

Deliverable

Project Acronym:	ImmersiaTV
Grant Agreement number:	688619
Project Title:	<i>Immersive Experiences around TV, an integrated toolset for the production and distribution of immersive and interactive content across devices.</i>

D2.2 Professional User Requirements

Revision: 1.1

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Delivery date: M24

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 688619

Dissemination Level

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

Abstract: This deliverable reports on Task 2.2, requirements workshops with professional users. The outcome of this deliverable is a set of professional user requirements for the offline and live produced content scenarios within the Immersia TV project.

REVISION HISTORY

Revision	Date	Author	Organisation	Description
0.1	15/02/2016	Luk Overmeire	VRT	ToC
0.2	15/03/2016	Luk Overmeire	VRT	First version based on user workshops
0.3	08/04/2016	Marieke Lycke	VRT	Structure
0.4	12/04/2016	Luk Overmeire	VRT	Second version based on user workshops
0.5	15/04/2016	Luk Overmeire	VRT	Final version adding technical workshop
0.6	06/06/2016	Pau Pamplona	i2CAT	Format review and template adjustments
0.7	20/12/2016	Gregg Young	VRT	First version of second pilot
0.8	23/12/2016	Luk Overmeire	VRT	Reviewed version of second pilot
0.9	29/05/2017	Luk Overmeire Gregg Young	VRT	Revision after mid-term review
1.0	22/12/2017	Luk Overmeire Gregg Young	VRT	First version of pilot 3
1.1	30/01/2018	Luk Overmeire	VRT	Reviewed version of pilot 3

Disclaimer

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EXECUTIVE SUMMARY

This deliverable describes the detailed professional user requirements needed for offline and live produced content in ImmersiaTV.

This deliverable will be a living document that will be updated iteratively by insights gained in Task 2.2 activities, content ideation Proof of Concepts (Task 2.3), content creation (Task 2.4) and pilots (Task 4.2).

In the first version of the deliverable (M03), we report on the two user workshops related to the offline content production scenario that took place in February and March and we discuss the derived requirements from these workshops.

In the second version of the deliverable (M10), we report on targeted interviews with professional experts based on a questionnaire related to the live production workflow. We discuss the requirements extracted from these interviews and set up the creative workflow for a 360° video live production.

In the third version of the deliverable (M19), we report on professional user requirements for a refined version of the off-line and live pilot. In the off-line pilot, an exploration mode is introduced where the end-user is able to explore different paths and the experiences on the different devices (TV, tablet, HMD) are not fully coherent. In the live pilot, different new features are introduced, mainly focussing on giving more interactivity to the end user and a more immersive experience through spatial audio. For this purpose, dedicated professional user workshops were organized that focused on both pilots. We discuss the new requirements and creative workflow needs for this novel concepts.

This document lists both content format requirements and creative workflow requirements. Content format requirements are first examined from a generic storytelling point of view. Next, a first set of guidelines for synchronized VR content across devices is documented, and interactive VR experiences based upon the ImmersiaTV portal concept are mapped on specific requirements. Some of the interesting content formats resulting from the user workshops are described in more detail. The creative requirements are described for each of the VR production workflow steps: preproduction, production, post-production, publication. Integration of VR and classical production workflows is discussed.

Finally, an overview of professional user requirements is presented.

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LIST OF ACRONYMS

Acronym	Description
HMD	Head-mounted display
PoC	Proof of Concept
PoV	Point of View
UI	User Interface
VR	Virtual reality
WP	Work Package

1. INTRODUCTION

1.1. Purpose of this document

The idea of this deliverable document is to detail the different professional user requirements for off-line and live omnidirectional content production scenarios as investigated in Task 2.2. The outcome of this task is a set of structured insights and requirements that together with the insights and requirements acquired in Task 2.1 will serve as input for the production scenarios and requirements analysis process in Task 2.3 and finally the pilots in WP4.

The T2.2 activities to gather the professional user requirements were executed in parallel with T2.1 activities on the end user requirements. The simultaneous organisation of the user workshops in the first iteration of the project (M3) enabled us to bring together end-user and professional user expectations and generated a first shared vision about the ImmersiaTV concept.

The first workshops were organized early in the project (M3) to explore the context of users and to already involve users in the idea and concept development phase of the project. This is in line with the more recent human centred-design approaches that take into account the social and cultural context of the user from the start in order to get a true (necessary) insight into users' needs, values and expectations (Sanders, 2005).

At the start, a very open approach was thus applied in order to explore general experiences with and expectations towards VR, as both omnidirectional content formats and corresponding production workflows are new for professional users. Only after this the ImmersiaTV concept was carefully introduced.

The gathered insights were then translated into a set of end-user experience requirements in D2.1 and a set of professional content format requirements and creative workflow requirements for D2.2. In the first iteration (off-line documentary), these lists of informal requirements representing the user's voice, contain both generic VR requirements as ImmersiaTV-specific requirements.

The D2.1 and D2.2 insights and requirements will serve as input for the detailed software requirements and technical specifications regarding content production and end-user experience, and the content ideation process, pilot content and production scenarios in D2.3. More specifically, end user experience requirements (D2.1) and professional content format requirements (D2.2) feed the content ideation process to define the pilot content scenarios (D2.3); while the professional workflow requirements that are relevant within the scope of ImmersiaTV (D2.2) are elaborated in more detail into a list of formal software requirements and technical specifications (D2.3).

By having iterative contacts with both end-users and professional users, as well as with the project partners and other stakeholders already from an early stage of the project, different relevant social and technical aspects were mapped and we go through a funnel approach for defining the final scenarios and use cases.

In the second iteration (live pilot), we conducted targeted interviews with professional users, putting more focus on the ImmersiaTV concept itself, compared to the first iteration.

In the third iteration of the off-line pilot, we focused on refining the off-line scenario by introducing and elaborating the notion of exploration mode, having a specific format in mind (whodunnit). The third iteration of the live pilot focuses on providing advanced functionalities for the end user in a live context (sports-entertainment) and how this impacts the professional user workflow.

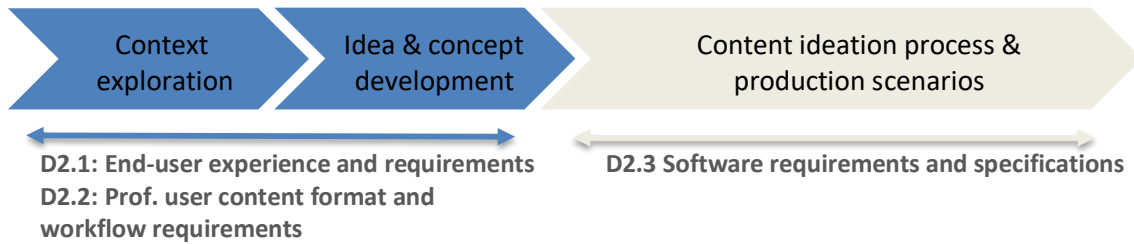


Figure 1: Illustration requirement creation process in WP2

The links between the requirements in the different deliverables, as well as the interrelationship of the prof user content format and creative workflow requirements are indicated in Section 7 for clarification purposes.

The requirements are numbered in a three-layer manner: e.g. R.2.1.1. Where 'R' stands for requirement, the first number refers to Task 2.2 (professional user requirements), the second number refers to pilot 1 (offline documentary), whereas R.2.2.1 refers to pilot 2 (live event), the third number listing the requirements.

1.2. Scope of this document

The objective of task 2.2 is to define professional user requirements for the different pilot scenarios. In the first phase of this task (pilot 1), the focus was on defining professional user requirements for the offline content scenario. This is done in two co-design workshops with professional and end users. The workshops for professional users focused on the following specific aspects:

- *General user experience of the omnidirectional video*: How do professional users experience watching omnidirectional video content in different genres and via different devices (HMD, Google cardboard)? How do they evaluate the usability of VR devices and different content formats (in general and for their specific expertise domain)?
- *Omnidirectional content formats*: What do professional users see as the most appropriate formats or genres to integrate omnidirectional video content? What kind of omnidirectional content formats would they create?
- *Synchronised content across multiple devices*: One of the main focus of the ImmersiaTV project is synchronized content across different devices (TV-set, tablet, HMD). How do professional users evaluate the usage of different devices to watch omnidirectional content in combination with regular TV-content? How do they think end-users will experience it and how will they switch between devices? How do they see the production of VR in their regular workflow?
- *Interactive formats and portals*: A second central aspect in the ImmersiaTV project is the use of interactive formats and the application of interactive features such as portals. Relevant questions here include: What is the balance of control between the user and the director? What kind of cues should guide the user in the omnidirectional experience? How could portals be a relevant part of the omnidirectional viewing experience?
- *VR production workflow*: What are the differences between a VR production workflow and a TV/online workflow? Can these two workflows merge in the future? How?

Which tools, technologies and workflow requirements are necessary to enable content creators to make better VR production with minimal overhead?

In the second phase (pilot 2), professional user requirements for live VR-based content scenarios are assembled. In this case, we conducted a number of targeted interviews with VRT media professionals who have a large expertise in live event capturing, focusing on similar aspects as above: synchronization, interactivity and workflow. In particular for live events, we have an extra focus on the following aspects:

- Finding the right *balance between user interaction and director's choice* in terms of storytelling for live omnidirectional content. In the case of using 360° video as extra content, the user has the ability to be his own director, to choose from optional cameras set up around a live event to evoke presence. Therefore, we have to consider whether we also want to guide the user by directing this content, and how we will enable this in the user interface, e.g. within an optional channel?
- Identification of the most interesting *use cases for live VR*. Which live formats can benefit substantially from 360° video content? Where do you see the most potential for end users to be present and have a 360° experience?
- *The interaction between TV and HMD* in terms of coherent storytelling for live scenarios. Is the audio from the TV identical with that in the HMD or do we use a separate audio track with spatial audio from the location? Or do we combine both in an audio mix? What features should be developed in the user interface of the HMD and is there a connection with an additional graphical interface element built on the TV?
- *Live production workflow*. What are the desired features and priorities for a live directing tool? What are the requirements and expectations for pre-production and live streaming? How does this differ from regular TV production?

In the third phase, for the off-line pilot 3, we refine the concepts of pilot 1 (off-line content scenario) by introducing the notion of “*exploration mode*”. Exploration mode further extends the “*broadcast mode*” of pilot 1, by allowing the viewer to explore different paths and to navigate across scenes, such that the order of the scenes and events of the received content is not necessarily coherent across devices. While in pilot 1, content was broadcasted across TV, HMD and tablet in a complementary but fully synchronized way (with TV content as the main screen), exploration mode allows to interrupt this coherent broadcast mode and to “pause” TV play-out in order to allow for user exploration of specific parts the story on HMD and tablet. As such, exploration mode can be defined as interactive storytelling on multiple devices.

To elaborate the professional user requirements that specifically come with the exploration mode, we conducted a new workshop with professional users that focused on the following concepts and aspects that are related to exploration mode:

- **Interactive storytelling on multiple devices:** what is the interrelationship between HMD, tablet and TV in exploration mode? What is the interplay between HMD and tablet during break-out moments where the TV is paused? What is the optimal frequency and duration of exploration mode “break-out” moments? Can and should a user action on one device have impact on the content flow on other devices?
- **Branched storytelling:** the viewer can choose the various paths of the narratives. Is this for HMD only, or can it apply to tablet as well? How would branched storytelling work over different devices? How to cope with the uncertainty of the duration depending on viewer's choices? Should the different paths lead to the same end or not?
- What is the distinctive **role of each of the devices** in exploration-based storytelling? For which type of scenes should the viewer be able to explore? Should the

TV experience be “idle” if exploration mode is active at some point(s) along the storyline, should it show a tv version of the HMD content or should it contain own content?

- Identification of the most interesting **use cases** for which exploration mode can bring most added value from a storytelling point of view
- **Social viewing**: which are the requirements if viewers watch content together with others. How can the exploration mode be compatible with the social viewing situation?
- **Creative workflow**: what are the workflow requirements related to exploration mode? Which are the new challenges compared to pilot 1 for preproduction, production, post production and play-out

Next to exploration mode, pilot 3 also aims to introduce **binaural audio** in the ImmersiaTV content creation process, as part of the content experience. Obviously, binaural audio can be applied in both broadcast and exploration mode. In this iteration, we focus on how binaural audio can support exploration mode scenarios, and on the related workflow requirements.

For the live pilot 3, new functionalities extend live pilot 2. The main focus is on giving more interactivity to the end user and delivering a more immersive experience by adding spatial audio to the live scene.

A new workshop with professional users was conducted exploring additional features inside the live ImmersiaTV concept, starting from the live pilot 2 context. Further elaboration on the impact on the production workflow was also performed.

Focus of the workshop was on:

- Giving more **interactivity** to the end user: live pilot 2 introduced the ‘director’s view’ mode, in pilot 3 the focus is on how we can give the end user full control of the interactive 360° experience during a live sports or entertainment event.
- **Immersive audio**: how can spatial audio give a more immersive experience to the end user. How can this be dealt with in (post-)production, what are the thoughts on binaural audio?
- Impact on the **creative workflow** of the professional user: what are the new requirements on top of the ones defined in live pilot 2?

1.3. Status of this document

This document is the third version of D2.2 with delivery foreseen in M10, combining the professional user requirements of off-line documentary production and live production (iteration 1 and 2).

The work done in Task 2.2 is an iterative process. The requirements are iteratively refined through a combination of small and focused tests in the field with production teams (Task 2.3 – Content ideation & production scenarios) and follow-up workshops.

1.4. Relation with other ImmersiaTV activities

The relationship between this task and the other WP2 tasks and relevant WP3 and WP4 tasks is shown in the figure below.

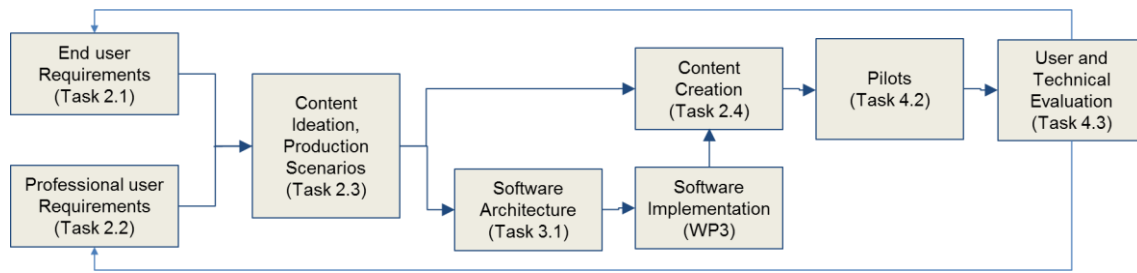


Figure 2: Relationships between different tasks

2. METHODOLOGY: PROFESSIONAL USER REQUIREMENT WORKSHOPS

2.1. Off-line documentary: Co-Design Workshops

Based on a set of co-design workshops with professional content creators (directors, editors, interaction designers,...), blueprints for omnidirectional content formats and functional requirements are established.

2.1.1. Motivation for the workshop approach

See 2.1 in D.2.1 for end-users. In the workshop with professional users extra reflection on the VR production workflow was done.

2.1.2. Detailed workshop procedure

In the first stage of the project (beginning of 2016), two user workshops of 2,5 hours each were held at VRT (see Figure 3). In preparation of these workshops, a small road show was done in various departments of the company introducing VR technology, showing some interesting examples and motivating editors, producers, etc. to participate in a workshop. The workshops were organised in parallel with the end-user requirement workshops that are reported in D2.1. For the introduction and the closing discussion, the end-users and the professional users were brought together. The feedback on VR experiences and the ideation exercise took place in separate groups.

The professional user workshop consisted of the following segments: an introduction, reflection on the VR workflow, a content ideation part and a discussion. The goal of these segments is briefly described underneath. A more elaborate preparation of the workshop can be found in annex I.

- **Introduction**

During the introduction the context and goal of the ImmersiaTV project is explained and the participants could present themselves, their role within the company and their experience with VR. Since most people didn't have experience with VR in advance, it was ensured that every participant saw multiple VR examples (see Annex I for more details). In a group discussion they could give feedback on their experience: what did they feel as the main opportunities and barriers for omnidirectional video?

- **VR Workflow**

Furthermore, two VR experts from Fisheye, a Belgian production house specializing in VR production, were invited to contribute. Starting from a brief explanation on their VR workflow, the participants were encouraged to think about the differences of VR production with their standard TV/online workflow and the potential pitfalls it could bring.

- **Idea generation and format**

Smaller groups of two or three persons were made to develop and elaborate their own content format based on their professional expertise. Therefore, they received a pitch template (title/slogan, summary, target audience, genre, type of interactions, and the amount of interactions), a program timeline and a print-out of a common VR workflow, so they could map their concept to the workflow.

- ***Discussion with professional users and end-users***

For this part of the workshop, the professional users and the end-users are gathered around the table.

- *Presentation of professional content formats to end-users:* Professional users presented their concepts to the end-users. The end-users could ask questions and there was a discussion on the developed concepts. In the discussion, we focussed on the professionals' view of the user (what kind of user experience and user expectations did they have in mind for their developed concept) and how users evaluate this.
- *Presentation of end-user formats to professional users:* Also the end-users briefly presented their concepts followed by a discussion.



Figure 3: Two workshops with professional users were held at VRT

2.1.3. Participants

24 professional users in total participated in the discussions. As shown in the table underneath, a good combination of people with different backgrounds and functions was chosen. Furthermore, two experts VR from Fisheye were invited to contribute (not listed in the table).

Name ¹	M/F	Age	Genre	Function	Experience with VR
Dieter	M	34	docu	editor (Koppen)	Y
Annabelle	F	26	docu	digital video editor (Vranckx)	N
Victor	M	28	docu & news	online editor (Vranckx)	N
Catherine	F	42	news and information	editor (Canvas)	Y
An	F	24	information	production assistant (Canvas)	Y
Eveline	F	40	music shows	editor, content coordinator	N
Arthur	M	36	Human interest	editor & reporter (Iedereen Beroemd)	N
Eli	M	38	human interest	editor, reporter, director (Iedereen beroemd)	N
Jacob	M	25	web	online editor (TV - Eén)	N
Dan	M	56	fiction	director fiction (Thuis, FC De Kampioenen)	Y
Tobias	M	23	digital radio	creative developer/web designer	Y
Bart	M	29	digital radio	digital creative/web	N
Koen	M	24	digital radio	web editor	N
Floris	M	49	Technic	technical architect	N
Sophie	F	26	kids	online editor (Ketnet)	N
Nicolas	M	28	kids	online editor (Ketnet)	N
Boris	M	33	kids	news editor (Karrewiet)	N
Jeremy	M	27	/	camera, director, motion graphics	Y
Jonathan	M	22	lifestyle	student "Media and Entertainment Business"	N
Lea	F	20	lifestyle	student "Media and Entertainment Business"	Y

¹ Names have been altered to ensure anonymity of the participants.

Ward	M	18	lifestyle	student “Media and Entertainment Business”	N
Chris	M	50	human interest	senior editor	N
George	M	38	/	creative producer	N
Joel	M	39	news	ENG (Electronic news gathering) mobile	Y

2.2. Live events: Interviews with experts

By proposing a questionnaire to the professional users, we tried to get an insight into the existing live formats of today as well as the potential added value of and compatibility with a simultaneous VR format and the deriving related requirements.

2.2.1. Detailed questionnaire

The questionnaire is built up around three segments. The first two segments focus on the content ideation, with an ‘open part’ questioning the interviewee to come up with creative formats and features, and a ‘guided part’ asking to comment on two proposed mock up user interfaces for possible pilot cases (a sports and a music show). The third segment focuses on the professional tooling needed for a 360° video director.

PART ONE: Ideation – OPEN

1. How do you see 360 VR video in a live event? (link with other platforms, social, devices)
2. Who is the target audience?
3. How do you see interactivity (user versus director, use of portals)?
4. How do you see the interaction between the TV and the HMD (including the role of audio)?
5. How do you see the user interface? Which functionalities should be present?
6. Which use cases are more suitable for 360 live coverage?
7. Is there a professional demand to share the content afterwards online? Only for HMD? What are the requirements, e.g. possibility of finishing?

Technical sub-questions were added for more technical oriented interviewees:

8. Production - How do you see this technically? What are the synergies with regular TV recordings? What part of the (live) crew will also be engaged in VR production?
9. How can the existing TV-oriented architecture be combined with a 360 video set up?
10. Pre-Production - How to prepare a live VR production? How long in advance should research and testing be planned? How does this relate to a regular TV live production? Are there additional or specific requirements?

PART TWO: Ideation – DIRECTIVE

This section focused on possible candidate use cases for the ImmersiaTV live pilot, which are presented to the interviewee by means of mock-up interfaces: a sports event and a live music show. The following mock-ups were presented to trigger the ideation process.



Figure 4: Mockup interface for HMD experience (cyclocross)

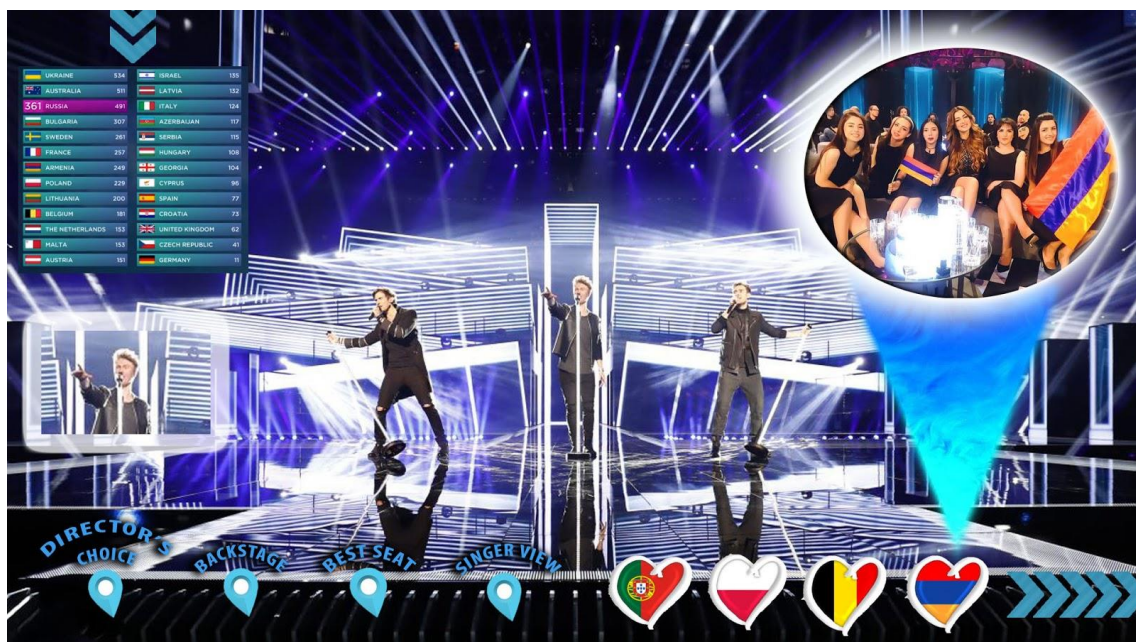


Figure 5: Mockup interface for HMD experience (Eurovision song contest)

Questions related to the mock-ups:

1. What do you think of the example(s)? What are the first impressions and comments that come to mind? What are the differences or additions to the open brainstorming in part one?
2. What would you change and why?
3. Do you think this concept provides additional experience to the viewer? Why (not)?
4. Which of the two examples works best for you, and why?

5. Do you have comments on the design, display implementation or usability? How do you see the activation of a portal visualized?

PART THREE: Live control tools

In this section the interviewee was asked to list up the possible features and priorities of a director tool for live events VR.

1. Which balance should there be between preconfiguration and dynamically adjusting?
2. How can (live) VR and regular storytelling be aligned?
3. What are the requirements for Live Preview for the operator? E.g. the result of a transition: what are the needs before and during the live production?
4. What similarities and differences are there with regular control tooling?
5. How to improve the quality of experience? E.g. use of heatmaps to adjust points of interest.

2.2.2. Participants

Name ²	M/F	Age	Genre	Function	Experience with VR
Jan	M	36	Entertainment	TV Director live shows	N
Eva	F	39	Media Production	Producer live entertainment shows	N
Lieve	F	35	Media Production	Producer live entertainment shows	N
Joris	M	35	Children TV-entertainment	Director live events and tv shows	Y
Andy	M	42	Live set-ups	Technical project lead for live broadcasting events	Y
Martin	M	39	Sports events	Chief editor online	N
Christoph	M	49	Sports events	Technical project lead for live broadcasting events	N

2.3. Refined off-line scenario

² Names have been altered to ensure anonymity of the participants.

2.3.1. Motivation for the interviews

In this third iteration, interviews were organized with professional users with a specific focus on the exploration mode. The goal of these interviews was to get a deeper insight into how interactive storytelling over multiple devices is seen, to define the exploration mode and to get feedback on how interactive storytelling affects the production workflow.

2.3.2. Detailed questionnaire

A 30 to 60 minute interview was conducted with each professional user individually. Two interviewers were present during each interview: one person leading the interview and one person assisting and taking notes. All interviews took place in Porto (Portugal) at the Lightbox offices.

The questionnaire consisted of two parts. The first part was discussed with all the participants and started with an 'open part' that focused on interactive storytelling in general and a more 'guided part' where the ImmersiaTV concept was discussed and reflections were gathered on branched storytelling. The second part focused on the technical tooling. In this part, specific questions were asked to the professional users depending on their function.

PART ONE:

- Interactive storytelling:
 - o How do you see interactive storytelling?
 - o What type of story or content do you want to see made interactive? For which programme types would this be interesting or provide added value?
- The ImmersiaTV concept:
 - o How do you see interactive storytelling on multiple devices (Immersiatv concept: HMD, TV, Tablet)?
 - o What is the added value of exploration mode from a storytelling point of view?
 - o How do these multiple devices interact with each other inside the story?
 - o How do you see the interface over multiple devices? How do they work together inside the story?
 - o How to cope with the differences of the duration of exploration mode (or branched storytelling) depending on viewer's choices?
- Branched storytelling:
 - o How do you see branched storytelling work over different devices?

PART TWO:

- What kind of tooling is needed to make the exploration mode possible?
- How will the exploration mode/interactive storytelling affect your production workflow (preproduction, production, post production, publication)?
- Which changes must be made in the edition, distribution and display tools to deal with binaural audio? Does this introduce a relevant complexity in the production?

2.3.3. Participants

10 professional users were interviewed. As listed in the table below, an effort was made to have a combination of people with a different background and function. 4 interviewees had professional experience with VR.

Interviewee ³	Age	M/F	Function	Familiar with ImmersiaTV?	Experience with VR
Mario	23	Male	VFX Artist	Y	Y
Noyon	26	Male	VFX Artist	N	N
Patricio	41	Male	VFX Supervisor	Y	Y
Miguel	31	Male	Editor Supervisor	Y	Y
Pablo		Male	Editor/Camera Operator	Y	N
Goncalo	28	Male	Editor	Y	N
Lenz	35	Male	Sound Tech	Y	Y
Dias	31	Male	VFX Artist	N	N
Dillon	32	Male	Camera Operator	N	N
Catarina	30	Female	Producer	N	N

2.4. Refined live scenario

The live pilot in the third iteration of the ImmersiaTV project, further elaborates on the main insights from the pilot 2 live scenario (including both workshop and pilot). In pilot 3 audit, the

³ Names have been altered to ensure anonymity of the participants.

emphasis lies on providing more interactivity to the end user and on exploring more immersive experiences through spatial audio.

2.4.1. Method and Questionnaire

The open ideation part in the live pilot 2 workshop (see Section 2.2) introduced a broad overview of possible ImmersiaTV features during a live event. Specifically for live pilot 3, an internal ideation workshop of the Immersiatv consortium during the General Assembly in November was organised, building further upon already developed features in live pilot 2. A targeted questionnaire was derived from this consortium workshop to interview professional users in a second stage.

The questionnaire exists of two parts. The first part starts from the director's tooling built for live pilot 2. Which features, made for the director, can be transposed to the end user or are complementary for both? Which new features can be added? The focus of the second part is on audio in an immersive live environment and how spatial audio production has an impact on the existing professional workflows.

PART ONE:

First, the ImmersiaTV live director's tool is explained (see Figure 6) to the workshop participants.

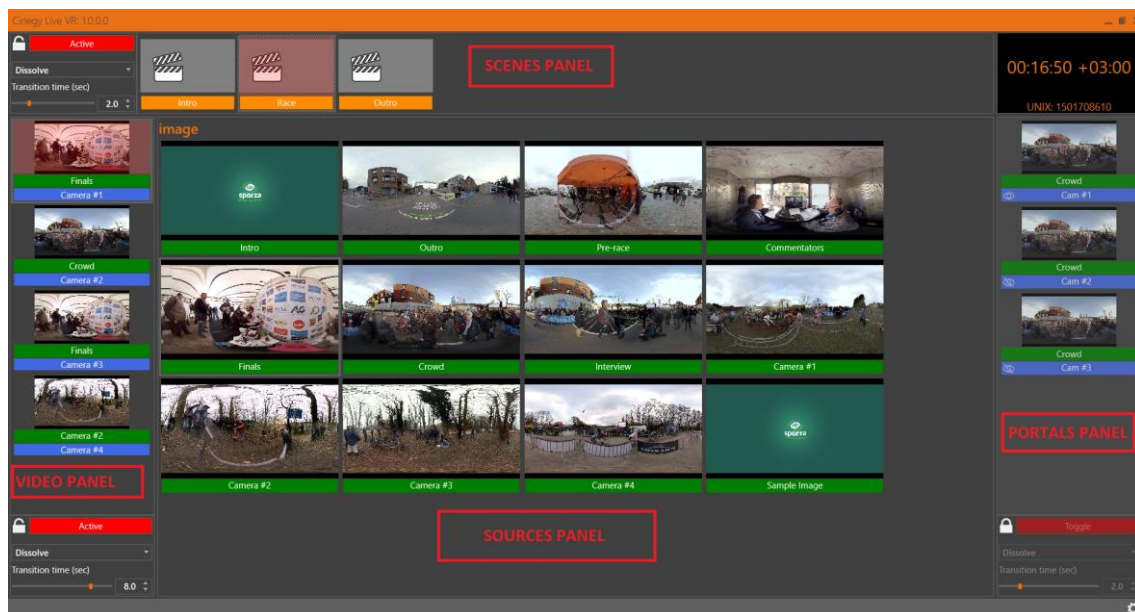


Figure 6 - Cinegy Live VR software interface

- General impression, which features for the professional user can be transposed to the end user?
- Sources panel / video panel (overview of all incoming sources):
 - How much “freedom to explore” does the professional user give to the end user?
 - To which extent should the end user get access to available active sources?
 - How do you see the coordination between the director and end user, taking into account both have access to the same sources? How will the professional director intervene with the choices made by the end users?
 - Which features are (not) complementary for professional and end user?

- Which additional professional features should be added to the Cinegy LiveVR tool ?
How do these extra features augment the end user experience?
- Scenes configuration panel (portals):
 - The scene configuration with portal set up in live pilot 2 is done by the director, but is restricted to the main omnidirectional view only. Can we give more advanced interactivity options to the end user regarding the scene configuration?
 - Can you elaborate on different scene configuration set ups and how these impacts storytelling during a live sports and entertainment event.
- Are there features that might give more interactivity to the end user and are not in the ImmersiaTV concept of a live event now?

PART TWO:

- How would you implement immersive audio in an advanced live ImmersiaTV concept?
Extend on how this impacts the professional user workflow.

2.4.2. Participants

7 professional users were interviewed. As listed in the table below: 3 live directors, 2 producers and 2 VR professionals participated.

Interviewee ⁴	Age	M/F	Function	Familiar with ImmersiaTV?	Experience with VR
Karel	40	Male	TV technology in live set ups / live director	Y	Y
Frank	47	Male	Live director	N	Y
Floris	45	Male	Digital Producer	Y	Y
Arne	51	Male	TV technology in live set ups / live director	Y	N
Peter	40	Male	Producer	N	Y
Filip	43	Male	VR producer, 360 video	Y	Y

⁴ Names have been altered to ensure anonymity of the participants.

Fredo	41	Male	VR innovator	YES	YES
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3. CONTENT FORMAT REQUIREMENTS

From the discussions during the user workshops and expert interviews, different content format requirements have been identified. In this section, these requirements are structured and described in more detail, for both the off-line documentary (pilot 1) and live event experiences (pilot 2). General requirements are documented in section 3.1. Next, we address the specific ImmersiaTV challenges with regard to synchronized multi-platform content experiences (section 3.2), and portal-based and more generic interactivity (section 3.3). In section 3.4, examples of omnidirectional program formats that came out of the workshops are documented

3.1. Generic requirements

3.1.1. Off-line documentary

One of the main challenges for VR content production is the development and exploration of a totally new cinematographically language, and to find out how to tell good stories with omnidirectional video. In this section, the main findings with regard to generic content format requirements resulting from the professional user workshops are described.

Requirement R.2.1.1 – The content creator shall take into account that VR experiences are about presence, “being there”.

- Give user insights in situation/context of the story, and avoid imposing “subjective” choices of the director. Consider creating a “suspension of disbelief” context for the viewer, or go for seemingly free interactivity with subtle guidance.
“For understanding certain situations, convince the user that you are not imposing your viewpoint can be beneficial.”
- Use the correct perspective in function of story. Eye-level perspective (by taking care of appropriate height of tripod) is preferred, as some people find it weird if they don’t look from eye level.
“In the dressing room scene, the musicians looked like giants.”
- The user expects to see him/herself when looking down - e.g. use of leap motion technology to see your own hands.
- The user experience should be tactile/tangible.
“I experienced this concert in VR, but I did not feel it. I was not in the place, it was not tangible.”
- Give the user the opportunity to see more (details) than they would do in reality.
- Consider increasing the feeling of presence by “talking to the viewer” (passive actor) or if possible making them an “active” actor.
- Avoid ruining the myth.
“I don’t want to see the locker room of my music idol.”

These findings are completely in line with the first feedback in the end-user workshops (see D2.1). Users also refer to the sense of presence and the eye-level perspective. They also ask for specific haptic feedback as is also mentioned in these workshops.

Requirement R.2.1.2 – The content creator should consider the use of gamification paradigms to improve the storytelling for VR

- Most VR content now is technical, and too static. One of the reasons for this is that VR production still is a technical workflow that causes more technical profiles to experiment with the format. To improve the formats more storytellers should be involved in the production process.
- Don't start from existing formats and think how we can do this in VR; think of new formats! Technology creates the context here.
- Use of gamification paradigms: the use of game-specific features can give the viewer more interaction with the environment:
 - Information overlay (energy level, position, level or position in the story), choice of attributes (in games typically weapons, but could be other in a 'normal' story i.e. an attribute related to the storyline)
 - changing between characters ("through the eyes of a person of choice"), choice of storyline (opportunity to see the project again and have a different outcome, perspective, or a partially or even an entirely different story altogether)
 - transportation from one storyline to another, from one scene to another through the use of portals.

This was also reflected in the end-user workshops (D2.1) in terms of the first person perspective, standing in someone's shoes and experiencing the content from that perspective.

Requirement R.2.1.3 – The content creator shall make proportional use of omnidirectional content

- Take into account capturing constraints: available time,... Therefore limit VR production to moments where 360 is relevant.
"I could imagine shooting the climbing in a container in 2D, while doing the in-the-container shot in VR."
- Select specific VR "moments" (in the boat, in the container...).
- Take care of switching between 360 and 2D in HMD:
 - Keep it in HMD; putting the headset on and off does not seem realistic.
 - Use 2D crop in HMD with remaining 360° image black, so the viewer is still able to turn their head.
 - A fixed 2D in a headset that follows viewer movements will probably make people nauseous.
- Allow the user to choose between auto switching to 360°, or to configure the "frequency" (sometimes, never).

In the end-user workshops, there was a clear preference for shorter 360° fragments inserted in a regular TV-format. This is in line with this professional requirement that not everything should

be in 360°. The only exception is in sports, there users would like to see the game as if they were there, by being able to look around from a seat in the stadium, or from a spot along the trail in a cycling competition.

Requirement R.2.1.4 – The content creator shall be able to play with the viewing angle & viewpoints

- Adequate viewing angle (highly) depends on the content. Example practices include:
 - Full 360°: e.g. for locations where you would never come in reality. The location must be carefully chosen.
 - Enlarge viewing angles in specific scenes (e.g. action scenes - “looking out of helicopter”) and use 40° extension for other shots (e.g. police series).
 - For sitcoms: 270° views can be considered (cfr. 3 sides decors).
“Although I would like to have a bigger viewing angle, I don’t like to turn my head fully backwards when I am watching VR in my sofa (lean back experience). In a lot of cases 270° is enough.”
- We might consider working with a “basic format” (cfr. 16:9 format for broadcast TV).
- Viewpoints or perspective: where should the camera be? In the best seat of the concert hall, next to the lead singer or in the crowd? The director has to decide filming on one of these locations, let the user choose their own perspective or switch location through transitions in the video.

For end-users the perspective was very important (natural eye-height). They also would like to be able to switch perspectives, for example take a certain position in a scene or switch to a ‘god-perspective’ with a full overview. Important is that users are able to choose this perspective for themselves and take control. For events like a concert or festival, it is also important not to be too close to the content, but to be able to select the position in the scene.

Requirement R.2.1.5 – The content creator shall carefully consider the viewer’s role in the story

- Find a good balance between observation role versus becoming part of the story.
- Potential approaches include static scenarios (one location), the first person (in the skin of, re-experience own experience), ...
“I would be interested to experience the best seat in a concert of Paul McCartney. Exclusivity, in particular, will work.”
- Enable the user to look around even beyond what you would be able or willing to do in reality
“Imagine the possibility to look unabashedly to other people”
- Question the role of the documentary presenter, the viewer becomes the presenter

This is completely in line with the end-user requirements; they do want to be in control (see D1.2)

Requirement R.2.1.6 – The content creator shall define the “beats” & find a good balance between static and dynamic shots

- The principle of rhythm/pace of story “beats” is probably similar as for TV (after X min of tension you need some rest). Avoid overloading the user with impulses.
- The introduction of movements: these types of shots are hard to capture at the moment. More blur is typically introduced, increasing the chance of people getting nauseous.

Requirement R.2.1.7 –The content creator shall take care of the balance between guidance and freely looking around

- In linear 2D TV program creators are used to guide the viewer by using a voice-over, choosing the “right” crop and cuts to tell their story. Instead, in VR the user themselves can decide where to look at. This gives the user the feeling to have a more authentic view on the situation, but also makes it more difficult for the creators to tell their story. In VR the balance will have to be searched between guiding the user to tell the story and making sure they saw essential clues without restricting their decisions to freely look around.
- Creators have to let the users create their own experience and, if necessary, direct them with subtle pointers.
- Ways to guide the user are:
 - Voice-over (“look at your right”)
 - Binaural audio (sound from specific direction)
 - Music (emotional effect)
 - Person/animation on screen guides/points out where to look at

For end-users it is important that they are able to select whether they indeed receive this guidance or not (could be something they can switch on and off). Furthermore, natural cues are considered really important (the person that points to a certain direction, a bird that flies in a certain direction,..) The viewing experience may not be interrupted by an unnatural cue.

Requirement R.2.1.8 – The content creator shall apply good usage of transitions and cuts in VR storytelling

- There is a need to learn how to best introduce cuts or apply transitions, e.g. when there is a change of location
- Take into account the mixed reaction of people on hard cuts (okay versus annoying). Guidance based on audio or user selection (‘click when you want to go to another/the next location’) can help.

From the end-user perspective, control is necessary. They find it really disturbing if there is an abrupt switch in the viewpoint.

Requirement R.2.1.9 – The content creator shall be able to adequately address the social aspects of the VR experience

- A potential problem in VR content experiences is that viewers are looking on their own. There is no communication with other people while watching VR in HMD. Extensions that enable even basic social interaction inside HMD experience can deliver added value.

In the end-user workshops, this was a very important requirement. Social viewing should be supported, either in the real-life social experience when viewers watch together, or in the virtual experience, for example by a representation of friends and family as avatars.

3.1.2. Live event

In this section, we summarize and structure the feedback given by the professional users in covering live event experiences making use of both directive and omnidirectional video. Based on the responses and discussions of the questionnaire (see Section 2.2.1) we extracted the following requirements.

Requirement R.2.2.1 – The content creator shall take into account that the point of view (PoV) in live VR has a direct impact on the user experience.

PoV is used here both literally as figuratively, meaning that the place of the camera in the field and the place of the person's point of view in the story has both a fair amount of impact on the immersive experience.

- 'The best seat in the house experience': Giving the viewer the feeling of being present, sitting or standing on the best spot of the event, is an experience VR can offer in contrary to television.
The viewer's PoV can be the one of a spectator in the field. For example in a sports event, the viewer can check details of hazardous situations from a perspective natural to human eyesight, while in standard television long lenses and high or low perspectives can cause optical aberrations. When choosing a PoV natural to the human posture, you get an actual idea of the real surroundings of the event, of the size, scale and of the extraordinary performance put up by the event contenders, whether it is a sports event or a music show.
- PoV in the story's perspective: Where you are as a viewer influences the way the storyline unfolds, like choosing a side. On traditional television, for a live event, a director is telling a story using their multicam setup. They frame the event, choosing different angles and covering actions. In a 360° video the spectator is given the freedom to look around or to choose which camera to view in which order. It is comparable with an embedded journalist choosing to stand behind the police force or between the strikers. The role of the viewer and his place has an impact on how they will interpret the events happening around them.

From the end-user perspective, the importance of PoV and the sense of presence was indeed confirmed. At the same time, users expect to have the option to select between different viewpoints. A possible issue that needs to be taken into account is that users might miss part of the action when they are watching in a different direction than where the action takes place (e.g. miss the goal in a football competition).

Requirement R.2.2.2 – The content creator shall take into account that synchronisation is key.

When streaming content on multiple devices, the issue of relative latency has to be taken into account. It is a major downfall to the user experience when one device is out of sync with the other one. This is especially the case in the concept of ImmersiaTV where the viewer uses the main TV as a guide covering the event and the 360° video as extra content, in a supporting role,

taking the lead only from time to time. It is obvious that when e.g. a goal is scored on the TV, the user wants to have the same sync content on the HMD, whether they are standing between the fans or next to the dug-out.

From the end-user perspective, this is also a necessary requirement.

Requirement R.2.2.3 – The content creator shall use audio to evoke the feeling of being present on the actual place of the event.

It seems that a mix of both - environmental ambience and the commentator's voice of the TV edit - is the preferred solution. That way, the user can keep track of the story of the live event through the commentator's voice, but when looking into the HMD, the additional background track with the environmental ambience enhances the feeling of being present.

Positional head movements can be incorporated into the sound layer, so a 3D sound experience is provided, giving an even more real-presence experience to the viewer.

In the pilot 1 user test (D.4.5) it became clear that users expect an omnidirectional sound as well. In this pilot, only the TV had sound, which led to a more limited immersive experience.

Requirement R.2.2.4 –The content creator shall give spatial orientation to the user.

In VR the user is present at a stationary place at a live event. Nevertheless, users do not (yet) have the ability to walk around and they typically do not have the spatial orientation of the venue where the live event takes place. Therefore, a viewer watching into the HMD, has to be guided through the event and informed of where the cameras are located. This can, for example, be done by providing a simple location map. For live sports events covering a race that has a 'head and a tail', it seems preferable to mark the position of the leaders (provided that the accuracy is high enough).

3.2. Synchronized content across devices

3.2.1. Off-line documentary

The goal of ImmersiaTV is to synchronize content across devices. This implies additional requirements, on top of the requirements specified in section 3.1. During the workshop, the initial feedback on this was very limited, indicating it is not an intuitive concept for professional storytellers. The main remarks are listed below.

Requirement R.2.1.10 –The content creator shall give the user the choice when to switch between devices.

- Give the user the choice if they want to look in VR during or after the episode/documentary.
Probably also social aspects will determine this choice. What will user do in different situations: when they are watching alone or together with others, both in the case where there is only one HMD available or when everybody has one.
- Professionals are finding it hard to believe viewers will switch between devices during an episode (except for live scenarios). They see it more as a separate experience, e.g. before or after the program. In some occasions, however added value of the use of VR during a program can be seen, e.g. to deliberately create more empathy and better connect the user with the program topic, for instance a TV documentary on life in a

women's prison could be enhanced with VR content to make the user more connected with the living conditions.

Here we see a clear difference with the end-user expectations. They do see themselves make use of these second screen VR experiences, but it should indeed concern shorter fragments and content that has an added value for them.

Requirement R.2.1.11 –The content creator shall not mix TV storytelling with VR storytelling.

Each technology device comes with its own language to provide good storytelling experiences to the end users. TV was different from radio, digital web storytelling formats are now maturing and omnidirectional content formats for HMD experience will become a different chapter in this evolution, which we are just starting to explore. Amongst the main differences that can be assumed at present are differences in storytelling pace, type of edit decisions, (interactive) viewer journeys,...

In the end-user workshops and during occasional contacts, professional content creators consistently indicated they are not in favour of mixing different storytelling languages (TV + VR) into one coherent storytelling experience, as they see no added value in doing so.

For end-users it is difficult to make this distinction. In the examples they came up with themselves, it is often a sidetrack in a traditional broadcast format.

Feedback on opportunities for synchronous multi-device playback

- Interesting scenarios possible for live (sports) event.
- In general content creators see at first sight no obvious added value for documentary scenario except in specific cases, such as specific scenes where emotional empathy for the docu topic can be increased.
- Maybe during commercials (not applicable for VRT).

Some of the concerns from professionals for synchronized content across devices refer to the **requirements** expressed in section 2.1, more specifically to requirement R.2.1.3 ((make proportional use of omnidirectional content)). Both 360 as 2D videos have their own language,... and thus have their own advantages and disadvantages. Professionals, hence, think some scenes or stories have added value when seen in 360 where others don't benefit from it. Therefore they will have to search for the balance between 360 and 2D and adapt their storytelling to the 360 or 2D situation.

3.2.2. Live event

In contrast with off-line formats, synchronized content experiences across TV and HMD has been confirmed as a very interesting and promising concept for live formats. In addition, professionals also believe in an HMD-only interactive event experience, as such the ImmersiaTV system should leave the choice to the viewer how exactly they want to experience the event. From requirement R.2.2.2, the following guidelines can be derived.

Requirement R.2.2.5 – The content creator shall make sure that the storytelling over multi devices runs parallel such that the combination of 360 and TV storytelling is optimized.

Synchronize all outputs of the different devices.

As already mentioned in Section 3.1.2, professional users strongly believe that synchronisation of the content on the devices can be a key asset in covering live events experiences and this in contrast to off-line production where the interesting opportunities are a bit more confined. Whether it is sound or video, not being in sync will destroy the viewing experience of the

spectator immediately. Even a latency of just a few seconds can significantly distort the viewing experience.

Provide a seamless coverage of the live event.

Because the viewer wants a seamless coverage of the live event, the viewing experience has to be solid. Therefore, the first image seen by the viewer in the HMD, should optimally also be aligned with the storyline created by the director of the 2D TV live multi-cam setup.

Furthermore, to experience the concept of presence in 360° video, the viewer wants to jump directly to where the action is or where the story unfolds, and not arrive in viewpoints that have no interesting content to offer at that point in time.

3.3. Interactive VR experience and portal concept

3.3.1. Off-line documentary

This section describes the professional requirements and feedback on the application of portals, and more generally interactivity within the ImmersiaTV context. This section should give a clear view on specific scenarios where portals can be applied, or where other interactivity based approaches are preferred. Specific implications of portals (or more generically, AR objects) on VR content experiences and creative workflows will be explored.

Why interactivity?

- To get feedback from users
- If a user can have impact on the situation, the “being there” experience increases. For example, they can choose story paths to interact with content (choose yes/no, left/right, ...). This is also a way to make the experience more personalized.
- Increase immersion, for example, by indicating emotional status.
- Concepts based on gamification:
 - o Being an adventurer, detective, research journalist, ...
 - o Allow for different paths (and timings) but with same “end point”; don’t make this too complex.

Portal-based interactivity

A first set of interesting applications of portals have been identified:

- Location awareness: interactive map (e.g. when looking left) to follow and act on story locations.
- Story viewpoints: selecting other points of view e.g. journalist on the place of action.
- Repeated action (sports): especially in the case of multiple repeats.
- Extras with specific details, e.g. (pre-captured) “how to” video during a cooking program.
- Portals to go to other videos, for example archive content.

How can we apply interactivity?

- Ways to interact: click on Oculus⁵, look at something long enough, control with smartphone/separate controller in your hands (e.g. handheld controllers with HTC Vive), gesture controls via leap motion. Walking around and zooming in can also be interesting interactions.
- Options can be given when frame freezes with choices appearing, or
- User can interact with content augmentation layer in location:
 - Adding virtual objects or
 - Boxes to get extra information e.g. infographic layer above content.

Balanced use: should be dosed throughout the story, e.g. discussion if VR has to be lean back like TV or needs more interaction to keep it interesting.

Many of these interactive storylines can be mapped on the [requirements](#) expressed in Section 3.1.1:

- Requirement R.2.1.1 – The content creator shall take into account that VR experiences are about presence, “being there”.
- Requirement R.2.1.2 – The content creator shall be able to use gamification paradigms to improve the storytelling for VR
- Requirement R.2.1.5 – The content creator shall carefully consider the viewer’s role in the story
- Requirement R.2.1.7 – The content creator shall take care of the balance between guidance and freely looking around

We introduce the following two additional requirements as they have a specific link to the ImmersiaTV concept.

Requirement R.2.1.12 – The content creator shall be able to apply interactivity via portals

With a small pointer a viewer can ‘gaze’ to an icon in the interface and by keeping this staring for a couple of seconds, the new viewpoint will be activated.

Requirement R.2.1.13 – The content creator shall be able to include extra graphical content in the HMD interface

Extra graphical information to point to extra information in the environment, e.g. names, subtitles, a location map

3.3.2. Live event

This section points out how we can introduce interactivity during a live event, why and how the viewer would like to have such an interactive experience and what tools can be used.

How can we apply interactivity via portals?

A portal in a live set up is a gateway to another videostream (another camera viewpoint) or more generally to another 360° scene composition.

- The gaze feature: the direction the viewer is watching in the HMD. With a small pointer a viewer can ‘gaze’ to an icon or a portal containing a small piece of video representing a new viewpoint in the interface. The new viewpoint will be activated when the viewer keeps staring at this for a couple of seconds.

Other options to include in the interface

- A graphical map, so the viewer has a spatial awareness of the venue.
- A live feed of the 2D TV, e.g. to follow the leaders or the action happening on other places.
- A director's choice: a cut made by a director making use of the different 360° video camera streams on the event. The director's choice should keep mainly track of where the action takes place.

In Section 3.4.2 we discuss the different possible live use cases illustrated with example interfaces. Mock-ups will be included for a visual representation.

Requirement R.2.2.6 - Apply interactivity via portals

With a small pointer a viewer can 'gaze' to an icon in the interface and by keeping this staring for a couple of seconds, the new viewpoint will be activated.

Requirement R.2.2.7 - Include extra graphical content in the HMD interface

A location map, a 2Dtv live feed, information about the race, ...

3.3.3. Live event

In the advanced live pilot 3, the following content format requirements regarding interactivity are added.

Requirement R.2.2.8 – The content creator shall have full control over the live content, (possibly) enabling the content viewer to play, pause and resume transmission.

This requirement entitles the professional user (director) to decide whether and when the user can have full control of incoming streams in terms of stopping, pausing and resuming them. Whereas the director enables these features in the Cinegy Live VR tool, the end user will use these in the HMD.

Requirement R.2.2.9 – The content creator shall have the possibility to offer replays of live content to the viewer, mixed with the live experience.

Replay of content is a common action used in e.g. live sport broadcasts. The immersiaTV concept should give the same option to the live VR director, enabling him or her to replay an important action during the event, e.g. a goal or an event highlight.

Requirement R.2.2.10 – The content creator shall have the possibility to share the point of view of the HMD onto the television.

Showing the point of view of the HMD on the television, as directive live content, can enhance the storytelling experience of a live event.

Requirement R.2.2.11 – The content creator shall be able to provide more advanced interactive experiences to the viewer, diversifying the level of interactivity on a per omnidirectional scene basis.

In pilot 2, the user interactivity was limited to selecting viewpoints and play the corresponding (portal) content inside the HMD experience, without any additional or customized interactivity within the selected omnidirectional scene. In pilot 3, the user interactivity has to further extended to enable this kind of refined interactivity patterns.

Requirement R.2.2.12 – The content creator shall be able to enforce a specific portal or scene configuration on-the-fly, jumping from one scene to another, as an equivalent of a user-triggered (inter)action.

While the main goal is to give the user freedom of exploration options as much as possible, in some occasions the director may want to intervene due to important/interesting events happening. However, the director should do this with care.

3.4. Exploration mode (refined off-line content scenario)

This section groups the professional content format requirements that are specifically related to the introduction and application of the exploration mode for off-line content scenarios in the context of pilot 3, as an extension of broadcast mode of pilot 1 (covered by Sections 3.1.1, 3.2.1, 3.3.1). We summarize and structure the feedback given by the professional users during the dedicated workshops focusing on exploration mode. Based on the responses and discussions of the questionnaire (see Section 2.2.3) we extracted the requirements listed below.

To clarify the precise creative context of these requirements, Figure 7 illustrates the concept of exploration mode as envisioned for pilot 3 (off-line), and how it differs from broadcast mode (pilot 1).

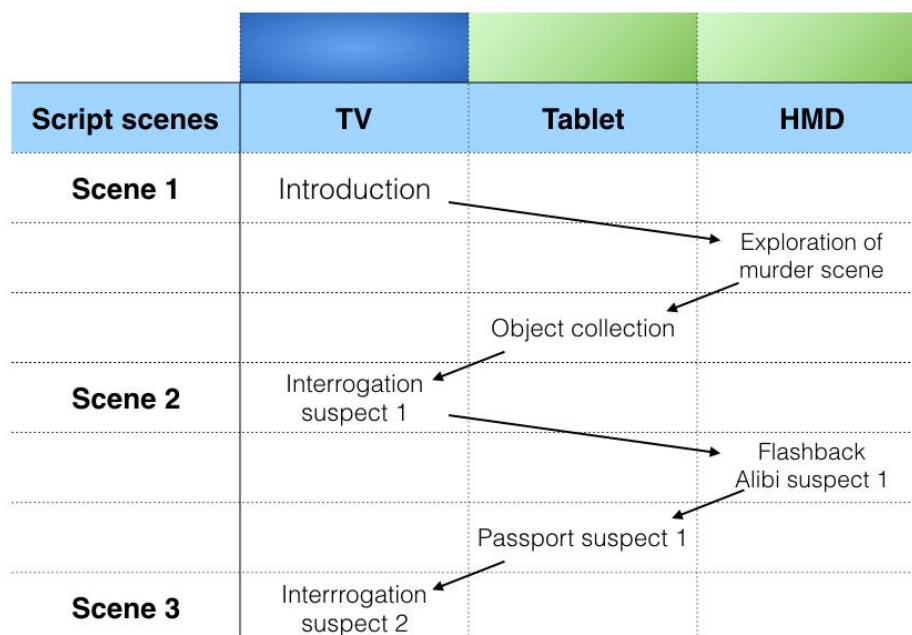


Figure 7 - Concept of ImmersiaTV exploration mode experience

Requirement R.2.3.1 – The content creator shall take care that exploration mode-based storytelling is seamless across devices.

Exploration mode differs from broadcast mode mainly on the aspect of content synchronization. Whereas in broadcast mode synchronized content refers to the same scene (from a different

viewpoint), the same moment in time and location, in exploration mode the storyline on the television is interrupted and switches to the HMD device into another scene (time, location) in the story, potentially providing another subjective view on the unfolding story. The very act of this 'break out' has to be a seamless experience for the viewer.

To keep the story going and the viewer eager to explore more of the storyline, the content creator should never forget the bigger picture and take extra care on how much information is given to the end user at which time. This is a creative requirement, story elements for example as '*inciting incident*'⁶ and '*suspension of disbelief*'⁷ are possible tools that can be used by the content creator to masquerade the 'break out' interruption. Very comparable with a 'cliffhanger' at the end of a comic book page that will let you turn the page to see how the story evolves, the content creator telling a story in exploration mode should use their creative ability to make the changing of devices seamless, keeping the viewer eager to continue the storyline.

Requirement R.2.3.2 - The interface over multiple devices should be simple, coherent and invisible.

Following up on R.2.3.1, to make the storyline seamless over devices using creative storytelling elements, the user interface on all devices should be simple, coherent and non-intrusive, not breaking the user experience. The user interface should involve as less handling as necessary, not interfere with useless actions on each device, putting the story upfront.

The design of the interface should fit the art direction of the story and be coherent over all devices, taking care of the typical design elements and handling parameters of each device. The interface should be almost 'invisible' to the end user.

Goncalo – "I want to see the information and not the interface."

Requirement R.2.3.3 – The scenario, as written and implemented by the content creator, shall put one device in the lead of the main storyline, to which content on the other devices is complementary. The preferred lead device for the main storyline is TV. HMD and tablet become active when exploration mode is activated.

One of the key added values of the Immersiatv concept is the social activity of watching a linear tv broadcast extended with HMD content in group, as opposed to the 'isolated' experience of watching content inside an HMD or on a tablet. In both pilots, (1) off-line and (2) live, the television is the main device, the tablet and HMD run in sync and are second screens, giving an interactive experience and the immersive feeling of being present. Exploration mode in pilot 3 is formally different to the broadcast mode concept of pilot 1 and 2, so the question can be raised if one device (tv) still has to take the main lead. During the workshop interviews, professional users clearly state to keep the storyline clear and social to all viewers. It is important not to overdo the concept of exploration mode and use it with care. It is highly recommended that one main device tells the storyline, preferably the television as it is the most accessible device for each viewer. The HMD and the tablet are best used as 'break out' devices which give extra content complementary to the main device (tv). In a whodunnit script

⁶ The inciting incident is the first scene or event that hooks the viewer into the story and gets the narrative rolling.

⁷ Suspension of disbelief is the willingness to suspend someone's doubt or scepticism and believe something surreal for the sake of enjoying a good story.

e.g. the HMD can be used to explore the murder scene, activating objects on the tablet, which is used as a notebook to collect clues which lead to the murderer.

Miguel: “The secondary devices should extend the primary (TV).”

Requirement R.2.3.4 – The content creator shall take care that each device has its own relevance and added value in the multi-device storytelling.

In exploration mode, there is no synchronised content running parallel on all devices (cfr. broadcast mode). The main device tells the storyline (television, see R.2.3.3) and is paused to activate exploration mode on the HMD and tablet. Different content complementary to the main storyline is shown on these “second screen” devices. Specific content requirements have been gathered for the HMD in the context of an off-line documentary for pilot 1 and remain valid for pilot 3 off-line (section 3.1.1. Generic requirements and section 3.3.1 Interactive VR experience and portal concept). The tablet has specific tactile features: swipe, drag, roll and pinch. To give relevance to each device, the content creator shall take into account that these devices have specific content requirements and added-value features.

For example, the subjective perspective that comes with the HMD experience can be used to give the viewer a more active role in the story. No longer is the viewer only a bystander, they can become one of the police officers in a murder mystery, exploring the scene. Subjectivity will enhance the amount of immersion into the story.

Genre-specific elements carefully mapped over the different devices can optimize the added value in terms of storytelling. For a whodunnit script, the tablet can for example be used as a notebook where different elements (objects, statements of suspects) can be investigated, collected and reviewed.

Requirement R.2.3.5 – The content creator can create break-out segments from the main (tv) storyline where the viewer can enter exploration mode on the HMD and tablet.

In R.2.3.3 the television is stated as the main device and the HMD and tablet are second screens. The main storyline is told on the tv screen and extra content is given on the other devices (R.2.3.4). The concept of ‘breaking out’ of the main storyline is introduced in R.2.3.1. This requirement puts extra focus on this specific element of exploration mode inside the Immersiatv concept. Different to broadcast mode, the story is interrupted, the main storyline pauses to break out to other scenes on other devices. Exploration mode can only be implemented by taking into account the full concept of ‘interruption’ and ‘break out’ scenes from the start.

The content creator has to create these ‘break out’ moments already on the level of script development, cutting up an existing linear script will not work as it is not designed specifically for exploration mode.

Requirement R.2.3.6 – The content creator shall take care that switching to exploration mode is properly signalled to the viewer by the TV content.

While exploration mode seems more open than broadcast mode, it is still well defined and scripted. The viewer has no lead, each ‘break out’ moment is structured in time and has a specific role in the whole of the story, in other words, it is there for a reason. The viewer is not part of an open world where they can freely explore by preference of device or by chosen scenes. The content creator leads the viewer to each ‘break out’ and therefore to each device. As the tv is the main device, the tv content has the lead, it has to be clear to the viewer when an interruption takes place and a ‘break out’ towards other devices is presented.

There are different ways to raise attention to the viewer, in best practices it would be the tv content steering towards a ‘break out’, supported by a graphical symbol acknowledging the

switching of devices, e.g. the police detective looks into the camera and invites the viewers to join him or her to the murder scene, a symbol of an HMD appears in the corner of the tv screen, indicating that a 'break out' to the HMD is occurring.

Requirement R.2.3.7 – The content creator shall carefully consider the application of break-out exploration mode segments in terms of frequency and timing.

Following up on R.2.3.3 and R.2.3.5, where it is stated that the television is the head device portraying the main storyline and that the content maker accomplishes 'break outs', professional users point out that the content creator should handle with care the frequency and timing of these interruptions, so they don't disturb the main overall story. Interrupting the storyline should follow a rhythm, feeling natural to the viewer. Each 'break out' should have a function and only be put in place if it delivers an added value to the story and to the end user experience. The well-known "Kill your darlings" phrase is also here very appropriate, the main arc of the story is more important than the possible attractive break out scenes.

Lenz - "The viewers are used to have the content presented to them, exploring related content on HMD can only work in some cases, and on particular moments, not in the full movie."

Requirement R.2.3.8 – The content creator shall take care that the storyline on the main device (tv) is paused when exploration mode is activated.

Exploration mode is activated when a 'break out' from the main storyline is accomplished. The viewer should have some freedom with respect to how long they stay in exploration mode, the main storyline on the head device (television) will continue after the viewer decides to exit exploration mode. By all means the lead device (tv) should be paused as the timeframe of exploration mode is not pre-defined, but depends on the time spent by the end user before they decide to switch back to the main storyline.

There are different options proposed during the workshops on what content is shown on the television while it is paused. An actual freeze frame or a graphical symbol could signal the 'pause' state. As an alternative, the social engagement of the end viewers in group could be raised by showing a 'mirror' view or a 'point of view' of (one of) the HMD(s) on the television. In the latter case, interaction will be stimulated as the end user viewing the HMD content will be guided by the other viewers following his 'point of view' on the television.

Requirement R.2.3.9 – The content creator should not mix "broadcast mode" and "exploration mode" storytelling for the same story.

Exploration mode and broadcast mode each have distinguishing characteristics, the content is different on the devices: where 'broadcast mode' shows the same subject or event at the same time and location on the different devices, 'exploration mode' shows different scenes in a storyline over multiple devices, each scene has a different subject, time and location.

It is advisable to not mix both modes as the set up at the beginning of a story should be clear to the end user. Each device has its purpose, switching the functions of a device during a story will break the user experience and also lead to confusion.

Showing the point of view of the HMD on the television as mentioned in R.2.3.8 is not broadcast mode, as it shows a different scene in time/location/subject as the previous scene on the television. The television content is not in lead here, its purpose is to enhance the social engagement of all the users while the television is paused.

Requirement R.2.3.10 – The content creator shall only apply user interaction with the story when exploration mode is activated.

When the television is telling the arc of the story as the main device, the secondary devices will not be active during the scenes shown on the television. The focus of all viewers should be on the main storyline, not missing out on important details given by the content creator.

On the other hand, missing out on information on the secondary devices is part of the gamification in exploration mode and will add extra experience to the end user.

Interactions can be implemented based on the concept of interactive portals, the viewer in the HMD can choose which portals they activate (enters), branched storylines can give complementary content and makes the final viewing experience different for each end user choosing different options.

Requirement R.2.3.11 – The content creator shall consider interactions between HMD and tablet when exploration mode is activated. Preferably, only one device should be the lead device that triggers events on the other device.

Depending on the use case and content, it is preferable in exploration mode to put one device (HMD) in the lead to activate content on the other device (tablet). For example in case of a whodunnit scene, in the HMD the viewer explores a murder scene, objects recognised and highlighted will appear on the tablet. The HMD fits the activity of exploring, the tablet is more suitable as a handy device to store and explore information (notebook).

Requirement R.2.3.12 – The content creator should consider to provide the viewer with the option to return back from exploration mode to the main storyline (TV).

In theory, exploration mode can come without strict timing boundaries. Good practice includes the possibility of returning to the main storyline at given points in time or when the viewer chooses to, taking into account that the story experience is still preserved.

Requirement R.2.3.13 – The content creator should consider the application of branched storytelling in exploration mode. When applied, it should be limited to one device, preferably the HMD.

By preference, the choices made by the viewer should have no impact on how the story continues in other devices.

Giving the viewer different options in exploring the story can enhance the experience. This can be done in exploration mode as the main storyline is the arc of the story and cannot be touched (R.2.3.5). “Branched storytelling” implicates a complex structure of different (sub-)storylines. Within the ImmersiaTV multi-device set-up it is advisable to keep the multi-track storytelling in the HMD, the end user can e.g. select how a suspect should be interrogated (. By preference, the choices made by the viewer should have no impact on how the story evolves as a whole.

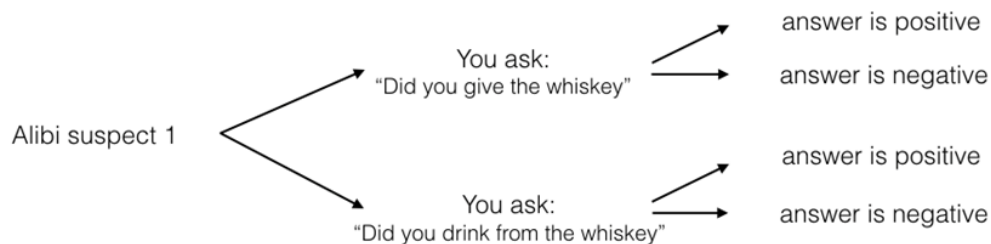


Figure 8 - Example of branched storytelling in exploration mode (whodunnit)

Requirement R.2.3.14 – The content creator should take into account social viewing aspects, but also cater for single viewer experiences at the same time.

In general the ImmersiaTV concept starts from the television social viewing experience, on this aspect broadcast mode and exploration mode are similar. Multiple users can interact during the whole experience as the tv is the main device and the tablet and HMD both give room for interaction between end users.

A single viewer in (multi-device) broadcast mode has more or less a similar experience as a single viewer watching only the television, the devices are added value. In exploration mode however this is not the case as different scenes are mapped out over multi devices each giving specific and relevant information about the story. E.g. Objects activated in the HMD, appear on the tablet. A single user must have the ability to investigate these objects on the tablet after they exit the HMD scene before going back to the main storyline on the television.

Requirement R.2.3.15 – The content creator should take care that interactions between HMD and tablet during exploration mode trigger the viewers to interact with each other on the content.

Content activated in the HMD and appearing on the tablet must give valuable input to the story. This input should trigger the viewers, surprise them and give them clues, pushing the viewers in certain directions whether they are right or wrong. Good storytelling is key here with extra care for structure and giving away of information. The more the story sticks to the viewers, the more they will interact on the content.

EXPLORATION MODE USE CASE

With respect to interesting use cases to apply the concept of exploration mode, **fiction** has been identified and selected as a particular interesting case. In deliverable D2.3, a scenario will be elaborated for a whodunnit (detective story). The creative workflow requirements related to the exploration mode content scenario are documented in Section 6 and are mainly based on a whodunnit fiction programme. However these requirements are also applicable in other use cases, such as documentaries based on exploration mode.

3.5. Examples

This section presents some of the different content formats created by professional users during the workshops. Since each user started from their own expertise domain not only documentaries, but also fiction and kids formats are proposed.

3.5.1. Off-line VR formats

Documentary format

- Summary: Documentary journalists working in the Middle East imagined the format “In the footsteps of a refugee”, in which they want to present the user a realistic image of the circumstances and difficult decisions a refugee family encounters on their route to Europe. For example, from Aleppo to Great Britain.
- User experience:
 - They don’t want to make everything in VR, due to timing issues but also because not everything is interesting enough to see in 360° view. Since the professional users didn’t believe end-users would put the headset on and off, they decided to also show the remaining 2D material as a cropped image in the headset (the remainder filled up with black background). F.e. climbing in a container is filmed in 2D, view in container is recorded in 360.
 - To guide the user they would use:

- Music & voice-over
 - Interactive elements like a map, ...
- Added value: Using VR for this type of format has multiple advantages:
 - o Exclusive location can be shown without suggestive director decisions.
 - o The user has the feeling of being one of them, which can generate more empathy than a usual 2D documentary.
- Interactions and portals can be introduced to the user so:
 - o They can decide when they want to proceed to the next screen (i.e. when they are looking around in a location)
 - o Showing an extra information layer
 - o Making it possible to view archive material.
 - o Other options that were put forward in a similar docu format: they can decide which route they want to follow (f.e. the bureaucratic route or the illegal route)
→ without making it a game.

Kids format

- Summary: Children have a wild imagination, which makes them an ideal target for VR content. Creators of Ketnet, the kids channel in Flanders, suggested a game that can be played after their broadcast time as a way to end the Ketnet evening. In this game, the users get stuck in the Ketnet studio where they have to run through a trail. During their run they come across checkpoints where they have to fulfill a task to go further. This task can be filled in on different ways: a quiz, searching something, doing something,... Doing it correctly will lead them closer to the finish, but if the task fails they'll be sent to a dead end and will lose time. The goal of the game: getting outside as quick as possible.
- User experience:
 - o To stimulate kids wrappers, the hosts of Ketnet, can tease them during the evening. The game itself is planned after broadcasting as a way to end the Ketnet evening.
 - o Playing it in teams can make it a more social experience.
 - o The advantage of using VR is that although everything (also an unrealistic situation) is possible, it will still feel like real life. For example, by opening a door in the studio at one checkpoint you can change your location to the jungle, ...
 - o Educational elements can be inserted to make learning more fun. Also by seeing it in almost real life, children are more likely to remember it.
- Interactions or portals
 - o Every checkpoint is a portal that can lead to a new room.
 - o Interaction is foreseen during the tasks. Answering a question by yes or no can be done by turning their head to the left or right, but also more complicated interactions are possible.

Lifestyle format

- Summary: Lifestyle programs on TV are almost always focussed on women. With the format "on the road" the creators wanted to offer something for men too. In this VR only format users are projected into the world of an online identity, from the minute they get up until they go to sleep. During the day different topics, from which the user can make a selection, pop up. For example, while going to the bathroom the user can decide if he wants to know more about fashion or technology. By registering what the user chooses a more personalized program can be set up in a later stadium.
- User experience:
 - o People marked that this concept feels a lot like Instagram but then alive.
 - o This program is made only for VR, so no TV derivative is made.

- The user can choose the duration of the program by their selection of topics they want to hear about.
- The creators wanted to make the online identity an unknown mysterious person for which each user can imagine his appearance on their own. Other people thought they would choose to look at the format based on this online personality, or in other words, they would like to know who he was to make it more reliable and personal advice (I am a fan of this man so I want to see what he does and what he likes).
- Interaction and portals:
 - During the episode, you can choose between the topics of that day.

Fiction format

- Summary: For fiction, an experience can be created by filming in first person, so users get the feeling they are one of the characters. An example where this can be interesting is an episode with a kidnapping scene. Users can then experience the situation in the role of the kidnapped character. Other characters can look them in the eyes, yell,... which makes it very confronting. In addition, the creators can pass on the thoughts of the character using a voice-over.
In a similar situation new characters can be introduced through their eyes in a way the user can get to know the character step by step: is it a man or a woman? How does he know the other characters? ...
- User experience:
 - User can choose if they want to watch VR content during the episode (in sync with television), or afterwards.
- Multi-device experience:
 - During the episode an alert can be shown on screen to let the user know synchronized VR content is available in the headset.

Music format

- Summary: In this format, users can get an exclusive view behind the scenes of a festival or music program (f.e. The Music Industry Awards or the preparations of Eurosong in Flanders). They can walk around backstage and see the different artists in the artist village. When they come across one of them, they can interact and for example choose to follow them from first person perspective. From this view they can see their band just before they're entering the stage, the performance on stage,...
- User experience:
 - By getting backstage the user can have entrance to exclusive location.
 - They can also see a concert from different and more unique viewing points, for example front row or through the eyes of the artist itself. Recordings of this last one can also bring karaoke to the next level.
- Interaction and portals:
 - Walking by one of the artists backstage different interactions are possible:
 - Seeing the concert through the eyes of the artist (or at well-chosen locations): from the preparations in his lodge until the interviews after the concert.
 - Going to a Spotify list of the artist (with their songs or songs they selected as a curator).
 - Starting karaoke with the festival crowd as the audience.

What we noticed is that the examples created by the professionals are more or less in line with the formats developed by the end-users (see D2.1.)

The main differences we see in the professional formats versus the end-user formats:

- While the end-user formats all relate to TV as the main screen, in the professional VR formats also full VR experiences (not linked to a TV program) were developed. This is also linked to the specific assignment, which was more open in the professional workshop than in the end-user workshop.
- In the examples of the end-user, they do see themselves putting on and off the HMD for up to 3 or 4 times during a program. The professional users expect that users would not be willing to do so, so they also did not integrate this very often in their formats.
- The gaming aspect is present in some of the professional examples, while this is only limited to the end-user examples (only as a kind of quiz question as part of a program in order to win something, not as an actual content element of a program). In the end-user examples, there is no real gaming aspect in which people could explore different paths with a different end-result in the VR content.
- While in the end-user workshops a lot of attention was paid to how people would consume these examples in a social setting (in real-life or virtual), this was not that present in the professional examples. Here the viewer seems to be more considered as an individual consuming the content on his own.

3.5.2. Live event formats

In this section, we work out and elaborate on two concrete live formats, a sports event (cyclo cross) and a music show (Eurovision song festival). These formats came out of the targeted interviews with the professional users as two of the most interesting use cases for 360 live video creation, and apply to both live pilot 2 and 3.

Cyclocross

In December 2015 the cyclocross of Overijse was captured in 360 video offline⁸, as a first test developed at VRT together with external production company Fisheye⁹. We incorporated the findings from this first PoC and the feedback from the professional users. A cyclocross is a closed circuit race where for one hour cyclists ride laps on difficult terrain. The audience is standing alongside the track, cheering its favourite contenders. The race has different phases. Before the start of the race, all cyclists are preparing for the race and the main contenders are being interviewed. This is broadcasted live. Secondly, there is the start of the race with all cyclists going full force to have the best position before going into the field. Then there is the race itself with different laps during one hour. Eventually, there is the finish of the winner, followed by the arrival of all the other competitors. Immediately after the race there is the celebration of the three best cyclists on stage, again with interviews. One of the typical character traits of cyclocross is the huge fanbase, with lots of noisy crowds all spread over the circuit.



Figure 9: Example of hazardous circuit and large crowd at a cyclocross race

The camera positions have to be set strategically, taking into account the following parameters:

- the race consists of recurring laps
- there are hazardous situations on different locations on the circuit
- there are different phases: pre-start, start, race, finish, winner celebration and interviews

⁸ <https://www.youtube.com/watch?v=egS9WIKxCxM>

⁹ <http://fisheyevr.eu/projecten>

- extra elements next to the race that are interesting for home viewers: big loud crowds, celebrations, a peek in the production car or commentator cabin, ... Being able to feel part of the atmosphere at the event via VR can be attractive for many viewers at home.



Figure 10: Interactive HMD experience for cyclocross with map insert (top) and head of race portal insert (bottom)

Taking into account the findings of the first (off-line) PoC and translating these insights into a live scenario, a mockup user interface can be made that shows the different features as mentioned in R2.2.1, R2.2.5 and R2.2.6 (see Figure 10).

Mock-up interface explanation

Camera icons under

The viewer can choose which camera they wish to activate, at this moment we see the active camera 3, lit up in red. The camera is set up at a hazardous situation: the stairs. It is placed at 'the best seat in the house', there is no better place to see the performance of the cyclists climbing the hill. Optionally the director can light up other icons in other colours to mark important actions happening at that camera.

Director's choice icon

There is the option to follow the director's choice, which means that the viewer leaves the intercutting between cameras in the hands of the director, who follows the action in the race and normally has the best overview of the race situation at any point in time. The director's viewpoint can, for instance, be the head of the race or an interesting activity happening on or around the track.

Drone icon

Optionally a drone shot can give a scenery overview, additional to the map overview.

Map upper right corner

To have an idea of the track or the venue, a map is added. The map gives an overview of where the cameras are placed. Especially in a race like cyclocross where the cyclists do different laps, it is a very useful tool to follow the upcoming hazardous places on the field at any point in time. The map view is interchangeable with the live feed from the 2D TV. By 'gazing' to the blue arrows, the map switches to the TV feed. Remark that any of the TV cameras can serve as TV feed, not only the directed output signal.

Live 2D TV view

A live feed of the 2d TV. At any moment the head of the race can be followed, so the viewer can stay longer in one omnidirectional camera viewpoint and choose to jump to another camera when the head of the race is close by. In general at all moments it is possible for the viewer to follow the head of the race. There is also an option to clear the interface removing the map and live feed so that the viewer can create and direct their own story. Because we have a 360° view, the mock-up can be misleading, the different features can be placed on areas in the 360° degree spectrum left or right where less important actions take place, leaving the most important field of view open.

Eurovision song contest

The Eurovision song contest is one of the biggest music shows in the world. Each year, all European countries appoint one singer or music band to represent their country and to compete in the main event, organised by the country of the last winner. The best song is chosen based on a voting system taking into account the public's choice and the appreciation of a professional jury. The set-up is well known, next to the stage where the artists perform, there is an area called

“green room” where each country has an artist-table where they follow the show and the dividing of the points at the end of the show.

As stated in requirement R.2.2.1, the camera set-up has to be put in several places that might be interesting to the viewer, to give them a genuine immersive experience of the event:

- the best seat in the house to see the show, close to the stage
- around the artists tables, covering enough tables so each viewer can follow his favourite country
- different other options: on stage from the artists PoV, backstage to have a ‘behind the scenes’ look, TV commentator’s PoV, ..

A mock-up interface gives a clear view of how these features may work in an HMD viewing experience.

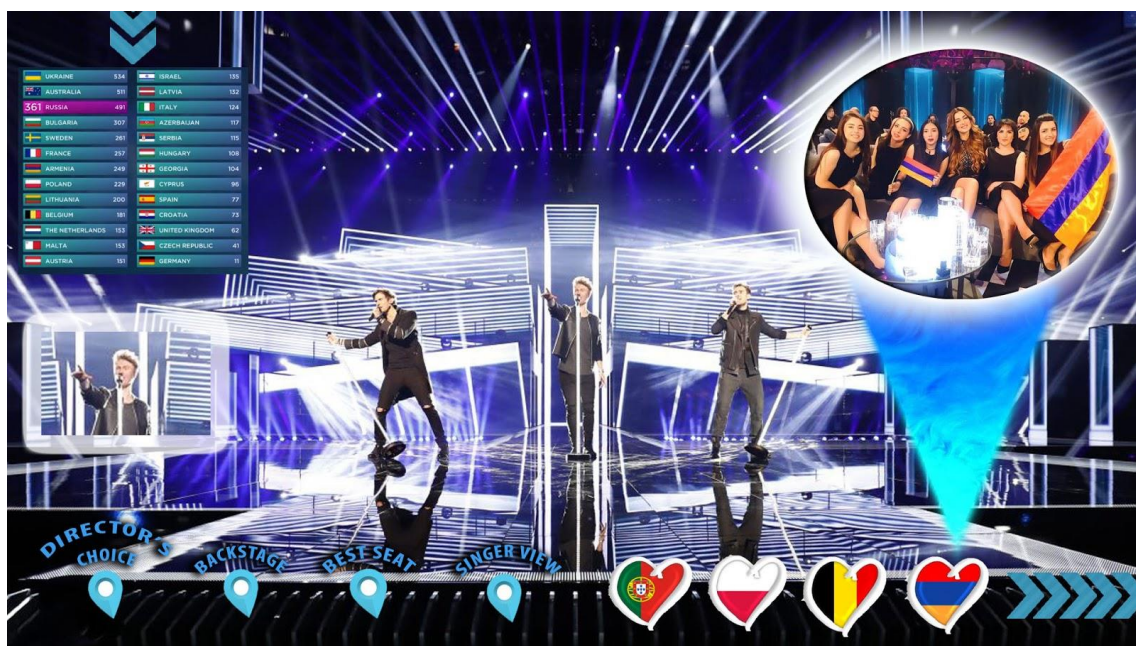


Figure 11: Interactive HMD experience of the Eurovision song contest

Country icons

A typical element during the Eurovision song contest is the intercutting between the live stage show and the artists’ tables. The audience is diverse: people in each European country support their artist. In the interface, the viewer can choose which artist table from which country they want to follow, potentially switching between different tables.

Pin Icons

In contrast to cyclocross, the specific order of camera viewpoints in the HMD experience is less important as the viewer is not watching a race with contenders moving from camera to camera. In the Eurovision use case, the HMD viewer can create their own story, watching the show in the best seat in the house, from the artists PoV, have a look backstage or step into the hectic world of the TV director. The fear of missing out on important events during the contest is expected to be considerably lower than for cyclocross.

Graphical elements in the interface (also useful as second screen content)

A graphical table showing the marks of each act can be added in the HMD view, so viewers can keep track of the contest, follows the points given to each country and see which countries are leading. Presenting this information on a second screen device such as a tablet would also provide added value to the multi-device experience.

Live 2D TV view

A live feed of the 2D TV stream that gives the viewer the option to always keep track of what's happening on the television screen.

The graphical elements and the live feed can be placed in the full 360-degree scene composition of the HMD viewer and there is the option to switch them off or flip them back into the view.

4. CREATIVE WORKFLOW REQUIREMENTS - DOCUMENTARY

In this section, we will focus on the specific requirements for a 360° content production workflow. From the user workshops, the first set of professional requirements for VR production in ImmersiaTV has been gathered. These requirements are documented and structured according to the different steps in the production and publication flow:

- Preproduction
- Capturing/production
- Post-production
- Publication

The creative workflow requirements will be gradually refined by insights gained in the iterative testing in the content ideation phase (see deliverable D2.3).

4.1. Preproduction

One of the main guiding principles for VR content production, which was confirmed in the professional user workshop brainstorms, is the need to start thinking from post-production (and work backwards). Essentially this means that:

- 1 - The story has to be prepared carefully in terms of storytelling experience and applied VR concepts and interactivity ("create the 360 world for your VR story").
- 2 - The shooting has to be prepared carefully
- 3 - A 360-aware shot list/storyboard and call sheet is developed

1 - Prepare the story:

- Define the role of the viewer in the VR experience: are they spectator, personage/first person, ghost/character, impact/no impact, will they discover who they are,...
- Carefully consider the use of 360° versus regular shot taking into account relevance and added value.
- Use of 360° establishment shots, choose the locations carefully.
- Stereoscopic content: consider the added value.
- Application of interactivity patterns.
- Take into account that e.g. guiding user through a "refugee camp" VR story requires lots of hard scripting.

2 - Prepare the shooting:

- Estimate feasibility of capturing VR versus directional video, e.g. based on available time to shoot a specific action.
- Prepare to filter out the 360° camera in postproduction: think about where you want to place the camera (ground underneath, reflections, shadow).
- Traditional documentary production (e.g. the Syrian war) is typically based on filming around interesting things that happen on the spot, based on which a good story is created afterwards in (post-) production. VR production brings about a higher complexity; everything is shot in one moment and almost requires pre-capturing scripting and try-outs.
- Decor: find good decors where no manipulation in post-production is needed.
- Choice of cameras highly depend on the content or scene that has to be captured; e.g. GoPro rig with 3 versus 7 cameras
 - 3 GoPros: stitching is easier (better for motion)
 - 7 GoPros: better resolution, but stitching is harder.
- Use of spatial audio: spatial audio can make a real difference in creating the feeling of presence, but effort versus expected added value in terms of storytelling should be taken into account.
- Anticipate that some people do not want to be part of the content

3 - 360° scenario/shot list & call sheet

- Concept of story beats: story beats can be defined as chapters or important actions in your story. Similar as for traditional TV production, these story beats form the beating heart of the VR storytelling experience, and have to be carefully prepared and the beats have to be spread carefully throughout the program format.
- On-location research: current practices include preparation of the different scenes (beats) on paper or e.g. using Google Sphere-based VR picture, Google Streetview. Given the complexity and multiple parameters to consider while preparing an interactive VR docu, the need for 360° video based material in this pre-production phase can be anticipated, e.g. use of low-end VR camera (e.g. Ricoh Theta).
- Visual documentation of “story beats” in a shot list/call sheet: ideally this would include video-based and/or “animatic”-like tooling to prepare shooting in order to have an impression in advance:
 - Professional user can indicate viewing angle (per shot), storyboard, interactions, camera positions, audio, ...
 - Possibility to have a first impression and validation of the interactive VR experience, even before the shooting.
 - Director and production designer get a more clear vision of the VR world before going on set which allow them to better plan lightning, camera and microphones positions and hiding crew.

In summary, we can identify the following preproduction requirements:

Requirement R.2.1.14 – The content creator shall have tools for pre-production, to define the VR world and content format and to enable more complex and interactive 360° scripting possibilities

There is a need for pre-production tooling that helps content professionals in their production preparation process and to cope with more complex scenarios that come with VR production. These tools should guide and stimulate them to start “thinking from post production” and help them define and elaborate more complex 360 scripting taking into account the format requirements defined in Section 3.

Requirement R.2.1.15 – The content creator shall be able to previsualise the 360° world of the story based on rough 360° video footage of the location

Previsualisation of this 360° world of the story based on rough 360° video of the location would help content creators to better prepare the subsequent production steps (capturing and post production).

To refine and elaborate on this and derive more specific tooling requirements, further in-depth interviews with VR production experts and, more importantly, insights gained from iterative testing are required.

4.2. Production

As mentioned before, capturing omnidirectional content is fundamentally different from capturing directional content. The main differences are:

- Capture crew should be careful not to appear in the captured content, except if there is a purpose for their presence in the story. It is, therefore, difficult or sometimes impossible to know if a take is successful or not.
- In contrast with directional video where multiple independent takes can together form one scene; omnidirectional content typically consists of multiple actions and/or points of interests that have to be captured simultaneously in one shot. This also brings about an increased need for pre-shooting try-outs and good scripting/preparation of the planned actions.

The following production requirements for capturing have been identified:

Requirement R.2.1.16 – The content creator shall be able to have an on-location live preview in VR of the camera view (before the actual shooting takes place) and captured content, including omnidirectional video and audio preview on the set

Requirement R.2.1.17 – The content creator shall be able to have an on-location live replay in VR of captured content, and resulting format experience

This also refers to the ability to evaluate the feeling of presence and immersion effect of the captured content. This includes both omnidirectional video and audio preview on the set, to verify if the shot “feels” good. In current practice, this is typically based on the opinion of actors, or with the help of a hidden camera in the background. On-location preview in VR is expected to significantly improve the final quality.

Requirement R.2.1.18 – The content creator shall be able to automatically label and sort captured shots

Requirement R.2.1.19 - The content creator shall be able to fast ingest (after capturing) or to stream (before capturing) the captured shots, in order to enable instant preview

E.g. playing out captured shots along with shots captured during the research phase.

Requirement R.2.1.20 - The content creator shall be able to use live VR preview tooling that integrates with the VR storyboard (preproduction phase)

E.g. adjust viewing angle, insertion of portals, adding AR objects,...

Requirement R.2.1.21 – The content creator shall be able to use similar functionalities for live preview as for the VR storyboard tooling in preproduction.

Requirement R.2.1.22 – The content creator shall be able to use an intuitive dashboard indicating the status of the used cameras in shooting

E.g. battery level, memory cards, settings camera and remote control of cameras.

Requirement R.2.1.23 – The content creator shall be able to use specific 360 video camera equipment with requirements including high mobility, weight, robustness, rainproof, mud-proof, stability.

4.3. Post-production

At present, the burden of post-production is one of the main bottlenecks and concerns with regard to VR content creation. Especially in more complex scenarios, such as targeted in ImmersiaTV, there is a strong need to simplify post production flows for stitching, editing, interaction design, transitions between VR scenes, ... To some extent, this is expected to be solved by the market evolution, e.g. more automated stitching solutions based on integrated multi-cam VR capturing solutions.

Requirement R.2.1.24 – The content creator shall be able to use tooling that provides better integration of the process of rough stitching, editing and final stitching in the production chain

A particular requirement, based on current stitching and editing experiences, is to better integrate the process of rough stitch, editing and final stitch production chain. The most important requirement here is that the production tools, used in ImmersiaTV, should allow taking into account project metadata and editing decisions and exchange this metadata between the different steps in order to avoid double work. E.g. adjusting in- and out-points in the final stitching process (VideoStitch), based on EDL metadata of the editing tool (Adobe Premiere), taking into account stitching calibrations of earlier frames (manual stitch improvement in PTGui).

As creative people currently lacks the experience of producing content formats the ImmersiaTV project is aiming at, there are no more specific or detailed user requirements that have emerged directly from the user workshops. These professionals first need to start working with these tools in order to be able to give more specific requirements.

However, a first version of post-production requirements can be derived indirectly from the identified creative format requirements (Section 4), and the technical findings of an internal ImmersiaTV workshop at the LightBox premises in which the partners (VRT, Lightbox, PSNC, VideoStitch, Cinegy, i2CAT) investigated possible workflows to achieve these creative goals in a first Proof of Concept. This first test and the resulting findings are described in section 7.1, and detailed specifications for post-production tooling are documented in detail in Deliverable 2.3. The identified requirements from the practical workshop in Porto are:

Requirement R.2.1.25 – The content creator shall be able to use a more simplified post production workflow that minimizes the required manual steps and used tools. This includes:

- **2.1.25.1: Stitching**
- **2.1.25.2: Editing and compositing for 360 scenarios**
- **2.1.25.3: Adding interactivity and portals**
- **2.1.25.4: Synchronous multi-platform content (tv, HMD, tablet)**

The main purpose is to automate and simplify as much as possible the necessary post-production steps (stitching, editing, compositing, adding interactivity, defining multi-platform content synchronisation,...), while maximizing creative means and flexibility for the content professional.

Requirement R.2.1.26 – The content creator shall be able to use preview capabilities in post-production, including HMD and ImmersiaTV Player output viewing.

Requirement R.2.1.27 - The content creator shall be able to export to different platforms in an automated way

4.4. Publication

In accordance with the expressed concerns of (off-line) synchronized multi-device content experiences, specific user requirements with regard to publication scenarios for synchronized multi-platform delivery have not emerged from these first two workshops.

For publication of VR content in general, the consensus is that current publication options are very limited and also require a bit too much effort from the end user, albeit just a couple of manual steps.

Requirement R.2.1.28 - The content creator shall be able to use tooling for better findability and searchability of own produced VR content

Findability and searchability of own produced VR content, provided by a user-friendly VR app that gives access to a library of available own VR content being produced by a broadcaster, is recognized as one of the main requirements to increase visibility and user awareness and to better reach the audience. Apps could be developed and published on the Google Play and Apple App Store for Cardboard-like HMD's, and the Oculus Store on Gear VR. This would allow us to offer a centralised experience for all of our productions, while keeping the publishing power in our hands. It also diversifies our productions from productions on the traditional YouTube, Littlestar & VRideo channels. If such a platform would be shared between broadcasters, e.g. in an EBU context, its added value would further increase. The app would need to be user-friendly to stimulate returning visits, and a notification system would need to be included to warn the users of new productions that are available.

Requirement R.2.1.29 - The content creator shall be able to use a custom developed play-out solution that supports interactivity and synchronisation scenarios.

For the interactivity and synchronisation aimed for in ImmersiaTV a custom developed solution is needed since none of the existing 360° content players support these kinds of functionalities.

4.5. Integration with classic production workflows

In general, simultaneous and orchestrated production of omnidirectional and TV content is not straightforward. Merging these different types of content is a challenge in each step of the production workflow. However, we need to find ways to avoid completely separated and double effort production workflows and to find interesting and efficient synergies. How to integrate classic TV production and novel VR production is a major challenge to tackle, and should be taken into account and contemplated in further testing scenarios in ImmersiaTV. Potential synergies include:

- Synchronized play-out experiences to TV and HMD (see D2.3 specifications with regard to ImmersiaTV Player).
- “Second screen”-type of VR-based extensions before, after and in between TV programs, during breaks, ...
- Smart metadata annotation that allows interlinking of related TV and omnidirectional content, such that it can be packaged together in content offerings to the consumer or allow for new content creation.
- Reuse of omnidirectional video for regular TV production.
- Reuse of TV or archive content in omnidirectional content formats.
- Joint pre-production efforts such as on-location research and integrated call sheets.

Specific requirements will be added in the course of project based on gathered content ideation insights.

5. CREATIVE WORKFLOW REQUIREMENTS - LIVE VR PRODUCTION

In this section, we will focus on the specific creative requirements for a 360 live production workflow. These requirements are documented and structured according to the different steps in the production and publication flow:

- preparing the live-production
- live production
- publication

The focus is on the live production, however, in concrete cases it is possible to add a post-production step similar to an offline production as explained in Section 4.3. The VR live production pipeline is very similar to the standard live TV production. It runs parallel phases, from pre-production to publication. There are some special creative inputs needed at a certain stage, as pointed out in following steps.

For clarity reasons, we will describe the live pilot 2 and 3 requirements, based on the same use case of a cyclocross event in this section.

5.1. Preparing a live production

At this stage, the director gets a clear view of the event that takes place, checking the location and building possible storylines.

Location visit

Parallel to the live 2D TV pre-production phase, about one month before the actual event day, the director and the head technician visit the venue to check possible camera set-ups and possible technical or creative obstacles to tackle.

In the case of the cyclocross or any sports event with a local circuit or event stadium, a map is configured where the best and interesting points are located around the track, taking into account the requirements summed up in R.3.1, giving the viewer 'the best seat in the house' experience.

In the case of a music event, based on a 3D model made by the set designer, an almost accurate representation of the different camera shots can be generated, if preferred even animated in 3D modelling software.

Creating 360 scenes and storylines

The 360 video director defines their ideal camera setup, determined by these inputs, they tell the story of the live event on the production day. Storylines obviously differ, according to the kind of event (sport/music) that is captured. For example in the case of the Eurovision song contest, there is a table set up in the venue (green room), housing the performers following the show, but this is not the case in every music show. So the director has to take extra care, since this is an additional storyline next to covering the main stage performance. In the case of cyclocross, after the race, the winners are prepared to go on stage and being interviewed. This takes place in a separate area out of the view of the spectators. It could be interesting to put a camera inside this area, to give a behind the scenes experience. Again, not all sports events have the possibility to reveal this extra behind the scenes content.

Once the director has a clear view of the camera setup he will preconfigure 360 scene composition(s) for the specific live event interactions. The scene composition defines the different composing elements (video, portals, icons, graphical info) of the HMD experience, the interaction points, and possibly the interaction patterns between different 360 scenes. Different

360 scenes can be defined for different moments or phases during the event (e.g. before, during and after the race).

Requirement R.2.2.13: the content creator (director) shall be able to preconfigure scene compositions for the HMD experiences, (ideally) starting from existing templates.

An additional requirement for live pilot 3 is:

Requirement R.2.2.14: the content creator (director) shall be able to position the cameras in the preconfigured 360° scene, mimicking the real world coordinates.

As illustrated in Figure 12, portals to the different camera views can be defined in the 360° scene configuration, based on the anticipated coordinates of the camera.

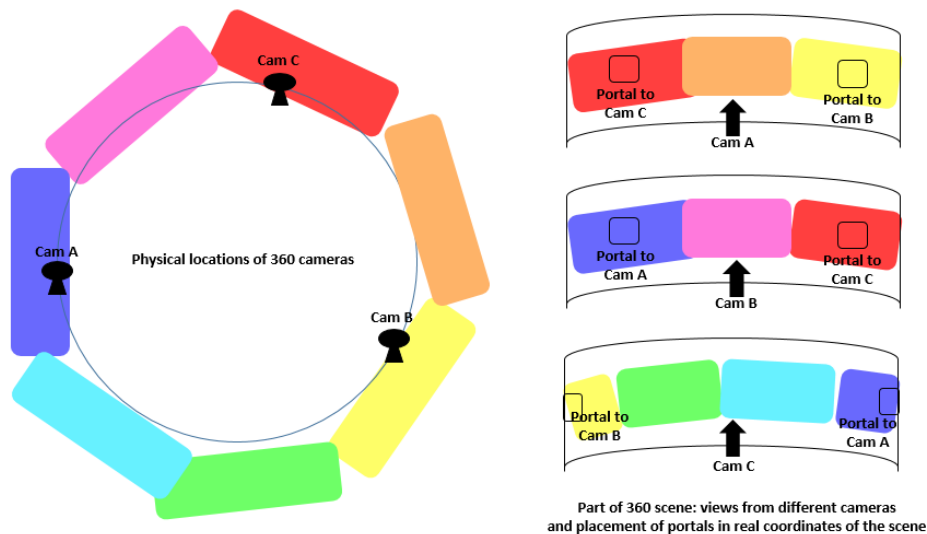


Figure 12 - Positioning of portals representing real camera coordinates in the 360° scene.

5.2. Production

The production phase usually starts the days before the event, in some cases the day of the live broadcast itself. Two components stand out:

- testing the live experience
- live production

In current productions, it is already possible to use 360 cameras that can autostitch and have live preview functionality.

Requirement R.2.2.15: the content creator (director) can use cameras with autostitch and live preview ability.

On field camera testing

When the technical set-up is in place, all the equipment is tested. Besides the working functionality, the director tests if the camera configuration serves the storylines they had in mind.

Requirement R.2.2.16 - The content creator (director) must have a clear view of all incoming sources.

This requirement applies to before the race, as well as during rehearsal of non-broadcasted races and live production context.

An assistant in the field adjusts the cameras, while being in contact with the director in the control car, who has a live preview on screen and in the HMD. Syncing of the different cameras can be done with a digital clapperboard with timecoding, especially working with different types of cameras. Camera signals have to be delayed with the needed time delta such that all cameras are in sync.

Requirement R.2.2.17 - The content creator (director) must have the ability to measure the different camera delays and synchronize between the different 360 video cameras.

The HMD already has the scene templates installed and linked with different cameras. The director checks all the specs, bearing in mind the kind of experience the viewer should encounter for that specific place in the field. Height and positional place of the camera are key here.

After all cameras are setup and configured to the director's satisfaction, the director can do a full rundown, similar to the one executed during the live broadcast. This rundown will be done by live tooling equipment. The director checks the interactive features in the HMD:

- activation of different viewpoints
- trying out predefined transitions
- switching on and off the 2D live feed
- interaction with the circuit map

Technical check-ups like testing the live synchronisation between the different omnidirectional and directive cameras, and audio mix between the 360 environment and the live commentating can be done here as well.

Requirement R.2.2.18 - The content creator (director) can perform a live preview of the interactive HMD experience.

Live production

The director is active with the live broadcast tooling, feeding the 'director's choice' output.

In some cases as mentioned before, the director can activate different templates for the HMD, if the activities in the field differ in the course of time.

For example the different stages during a cyclocross event: start, race, after race activities. The director loads a new template after the winner is known and no riders are left in the field. The point of attention now goes to the behind the scenes look and the celebration on stage. The 360 live tooling is built up by the following requirements.

Finally, the director can also define the second screen experience, e.g. a mosaic of available omnidirectional and directive streams with basic interaction features.

Requirement R.2.2.19: the content creator (director) can select, initiate and change scene compositions for the HMD interface: removing icons, change camera source,...

Requirement R.2.2.20: the content creator (director) can make cuts or transitions between different sources, both directive and omnidirectional streams.

Requirement R.2.2.21: the content creator (director) can see a live preview of 360 scenes before putting an updated version on air.

An additional requirement of live pilot 3 refers to the ability to edit and add replays of live content as part of the immersive experience. Furthermore, he should be able to “mimic” user interactions from the director’s tool, and likewise have the ability to show HMD content on the television e.g. to emphasize specific events happening in the HMD view. Contrary to pilot 2, where interesting viewpoints are always pushed to the viewer, the director should be able to just highlight an interesting camera viewpoint leaving the viewer the choice to select it. Moreover, the director should also be able to adjust the positioning of the cameras as portals within the interactive 360° scene, based on the actual real world coordinates of the camera, already listed as Requirement R.2.2.9. Finally, the director should have the means to configure the scene composition and portal set-up for each of the individual omnidirectional viewpoints.

Requirement R.2.2.22: the content creator (director) can record highlights and dynamically replay them to the end user.

Requirement R.2.2.23: the content creator (director) can enforce the switching to another omnidirectional scene or activation of a portal.

Requirement R.2.2.24: the content creator (director) can enforce that the omnidirectional view (user defined or director defined) is shown on the television.

Requirement R.2.2.25: the content creator (director) can configure portals and interactions on the level of each omnidirectional scene.

Requirement R.2.2.26: the content creator (director) can highlight an interesting viewpoint to the viewer instead of pushing it.

Requirement R.2.2.14: the content creator (director) shall be able to position the cameras in the 360° scene, mimicking the real world coordinates.

5.3. Post-event experience and analysis

The following requirements have been identified:

- With all the metadata gathered during the live event, heatmaps can be generated to check if the predefined storytelling concepts correspond with the actual viewing data from the users, to learn best practices.
- In addition to the classic race TV summary, the director can create 360 video post-experiences consisting of the best 360 moments of the race.

Requirement R.2.2.27: the content creator has post-event access to heatmaps with the viewing data visualised to learn best practices.

Requirement R.2.2.28: the content creator can create post-experiences consisting of the best 360 moments of the live event.

For live pilot 3, the following publication requirement is added.

Requirement R.2.2.28 – The content creator shall be able to publish a 360° after-experience of the live event on social media based on a predefined or user tracked path.

The director or communication manager should have the possibility to publish live content based on the HMD content on social media, for communication, and marketing the event on online platforms.

6. CREATIVE WORKFLOW REQUIREMENTS – REFINED OFF-LINE SCENARIO

In this section, we will focus on the specific creative requirements for a fictional whodunnit content scenario (pilot 3), that is based on exploration mode. These requirements are documented and structured according to the different steps in the production and publication flow:

- preproduction
- production (capturing)
- post production
- publication

6.1. Preproduction

For a fiction programme in general, the preproduction phase includes multiple steps: possible location research, scenario writing, preparation of the shooting (call sheet, decor), etc. The core of the preproduction phase is the **scenario breakdown**, that will drive all other preproduction and production activities. In this respect, widely used state-of-the-art scripting tools for fiction, such as Final Draft¹⁰ also offers organization tools, script breakdowns, production planning and reports to help with preproduction tasks and allowing all members of the creative crew (from director's assistant over technical crew to art director) to collaborate on the project beyond the actual writing of the script.

Accordingly, the scenario breakdown will also be the centerpiece within the ImmersiaTV exploration mode concept (e.g. for a whodunnit). Scenarios for interactive multi-device content experiences that are based on exploration mode, can quickly become rather complex so tools to support and ease the (pre) production process are much needed.

Extending existing or building new scriptwriting tools with corresponding features for interactive multi-device exploration mode content experiences, is out of scope for the ImmersiaTV project. However, defining a **scripting template** for (multi-device) exploration mode scenarios would be a very valuable first step to facilitate and simplify the preproduction and production phase.

In Figure 13 and Figure 14 two scripting templates visualize the ImmersiaTV pilot 3 off-line concept used in the pre-production phase.

Figure 13 shows a clean template:

- From top to down, the scenes of the script are line up
- From left to right, each device (TV, tablet, HMD) has its own column

The television is the main device where all new scenes start. The tablet and the HMD combined, represent the 'Exploration Mode'. The scenes 'break out' from the main device to the 'Exploration mode'.

¹⁰ <https://www.finaldraft.com>

In Figure 14, an example of a possible script for a whodunnit is mapped into the model canvas. Scene 1 describes the introduction scene of the story, it ends with e.g. a police officer inviting the viewers to visit the murder scene. The ‘break out’ is accomplished by switching to the HMD device where the viewers can explore the murder scene. Each object “spotted” in the 360° environment will pop up on the tablet, where more information is given, e.g. the glass contains whiskey and poison. After the viewers decide to end exploration mode for this scene, the storyline continuous with the subsequent on the main device, the full cycle will be repeated for each scene.

	Main Device	Exploration	Mode
Script scenes	TV	Tablet	HMD
Scene 1			
Scene 2			
Scene 3			

Figure 13 - Scripting template for off-line pilot 3 (exploration mode)

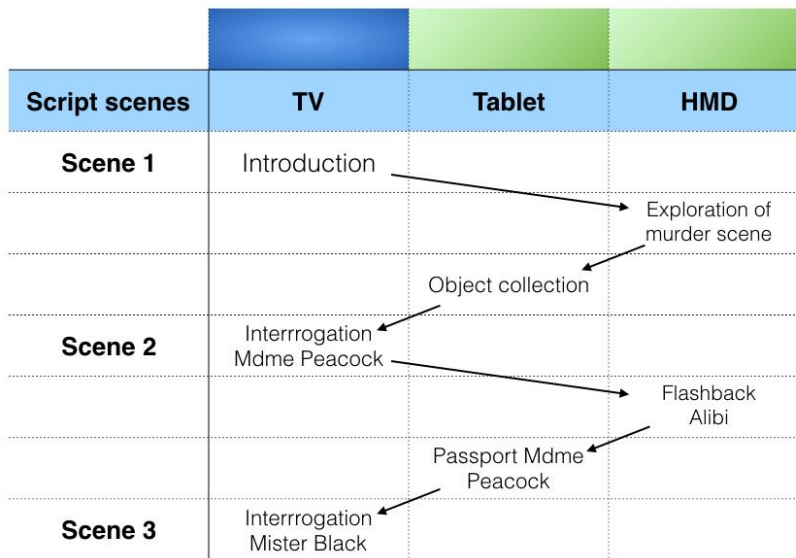


Figure 14 - Example script for whodunnit (off-line pilot 3)

Requirement R.2.3.16: The scenario writer shall use a common scripting template to elaborate the scenario breakdown and detailed script (structured script).

The written scenario, conforming to the scripting template, will allow to efficiently prepare the next steps in the production process.

In case branched storytelling is applied, the structured script should formally describe this.

Requirement R.2.3.17: The common scripting template should allow for branched storytelling.

Branched storytelling implicates a complex structure, especially applied to the ImmersiaTV concept with script break outs over multi devices. As the television is the main device which is exposing the arc of the story and the tablet is the collector of informational facts (e.g. notebook in a whodunnit), the HMD is the preeminent device to apply branched storytelling.

The template structure of the ImmersiaTV concept (Figure 13) is a vertical mapping of the script over multi devices along the storyline. In general, branched storytelling is portrayed as a horizontal diagram of multiple branches reaching out and often coming back to the 'main branch'.

As not every HMD 360° scene inside the ImmersiaTV concept asks for branched storytelling and to keep the template well-arranged and easy to view, it is advisable to use an annex for each branched HMD scene where a horizontal structure is applied. A color code or symbol indication

in the HMD column can be used to refer to a branched scene in the annex of the template (Figure 15).

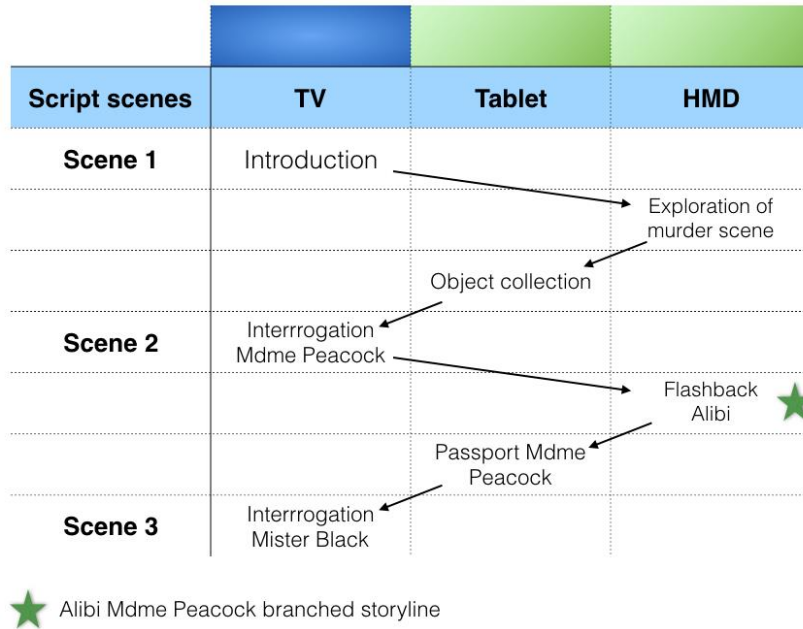


Figure 15 - Branched storytelling annex annotation in exploration mode script template

6.2. Production

In contrast with broadcast mode, implemented in pilot 1, exploration mode separates TV content (main storyline) and HMD/tablet content (explorative content) in time. Compared to pilot 1, this relaxes the requirements during shooting, and takes away the restriction of simultaneous shooting of directive shooting on the one hand, and 360° shooting on the other hand. Therefore, the restricted shooting options as imposed for pilot 1 (see Section 2.1.1 in Deliverable D2.3), do not longer apply for pilot 3.

Creative workflow requirements (production) R.2.1.16 and R.2.1.17 on live 360° preview capabilities before and after the shooting, as specified for pilot 1, are also applicable for pilot 3 (exploration mode).

R.2.1.18 (automatic labelling and sorting captured shots) can be further refined into a new requirement as follows.

Requirement R.2.3.18: The content creator can link the captured shots to the structured script.

Typically on the set, this work is dealt with by the director's assistant.

Pilot 3 aims to introduce **spatial audio** in the HMD content experience, to further increase the immersiveness and feeling of presence of the viewer when exploration mode is activated. This has implications to both the production and post production workflow (see Section 6.2.3.2 Audio Post Production).

Requirement R.2.3.19: The audio engineer on set should record two different audiotracks: one binaural and one directive.

While background ambience can typically be recorded directly as binaural audio (by 360° cameras or binaural microphones), specific sounds that are important to tell the story (e.g. a falling object hitting the floor) and narration/conversation should be captured in a directive way to optimize the recorded quality and to give the option in post production to place the object-based audio in the 3D audio space.

6.3. Post production

Most of the creative workflow requirements relate to the post-production phase, where the exploration mode experience is put together. The creative challenges in post-production can be subdivided in the following sub-categories:

- Challenges related to editing: interaction between sequences, branching, non-fixed timeframes of HMD/tablet exploration vs fixed timeframes of TV main storyline
- Challenges related to use spatial audio
- Challenges related to interaction design and visual effects

6.3.1. Editing

Requirement R.2.3.20: The editor shall be able to select the appropriate project mode (broadcast mode vs exploration mode) by customizing the overall editing project settings.

Exploration mode differs from broadcast mode in that active timeframes of TV scenes and HMD/tablet segment are not time-synchronized in exploration mode, and that timeframes of exploration mode segments (on HMD/tablet) are also non-fixed. This implies a fundamental difference in timeline behaviour, which should be indicated by the project mode setting.

Apart from these differences, the pilot 1 plug-in functionality enabling to map the different sequences on the edition timeline to specific output devices and to indicate which sequences refer to portal interactivity should be preserved and further extended.

Requirement R.2.3.21: The editor shall be able to indicate and specify the interaction between HMD and tablet for exploration mode segments.

It is not mandatory to implement interaction between HMD and tablet for each of the exploration mode segments of the whodunnit. In case of interaction, the editor shall specify the conditional events upon which user actions or story events trigger corresponding events on the tablet. More specifically, think of a viewer gazing into a specific object in the HMD resulting in background information about this object popping up on the tablet.

Requirement R.2.3.22: The editor shall be able to define specific areas in the HMD omnidirectional video content that can activate tablet events.

These specified areas can be considered as a special type of “portals”, that are invisible to the viewer but can trigger new events on the tablet.

Requirement R.2.3.23: The editor shall be able to add still pictures to the timeline that correspond to information shown on the tablet.

The next two requirements deal with providing interactivity to the viewer to restart or end the current exploration mode segment:

Requirement R.2.3.24: The editor shall be able to define and add a specific (visible) portal to the HMD content that enables the viewer to return from exploration mode to the main storyline (TV).

Requirement R.2.3.25: The editor shall be able to define and add a specific (visible) portal to the HMD content that enables the viewer to replay the current exploration mode segment from the start.

Closely related to the two previous creative requirements, the storyteller should be able to limit the maximum duration of an exploration mode segment (optional feature).

Requirement R.2.3.26: The editor shall be able to specify (maximum) duration of an exploration mode segment.

For branched storytelling, the timeline should be more adaptive and allow to create multiple branches from one timeline track. The editor should also be able to specify the conditions under which the subsequent sub-branch is selected, and to connect this logic to graphical elements that are placed on the content. To indicate the main (starting) branch on the editing timeline, the editor should be able to label a timeline track for “branched storytelling”.

Requirement R.2.3.27: The editor shall be able to apply branched storytelling in the project timeline, to label the main branch and to specify the conditions for sub-branching.

6.3.2. Audio post production

Pilot 3 aims to introduce **spatial audio** in the HMD content experience. During post production the audio engineer can consider to place these directional audio tracks in 3D audio space, and subsequently to mix these primary audio tracks with binaural ambience audio. Ideally, a 3D space-enabled user interface allows the editor to add spherical coordinates to the spatial primary audio.

Requirement R.2.3.28: The audio engineer shall be able to map directional high-quality audio to 3D space coordinates to create spatial audio for a specific story scene (exploration mode activated).

Requirement R.2.3.29: The audio engineer shall be able to mix directional or spatial primary audio with binaural ambience audio.

Requirement R.2.3.30: The audio engineer shall be able to add spatial/binaural audio to the project timeline.

6.3.3. Graphics

The vfx artist is responsible for creating (graphical) visuals that need to be integrated with the edited content. In the context of pilot 3, this mainly refers to graphical elements to allow the viewer to select a story branch, and to replay or to exit an exploration mode segment.

While their workflow process to create the visuals will not significantly be impacted, they will need specific plug-ins for the tools they use to interact with the editing tool and the applied interactive features, or at least a way to describe these dependencies.

Ideally, like the audio engineer, the vfx artist would work in a 3D space environment to place the created graphical elements in the story space. However, the latter is out of scope for ImmersiaTV.

Requirement R.2.3.31: The vfx artist shall be able to add or link graphical elements to the project timeline, and to describe the interactive dependencies with other timeline tracks .

6.4. Publication

The creative requirements for publication are similar to pilot 1, i.e. a custom play-out solution should be developed that supports multi-device content playout, but specific features need to be added to support exploration mode in pilot 3.

Requirement R.2.3.32 - The content creator shall be able to use a custom developed play-out solution that supports exploration mode-based multi-device scenarios.

For the exploration mode aimed for in the refined off-line pilot 3 the custom developed play-out solution needs to be further extended that can deal with the different new features beyond pilot 1 (broadcast mode) scenarios:

- User-triggered interactivity between HMD and tablet, including the concept of invisible portables
- Non-fixed timeframes for HMD (and tablet) exploration mode and handling of TV storytelling when exploration mode is activated
- Branched storytelling features

7. ITERATIVE IDEATION

This section describes small-scale and focused test scenarios that have been performed to gain insights in both content formats and practical VR workflows. Suggestions for further ideation tests are also documented.

7.1. Proof-Of-Concept 1: Workshop in Porto

As a first Proof-Of-Concept, a technical workshop was held in Porto, organised by LightBox. One of the main goals of this workshop was to generate concrete insights on specific plug-in requirements for post-production tooling that cover the application of interactivity and portals in ImmersiaTV. The envisioned VR production workflow was set up and tested hands-on by the different WP2 partners involved. A more elaborate preparation of the workshop can be found in annex 0. Detailed specifications and production scenarios that resulted from this first workshop can be found in Deliverable 2.3.

DAY 01:

The extensive tests on day 1 answered several of the open questions and issues that raised during pre-workshop VR production tests. Thanks to collaboration of all individuals and their combined knowledge, we gathered several insights and learnings on preparing, capturing and stitching a 360 production.

A/ Shooting the Scene

- Never shoot omnidirectional and directional scenes that are meant to be synchronized separately. We shoot our scenes independently, first with the 360 Rig and after with the directional cameras. The problem is that adequate synchronization will never be

possible because the acting (movements, moving objects, timings...) will never be exactly the same between takes.

- A good method to apply on the shooting set is to pick up the tripod holding the 360 rig at the end of each take and rotate it in 180 to 360 degrees. Later in post-production, this movement of the cameras on the rig will give a clear idea if the cameras are synchronized correctly.
- The best way to shoot a documentary with omnidirectional and directional cameras simultaneously would be to have some micro 2k cameras around the set, hidden by props in the set design. This approach still necessitates some rotoscoping of the micro cameras to remove them from shot but this will be easier than removing an entire crew with filming equipment. This approach also requires the set designer and continuity crew to pay extra care and attention to the props and cameras in between takes.
- Another good approach is to put the directional cameras and crew in an area where there will be no interaction of characters or moving objects. In this case, another take of the same scene without the crew and directional cameras suffices to be able to remove them in post-production. A disadvantage of this approach is that the director will not have point of views that cover all the action from various points like in the previous approach.
- All the clean plates generated must be filmed and not photographed because with a still picture of the empty room there will not be the usual film grain, or moving objects (e.g. trees) if there are any in the scene.
- Some use cases allow the presence of the crew on set with directional cameras e.g. music concerts, sports events, presentations, TV news and any projects where these objects can be seen as logical part of the big picture.
- Extra attention has to be paid to the lighting of the scenes. In cinema, in a directional shooting, the director of photography (DoP) can place light projectors behind the camera to light a scene. In a 360 scene this is not possible. For outdoor sets, there is only the need of sufficient natural ambient light. If it is an interior set, the DoP has to illuminate the scene with props from the set such as lights from lamps specifically placed on the set for that purpose.

More details on shooting options can be found in Deliverable 2.3, Section 1.1.

B/ Post-Production (Stitching, Compositing and Editing)

As a first step, we stitched the output of our camera rigs to build the omnidirectional equirectangular video.

Lessons learned are:

- By moving the camera rig at the end of the take, the VideoStitch software gives a more accurate result on the synchronization, by aligning the motion of all the captured video. By changing the position of each video on the timeline the synchronization can be further optimized before starting the stitching process. This way, and finally, we will have the perfect synchronization to finally move to the stitching (*Figure 16*).

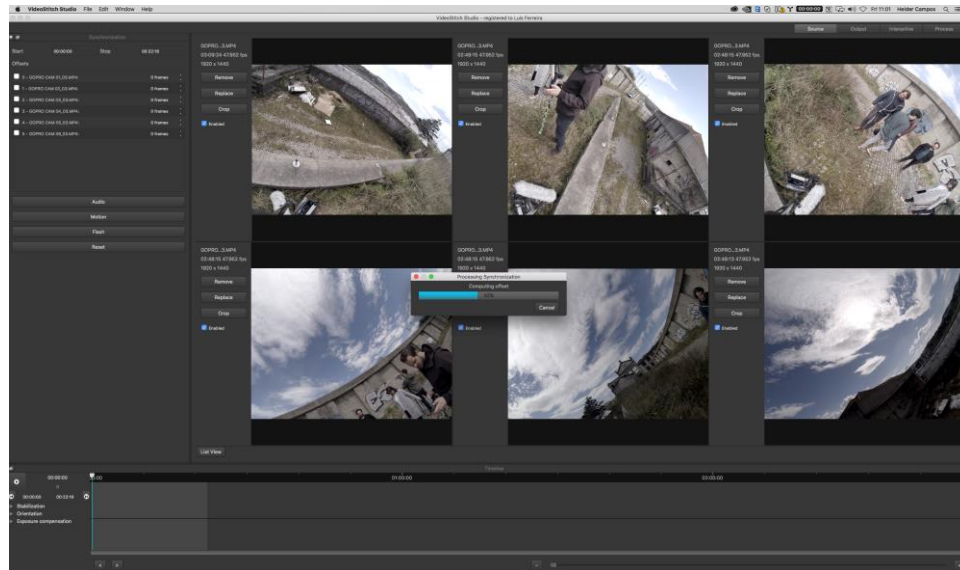


Figure 16: Synchronization of 360 cameras

- PTGUI is a helpful software tool to make a perfect stitch of the camera rig output. Especially for parallax issues between cameras, PTGUI allows selecting areas to be ignored in (for example) camera A, and only use the same information from camera B (Figure 17).

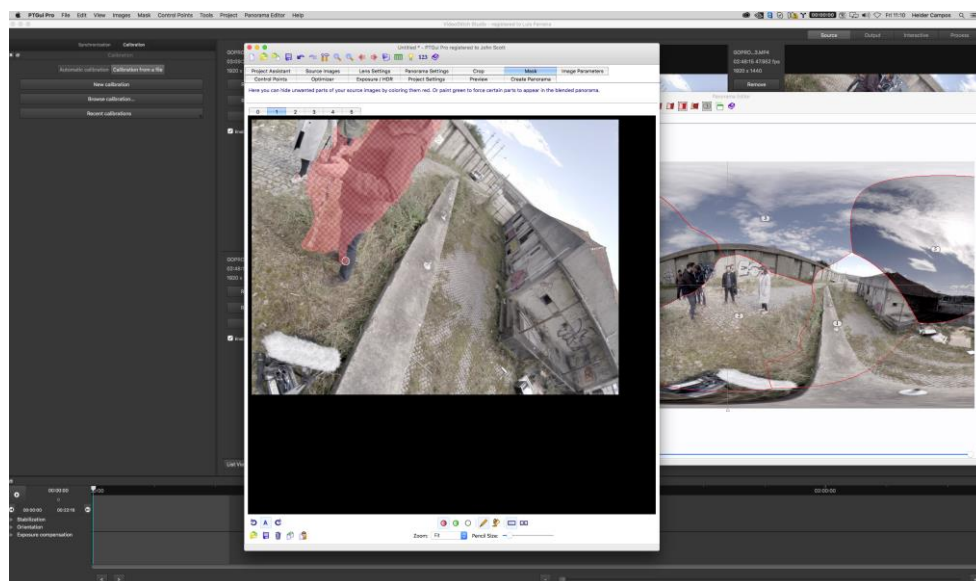


Figure 17: Manual stitching with PTGUI

- Stitching solutions are still in their infancy, e.g. minor parallax problems are difficult to avoid for now. Keeping the actors at least three meters from the camera rig can leave these stitching and parallax problems largely unnoticed, by making a perfect stitch for the actors and ending up with some bad stitching in unimportant areas with no character interaction in the scene. Minor parallax stitching issues can be resolved in AfterEffects and Photoshop and correct these minor issues by painting out what we don't want to be seen and fixing the parallax problems.

DAY 02

C/ Mettle Skybox Plugin - After Effects Environment

The Mettle plugin “Skybox” allows interpreting the stitched omnidirectional video, and expanding it into a cube representation of our camera rigs, making it possible to work on each camera separately and add graphics to a specific spot in the 360 scene. This delivers the positions of the 6 cameras, working on the video captured with the 6x GoPro rig: frontal, back, top, bottom, right and left. We now can go inside one of the cameras and create a circle for a portal that contains, for instance, a directional video of the actors. By having the cameras separated and by adding the portal to one of the cameras the result can be viewed directly in AfterEffects. This portal can be moved Up, Down, Right, Left anywhere in the omnidirectional video.

The Mettle Skybox plugin also allows to create transitions based on a black and white matte composition layer. The transition can be exported as an h264 movie file that can be applied in the ImmersiaTV plugin as a transition between clips.

With the Skybox plugin, we can also clean or correct the elements that have to be removed from the footage. To do so, Skybox gives a flat cube map layer (Figure 18), that can be exported as a Photoshop layer and further cleaned in Photoshop.



Figure 18: Cube Map Flat Representation

An example is the removal of the tripod supporting the rig. To remove it in Photoshop we just need to copy (clone stamp tool) the surrounding area of the tripod and paste that information on top of our tripod (see Figure 19).

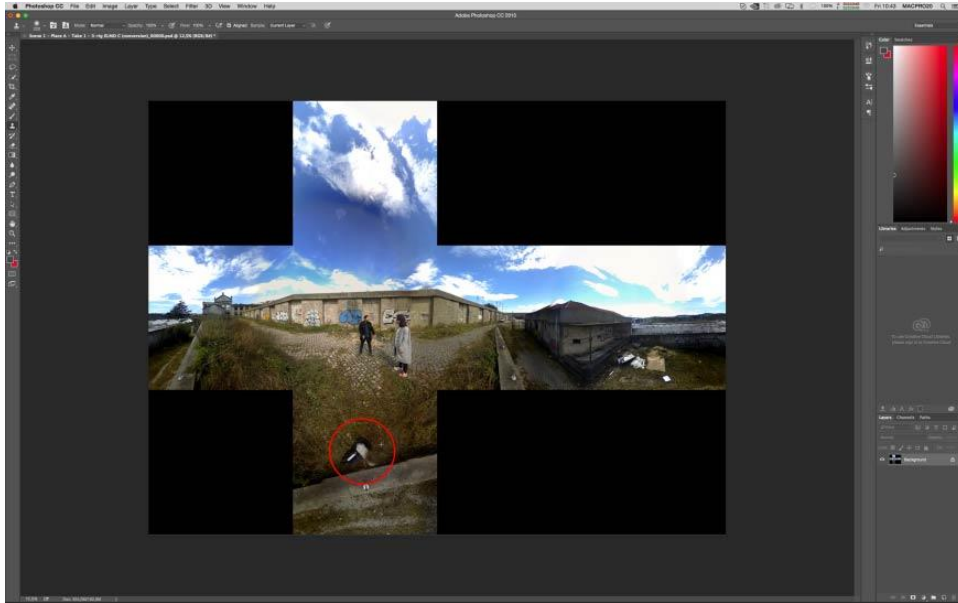


Figure 19: Cleaning the tripod rig from the scene

The cleaned footage is then reimported in After Effects, and added on top the cube map to mask the areas we are cleaning.

D/ Immersia TVPlugin – Adobe Premiere environment

The ImmersiaTV Plugin allows to import an omnidirectional video to the timeline and add one or more directional videos on top. A portal - circular, square or with a pen tool – can be created and assigned to the directional video. As such a portal with directional video has been created inside an omnidirectional scene. Possible improvements of the ImmersiaTV plugin, such as adding matte transitions to the plugin for portal-based transitions between two omnidirectional videos, have been discussed.

The optimal interaction between Adobe After Effects (AE), Adobe Premiere (AP) and ImmersiaTV plugin (IT) was another big topic of discussion. We concluded that the only interaction between AE and AP would be the possibility to create dynamic transitions in AE to be exported as an h264 file to AP and to be used by IT.

We also tested the synchronization of the omnidirectional video with the 2D editing of the short film. Due to different acting and timings, this was impossible, even when using only small pieces of the directional footage and adds them at a specific time in the omnidirectional timeline. In a particular scene where the actor points to something in the distance and smiles at the other character, the expressions in the omnidirectional and directive versions are very different. This would confuse the audience right away and pull them out of the immersive world they are in.

Detailed requirements for the ImmersiaTV plugin can be found in Deliverable 2.3, Section 3.2.

DAY 03

The Cinegy toolset was presented, including the specific live TV directing software Cinegy Live. A first brainstorm was held on the technical and logistical aspect when applying the drawn conclusions for an offline editing environment to a live editing/directing context. Implementation of television directing concepts and real-time assembly of omnidirectional and directive video in a live broadcast environment was debated, based on Cinegy Live.

Through this discussion, among other technical findings, we concluded that there needs to be a separate director for the HMD output - there are too many decisions to be made which cannot combine with those of a TV environment.

A point of attention is that LightBox is fully equipped with MAC desktops and the Cinegy platform only supports Windows. Interaction with Adobe Premiere is supported to some extent, but additional, direct localised integration within Premiere will be required in ImmersiaTV. This could be developed further upon existing drag and drop functionality of the Cinegy platform.

FINAL SCRIPT

Character A – Male

Character B - Female

SCENE 01

The two characters are far from the factory looking at it from a distance. The factory is far away from them and they talk to each other.

B – Are we sure we want to go in there?

A – Come on it will be fun.

B – But you’ve heard of that man who disappear in..

A – Come on you will be fine just don’t think about those shenanigans.

B – I don’t know. My momma always told me to pay attention to the myths.

A – Ahh come on. You really don’t think ghosts exist do you?

SCENE 02

We transition to the front of the factory in a 360 wipe and our characters are now near the entrance. A continues talking.

A – Besides, if it were true there’s a ghost in there the news would already talked about it

B – I really don’t know. I don’t feel it’s a good idea at all.

A – Ok. Let’s then make a deal. I promise to go inside first and if there isn’t

SCENE 03

We cut to the inside of the factory where from a window we see the characters outside talking.

A - anything scary I will call you ok?

B – No I don’t want you to go also.

A – Come on it will be more fun than scary

The character A moves away from B and enters.

SCENE 04

The character A walks inside the factory. From a distance the ghost watches him walking around and gets closer to him.

A – See? There's nothing here.

The Character A is looking to the door while he says that. The Ghost moves closer without him noticing.

The ghost is closer and closer to him. Character A is still facing the door.

A – There's no need to be afraid. I told you that... AHHHHHH

RESULTING VIDEO ASSETS

The following assets have been produced in the Porto workshop:

- 01 PROJECT (Adobe Premiere Project File)
- 02 MEDIA (Footage Used)
- 03 VFX (Stitched Footage and Transitions)
- 04 AUDIO (Captured Audio)
- 05 FINAL OUTPUTS (End Files)
- 06 DOCUMENTATION

7.2. Content ideation suggestions

In this section, suggestions for further Proof-Of-Concept testing are formulated. These suggestions are mapped on potential production cases and take into account the content format requirements of Section 6.3, aiming to further explore and refine them.

Case 1: Oil worker in Syria – News

Use basic portals, transitions and viewing angle

- What: use basic portals in 360° in short documentary
- Goal: test improved storytelling (requirement R.2.2), different kinds of transition (requirement R.2.8) and investigate the balance between guided viewing and 360° free exploration (requirement R.2.4).
- Use of portals: test how this can be easily achieved by a documentary maker and how a viewer perceives this
 - Video: archive material, news item, different footage from a similar person,...
 - AR layer data: name, age, location, ... of the main character
 - photos: e.g. of his relatives

Case 2: Different characters in asylum seekers centrum – Human interest

Test first person, user role, gamification, transitions

- What: test basic interaction, choose character (requirement R.2.5), gamified elements (requirement R.2.2) in a VR documentary
- goals:
 - enable a choice between character ("through the eyes of...")
 - test improved storytelling: gamification elements like energy level, ID, frustration level...

- mix guidance (audio) and freely looking around (requirement R.2.7)
- explore transitions (requirement R.2.8)
- portals:
 - test how a documentary maker needs to prepare for this (tooling requirements)
 - test how a viewer reacts and interacts with the different characters

Case 3 - Live VR Test Stubru Club69-concert

Live Interactive 360 stream during a music concert

- What: live stream with up to 3 different camera viewpoints, normally of an internationally renowned artist or band, for 150 spectators
- Goal: test which platform can properly show this live 360 feed and in which quality
- Targeted devices/platforms: web, Facebook, Gear VR, smartphone

Case 4 - Interactive VR News for children (6-12 years old)

Interactive VR storylines; optional: gamification, social viewing experience and synchronized multi-device content.

- What: children can freely interact with news storylines and characters, and discover headlines, video and extra information.
- Goal: test how to allow children this type of interactive storylines (requirement R.2.2), and evaluate their interaction patterns
- Portals/AR interactivity: can be interactive quiz with portals to video fragments, or AR overlay questions where children can choose the right answers;
- Extra: investigate the social aspects of watching VR (requirement R.2.9)
 - How can the VR-experience on an HDM be 'broken' to allow for normal communication with others being present? Example: mother informing children that dinner is ready.
 - How can I watch this content together with friends or family over an HDM? Interaction with controls, like Leap Motion or Oculus controller, could be very useful.
 - How can the (normal) TV screen be used for parental control? Show synchronised VR content in 2D.
- Device: optional use of the Leap Motion would be useful for interaction with hands, controlling gamified elements (score on the quiz, energy level, ...)

Case 5 - Justin Bieber 360° Live & Interactive

Interactive live 360° interview or session

- Target group: young people 16-25 years
- Goal: test live 360° interview or session with interactive portal-functionality, e.g. the possibility to answer polls or to ask a question in the VR experience
- Extras: share in VR on social media; make a documentary or report of this live experience

Case 6 – Oil worker in Syria on TV and HMD simultaneously

Synchronized multi-device short docu experience

- what: create a synchronized docu format for TV and HMD, based on available VR and TV footage
- goal: find out the feasibility, opportunities and bottlenecks in case of synchronization of TV and HMD storylines.

7.3. Proof-Of-Concepts

Wonen.tv case

Wonen.tv is a new TV show airing on the VRT main channel Eén (One), going prime time on Wednesdays starting from January 2017. Wonen.tv is a housing show with different sections during a 40 minute slot. One of the sections is looking into an extraordinary house with an architect explaining why the house is exceptional compared to other houses. The architect gives a tour in the house. Next to the TV show there is a website (wonen.tv) with a lot of extra content, complementary to the show, with more in-depth information.

For this website we teamed up with an external company called Pow3D, to make a full 360 photo tour in the house implementing the concept of portals so viewers can teleport from one room to another one back and forth, with extra media (video, audio) that can be activated by gazing to an icon set up in the 360° environment. The player was made with WebVR technology.

Lessons learned include gaze features, where the viewers' view is accessible, where to put icons in a 360 environment, which places work or do not work. Best practice is to put the icons in the area normal to human posture.

The wonen.tv PoC has yielded more insights in building interactive portal-based 360° experiences for broadcast formats. In particular, R.2.1.1 (presence), R.1.2.2 (storytelling) R.2.1.4 (viewpoints) and R.2.1.5 (viewer's role in the story) are applicable. Also, while the online HMD experience is not in sync with the television show, the interconnection between the two experiences is an interesting research topic.

8. OVERVIEW OF USER REQUIREMENTS

An overview of the professional user requirements for the different pilots is listed below. For each of the pilots, we distinguish between content format requirements (Section 3) and creative workflow requirements (Section 4 for pilot 1, Section 5 for live pilot 2 and 3, Section 6 for off-line pilot 3).

To clarify the relation between the requirements in D2.1, D2.2 and D2.3, we add a column to indicate the following links:

- Professional content format requirements are mapped onto end user experience requirements (D2.1). Both set of requirements are input for content ideation and pilot content scenarios in D2.3. Examples “traces” and explanation can be found in D2.3 (Sections 2.1.4 for off-line documentary and Section 2.2.4 for live events).

Professional creative workflow requirements are mapped onto software and technical requirements (D2.3). The creative workflow requirements are input for the user scenarios (Section 3 of D2.3) corresponding to the different stages of the ImmersiaTV workflow, from where the software requirements and technical specifications are derived. Interrelationship of professional content format and creative workflow requirements are indicated in a separate table.

Pilot 1 - Off-line documentary

Content Format requirements

	Generic Requirements	Link with D2.1 req
R.2.1.1	<p>The content creator shall take into account that VR experiences are about presence, “being there”</p> <ul style="list-style-type: none"> - 2.1.1.1: show insight in situation without subjective choice of director - 2.1.1.2: use a correct perspective and height of camera - 2.1.1.3: see yourself/character in images when looking down - 2.1.1.4: add tactility and tangibility - 2.1.1.5: give user active role/give user impact on story 	R.1.1.10 R.1.1.13
R.2.1.2	<p>The content creator should consider the use of gamification paradigms to improve the storytelling for VR.</p> <ul style="list-style-type: none"> - 2.1.2.1: search for new VR formats (do not start from existing TV formats) - 2.1.2.2: connect technical people with storytellers - 2.1.2.3: apply the gamification paradigms 	R.1.1.11
R.2.1.3	<p>The content creator shall make proportional use of omnidirectional content</p>	R.1.1.6 R.1.1.8

	<ul style="list-style-type: none"> - 2.1.3.1: find balance between 360° and 2D (keeping available time, ... in mind) - 2.1.3.2: take care of switching between 360 and 2D in HMD(/TV) - 2.1.3.3: allow the user to choose between auto switching to 360°, or to configure the “frequency” 	
R.2.1.4	<p>The content creator shall be able to play with the viewing angle & viewpoints.</p> <ul style="list-style-type: none"> - 2.1.4.1: play with different viewing angles and transition when viewing angle change - 2.1.4.2: experiment with different viewpoints 	
R.2.1.5	The content creator shall carefully consider the viewer’s role in the story	R.1.1.11 R.1.1.12 R.1.1.13
R.2.1.6	<p>The content creator shall define the “beats” and find a good balance between static and dynamic shots.</p> <ul style="list-style-type: none"> - 2.1.6.1: define a good rhythm/pace of story “beats” - 2.1.6.2: find a good balance between static and dynamic shots 	
R.2.1.7	The content creator shall take care of the balance between guidance and freely looking around.	R.1.1.14 R.1.1.15
R.2.1.8	The content creator shall apply good usage of transitions and cuts in VR storytelling.	
R.2.1.9	The content creator shall be able to adequately address the social aspects of the VR experience.	R.1.1.4
	Synchronized content across devices	
R.2.1.10	The content creator shall give the user the choice when to switch between devices.	R.1.1.6 R.1.1.7
R.2.1.11	The content creator shall not mix TV storytelling with VR storytelling.	
	Interactivity and portal concept	
R.2.1.12	The content creator shall be able to apply interactivity via portals.	R.1.1.11 R.1.1.12 R.1.1.13
R.2.1.13	The content creator shall be able to include extra graphical content in the HMD interface..	

Creative workflow requirements

	Preproduction	Link with D2.3 req
R.2.1.14	The content creator shall have tools for pre-production, to define the VR world and content format and to enable more complex and interactive 360° scripting possibilities.	
R.2.1.15	The content creator shall be able to previsualise the 360° world of the story based on rough 360° video footage of the location.	
	Production	
R.2.1.16	The content creator shall be able to have an on-location live preview in VR of the camera view (before the actual shooting takes place) and captured content, including omnidirectional video and audio preview on the set.	R-EDIT-1
R.2.1.17	The content creator shall be able to have an on-location live replay in VR of captured content, and resulting format experience.	R-EDIT-1 R-EDIT-12 R-EDIT-13 R-EDIT-14
R.2.1.18	The content creator shall be able to automatically label and sort captured shots.	
R.2.1.19	The content creator shall be able to fast ingest (after capturing) or to stream (before capturing) the captured shots, in order to enable instant preview.	R-EDIT-1
R.2.1.20	The content creator shall be able to use live VR preview tooling that integrates with the VR storyboard (preproduction phase).	R-EDIT-12 R-EDIT-13 R-EDIT-14
R.2.1.21	The content creator shall be able to use similar functionalities for live preview as for the VR storyboard tooling in preproduction.	R-EDIT-12 R-EDIT-13 R-EDIT-14
R.2.1.22	The content creator shall be able to use an intuitive dashboard indicating the status of the used cameras in shooting.	
R.2.1.23	The content creator shall be able to use specific 360 video camera equipment with requirements including high mobility, weight, robustness, rainproof, mud-proof, stability.	

	Post-production	
R.2.1.24	The content creator shall be able to use tooling that provides better integration of the process of rough stitching, editing and final stitching in the production chain.	
R.2.1.25	<p>The content creator shall be able to use a more simplified post production workflow that minimizes the required manual steps and used tools. This includes:</p> <ul style="list-style-type: none"> - 2.1.25.1: Stitching - 2.1.25.2: Editing and compositing for 360 scenarios - 2.1.25.3: Adding interactivity and portals - 2.1.25.4: Synchronous multi-platform content (tv, HMD, tablet) 	<p>2.1.25.2: R-EDIT-2 R-EDIT-10 R-EDIT-11</p> <p>2.1.25.3: R-EDIT-6 R-EDIT-8</p> <p>2.1.25.4: R-EDIT-7 R-EDIT-9</p>
R.2.1.26	The content creator shall be able to use preview capabilities in post-production, including HMD and ImmersiaTV Player output viewing.	R-EDIT-12 R-EDIT-13 R-EDIT-14
R.2.1.27	The content creator shall be able to export to different platforms in an automated way.	R-EDIT-15
	Publication	
R.2.1.28	The content creator shall be able to use tooling for better findability and searchability of own produced VR content.	
R.2.1.29	The content creator shall be able to use a custom developed play-out solution that supports interactivity and synchronisation scenarios.	R-PLAY-1 up to R-PLAY-11

Interrelationship of content format and creative workflow requirements in pilot 1 (off-line) scenarios are shown in the following table:

Content format req	Related creative workflow req
R.2.1.2 Gamification paradigms	R.2.1.25.3 Interactivity and portals
R.2.1.3 Proportional use of VR	R.2.1.25.2 Editing and compositing 360
R.2.1.4 Play with viewpoints	R.2.1.25.2 Editing and compositing 360

R.2.1.7 Balance of guidance and looking around	R.2.1.25.2 Editing and compositing 360
R.2.1.8 Transitions and cuts in 360	R.2.1.25.2 Editing and compositing 360

Additional remarks regarding professional user requirements:

- R.2.1.2: The use of gamification paradigms are in scope of pilot 3
- R.2.1.14 & R.2.1.15: preproduction tools are not in scope of pilot 1 of ImmersiaTV, and will probably not be implemented in the project (low priority).
- R.2.1.22, R.2.1.23: these are not translated into specific ImmersiaTV technical requirements, but form part of technical evolution in the market to be expected
- R.2.1.24: from the second pilot 1, Oras 4i and Studio.One cameras used in the project, provide auto-stitching functionality

R.2.1.27: out of scope for ImmersiaTV

Live event (pilot 2 and 3)

The additional requirements for pilot 3 are indicated with "Pilot 3" in the left column.

Content Format requirements

	Generic Requirements	Related D2.1 req
R.2.2.1	The content creator shall take into account that the point of view (PoV) in live VR has a direct impact on the user experience <ul style="list-style-type: none"> - VR has a direct impact on the user experience. - The best seat in the house experience': Giving the viewer the feeling of being actually present. - The role of the viewer and his place has an impact on how they will interpret the events happening around them. 	R.1.2.4
R.2.2.2	The content creator shall take into account that synchronisation is key. <ul style="list-style-type: none"> - When streaming content on multiple devices, the issue of latency has to be taken into account. 	
R.2.2.3	The content creator shall use audio to evoke the feeling of being present on the actual place of the event.	
R.2.2.4	The content creator shall give spatial orientation to the user.	
	Synchronized content across devices	

R.2.2.5	The content creator shall make sure that the storytelling over multi devices runs parallel such that the combination of 360 and TV storytelling is optimized.	R.1.2.1
	Interactivity and portal concept	
R.2.2.6	The content creator shall be able to apply interactivity via portals.	
R.2.2.7	The content creator shall be able to include extra graphical content in the HMD interface.	
R.2.2.8 (Pilot 3)	The content creator shall have full control over the live content, (possibly) enabling the content viewer to play, pause and resume transmission.	R.1.3.14
R.2.2.9 (Pilot 3)	The content creator shall have the possibility to offer replays of live content to the viewer, mixed with the live experience.	R.1.3.13
R.2.2.10 (Pilot 3)	The content creator shall have the possibility to share the point of view of the HMD onto the television.	
R.2.2.11 (Pilot 3)	The content creator shall be able to provide more advanced interactive experiences to the viewer, diversifying the level of interactivity on a per omnidirectional scene basis.	R.1.3.12 R.1.3.16 R.1.3.18 R.1.3.19
R.2.2.12 (Pilot 3)	The content creator shall be able to enforce a specific portal or scene configuration on-the-fly, jumping from one scene to another, as an equivalent of a user-triggered (inter)action.	R.1.3.13 R.1.3.15

Creative workflow requirements

	Preproduction	Link with D2.3 req
R.2.2.13	The content creator (director) shall be able to preconfigure scene compositions for the HMD experiences, (ideally) starting from existing templates.	R-PROD-3
R.2.2.14 (pilot 3)	The content creator (director) shall be able to position the cameras in the preconfigured 360° scene, mimicking the real world coordinates.	R-PROD-6
	Production	

R.2.2.15	The content creator (director) can use cameras with autostitch and live preview ability.	R-CAP-1 R-STITCH-3 R-STITCH-4
R.2.2.16	The content creator (director) must have a clear view of all incoming sources.	R-PROD-3
R.2.2.17	The content creator (director) must have the ability to measure the different camera delays and synchronize between the different 360 video camera.	R-PROD-2
R.2.2.18	The content creator (director) can perform a live preview of the interactive HMD experience.	R-PROD-3
R.2.2.19	The content creator (director) can select, initiate and change scene compositions for the HMD interface: removing icons, change camera source, ..	R-PROD-3
R.2.2.20	The content creator (director) can make cuts or transitions between different sources, both directive and omnidirectional streams.	R-PROD-3
R.2.2.21 (pilot 3)	The content creator (director) can see a live preview of 360 scenes before putting an updated version on air.	R-PROD-3
R.2.2.22 (pilot 3)	The content creator (director) can record highlights and dynamically replay them to the end user.	R-PROD-7
R.2.2.23 (pilot 3)	The content creator (director) can enforce the switching to another omnidirectional scene or activation of a portal.	R-PROD-5
R.2.2.24 (pilot 3)	The content creator (director) can enforce that the omnidirectional view (user defined or director defined) is shown on the television.	
R.2.2.25 (pilot 3)	The content creator (director) can configure portals and interactions on the level of each omnidirectional scene.	R-PROD-6
R.2.2.26	The content creator (director) can highlight an interesting viewpoint to the viewer instead of pushing it.	R-REC-9
	Creative workflow – Post-event	
R.2.2.27	The content creator has post-event access to heatmaps with the viewing data visualised to learn best practices.	

R.2.2.28	The content creator can create post-experiences consisting of the best 360 moments of the live event.	
R.2.2.29 (pilot 3)	The content creator shall be able to publish a 360° after-experience of the live event on social media based on a predefined or user tracked path.	R-REC-10

Interrelationship of content format and creative workflow requirements in pilot 2 (live event) scenarios are shown in the following table:

Content format req	Related creative workflow req
R.2.2.2 Synchronisation is key	R.2.2.11 Measure camera delays and synchronize between cameras
R.2.2.4 Give spatial orientation to the user	R.2.2.8 Preconfigure scene compositions R.2.2.13 Select, initiate and change compositions
R.2.2.6 Interactivity via portals	R.2.2.13 Select, initiate and change compositions R.2.2.14 Cuts and transitions between directive and omnidirectional streams
R.2.2.7 Include graphical content in HMD experience	R.2.2.13 Select, initiate and change compositions

Additional remarks regarding professional user requirements:

- R.2.2.3 (audio to evoke feeling of presence) is in scope of pilot 3
- R.2.2.8 (preconfigured scene composition) is also part of preparation process of live production; for live pilot we don't make the distinction between preproduction and production phase in D2.3
- R.2.2.9: this requirement refers to capture and stitching as part of the production.
- R.2.2.16: heat maps are not in scope of the first phase of ImmersiaTV

Interrelationship of content format and creative workflow requirements in live pilot 3 scenarios are shown in the following table:

Content format req	Related creative workflow req
R.2.2.9 Replays of live content	R.2.2.22 Record, edit and replay on-the-fly
R.2.2.10 Sharing HMD view on television	R.2.2.24 Omnidirectional view (user/director) is shown on television by director's action

R.2.2.11 Advanced interactive experiences, on a per omnidirectional scene basis	R.2.2.25 Configuration of scene/portals per omnidirectional viewpoint R.2.2.26 The content creator (director) can highlight an interesting viewpoint to the viewer instead of pushing it.
R.2.2.12 Enforced portal viewing or scene change by director	R.2.2.23 Enforce switching to another omnidirectional view in live director tool

Pilot 3 - Off-line whodunnit (exploration mode)

Content Format requirements

Req no	Requirement description	Link with D2.1 req
R.2.3.1	The content creator shall take care that exploration mode-based storytelling is seamless across devices.	R.1.3.7
R.2.3.2	The interface over multiple devices should be simple, coherent and invisible.	
R.2.3.3	The scenario, as written and implemented by the content creator, shall put one device in the lead of the main storyline, to which content on the other devices is complementary. The preferred lead device for the main storyline is TV. HMD and tablet become active when exploration mode is activated.	R.1.3.2
R.2.3.4	The content creator shall take care that each device has its own relevance and added value in the multi-device storytelling.	R.1.3.7
R.2.3.5	The content creator can create break-out segments from the main (tv) storyline where the viewer can enter exploration mode on the HMD and tablet.	R.1.3.3
R.2.3.6	The content creator shall take care that switching to exploration mode is properly signalled to the viewer by the TV content.	R.1.3.5
R.2.3.7	The content creator shall carefully consider the application of break-out exploration mode segments in terms of frequency and timing.	R.1.3.2

R.2.3.8	The content creator shall take care that the storyline on the main device (tv) is paused when exploration mode is activated.	R.1.3.4
R.2.3.9	The content creator should not mix “broadcast mode” and “exploration mode” storytelling for the same story.	R.1.3.3
R.2.3.10	The content creator shall only apply user interaction with the story when exploration mode is activated.	R.1.3.6
R.2.3.11	The content creator shall consider interactions between HMD and tablet when exploration mode is activated. Preferably, only one device should be the lead device that triggers events on the other device.	R.1.3.6
R.2.3.12	The content creator should consider to provide the viewer with the option to return back from exploration mode to the main storyline (TV).	
R.2.3.13	The content creator should consider the application of branched storytelling in exploration mode. When applied, it should be limited to one device, preferably the HMD.	R.1.3.6
R.2.3.14	The content creator should take into account social viewing aspects, but also cater for single viewer experiences at the same time.	R.1.3.1
R.2.3.15	The content creator should take care that interactions between HMD and tablet during exploration mode trigger the viewers to interact with each other on the content.	R.1.3.1

Creative workflow requirements

	Preproduction	Link with D2.3 req
R.2.3.16	The scenario writer shall use a common scripting template to elaborate the scenario breakdown and detailed script (structured script).	
R.2.3.17	The common scripting template should allow for branched storytelling.	
	Production	

R.2.3.18	The content creator can link the captured shots to the structured script.	
R.2.3.19	The audio engineer on set should record two different audiotracks: one binaural and one directive.	R-CAP-8
	Post-production - Editing	
R.2.3.20	The editor shall be able to select the appropriate project mode (broadcast mode vs exploration mode) by customizing the overall editing project settings.	R-EDIT-20
R.2.3.21	The editor shall be able to indicate and specify the interaction between HMD and tablet for exploration mode segments.	R-EDIT-23
R.2.3.22	The editor shall be able to define specific areas in the HMD omnidirectional video content that can activate tablet events.	R-EDIT-23
R.2.3.23	The editor shall be able to add still pictures to the timeline that correspond to information shown on the tablet.	R-EDIT-23 R-EDIT-25
R.2.3.24	The editor shall be able to define and add a specific (visible) portal to the HMD content that enables the viewer to return from exploration mode to the main storyline (TV).	R-EDIT-21
R.2.3.25	The editor shall be able to define and add a specific (visible) portal to the HMD content that enables the viewer to replay the current exploration mode segment from the start.	
R.2.3.26	The editor shall be able to specify (maximum) duration of an exploration mode segment.	
R.2.3.27	The editor shall be able to apply branched storytelling in the project timeline, to label the main branch and to specify the conditions for sub-branching.	R-EDIT-26
	Audio post production	
R.2.3.28	The audio engineer shall be able to map directional high-quality audio to 3D space coordinates to create spatial audio for a specific story scene (exploration mode activated).	
R.2.3.29	The audio engineer shall be able to mix directional or spatial primary audio with binaural ambience audio.	
R.2.3.30	The audio engineer shall be able to add spatial/binaural audio to the project timeline.	

	Graphics	
R.2.3.31	The vfx artist shall be able to add or link graphical elements to the project timeline, and to describe the interactive dependencies with other timeline tracks.	
	Publication	
R.2.3.32	The content creator shall be able to use a custom developed play-out solution that supports exploration mode-based multi-device scenarios.	R-REC-12 to R-REC-27

Interrelationship of content format and creative workflow requirements in pilot 3 (off-line) scenarios are shown in the following table:

Content format req	Related creative workflow req
R.2.3.1 Seamless exploration mode experience	R.2.3.32 Custom developed playout solution supporting exploration mode
R.2.3.2 Simple, coherent interface over multiple devices	R.2.3.32 Custom developed playout solution supporting exploration mode
R.2.3.3 TV is main storyline, HMD/tablet active when exploration mode is activated	R.2.3.16 Scripting template for exploration mode R.2.3.20 Exploration editing project mode
R.2.3.5 Break-out segments to enter exploration mode on HMD/tablet	R.2.3.20 Exploration editing project mode
R.2.3.6 Exploration mode is signalled on TV	R.2.3.32 Custom developed playout solution supporting exploration mode
R.2.3.7 Exploration mode segments: frequency and timing consideration	R.2.3.26 Editor specifies duration of exploration mode segments
R.2.3.8 Storyline on tv is paused when exploration mode is active	R.2.3.32 Custom developed playout solution supporting exploration mode
R.2.3.9 Do not mix “broadcast mode” and “exploration mode” for the same story.	R.2.3.20 Exploration editing project mode
R.2.3.10 User interaction only applied when exploration mode is activated	R.2.3.25 Replay current exploration mode segment
R.2.3.11 Interactions between HMD and tablet when exploration mode is activated.	R.2.3.21 Interactions HMD/tablet R.2.3.22 Define specific areas in the HMD for interactions

	R.2.3.23 Still pictures as information shown in tablet
R.2.3.12 Return from exploration mode to main storyline	R.2.3.24 Portal in HMD view to return to main storyline
R.2.3.13 Branched storylines in exploration mode (HMD)	R.2.3.17 Scripting template allowing branched storytelling R.2.3.27 Branched storytelling in project timeline
R.2.3.15 Trigger interactions between HMD and tablet viewers	R.2.3.21 Interactions HMD/tablet R.2.3.22 Define specific areas in the HMD for interactions R.2.3.31 Graphical elements on timeline and interactive dependencies with other timeline tracks

Note that the audio post production requirements R.2.3.28, R.2.3.29 and R.2.3.30 are introduced in pilot 3 to increase immersiveness and feeling of presence of exploration mode segments. These creative workflow requirements are linked to the generic content format requirement R.2.1.1, already laid down for off-line pilot 1.

9. REFERENCES

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10. ANNEX I – DETAILED WORKSHOP OUTLINE AND PLANNING

PART 1: INTRODUCTION

Introduction & demo (15min)

idem as end-user workshop

- Informed consent
- The project scope and aim of the workshop is briefly explained
- Participants present themselves briefly (name, age, occupation, possible previous experience with VR)

Participants can experience some VR examples during +- 15 minutes. They can try out the available examples in an open space in which the material is available. Some participants chose to watch the examples while standing, others were seated. Not every participant tries out every example. The main aim of this exploration phase is to offer participants a VR experience with varied content.

All examples were exhibited with Samsung Gear VR HMD (SM-R322).

Samsung Galaxy S6 as input device, with a 5.1-inch WQHD [Super AMOLED](#) display:

- resolution: 2560x1440
- ppi: 577
- pixel lay out: RGBG PenTile

Content list:

- Red Bull F1 VR :

content description: driver seat in Formula 1 test ride, 360video

format: youtube streaming

resolution: 3840x2048

frames/s: 30

mimetype: vp9

audio: AAC stereo

example frame:



link: <https://youtu.be/wfNvZwN87Hg>

- Gunjack:

content description: spaceship shooter game, graphical vr game made with Unreal engine

format: Samsung Gear / Oculus store

resolution: n/a

frames/s: n/a

mimetype: n/a

audio: n/a

example frame:



link: <https://www.oculus.com/experiences/gear-vr/969815736436279/>

- Clouds over Sidra:

content description: documentary, girl guided tour through refugee camp, 360 video

format: Within app. In Samsung Gear store

resolution: 3840x2048

frames/s: n/a

mimetype: vp9

audio: n/a

example frame:



link: <https://with.in/watch/clouds-over-sidra/>

- News studio VRT:

content description: repo from the news studio in VRT with a portal concept, 360 video

format: youtube streaming

resolution: 3840x2048

frames/s: 30 f/s

mimetype: vp9

audio: AAC, stereo

example frame:



link: <https://youtu.be/lzwzB41lgYE>

First feedback on VR experience (30min)

similar as end user-workshop,

but also thinking about production aspects and differences with TV

- Based on the examples they experienced, participants will give their first reactions on the experience. This will be recorded on tape and summarised on a flipchart by the moderator.
- Respondents will first reflect their ideas, then the moderator will ask further on specific aspects
 - o Main opportunities & barriers they identified.
 - o Evaluation of HMD? Cardboard?
 - o What do they think of the examples with portals?
 - o VR is announced as game changer: the devices are there, the consumer is interested, big players like Samsung and Facebook are going along. What do they think of that?
 - o Which function should VRT have in this story?
 - o For which type of content do they think VR is specifically suitable for? Why?
 - o For which type of content do they think VR is not suitable for? Why?
 - o What role do you see for VR in the future TV viewer experience?

PART 2: IDEATION and FORMAT

Participants can create their own VR experience.

Workflow VR production (5min explanation + 10min discussion)

specific for professional users

- Fisheye (Belgian production house specializing in VR production) is invited to explain their common VR production
- Participants could ask questions and are asked to give their first impression.
 - o What are the differences with TV/online workflow?
 - o Where do they foresee difficulties?

Creation format (30min)

*similar as end-user workshop,
but also focus on possible production workflow*

In teams of 2 or 3, professional users will be asked to create a VR experience starting from their expertise domain.

To guide them they will receive:

- A template pitch: title/slogan, summary, target audience, genre, type of interactions, amount of interactions (extra info, move to side paths)
- A timeline program: how would they map out their program in time, when do they foresee which interaction?
- A workflow print-out, so they can map their concept to the workflow

Presentation and discussion format (20min)

*similar as end-user workshop,
but also reflection on production process*

- Professional users will briefly present their designs to each other and can also ask each other questions.

- They will reflect on the difficulties they experienced when coming up with a concept and on the different aspects they already reflected upon when thinking about the concept:
 - o Relation to topic (are you as a creator/distributor present or not, distance towards subject or not, author-driven or not)
 - o Recording: which tools are necessary in preparation, on set and afterwards? Where is the director, cameraman? What about audio? What about batteries? Synchronicity?
 - o What do you need? From equipment, technical expertise, ...?
 - o How do they want to give and take control to/from user?
 - o What kind of user experience do they want to achieve? How does this differ from a non-VR experience?
- Have they integrated the portal concept? Why (not)? What do they see as the main opportunities and barriers specifically for portals?
- How do they feel about multi-platform content? Do they think it is beneficial to rethink content for a multi-platform environment? Should end-users be free to choose the device, or should the content delivered tell them what device to use at each moment? What do professional content producers feel is more convincing for the end-users?

PART 3: DISCUSSION (40min)

together with end-users

For this part of the workshop the professional users and the end-users are gathered around the table.

First the moderators of the end-user workshop briefly present some of the main findings of the end-user workshop: what were the main opportunities and barrier they identified? How was the portal concept evaluated? etc.

Then the professional users present their concepts to the end-users. The end-users can ask questions and there is a discussion on the developed concepts. In the discussion, focus will be on the professionals' view on the user (what kind of user experience and user expectations did they have in mind for their developed concept) and how users evaluate this.

11. ANNEX II – TECHNICAL WORKSHOP IN PORTO

GOAL OF THE WORKSHOP

The main goal of this workshop is to allow the different partners involved in WP2 to set up and test the end-to-end VR production workflow in ImmersiaTV: capture, stitching, post production and publication/play-out of immersive content. This will also cover synchronized multi-device play-out and the use of portals.

The aim is to kick-start and accelerate further iterative testing (content ideation) and to anticipate on and reduce technical issues during documentary and live production.

The workshop aims to give the necessary insights in the specific plug-in requirements for post-production tooling (addressing the portal and more generally the interactivity concept) that is needed to produce and implement the ImmersiaTV content formats in scope of Pilot1 in an efficient and user friendly way.

DAY 01

The first day of the workshop is dedicated to structure a storyline, capture and stitching.

Creation of VR storyline (1 hour)

As a starter, a brief VR storyline is discussed and worked out with synchronized multi-device delivery and the concept of portals in mind. Targeted duration of the VR story is a couple of minutes.

Input: content format insights gathered in the user workshops will be taken into account.

Output: a content scenario and a clear idea on how to produce the different shots (location of cameras, choice of cameras, directive shots); preproduction requirements.

Shooting (2 hours)

In this slot, the VR storyline is captured. The idea is that each participant will capture parts or shots of the story, so all partners can build up knowledge on how to capture in VR in practice.

Output: captured VR content, production requirements.

Stitching (2 hours)

The captured shots are ingested, synchronized and stitched. The VideoStitch workflow is first explained and discussed, in order to get more insights on pros and cons of current VideoStitch tooling. Missing features of VideoStitch software, or requirements regarding integration with other tools for ImmersiaTV content production are considered. All participants get hands-on experience with the VideoStitch software by doing the stitching for the captured content.

Input: captured VR content.

Required tools: 360CamMan (ingest), Adobe Premiere (synchronization), VideoStitch software (stitching), PTGUI (stitching)

Output: stitched VR content, production requirements

Editing and Transfer to ImmersiaTV Player (3 hours)

The VR story is edited in Adobe Premiere with (synchronized) content produced. Basic editing is performed for two audiovisual outputs: 1 for the TV set and one for the head-mounted display (and tablet in HMD mode). The produced content is transferred to the ImmersiaTV Player and a first visualisation of multiplatform content will be done.

Input: stitched VR content

Required tools: Adobe Premiere (After Effects), ImmersiaTV player

Output: content produced for TV and HMD, a working demonstrator of synchronized multiplatform content, potentially additional requirements regarding synchronized multi-platform delivery

DAY 02

On the second day, the VR story is further refined by adding interactivity (portals) in post-production. The ultimate goal of the second day is to get clear insights in specific plugin requirements for post-production tooling that will enable to realize the ImmersiaTV goals in an efficient and user friendly way.

Mini content ideation brainstorm (1 hour)

The results obtained on Day 1 are discussed, in particular the synchronized multiplatform part. Fisheye explains the use of the Skybox Mettle plugin for the addition of portals in the story. The group discusses the benefits and shortcomings as well as possible improvements of this plug-in in the context of ImmersiaTV. The participants also discuss the addition of portals for the VR story in order to prepare the next slot.

Input: content produced on day 1, expertise with Skybox Mettle plug-in for portal creation

Required tooling: Adobe After Effects, Skybox plugin (demo version)

Output: first insights and requirements for portal-based VR production

Adding portals in the VR story (10h-14h)

In this slot, the participants do the practical video and audio editing, adding portals in AfterEffects based on the Skybox plug-in, with the help of Fisheye. The resulting content is transferred to the ImmersiaTVPlayer.

Output: VR story with portals produced, possible additional insights for portal-based VR production

Brainstorm (4 hours)

In this slot, the portal-based content that has been transferred to the ImmersiaTV Player is tested and evaluated. Scene typologies are explored and discussed. Participants analyse and discuss into detail the prototype plug-in requirements for ImmersiaTV, as well as the necessary features in the ImmersiaTV player.

Output: insights and requirements for Adobe plug-in (portal/interactivity), desired features for ImmersiaTV player, scene typology insights.

DAY 03

This day is dedicated to analyse the Cinegy platform (Archive and Live). For Live, training is provided. For Archive, the goal is to set up the video repository on the suitable laptops, and ingest material captured and produced in the workshop (hands-on experience).

Output:

- working environment of Cinegy tooling on power laptop(s)
- hands-on experience in Cinegy tooling for further use in ImmersiaTV
- insights on the customization of Cinegy live needed to deliver the ImmersiaTV use cases