Deliverable

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D4.2 Pilot Execution Report

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Abstract: This deliverable reports on Task 4.2 pilots. The outcome of this deliverable is a description of the pilot 1 execution for the offline produced content scenarios and pilot 2 execution for live event content within the ImmersiaTV project.

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REVISION HISTORY

EXECUTIVE SUMMARY

This deliverable describes how the pilots of the ImmersiaTV project were conducted, resulting in a documentary demonstrating the content for pilot 1 and a live cyclocross experience for pilot 2.

In the first version of the deliverable (M10), we reported on the first pilot within the project which took place between May 2016 and December 2016 and we discuss the derived insights and lessons learned.

In this second version of the deliverable (M25), we add a report on the second pilot within the project which took place on 6th and 7th of January 2017. We also elaborate on the gained insights, and the specific challenges experienced during the execution of the pilot to derive the main lessons learned.

This document lists both content, used tooling and evaluation activities of the pilots.

For pilot 1, the content section first describes the scenario of the pilot and how it was transformed from pre-production to post-production into the final demonstrator. Special attention is given to the impact of the ImmersiaTV concept to each step of the production. Next, the tools that were used during the pilot are presented. Finally, the activities to evaluate the pilot, from the perspective of the software tools as well as the developed documentary, are introduced.

For pilot 2, the content section describes the detailed pilot scenario, how it was prepared beforehand, including both the interactive 360° scene configuration as well as the on-side deployment of the end-to-end ImmersiaTV workflow on the field, and how the live production tool was used to create the interactive end user experience. Finally, we introduce the evaluation activities for professional director and end user experience, which are further elaborated in Deliverable 4.4 – User Evaluation.

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LIST OF ACRONYMS

Acronym	Description
CPU	Central Processing Unit
GOP	Group of Pictures
GPU	Graphics Processing Unit
HD	High-definition
HMD	Head Mounted Display
IBC	International Broadcasting Convention
IP	Internet Protocol
MPD	Media Presentation Descriptor
MPEG-DASH	Moving Picture Expert Group - Dynamic Adaptive Streaming over HTTP
MPEG-TS	MPEG Transport Stream
NEM	New European Media
OB van	Outside Broadcast van
PhD	Doctor of Philosophy
Pr	Adobe Premiere Pro
RTMP	Real-Time Messaging Protocol
RTP	Real-Time Transport Protocol
RTSP	Real-Time Streaming Protocol
SDI	Serial Digital Interface
UCP	Universidade Católica Portuguesa
UHD	Ultra-high-definition
VR	Virtual Reality
WP	Work Package
XML	Extensible Markup Language

1. INTRODUCTION

1.1. Purpose of this document

This deliverable documents in detail the execution of the pilot 1 and 2 within the ImmersiaTV project as described in Task 4.2: pilots. The pilot of WP4 was executed based on the insights and requirements acquired in Task 2.1: end user requirements and Task 2.2 : professional user requirements, and the scenarios during the content ideation process in Task 2.3.

1.2. Scope of this document

The WP4 pilots are a vital part of the ImmersiaTV project. The aim of this deliverable is to describe in more detail the execution of pilot 1 and 2: pilot scenario, specific planning and preparation, used production infrastructure and tooling and pilot evaluation.

This includes the following sections:

- ***Pilot content:*** in this section we describe the content produced for pilot 1 and 2 and elaborate on how the content production was performed
- ***Pilot tooling***: describes the different tools and components used in pilot 1 and 2
- ***Pilot evaluation***: describes the different user evaluations executed for pilot 1 and 2

1.3. Status of this document

This is an intermediate version of D4.2 containing the combined delivery foreseen in M10 and M19. Due to the fact that cyclocross races are only organized during the winter period, the pilot 2 execution had to be postponed and took place early January 2018 (M25).

1.4. Relation with other ImmersiaTV activities

The relationship between Task 4.2 and the other WP4 Tasks and relevant WP2 and WP3 Tasks is shown in Figure 1.

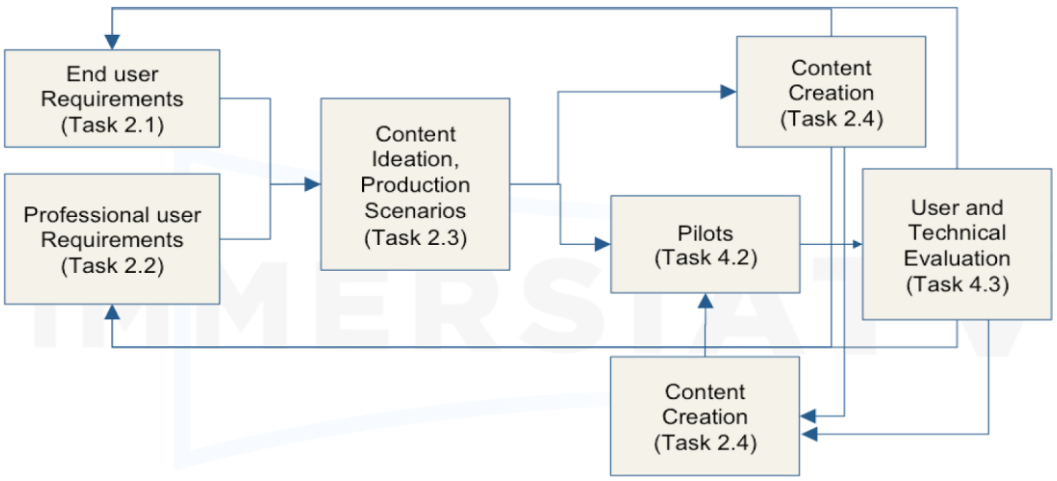

Figure 1: Relationships between different tasks

2. PILOT CONTENT

This first ImmersiaTV pilot focuses on the creation of offline content for head mounted display (HMD) television sets and second screens. The second ImmersiaTV pilot stages a live sports event experience for a similar set of multi-devices. This section will describe the content of this first and second pilot, starting from the pilot scenario (2.1) to its execution (2.2). In 2.3 the lessons learned are set out.

2.1. Pilot scenario

2.1.1. Pilot 1 scenario

Pilot 1 is described as an offline scenario documenting the daily life of a young football player and his family, all this done using immersive content and regular directive video. To produce a consistent story, it was necessary to prepare a script taking into account the additional opportunities and alternatives brought by the combination of multiple types of content and devices. This was also critical during the edition process.

In the documentary, we follow the steps of David, a young Portuguese athlete who joined Dragon Force, FC Porto's football school, to pursue his dream of becoming a successful football player. During his busy, hard-working days, we will meet his family, his friends and the dedication of this 14-year-old dreamer. Shot in immersive technology, "**Dragon Force: The Making of Future Heroes**" gives the audience a literal inside view of what it takes to become one of the greatest football players.

The full scenario of the first pilot is given in annex I. Just like the final cut of a movie does not 100% correspond to the shooting script, also the prepared scenario was subjected to revision and modification in the post-production process. As a consequence, the actual pilot differs from this script.

2.1.2. Pilot 2 scenario

In pilot 2, a sports event (cyclocross) is captured live with several 360° video cameras in the field extending the traditional broadcast directional camera set-up. All omnidirectional camera streams and the directive TV output signal are synchronised with each other. The omnidirectional streams are gathered in the live director's tool where a preconfigured omnidirectional scene set-up enables the content creator to direct the streams to multiple devices displaying the content to the end user.

A cyclocross is a cross-country bicycle race, similar to a mountain bike race, that typically consists of about eight laps of a short circuit featuring pavement, wooded trails, grass, steep hills and obstacles requiring the rider to quickly dismount, carry the bike while navigating the obstruction and remount. The race lasts about an hour.

In the ImmersiaTV concept, the end user can follow the race over multiple devices in sync with the traditional broadcast on television. On the HMD or tablet a similar scene set up is preconfigured (Figure 2) giving the end user the ability to be their own director:

- 4 circular portals represent the 360° cameras placed around the circuit at interesting locations;

- a map gives an overview of the camera set-up on the circuit (left upper corner), allowing the viewer to select a location of interest;
- the directional live broadcast is displayed (right upper corner) to address the fear of missing out important race events;
- a map and TV icon makes it possible to switch the map and directional broadcast on or off (right down under).

The director can push any interesting live camera feed to the end user to be sure they do not miss any interesting action while exploring the race on the HMD or tablet. In case of technical errors or for storytelling purposes, the director also has the possibility to change the scene configuration and switch portals on or off. The cameras are placed over the field on unique locations where it is impossible or at least very difficult for a visitor to come, e.g. in restricted areas where only professionals are active or at hazardous points on the track. The combination of the director's point of view (both on the television and on the mobile devices) and the end user's freedom to create their own story gives 'a best of both worlds' experience. It combines the comfort of being at home having the best possible view on how the race unfolds on the one hand, and the feeling of being there at the most interesting locations at the same time.

Figure 2: Example of an omnidirectional scene set-up by the director

2.2. Pilot execution

2.2.1. Pilot 1: off-line documentary

The first pilot was executed in a traditional three-step process used in filmmaking: pre-production, production and post-production. In every step decisions had to be made that impacted the scenario and the final result. Since the combination of 360° and 2D video is relatively new, all steps were handled with extra care, trying to learn more about what the Immersia concept is and what it can do.

Pre-production

During pre-production we had to decide what shooting 360° and 2D at the same time means. Usually, everything is done for the sake of what's in front of the camera since the remainder behind the camera is unseen**.** In this specific 360° case, the complete surrounding is captured by the camera. Therefore, a couple of important points had to be considered:

1. How to synchronize between 360 and 2D cameras.
2. How to take full advantage of a shooting space, or set, in order to: hide the 2D cameras from the 360° view, record sound, and move the crew to unseen places in ways that wouldn't hinder production.
3. Understand basic stitching limitations and choose where to shoot accordingly.
4. Get to know how the 360° camera rig would behave during production.
5. Explore the plug-in and get to know its frameworks. Try to have a clear idea of what can be done until the IBC Exhibition.

The following paragraphs will discuss these points in more detail.

In order to correctly achieve synchronization (point 1), two requirement emerged. First, it was mandatory to correctly use a clapper and try to have all directive cameras pointed at it at the moment of clapping for sync. This requirement also counts for the 360° rig which needed to have a clear view at it. Secondly, and this was a big issue during pre-production, we had to make sure that the files coming from *all* cameras had the very same frame rate. At the beginning this was an issue, but it was eventually fixed early on and it practically did not pose any problems during the actual post-production.

Regarding the shooting space or set (point 2), we had to learn how to choose and compose a scene with a set of limitations in mind, for example: is this a 360° appealing space? Will the consumer's point of view be worthwhile here? Hence, we learned about the major elements that make a 360° scene worth a consumer's time: *points of interest, information organization, complementary narrative events and proximity***.** Some of these elements were used in pilot 1. However, before we could exercise this approach to the 360° image plane, we needed to solve the very basic problem of how to hide the directive cameras and crew. While searching for shooting locations good hiding spaces had to be taken into account. The locker room scene is a good example, since the used locker room in pilot 1 had in numerous lockers all around the area where the action would take place. After some testing, we concluded that the directive cameras could be fitted into the lockers, hiding them effectively from the 360° view and still making the synchronization process possible. A similar approach was implemented in all other scenes. An exception was made for the football game at F.C. Porto's Dragon Stadium considering that, due to an incredible amount of limitations for security and permit reasons, room for experimentation and possible locations for camera placing was considerably lower compared to other scenes.
In regard to sound, we used a method like the ones employed for directive cameras. There were hidden microphones to record ambience and environment, but mostly, we used lav microphones[1] tucked away in people's clothes. This was the best way to ensure audio coverage without compromising the immersive experience we were aiming to achieve.

When researching for a safe and effective way to correctly stitch a 360° image (point 3), testing was needed. This meant we had to explore different spaces with different typologies. That way, we came to realize that crowded spaces with lots of people would create problems on the stitching lines. After doing a test shoot on a subway, we noticed how hard it was and thus had

[1] https://en.wikipedia.org/wiki/Lavalier_microphone

to circumvent that problem by filming at a time of the day when the number of passengers was at the day's lowest. This still posed some issues during post-production, but thanks to extensive testing they were severely minimized.

All throughout this process, we were getting to know the 360° camera rig system, trying to understand its limitations, what works best and what isn't really a good idea to do (point 4). No issues occurred during the test phase, but it was only during actual production that one of our rigs malfunctioned (for reasons that are unclear), forcing us to halt production and schedule a reshoot for that very same scene.

While the testing on location took place, another part of the team was focused on running tests with the plug-in (point 5), using test footage previously shot. This allowed us to have a clear idea of what would be possible within the given timeframe and how different updates of the software impacted our workflow.

Production

A well-thought strategy and extensive testing of all the above mentioned elements in pre-production contributed to a relatively smooth and uneventful production process. The only problems encountered were the limitations imposed at the soccer game and the malfunction of one of our 360° rigs during shooting which caused significant delays.

Post-production

The entire post-production process was divided into four phases: editing 2D scenes, synchronizing them with the final omnidirectional image, creating the narrative structure for the pilot and designing the portals (a heavily technical task).

The first phase was to make sure we had all the 2D scenes assembled internally. In other words, the TV component of the project had to be finished as soon as possible, so we could focus on the important task at hand.

Once we established a correct synchronization between both images, the two latter phases that took the bigger part of the post-production process were essentially the narrative structure of the pilot and portal design. This is where we departed from the shooting script and reorganized certain events, eliminated or reduced others. It is commonplace in filmmaking that during the edition the transformation and interpretation of the material brought forth by the cameras take place. And so, since we felt the need for a common narrative thread that connected the entire pilot, the idea of dividing the interview scene between the kid and the coach seemed like a very organic and cinematic solution to create some mystery, but also to immediately tell the audience what the character cares about and the team of the story is - David's love for soccer and the place Dragon Force team has in his life. Structurally speaking, this was the biggest change in the shooting script.

As mentioned before, other changes that occurred during the editing process had to do with the elimination and/or reduction of a certain scene or even a narrative event. Some scenes, like the breakfast or subway scenes were substantially trimmed for a very simple, yet valid, reason: if after a certain point, a scene has nothing else to give us, if its narrative value drops, then it should be cut. However, ImmersiaTV being a joining of different types of images, another criterion developed which leads us back to the point of *what makes an omnidirectional image worthwhile?* If there is nothing there, as was the case with the previously mentioned scenes, then we must cut.

When it came to portal design, the 2D camera material used in the TV edit was the sole 2D material we had available. This meant we needed to be creative about what we would show the

user, in both HMD and tablet. Since the portal-based interactivity wasn't working at the time we were preparing pilot 1 for the IBC debut, we only had access to two non-interactive features of the plug-in: *user reference* and *world reference* (i.e. a portal containing video travels, respectively, does not "travel" when the user looks around, see deliverable D2.3 for introduction of these concepts). It was then decided that the approach would be to provide an as different experience as possible between HMD and tablet. In order to do so, we switched the portal typology for each content and varied their respective position on the omnidirectional plane.

To conclude, the first pilot was executed without any major setbacks, only running into technical issues and problems (as previously mentioned) which cannot be foreseen in advance, but such is the nature of this industry and of a project such as this one.

2.2.2. Pilot 2: live cyclocross experience

Pilot 2, as any live production, consisted of two key phases: pre-production and production. These phases are described in detail in this section. Typically for live event coverage, preparation is key, all efforts in this phase are aiming towards one production date where all pieces have to fall into place.

Pre-production

- ***Building a live lab set-up at the VRT premises***

The set-up had to be able to process 3 incoming RTMP streams from the Orah cameras, 2 RTMP streams from the AZilPix Studio.One cameras and one RTSP stream containing the directed TV output signal from the OB van. As each camera stream corresponds to approximately 10 Mbps, the performance of the processing units should be proportionally accommodated. Two laptops and one PC with sufficient CPU and GPU power, a gigabit router and a switch to cover all the incoming and outgoing Ethernet cables have been set up at VRT side. Cinegy Transport and Cinegy Live VR have each been installed on one of the laptops, and one additional instance of Cinegy Transport was installed on the PC as well. Testing revealed that Cinegy Transport is able to process two incoming streams per laptop/PC. CPU and GPU performance have been tested for the full set-up. To mimic the incoming stream of the television broadcast, a camera with SDI output was playing a continuous stream to an SDI/IP encoder where it was converted to an IP stream (RTSP) and ingested in Cinegy Transport. All different cameras have to run in sync with the television broadcast stream. As the Orah cameras do not output genlock[2], syncing had to be done manually. A timecode clock was held before the cameras and Cinegy Live VR made it possible to adjust the time code of each stream. For practical reasons of availability, Studio.One cameras were tested. On these occasions, AZilPix delivered an RTMP stream running from their base office.

To simulate the cyclocross experience, as delivered in pilot 2, for evaluation and dissemination purposes after the event, all streams have to be recorded during the race. Hardware

[2] Genlock (generator locking) is a common technique where the video output of one source, or a specific reference signal from a signal generator, is used to synchronize other television picture sources together. See: en.wikipedia.org/wiki/Genlock.

performance and capacity to continuously record all incoming streams for one hour (corresponding to the duration of the race) have been tested as well at the VRT lab set up.

The omnidirectional scene set-up has been made in Cinegy Live based on a visit of the cyclocross location one month before the race. A camera map was composed and designs of the icons had to be made and imported as assets in Cinegy Live, which are available to the director to create the end user experience (see Figure 3). Portals were linked to each asset corresponding with a camera stream. A map of the circuit and the directive stream of the linear broadcast were added as extra icons to switch the portals on or off in the interface. The pre-configured scene in Cinegy Live was tested with the web player on each device.

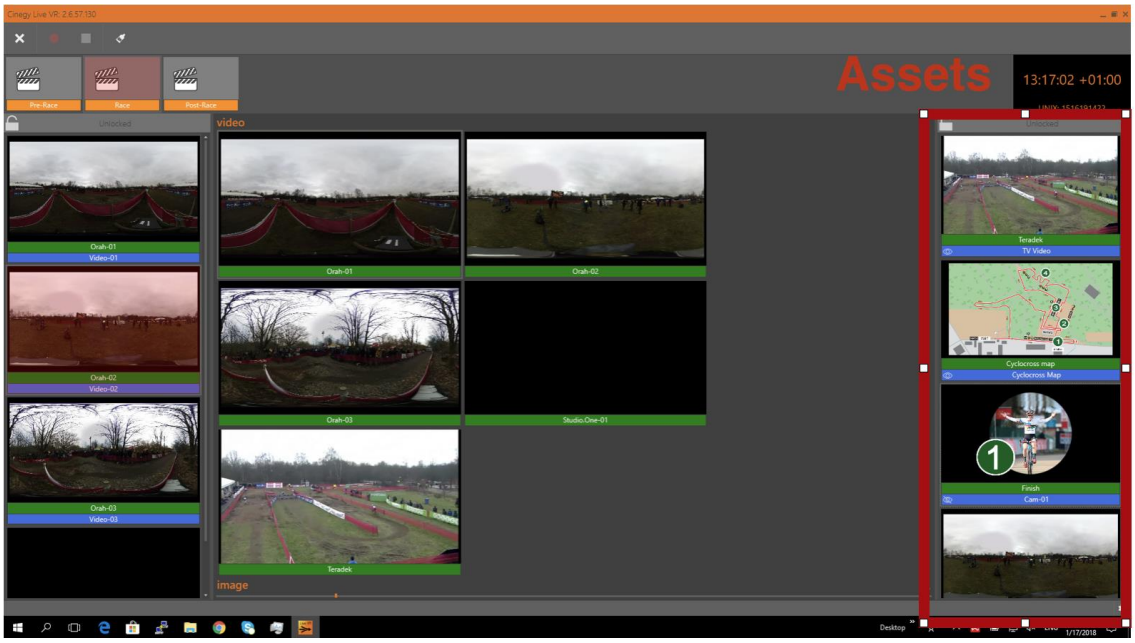

Figure 3: Design assets available to the director to create the GUI for end user experience.

On the player side, the decision to go for a web player made it easy to access the player on all devices running a chrome browser.

- ***Integration of the lab set-up with broadcast pipeline***

Ethernet cables (Cat 5) must be 100 meter or less to be certified. As the cyclocross circuit in Leuven covers an area of approximately one square kilometre, transfer over fibre cables is necessary. These cables are spread out over the field to transport all the camera streams to the TV compound. A successful pre-test in the VRT lab environment has been done to simulate the on-field deployment of the 360° cameras. All cameras were connected with a Nevion break-out box streaming the IP signal over fibre to the ImmersiaTV demo set-up.

- ***Production preparation with organising partners (Golazo / Sporza)***

The technical set-up in the field the day before the race and the close collaboration with the television crew during the race was carefully planned beforehand. A production document (see Annex III) gathered all information for the whole audio-visual production, including the ImmersiaTV pilot test. One month before the pilot, a trip to the race location was organised with all key professionals to prospect the technical requirements (cabling, camera positions, TV compound arrangements, etc..). Next to the technical set-up, the authorisation of the ImmersiaTV test during an official cyclocross race and all the logistics (accreditation, parking, dedicated container on the tv compound ,...) had to be cleared together with organising partners Golazo and the production crew of Sporza (the VRT's sports department).

Live Production

- ***Infrastructure deployment one day before cyclocross event***

The day before the race, the complete installation of cabling, infrastructure and ImmersiaTV live production set-up was done and tested. Within a very short timeframe a full audio-visual broadcast installation with a multi-cam set up was deployed in an open air habitat full of natural and artificial obstacles. Over the entire area of the cyclocross a network of cables was installed to distribute all camera data to the TV compound. Camera positions, which were roughly defined in pre-production, are re-checked in the field and selected/adapted in function of good storytelling. The resulting camera plan is shown in Figure 4: the red numbered circles represent the TV cameras (about 20 in total), and the orange ones are the omnidirectional cameras. The different 360° camera positions selected are:

(1) Spectacular descent in the wood (see also Figure 5 and Figure 6);
(2) Bike changing and cleaning zone: no spectators allowed here;
(3) Beam obstacle near the VIP pavilion;
(4) Camera at the height of the finish line.

Figure 4: Camera plan for cyclocross pilot

Unforeseen difficulties were solved at this stage, e.g. obtaining the best possible camera position without creating a hazardous situation for the cyclists (see Figure 5 and Figure 6). At the TV compound the ImmersiaTV set-up was installed and all incoming streams were tested, including the incoming stream from the TV broadcast play-out (see Figure 7). After the full field installation was done and camera data reached Cinegy Live through Cinegy Transport, the camera plan map in the end user interface was updated with the real camera coordinates around the track.

Figure 5: 360° camera set-up and tuning before the race.

Figure 6: 360° camera position at a spectacular circuit location.

Figure 7: Testing the ImmersiaTV set-up in the pilot container.

- ***Live production at event date***

The cyclocross event started early in the morning with several pre-races before the men's elite race. The entire set-up had to be ready, up and running before thousands of supporters entered the circuit. Most cameras were placed safely out of reach of the crowd, nevertheless a team of volunteers was put together to keep an eye on our equipment in the field, ready to intervene when necessary (e.g. to cover up in case of rain). During the pre-races, we were able to test the full set-up one last time, especially the directing practice for the live director and the accuracy of the pre-configured scene based on real race content. During the men's elite race, all streams were recorded, the director pushed scenes to the end user through Cinegy Live, an evaluation was done by Imec (Smit) and several end users tested the different devices in the ImmersiaTV concept (Figure 8).

Figure 8: End users testing the live ImmersiaTV experience

2.3. Lessons learned

2.3.1. Pilot 1

1. Simultaneous storytelling allows for new points of view in terms of narrative.

What we're used to, by the so-called traditional media, is to have our point of view be guided by the director and/or the editor. The simultaneous storytelling that this project allows, changes all that. Now, the user can have access to other viewpoints on the action that were not present before. Let's say that a 2D TV version of the content shows us a mother yelling at her son for something he allegedly did. All we're shown is the mother yelling and the kid looking down, afraid and sad. However, if we decide to look around the room while using the HMD display, we might be able to see his younger brother hiding behind a piece of furniture, laughing. By doing so, we're changing the meaning we're given through the 2D perspective. Only by immersing ourselves in that world and actually wanting to find something else, besides what we've been previously showing, we will be able to see it.

This way of thinking was not yet used in pilot 1, since it was only discovered during post-production, after experimenting with complementary narrative structures while editing the main narrative body. Although it could have been interesting in the kitchen scene. Mom, for example, could have asked the kids if they've seen the cat. As they answer no, the user could have seen the cat hiding under the table.

2. Producing content that mixes 2D images with 360° requires a different approach to production but most of all to post-production since editing becomes a whole different task.

Linearity versus non-linearity is a pretty tackled subject in the world of editing, whether it's film editing or in this specific case video editing. However, when mixing two very different ways of perceiving reality itself - from 2D to 3D - this discussion must fundamentally change. What we should be reflecting on, instead of linear versus non-linear, is simultaneous versus concurrent, or in other words synchronous versus asynchronous. This being said, if it's only a matter of having synchronized images and sounds that's not really the point. When we enter upon such a debate we must come to face with another, deeper, question: objectivity versus subjectivity (supposing we can clearly tell the two of them apart). For the sake of the current line of thought, let's consider that 2D represents objectivity while 360° (or 3D) represents subjectivity. Linearity or non-linearity can still be a part of this discussion but what makes it truly interesting is the fact that this deeply transforms editing, the art of assembling images, by opening up the possibility of a multiverse of actions. This multiverse of actions opens up new possibilities for plot, sub-plot, narrative, backstory, overshadowing other narrative construction related subjects.
As a result, editing is no longer the joining of two images to create meaning, but more about creating a carefully constructed narrative web that is solid enough to sustain itself on a objective (2D) language, linear or non-linear, and at the same time interesting enough to become subjective (3D) by inviting the user to immerse himself into that world and/or story. It is clear that we're not dealing with a simple concept anymore. A triangle arises: we're talking about ***linear or non-linear synchronicity that must be both objective and subjective at all times***. This could lead to interesting research on the evolution of storytelling.

2.3.2. Pilot 2

In this section, we point out the main lessons learnt from the live pilot 2 execution with regard to the ImmersiaTV concept applied to live sports experiences. The main insights and take-aways are as follows:

1. Scene set-up before the event is essential in the ImmersiaTV live concept.

In a linear multi-cam live broadcast, the set-up of all cameras is key in terms of storytelling. It is essential to plan where each camera is placed, which kind of focal lens is used and what content the camera can cover during the live event.
In the ImmersiaTV concept a lot of freedom is given to the end user, they can choose their point of interest and which camera they want to activate, thus becoming their own director. The interface given to the end user will be a key element to their perceived quality of the experience. It has to be easy to use in a natural way, the viewer must understand the graphical interface immediately so it will not become an obstacle in experiencing the event. An important task is granted to the director before the event; he/she should analyse the 'storyline' of the live event, trying to visualise how an end user will experience this event and then based on these insights, create the appropriate interactive interface. Designs of the portals (interaction points) should match the event's context and should be self-explanatory to guide the end user in terms of where they can find content of interest.
A related observation is that in the current version, the placement of each portal has to be done manually in Cinegy Live through inputting x and y coordinates of specific image areas. There is neither a direct preview nor a tactile configuration tool such as the ability to move portals towards more suitable positions. As such, it is a trial and error process that can be optimized.

2. Live previews of the user interface are essential for the director.

Standard multi-cam software or hardware tooling always have a playout screen to visualise the experience provided to the end user. It is a continuous checkpoint for the director to see the result of his or her action. Typically, this is the main central screen in a multi-cam production. ImmersiaTV has a multi device output, so a triangled or squared preview could be a solution.

3. A dedicated 360° director is not mandatory during the event.

During the execution of live pilot 2 it became clear that the role of the director is actually minimal in case of a multi-camera set-up consisting of 4 cameras. Pushing content to the end user can also distract the experience of exploring a 360° viewpoint, so minimal editing is recommended. Most of the director's creative work is done before the event, i.e. while setting up the interactive user interface.

4. ImmersiaTV concept as a modular system

From a storytelling point of view it is not always necessary or practical to set up a full pipeline for a multi-device output with the television as the main screen. During the execution of live pilot 2, the possibility to e.g. only output the tablet interface on an online platform, could already give an interesting extra experience to the viewer. As HMD's are not yet widely spread, it might be an interesting viewpoint in the continuing exploitation of ImmersiaTV.

5. Interlink the TV broadcast content with ImmersiaTV camera set-up.

As mentioned before, a directional television broadcast depends on the good coverage of a certain event with a multi-camera set up. There is a main protagonist or subject during this event, in case of a cyclocross it is the race itself, in case of a music event it is the main stage with the artist performing. In a lot of cases the coverage of the main subject is combined with other side subjects, e.g. an interview with an expert about an incident that happened during the race or an interview with a fan of the artist. This is done for storytelling reasons, to make the live event more entertaining, giving more insights on what is happening or about to happen. These are unique moments that would be very suitable to experience in 360° video. To integrate these moments into the ImmersiaTV concept, a collaboration between the television director and the ImmersiaTV director is necessary, as they need to anticipate and script beforehand the type of planned interventions during the live broadcast. The camera positions of the 360° cameras should obviously be mapped at the locations of these interventions. More specifically, an automated link between the camera that is on air and the near-by 360° camera that captures that same moment would be very helpful, to build experiences that allow the viewer to switch devices to watch that particular moment.

Technical issues

- During the pilot 2 execution, a number of technical issues and difficulties occurred which are documented in more detail in Deliverable 4.4. The main technical issues encountered can be summarized as follows:**Connection to one of Orah cameras was periodically lost** (about 5 disconnects during 1 day), i.e. no longer available in the network while still on-line and active.
  Remedial action: a team of volunteers kept an eye on the cameras, and could be contacted by the core team in the ImmersiaTV compound in case of problems.
- **Connection between client webplayers and sync manager could not be established**, while working fine in previous tests in the VRT lab environment.
  Workaround: consisted of manually setting up the correct timing on all devices such that the synchronisation manager was not required
- **Player behaviour on mobile devices was not fully operable**: the player was hosted by Live VR and opened on a Samsung S7, a Samsung Galaxy Tab S2 and a Windows 10 laptop in

Chrome. All devices were connected to Cinegy Live via the same wireless network. On the laptop, the player was always displaying the live VR stream and TV insert (2 live streams simultaneously) on every attempt. On Tablet and smartphone however there were difficulties to display all streams.
Remedial action: if we kept the TV stream invisible during initialization (portal hidden) the VR streams were displayed fine and kept fine, also when the portals were made visible afterwards.

- **Live stream shows stable reception when several streams are active, suffers from glitches after adding extra stream**: During pilot 2, stable stream reception and playback in the player were achieved. However when an extra stream was added, short term glitches appeared during playback, indicated as frame drops in the logs. The drops seemed to be unrelated to processing performance: when only recording of the incoming stream was tested the CPU and GPU load of the corresponding machines remained within 5-10% only. It looks like there is an issue with the network hardware reaching a certain maximum output level. As streams were captured independently on different machines, they could not affect recording of any other stream directly.
  Remedial action: New hardware is expected to overcome this issue.

3. PILOT TOOLING

3.1. Pilot 1

This section describes the production tooling used to create pilot 1 content and the infrastructure deployed to deliver and display it. This is based on the work carried out in WP3 which represents the software implementation by the ImmersiaTV partners. All necessary stages for running the pilot are listed in Figure 9. The implemented tools have been mainly used in two stages of the project:

1. **Content edition**: the creation of content (i.e. shooting of the documentary) started before the pilot and the edition took place during part of the first pilot, starting in M08 until M09. Right before IBC (M09) a first full-length version of the documentary was ready. To achieve this goal, production teams edited content with Adobe Premiere Pro and the post-production tools developed by i2CAT and PSNC. These tools were also useful during the pilot execution phase, e.g. to run tests, and to improve the initial version of the documentary.
2. **Content display**: With "content display" we understand all the processes and technologies necessary to watch the content. From our perspective this process includes content encoding and distribution, using the MPEG-DASH standard and DOCKER containers, followed by the content consumption in multiple and synchronised devices.

In the following sections, there is a detailed description of what and how elements have been used during pilot 1.

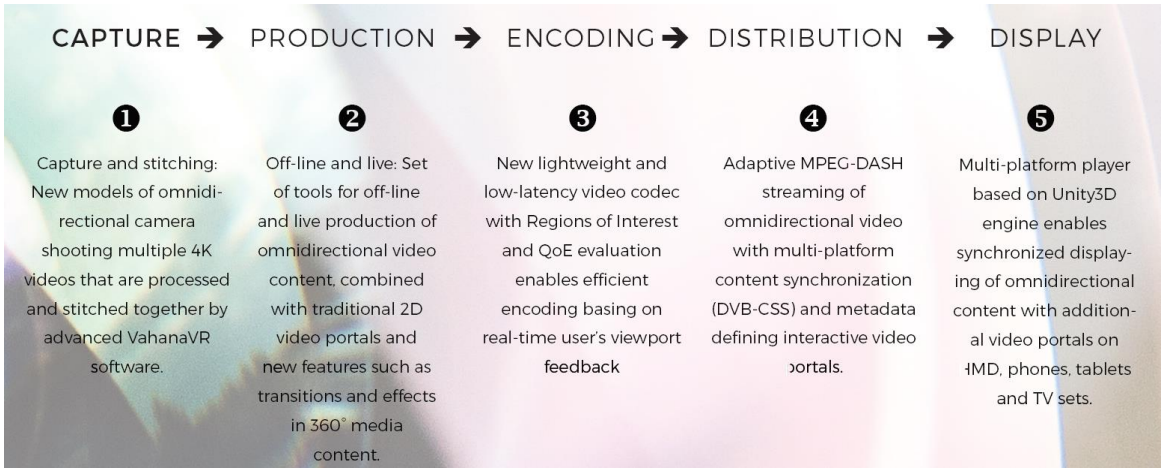

Figure 9: The production workflow

3.1.1. Content edition toolkit

Description

For pilot 1, ImmersiaTV offers a plug-in on Adobe Premiere Pro with two sub-components for the production of omnidirectional content. The first one is an offline production service to simplify omnidirectional video editing and post-production. This service enables synchronization and combination of both immersive and traditional video clips into a single production pipeline in Adobe Premiere Pro, for instance when creating transition portals used to add directed videos in an omnidirectional scene. The second service controls the content export process. When exporting a project, users (content producers) will be able to select what content is exported (360, portals, directive) and on which devices it will be available.

The current main features are summarised below:

- Combine immersive experiences with traditional content and introduce elements of interaction;
- Simultaneous off-line production for different devices;
- Simple user interface tailored to a video-editor workflow;
- All this features have been packed and integrated in a plug-in for Adobe Premiere Pro, a reference software for all video and content editors. The plug-in is shown in Figure 10.

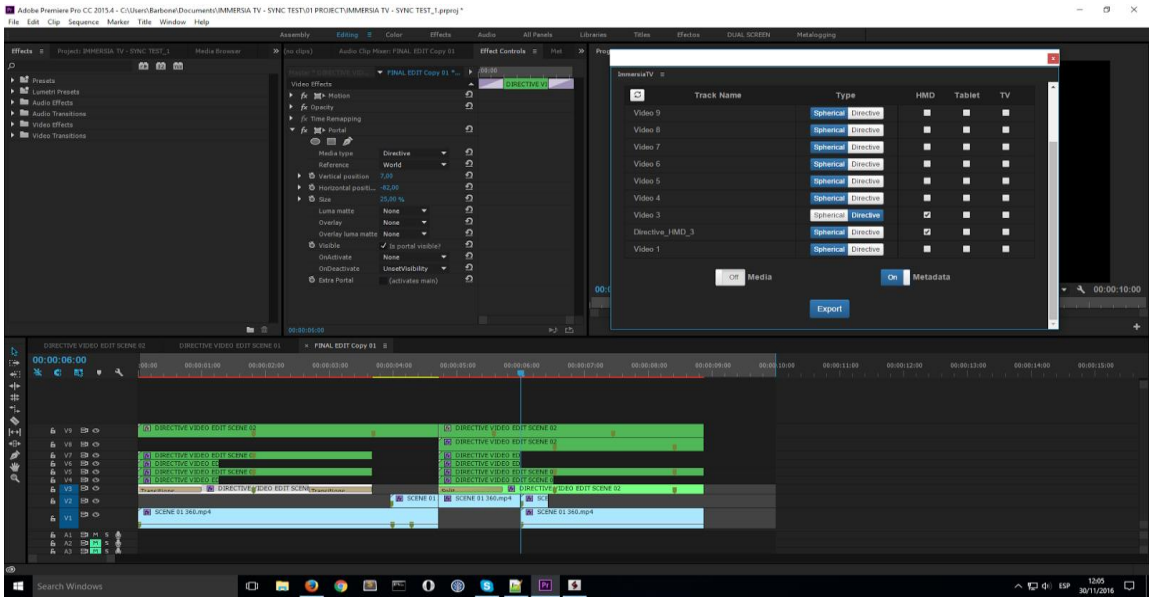

Figure 10: The plug-in for Adobe Premiere Pro. In the left-hand of the screen, there is the control menu for portals. On the right-hand side the export feature, in which users can customise what content and devices are used to visualise the content, can be seen.

With this approach it is possible to define different content timelines for different devices, to synchronize and to set relations between them, thereby mixing immersive and non-immersive footage into an appealing end user experience. The editor can introduce elements of interactivity with the portal effect, allowing viewers to influence the content shown.
The final project is straightforwardly exported to be directly delivered to the multi-platform audience devices.

Application in the pilot

Once the directive and non-directive contents were shot, it was necessary to create a coherent story mixing both type of content, and also the portals and transitions. Using Adobe Premiere Pro (Pr), the linear documentary was created following the regular TV production chain. This process was then followed by the inclusion and synchronisation of the 360° videos and the creation of scenes (a pack of synchronized 360 streams) using the plug-in developed for this purpose. Transitions between scenes were added later, trying to synchronise these transitions with the original ones created in the main directive content. The final step was the addition of *Interactive Portals.* Again, using the plug-in for Pr, some portals were added as a test, just to display additional content which was not part of the core of the story (alternative views, etc.). It is important to highlight that portals usage is evaluated from different perspectives, including what kind of content adds more value and how and when this is displayed.

The second part of the edition focuses on the export process. Once the project is finished it is necessary to export the files by selecting the targeted device and the type of content being exported (i.e. omnidirectional or traditional video), and associated metadata to compose them (for instance, location of traditional video inserts in an omnidirectional video). This can now be done easily with the Adobe Premiere Pro plug-in. The result can then be stored online in a server from where it will be consumed.
More specifically, this solution has been used in pilot 1 during the production of the documentary and its later improved releases. Finally, as part of a training session at Catholic University of Porto (UCP), the plug-in was showcased and its main features were introduced in a hand-on session.

3.1.2. Content distribution and display toolkit

Next to the edition tools, also a publication and distribution pipeline has been implemented, as well as a multi-platform player to play the different contents. We further explain the main components and the most important parameters selected for Pilot 1.

The publication of content has been done through a web application developed with modern web technologies such as Node JS[3] and AngularJS[4]. This web application lists content exported from the Premiere post-production tool that is ready to be transcoded to MPEG-DASH[5] (see the drop down menu option "Convert" inFigure 11).

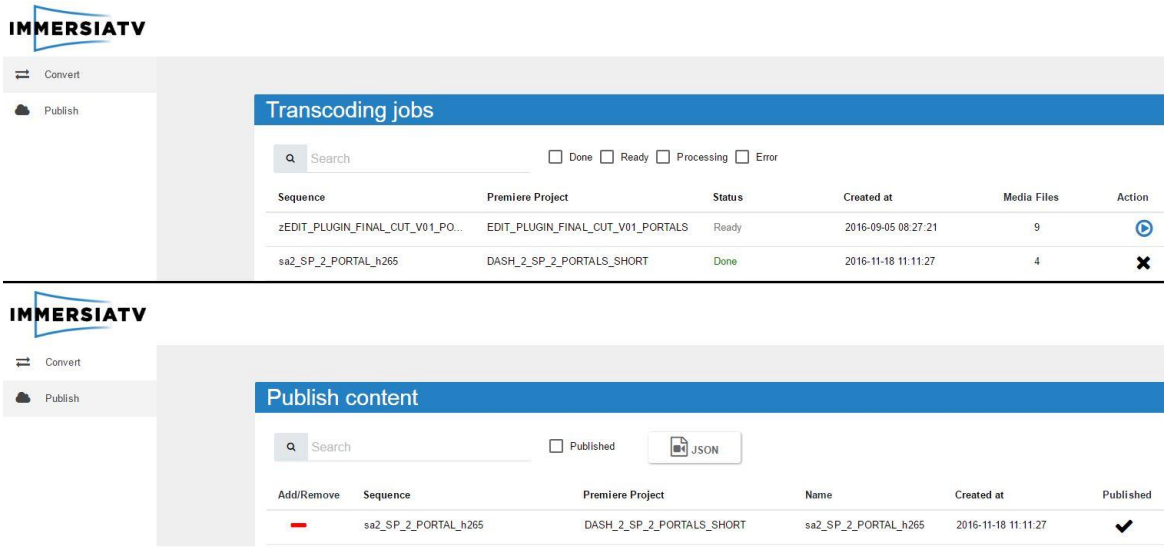

Figure 11: The distribution and publication web application view. Convert to MPEG-DASH section on top, publication content below.

Once the MPEG-DASH conversion has ended, new content will appear in the section "Publish" of the web page, where the user, for example a broadcaster, can publish content for its later consumption by the end users.

The publishing action consists in making the url of the XML metadata, which in turn contains the MPEG-DASH MPD (Media Presentation Descriptor) paths, publicly available and ready to be consumed by the player that already knows what the URL of the published XML file is.

To provide a more robust infrastructure, along with the web application an Nginx web server was deployed to distribute the content. This secures media distribution regardless of the web application's state and therefore makes it more robust, for example to DDoS attacks. All the different modules have been deployed inside a Linux server using the Docker platform.
The media encoding process is implemented as a cloud service, running on a Linux server using the Dockers virtualization tool.
To encode the video we first resize the video source according to the desired output resolution. For this, the main configuration parameters are: a regular GOP (Group of Pictures) referred to

[3] Open-source, cross-platform JavaScript runtime environment for developing a diverse variety of tools and applications. https://nodejs.org/en/
[4] JavaScript-based open-source front-end web application framework. https://angularjs.org
[5] Adaptive bitrate streaming technique. https://en.wikipedia.org/wiki/Dynamic_Adaptive_Streaming_over_HTTP

the length of the MPEG-DASH segments, and a constant bitrate. The video and audio streams are encoded in H.264 and AAC based on MPEG-DASH (ISO/IEC 23009-1:2014). This process is performed using the multimedia framework Ffmpeg[6].

The next step is to generate the MPD and the MPEG-DASH fragments from the preprocessed video. The main configuration parameter is the length of the fragments. This process is performed using the GPAC[7] framework , specifically the MP4Box tool[8]. The generated media is divided in 3 different sets: 360, TV and portal videos (i.e., video inserts). The chosen resolutions are HD (1080p) and UHD (2k, 4k) for the 360 and TV video, and 420p for the portal video. The final media set is (4k,4k,420p), (2k,2k,420p), (1080p,1080p,420p) with fragments that have a length of 3 seconds.

Furthermore, we designed the user experience of the end-user for each of the three consumption devices. The general workflow is as follows. The player starts showing a content list downloaded from the content publication server. Once the content is selected, the player parses the xml file assigned to that content. The parsing of the xml file triggers the creation and destruction of geometric shapes that will appear in the scene, over which the different videos will be rendered. These shapes are currently spheres for omnidirectional videos and rectangles for directive videos. The position of the shapes and their visualization in the scene will depend of the device, as defined explicitly in the xml file. Basic interaction is managed on the shapes, for example to enable or disable other shapes or trigger transitions between them. Further work in this direction will continue towards preparing pilot 3.
Finally, all the devices are synchronized with each other, as well as the playout of all the videos in each device. For this purpose, a specific module to manage the session has been implemented, based on the DVBCSS standard[9].

[6] Software project that produces libraries and programs for handling multimedia data. https://ffmpeg.org
[7] https://gpac.wp.mines-telecom.fr/home/
[8] https://gpac.wp.mines-telecom.fr/mp4box/
[9] https://www.dvb.org/standards/dvb_css/

3.2. Pilot 2

This section describes the production tooling used to generate pilot 2 content and the infrastructure deployed to deliver and display it on the selected devices. This is based on the work carried out in WP3 which represents the software implementation by the ImmersiaTV partners. The capture and display parts of the live production chain are almost the same as for the Pilot 1. The following cameras were used during the event:

- Orah 4i 4K@30 fps, omnidirectional;
- Studio.One 4K@30 fps, omnidirectional;
- Traditional TV content delivered live, 1080i@25 fps.

The live production tooling consists of 2 software applications: Cinegy Transport and Cinegy Live. The display part of the chain consists of the ImmersiaTV web player that can be started on all device types (smart TV, HMD and tablet).

The pipeline set up during the cyclocross race is shown in Figure 12, where the ingest of each stream (RTMP, RTSP) runs through Cinegy Transport communicating with Cinegy Live. Additional recording is done on an extra hard disk. On the playout side, a local network is set up (router) communicating with mobile devices.

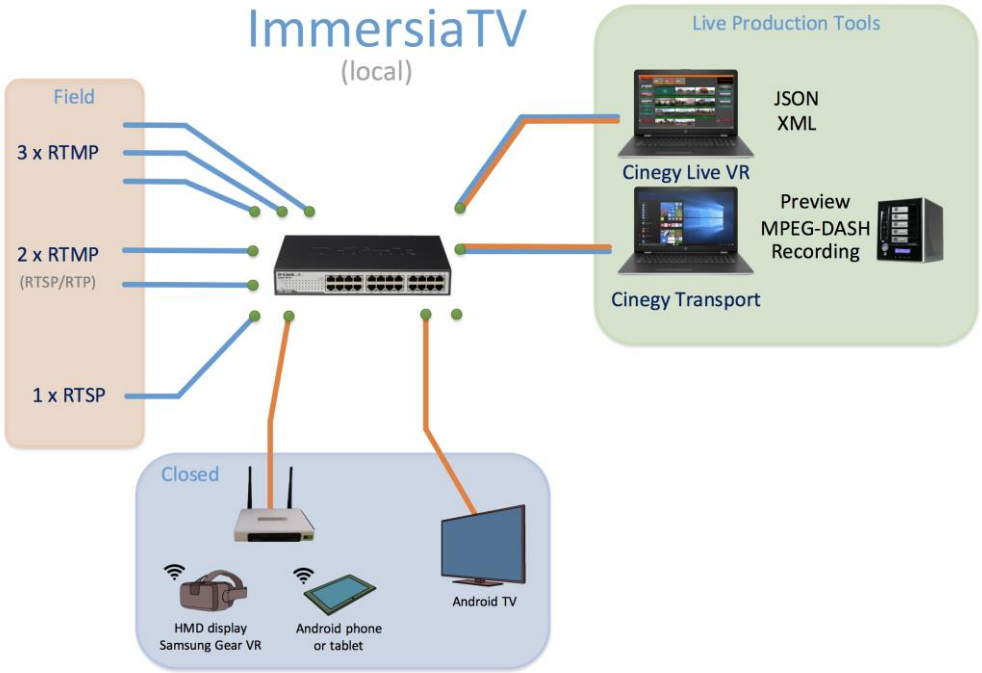

Figure 12: ImmersiaTV live pilot 2 pipeline

Detailed information regarding production, encoding and distribution parts is provided in the following sections.

3.2.1. Live production tooling

For live production ImmersiaTV offers a dedicated tool used to:

- design and configure the content for all device types at preproduction stage;
- introduce dynamic updates where necessary by switching the point of view for the users, enabling/disabling user interface elements, etc. during the live event.

The main features are summarized below:

- dedicated operator interface to combine the immersive experience with traditional content;
- provide interaction elements within the content adapted for each device capabilities;
- provide advanced controls over encoding and distribution parameters;
- provide a convenient interface for live production during the event.

As the nature of activities during live event preparation stage and during the event itself are quite different the Live VR user interface is split into 2 major sections:

- Advanced configuration used during preparation stage;
- Simplified interface for interacting with the content during the live event.

Configuration

During preproduction, Live VR allows the operator to configure all aspects of complex live production beforehand reducing the load during the event itself. The following configuration areas are available:

- Scenes
- Sources
- Devices
- Web hosting

Scenes configuration (see Figure 13) allows the operator to define the distinct “views” that can have different configuration of interface elements available for the viewer (for example, number of portals and allowed user interactions). Each interaction point / interface element (portal) has its own set of properties defining its location, shape and target devices.

Imported assets such as static images used as interactive buttons (portals) can be edited with the corresponding ‘pen’ sign at the end of the line. With the ‘garbage’ sign the assets will be deleted from Cinegy Live. Edition of the assets is done for positioning the assets in the 360° environment of the scene, by setting x- and y-coordinates. Currently, there is no graphical visualisation of the constructed scene, nor a preview to check if the scene is qualified for the end user during the specific event. To check the scene, the web player has to be activated and reloaded with each adjustment.

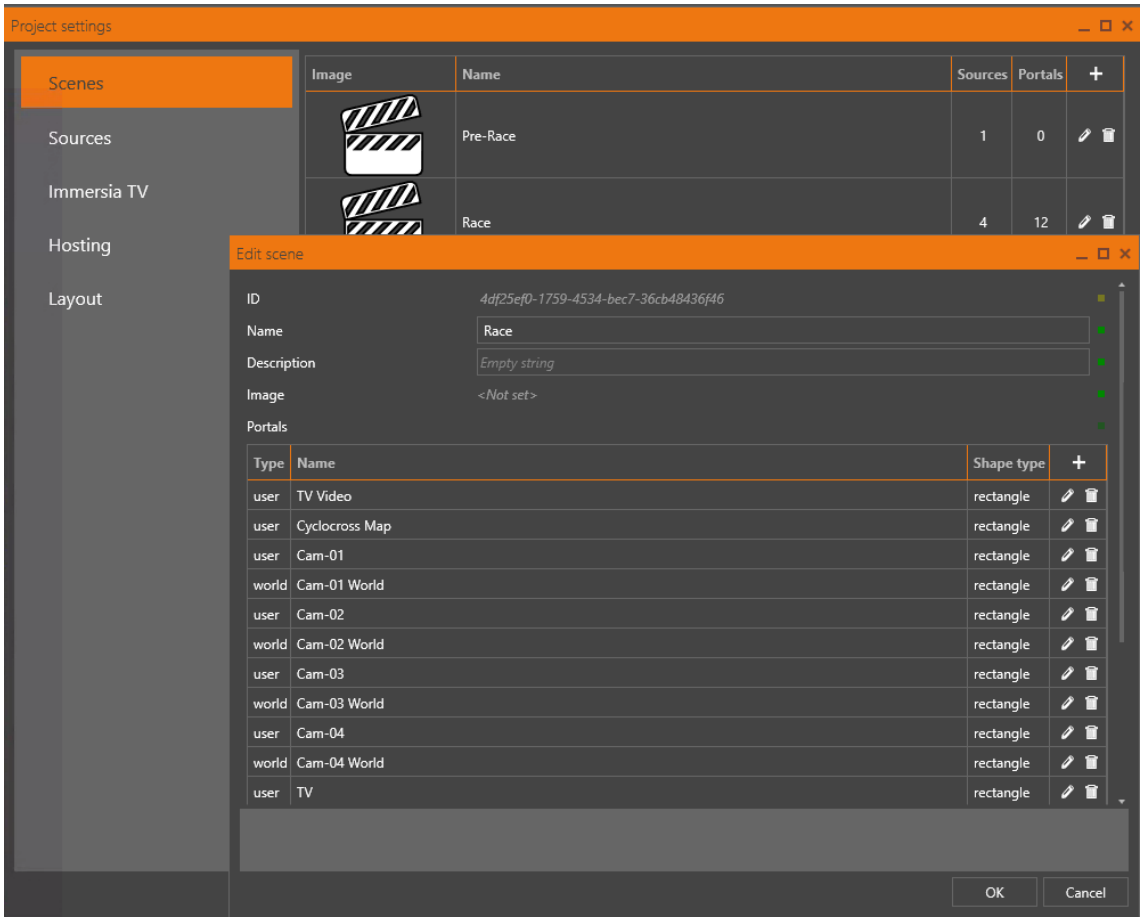

Figure 13: Live VR Scenes configuration

Sources configuration (see Figure 14) allows the operator to define the list of available sources (live streams and/or static images), their properties (synchronization parameters, delivery protocols, etc.), encoding parameters applied during MPEG-DASH stream generation, etc. The same dialog also provides real-time preview of the media for the convenience of the operator.

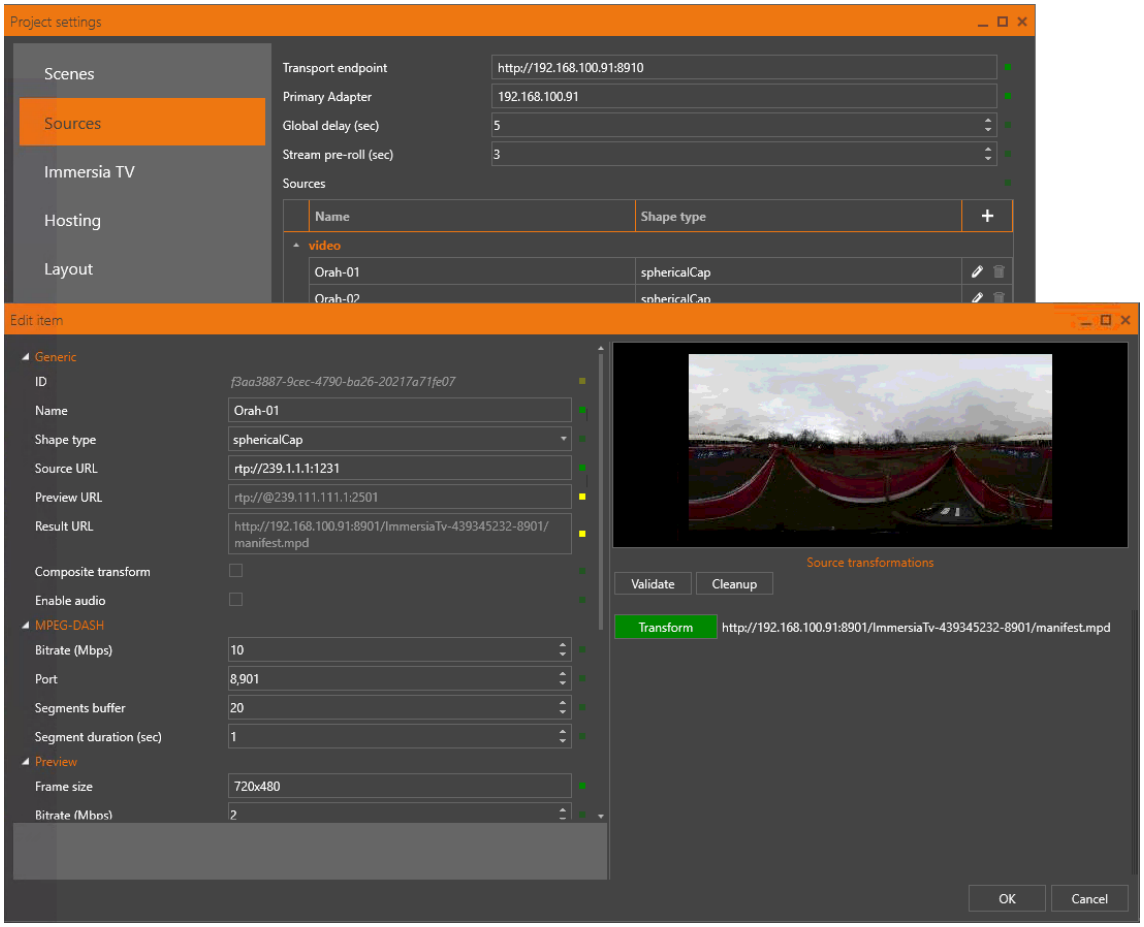

Figure 14 Live VR Sources configuration

Devices configuration (see Figure 15) allows the operator to define the device types to generate content for and some additional technical parameters (like the type of graphical transition effect to be applied when changing the viewpoint).

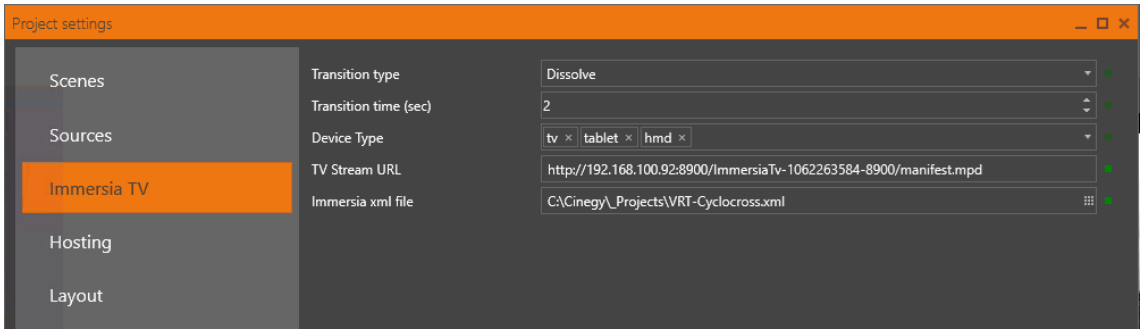

Figure 15 Live VR Devices configuration

Web hosting configurations allows the operator to define the technical aspects of distributing the ImmersiaTV XML for the external players (see Figure 16).

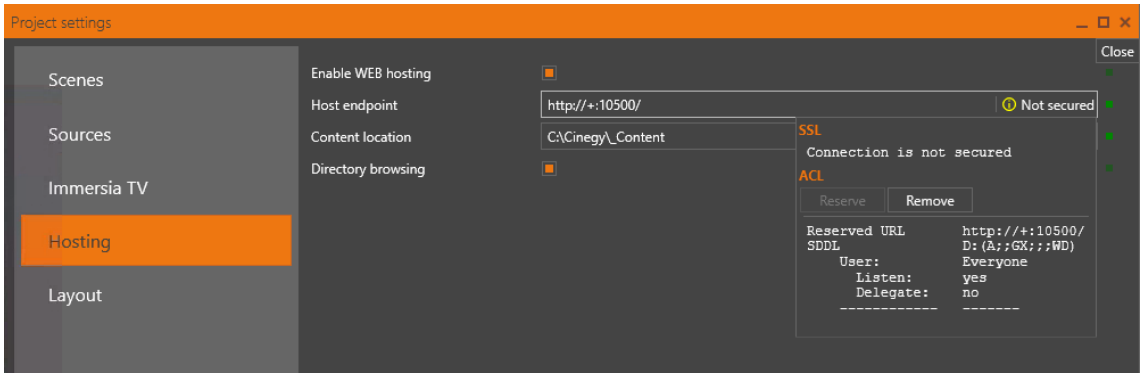

Figure 16: Live VR Web hosting of ImmersiaTV XML

Due to the amount of settings to be defined, the preproduction stage requires additional time to be spent designing the user experience to be delivered during the live production.

Interface during live events

The operator interface during the live production is simplified and optimized for convenient operation in a fast-changing environment (see Figure 17). All operator-initiated changes to the live content are initiated via click, double-click or drag-and-drop operations. The same operations are also accessible on touch-enabled devices.

Figure 17 Live VR operator interface

The interface provides:

- Scenes panel (top left): a general overview of the available scenes to switch between. For the cyclocross three different scenes have been preconfigured: pre-race, race, post-race.
- Source panel (middle): overview of all incoming sources and used images
- Portal panel (right): a list of corresponding portals (interface elements and interaction points). Each portal is linked to an asset (incoming source, or static image) and can be switched on or off, e.g. in case of a camera malfunction the director can remove the corresponding portal from the scene.

- Video panel (left): a live preview of the selected source streams. The active main omnidirectional stream is marked in red. By double clicking the director can push a new main viewpoint to the end user, e.g. in case that an important race event is happening. In other words, the edition of the streams by the director takes place in this panel.

While limited user exploration features can be enabled, the changes made by operator have the priority over any local choice made by the user. So, the operator, for example, can initiate a viewpoint switch via either activating the viewpoint by double-clicking it or by replacing the source stream by drag-and-drop of the new content.

Depending on the user device type the final view of the live production can be different. For example, Figure 18Figure 18 shows the typical view for the user of the tablet device:

Figure 18 Tablet view of cyclocross experience

The interface contains two non-interactive elements (cyclocross map top left and traditional TV live insert top right) and several interactive elements that allow user-initiated changes of the viewpoint (bottom left) or toggling the map/TV insert visibility (bottom right).

3.2.2. Content processing and distribution

All live streams processing is done via a second component of the Live Production Tools package – Cinegy Transport. This component is implemented as a Windows OS service, so it has virtually no user interface. All the configuration is done via API from the convenient Live VR interface.

Cinegy Transport is responsible for the following:

- Synchronisation of live streams;
- Live preview generation;
- Live re-encoding of the source stream;
- Live MPEG-DASH generation and distribution.

Live streams synchronization is done on the transport level by delaying the corresponding packets by a specified amount of time and re-transmitting as a new MPEG-TS stream. As each source has its own sync delay this allows to synchronize any number of live sources regardless their content delivery protocol (RTMP, RTSP, RTP).

Once the streams are in sync the live preview version of the source stream is generated. As the source streams are 4K@30 fps H.264 encoded ones, in order to reduce the requirements for the Live VR machine that displays the live preview for the operator, a proxy version of the source stream is generated live with reduced frame size and bitrate.

The stream is also re-encoded to ensure conformance with MPEG-DASH (ISO/IEC 23009-1:2014) delivery specification in H.264 and AAC. Optionally, NVIDIA accelerated encoding and decoding process can be used to reduce the requirements for the Transport machine as all streams have to be processed in real-time.

Once each stream is in sync and ready for the distribution Transport generates an MPEG-DASH MPD (Media Presentation Descriptor) file and makes it available for the external consumers for download and playback. Together with the ImmersiaTV scene description this forms a complete package as a result of live production to be consumed by ImmersiaTV player. The conversion and publishing are done in real-time and synchronously for all streams. Metadata are repeatedly updated to reflect changes in the scene composition. The end user devices must periodically download the content's xml file and update the display. Except for this, the general workflow at user side is the same as for Pilot 1 and description from 3.1.2 remains valid.

4. PILOT EVALUATION

4.1. Pilot 1

The pilot evaluation activities for pilot 1 were outlined in deliverable 4.1. In this deliverable we give an overview of the specific evaluation activities related to 1) the software tools and 2) the developed documentary. These activities took place between May 2016 and December 2016. The specific results of the different mentioned evaluation activities can be consulted in deliverable 4.4.

4.1.1. Content creation toolkit

Iterative development of the plug-in

A first evaluation activity, starting in May 2016, was the feedback on the developed content creation toolkit and more specific on the developed plug-in. To ensure a user-centered design process, multiple iterations were planned in which content producers at both Lightbox and VRT tested the software. Feedback was provided via an online survey as well as during dedicated feedback meetings via conference call. The remarks of the professional users were integrated as much as possible in the new developed versions of the software plug-in. A new version of the software was released and tested on a weekly basis. Additional evaluation activities for the content creation toolkit will take place at Lightbox and VRT in the first quarter of 2017.

Immersive content production workshop

On Monday November 21, a half-day workshop on immersive video content production was organised at the UCP (Universidade Catolica Portuguesa) – see Figure 19. This workshop was organised as part of the Science and Technology Week 2016 in Porto. The workshop consisted of a lecture explaining the different tools and a hands-on session in which participants could test the software. 12 people participated in the workshop, consisting of a mix of university staff, PhD researchers and master students. All participants completed an evaluation form after the workshop.

Figure 19: Workshop at UCP

The workshop was divided into two parts. In the first part VideoStitch explained how videos can be acquired and stitched. Here different cameras and rigs were presented and the post-production stitching workflow was explained. In the second part, Lightbox discussed how to edit and add metadata. The use of the Adobe Premiere Pro plug-in was demonstrated and the required actions to set-up a project and add timelines was described. Participants could then test and experiment with the different tools. The full programme of the workshop is given in 'Annex II – Detailed workshop outline'.

4.1.2. Demo booth at IBC and NEM

ImmersiaTV was represented with a demo booth at both IBC [10]in Amsterdam, the Netherlands (September 9-13, 2016) and NEM [11]in Porto, Portugal (November 23-25, 2016). In both events the first pilot was demonstrated, including the developed toolkit and the immersive documentary. Participants could try out the documentary on the HMD and tablet in combination with the television set and could also try out the developed software plug-in. At IBC informal evaluations took place including discussions with participants and the recording of some video testimonials. At NEM, participants who visited the demo booth were asked to answer some questions on their experience (Computer Assisted Personal Interview CAPI via tablet). In total 20 people shared their experience with the pilot demo at NEM. The ImmersiaTV demo, shown in Figure 20, has won the NEM award for best demo booth.

[10] International Broadcasting Convention. http://www.ibc.org
[11] New European Media Summit. https://nem-initiative.org

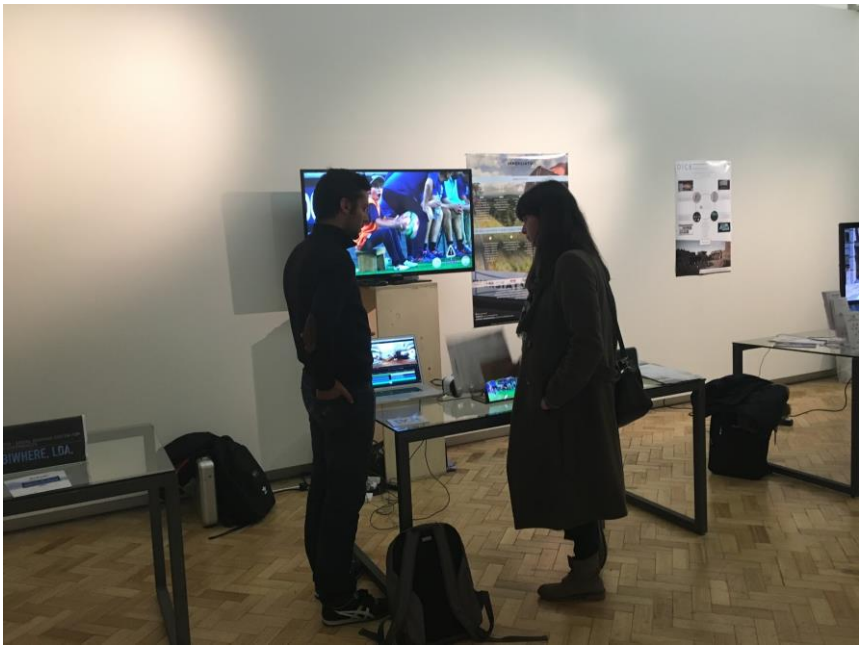

Figure 20: The demo booth at NEM

4.1.3. Closed pilot at UCP

On November 21st and 22nd, a closed pilot test took place at the UCP – see Figure 21. 28 participants tested the developed immersive documentary. Respondents could participate individually or in teams of 2. The pilot activity consisted of a viewing of the documentary in which participants could decide for themselves how they wanted to make use of the different available devices (TV, tablet or Head-Mounted Display). Each session was observed to see 1) how participants made use of the different devices during viewing; 2) how they used the different devices (e.g. sitting, standing, ...) and 3) which social interactions they had during viewing (e.g. talk about the content etc.). After the viewing, an interview took place to discuss their viewing experience.

Additional pilot activities that will take place in the first quarter of 2017 include: closed pilot test in Brussels and a semi-open pilot test (see D4.1. for a full description).

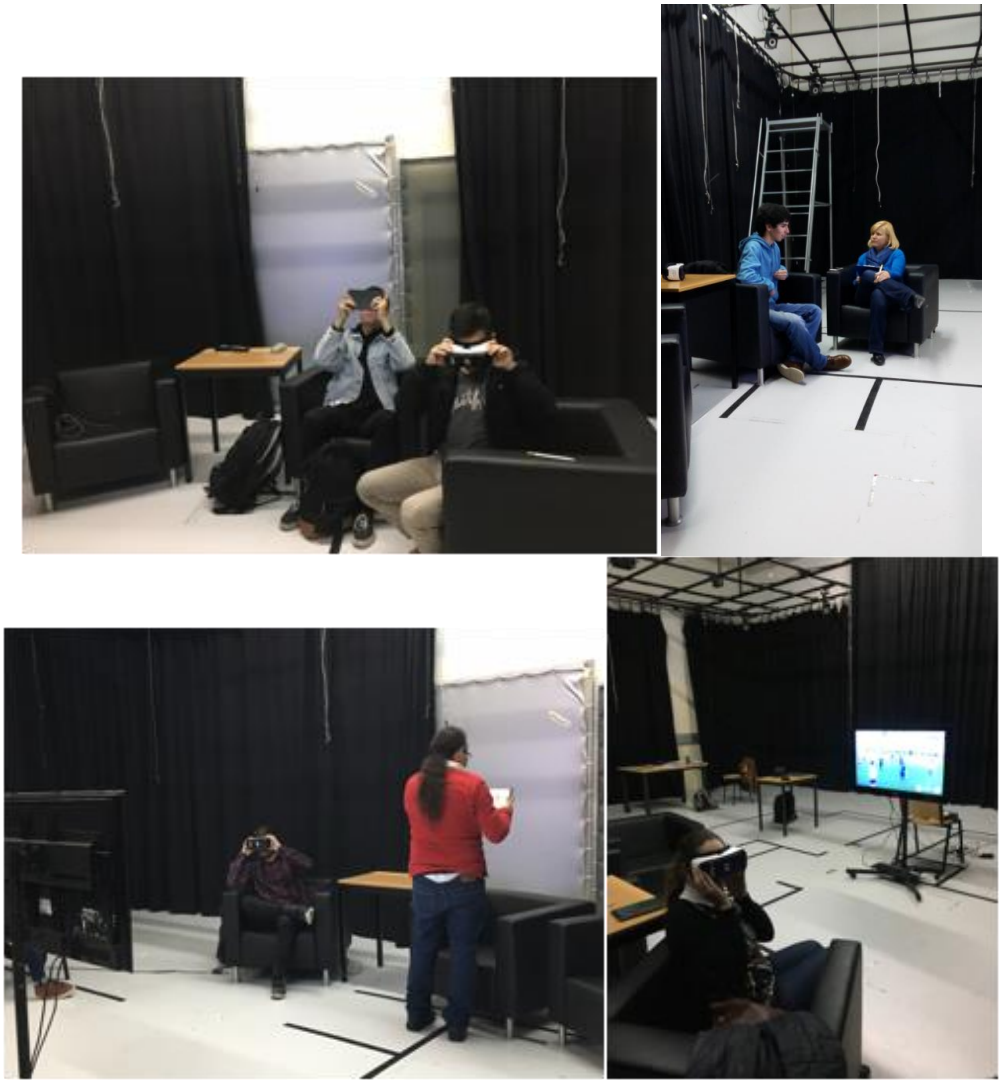

Figure 21: Pilot 1 evaluation at UCP

4.2. Pilot 2

The pilot evaluation activities for pilot 2 were outlined in deliverable 4.1 (iteration 2). In this section, we give an overview of the specific evaluation activities related to 1) the software tools and 2) the cyclocross event. These activities took place between December 2017 and January 2018. The specific results of the different mentioned evaluation activities can be consulted in deliverable 4.4 (iteration 2).

4.2.1. Director's toolkit (professional user evaluation)

For the professional user evaluation of the director's toolkit, three phases of testing with professional users have been successfully completed.

Phase 1 (preparing the pilot): iterative development and testing of the live production toolkit
First the software was iteratively developed and tested by professional users with a direct link to the ImmersiaTV project. Professional users at VRT, Cinegy, i2cat and PSNC tested the software and provided feedback via online and offline meetings and via email. They did a technical

evaluation of the software to ensure that the requirements are implemented as requested. The remarks of the professional users were integrated as much as possible in next software releases are targeted for optimizations and stabilization based on the received feedback. New versions of the software were released on a regular basis between in November and December 2017.

Phase 2 (pilot execution): professional user evaluation in a live scenario
During the live pilot execution (cyclocross event in Leuven on January 2018), a professional editor familiar with the ImmersiaTV project tested the toolkit in a real live scenario. Feedback was gathered by means of observation and an interview. The professional user was asked to continuously 'think out loud' while using the live production software and its basic functionalities during the race (think-aloud evaluative method) and was asked additional questions about his actions by the imec researcher when required.

Phase 3 (rebroadcast after the pilot): professional user evaluation in a simulation of a live scenario

In the final phase, two professional directors with no direct link to the ImmersiaTV project have tested the software in an offline simulation of a live scenario by reusing the live 360° camera streams recorded during the cyclocross pilot and preparing them for a simulated live broadcast. After a short introduction, the test users were asked to 'play around' with the software. Also here, feedback was gathered by means of observation and an interview. The tests took place at VRT premises in January 2018, one week after the cyclocross event.

4.2.2. Closed pilot test (end user evaluation)

Two closed pilot evaluation activities have taken place with end users for pilot 2.

Closed lab test in Brussels (I)

In December 2017, a first closed pilot test took place at the imec premises in Brussels.

First, 7 respondents were invited to watch a developed demonstrator for pilot 2, showing a live multi-device simulation of a soccer game. Respondents could participate individually or in teams of 2. A web-based set-up was applied, that consisted of a web server deployed in Poznan (Poland) with content for head mounted displays, tablets and television. On the tablet and HMD, three portals allowed to interact with the content and switch viewpoints (see Figure 22). While viewing the content the participants could decide for themselves how they wanted to make use of the different available devices (TV, tablet or HMD). Each session was observed to see 1) when participants made use of which device during viewing; 2) how they used the different devices (e.g. sitting, standing, …) and 3) which social interactions they had during viewing (e.g. conversations about the content). After the viewing, an interview took place to discuss the developed demonstrator and the interactive multi-device viewing experience.

Figure 22: Screenshot of tablet view (left) and HMD view (right) for soccer game simulation.

Closed lab test in Brussels (II)

In January 2018, a second closed end user evaluation of pilot 2 took place at the VRT premises in Brussels. 6 respondents were invited to watch an offline simulation of the cyclocross event, based on the recorded live 360° camera streams which had been prepared for a simulated live broadcast. All respondents participated in teams of 2. A web-based set-up was again applied, which consisted of a web server deployed in Poznan (Poland) with content for head mounted displays, tablets and television. On the tablet and HMD, there were 4 portals (implemented as icons) to interact with the race content (see Figure 23). The portals allowed users to switch between 4 different 360° camera sources. Furthermore, in the omnidirectional view a map of the cyclocross circuit indicating the location of the different cameras was shown (left upper corner) along with the live directive stream (right upper corner). The map and the live directive stream could be switched on and off (icons right bottom corner). The pilot activity consisted of a viewing of the content in which participants could decide for themselves how they wanted to make use of the different available devices (TV, tablet or Head-Mounted Display). Each session was observed and the participants were encouraged to continuously 'think out loud' and give their thoughts on the viewing experience. After the viewing, an interview took place to discuss the live pilot demonstrator and the viewing experience on the different devices in-depth.

Figure 23: Screenshot of HMD view of interactive cyclocross experience

Additional pilot activities that will take place in the first quarter of 2018 include the semi-open and open pilot test (see D4.1. for a full description).

5. ANNEX I – PILOT 1 SCENARIO

SCENE 1

KID'S ROOM

It's early in the morning, the room is still dark and the kid is sleeping in his bed. Viewers can hear footsteps coming from one side (the side of the door). Someone opens the door.

[**TV**: user will hear the steps and a transition will enable them to see the mother walking into the room and waking up her son. It is possible to include an icon alerting TV viewer that he can get extra info on other device.]

[**HMD**: The footsteps will indicate that the user can look the way where the sound (steps) comes from by moving his head. He will see the mother opening the door and entering the room. Spatialized sound.]

[**Tablet**: user can see extra info about the location. For example: Portugal, Porto, 07:30, Silva house.]

The mother enters the room, stays a little while watching her son sleeping and starts to wake him up.

MOTHER:

David, it's time for you to wake up.

The kid initially turns his face around but then he raises his head and looks for his football gear the other side of the room.

[**TV**: 4 shots: sleeping; door opening; mother talking; kid looking at the football gear; kid getting up.]

[**HMD:** Can watch what the kid is watching.]

[**Tablet**: Can watch what he is watching.]

The kid gets up and goes to the kitchen for breakfast.

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SCENE 2

FAMILY IN THE KITCHEN

Conversation between the members of the family around the kitchen table while having breakfast. Mom (Teresa), dad (Miguel), the kid (David) and his sister (Maria).

Users can hear other noises such as a cat (Emilio) meowing.

The conversation is a normal one, from a family point of view. Father asks David how is it going in the football club. The sister says she wants to join too. The family smiles and say she can, when she's a little bit older.

Mother alerts kid for the fact that school is very important. That his grades should be good, not only good at football but also at school.

The camera goes from one person to another, as they are talking.

[**TV**: subjective camera, like if the user was sitting with the family. Only sees cat when it enters framing by climbing to the table. There are some details, complementary to the story but not relevant for main narrative, that will happen only on other devices. This way we prevent the TV of feeling like he is missing out something important.]

[**HMD**: subjective camera, like if the user was sitting with the family. The HMD user can look for the cat when he hears it; when the user focus his attention on the cat, a portal comes up. He can see graphic info about the cat: name, for how long it is with the family, etc.]

[**Tablet**: icon indication of more info of each character. Each person at the kitchen has a graphic ID: name, age, job, etc. User can look for the cat and see graphic ID about it too. When he stops at Emilio the device vibrates, a call to action, so the user can click for another video of Emilio: ex: Click on Emilio and find out what it has done to the ham that was at the kitchen table. If the user goes for the cat video he must be aware that he will lose the image of main narrative. Assuming that the user on the tablet will have the TV on, he will be able to see the main narrative on TV and simultaneously, check the cat video. When he dismisses the cat video he will be sent to the point where the main narrative is now, fully aware that he missed some parts.]

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SCENE 3 AND 4

STREET AND SUBWAY

The kid is walking with with a sports bag to the metro station. It is a short walk.

[**TV**: user sees the kid perspective (subjective camera). Icon allerting for more info on other devices.]

[**HMD**: subjective camera. User can see the street, other people passing by, neighbors saying hello as it was for him.]

[**Tablet**: can see the street (arrows that indicate the abbility to move around, other people passing by, see graphic info of the neighbourhood, ex: the location of the kid and the location of the field, how far he is.]

The kid enters the subway and sits down with a ball in his hands. The ball falls.

[**TV**: user first hears someone talking and then sees the person who catches the ball and returns it to the kid.]

[**HMD**: user can see the subway and where does the ball go. Another kid (a team colleague: Fábio) catches the ball and starts talking to the user has if he was David.]

[**Tablet**: can see the subway and where does the ball go. Another kid (a team colleague: Fábio) catches the ball and starts talking to the user has if he was David.]

Fábio returns the ball to David and sits next to him.

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SCENE 5

DRAGON FORCE LOCKER ROOM

At this scene all users will feel what it's like to be at a locker room. There will be no dialogues, just the kids getting ready for the practice. They talk, laugh, joke around. The purpose is for the users to feel the atmosphere, like a sneak peek.

Users hear a whistle and watch the kids running to the field, leaving the locker room empty.

Kids getting into the locker room. All the kids playing around and heading to the field when they hear a whistle.

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SCENE 6

THE FIELD – INTERVIEW

At the field, the kid starts talking about himself.

DAVID

I'm David, I'm 14 years old and this is my left foot (laughs).

All users can hear the other kids laughing out loud and saying: Next Messi; He's the best!, …

[**TV**: user can hear the other kids but only when the plan changes they are able to see them.]

[**HMD**: when he hears the other kids, user understand that he can move his head to see the others kids, the field and the surrounding areas.]

[**Tablet**: user can see the others kids, the field, the surrounding areas. Dragon Force logo appears. If he taps on the logo, it will show extra info about the football school.]

The interview is conducted between coach and player. They are changing the ball while they are talking. They run, laugh, make and answer questions.

When the coach asks who is his favourite player, David answers Messi. As he talks about him, images of the international football player start to appear in the screens in different ways.

[**TV**: user can see the change of focus between each one. Icon appears when Messi's footage appears on other devices, alerting for him to connect to the tablet to watch it.]

[**HMD**: user can see both of them or just one of them, by turning his head. A portal appears with footage from Messi.]

[**Tablet**: user can see both of them or just one of them. When the kid starts talking about Messi, the user can see an icon alerting for other video of Messi, with all the player outstanding statistics (goals, awards, etc.); icon to go back at any time to the main narrative.]

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SCENE 7

THE GAME

Shots of the game between David's team and another one. When he strikes the ball, the shot changes to the goalkeeper. He jumps to stop the ball but it just passes right through. GOAL!

[**TV**: user can see the change of focus between each one; follows the director's choice.]

[**HMD**: user can chose the camera's point of view. From the field, from the team bench of from the audience. When David strikes a goal, a portal opens with footage of simmiliar strikes in the history of football.]

[Tablet: user can chose the camera's point of view (from the team bench, from the audience or in the field).]

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SCENE 8

FAMILY TRIP

The family is in the car, driving home. During the trip, they talk about the game, how exciting it was to see David leading his team to victory.

[**TV**: user can see each person when they are talking. follows the director's choice.]

[**HMD**: user is "seated" in the backseat, like if he was on the car too. From this point of view, he can rotate the head and see the kid and his sister, one in each side. In front, he can see the mother and father. Can look away through the window.]

[**Tablet**: user can look away through the window, can focus on one person.]

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SCENE 9

THE SCHOOL

Another day. David is at school. Classroom shot. Omni camera shoots the class and the recess (playing football, of course).

[**TV**: user can see a master shot of the classroom with transitions to close-ups of the students and teacher.]

[**HMD**: user can see the students side of the classroom (180º) and the teatcher side (180º). Teacher is talking about a mathematical concept. When the user focus on the teacher the board becomes a portal with graphic footage of the mathematical concept explained like football. Pythagorean theorem explained like 3 kids were changing the ball between them.]

[**Tablet**: user can see the students side of the classroom (180º) and the teatcher side (180º). Teacher is talking about a mathematical concept, the Pythagorean theorem. An icon appears that can lead the user to a website (wikipedia) for the definition of the concept, allerting that he will lose the image of main narrative but keeping the sound of it. He will be able to still hear the teacher but will be led to na outsider webpage. User can go back to the classroom whenever he wants, fully aware of what he missed.]

The bell rings and all the kids run to the yard. The teacher tells David to wait a little longer and starts talking with him.

[**TV**: user can see the students leaving the classroom. And then a transition to the teacher/student conversation.]

[**HMD**: user can see the students leaving the classroom and can see them outside playing but now at a certain distance. If he looks the other way, to the classroom, he can see the teacher/student conversation. The user hears in surround both the kids outside and the conversation inside. Depending on where he is focused, he hears the sound louder. This will indicate the user that he can see both scenes by moving his head in one direction or the other.]

[**Tablet:** user can see the students leaving the classroom and can see them outside playing but now at a certain distance. He can go outsider but he must be fully aware that he will lose the conversation.]

The teacher tells David that although he is a great promise in football, he must not forget to complete his studies. A football career is short and he must have the knowledge to continue studying so he has a brilliant future even after his career in sports.

David thanks his teacher's advice and says he knows that. Other football players are also university graduates and he wants to do the same.

[**TV**: user can watch the conversation.]

[**HMD**: user follows the conversation. When David talks about other football players who graduated, a portal appears with footage of famous footballers who finished college.]

[**Tablet:** can choose between watching the conversation of watching the kids playing outside.]

David leaves the classroom to meet with his colleagues. He comes back and says to the teacher:

DAVID

Miss, I would like you to come one day to watch a game.

Even if you don't like football.

He then runs to the field.

END CREDITS

End credits appear graphically with extra footage of the making of.

[**TV**: user watches end credits and windows with footage of the making-of.]

[**HMD**: Watches the kids playing outside with end credits above and a portal showing the making-of.]

[**Tablet:** Watches the kids playing outside with end credits above. Links for the companies who created the documentary and video of the making-of.]

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6. ANNEX II – DETAILED WORKSHOP OUTLINE

9.30h - Welcome
9.35h - **1st Part: Acquiring videos and stitching them (VideoStitch)**

1. INTRODUCTION
We will provide some information on VideoStitch and the trainer, and let the attendees introduce themselves, including what they know about 360° videos.

2. 360 VIDEOS: CAMERAS, RIGS AND ISSUES
We will show here some examples of existing cameras and rigs, and discuss the main differences between them.
We will also explain video stitching and show the big picture, and make sure the students understand what parallax issues are.

3. TYPICAL POST-PRODUCTION STITCHING WORKFLOW
This section will present the typical workflow of post-production stitching with VideoStitch Studio.
In particular, the students will be walked through the following steps:
○ synchronization: making sure all the inputs are temporally aligned
○ calibration: automatically discovering the relationships between the cameras on the rig
○ color correction: the cameras are usually independent systems, with their own exposure and white-balance settings. How do we make up for them?
○ stabilization: if the camera rig is moving, sudden position changes will result in motion sickness for the viewers in an immersive helmet. Fortunately, this kind of motion can be smoothed out
○ orientation: the calibration has no knowledge about the horizon, how can we reorient the video to preserve it?
○ blending configuration: there are several blending options to limit the artefacts due to the cameras parallax
○ rendering: this final step actually exports the 360° video

4. HANDS-ON SESSION
The students will have an opportunity to stitch themselves a 360° video, under the guidance of the trainer, either on their own laptops, or on the trainer's machine.

5. OTHER USE CASES
We will briefly discuss live/real-time stitching with Vahana VR and introduce the Orah 4i camera, and the workflow differences with post-production stitching.

6. FURTHER READINGS
As a conclusion, we will present our YouTube tutorials at https://www.youtube.com/user/TheVideoStitch and provide our user guide to the students.

11.00h - **2nd Part: Editing and Metadata (LightBox)**

1. INTRODUCTION TO THE PLUG-IN IN PREMIERE PRO
Provide some background on the editing side of the project and introduce the framework and workflow used to assemble the pilot showcased at IBC. Define the typology of the plug-in and where to find it in the app.

2. SETTING UP THE PROJECT & TIMELINES
Explain the resolution we're working in, and why. Having a correct project setup and correctly configured timelines is an important step in order to understand the proper way to use the tool at hand.

3. EXERCISE #1 - CREATING PORTALS
Introduction to the types of portals and types of media related to each one. The

audience will be given two separate scenes. In the first one, we'll be working on how to correctly place a single "normal" portal. On the second one, we'll introduced other types of portals, but most importantly, they'll be left to try it out by themselves.

4. EXERCISE #2 - SCENE TRANSITIONS

After a correct comprehension of the portals and their framework is established, it's time to introduce scene transitions on a 360o plane. This will be applied between the two previously edited scenes in order to come full circle and give a good sense of how the first pilot was put together.

5. THOUGHTS AND REFLECTIONS ON THE PARADIGM SHIFT BROUGHT BY IMMERSIA TV

Based on the additional notes provided for the IBC presentation created by Lightbox, and seeing as this workshop is directed towards the Research Centre for Science and Technology of the Arts, we think it's befitting to end this by sharing our thoughts on this matter. Focusing on the two main take-aways: simultaneous storytelling allows for new points of view in terms of narrative, and, producing content that mixes 2D images with 360o requires a different approach to production but most of all, to post production - editing becomes a whole different process.

7. ANNEX III LIVE PRODUCTION DOCUMENT

A television broadcast production document incorporates all necessary information regarding the specific event captured for television broadcast. All people, equipment, logistics and timings are lined up, for everybody involved in the production to consult. For the Soudal Leuven Cyclocross the production document comprehends 29 pages (tabs) in an excel file. The production document contains information on deployed personnel, planned activities, transport management, cabling infrastructure, video material, audio material, contribution link, recordings, TV compound plan, detailed camera plan & labelling, lighting and power infrastructure, …

Details on ImmersiaTV deployment have been integrated in this overall production document, in particular with regard to power and cabling infrastructure, compound plan and camera plan.

The description of this production document is beyond the scope of this deliverable. The production document Excel sheet itself can be made available on request.