ETSI GR ARF 002 V1.1.1 (2019-07)

Augmented Reality Framework (ARF)
Industrial use cases for AR applications and services

Disclaimer

The present document has been produced and approved by the Augmented Reality Framework (ARF) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG.
It does not necessarily represent the views of the entire ETSI membership.

Reference

DGR/ARF-002

Keywords

augmented reality, interaction, interoperability, teleservice

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group Augmented Reality Framework (ISG ARF).

The ISG ARF shares the following understanding for Augmented Reality: Augmented Reality (AR) is the ability to mix in real-time spatially-registered digital content with the real world. The present document describes the most relevant use cases identified via a survey conducted with the help of an online questionnaire.

Modal verbs terminology

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

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Executive summary

The present document summarizes the results of a questionnaire issued by the Industry Specification Group Augmented Reality Framework (ISG ARF) on industrial use cases and reviews of two workshops held by the ISG ARF, where a number of use cases were presented. These results are presented in categories such as:

- most relevant use cases;
- challenges of AR;
- scale of operation;
- accuracy for the positioning of augmentation;
- data sources for augmentation data;
- data security;
- data sharing;

- mode of operation;
- environmental conditions; etc.

Based on this analysis it is possible to identify the most relevant parameters and operational conditions for Augmented Reality in the industry and thus elaborate a requirements document for industrial use cases.

Introduction

The Industry Specification Group Augmented Reality Framework (ISG ARF) has been established to synchronize efforts and identify key use cases and scenarios for developing an Augmented Reality (AR) framework with relevant components and interfaces and to provide technical requirements for AR specifications in order to ensure interoperable implementations that will benefit both technology providers and end-users. The first step of the work of the ISG ARF was to collect the most relevant use cases in the industrial sector and to identify the required operational conditions for these use cases.

1 Scope

The present document presents and classifies industrial use cases for AR applications and services. It forms the basis for the requirements document to be drafted ETSI GS ARF 004 [i.2].

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

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

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

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

[i.1] ETSI GR ARF 001: "Augmented Reality Framework (ARF); AR standards landscape".

[i.2] ETSI GS ARF 004: "Augmented Reality Framework (ARF) Interoperability Requirements for AR components, systems and services".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

digital twin: virtual representation of a physical product or process, used to understand and predict the physical counterpart's performance characteristics

3.2 Symbols

Void.

3.3 Abbreviations

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

2D	2-dimensional
3D	3-dimensional
AG	Aktien Gesellschaft
AR	Augmented Reality
ARF	Augmented Reality Framework
ATEX	ATmosphères EXplosibles
CAD	Computer Aided Design
CBRN	Chemical, Biological, Radiological and Nuclear

DCC	Digital Content Creation
FoV	Field of View
HAZMAT	HAZardous MATerials
HHI	Fraunhofer Heinrich Hertz Institute
HMD	Head Mounted Display
IEM	Fraunhofer-Institut für Entwurfstechnik Mechatronik
IFF	Fraunhofer-Institut für Fabrikbetrieb und -automatisierung
IoT	Internet of Things
ISG	Industry Specification Group
IT	Information Technology
LIST	Luxembourg Institute of Science and Technology
OS	Operating System
QR	Quick Response
SLAM	Simultaneous Localization And Mapping
TM	Trade Mark
TV	Television
WIFI™	Wireless Ethernet

4 Overview of industrial Use Case analysis

The following overview is the result of a survey based on an online questionnaire (see Annex A) carried out in the period between February 28th and May 1st 2018 and a review of contributions to the two ARF workshops in Berlin and Paris (see Annex B).

Altogether 77 persons from 16 countries responded to the questionnaire. The distribution of countries was as follows:

- 43 % from Germany
- 24 % from France
- 5 % from Canada
- 5 % from USA
- 5 % from Spain
- 5 % from Italy
- 13 % from other countries

Most responses came from the general "Technology" sector (21 %) followed by Academic Research (18 %) and IT (15 %). Other distinct sectors were automotive (6 %), basic industries (6 %), consumer services (4,5 %), education (4,5 %). The remainder (around 25 %) of the responses was distributed over other sectors (e.g. energy, finances, aerospace, telecommunication, media). Among the occupations of the participants "Research" clearly dominate (32 %), followed by "Architecture and Engineering" (17 %), "Computer and Mathematical" (12 %) and "Management" (12 %). 57 % of the participants defined themselves as "Technology Providers" and 35 % as "Technology Users". The expected benefits of AR technologies showed a rather homogenous distribution over the different areas, with a slightly higher ranking of "Better Training Methods" (50 %).

The following benefits of AR technologies are expected:

- Better training methods (50 %)
- Increasing sales (31 %)
- Better productivity (31 %)
- Better quality of products (27 %)
- Better traceability of operations (23 %)
- Better security for workers (19 %)

- Other (31 %)

Other specifically mentioned benefits were:

- better information delivery;
- visualization of sensor data through digital twins and IoT sensors;
- new research possibilities;
- remote diagnostics;
- help in diagnostics;
- process acceleration;
- higher level of information for decision making;
- easier documentation;
- faster reaction for remote assistance;
- buying decision information;
- faster and better service;

which however in most cases could also be assigned to the categories listed above. Answers illustrate the holistic nature of AR.

The participants were also asked, what their level of maturity with respect to AR usage is. The answers showed a rather homogeneous distribution with values between 9 % and 18 % over the seven categories ranging from "we never heard from AR" to "we already deployed an operational solution". Almost 60 % already work on AR solutions, either by conducting some pilot studies (14 %), proof-of-concept studies (17 %), deploying operational solutions (9 %) or already running operational solutions (18 %).

The most relevant Use Cases are shown in Figure 1.

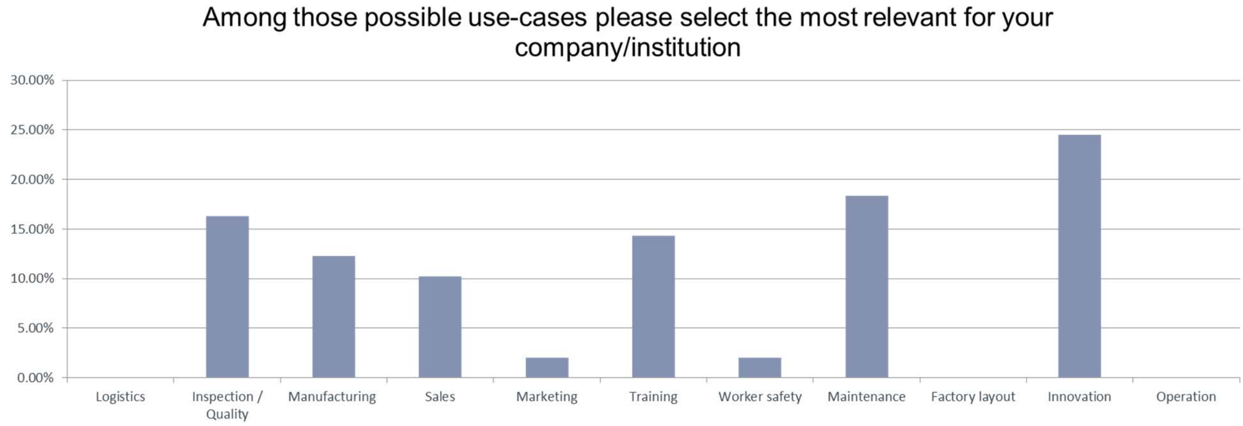

Figure 1: Most relevant Use Cases mentioned in the questionnaire

Surprisingly, sales & marketing does not hit the top three use-cases among the participants of the survey and logistics, worker safety and factory layout planning were not identified among the priorities. This may be attributed to the limited number of answers to the questionnaire and imbalanced profiles of the participants over all business sectors.

As far as operating systems for AR devices are concerned, Android^{TM} is the dominant OS (43 %) followed by Windows^{TM} (25 %) and iOS^{TM} (23 %).

The main challenges identified in the questionnaire are summarized in Figure 2.

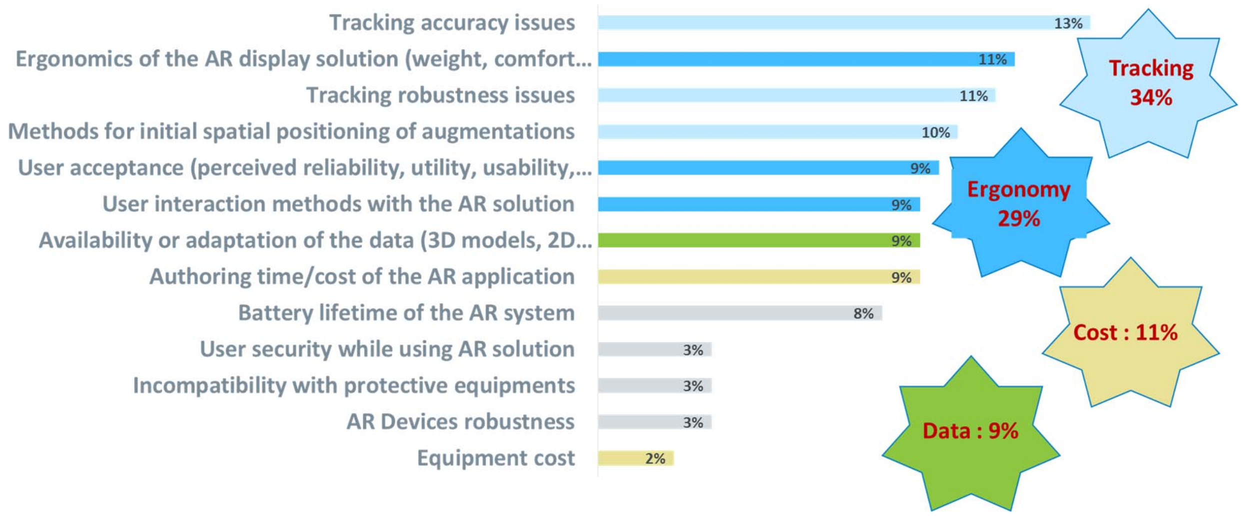

Figure 2: Today's challenges for AR

Tracking accuracy and robustness, initial positioning (34 %) and ergonomics of AR devices resulting in limited user acceptance (29 %) are the dominating challenges. Availability or adaptation of data and authoring time/costs are other important challenges as well as battery life time.

In spite of these challenges participants declared a stronger AR demand and a higher acceptance of AR during the last two years.

Additional information on industrial use cases could be gathered during the two workshops held by ISG ARF in Berlin (1.2.2018) and in Paris (23.5.2018). There were a number of presentations on use cases from various fields. An overview of these presentations can be found in Annex B. The structure of Annex B is the same as in the questionnaire, however there is not always information available for every category, therefore it is difficult to get quantitative results from this overview. However, this overview supports the general outcome of the questionnaire.

5 Usage conditions

5.1 Overview

This clause describes the usage conditions of AR technologies regardless of the use cases as expressed in the responses to the online questionnaire (see Annex A). It is subdivided into "Usage environments", "Operating conditions" and "Augmentation data sources".

5.2 Usage environments

The scales of usage vary from "Letter Scale (A4 letter size)" to "World Scale (~1 000 m^2)", while "Room Scale (~10 m^2)" is dominating (39 %). The given values are depicted in Figure 3.

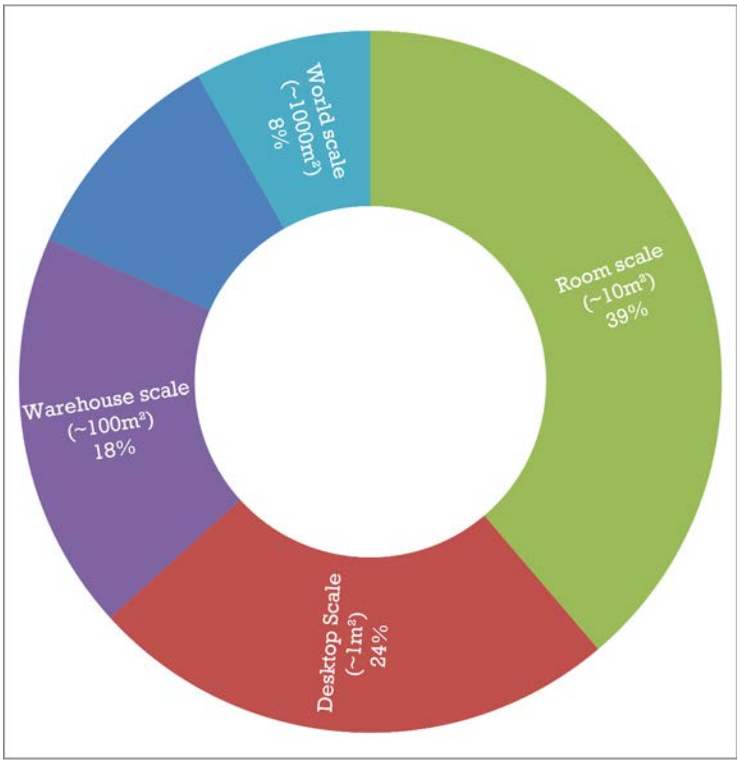

Figure 3: Room scales for AR applications

In addition, in 43 % of the responses there are user friendly or office conditions, in 47 % the conditions are medium difficult, which may include dust or water projection, mid temperatures and small vibrations. Only 10 % are extremely hard conditions, e.g. direct rain exposure, high temperatures, a lot of dust and high vibrations.

5.3 Operating conditions

65 % of the participants want the AR user to have his hands-free while using the solution. 85 % of the respondents want the augmentations to be precisely located relatively to a real equipment or object. 73 % of contributors expect an accuracy of a few millimetres or under. In 88 % of the cases a viewing distance of less than 5 meters to the object (44 % close to hand) is required. 41 % expect the augmentation to be shared among several users, which has significant implications for the use of head-mounted displays.

In 57 % of the cases there is a model evolving over time (e.g. step by step assembly of a mechanical structure), in 43 % it is static.

In 63 % of the cases the scenes to be augmented are mostly static, whereas in 37 % there are moving objects or persons.

5.4 Augmentation data sources

78 % of the participants identified CAD models as source of information for AR application. 52 % of these data have a high level of confidentiality. These data have to be stored on sovereign clouds, internal servers or on the AR devices with an extremely high secure access control.

6 Detailed description of the 4 dominant Use Cases

Besides "Innovation" the most dominant Use Cases identified in the survey are:

- Inspection/quality
- Maintenance

- Training
- Manufacturing

Therefore, these four Use Cases are taken as the basis for a more detailed analysis. They will also be used to identify relevant standards or lacks of and to define the further activities of the ISG. "Innovation" has been disregarded, although it has the highest score in Figure 1, because "Innovation" is not really an industrial use case but rather reflects that many participants in the questionnaire came from universities or research institutes. Therefore, the answers from academia have also been disregarded from the subsequent analysis, although comparison shows that results with or without academic institutions are not significantly different.

Disregarding the answers of academic institutions 55 % of the answers to the questionnaire came from technology providers whereas 38 % came from technology users (see Figure 4).

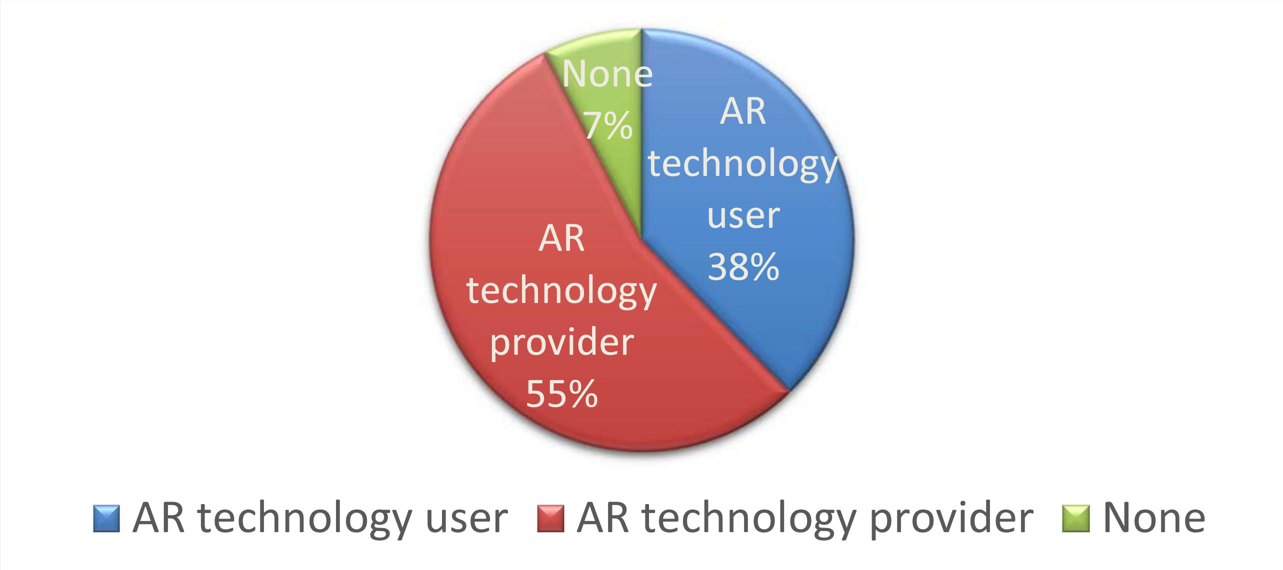

Figure 4: Participant's profile

With respect to augmentation precision, there are different requirements concerning the accuracy in the four main use cases. While inspection and training require accuracies of a few millimetres or even below, maintenance and manufacturing partially accept higher tolerances (see Figure 5).

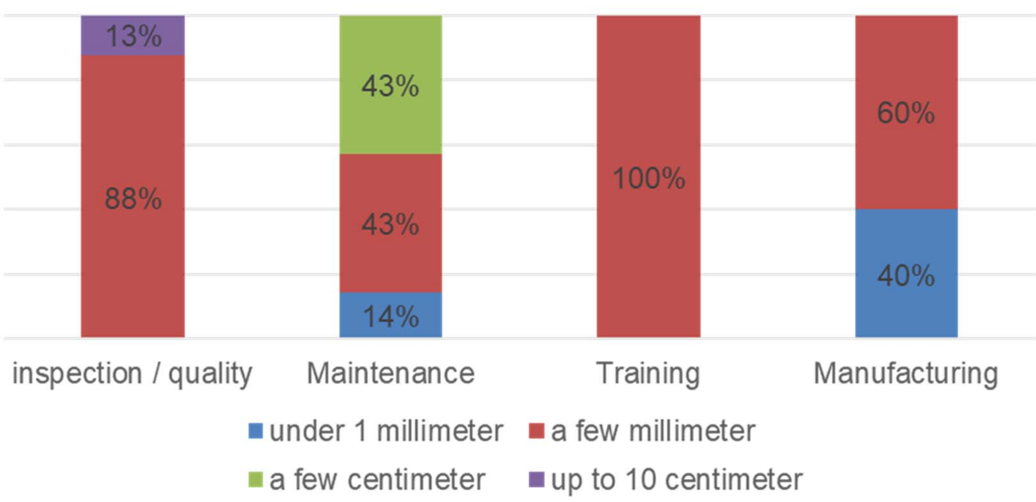

Figure 5: Accuracy of augmentation

73 % of the respondents identify CAD models as a possible source of information for augmentations.

As far as security is concerned, 52 % of the participants declare their data need a high level of confidentiality. For them data have to be stored on sovereign cloud, internal server or on the device with an extremely high secure access control.

Sharing the viewing of augmentations between several users is expected by 60 % of the participants. This has significant implications for the use of head-mounted displays. However, this is also depending on the use case (see Figure 6).

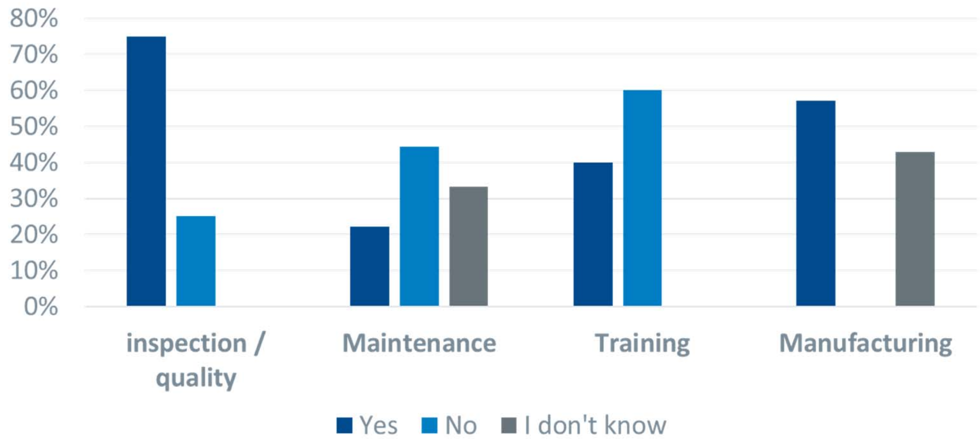

Figure 6: Sharing the viewing of augmentations

For 65 % of participants it is required to have their hands free while using the AR application. However, this is also depending on the use case (see Figure 7).

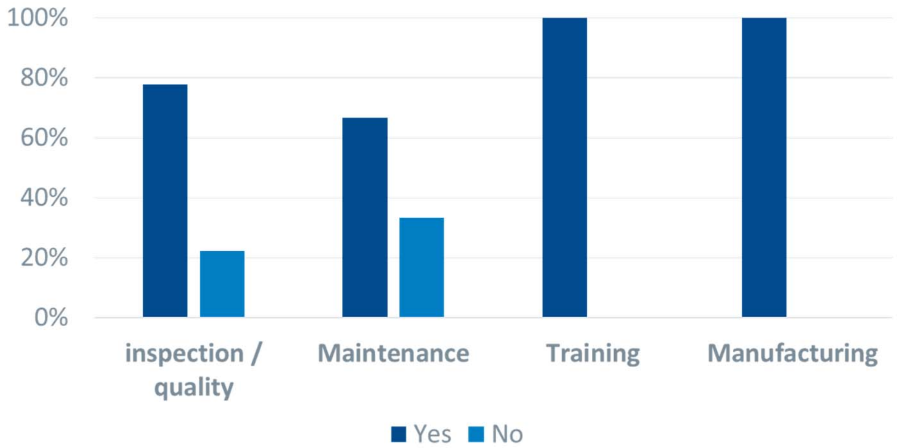

Figure 7: Percentage of hands-free operation

In about 2/3 of the use cases the environment or area of interest is evolving over time (e.g. step-by-step assembly of a mechanical structure) as depicted in Figure 8.

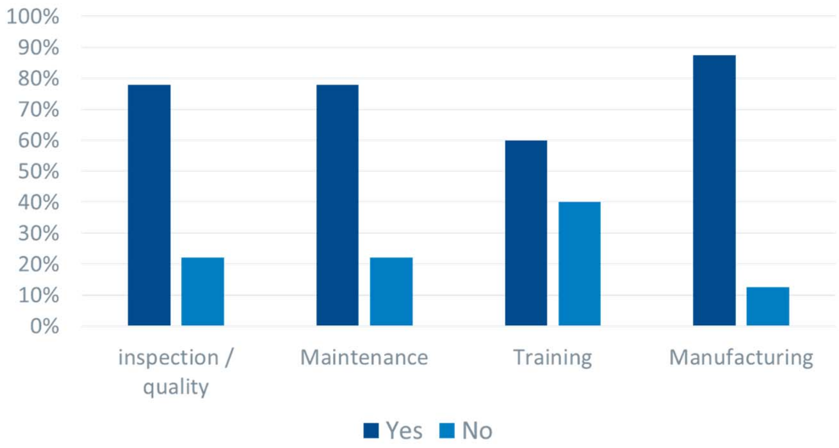

Figure 8: Percentage of evolving augmentations

Room-Scale (area of ~10 m²) is the predominant size of AR usage for the participants. However, extreme values (Letter scale or World scale) are also mentioned several times (see Figure 9).

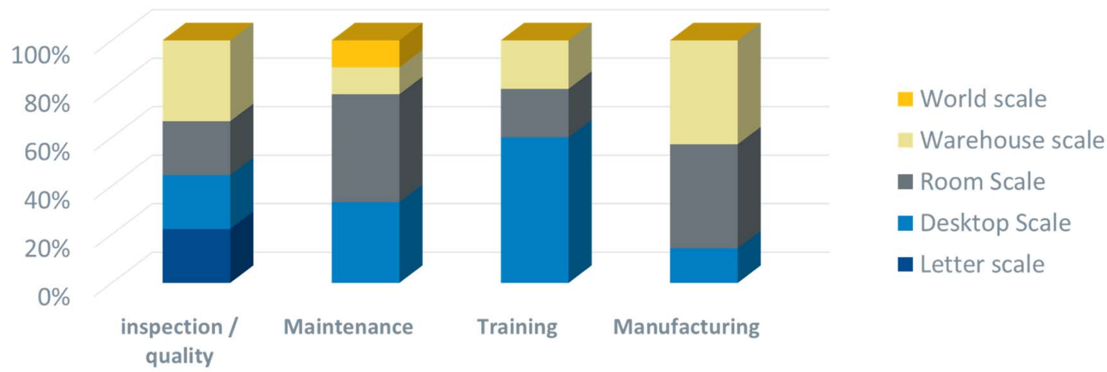

Figure 9: Size of the area of interest, where augmentations may occur

With respect to dynamics, in about 40 % of the use cases there are moving objects or people, around or inside the area where augmentations are located; in 60 % of the use cases the objects are static.

With respect to environmental conditions more than 70 % of the users operate under medium to hard conditions (see Figure 10). 19 % of participants declare the working environments are even subject to explosive atmospheres (ATEX certified devices required).

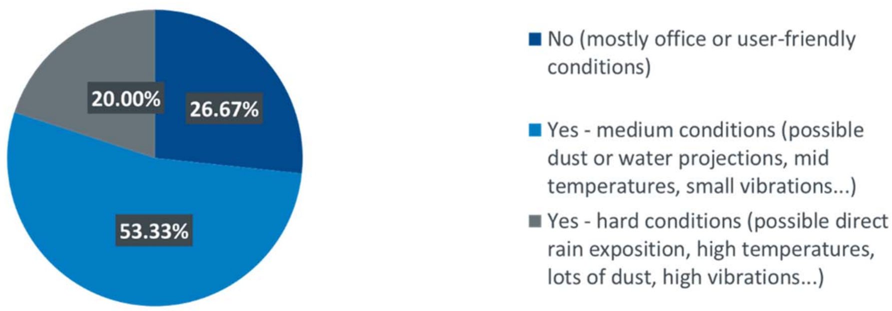

Figure 10: Environmental conditions of AR applications

As shown in Figure 11, Android™ is the dominant operating system in AR application (46 %), followed by Windows™ (28 %) and iOS™ (19 %).

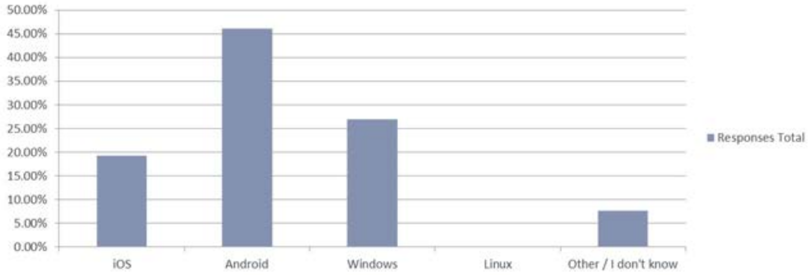

Figure 11: Share of operating systems in AR applications

The remainder of this section is dedicated to benefits and challenges of AR. Figure 12 describes the expected benefits of AR in the four main use cases.

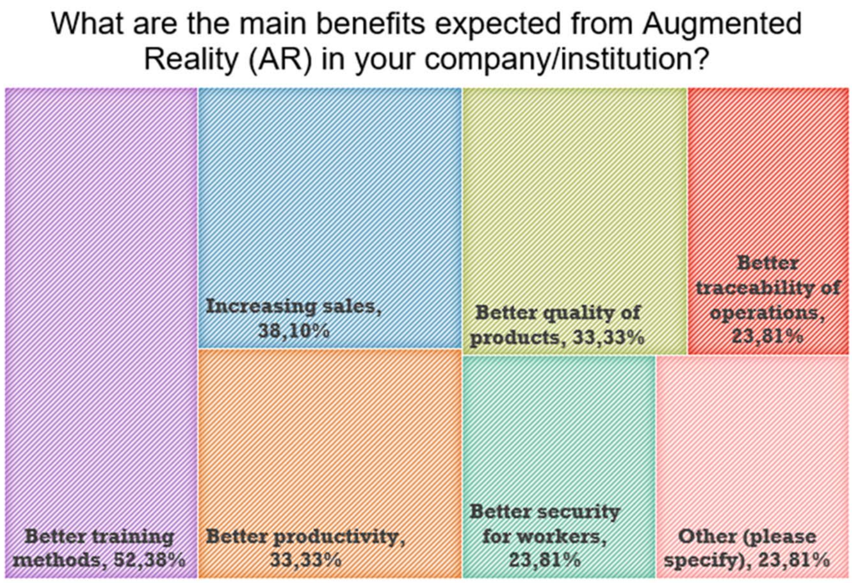

Figure 12: Expected benefits from AR usage

A rather homogeneous distribution of responses has been noted, which illustrates the holistic nature of the uses of augmented reality. Training is identified as the main outcome of Augmented Reality.

7 Typical industrial Use Cases

7.1 Overview

In the following clauses, four typical use cases are described, which belong to the four categories mentioned in clause 6.

7.2 Use Case 1: Wireless network and IoT installation

7.2.1 Context

In the industry, but also at home, wireless networks are backbones that support numerous devices and objects from the Internet of Things.

The deployment of that kind of infrastructure in factories or at home is sometimes complex due to the intangible nature of wave propagation. An interesting challenge is how to place emitters and repeaters to optimize the wireless coverage.

Once the coverage is well tailored and established, the installation of the connected objects is another interesting challenge. The objects have to be identified and integrated safely in the network, but also localized with their position and orientation in the real world. Indeed, this location information is highly valuable to provide smart contextual services to the end user.

A typical use of the position of the object is to provide access to information or to an interface on the objects that are in the user Field of View (FoV). It can also be used to ease the construction of home automation scenarios involving different objects; making a switch command different sets of lamps or blinds for example.

AR can greatly facilitate the wireless network deployment, the installation of objects, and afterwards, it could also help provide rich contextual services to use or to service them.

7.2.2 Scenario

7.2.2.1 Objectives

The present scenario describes how AR can help to build a map of the environment to forecast the wireless coverage, and to place radio emitters and repeaters.

Then AR will be used to ease the installation of sensors, actuators and all kinds of smart devices.

7.2.2.2 Building the map of the environment to be equipped

The installation technician takes an AR enabled device. Thanks to a SLAM algorithm, the device is constantly geolocalized. The technician can point the camera of the device successively towards each wall to get their normal vectors. From the sequence of normals, the position of each wall can be deduced. Then the shape of the room can be modelled by intersecting the identified walls.

The technician can then point to the borders of each aperture, i.e. doors and windows, to add them to the map.

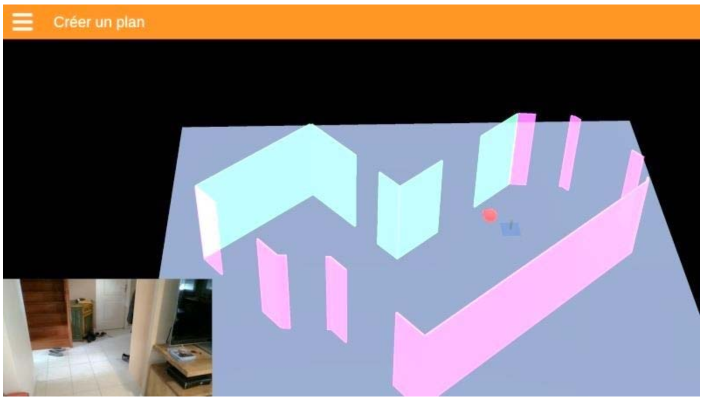

Figure 13: Resulting room map

Figure 13 presents walls, whose colours indicate their material, and voids indicating where the different apertures are.

7.2.2.3 Checking the radio coverage

Once the environment map is built, a place for the WIFI emitter to be installed may be chosen. The emitter position and the map information will now feed a prediction tool to compute the WIFI coverage as shown in Figure 14.

Figure 14: Resulting WIFI coverage prediction

The same map could be used to evaluate the coverage for other wave length and technologies like those generally used by IoT standards.

7.2.2.4 Placing connected objects in the environment

Once the coverage has been checked, IoTs may be deployed and sensors, actuators and other smart devices may be placed throughout the house.

Each object is associated with a digital twin, or "digital avatar". This virtual representation of a real object is made of two parts.

A visual representation can be seen through an AR enabled device as shown in Figure 15. It is collocated with the real object, and indicates that the user can get some information from it, by pointing at it for example.

A hidden part contains the information about the object and could also provide a handle to access it.

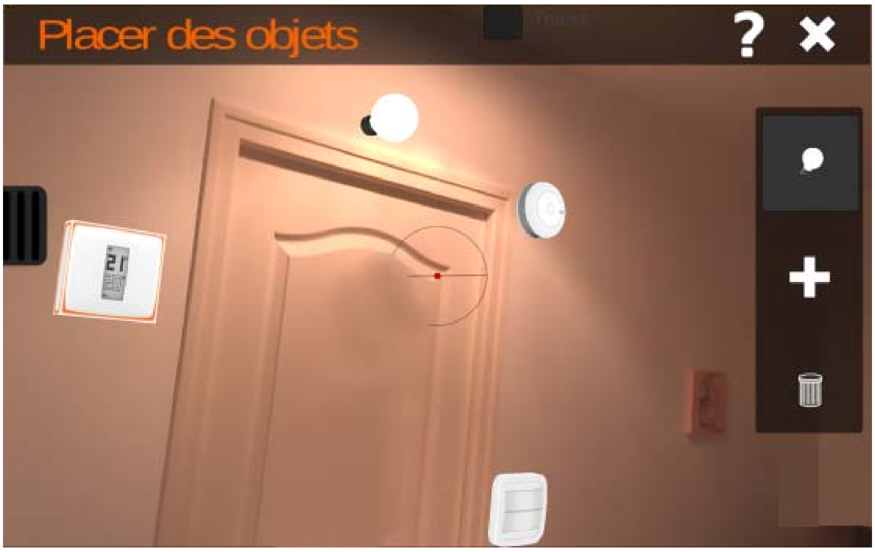

Figure 15: Digital avatars placed in the real world

The augmented reality device will allow to anchor the avatar near or over the real object and to establish a link between them.

7.2.2.5 Searching and selecting objects

As said before, by using an AR enabled device, the user will be able to see the avatars associated with each object and to directly interact or service it.

7.2.3 Advantages

The scanning of the environment to build a map can be performed quickly by anyone without the need of dedicated measuring equipment.

The positions of the objects are stored with a simple point and click operation.

Interacting with the objects is performed in the same way.

7.2.4 Needed characteristics

In every step of the scenario, the user's smartphone has to be rigorously and robustly registered with the real environment, and be able to quickly relocate in case of position loss.

The system has to be able to:

- Get the normal of a wall even if it is not textured.
- Extract a valid plane even from a small point cloud area.
- Position anchors in the real world to hook digital twins associated with each IoT, and share them with all the users who need to interact with them. A centimetre scale precision is enough.

7.3 Use Case 2: Service Remote Support

7.3.1 Introduction

In today's competitive working environment cost and time pressure are business-relevant issues for service and maintenance and in a world of more and more connected work flows there are rising demands on availability and service quality. Additionally, the technical complexity of solutions is increasing as well as the amount of data that needs to be processed and evaluated as part of the work process.

The transfer of knowledge is essential for guaranteeing a certain level of service quality and experience and skills need to be transferred fast and efficiently to employees and subcontractors. The well-known paper-based documentation is upgradable in an extensive way but there are no feedback functions foreseen and its usage can become impractical, especially for outdoor activities. Documentation has to be kept up-to-date and it should be centrally provided without any media disruption. The level of detail of such a documentation needs to be adaptable to the problem that needs to be solved and to the knowledge of the employee. Newcomers may get a step-by-step description whereas experts only have to check items provisioned by a check list.

7.3.2 Supporting functionalities in an AR environment

Figure 16 demonstrates an example for working in an AR environment. It shows the AR-supported wiring inside a switching unit.

Figure 16: Wiring inside a switching unit

In order to make such a scenario happen as shown in Figure 16, new functionalities have to be developed and included into the current working process. These functionalities are as follows:

- Display of documentation in the AR device
- Easy handling of documentation by voice and gesture control
- Sharing of documentation with remote support
- Display of information for step-by-step instructions via augmentation directly into the working area
- Adaptation of information display depending on the actual field of view
- Level of supporting details can be selected by the worker
- Remote support for the connection to experts for video based guidance

7.4 Use case 3: Training

7.4.1 Context

NOTE: This work has been carried out within the framework of the EU H2020 TARGET project and the system presented was developed by the Luxembourg Institute of Science and Technology (LIST). At the time of writing the system is still being improved.

At present, law enforcement and rescue agencies train their staff for radiological incidents using three distinct modalities:

- physical simulations (using live sources, simple mock-ups or simulants);

- multimedia simulations;
- desktop-based simulations.

Physical simulations provide a level of training which is the closest to real conditions, and can be used as mission rehearsal exercises and to improve readiness. Using real resources, physical simulations are expensive, mobilising resources that could be spent elsewhere for the time of the training, and may put these resources at risk. Multimedia and desktop-based simulations do not have these drawbacks but instead lack fidelity, in particular equipment fidelity. This kind of training (e.g. Command Post Exercises, Tactical Exercises without troops, etc.) can be well suited for strategic, and tactical-level operator training but clearly lacks simulation fidelity for operational-level operators.

Firearm training simulators (for instance VirTra V-ST Pro™) address this problem by providing operators with real equipment and allowing them to shoot munitions on videos beamed on a screen. While these simulations are less expensive than physical simulations, are photo-realistic and offer hands-on training, they do not allow for real operator movements.

7.4.2 Application scenario

Chemical, Biological, Radiological and Nuclear (CBRN). This scenario consists of using Augmented Reality and real world objects to simulate a clandestine radiological laboratory using simulated detection devices and radiological sources. The aim is to let teams train in the detection, identification and ultimately the extraction of dangerous materials while guaranteeing the involved operators' safety. Augmented reality allows for a safer training (than using simulants or live sources) and importantly can be used to display contamination or dispersal of chemicals, etc. which cannot normally be seen.

The primary points for the training are as follows:

- The first responders (2 person team) enter into a suspicious room such as a clandestine laboratory. They have to check the area for any dangerous substances and measure the dose level.
- The trainees use virtual devices to simulate the detection equipment that such a team would be able to use.
- Radiological substances are simulated and can be displayed in the augmented reality.
- The first responders have to work in personal protective suits.
- A minimum of two trainers is required to arrange and support the training from professional personal development perspective.

7.4.3 System requirements

7.4.3.1 Overview

For the training scenario environment, augmented reality is used. This implies that some objects are real, namely there is one bed, one table, simple laboratory set, possibly other accessories (e.g. bottles or boxes) and some objects are virtual, including selected radiological substances and simulated casualties (see Figure 17). Training scenario is focused on the operational/tactical level. The primary objective is to train first responders on site in radiological procedures.

Figure 17: AR HAZMAT training scenario

7.4.3.2 Requirements analyses

The requirement was to have the modelling of the dispersion of dangerous radiological elements in an Augmented Reality Scene while optionally giving visual and aural clues to the user. Typical CBRN dangerous elements include: fluids, gases or solids. In this case, it was particularly interesting to model radiation contaminating elements that might be spread into a scene while performing tasks, for example if the first responders touch multiple surfaces and therefore spread some radiation.

Augmented reality has a significant advantage over virtual reality in that the trainees can visit a real environment (e.g. an office) and add to this some virtual elements. This allows them to see, touch and interact with a mix of the real world surrounding environment and the augmented reality aspects, therefore potentially improving the experience.

In order to extend the richness of the real elements of the scene, the possibility to designate as many of them as needed as contaminable objects was required. That is, such designated objects should become contaminated if they come into contact with contamination sources. Furthermore, virtual objects and elements of the scene should also be contaminable. In addition to detecting contamination, visualisations may be added so that the trainees can see which areas have become contaminated.

At the end of the exercise, all CBRN personnel should pass through a decontamination process. In real cases, this decontamination process consists of cleaning the agent with the CBRN suit on, immediately after leaving the dangerous area. For this procedure, it is irrelevant whether the agent has been contaminated or not, as every part of the suit has to be cleaned with a high-pressure cleaning liquid jet. The requirement was to model this decontamination procedure.

7.4.3.3 Spreading Contamination

The primary element of this model is the "contamination spot" or "contamination source". This atomic element has a remaining amount of radiation, a minimum amount of radiation and a location in the scene. When enabled, the visualization of a contamination spot consists of a green/yellow, sphere with a degree of transparency that has a cyclic animation of contraction and expansion. Audio is used to indicate when contamination occurs.

7.4.3.4 Radiation Field

For the visualisation of radiation fields, initially a directional particle system with a gradient of colours was designed in order to provide a visual cue to the user about the danger zones of a radiation source. The current version uses a dual particle system, which models each radiation source as a sphere. The size of these spherical zones can be adapted to different radiation field intensities without significantly affecting the visual aspect of the particle system and they more accurately describe, visually, the radiation situation modelled underneath.

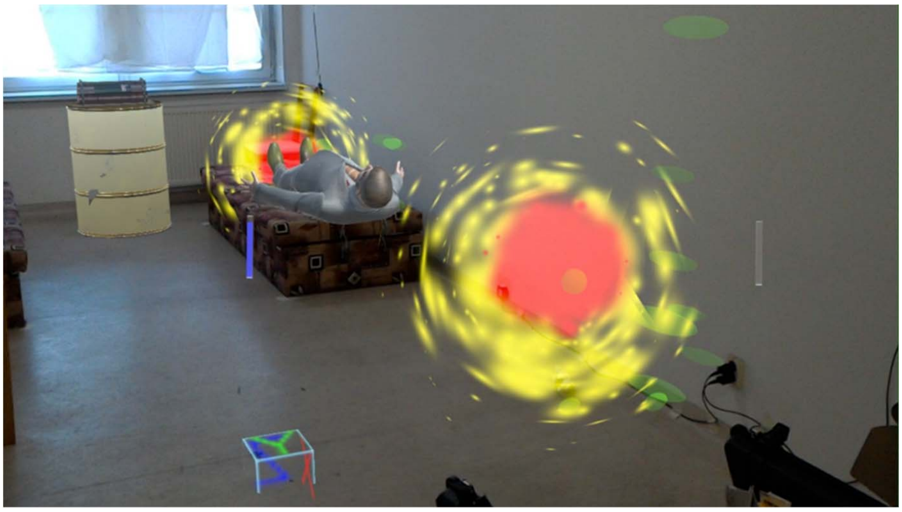

Figure 18: Contamination fields are represented by the red and yellow zones

7.4.3.5 Decontamination process

An important requirement is that the trainees are made aware of the importance of decontamination and how to undertake this step (see Figure 18). For this to take place the trainee stands on a designated location within the environment, the other trainee (decontaminator) see holograms superimposed over the other trainees body (see Figure 19). Using positioning trackers the decontaminator has a simulated liquid spray which turns the holograms blue as that part of the other trainees body is cleaned. This approach allows for a clear indication as to how effectiveness of the decontamination step.

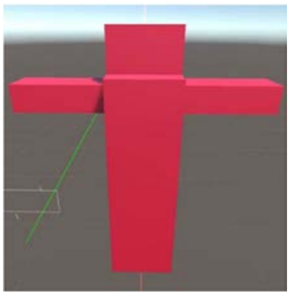

Figure 19: An example of the augmentation that the decontaminator sees over the trainee's body

7.4.4 Conclusions

The primary benefit of augmented reality is that it is possible to simulate radiation sources without the inherent risk of using live materials. Furthermore, augmented reality can make invisible items visible for example radiation. These two aspects coupled with the ability to see how contamination spreads and the decontamination step demonstrate some of the unique benefits that augmented reality can bring to radiological incident training which go above and beyond existing approaches.

7.5 Use Case 4: Manufacturing

7.5.1 Context

The manufacturing and training processes have been optimized so much over the last decade that new technologies like augmented reality, cloud computing, artificial intelligence, internet of things and others are beginning to be taken into consideration in the attempt of further improving the Key Performance Indicators (KPI) of production plants. AR is considered one of the 10 strategic technologies for Industry 4.0. Research shows that AR can reduce assembly errors, assembly time and training requirements and can increase the recall of work instructions, among other positive effects.

7.5.2 Challenges

In order for an assembly line to work at full speed, surprisingly, the most important thing is not the speed of the operators completing the assembly tasks, but the human error prevention. It has been demonstrated that errors that occur during assembly tasks have one of the biggest negative impact on the KPIs. Generally, operators who lack experience or the ones who are not properly trained commit the most errors. On the other hand, training is generally a process that takes time and resources and it cannot guarantee the error prevention.

The following challenges in manufacturing tasks that lead to assembly errors have been identified:

- An operator at each workstation: in order for an assembly line to function within the planned timeframe, an operator has to be present at each workstation.
- The assembled product changes several times per day on the same assembly line: the operator does not notice the change and continues using components from the previous assembled product or even complete tasks from the previously assembled model.
- The demand for certain products fluctuates: in this case flexible lines and polyvalent operators are required in order to supplement the required manufacturing positions in order to keep up with the high demand.
- The number of seasonal operators can go as high as 70 % in certain periods of the year: these operators are not productive right away because a training session is required to qualify them for the tasks to be done.
- A new product is introduced: generally most of the operators do not have the knowledge for assembling the new model, therefore training sessions are required.

Direct impact on the assembly line when a human error is produced:

- The slowest operator dictates the line output rate (considering that the workstations are correctly balanced).
- An assembly error which is detected at some point during the assembly process can slow down the production rate or even completely stop it for a certain amount of time.
- An assembly error, which passes through undetected, can make the client return the final product, which is a very costly operation.

In order for an operator to become fully productive, the training process can last anywhere from a few hours to days or even weeks depending on the workstation. Moreover, training cannot ensure that errors will not be committed by operators.

This is why, in order to overcome (at least partially) these issues and limit? reduce? training sessions even for experienced operators, real time help during the manufacturing tasks is considered to be one of the necessities in the context of Industry 4.0. Research shows that with the help of AR technology, these challenges can be restrained and the assembly errors made by operators can be greatly decreased.

7.5.3 Application scenario

Even though everything from the conceptual stage of the product, to material feeding and workstation balancing are important tasks in a production plant, the most important task is the actual assembly process of the product, which is conducted by operators.

Most challenges described previously can be avoided or resolved (at least partially) by providing a system that is able to guide the operators through performing assembly tasks in real time and prevent them from committing errors. The usage of the system should not require the supervision of an instructor; therefore it has to be self-explanatory, available at any time and reusable, completely or per task. In order to improve it even more, the system has to also consider the operator's comfort by lowering the cognitive workload and increase his satisfaction. This kind of system can lower the risk of assembly errors, delays and other issues that might affect the line performance, implicitly the productivity, therefore the revenue.

7.5.4 System requirements

Below are presented the main functionalities which are required for a manufacturing procedure assistant in AR.

1) **Operator identification:** the system is able to identify the operator. AR content is dynamically changed based on user preferences or experience. The identification can be performed by using one of the following options:

    1) Badge scan (external device, see note, or AR device directly)

    2) Retina scan (e.g. an external camera, see note, or HS2)

    3) Face recognition (e.g. external camera, see note)

    4) Manual identification (e.g. by name or by operator's unique ID):

        a) Voice recognition - the operator provides this information by voice

        b) Keyboard (virtual or not)

        c) Choose from a list (directly in the AR training application or by using another device, like a touchscreen or a tablet, which communicates with the AR device)

NOTE: Able to communicate with the AR device.

2) **Workstation identification:** the system is able to identify the workstation. This step is required in order for the system to be able to show the correct AR content based on the tasks to be performed at the current workstation. The following methods can be used in order for an AR system to be able to identify the current workstation:

    1) Marker (QR code, image) identification - the operator scans a specific marker (could be anything from a QR code to a printed image that has been already fed to the system) by using his AR device.

    2) 3D model recognition / environment identification / spatial understanding (e.g. HS2) - the AR system is able to identify the workstation by matching the 3D model (partial or complete model) of the workstation with the real environment. This process is completely transparent from the operator's point of view because no specific marker or object has to be scanned by the operator.

    3) Manual identification - the operator is required in the same way as in section *1.4 Manual identification* to specify the workstation he is currently at.

    4) Badge scan - if the operator is attached to a workstation he can use his AR device in order to scan his badge or scan it with an external device which is able to communicate the data to the AR system.

3) **Workstation anchored (static) data:** generally, depending on the workstation, textual information like instructions accompanied by videos, images or 3D objects (animated or static) can be anchored at fixed locations in the operator's workplace. These locations are indicated as soon as the workstation has been identified, based on the operator's preferences and experience. An operator with enough experience at the current workstation might not need some of this information so he can choose to hide it by using commands provided by the application like: vocal commands, 3D gestures or gaze. The system registers the operator's preference and by default hides this information in the upcoming sessions. This step is also helpful in the case where new information is available for the current workstation, for example a tool has been replaced with another one, new statistics are available or AR content for a task has been added and is now available. The system informs the operator by sending notifications in AR about the new data that he can visualize and the location where this is anchored.

4) Manufacturing (assembly) procedure step by step:

   1) **Display tasks (optional):** depending on the operator's preference, each task of the procedure can be presented in AR, one by one, as in a training session. By default this option is activated and each task is presented to the operator, one by one, as in a training mode. In order to stop receiving assembly tasks in AR the operator can inform the system about it (e.g. use a vocal command "*stop help all*"). The system has to allow the operator to deactivate a single assembly task (e.g. use a vocal command "*stop help task*"). In the case the display task is active, for each step, arrows are used to point the operator in the right direction. Once the component or tool that has to be used in the current assembly task is in the field of view of the operator, it is highlighted, see Figure 20, in order for the operator to observe it. Depending on the task, its complexity and operator's preferences, the task can be explained by using textual information along with images, videos or 3D objects, 3D animations only, videos only, etc. For some tasks, an animation can be displayed in the anchored location if the real environment is too complex in order to match the animation correctly in AR. The example presented in Figure 21 demonstrates how a task can be presented to the operator by using a 3D animation where the position and the previously indicated tool are shown to the operator in AR. An experienced operator can opt to not visualize these instructions; therefore, based on his preferences the system will adapt correspondingly and filter out the information which is not of interest to the current operator. This is the reason why this step is optional, because it can be completely ignored for operators which do not need help in performing any assembly task. On the other hand, the operator can activate or re-activate the help for a given task (e.g. use vocal command "*help task*"). The AR application starts displaying AR assembly information for the current step every time this task is active, until a new command from the operator is provided (e.g. use vocal command "*stop help task*").

Figure 20: Current tool detection

Figure 21: Assembly task animation

2) **Task validation and error detection and prevention:** this step is the most important functionality of a manufacturing assistant application in AR. The task validation can be manual or automatic, depending on the task complexity and on the intelligence of the AR system:

a) Automatic validation: in the case of an automatic validation the system is able to automatically validate the actions performed by the operator. This step could be transparent to the operator, meaning that as soon as the task is complete, depending on user's preferences, a confirmation sound can be played or a visual notification can be displayed. The system is capable of detecting the current task. For example, a number along with the name of the task could be displayed in the peripheral view of the operator. The task number, even if not displayed, is crucial because the system has to keep track if a task was skipped for example. In the case where the system detects that task number N+1 was performed before task N then a notification message is displayed to the operator together with an explanation (**error detection**). When possible, an AR indication (e.g. circle with an arrow) can be overlaid on the physical object in order to help the user identify what action has been skipped by him. The second functionality is the **error prevention.** The system displays AR content (in the simplest cases a 2D shape) on top of physical objects in order to remind the user what is the next step of the procedure. An example is described in Figure 22: the first screw (on the right) has already been placed so the system will highlight the location where the second screw has to be assembled in order to prevent the operator forgetting about it. The operator can opt for getting a visual or an audio confirmation once a task is successfully completed, or he can opt not to have any confirmation at all.

Figure 22: Assembly error prevention

b) Manual validation: in the case of a manual validation, the operator asks for the help of the system to get information about the task he completed if he is not sure about the correctness of his actions. The operator is shown in AR, images and/or a video with the completed assembly task in order to be able to decide whether his work is correct or not. If in doubt, the operator has the possibility to ask for the available assembly data in AR (e.g. by vocal command "*show help task*") or even to inform the person responsible for the line about the issue he encountered (e.g. by vocal command "*need help*"). If his assembly work is correct, then he validates the step by himself (e.g. by vocal command "*validate task*"). Once a task has been manually validated by the operator, the corresponding AR validation content is hidden and the system passes to the next step. The user commands can consist of other actions in addition to the vocal commands given as example: 3D gestures, gaze, eye tracking, etc.

c) Once a task has been validated (automatically or manually) task N+1 (the next one) is activated. The loop continues with the task validation and error detection and prevention as described above.

3) **Operator feedback:** even if it is not a required step, user feedback could be extremely helpful for different reasons: physical and psychological acceptance, information usefulness, improvement ideas, etc. The feedback can consist in a set of questions per task (displayed immediately once a task is completed) or per entire manufacturing procedure. The operator is asked for feedback only the first time he uses the system for an assembly task or when an instruction procedure has changed. Another scenario where feedback could be asked from the user is when an error is detected by the system: the operator is asked if the error detection system was accurate and helpful. This information is presented as a textual information in AR and the operator answers pointing at one of the "Yes" or "No" buttons. The collected data from the operator is then used to improve the manufacturing procedure in AR.

7.5.5 Benefits of AR usage

Research shows that AR can reduce:

- assembly errors by detecting and preventing human mistakes while performing assembly tasks;

- assembly time by providing visual aids that can be easily understood and followed by the operators in real-time;
- training requirements by eliminating the need of an instructor;
- the cognitive load of the operator by overlaying virtual 3D content on the real objects.

It has been demonstrated that AR can increase:

- the recall of work instructions;
- productivity in general by providing help to prevent human errors;
- the adaptability of the operators and implicitly of the assembly lines;
- the satisfaction of the operators.

All these benefits provided by a real time manufacturing assistant in AR can lead without a doubt to an important increase of the KPIs of manufacturing plants in the context of Industry 4.0.

8 Conclusions

The investigations of ISG ARF have identified four most important groups of use cases for Augmented Reality in the industrial sector. These are inspection/quality assurance, maintenance, training and manufacturing.

These findings can be used to formulate requirements for further work of the ISG. These requirements will then be used together with the standards landscape document [i.1] and the Framework functional architecture to identify missing standards for this architecture.

The main conclusions for the requirements can be drawn from the usage conditions. In order to meet the requirements of all four categories, environments from letter scale up to large scale have to be supported, especially for inspection and manufacturing, large scale support is required by up to 40 % of the use cases. For more than 70 % of the use cases there are medium to hard environmental conditions like rain exposure, high temperatures, heavy dust or strong vibrations and only in 27 % there are user friendly conditions. This means, that at least two different classes of devices are needed, but a third device category for friendly environments could be worthwhile for cost reasons. Hands-free operation is also required in the majority of cases, which means that some kind of HMD or fixed installation will be required, tablets or phones are not sufficient.

The vast majority of users need the augmentation to be placed on real objects with high precision. In most cases the viewing distance is below 5 metres and almost in 44 % of the cases close to hands. Although most of the scenes to be augmented are static, in a considerable amount of applications (40 %) there are moving people or objects in the scene, which puts a burden on the required processing speed.

A relatively high number of users (around 60 %) want to share the augmentation with others, which has a severe implication on the AR architecture. The majority of users require augmentations over time, which has some implications on the architecture but a lot of implications for content generation and the related costs. CAD models are the dominant source of information for augmentation. Surprisingly, only 52 % declare that their data need a high level of security, but this may be explained by the fact, that a relatively high number of companies are still in a trial phase of AR and therefore not all implications are so clear yet. Security aspects will play an important role, especially for the protection of product data, IPRs and know-how.

The dominant operating systems are iOS™, Android™ and Windows ™, which is not surprising, because AR applications usually run on mobile devices.

Annex A: Augmented Reality (AR) in the Industry survey

"If you wish to provide your email at the end of this survey (optional) we will send you the report in about 2 months' time".

Time required to fill in the questionnaire is estimated on average at 15 mn.

Who you are

Please tell us a bit more about yourself

Your company Country

Your company sector of activity

Automotive
Academic Research
Basic Industries
Finance
Capital Goods
Healthcare
IT
Consumer Durables
Consumer Non-Durables
Public Utilities
Consumer Services
Technology
Energy
Transportation
Education

Other (please specify)

Which of the following answer best describes your current occupation?

Arts, Design, Entertainment, Sports, and Media
Office and Administrative Support
Transportation and Materials Moving
Building and Grounds Cleaning and Maintenance
Construction and Extraction
Personal Care and Service
Education, Training, and Library
Computer and Mathematical

Installation, Maintenance, and Repair
Production
Legal
Food Preparation and Serving Related
Business and Financial Operations
Protective Service
Healthcare Support
Farming, Fishing, and Forestry
Life, Physical, and Social Science
Sales and Related
Community and Social Service
Management
Healthcare Practitioners and Technical
Architecture and Engineering
Research
Other

In relation with your company's activity and your current occupation, are you or would you be more an AR technology user or an AR technology provider?

- [ ] AR technology user
- [ ] AR technology provider
- [ ] None

What are the main benefits expected from AR in your company/institution?

- [ ] Better traceability of operations
- [ ] Better productivity
- [ ] Better quality of products
- [ ] Better security for workers
- [ ] Increasing sales
- [ ] Better training methods
- [ ] Other (more information)

*** How would you describe the level of maturity of your company/institution related to AR technologies?**

We never heard of Augmented Reality
We think that it may be valuable to our company
We plan to launch a pilot study
We are currently working on pilot studies or proofs of concepts

We already realized a proof of concept or pilot study
We are currently building or deploying an operational solution
We already deployed an operational solution

How many people currently work on that subject? (Please enter the number)

Add more information if needed

When did you start your AR activities (if relevant)? (please enter the year)

*** Do you have an interest in implementing an AR based device use case (for example a smartglasses based AR use-case)?**

- Yes
- No

#1 - USE CASE ANALYSIS

***Among those possible use-cases please select the most relevant for your company/institution**

Logistics (picking assisted by vision, indoor AR guidance...)
Inspection / Quality (CAD model superimposed on reality, ...)
Manufacturing (worker assembly task presented in AR mode, ...)
Sales (product presentation in context, augmented catalog,...)
Marketing (trade show animations, augmented packaging...)
Training (step-by-step AR training on real object...)
Worker safety (Visualization of hazardous areas, ...)
Maintenance (field operations assisted with AR procedures, ...)
Factory layout (design and evaluation of a layout with AR solutions)
Innovation
Operation (Plan management)

Tell us more about the use-case selected above

*** What are the main benefits expected from this use-case?**

- ☐ Better traceability of operations
- ☐ Better productivity
- ☐ Better quality products
- ☐ Better security for workers
- ☐ Increasing sales
- ☐ Better training

*** Usage duration of the AR solution per day**

- ☐ several minutes
- ☐ few hours
- ☐ whole work day

*** Is it mandatory for the user of the AR system to have his hands free?**

- ○ Yes
- ○ No

*** Please tell us if the user of the AR solution has to wear some protective equipments**

- [ ] Helmet
- [ ] Gloves
- [ ] Protection glasses
- [ ] Breathing masks
- [ ] Hearing protection
- [ ] Welding mask
- [ ] NONE

What is the level of data confidentiality you want to visualize in AR?

None, these data can be public and accessible to anyone.
Low, the data can be stored on an external cloud with dedicated access rights.
High, the data must be stored on a sovereign cloud with high secure access control.
Very High, the data must be stored on internal severs with a high secure access control.
Extremely high, data are stored on the device with an extremely high secure access control and cannot be downloaded from a server, either internal or external.

Please tell us what type of network can the user of the AR solution access to

No network available
Cellular network
WIFI company network
Wired company network

*** Please describe the localization & lighting conditions where the AR solution are/will be used**

Indoor - uncontrolled/variable lighting (inside a house or an office for example)
Indoor - with controlled artificial lighting (inside a factory for example)
Outdoor - with possible direct sunlight
Possibly indoor & outdoor

*** Will the user possibly be exposed to difficult environmental conditions like rain, temperatures, vibrations...?**

No (mostly office or user-friendly conditions)
Yes - medium conditions (possible dust or water projections, mid temperatures, small vibrations...)
Yes - hard conditions (possible direct rain exposition, high temperatures, lots of dust, high vibrations...)

*** Is the environment or area of interest evolving over time (ie: step by step assembly of a mechanical structure...)?**

Yes

No

From which type of sources will the augmentations come from?

CAD models (CATIA, Solidworks, Autocad, ...)

DCC models (3dsmax, Maya, ...)

ERP

Knowledge base

"Office" documents

Other (please specify)

Do the augmentations need to be precisely located relatively to a real equipment or object?

Yes

No

If YES, what is the minimum expected accuracy for augmentations positioning?

under 1 millimeter
a few millimeters
a few centimeters
up to 10 centimeters
up to 1 meter

*** Does this use case involve collaboration or sharing of the screen between multiple users?**

Yes

No

I don't know

If some mobile devices (tablets, smartphone, smartglasses, ...) are already deployed for AR applications in your company, what are the corresponding operating systems?

iOS

Android

Windows

- [ ] Linux
- [ ] Other / I don't know

*** Please describe the dynamics of the application environment (moving things or persons around or inside the area where augmentations should be located)**

Mostly static objects / persons
Mostly moving objects / persons

*** Please describe the size of the area of interest (space where augmentations may occurs)**

Letter scale (~A4/letter paper size)
Desktop Scale (~1 m²)
Room scale (~10 m²)
Warehouse scale (~100 m²)
World scale (~1 000 m²)

*** What is the expected size of the content you superpose to augment your reality?**

a few centimeters
Between 10 cm and 1 meter
Between 1 and 10 meters
Between 10 and 100 meters
Above 100 meters
multiple sizes

*** What is your typical working distance?**

Close to hand
1 to 5 meters
5 to 10 meters
Above 10 meters

*** What type of interaction would you require with the augmentation?**

- ( ) 2D interactions (through menu for example)
- ( ) Remote 3D interactions (manipulating remotely the augmentation)
- ( ) Direct 3D interactions (manipulating the augmentation by touching it with the hand)
- ( ) Others (please specify)

None

*** In case of interaction, would you require haptic feedback?**

Yes, required
Yes, could be useful
No, not required

*** Is the working environment where the AR solution is used mostly composed of magnetic materials (iron, steel, ...)?**

Yes
No

*** Is the working environment subject to explosive atmosphere?**

Yes
No

If you already have conducted some tests for this use-case, what are the difficulties you have encountered?

Tracking robustness issues
Tracking accuracy issues
Methods for initial spatial positioning of augmentations
Battery lifetime of the AR system
AR Devices robustness
Ergonomics of the AR display solution (weight, comfort, ...)
Authoring time/cost of the AR application
Incompatibility with protective equipments
Availability or adaptation of the data (3D models, 2D assets, ...)
User interaction methods with the AR solution
User security while using AR solution
Equipments cost
User acceptance (perceived reliability, utility, usability, safety, ...)

Other (more information)

Feel free to add any details concerning this use-case:

*** Would you like to answer the same batch of questions for another relevant AR use case for your company/institution?**

Yes No

AR identified bottlenecks & limitations - This is the last page of this survey

Generally speaking and according to your opinion, which are the most important challenges AR solutions are facing nowadays?

Issue #1

Tracking robustness issues
Tracking accuracy issues
Methods for initial spatial positioning of augmentations
Battery lifetime of the AR system
AR devices robustness
Compatibility with protective equipments
User security while using AR solution
Ergonomics of the AR display solution
Authoring time/cost of the AR experience
Availability or adaptation of the data (3D models, 2D assets, ...)
User interaction methods with the AR solution
Equipment cost
User acceptance (perceived reliability, utility, usability, safety, ...)

Issue #2

Tracking robustness issues
Tracking accuracy issues
Methods for initial spatial positioning of augmentations
Battery lifetime of the AR system
AR devices robustness
Compatibility with protective equipments
User security while using AR solution
Ergonomics of the AR display solution
Authoring time/cost of the AR experience
Availability or adaptation of the data (3D models, 2D assets...)
User interaction methods with the AR solution

Equipment cost
User acceptance (perceived reliability, utility, usability, safety, ...)

Issue #3

Answer Choices
Tracking robustness issues
Tracking accuracy issues
Methods for initial spatial positioning of augmentations
Battery lifetime of the AR system
AR devices robustness
Compatibility with protective equipments
User security while using AR solution
Ergonomics of the AR display solution
Authoring time/cost of the AR experience
Availability or adaptation of the data (3D models, 2D assets, ...)
User interaction methods with the AR solution
Equipment cost
User acceptance (perceived reliability, utility, usability, safety, ...)

Other pitfalls?

How would you assess the change in acceptance of AR in the last two years?

Answer Choices
Negative - people are disillusioned and accept AR less than in the past
Neutral - people accept AR as in years before
Moderate - people believe in AR a bit more than in years before
Positive - people accept and demand AR more than in last years
Highly positive - people demand AR significantly more or are likely to demand more

Annex B: Review of presentations at ISG ARF workshops in Berlin and Paris

NOTE: Empty cells mean "no information is available".

1) Review of presentations at 1st ISG ARF Workshop in Berlin

Category / Presenter	Technicolor™	Orange™	HHI	Ubimax™	Fraunhofer IEM	Fraunhofer IFF
AR Benefits	Better home entertainment	Easier planning of cabling and WIFI router positioning	More efficient processes	- Higher Speed - Fewer Errors - Greater Flexibility - Employee Satisfaction	Service is getting more important in industry and therefore efficient service tools are required	Search and Find Task. Compare virtual to real world. Avoid Rendering Phobia.
Use Cases	AR at home, entertainment applications, augmentation of regular TV programmes, home automation, gaming	IoT Cartography WIFI Planning Field observation	- Medical - Security - Industrial Production and Inspection - City guide - building construction	- Materials Management & Logistics - Production &Quality Assurance - Service & Maintenance - RemoteSupport	- Intelligent service engineering - AR-based maintenance instructions - Component installation with AR support - AR-supported training instructions - Error database with AR support - AR-based remote expert - AR-based repair instructions	- Maintenance of industrial machines in operation - Check and Protocol of Machines - Plant (Flower, Tree) visualization to plan vegetation - Marketing and Sales Support
Type of AR Data	All kind, 2D, 3D	Room geometry data	All kind, 2D, 3D	Mainly 2D data	All kind, 2D, 3D	2D Static Information, Sensor data, Process status, 3D
Confidentiality of AR data	Not critical	Not critical	Low to very high	High, very critical	critical	critical
Sharing of AR data		yes	yes	yes	yes	Yes
Hands free operation	no	no	yes	yes	yes	Partially
Room scale	Living room	Living room, apartment	Few meters to hundreds of meters	Few meters	Few meters	Navigation: large scale, Service support: few meters
Dynamicity of AR environment	Scenes are dynamic	static	Static and dynamic	Static and dynamic	Static and dynamic	static

Category / Presenter	Technicolor™	Orange™	HHI	Ubimax™	Fraunhofer IEM	Fraunhofer IFF
Environmental conditions	Home environment, not critical	Home environment, not critical	All kind of environments	Factory environment	Factory environment	Factory environment
Operating Systems						Android, WebKit
Acceptance of AR	Not clear if users at home will accept AR glasses	not clearfor technicians and end users	Not yet evaluated	High acceptance		Accepted as additional feature
Challenges of AR	*Devices:* Smartphone: too small displays. Tablets: not easy to handle Glasses: costs, comfort, design, weight, FoV, battery, health issues. Technical: dynamic scenes occlusions, registration, light management, content delivery.	Tango™ no longer supported	- Registration of real and virtual scene - smooth, low latency tracking - registration of multi-modal data - Content creation and rendering - adaptation of scene properties - lighting/occlusions between real & virtual - clearly visible embedding of information - Interactivity (gesture interfaces) - Low latency processing on embedded devices (glasses) - distribution of processing locally/cloud - low latency, high bitrate networking	-	-	- Currently compromises between cost, tracking stability, FoV, and energy consumption - Energy consumption does not allow long time usage. - Tracking stability critical in changing environments - Interaction is not really hands free. Reduction of interaction needs required

2) Review of presentations at 2nd ISG ARF Workshop in Paris

Category / Presenter	TARGET™	Boudin SAS™	DIOTA™	Ericsson™	Schneider Electric™	DAQRI™	Eurovia™
AR Benefits	Training of different scenarios, partially with low probability of occurrence		Reduced time for tasks Higher quality Higher productivity		Speed up of training process Minimization of the Language barrier remotely training new trainees Reduce the travel costs Reduced system downtimes Reduced error rates Speed-up of operations Intuitive access Understanding of field issues Improved field experience & knowledge On time access to KPI's Improved security & safety	Faster and more accurate work	
Use Cases	Training for security personnel Operational level Tactical level Strategic command level	mold maintenance Testing validation	Aerospace Automotive Railway Shipbuilding Machine construction Petrochemicals Energy -> Planning Design Prototyping Production Maintenance Inspection Control Marketing Training	VR360: Live or VOD Enterprise monitoring Device offloading gaming (Cloud) Remote Control Machine Remote human Assistance AR Automatic AR (cloud based service) AR/VR call	Exhibition Training Assisted Production Engineering Maintenance Interactive Catalogue Pre-Sales Industrial Training Environment	DESIGN BUILD OPERATE RETROFIT Enterprise Solutions: Field service Facilities and assets Workforce training Production workflow Simulations Museums Trade shows Future concepts Education	Planning of building plants Maintenance Visualization of completed urban developments Visualization of underground services Positioning, navigation during construction

Category / Presenter	TARGET™	Boudin SAS™	DIOTA™	Ericsson™	Schneider Electric™	DAQRI™	Eurovia™
						Remote assistance Scanning of surrounding Maintenance with tagging of priorities Design and modelling Guidance for assembly	
Type of AR Data			3D models Work instructions Contextual information	Video Graphics Control information		e.g. BIM	
Confidentiality of AR data			Depending on application				
Sharing of AR data			yes	yes			
Hands free operation			yes	yes			
Room scale			Small to large	Depending on application		Small to very large (buildings)	Medium to large areas
Dynamicity of AR environment			Depending on application	-			
Environmental conditions			Depending on application				Mostly outside
Operating Systems							
Acceptance of AR			high	-			
Challenges of AR			Stability of AR information at large sites	Indoor, outdoor, real time, reliability, mobility	variability of mobile devices and OS variability of AR Servers & communication protocols Cyber-security		

Annex C: Authors & contributors

The following people have contributed to the present document:

Rapporteur:
Dr. Ralf Schäfer, Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute

Other contributors:
Dr. Jens Johann, Deutsche Telekom AG

Mr. Traian Lavric, Institute Mines-Telecom

Mrs. Nicole Le Minous, Orange

Mr. Aurel Machalek, University of Luxemburg on behalf of H2020 Target project

Mr. Eric Villain, Orange

History

Document history		
V1.1.1	July 2019	Publication