR system with application can satisfy with their requirements or not.

For examples: XR application performances, battery maintain time

The purpose is to qualify specification of multimedia XR systems

# E-3. Normative References: ISO/IEC CD 18520

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ISO/IEC JTC1 SC24 focuses on "Computer graphics, image processing and environmental data representation".

SC24 WG9 is now preparing a standard for benchmark method of AR/MR camera tracking algorithms.

ISO/IEC CD 18520 "Benchmarking of vison-based geometric registration and tracking methods for MAR*"


Reference: Koji Makita, et al., "Benchmarking indicators for AR/MR camera tracking", Information Processing Society of Japan SIG TechnicalReport vol.2014-CVIM-190 No.41(2014)

*MAR(Mixed and Augmented Reality)

# E-3. Differences from ISO/IEC CD 18520

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ISO/IEC JTC1 SC24 "Computer graphics, image processing and environmental data representation" has been working for "Mixed and augmented reality (MAR) concepts and reference model". Now they try to make an IS for "Benchmarking of vison-based geometric registration and tracking methods for MAR". But, their target is not a whole system benchmarking but a computer processing function. Their method does not solve above problem because,

1. They uses some standard graphic data for camera image tracking benchmarking, but existing some systems uses not only user eye point camera but a depth camera or some extra outside cameras for tracking.

2. They focus on only a tracking function.

3. They does not focus on variety of real work requirements and variety of real work fields.

Now, we need a whole system benchmarking standard for variety of real work.

The purpose of the part 2 document is to specifies the evaluation methods for XR operation support system.

# E-4. Specific Specification for XR systems

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| Major Items | Minor Items | AR | VR |
|---|---|---|---|
| Delay Response | Time delay between sensing and displaying in a terminal. | ✔ | ✔ |
| | Time delay between servers and terminals. | ✔ | ✔ |
| Space Perception and Tracking | Tracking miss characteristic by long distance moving. | ✔ | ✔ |
| | Tracking miss characteristic by turn around. | ✔ | ✔ |
| | Space perception characteristic degradation by moving. | ✔ | ✔ |
| | Space perception characteristic dependency on luminance | ✔ | ✔ |
| Marker Recognition | Marker recognition characteristic dependency on distance and marker size. | ✔ | ✔ |
| | Marker recognition characteristic dependency on angular of marker. | ✔ | ✔ |
| | Marker recognition characteristic dependency on view field. | ✔ | ✔ |
| | Marker recognition characteristic dependency on luminance | ✔ | ✔ |

# E-5. What is Delay Response in a Terminal

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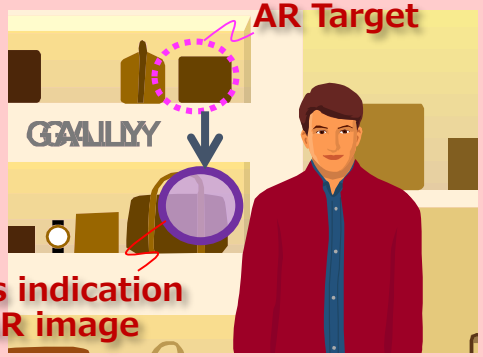
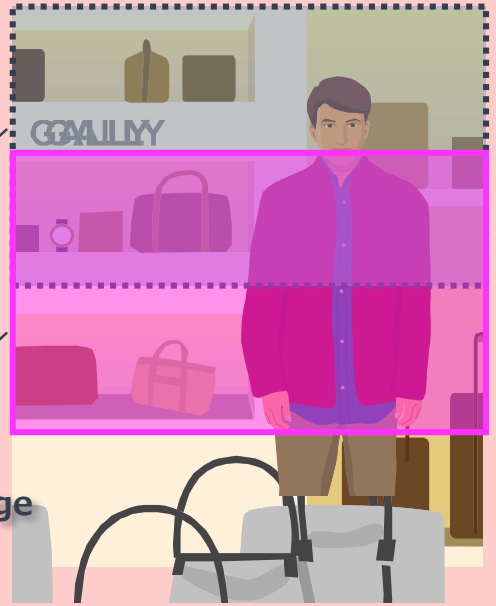
## Time delay between sensing and displaying in a terminal.







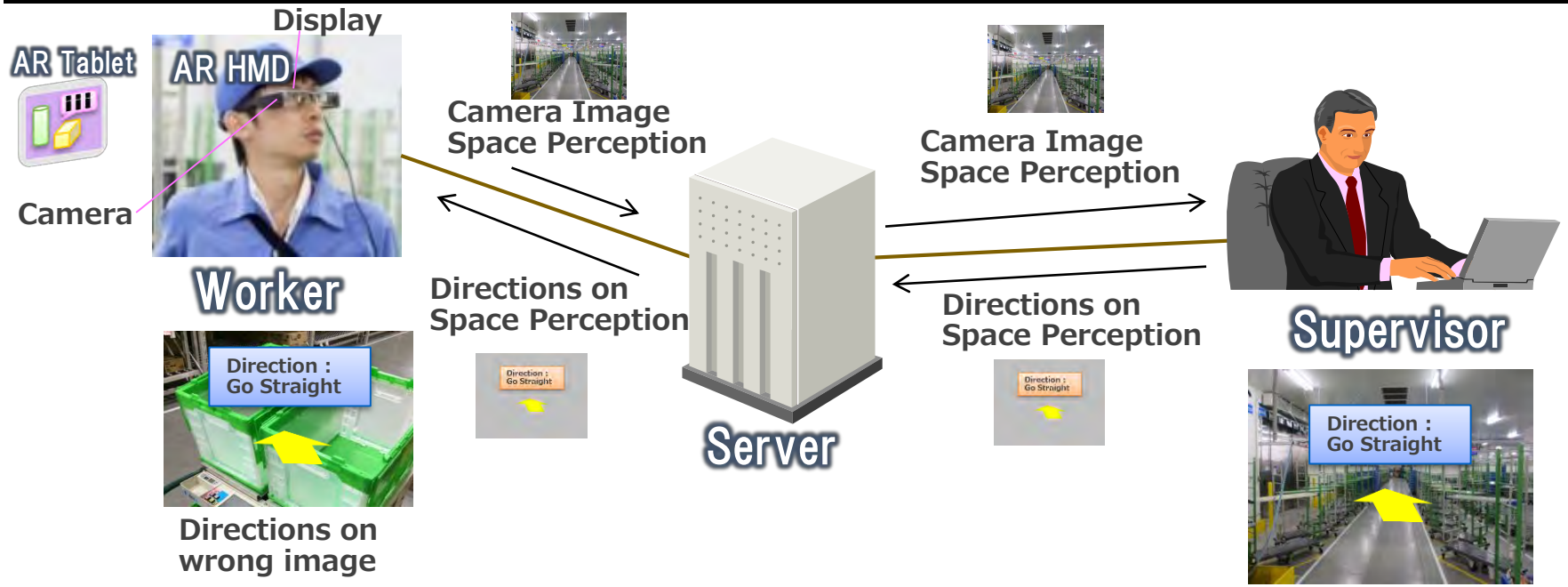



Related Parameters:
- Kinds of glasses model
- AR engine which enable to perceive space around user.
- Display conditions. Ex. definition, frame rate, and so on.

# E-6. What is Delay between Servers and Terminals (1)

HITACHI
Inspire the Next

## Example : Delay Response between AR terminal and PC



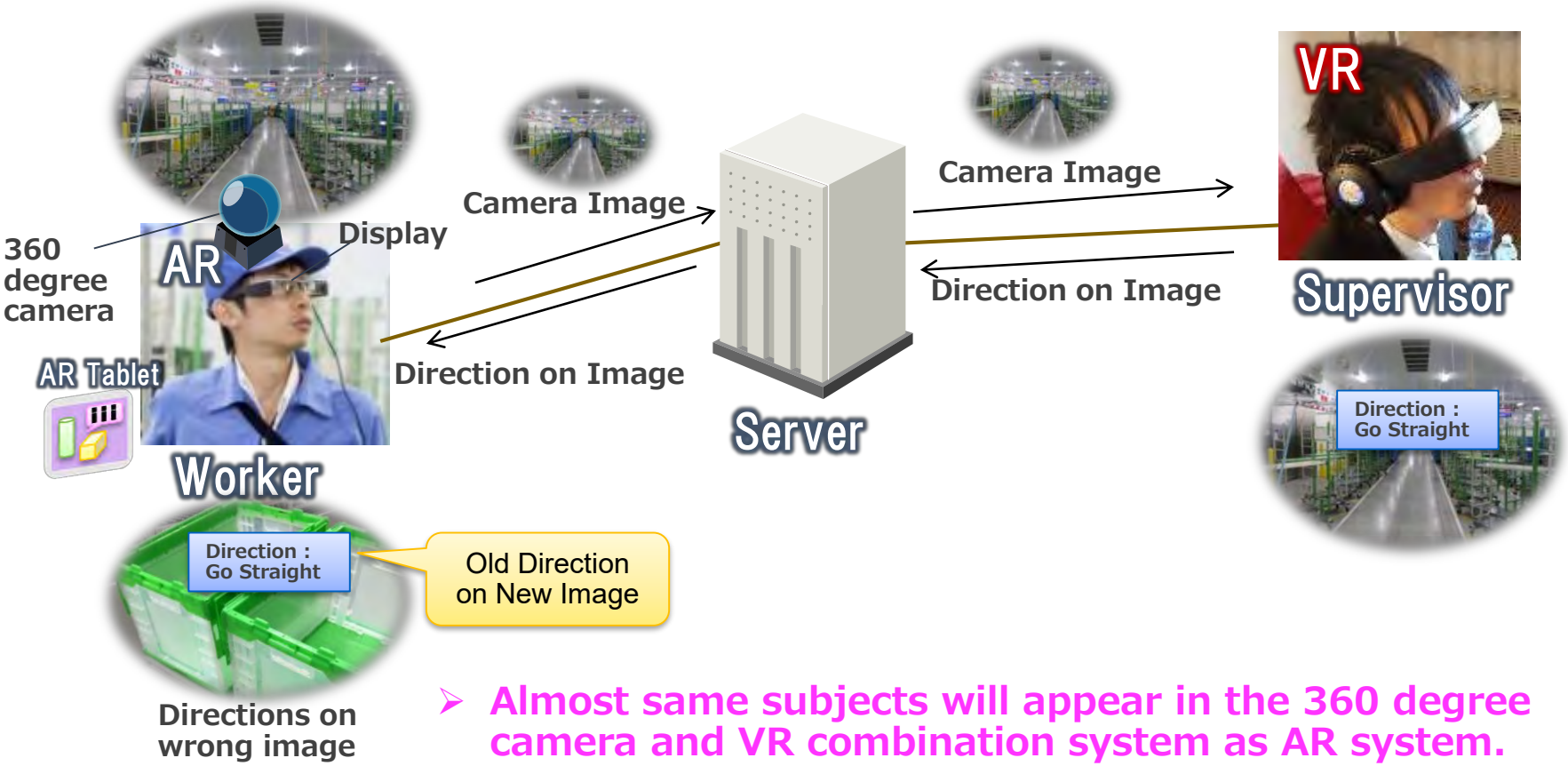

- If the time delay is large, the worker cannot receive accurate directions. In some cases, it cause dangerous situation for workers.
- It also suggests the necessity of communication data standardization.

Related Parameters:
- Kinds of glasses model
- AR engine which enable to perceive space around user.
- Communication Protocol and data semantic
- Display conditions. Ex. definition, frame rate, and so on.

# E-7. What is Delay between Servers and Terminals (2)

HITACHI
Inspire the Next

## Example : Delay Response between camera and VR terminal




- **Almost same subjects will appear in the 360 degree camera and VR combination system as AR system.**

Related Parameters :
- Kinds of glasses model AR and VR
- Communication Protocol and data semantic
- Display conditions. Ex. definition, frame rate, and so on.

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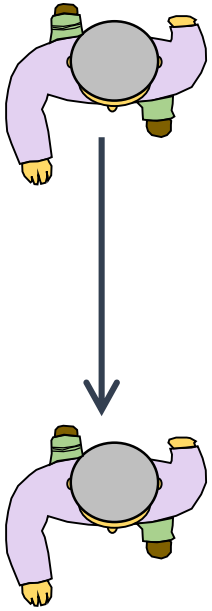
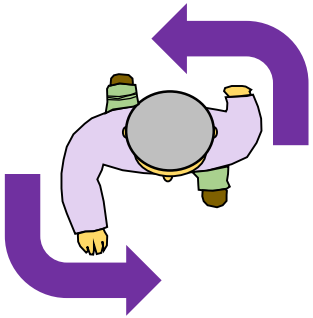
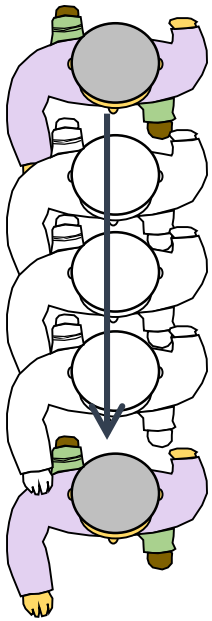
## Tracking ability for moving distance, turning around, or moving speed



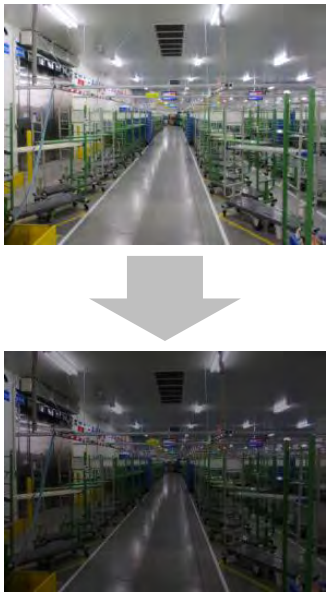
Tracking ability depending on long distance moving



Tracking ability depending on turning around



Tracking ability depending on moving speed



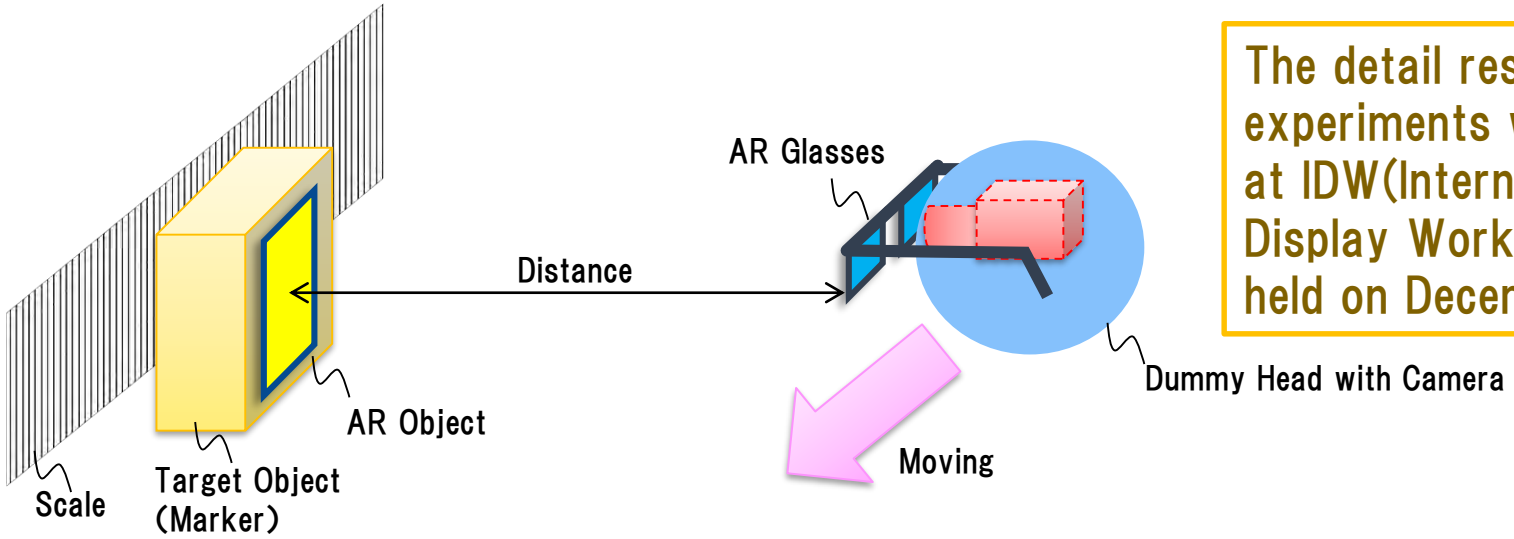
Tracking ability depending on luminance

Related Parameters :
- Kinds of glasses model AR and VR
- Space perception engine
- Moving distance, turning speed, and moving speed
- Luminance
- Display conditions. Ex. definition, frame rate, and so on

# E-9. Experimental Result Examples of Delay Specification

HITACHI
Inspire the Next

Purpose: To evaluate time delay between sensing and displaying in a terminal.




The detail results and experiments will be shown at IDW(International Display Workshop) 2017 held on December.

Results:

| Conditions | | Delay time Result | |
|---|---|---|---|
| Distance | Moving Speed | System A (AR Glasses of A company with C company AR software engine) | System B (AR Glasses of B company included AR Engine) |
| 1 m | 10 cm/s | 6 frame | Less than 1frame |
| | 20 cm/s | 6 frame | 1frame |
| | 30 cm/s | 7 frame | 1frame |
| 2 m | 10 cm/s | 6 frame | Less than 1frame |
| | 20 cm/s | 6 frame | 1frame |
| | 30 cm/s | 8 frame | 2frame |
| 3 m | 10 cm/s | 8 frame | Less than 1frame |
| | 20 cm/s | 8 frame | 1frame |
| | 30 cm/s | 8 frame | 2frame |

＊1 frame = 33.3 ms

Delay characteristic dependency on systems is significant.

It's helpful for users to regulate evaluation method and to show specification.

# Extra Slides: Information for Other Standardizing Groups

# F-1. ISO/IEC JTC 1/SC 24

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## ISO/IEC JTC 1/SC 24 "Computer graphics, image processing and environmental data representation"

<スコープ>
The current area of work for JTC 1/SC 24 consists of:
- standardization of interfaces for information technology based applications relating to computer graphics and virtual reality,
- image processing,
- environmental data representation,
- support for Mixed and Augmented Reality (MAR), and
- interaction with, and visual presentation of, information

<XRに関連するWG>
WG 6: Mixed and augmented reality (MAR) presentation and interchange ←実際にはモーションキャプチャなど3Dモデルの扱い
WG 9: Mixed and augmented reality (MAR) concepts and reference model ←AR/VR系

<作成中文書>

ISO/IEC AWI 21858 ---Information model for mixed and augmented reality (MAR) contents

ISO/IEC CD 18520 ---Benchmarking of vison-based geometric registration and tracking methods for MAR

ISO/IEC CD 18040 --- Live actor and entity representation in mixed and augmented reality (MAR)

ISO/IEC DIS 18039 --- Mixed and augmented reality (MAR) reference model

ISO/IEC AWI 18038 --- Sensor representation in mixed and augmented reality (MAR)

# F-2. IEEE SA (Standards Association)

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## VRAR - Virtual Reality and Augmented Reality Working Group

**Project**

P2048.1 Standard for Virtual Reality and Augmented Reality: Device Taxonomy and Definitions (P)
P2048.2 Standard for Virtual Reality and Augmented Reality: Immersive Video Taxonomy and Quality Metrics (P)
P2048.3 Standard for Virtual Reality and Augmented Reality: Immersive Video File and Stream Formats (P)
P2048.4 Standard for Virtual Reality and Augmented Reality: Person Identity (P)
P2048.5 Standard for Virtual Reality and Augmented Reality: Environment Safety (P)
P2048.6 Standard for Virtual Reality and Augmented Reality: Immersive User Interface (P)
P2048.7 Standard for Virtual Reality and Augmented Reality: Map for Virtual Objects in the Real World (P)
P2048.8 Standard for Virtual Reality and Augmented Reality: Interoperability between Virtual Objects and the Real World (P)
P2048.9 Standard for Virtual Reality and Augmented Reality: Immersive Audio Taxonomy and Quality Metrics (P)
P2048.10 Standard for Virtual Reality and Augmented Reality: Immersive Audio File and Stream Formats (P)
P2048.11 Standard for Virtual Reality and Augmented Reality: In-Vehicle Augmented Reality (P)
P2048.12 Standard for Virtual Reality and Augmented Reality: Content Ratings and Descriptors (P)

Established on December 2016

## AR-LEM - Augmented Reality Learning Experience Model (WG)

**Project**

P1589 - IEEE Draft Standard for an Augmented Reality Learning Experience Mode

Established on February 2015. The target is AR for "e-learning".

# F-3. Khronos Group

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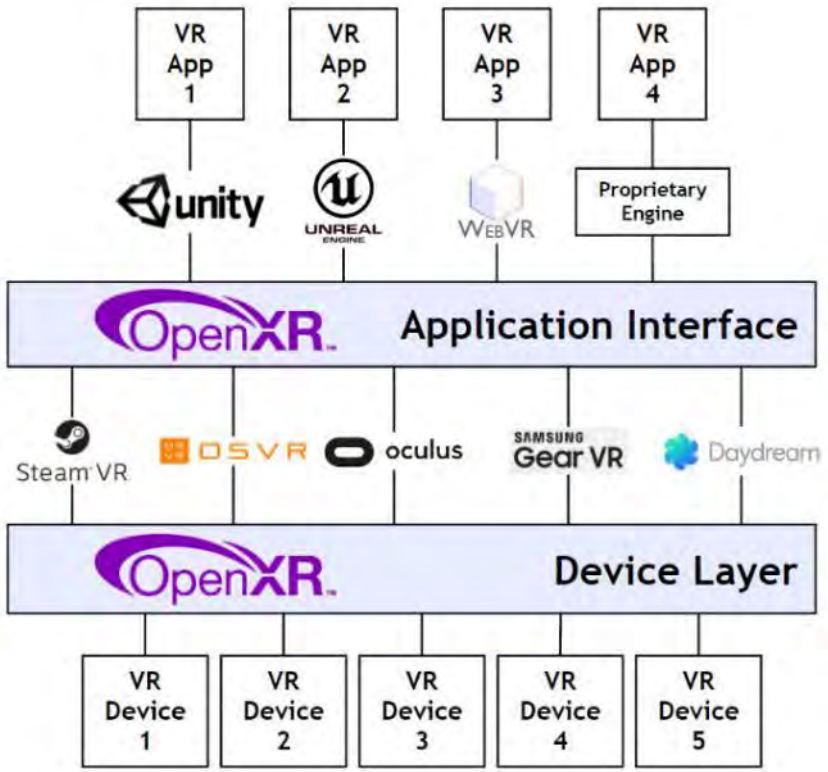
**Khronos Group is an open working group for standardization in USA. Main target is software API specification like OpenGL.**

## OpenXR Working Group

Established in February 2017.



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# AR/VR Special Interest Group

- Establish the hierarchical structure for AR/VR services, including physical connections, data transfer protocols, software drivers and application layers
- Define the basic communication data structure and communication channel between the source and sink devices
- Study the related technologies and algorithms, and standardize them to enable economic and efficient implementation
- Suggest any changes to existing VESA standards that may be needed for better AR/VR support
- Work with other standards bodies to merge suggested changes into related standards

Established on May 2017. Main target is to enhance of Display Port for AR/VR usage.