Deliverable

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C	Confidential, only for members of the consortium and the Commission Services	

Abstract:

This document is the second and final iteration of the deliverable and describes the basic technical infrastructure of the ImAc platform, including production modules, delivery and end-user equipment, based on the results of WP2's user centred design and resulting requirements of tasks T2.1 and T2.2.

REVISION HISTORY

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0.1	22-11-2018	Francesc Mas	CCMA	Contributions based on D2.2
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0.5	21-12-2018	Francesc Mas	CCMA	Contributions from partners
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1.0	04-02-2019	Peter	IRT	Final Review
1.12	08-03-2019	Francesc Mas	CCMA	Improvements in section 3.1
1.13	19-07-2019	Zora Schärer	RBB	Updated requirements after pre-pilot 2 results

EXECUTIVE SUMMARY

Note: *This deliverable D2.3 received a major update after the first iteration (published in March 2018) in order to provide a better insight on the genesis and the purpose of each system component. Additionally, the updated document provides more information to argue why the design and technologies chosen will suit best the goals of the ImAc project.*

ImAc follows a user centred design, where project developments are driven by real user needs. This is achieved by involving these users in each step of the design and implementation of the ImAc project. A number of professional users and end consumers were consulted, in order to obtain and define the accessibility requirements needed as an integral and intuitive part of any immersive experience. The resulted list of requirements was supplemented by partner's expertise in the media industry and together led to this document (D2.3) which outlines the key characteristics of the ImAc platform. The following list summarizes these:

- **End-to-end setting** – ImAc defines as starting points 1) the broadcaster's production environment, as well as 2) the variety of end user devices currently available on the market. Although ImAc aims at providing new services, that cannot be enabled by current production tools or platforms, the ImAc system architecture needs to be based on formats, interfaces and technologies that are widely supported in the industry. That applies for content production as well as web-based delivery and consumption. The ImAc system integration exemplarily shows how different ImAc components can be used and may be plugged into existing environments. That provides a blueprint for content producers and providers, who want to add results from the ImAc project into their services.
- **Familiar environment** – The newly needed ImAc authoring methods must be perfectly integrated in the established production workflows. This is important for the readiness of professional users and their efficient work in producing the new ImAc-enabled services. ImAc aims at developing dedicated editor tools for each of the most used access services (Subtitling, Audio Description and Sign Language). The designed UIs will follow the industry standards in that area, so that the tools will feel familiar to professional users.
- **Lightweight asset management solution** – The integrated asset management system in ImAc will provide a flexible and agile solution for the project to easily prepare test and demo content.
- **Use of Web-based technologies** – In contrast to other existing solutions, the ImAc platform will be developed by solely relying on standard web components and technologies, without requiring any specific hardware or the installation of additional software. The use of web-based components involves low computational load and guarantees universal (i.e., multi-network, multi-device and multi-platform) support. Therefore, it enables the production of ubiquitous media services, avoiding compatibility and reachability barriers. Web-based applications can be deployed on any browser-capable platform, regardless of the application environment of the specific device, the type of device, its brand, Operating System (OS) and version. Moreover, they can be deployed under the principle of "build once, run anywhere", and can be easily updated, which results in a reduction of maintenance costs, as all the

clients will be able to use the most recent release of the application by only updating it on the server side.

- **Ready to use software** – ImAc will develop all tools that are required to enable the production of ImAc-enabled services by broadcasters and similar media entities. But note: Not all modules are maintained software products.

Here in deliverable D2.3 Section 1 provides an overview of this document, describes the objectives and scope of the deliverable and also outlines how this work is interconnected with other ImAc activities. Section 2 describes how user requirements defined in D2.1 and D2.2 have been processed to select the needed ImAc feature sets and also support the definition of the technical architecture. Section 3 describes the architecture of the ImAc platform along the content flow from production to the consumer devices, starting with a rough overview of all components in section 3.1. The different ImAc components will form the production and distribution workflow for accessible content, based on professional user and end users' requirements that will define the whole system requirements specification.

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LIST OF ACRONYMS

Acronym	Description
AD	Audio Description
AST	Audio Subtitles
CDN	Content Delivery Network
DVB	Digital Video Broadcast
FOV	Field Of View
GR	Generic Requirements
HBBTV	Hybrid Broadcast Broadband TV
HMD	Head Mounted Display
HUR	Home User Requirement
PUR	Professional User Requirement
SaaS	Software as a Service
SFTP	Secured File Transfer Protocol
SL	Sign Language
SR	System Requirements
SR	Service Requirements
ST	Subtitles
UR	User Requirements
UI	User Interface
VOD	Video On Demand

1 INTRODUCTION

1.1. Purpose of this document

ImAc project was born with the firm commitment to ease the production and distribution of accessibility services in new immersive audiovisual contents, exploring the integration in all the processes that add up to the overall workflow.

The WP2 activities are a vital part of the ImAc project, as its objective is to lay the foundation for the project defining use cases, resulting requirements and the definition of the needed platform specifications. The aim of this deliverable is to define the system specifications and describe the needed basic technical infrastructure of the ImAc platform, including production modules, delivery and end-user equipment that are the base for the technical development of the immersive platform in WP3 and the accessibility services tools in WP4.

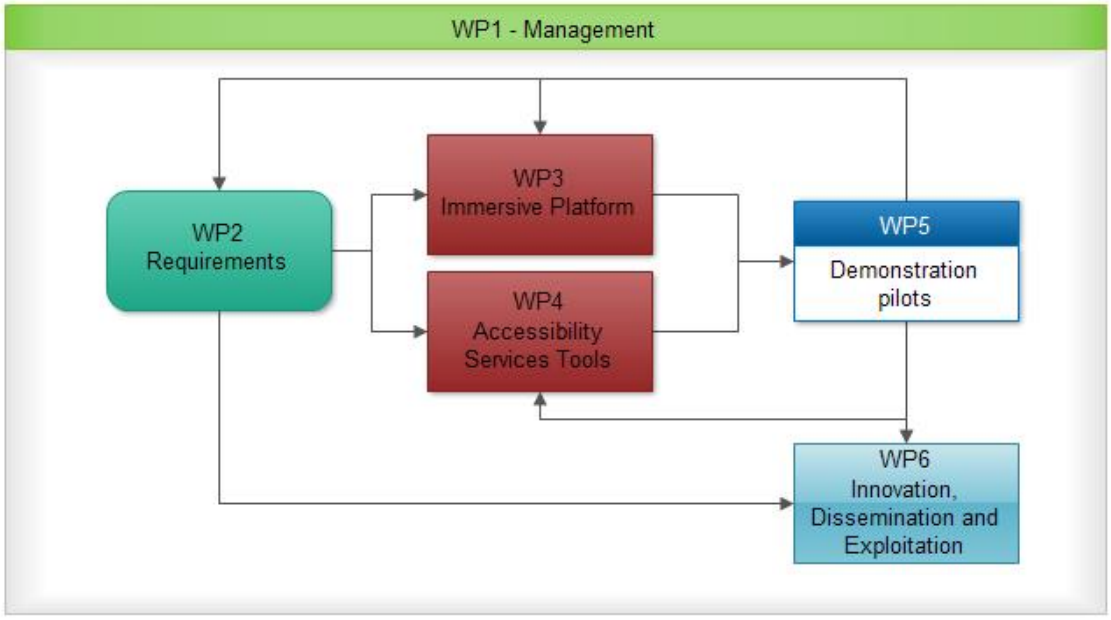

Figure 1: Diagram of relation between work packages and its cycles (iterations).

This document corresponds to the second iteration of Deliverable D2.3 and describes the technical infrastructure of the ImAc platform after the initial prototype implementation and testing with users' phase which brought new requirements and changes to improve the platform.

The document provides a specification for the functionality and basic architecture based on the results of WP2's user centred design and the resulting requirements established in T2.1 and T2.2, and describes the overall ImAc technical system specification, with an initial functional description, leading to a detailed platform related specification for each of the ImAc services to be implemented, including production modules, delivery and end-user equipment.

1.2. Scope of this document

The ImAc consortium agreed to follow a user-centric approach from the very start of the project as the best option, with intensive user-centred design activities in order to produce valuable user scenarios that, once evaluated and analysed, derived the user and technical requirements as shown on second iteration of deliverable D2.2, which were the key to define the ImAc platform specification.

As shown in previous related European projects on audiovisual accessibility, users with different sensorial levels ask project teams to work together with them.

The sentence “Don’t work for us, work with us” is often repeated in Accessibility forums & conferences, as it was for example during the “Enabling accessibility in a connected world” Workshop on 26th February 2016, within the Hbb4All project. For this reason, the ImAc project has dedicated 2/3 of the WP2 tasks to gather and analyse the end-users and professional users’ requirements, through meetings in focus group, and further improved and analysed these requirements in a second round, based also on the evaluation of WP5 demonstration pilot results.

The main objective of this deliverable is to define the main ImAc platform functionalities and specifications based on the user requirements, gathered in D2.1 & D2.2 that will be finally transformed in basic technical specifications to concrete the architecture of the new ImAc platform.

This document consists of two sections structuring its content:

- Chapter 2: ImAc Platform features
- Chapter 3: Technical Architecture

Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** defines the **features of the ImAc platform** at the level of Accessibility contents, consumer platform (player) and Production Tools, based in professional user and end users’ requirements.

Chapter 3 defines a **rough architecture of the ImAc platform**, dividing this architecture in different functional modules which will require communicating and interchanging information data with other platform modules.

These features and architecture definition is, at the same time, a compromise about what the project will develop for the second phase of the project, as it will generate results that will be tested during the second phase pilots.

As mentioned, in this document we’ll define a rough architecture of the ImAc platform, which will be introductory to the WP3 & WP4, where a deeper technical point of view will allow to improve first developments and develop new features that were not developed in the first phase of the project or that were included based on new and changed user requirements.

1.3. Status of this document

This is the second and final version of D2.3 and is a revision and improvement of the previous document D2.3 which was submitted in M05 of the project.

The document presents the final version of the ImAc system specification where new & modified requirements have been included and remarked in blue to discern from old requirements that where already presented in the first iteration of the document.

The last section of the document presents the rough technical infrastructure of the ImAc platform where several improvements in the definition of the modules and

intercommunications have been applied in agreement with the needs of the workflow and first phase developments from different partners.

1.4. Relation to other ImAc activities

In the diagram below, we can see the dependencies between tasks and deliverables and examine the relation of D2.3 to other ImAc activities.

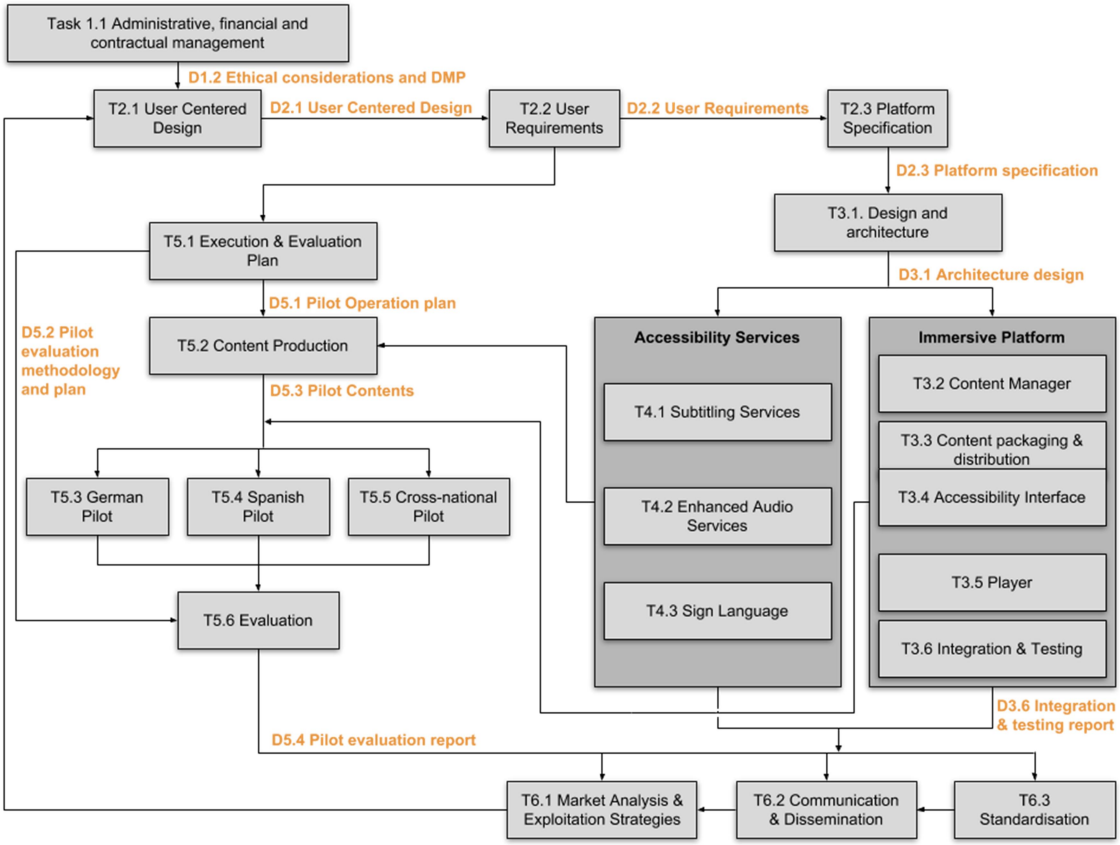

Figure 2: Diagram of tasks and outcomes (deliverables)

This 2nd iteration of the Deliverable D2.3 is the result of the last task in the roadmap of WP2, which will feed the 2nd phase of developments in WP3 & WP4 that will finally be tested with professional and end users in WP5 Demonstration pilots.

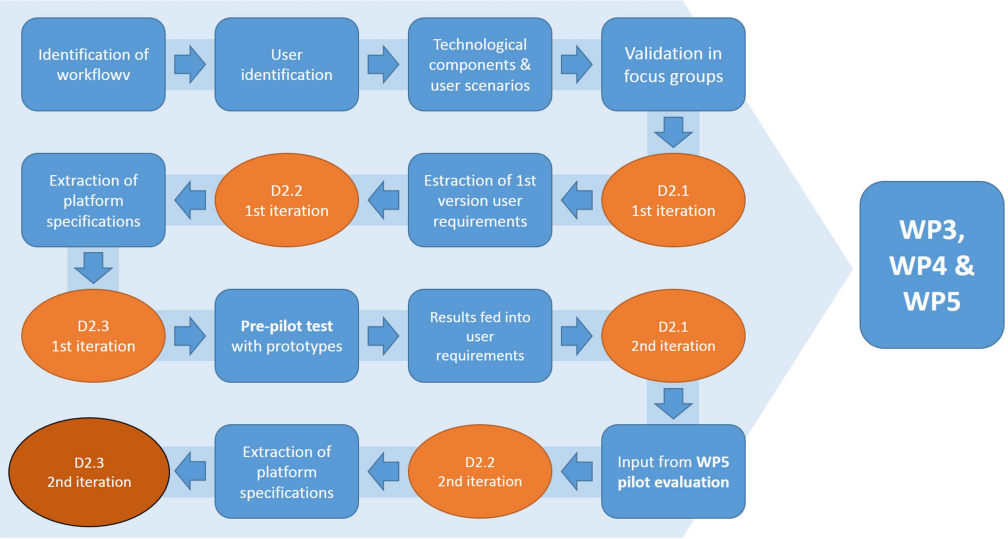

Figure 3: WP2 Roadmap of tasks

The information in this document will be used as the basis for T3.1 and its deliverable D3.1. This will further define the technical architecture of the ImAc platform in order to allow the development tasks in WP3 & WP4 to improve the first developments executed during the first phase of the project.

Second round of pilots in WP5 will allow testing and validation of the results from WP3 & WP4 and further refine these requirements, functionalities and architecture.

2 FROM REQUIREMENTS TO IMAC FEATURES

Accessibility requirements list was gathered from a range of professional users and end users, and supplemented with partner's expertise in the media industry. ImAc platform features are defined in chapter 2 with the aim of satisfying each and every one of the requirements.

Since the first iteration of Deliverable D2.2 was published, the list of requirements has grown, incorporating new & changed requirements. During the definition of the features described in the document the reader can discern the initial requirements and the new or modified ones, since these last ones are reflected in blue (e.g. PUR.01.01.1 refers to an updated version of professional user requirement PUR.01.01.0).

2.1 Features for accessibility content presentation

2.1.1 Common features for subtitle (ST) and sign language (SL) presentation

When it comes to presenting subtitles and sign language services in a 360°-environment, there are two main differences to traditional (2D) media that need to be considered:

1. There is no defined safe area in which the services should be displayed.
2. The user can freely change his FoV so it cannot be assumed that current speakers are always visible.

Safe area for 360°-environments

Regarding the first of the above points and its implications for the ImAc web player for tablets and smartphones to be used without VR glasses, we assumed the same ratio (16:9) and the safe area for interactive elements defined by the EBU guideline EBU R95 (https://tech.ebu.ch/docs/r/r095.pdf) in a HD format. Regarding the ImAc player for HMDs, it was considered important to define the "user's comfortable field of view" to properly position the accessibility contents and the interface controls. As a starting point for this definition, six viewing field levels ranging from 30% to 80% of a 16:9 field in a HMD were visualized in the pre-pilot tests. The subtitles were subsequently positioned bottom centred, bottom left and top centred in the each viewing field level to show the respective limits of each level. Similarly, the sign language videos were presented subsequently at the bottom right of each viewing field level. On the basis of the pre-pilot test results it was possible to narrow down the number of viewing field levels to only two levels which were the preferred by users. It was then decided to offer the users the possibility to personalize the comfort field of view in the three preferred levels that were chosen according to the pre-pilot tests. (HUR.02.49.00, HUR.02.50.00). Furthermore, a visual feedback (a dotted line) is displayed when a new comfort field of view is selected through the UI (HUR.02.49.01, HUR.02.50.01).

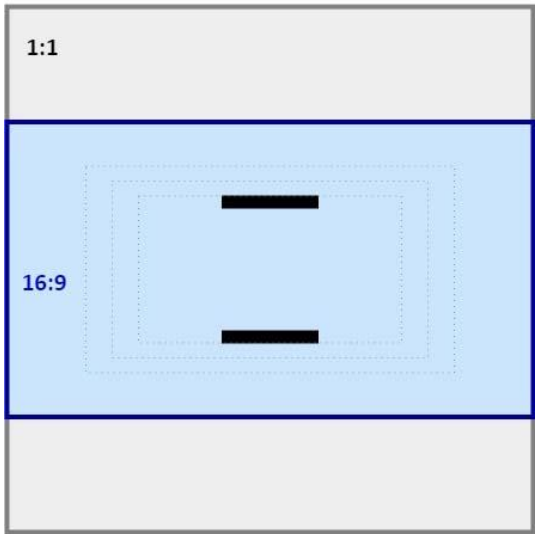

Figure 4: Subtitles placed within one of several pre-defined levels of a 16:9 viewing field in HMD view

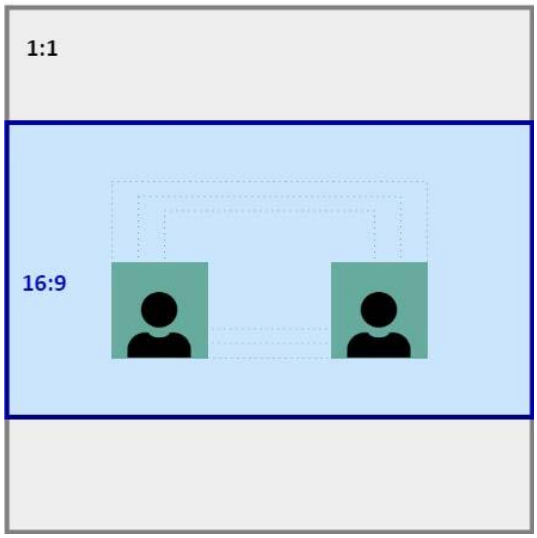

Figure 5: Sign language interpreter placed within one of several pre-defined levels of a 16:9 viewing field in HMD view

Speaker location indicators

Since the field of view can be chosen freely by the user in a 360°-environment, it is necessary to guide the user to the current speaker while subtitles or sign language videos are displayed. In this respect, different speaker location indicators were envisaged in ImAc and used for testing the home user's preferences:

a) Adding arrows (see Figure 6) (HUR.02.31.01, HUR.02.21.00)

b) Adding a radar field-like element (see Figure 8) (HUR.02.31.02. HUR.02.21.02). The possibility to show the position of the speaker in terms of depth in the radar is also being considered (HUR.02.66.00).

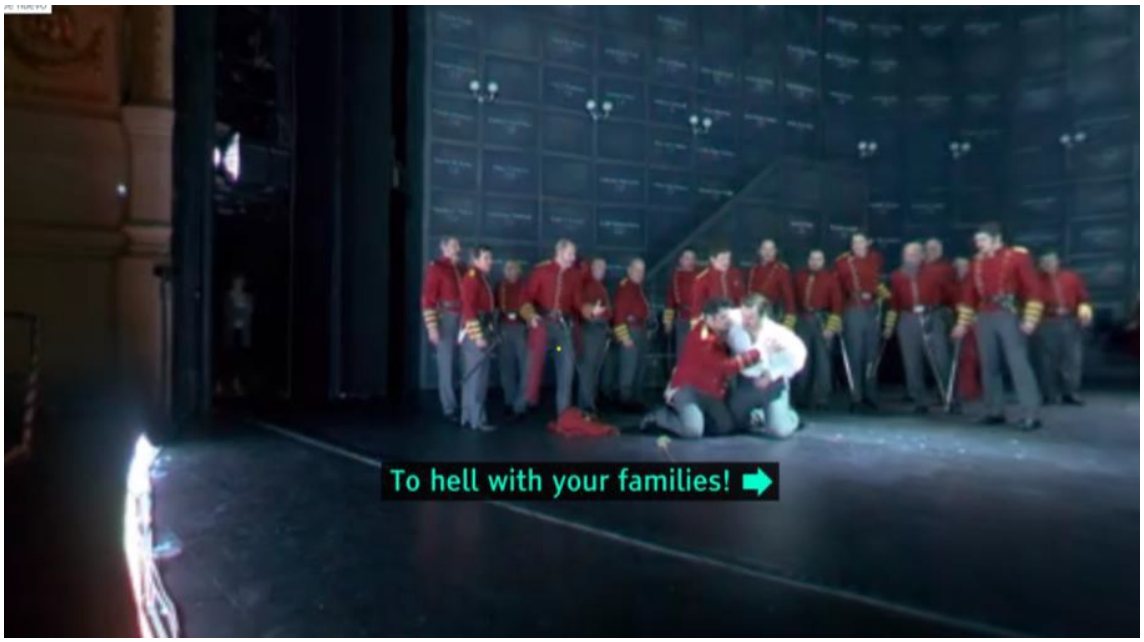

Figure 6: Arrow next to the subtitles to inform about the position of the current speaker

Figure 7: Arrow below the signer video to inform about the position of the current speaker

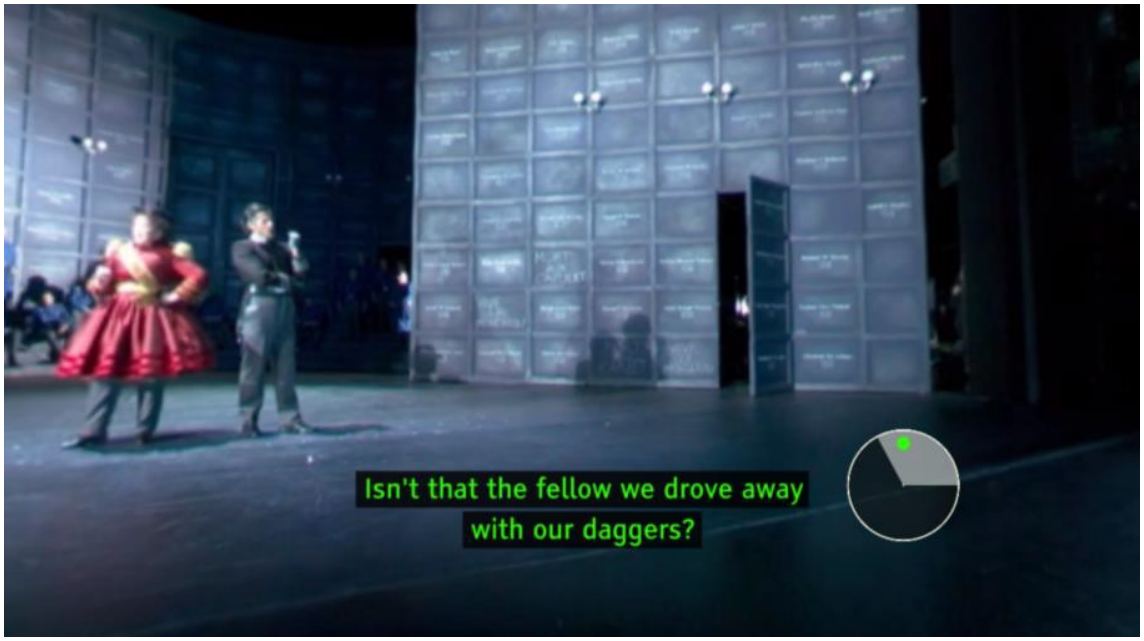

Figure 8: Radar next to the subtitles to inform about the position of the current speaker

2.1.2 Specific features for subtitle presentation

Main concept for the presentation

For the display of subtitles, the default presentation of RBB's HbbTV subtitles in a medium size (40px according to HD resolution of 720px height) with an adapted black background (80% opacity) is used in the ImAc player. It is obvious that the font size has to be adapted according to the comfortable field of view to avoid too many line breaks.

The subtitles are always presented on the same device on which the omnidirectional video is being presented. The use of additional screens for exclusively presenting subtitles is not an option desired by home users (HUR.02.08.00). In addition, subtitles will be always visible in the basic presentation mode (centred in the current field of view), regardless of whether the related speakers/objects in the 360º area are visible or not (HUR.03.05.00).

Regarding their position, subtitles are typically visible in the user's field of view in the middle slightly below eye line, two-lined (see Figure 8). The ImAc player will follow this approach (HUR.02.27.00), but it will allow dynamically setting different positions, as also required by users during the conducted focus groups. The most appropriate vertical position for subtitles depends on the user device (i.e. viewing environment) and/or on the user.

Approved subtitle characteristics:

Additional requirements for the subtitle presentation were introduced that were again based on existing usage concepts.

- **Colours to distinguish between different speakers (HUR.2.27.00):** The same colours will be used as per broadcaster's guidelines (3-4 colours). The use of specific colour palettes for colour-blind people will also be considered. (HUR.02.39.00)
- **Maximum amount of text for one subtitle:** The TV broadcast subtitle services are still based on the teletext limitations as well as on viewer behaviour, including their reading speed. This implies that the number of characters is limited to about 37 characters per line and it is suggested to use not more than 2 lines for a subtitle.

Presentation of visual notifications for sounds

It was foreseen that the player should provide visual notifications, as icons (see Figure 9), when relevant sound-related events are being presented, enabling their interpretation by the hearing-impaired users. (HUR.02.32.00) However, the pre-pilot 2 tests showed that this presentation mode was not favoured by users whatsoever (see D5.4). Therefore it was not implemented in the final version of the player.

Figure 9: Figure 9- Mock-up of subtitles with sound icons

2.1.3 Specific features for sign language presentation

Main concept for presentation

For the display of the sign language video, the medium video size recommended by the EU project HBB4ALL was adapted to the ratio of the head mounted display. The ImAc player enables the presentation of sign language videos synchronized with the related contents. A basic presentation mode for the signer video is always available on any device. In this mode, the signer video has a fixed position on the bottom right area of the comfortable FoV and the user decides in what direction he/she wants to look (HUR.02.18.00).

2.1.4 Features for audio description (AD) presentation

Based on the focus groups and pre-pilot tests, the following aspects were considered regarding the presentation of audio description for visually impaired people:

- Presentation of immersive/spatial/3D audio in general
- Location of the AD speaker in the audio scene
- Auditory cues to help users to orientate themselves

As a matter of course, all media assets (video, the main audio mix and audio description) are played back synchronized to the user (HUR.02.09.00).

Presentation of immersive/spatial audio in general

Various terms are used in that context, mainly immersive audio, 3D audio and spatial audio. All of them mean more or less the same: That the listener feels like he/she is located within the presented (audio) scene and can locate sound sources in different directions.

The focus group results led to the finding that an immersive audio scene will improve the user experience significantly for visually impaired people. Immersive audio helps them to orientate themselves in a 360°-environment, which is one of the key aspects to make 360° and VR presentations accessible for this user group (see also Portillo, 2017). [Portillo, C., (2017) Films Unseen: Approaching sound design alternatives to enhance perception and mental imagery models among audio description audiences on Sci-fi films].Consequently, ImAc envisages full support of immersive audio (HUR.03.06.00).

If headphones are used for playback, then the head movements of the listener should be tracked and appropriate audio processing applied, otherwise the audio scene would move together with the head movements and this would critically break the impression of being within the audio scene. The ImAc player will reproduce immersive audio for the best UX, in other words, the audio scene will stay fixed in relation to the virtual room whether it is used with head-tracked headphone reproduction or with a loudspeaker system. In the following, we will speak of a “spatially stable scene” in that case. When head movements are not tracked, or when a corresponding processing is not applied, the “spatially stable scene” is not possible.

Resulting functionalities for the ImAc user platform:

- Rendering of audio formats that are suitable for immersive audio are supported (HUR.03.06.00).
- Head-tracking will be supported and processed in order to provide a spatially stable audio scene.
- Rendering of traditional audio formats is used as a fall-back solution when immersive audio was not produced, is not supported by the user’s hardware or is not available for other reasons.

Locations of AD speaker in the audio scene

In traditional AD services that are usually provided for stereo or 5.1 systems, the AD track is mixed in such a way that it is located in the centre position (i.e. in the centre of the stereo panorama or to the centre speaker of a 5.1 system). As described previously, ImAc supports immersive audio that allows for additional options regarding the location of the AD speaker. ImAc will evaluate what AD speaker location is most comfortable to the user. Three different options were already presented to home users in the pre-pilot tests:

1) AD centred in the scene (traditional AD, voice of God)

2) AD anchored in the scene (friend on sofa) (HUR.02.42.01).

3) AD moves to where the action is (AD on action) (HUR.02.40.01).

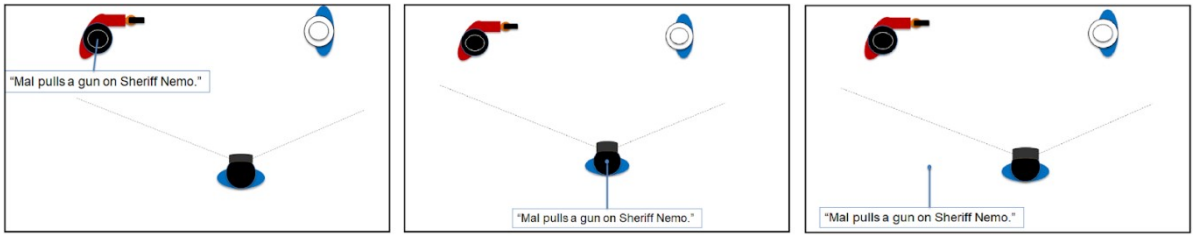

Figure 10: From left to right, graphics for AD on Action, AD Voice of God & AD Fixed in the Scene

The first two options described above are fixed locations. In addition, ImAc implemented an "action related positioning" of the AD speaker (HUR.02.40.01). It entails that the user hears the AD speaker from the same direction where the described action takes place.

Resulting functionalities for the ImAc user platform:

- An appropriate way for selecting from different AD options is provided (refer to section 2.1.6)
- Simultaneous rendering, mixing and repositioning of multiple audio tracks is supported.

Secondary AD tracks

A secondary AD can be provided for the user, describing the action or details happening outside the current user view, thereby avoiding the description of too many details/actions in the main AD track. As soon as an outside event is happening, the user can hear a beacon (beep) attached to that direction. He/she can then pause the main AD track and play the secondary audio track (HUR.02.45.01).

2.1.5 Features for audio subtitles (AST) presentation

Audio subtitles, also referred to as spoken subtitles, allow providing an audible alternative to subtitles intended for the translation of a foreign language. An example for a common application is a news programme in the viewer's native language that has some clips (usually interviews with foreigners) in other languages. Here, subtitles are provided for translation and the spoken version (audio subtitles) can be provided to allow visually impaired viewers to understand the content. Similarly, audio subtitles allow visually impaired people to enjoy a non-dubbed film subtitled in their native language.

The ImAc UI (Fig.12) includes a direct button in the main front end to switch on/off the audio subtitle service (HUR.02.51.00) and a dedicated audio subtitle menu allows personalization options (see section 2.1.6).

2.1.6 User Preferences

One main point that resulted from the focus groups conducted with home users was the need for personalization options for accessibility services. This enables home users to customize the player based on their preferences or on their sensorial capacities. In this context, we also referred to research results from previous EU projects like HBB4ALL and DTV4ALL, covering TV and VoD services.

The customization options that will be provided in ImAc are listed in the table below. The specific UI and controls to enable these options will be designed. In some cases the user preferences options to be provided might depend on the target consumer device to be used.

Font size of subtitles (HUR.02.29.00)	Users will be able to select between different font sizes for subtitles presentation: - Small (1/24 of viewing field height) - Medium (1/18 of viewing field height) - Large (1/14.4 of viewing field height) (For comparison: for a TV screen dimension of 1280 x 720 these sizes would relate to a font size of 30px, 40px and 50px)
Position of subtitles (HUR.02.28.00)	Users will be able to select between a pre-defined set of positions in the viewing field: - Bottom  - Top 
ST Background (HUR.02.30.00)	Users will be able to select between different backgrounds for the presentation of subtitles: 1) semi-transparent box (80% opacity) 2) outline (2px for each font size)
Selection of subtitle tracks (HUR.02.25.00)	If different subtitle tracks are available, users will be able to select between them. This will include: - Multiple languages. - Normal vs easy-to-read subtitles.
Position of the signer (HUR.02.19.00)	Users will be able to select between a predefined set of horizontal positions for the signer: - Bottom right (traditional position, see Figure 7) - Bottom left
Size of the signer (HUR.02.20.00)	Users will be able to select between a predefined set of sizes for the signer: Small, Medium, Big
Selection of signer (HUR.02.60.00)	If different signer tracks with different languages are

	available, users will be able to select between them.
Adjust audio level of AD and main audio separately (HUR.02.55.00)	The user will be able to adjust the level of the AD track in relation to the main audio with a GUI.
"Guide Me" option (HUR.02.61.00)	If users enable this option, they will be guided to the main action of the video by clicking on a specific point on the radar icon.
Adjust audio level of AST (HUR.02.56.00)	The user will be able to adjust the level of the AST in relation to the main audio with a GUI.

Table 1: Customization options to be provided by the ImAc player

Users can save preferences and customization options for every device, so future content consumption on that device will be automatically adapted to user preferences (HUR.02.13.00) and also will be adapted to take advantage of the capabilities of other devices used by the user (HUR.02.38.00).

2.2 Player features

This section describes the functionalities and options of the media player for the presentation of omnidirectional video in combination with the accessibility contents considered in ImAc, namely: subtitles, audio description and sign language videos.

The media player could allow the presentation of omnidirectional video in 2D and 3D stereoscopic when using an HMD. In case of stereoscopic video content, the different graphical components like the subtitles or signer video could be displayed at a comfortable depth in relation to the speaker presented in the omnidirectional video (HUR.02.68.00, HUR.02.64.00, HUR.02.65.00)

2.2.1 Media Playback Control

The ImAc player will include the proper functionalities to control the media playback of the considered media contents (including omnidirectional and accessibility contents). This includes "play", "stop", "pause", "resume", "forward" and "rewind", as well as "volume" setting, options (HUR.02.06.0).

Spoken feedback to the execution of these commands will also be provided (HUR.02.10.0), and the user will control the volume of this feedback (HUR.02.10.01).

2.2.2 User Interface

A key aspect of the ImAc player is the User Interface (UI) to be designed and adopted. This UI needs to consider the sensorial capacities of the target users, and the requirements and preferences identified in the focus groups, which are listed and described in this document. In addition, the UI to be designed will take into account the particularities of each platform and physical limitation of each screen. This will determine various relevant aspects regarding the presentation of the (immersive and accessibility) contents, such as the "safe area", the comfortable FoV, the objects' size and position, etc.

The UI will be modern, intuitive and efficiently interpreted/used by all users, regardless of their sensorial abilities. Besides, the recommendations provided in different accessibility standards (e.g. W3C WCAG https://www.w3.org/TR/WCAG20/) are being taken into account in order to provide an accessible player. It may also involve that multiple pathways for media control and interaction need to be provided.

The provided first releases for the presentation modes give an initial idea of the approach to be followed for the design of the UI.

To open and access the menu or UI, the viewer will need to look down about 45º for a few seconds. This way a visual button on screen can be avoided. A banner will inform about this option at the starting of the player (Fig.11) (HUR.02.63.00).

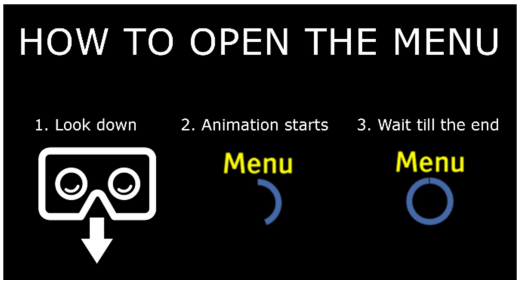

Figure 11: Banner with detailed instructions to open the ImAc player menu

In the following passages, the identified requirements regarding the visual menus, voice control interaction, and the personalisation options to be provided are listed. These requirements will also be considered as starting points for the design of the UI.

Visual Menus:

The UI (Fig.12) will include direct visual menus to provide access to the subtitles (HUR.02.24.00), audio subtitling (HUR.02.51.00), signer (HUR.02.16.00) and audio description (HUR.02.36.00), implementing the proper controls to enable switch on/off the different services. Other important features like “play”, “seek”, “progress bar” (HUR.02.62.00), “settings” or volume related controls (HUR.02.54.00) will be also accessible directly from the front end of the UI.

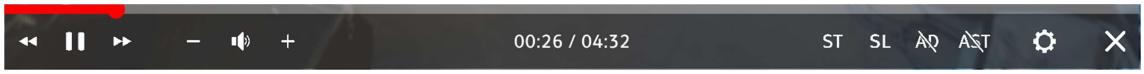

Figure 12: User Interface for the player with subtitles (ST), sign language (SL), audio description (AD) and audio subtitles (AST) direct access buttons.

The player will also enable the use of an enhanced accessibility UI (Fig.13) designed for low vision users (HUR.02.52.00), which will allow to access the service using a large interface with black background and white big letter text for the highest possible contrast, using the yellow colour to highlight the choice of the user (HUR.02.04.01). Spoken feedback of all interface controls (HUR.02.10.00) will be also provided, and the user will have also control of the volume of the spoken feedback (HUR.02.10.01). Likewise, visual feedback when selecting each control will be provided by changing its size (making it smaller) momentarily and changing its colour to yellow. These options are also provided for the traditional UI introduced before.

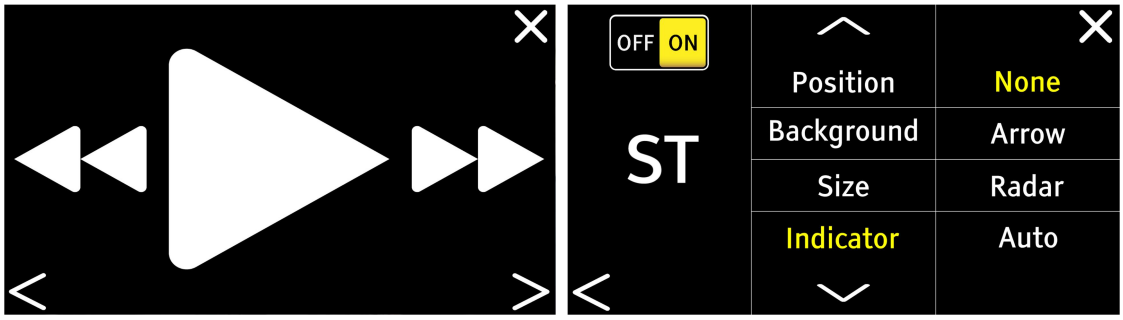

Figure 13: Two graphical examples of the enhanced accessibility UI designed for low vision users.

The player will provide configuration options to dynamically change the language of the graphical UI (HUR.02.58.00) and to change between the traditional (Fig.12) and Enhanced-Accessibility (Fig.13) menus during the consumption experience. The initial language and UI can be also selected in the ImAc portal, which is the initial webpage through which user select the videos to be watched.

The player will also support different personalization options to be set via a menu (HUR.02.17.00, HUR.02.26.00, HUR.02.37.01, HUR.02.53.00 and HUR.02.57.00). These options are detailed in the next sub-section.

Voice Control:

Apart from graphical menus and controls, voice control is also a very useful mechanism for media accessibility and will be provided for controlling the media player (HUR.02.59.00). Accessibility users are familiar with voice control and these days voice control is becoming an expected interface in accessibility services. The following table provides a first version of the list of the voice commands that will be supported:

Command	Action	State
Play / Pause	Play/Pause Toggle	With content queued up / playing
Skip back	Skip Backward	With content playing
Skip forward	Skip Forward	With content playing
Volume Up	Increases volume	In any mode. NOTE: With submenu of AD and AST open, this command would control the volume of the respective service
Volume Down	Decrease volume	In any mode. NOTE: With submenu of AD and AST open, this command would control the volume of the respective service
Subtitle	Open ST submenu	Playing content which has subtitles
Signer	Open signer submenu	Playing content which has signer
Audio description	Open AD submenu	Playing content which has AD
Audio subtitling	Open AST submenu	Playing content which has AST
On/Off	Switch on/off service	With submenu of one of the services open (ST, SL, AD, AST)
Easy to read on/off	Switch on/off easy-to-read mode of subtitles	With submenu of ST or AST open
Language	Open language submenu	With any submenu open that has

		language as a customization category (ST, AD, AST, general settings)
English / Deutsch / Català/ Español	Select language of service or of interface	With any of the language submenus open (ST, AD, AST, general settings) NOTE: Easy-to-read option is only available for ST and AST
Position	Open position submenu	With any of the position submenus open (ST, SL)
Top / bottom	Select position of subtitles	With subtitle position submenu open
Left / right	Select position of signer	With signer position submenu open
Background	Open background submenu	With subtitle submenu open
Semi-transparent / Outline	Select background of subtitles	With subtitle background submenu open
Size	Open subtitle size submenu	With subtitle submenu open
Small / medium / large	Select size of subtitles	With subtitle size submenu open
Speaker localization	Open guiding mechanism submenu	With any submenu open that has guiding mechanism as a customization category (ST, SL)
None / arrow / radar / auto	Select guiding mechanism	With any of the guiding mechanism submenus open (ST, SL). NOTE: radar option is only available for ST, forced perspective option is only available for SL
Area of display	Open comfort field of view submenu	With any submenu open that has comfort field of view as a customization category (ST, SL)
Small / medium / large	Select comfort field of view	With any of the comfort field of view submenus open (ST, SL). NOTE: The actual sizes behind the commands “small/medium/large” are not the same for the two services
Presentation mode	Open presentation mode submenu	With AD submenu open
Action / Head position / Soundscape	Select presentation mode for AD	With AD presentation mode submenu open
Settings	Open settings menu	In any mode
User profile	Open user profile submenu	With settings menu open
Save settings	Save currents settings of interface as user profile	With user profile submenu open
Load profile	Load user profile	With user profile submenu open
Next	Go to next menu group	With circular menu open (Enhanced Accessibility UI mode)
Exit	Exit menu	With any menu open

Table 2: Voice commands to be supported within ImAc Media Player solutions

All voice commands will be acknowledged with an audible response.

2.2.3 Synchronization Functionalities

The player will support the integrated presentation of the different accessibility contents in a synchronized manner. Synchronization across devices will be provided as well. It will guarantee a time-aligned presentation of the traditional contents on the main TV and the immersive and accessibility contents on the companion devices, for each target platform.

2.3 Accessibility content production features

Editor tools addresses the same professional user group that already exist for classical non-360º accessibility content production.

That means separate production tools are targeted for Subtitling, Audio Description and Sign Language since these services are typically produced separately and they are optimised for the specifics of each accessibility service.

Production processes are often highly optimized. The collected professional user requirements also suggest to keep the UI close to existing and established workflows.

ImAc services require to author additional data. The editor tools shall support creating and editing all data, “traditional” data (e.g. subtitle text and styling) as well as ImAc specific data, not only for displaying the content in 360º media (e.g. with an indicator to locate the speaker around the 360 image) but also for the distribution channels.

The producers always verify the accessibility content once all the elements have been created. For verification purposes the producers must also have the tools to preview the accessibility content in a mode similar to the ImAc player with the corresponding accessibility service (using HMD). Additional tools will be implemented in the editors in order to fulfil the ImAc requirements for subtitling, audio description and sign language content production for 360º media (e.g. tools to cut or split the video segments in the sign language editor).

After analysing the home user and the professional user requirements (obtained from ImAc Focus Groups, Pre-tests and first pilots) a list of specifications for each of the production tools was prepared.

Additionally, we have taken into consideration the expertise of some partners to include additional specifications that, although not explicitly required by end-users, we have considered necessary for an optimal workflow.

First, we’ll list the features that are common for the three editors:

- The editor will allow the professional user to edit ST, SL or AD in both VR-mode view (PUR.01.01.00) and equirectangular view (PUR.01.01.01). In VR-mode view the user can author relevant metadata for 360º/VR sign language, while in equirectangular view the user can use the editor for classic video accessible content authoring, without the 360/VR features.
- In the next generation of editors it is foreseen to allow the professional user uploading the video and the accessibility content file directly from the computer hard drive without the need to be connected to the ImAc platform..
- In the same way, during the first iteration, Accessibility Content Manager was used for the management of accessibility content files, but in the second iteration version it is foreseen to allow directly loading and saving those files from the computer hard drive using the main broadcast subtitling standard protocols as STL, WebVTT and EBU-TTD (PUR.01.07.0 & PUR.01.07.01).
- A 360-preview player for the low-resolution video playback will be embedded in the editor with the following characteristics:

- The video will be able to be viewed either as equirectangular (PUR.01.01.1) or VR mode view (PUR.01.01.0) (see Figure 14).

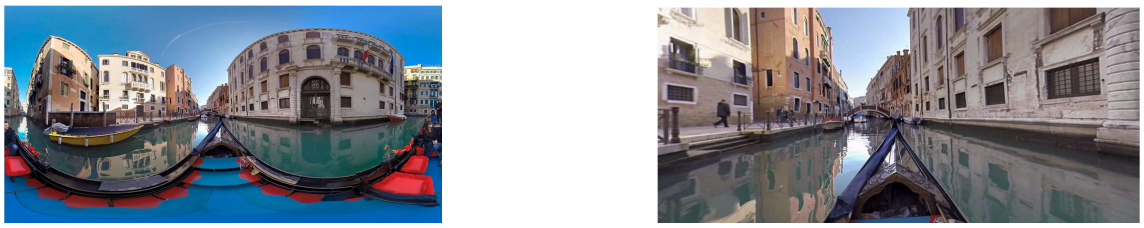

Figure 14: From left to right, equirectangular view (full 360º) and VR view (usually 90-105º)

- The editor will provide options to navigate through the video timeline by a customizable number of frames for forward/backward jump (PUR.01.04.00 & PUR.01.22.00) and by media time (PUR.01.05.00). This allows the user to jump to specific video positions, adding or subtracting a given amount of time to the input field for time code (PUR.01.05.01).
- The player will allow 360º video panning and zooming. The 360-player embedded in the editor will let the user move around the scene to facilitate the search of the speaker. For all video navigation options, shortcuts and input fields will be provided (PUR.01.03.00), and shortcuts will be configurable (PUR.01.16.00).

Subtitle editor

The subtitle editor, in addition to the common features of the previous list, must also comply with the features of the next list:

- The professional user can produce a subtitle by following the steps below (PUR.01.08.00):
  - **Producing the text:** The producer will have an input field to write the subtitle.
  - **Introducing the vertical and horizontal position** within the area of vision: The producer will be able to indicate a position for the subtitle or icon on the screen.
  - **Introducing the styling**: The producer will be able to select a predefined font setting (size, colour and other font attributes) with the purpose of identifying the speaker.
  - **Introducing time codes**: The producer will be able to indicate the timing codes to show and stop showing the subtitle.
  - **Indicating the VR position of the subtitle**:
    - the producer will indicate the **position of the speaker** in the scene, and the width of a "security angle" that covers the speaker (for example, from left shoulder to right shoulder) (PUR.01.08.02).
    - we also consider the possibility to introduce the **relative depth** of the speaker (PUR.01.08.05), especially in stereoscopic 360 contents.
    - the producer can create subtitles that are not related to a specific angle (PUR.01.08.01), for example, for a voice-over scene.
- The editor will be able to show graphical elements that inform about the orientation of the current speaker, so the professional user can have a simulation of the result.

- The professional user will be able to check the complete result, in this case the subtitles will be previewed over the video during the video playback for real time checking.
- The final check of the complete result can be done using HMD (PUR.01.02.00). Once the production has finished, the professional user will be able to watch the final result using a Head Mounted Display with high quality 360 video together with the 360º immersive audio. (PUR.01.06.00).

Audio description editor

The audio description editor, in addition to the common features of the first list, must also comply with the features of the next list:

- The professional user can produce an audio description segment by following the steps below:
    - **Create or import an existing audio description** content for a video asset (PUR.01.15.00). Every AD content can be defined as "**AD on Action**", "**Voice of God**" or "**Fixed in Scene**". The type of AD will depend on the content and the best option to describe the action will be chosen:
        - **AD on Action:** the AD is placed on the action, so the user will listen the audio in 3D coming from the area where the action is taking place (HUR.03.40.01).
        - **Voice of God:** the AD audio comes from above, so the user will listen the audio as mono.
        - **Fixed in the scene:** the AD is anchored to the scene, so it's like someone is sitting next to the user (left or right) (HUR.03.42.01).

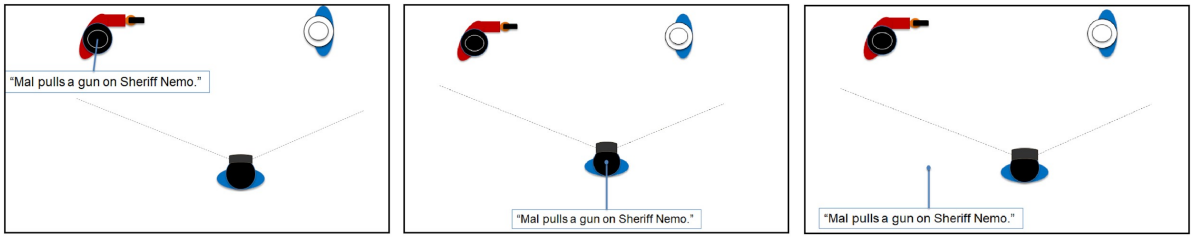

Figure 15: From left to right, graphics for AD on Action, AD Voice of God & AD Fixed in the Scene

    - **Writing or importing the script** for the audio description (PUR.01.10.0).
    - **Introduce comments**: The producer can indicate how this audio description script has to be recorded, for instance the tone of voice.
    - **Add information** regarding the role of an audio description segment. For example, to differentiate between main action and secondary actions AD (HUR.03.07.01).
    - **Recording of the audio** description segment: The producer will read out loud the corresponding script. Different voices can be used for different actions, for instance main action and secondary actions. The producer will get a visual feedback on the start and stop of the recording of an audio file (PUR.01.28.00).
    - **Assigning time codes** for the audio description segment, so the producer can decide the exact point of the video where the playback of audio description will start.
    - **Indicating the viewing angle**: the producer can indicate where the audio description is happening.

    - **Indicating the level of main audio:** the producer can indicate the level of the main soundtrack to help understanding the audio description (PUR.01.29.00).
    - **Check the audio description segment** with the preview video and the corresponding audio mixing of immersive audio content and immersive AD (PUR.01.14.00).
- The audio description editor will also allow to split and merge AD script and audio files (PUR.01.25.00 & PUR.01.26.00). The final AD script file can also be exported as a text file (PUR.03.15.00).
- The professional user will be able to check the complete result, so the professional user can playback the video with a simulation of the audio description mixed with the programme audio (PUR.01.12.00).
- The final check of the complete result in can be done using HMD (PUR.01.02.00). Once the production has finished, the producer will be able to watch the final result that will be available for end-users using a Head Mounted Device with high quality 360 video together with the 360º immersive audio and AD (PUR.01.06.00).

Sign Language editor

The sign language editor, in addition to the common features of the first list, must also comply with the features of the next list:

- The professional user can produce a sign language segment by following the steps below (PUR.01.09.00):
    - **Record a video** with the sign language interpreter using the webcam or **importing** a SL video.
    - Cut the specific sign language clip from the video.
    - **Define the vertical and horizontal position** of the sign language video if necessary.
    - **Define the dimensions** of sign language video.
    - **Introduce the time codes**, the producer will indicate the points of entry and exit of the sign language video.
    - **Indicate the position of the speaker:**
        - the producer can indicate the **position of the speaker** in the scene, and the width of a "security angle" that covers the speaker (for example, from left shoulder to right shoulder) (PUR.01.09.02).
        - the possibility to introduce the **relative depth** of the speaker (PUR.01.09.05) is also considered, especially in stereoscopic 360 contents.
        - The user is able to create Sign Language segments that are not related to a specific angle. (PUR.01.09.01).
- The sign language video segment will be previewed alongside the video for real time checking, so the producer can have an instant simulation of the result. The main video playback will be in the preview player and the sign language video segment playback with the interpreter will be in a separate window next to the player.
- The editor will be able to show graphical elements that inform about the orientation of the current speaker, so the professional user can have a simulation of the result.
- The professional user will be able to check the final result. In this case the sign language video segment will be played in a window next to the preview player in a synchronized manner.
- The final check of the complete result can be done using HMD (PUR.01.02.00). Once the production has finished, the professional user will be able to watch the final result

that will be available for end-users using a Head Mounted Display with high quality 360 video together with sign language content and 360º immersive audio (PUR.01.06.00).

Features for the production management

The contents for the accessibility services that the media companies offer are usually produced by external providers outside the video postproduction workflow. This means that new tools for the management of the accessibility content production workflow are needed, so the media company can, in a centralised and secure way, supply to the external provider the files required for the production (low quality video) and receive from the same provider the accessibility contents once produced. The management tools are also used to catalogue the accessibility contents and make them available to external systems.

Based on the requirements listed in the final iteration of deliverable D2.2 we define the list of features for the Content Management block:

- Uploading/Downloading contents:
  - A web interface will allow the professional user to upload and download the subtitling, audio description and sign language files to the platform (PUR.03.01.00).
  - The web interface will let the professional user to upload the low-resolution omnidirectional video that web editors need for the production of the pilot's accessible content (PUR.03.01.00).
  - The system will also provide an SFTP server for uploading high resolution omnidirectional video and a web interface to upload the required metadata about the high-resolution content to allow the automatic generation of low-resolution omnidirectional video required for the web editor tools. (PUR.03.12.00)
- Managing contents:
  - The professional user will be able to search for accessibility content by file name, content type, integrity and assignment (PUR.03.02.00).
  - Once the file or files have been uploaded, metadata can be edited such as the IDs that identify the corresponding media of one or several media asset management systems (PUR.03.03.00). The user can define the thumbnail shown in the GUI as preview of the video in lists (PUR.03.14.00).
- Activating the job of authoring accessibility content
  - The professional user can start one or several assets for the creation of subtitling, sign language and audio description, and assign the users to edit the contents (PUR.03.13.00).
- Publishing to internet
  - From the web interface the professional user will be able to trigger the packaging of subtitling, audio description and sign language once all the necessary files are ready (PUR.03.04.00). This process will be executed in the packaging block. There will be a section for general parameters required for the packaging and distribution modules (PUR.03.08.00) for the signalization of ImAc content required for distribution and playback.
  - From the web interface it will also be possible to monitor the state of the packaging (PUR.03.05.00).
  - The final packaging files can be downloaded to a local hard disk (PUR.03.06.00) or forwarded to a remote resource (for example, an external web server) (PUR.03.07.00).

3 TECHNICAL ARCHITECTURE OF THE IMAC PLATFORM

Chapter 2 has been dedicated to describe the multiple functionalities foreseen to be implemented in ImAc platform.

Based on these functionalities it was imperative to design an optimal architecture that must allow the production of accessibility content by professional users, and at the same time must ease the consumption to end users by offering the best user experience for all citizens.

The next sections draft this architecture, which has been divided in modules and grouped in four main areas, with the aim to offer a first high-level view of the full platform. Since the first version of deliverable D2.3, several changes were applied to the architecture due to first developments, and improvements in foreseen workflows based on professional requirements. Most of these changes are mainly applied on production (ImAc Platform) and end consumer areas (ImAc Player).

This architecture will feed the second iteration of deliverable D3.1, where a deeper technical implementation of the architecture will be provided to optimize the development of the ImAc platform with the aim to obtain the best results.

3.1 Overview of the end-to-end system

In this chapter we define the basic elements of the system, where production, distribution and consumer platform blocks have also been defined based in requirements presented in deliverable document “D2.2 User Requirement” and partner’s learnt experience. When a definition is related with a direct requirement, it is referenced to a HUR (Home User Requirement) or PUR (Professional User Requirement) with a number as defined in the final iteration of D2.2.

Figure 16 shows the logical layers of ImAc system environment: Content Production, Service Provider, Storage/Packaging/Distribution & Consumer Platform. The different green blocks in the diagram represent high level functionalities of the ImAc system and show the envisaged end to end workflow.

This figure has not experienced changes compared to the version presented in the first deliverable D2.3 and keeps representing the main logical layers of ImAc system environment.

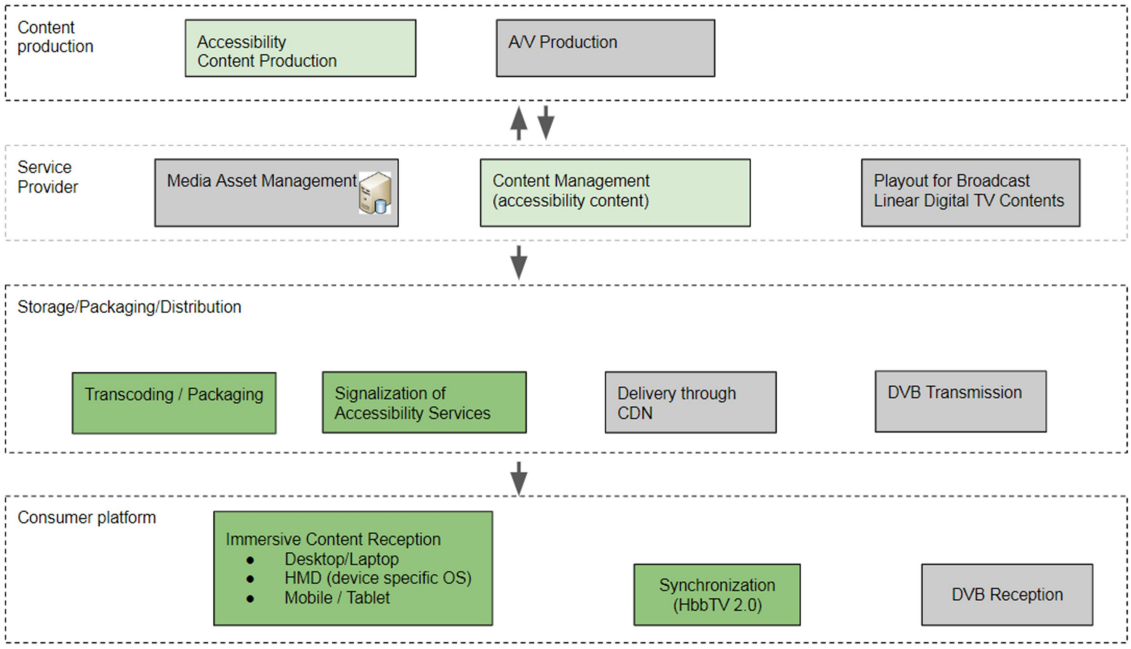

Figure 16: Basic Layers of ImAc system environment with functional blocks (green: relevant for ImAc project, grey: Not focus of ImAc)

Several blocks are highlighted in grey because they are not part of the ImAc platform but are relevant parts of the full workflow of production & distribution. ImAc does not focus on these parts, since ImAc's accessibility services don't require relevant changes of these system parts. We'll briefly define every one of these blocks before going in detail of ImAc blocks:

- **A/V Production** - refers to the content sent by the service provider to the ImAc platform for accessibility content production. For example, the service provider could send a 360 immersive short film and script to the ImAc platform with the aim to activate a job for the production of 360 subtitles and 360 audio description.
- **Media Asset Management** - MAM is closely linked to broadcast internal workflows, to allow the management of all contents, as for example importing, exporting, producing and storing contents.
- **Play Out** for Broadcast Linear TV – broadcast partners within the project considers the possibility to consume immersive content on companion screen synchronously to non-immersive VoD or linear TV content on SmartTV. The play out block is in charge of playing this linear TV.
- **DVB Transmission** - this block refers to the broadcast of digital terrestrial TV.
- **CDN Delivery** - as DVB Transmission broadcast linear TV, the Content Delivery Network is in charge of distributing IP streams through broadband in real-time (as linear TV) or as VoD. Usually this block is outsourced as a service.
- **DVB Reception** - Hybrid SmartTV, like those that are compatible with HbbTV standards, can receive audiovisual contents simultaneously or separately by both, broadband & broadcast channels. DVB Reception block refers to the Digital Terrestrial TV reception.

Let's summarize in the next section the main layer defined as basic elements of the ImAc system:

3.1.1 Content Production

The Content Production Layer is dedicated to production of all contents: Classic TV content, 360° media content and accessibility content. In ImAc, the accessibility content will be authored and produced. The additional possibilities of a 360° environment as well as the envisaged personalization options require an enriched accessibility content. The Content Production Layer addresses these aspects and all content, including the metadata to be provided to the next layer (Service Provider). The system requirements for Accessibility Content Production are described in section 2.3 (Content Production) in this document.

3.1.2 Service Provider

The Service Provider would be a Broadcaster, an OTT platform owner or online streaming platform.

The Service Provider Layer is where the management of a program is handled, including asset management, linking of additional content to main TV programs and scheduling playout. Typically, this is a broadcaster's or content owner's area of responsibility.

This block will interact with the content production blocks to order jobs about accessibility content production, to manage, upload and download contents.

3.1.3 Storage/Distribution

The Storage and Distribution Layer handles distribution via various channels. This covers content packaging, DVB transmission and IP distribution via Content Delivery Network (CDN) or a service provider's network. This layer provides all the data that is required by the large variety of consumer devices that can (co)-exist within the Consumer Platform Layer.

3.1.4 Consumer Platform

The Consumer Platform defines the platform where the end user will receive and consume the audiovisual content with accessibility services. This consumer platform will be based on the different platform possibilities, like for example desktop computer, head mounted display glasses, tablet or smartphone.

The Consumer Platform layer includes all required components for the presentation of the available ImAc contents, including traditional, immersive and accessibility contents, to end-users.

In ImAc, traditional TV contents will be played out on connected TVs. The 360º videos and the media accessibility assets will be played out on companion screens via a web-based player. The player will support different presentation modes and include customization options. Different interaction functionalities and modalities will be provided as well. These functionalities and features are detailed in Section 2.2 (Player features).

As indicated in the figure, ImAc will also provide synchronization solutions to ensure a time-aligned and consistent presentation of media contents across the involved devices. This feature will enable more immersive and engaging multi-screen experiences.

3.1.5 Logical Architecture

Based on the blocks described in the previous chapters, the logical architecture of the ImAc platform is introduced here. A key aspect is it's web-based design that follows a typical structure for catch-up TV services.

The ImAc platform takes into account the professional and end user requirements and the specifications derived from these requirements, is drawn in the form of a logical architecture (see Figure 17) that contains different modules that interact with each other to execute the necessary processes for the creation, management and distribution of audio-visual content and accessible services.

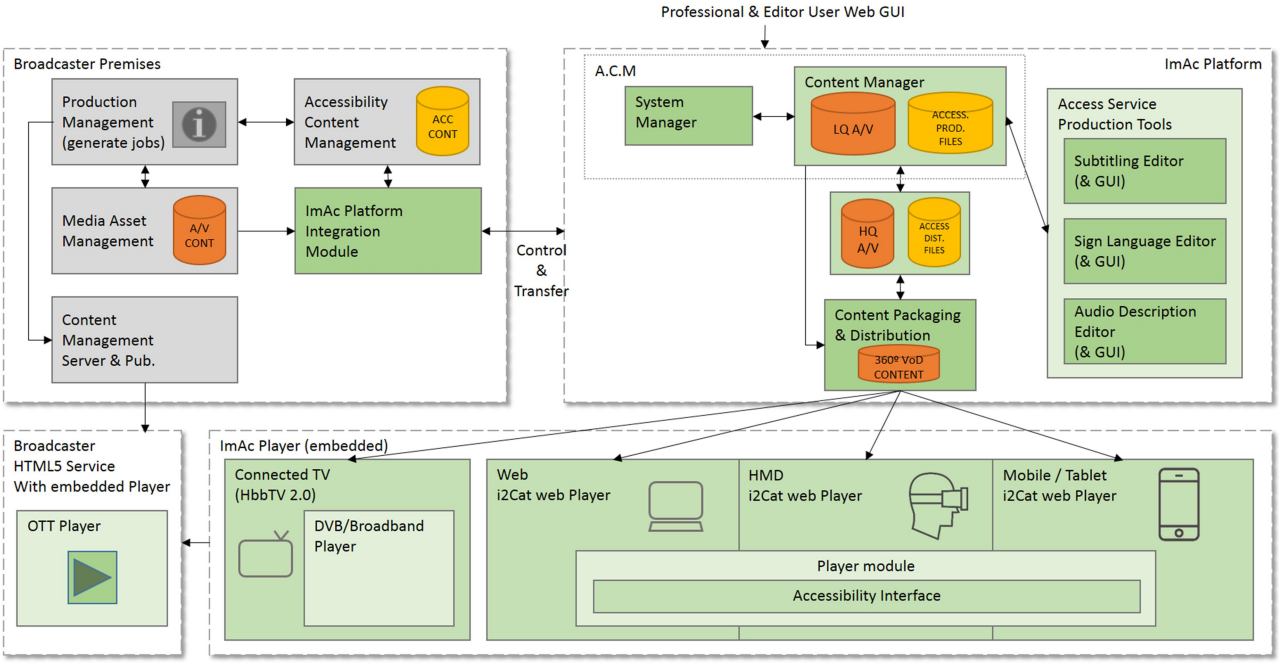

Figure 17: ImAc platform architecture

The architecture is divided in 3 main areas:

- **Broadcast Premises** - this area could be also represented by an OTT/IPTV platform owner or any content owner with the requirement to produce accessibility content for its audio-visual immersive content. A general overview of internal broadcaster workflows is shown, with the following modules:
    - Production Management module from where the different works of accessible content production are requested.
    - Accessibility Content Manager module to manage and store the ImAc produced contents.
    - Media Asset Management module which manages broadcaster media workflows, systems and assets throughout the multimedia production & distribution chain.
    - Content Management System + Publishing module allows the management, packaging and publishing to Internet of broadcast contents.
    - ImAc Platform Integration Module will be in charge to interconnect broadcaster workflows with ImAc platform and will allow all the

necessary communication to execute all required processes through a pre-defined API (Application Programming Interface).

- **ImAc Platform** - this area brings together all the main modules for the management, production, packaging and distribution of accessible contents and will be detailed in next sections:
    - **Accessibility Content Manager** which includes the System Manager and the Content Manager.
    - **Access Services Production Tools**
    - **Content Packaging & Distribution**
- **ImAc Player** (embedded) - The ImAc media player will be developed within the ImAc project ready to play all immersive accessible services and with an accessibility interface to ease the access to end users. This ImAc media player will be embedded in the web service of the broadcaster or OTT platform owner.

3.1.6 User Requirements

The logical architecture presented in the previous section is designed to accommodate all the professional and end user requirements defined in deliverable document D2.2 and, at the same time, allow a full system workflow that offers a complete solution for the authoring, managing and distribution of the accessibility services related to the 360º immersive contents.

In this section we will list the different requirements, relating every single one with the module that will host it.

As an example, a subtitling presentation requirement will be related with the Imac Player module because it will require to create this presentation mode within the Player web app.

The main 4 modules defined within the ImAc platform architecture that will host all the requirements are located in the ImAc Platform and ImAc Player areas of the platform architecture:

- ImAc Player module – defined within the ImAc Player area, represents a web app developed to play immersive contents and its accessibility services.
- ACM – defined in the main ImAc Platform area and formed by the System Manager and the Content Manager, this module is the main tool for the broadcaster or content owner to manage the audiovisual and accessibility contents.
- Access Services Production Tools – the second module in the ImAc Platform Area, joints the tools for the authoring of accessibility contents, like subtitling or sign language.
- Packaging & Distribution – the third module on the ImAc Platform Area has the responsibility for the packaging of the contents required for the distribution through OTT services.

The next table enumerates the different requirements, relating every single one with the module that will host it.

Type	System reference	No.	Version	Category	Title	Module
HUR	2	6	0	access/control	Multiplatform player for desktop, mobile phone (cardboard supported, gyroscope sensor based), TV, head mounted display	ImAc Player
HUR	2	54	0	access/control	Volume control of interface	ImAc Player
HUR	2	57	0	access/control	Personalization options for interface	ImAc Player
HUR	2	58	0	personalisation	Language selection for interface	ImAc Player
HUR	2	4	1	access/control	Access to Audio Description	ImAc Player
HUR	2	52	0	access/control	Access to Audio Subtitling	ImAc Player
HUR	2	59	0	access/control	Voice commands	ImAc Player
HUR	2	10	0	access/control	Player support for “screen reader functionality”	ImAc Player
HUR	2	10	1	access/control	Player support for “screen reader functionality”	ImAc Player
HUR	2	12	0	access/control	Remote control	ImAc Player
HUR	2	13	0	personalisation	User settings persistence	ImAc Player
HUR	2	14	1	access/control	Companion Screen as interface	ImAc Player
HUR	2	38	0	access/control	Interface adapted to user device	ImAc Player
HUR	2	62	0	access/control	Progress bar	ImAc Player
HUR	2	63	0	access/control	Access to interface	ImAc Player
HUR	2	68	0	access/control	Support of stereoscopic videos	ImAc Player
HUR	2	61	0	presentation modes	Accessibility interface - speaker location indicator	ImAc Player
HUR	2	66	0	presentation modes	Accessibility interface - speaker location indicator	ImAc Player
HUR	2	8	0	access/control	Subtitles always on Main Screen	ImAc Player
HUR	2	24	0	access/control	Switch on/off subtitles	ImAc Player
HUR	2	26	0	access/control	Selection of Personalization options for subtitles	ImAc Player
HUR	2	25	0	interface	Select subtitle tracks	ImAc Player
HUR	2	27	0	presentation modes	Accessibility interface for subtitles - presentation mode	ImAc Player
HUR	2	27	2	presentation modes	Accessibility interface for subtitles - presentation mode	ImAc Player
HUR	2	28	0	personalisation	Accessibility interface for subtitles - position in viewing field	ImAc Player
HUR	2	29	0	personalisation	Accessibility interface for subtitles - size	ImAc Player
HUR	2	30	0	personalisation	Accessibility interface for subtitles - background	ImAc Player
HUR	2	50	0	personalisation	Accessibility interface for subtitles - comfort field of view	ImAc Player
HUR	2	50	1	personalisation	Accessibility interface for subtitles - comfort field of view	ImAc Player
HUR	2	31	1	personalisation	Accessibility interface subtitles- speaker location indicator	ImAc Player
HUR	2	31	2	personalisation	Accessibility interface subtitles- speaker location indicator	ImAc Player
HUR	3	2	0	content	Accessibility interface for subtitles - notices for dramaturgically-significant sounds	ImAc Player

Type	System reference	No.	Version	Category	Title	Module
HUR	3	10	0	presentation modes	Visual display of audio content	ImAc Player
HUR	2	64	0	presentation modes	Display of stereoscopic subtitles	ImAc Player
HUR	2	67	0	presentation modes	Display of subtitles	ImAc Player
HUR	3	4	0	content	Simplified Subtitles	ImAc Player
HUR	3	5	0	presentation modes	Immersive Subtitles information	ImAc Player
HUR	3	11	0	content	Suppression of speaker location indicator - Subtitles	ImAc Player
HUR	3	1	0	access/control	Sign Language Service	ImAc Player
HUR	2	16	0	access/control	Switch on/off signer	ImAc Player
HUR	2	17	0	access/control	Selection of personalization options for signer	ImAc Player
HUR	2	60	0	interface	Accessibility interface signer - language	ImAc Player
HUR	2	18	0	presentation modes	Accessibility interface signer - basic presentation mode	ImAc Player
HUR	2	19	0	personalisation	Accessibility interface signer - position in viewing field	ImAc Player
HUR	2	20	0	personalisation	Accessibility interface signer - size	ImAc Player
HUR	2	49	0	personalisation	Accessibility interface for signer - comfort field of view	ImAc Player
HUR	2	49	1	personalisation	Accessibility interface for signer - comfort field of view	ImAc Player
HUR	2	21	0	presentation modes	Accessibility interface signer - speaker location indicator	ImAc Player
HUR	2	~~22~~ 21	~~0~~ 1	presentation modes	Accessibility interface signer - speaker location indicator	ImAc Player
HUR	2	7	0	access/control	Consumption of signer video in HoloLense[2]	ImAc Player
HUR	2	15	0	access/control	Multiplatform player for HoloLens	ImAc Player
HUR	2	65	0	presentation modes	Display of stereoscopic signer	ImAc Player
HUR	3	9	0	content	Sign Language Service	ImAc Player
HUR	3	12	0	content	Suppression of speaker location indicator - Signer	ImAc Player
HUR	2	36	0	access/control	Switch on/off audio description	ImAc Player
HUR	2	9	0	access/control	Playback of audio description	ImAc Player
HUR	2	37	1	personalisation	Selection of Personalization options for audio description	ImAc Player
HUR	2	55	0	access/control	Volume control of audio description	ImAc Player
HUR	2	40	1	content	Presentation mode for Audio Description	ImAc Player
HUR	2	42	1	content	Presentation mode for Audio Description	ImAc Player
HUR	3	6	0	content	Playback of 3D audio	ImAc Player
HUR	3	7	1	content	Different voices for main and secondary actions	ImAc Player
HUR	2	51	0	access/control	Switch on/off audio subtitling	ImAc Player
HUR	2	53	0	personalisation	Selection of Personalization options for audio subtitling	ImAc Player
HUR	2	56	0	access/control	Volume control of audio subtitling	ImAc Player
HUR	2	70	0	access/control	Simultaneous services	ImAc Player

Type	System reference	No.	Version	Category	Title	Module
HUR	2	71	0	presentation modes	Speaker identification	ImAc Player
PUR	1	1	0	editors	Watch low-res preview content	Access Serv. Prod
PUR	1	1	1	editors	Watch low-res preview content	Access Serv. Prod
PUR	1	2	0	editors	Watch hi-res preview content	Access Serv. Prod
PUR	1	3	0	editors	Navigate preview content by angle	Access Serv. Prod
PUR	1	4	0	editors	Navigate preview content by frame	Access Serv. Prod
PUR	1	5	0	editors	Navigate preview content by time	Access Serv. Prod
PUR	1	5	1	editors	Navigate preview content by time	Access Serv. Prod
PUR	1	15	0	access content	Create a new ImAc file	ACM
PUR	1	16	0	editors	Edit shortcuts	ACM
PUR	1	17	0	editors	Edit and preview mode for ImAc files	ACM
PUR	1	19	0	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	22	0	editors	Navigate preview content by defined number of frames	Access Serv. Prod
PUR	1	23	0	editors	Listen to audio content while navigating by frame	Access Serv. Prod
PUR	1	24	0	editors	Visual display of audio content	Access Serv. Prod
PUR	3	10	0	editors	Defining speaker location indicator options	Access Serv. Prod
PUR	1	8	0	ST editor	File operations	Access Serv. Prod
PUR	1	8	1	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	8	2	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	8	3	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	8	4	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	8	5	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	18	0	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	20	0	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	21	0	ST editor	Add subtitle text	Access Serv. Prod
PUR	1	25	0	ST editor	Add subtitle text	Access Serv. Prod
PUR	3	11	0	ST editor	Speaker introduction	Access Serv. Prod
PUR	1	6	0	editors	Navigate preview content by audio	Access Serv. Prod
PUR	1	9	0	SL editor	Add sign language video	Access Serv. Prod
PUR	1	9	1	SL editor	Add sign language video	Access Serv. Prod
PUR	1	9	2	SL editor	Add sign language video	Access Serv. Prod
PUR	1	9	3	SL editor	Add sign language video	Access Serv. Prod
PUR	1	9	4	SL editor	Add sign language video	Access Serv. Prod
PUR	1	9	5	SL editor	Add sign language video	Access Serv. Prod
PUR	1	31	0	SL editor	Set in/out points for non-contiuous display	Access Serv. Prod
PUR	1	32	0	SL editor	Speaker identification	Access Serv. Prod
PUR	1	10	0	AD editor	Create AD preview content	Access Serv. Prod
PUR	1	11	0	AD editor	Add AD preview audio to video	Access Serv. Prod
PUR	1	12	0	AD editor	Preview video and AD audio	Access Serv. Prod
PUR	1	13	0	AD editor	Add audio description	Access Serv. Prod
PUR	1	14	0	AD editor	Prelisten 3D audio content	Access Serv. Prod

Type	System reference	No.	Version	Category	Title	Module
PUR	1	26	0	AD editor	Edit audio description script	Access Serv. Prod
PUR	1	27	0	AD editor	Edit audio description script	Access Serv. Prod
PUR	1	28	0	AD editor	Display of AD assets in space and time	Access Serv. Prod
PUR	1	29	0	AD editor	Monitor recording of AD	Access Serv. Prod
PUR	1	30	0	AD editor	Define fading level of main audio	Access Serv. Prod
PUR	3	15	0	AD editor	Export AD script as text file	Access Serv. Prod
PUR	1	7	0	access content	File operations	ACM
PUR	1	7	1	access content	File operations	ACM
PUR	3	1	0	access content	Accessing content for ImAc enrichment	ACM
PUR	3	2	0	access content	Checking content for ImAc enrichment	ACM
PUR	3	3	0	access content	Assigning content for ImAc enrichment	ACM
PUR	3	12	0	assess content	Web interface for high-resolution file upload	ACM
PUR	3	13	0	access content	Assign users to edit ImAc files	ACM
PUR	3	14	0	access content	Define thumbnail for display of omnidirectional media	ACM
PUR	3	4	0	packaging, distribution	Triggering content packaging and distribution	Packaging & Distribution
PUR	3	5	0	packaging, distribution	Checking state of content packaging and distribution	Packaging & Distribution
PUR	3	6	0	packaging, distribution	Locally retrieving the packaging result	Packaging & Distribution
PUR	3	7	0	packaging, distribution	Directing the packaging result to a different resource	Packaging & Distribution
PUR	3	8	0	signalization	Configure the signalization of ImAc services	Packaging & Distribution
PUR	3	9	0	signalization	Monitor the signalization of ImAc services	Packaging & Distribution

Table 3: Requirements & modules table

3.2 Embedded workflow

ImAc targets a basic and functional workflow process with the goal to support all partners in preparing and running ImAc pilots and demonstrations. But at the same time the integration exemplarily shows how different ImAc components can be used and may be plugged into existing environments. It is not in the scope of the project to implement a highly functional and complex production environment, but to give a production solution that is prepared to be integrated with current environments.

Production environments operated by production companies may reach a high level of complexity depending for example of its size and the variation of use cases it supports. Although ImAc provides new services that are not covered by current production tools or platforms, the system architecture will be based on formats, interfaces and technologies that are typical in the broadcast world (e.g. video codecs, file formats, protocols). Doing so is expected to prepare an easy adaptation of ImAc solutions into real services. As described in

detail in Deliverable D3.1, the system is built around web technologies and open source libraries.

Setting up an end-to-end system and using it for most ImAc demos and user tests has various reasons:

- What we need is a system that can easily be adapted to changing requirements throughout the project. Changes on the content creation side need to be previewed in the player within a reasonable amount of time.
- It's one of the ImAc objectives to deliver solutions that provide a real benefit for the users. Working towards services that are realistic in all aspects (production effort, close to market technologies, compatible with existing user devices, etc.) is an essential aspect to achieve this goal. Thus, keeping developments close to existing production and delivery chains will pave the way for the introduction of ImAc services into a broadcaster's portfolio.
- The ImAc development reuses open libraries where possible (that is true for many parts of the system). Plugging them together to new tools is required to add ImAc functionalities where existing solutions do not fulfil the project's requirements. Since the exact requirements for each service is part if ImAcs investigation and is updated during the project, the tools need to be flexible.
- Future proof: The relevance of web technologies for delivering media content increases. It can be expected that solutions developed by ImAc on that basis have good chances to be adopted by other products and open libraries.
- Most features that were planned after evaluating the user requirements can be realized within the envisaged end-to-end workflow. That being said, there are some audio features that cannot be integrated into such a workflow easily, mainly due to missing support on client-side platforms. Features that fall under this category will be performed in a lab environment where they can be tested with less effort.

3.3 Dedicated web editor tools

Harmonizing new authoring methods with established production workflows is vital for the acceptance of new services. ImAc targets dedicated editor tools for each of the most used access services (Subtitling, Audio Description and Sign Language) and a centralized management solution for the production workflow. The designed UIs follows the industry standards in that area, such that the tools feel familiar to professional users.

Why web technologies?

Developing the editors with all the professional features in web technologies gives the opportunity to offer the production tools as SaaS (Software as a Service) where no installation on the final user is required, this business model would be difficult with Windows editors which are more adequate when offering the tools on a licences-based business model (which is also necessary in the market). The SaaS business model means that the tools can reach new accessibility content providers with low budgets. The constant improvement in web technologies means that this is the right decision for the future.

Why separate tools?

Although the web editors share common features and therefore common libraries (as they reside in the same web server), each of them has its own user interface which is optimised for the specifics of each accessibility service. For instance, the sign language editor focuses on

tools used for adapting the video segment recordings, the audio description editor focuses in creating a script and the tools for the right audio recording and automatic audio levels, and the subtitling editor focuses in positioning and styling the texts. Each interface must allow the producer to do their job in a very optimized manner.

Which is the impact and target?

Broadcasters use professional production tools for accessibility content that are focused on their sector as they are a part of the end-to-end solution for accessibility in TV programmes that are offered in parallel through broadcast and broadband channels, so they comply with the standards for TV and have the metadata that a TV station needs for the interconnection to their systems.

Although the current professional production tools for accessibility content can be used in any sector, they are mostly focused on the broadcasting sector. As broadcasters increasingly integrate new distribution channels such as web, new requirements have to be considered in accessibility content production and additional information and metadata about the content is needed to know how to feed each distribution channels simultaneously. Also, more metadata for the content elements is needed. For instance, in 360° media, the audio can be perceived to come from different directions such as the people (or objects) responsible for the audio element, so it is necessary to add graphical elements in the subtitle to guide the viewer towards the audio source.

Free tools are often targeting a more general community with different requirements which do not correspond to the specific needs of broadcasters, so this is why broadcasters prefer and need to invest in professional production tools.

By developing our own tools targeting broadcasters and other media companies with a vision of adding the new channels without disrupting the current production workflow and dedicated resources (for economic efficiency we want the content to be produced once and be used to supply all their channels), we can ensure that at the end of the project we deliver ready to use accessibility content production tools for 360º media that have a real impact on the sector. For RBB & CCMA it's not only relevant that the user tests can be done but also what they can get from the project to really use these services after the project.

3.4 Content Manager

A managing module for the broadcasters or media company is needed in the ImAc platform that allows them to manage in a centralised and controlled manner the acquisition and cataloguing of the accessibility contents that they require in order to offer accessibility services in their 360º videos.

Usually, in classical non-360º accessibility content production, the broadcaster or content owner outsources the authoring of accessibility contents. Due to copyright issues, only a low-quality version of the audio-visual content is sent to the accessibility producer.

In ImAc platform, the Content Manager is used by the broadcaster to send the low-quality videos to the external accessibility content providers and receive and catalogue the required accessibility contents that these providers produce.

In order to be a secured and complete professional system, this module must have administrative features such as access rights, management of accessibility content providers and register events in case of incidents.

As a central control, this module must also trigger the required automatic background processes such as video transcoding and audio mixing and communicate with external systems

and the rest of the ImAc components such as the content packaging and distribution module to initiate the publication. External systems and the rest of the ImAc modules must also be able to access the contents via web services.

As the Content Manager links the production of the accessibility content to external providers, it has an interface for external providers where they can access to their jobs. From each job (with information of the video and accessibility content to be produced) the provider can access to the corresponding editor which will automatically upload the video and return the accessibility content (when it's been produced) to the Content Manager.

3.5 Content Packaging & Distribution

The Content Packaging & Distribution layer provides a full set of content processing services which the service provider layer (and specially the Content Management block) can rely on.

Indeed, the Content Manager module will allow the user to produce accessible content (subtitling, audio description and sign language stream distribution) with audio-visual contents and then pilot the packaging and the distribution of contents thanks to the Storage/Packaging/Distribution layer.

The Content Packaging & Distribution layers will be used as an extension of the Content Manager described above. This module will communicate with the Content Manager in a close way thanks to APIs and protocols that will be defined into the ImAc project by following the best practices of the industry to be as interoperable as possible.

The Content Packaging & Distribution module will be also able to provide internal transcoding services to adapt contents to the ACM requirements. In this sense, transcoding capabilities will be used as well as for distribution than for internal adaptation of contents.

The distribution system will leverage the state-of-the art technology to deliver the best possible quality to all users depending on their capabilities. These technologies may be developed in the framework of the ImAc project. The wish of the ImAc consortium is to rely on standard technologies which means that our technological advances will be pushed to standardization bodies (such as MPEG or others) and industry consortiums (such as DVB or others).

This module will match four main required functionalities:

- Firstly, it will encode (or transcode) the audio and video content to adapt it to the distribution constraints (like network bandwidth) or target devices.
- Secondly, it will package the content inside a suitable container for delivery, and it will ensure that the content is segmented appropriately.
- Thirdly, this module will ensure a proper delivery that includes the signalling of the metadata according the editors' wishes.
- Finally, it will push the content to the appropriate network (whether using streaming protocols or file-based caching infrastructures).

In the framework of the ImAc project, the current workflow (with the main services provided) is explain below more precisely:

- The ingestion and the transcoding of 360º omnidirectional contents to low quality required for the web editors of the content management tools.
- The storage of the original contents and the different transcoded and packaged versions.

- The transcoding of 360º omnidirectional contents to multi-quality streaming files required for the distribution of contents through broadband public networks.
- The packaging of subtitling, audio description and sign language within the corresponding 360 omnidirectional contents. This packaging process will have to insert the proper metadata to ensure synchronization between each individual content and especially between the original audiovisual content and the additional accessible content.
- The distribution of the packaged contents to the client players through private networks or CDN. This distribution will take into account the devices targeted and validated by the ImAc consortium and will also allow two types of distribution:

    1. **VoD**: the content will be prepared as files on CDN storage ready to be distributed on a video on demand request.
    2. **VoD for TV linear program**: the content will be distributed to be consumed through companion screen synchronously to a linear TV content.

3.6 Player Module and target platforms

Maybe add:

- Real OBA playback is more easy to setup in a lab environment
- Specific hardware is required
- Some tests can be done outside the ImAc platform
- Describe technical design for audio (special challenge: high requirements on client side)

End-users will make use of several consumer devices to access the traditional, immersive and accessibility contents considered in ImAc, provided via the Content Packaging & Distribution module (see Figure 16).

As shown in the Consumer Platform block (Figure 4), ImAc considers different types of consumer devices, ranging from desktops/laptops, mobile devices (e.g. PC, tablets, smartphones...) and HMDs. This implies that the interaction and presentation features of the player need to be adapted to the characteristics of the target devices. . The use of **web-based components for the development of the player** is an advantage in that sense, as cross-platform support is easier to achieve, although taking into account the specific particularities of the different devices and platforms.

In general terms, the ImAc player will be able to play out the immersive contents (i.e., omnidirectional media), but most interestingly, it will integrate an **accessibility module/interface** to be able to present the accessibility contents in an easy way and to dynamically set the considered personalization options.

An objective of ImAc is also to provide support for multi-screen scenarios, so that different devices in a local scenario can be discovered, associated, play out the same or related contents in a synchronized manner, and even support interaction features. An example is the consumption of a director-controlled view of an event on a main TV augmented with the consumption of alternative 360º views and accessibility contents on companion screens.

The availability of commercial devices supporting the latest version of Hybrid Broadcast Broadband TV (HbbTV) 2.0 standard, at the time pilots need to be prepared (which is scheduled), will be of a great help in this aspect. It is due to the fact that it would allow leveraging the features provided by HbbTV 2.0 regarding the mentioned targeted functionalities. It would also allow considering broadcast linear (although not live) TV contents

to be played out on main (connected) TVs in the pilots. In such a case, the main TV will be able to process metadata inserted into the broadcast stream(s), signalizing the existence of accessibility services. It will also include the proper modules for service and device discovery, and for app launching. Inter-device synchronization capabilities are also provided by HbbTV 2.0 thanks to the adoption of the DVB-CSS (DVB Companion Screens and Streams) protocols.

4 CONCLUSIONS

The first tasks of the ImAc project have involved the survey and understanding of the requirements for both professional users and end users. This is important when consuming accessibility content in an immersive environment which is unfamiliar.

Within this new Immersive environment, little was still understood about the user requirements and behaviours making these first critical steps to discover and learn from the users themselves essential. The thorough work carried out so far in the first phase of task 2.3, enabled a precise definition of the features for the ImAc platform and led to the development of a platform architecture which aimed to facilitate an optimal development process to satisfy the user's needs.

First results of the ImAc platform were demonstrated and tested in WP5 where both, professional and end users, participated and contributed to improve the list of requirements.

This final version of deliverable D2.3 allowed to incorporate the new list of requirements to refine the definition of the features for the ImAc platform and also several changes applied to the basic architecture which will allow to improve the developments for a better performance in accordance with the professional requirements.

This wanted to ensure successful results which will be demonstrated and tested in the second phase of WP5, through the participation of both professional and end users through a process of new pilots.

5 REFERENCES

[Portillo, C., (2017) Films Unseen: Approaching sound design alternatives to enhance perception and mental imagery models among audio description audiences on Sci-fi films]