

Deliverable

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D2.1 End User Requirements

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Dissemination Level

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Abstract: This deliverable reports on Task 2.1, requirements workshops with end-users. The outcome of this deliverable is a set of end-user requirements for the offline and live produced content scenarios within the ImmersiaTV project.

REVISION HISTORY

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Disclaimer

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Statement of originality:

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EXECUTIVE SUMMARY

This Deliverable describes the detailed end-user requirements needed for both offline and live produced content in ImmersiaTV.

This deliverable is a living document that will be updated iteratively by insights gained in T2.1. end-user requirements as well as in content ideation Proof of Concepts (PoCs) (D2.3), content creation (D2.4) and pilots (WP4).

Specific focus is on end-user requirements for both (off-line) immersive documentaries (first iteration), live sports events (second iteration) and the delivery of content in 2 temporal modes: broadcast and exploration mode (third iteration).

In the first iteration of the deliverable (M3), we reported on the two end-user workshops related to the offline content production scenario that took place in February and March and we discussed the derived requirements from these workshops.

In the second iteration (M12), focus was on the end-user requirements for the live scenario. This was based on the results of a new focus group interview specifically addressing live content.

In the current iteration, which is the third iteration of this deliverable (M22 and M24), we focus on the end-user requirements for the third pilot. Pilot 3 consists of two different production pilots:

- *Pilot 3 - Offline content:* a refined version of the immersive documentary, where the exploration mode will be fully implemented. For this purpose, a focus group was organized that concentrated specifically on the exploration mode.
- *Pilot 3 - Live content:* a refined iteration of a live sports event, with the live introduction of multiple simultaneous user viewpoints and refined user interaction with the portals. For this purpose, interviews were organized with end-users.

A first version of the third iteration of this deliverable focussed on the pilot 3 offline content requirements and was submitted in M22. A second version of this deliverable with focus on the pilot 3 live content requirements was submitted in M24.

This document is structured as follows: in the introduction we discuss the aim of the task and the deliverable, followed by the explanation of the methodological approach. Next we present the research findings and the specific identified end-user requirements for immersive TV-experiences. A first set of requirements relates to the general VR experiences and requirements, followed by requirements related to synchronised content across devices, interactive VR experiences and content format requirements. The document is concluded with an overview of all end-user requirements.

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LIST OF ACRONYMS

Acronym	Description
HMD	Head-mounted display
ODV	Omnidirectional video
VR	Virtual reality
UX	User Experience
PoC	Proof of Concept
POV	Point of view

1. INTRODUCTION

1.1. Purpose of this document

This deliverable documents in details the end-user requirements for omnidirectional content in the offline content scenario as investigated in Task 2.1.: end-user requirements. The outcome of this task is a set of structured insights and requirements that together with the insights and requirements acquired in Task 2.2: content format and creative workflow requirements, will serve as input for the content ideation process in Task 2.3 and finally the pilots in WP4.

The T2.1 activities to gather the end-user requirements were executed in parallel with T2.2 activities on the professional user requirements. The simultaneous organisation of the user workshops 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, 2002). At the start, a very open approach was thus applied in order to explore general experiences with and expectations towards VR. Only after this the ImmersiaTV concept was carefully introduced, as VR is a rather new content format for both end-users and professional users. The gathered insights were then translated into a set of end-user experience requirements in D2.1 and a set of content format and creative workflow requirements for D2.2. The D2.1 and D2.2 insights and requirements will serve as input for the software requirements and technical specifications regarding content production and end-user experience, and the content ideation process and production scenarios 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.

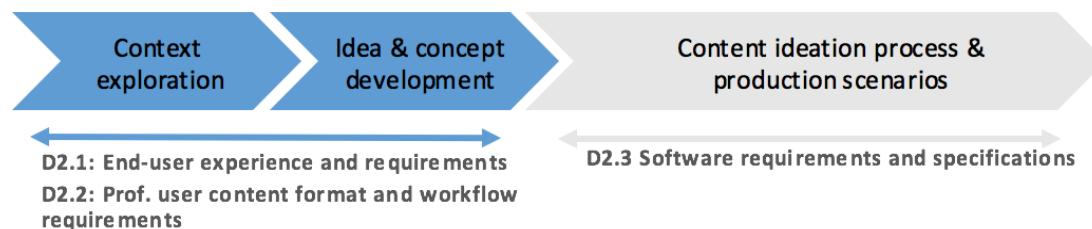


Figure 1: Illustration requirement creation process WP2

This document consists of three iterations. In the first iteration of the deliverable (M3), specific focus is on the end-user requirements for the offline content scenario as preparation for pilot 1.

In the second iteration of this document (M12), specific focus is on the end-user requirements for the live content scenario as preparation for pilot 2.

In the third iteration of this deliverable (M22 and M24), we focus on the end-user requirements for a refined version of the offline content scenario and the live content scenario as preparation for pilot 3. A first version of the third iteration of this deliverable focussed on the pilot 3 offline content requirements and was submitted in M22. A second version of this deliverable with focus on the pilot 3 live content requirements was submitted in M24.

1.2. Scope of this document

1.2.1. Iteration 1: offline content scenario

The objective of task T2.1 is to define end-user requirements for the different pilot scenarios. In the first phase of this deliverable, focus was on defining end-user requirements for the offline content scenario. The main scenario defined, in the ImmersiaTV project, that is taken into account is the residential TV-viewing scenario in which a user consumes video content in a home setting with access to multiple devices (e.g. tablet, Smartphone, HMD). The workshops focused on the following specific aspects:

- *General user experience of omnidirectional video:* How do 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? What types of possible discomfort do users experience? Did workshop participants have previous VR experiences and how do they evaluate those?
- *Omnidirectional content formats:* What do users see as the most appropriate formats or genres to integrate omnidirectional video content? What kind of omnidirectional content formats would they create for themselves? How do they evaluate the developed formats by professional TV makers?
- *Contextual factors:* What is the importance of different contextual factors such as social setting and pricing of the devices for the omnidirectional user experience? How can we develop omnidirectional viewing experiences that take into account social viewing aspects?
- *Synchronised content across multiple devices:* One of the main foci of the ImmersiaTV project is synchronized content across different devices (TV-set, tablet, HMD). How do users evaluate the usage of different devices to watch omnidirectional content in combination with regular TV-content? How do they prefer to switch devices?
- *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: How interactive do users want to be in exploring omnidirectional content? Does interactivity lead to a higher level of engagement? 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?

1.2.2. Iteration 2: live content scenario

In the second iteration, an additional workshop took place with specific focus on the live content scenario. In the discussion, similar topics as during the first phase were addressed:

- *General user experience of omnidirectional video:* In the second workshop, we focused on previous experiences with VR, and expectations on the use of omnidirectional video in a multi-device set-up.
- *Omnidirectional content formats:* In contrast to the first workshops, here we focused particularly on the live scenario. Discussed formats included different kinds

of live broadcast programs, including sports, news, reality shows and broadcasting of big live events.

- *Contextual factors:* What is the importance of different contextual factors such as social setting and pricing of the devices for the omnidirectional user experience? How can we develop omnidirectional viewing experiences that take into account social viewing aspects?
- *Synchronised content across multiple devices:* One of the main foci of the ImmersiaTV project is synchronized content across different devices (TV-set, tablet, HMD). In this second iteration, focus was on the different types of content and interaction on each device, as well as the switching between devices and the difference between tablets and HMD.
- *Interactive formats and portals:* In this workshop focus was on possible interactions and level of control between the viewer and the director, particularly in live scenarios.

1.2.3. Iteration 3: Offline content and live content scenario

In the third iteration, two user research activities took place. To gather end-user requirements for the pilot 3 offline content scenario, a workshop was organized with end-users. To gather requirements for the pilot 3 live content scenario, interviews were organized with end-users.

Offline content

An end-user workshop was organized with specific focus on the exploration mode. Whereas in the workshops organized for the first and second iterations of this deliverable the focus was only on the broadcast mode (the timing and order of the scenes and events are fixed at the production stage), this workshop addressed the broadcast mode and the exploration mode (the order of scenes and timing of events will change depending on the actions of the user who can explore different paths).

In the discussion, the following topics were discussed:

- *General user experience of omnidirectional video:* We focused on previous experiences with VR, and expectations on the use of omnidirectional video in a multi-device set-up.
- *Omnidirectional content formats:* What do users see as the most appropriate formats or genres to integrate omnidirectional video content?
- *Contextual factors:* What is the importance of different contextual factors such as social setting and pricing of the devices for the omnidirectional user experience? How can we develop omnidirectional viewing experiences that take into account social viewing aspects?
- *Synchronised content across multiple devices:* In this third iteration, focus was on the different types of content and interaction on each device (TV-set, tablet, HMD), as well as on the switching between devices and the difference between tablets and HMD. What could the role of the HMD and the tablet be in an exploration mode, compared to the broadcast mode on the TV?
- *Interactive and explorative formats and portals:* The focus was on possible interactions and level of control between the viewer and the content. At what

moments in the story/broadcast there is a desire for interaction with the content? How long should these interactions be? How do viewers want to be informed to use the HMD and tablet for additional content exploration?

Live content

Interviews were organized with specific focus on the live multiple user viewpoints and user interaction with a portal.

The following topics were discussed:

- *Synchronised content across multiple devices:* Focus was on different types of contents and interactions on each device (TV-set, tablet, HMD). What should the role of the HMD and the tablet be when compared to the TV mode? What extra content and experiences should be shown on the HMD and tablet?
- *Interactive and explorative formats and portals:* The focus was on possible interactions and level of control between the viewer and the content. At what moments in the story/broadcast is there a desire for interaction with the content? What should a portal look like on the HMD and on the tablet? How do end-users want to navigate on the HMD and on the tablet? How do viewers want to be informed to use the HMD and the tablet for additional content exploration?

1.3. Status of this document

A first intermediate version of D1.2 was delivered in M06 and a second iteration was delivered in M12. This is the third iteration of the document, delivered in M22.

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 below.

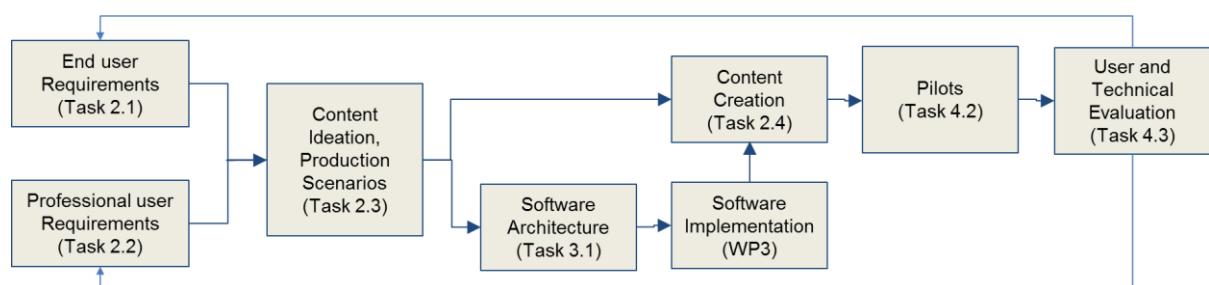


Figure 2: Relationship between different tasks

2. METHODOLOGY: USER REQUIREMENT WORKSHOPS

2.1. Motivation for the workshop approach

In order to obtain relevant requirements in this first exploratory stage of the project, a qualitative research approach is best suited to address in-depth the different user needs and expectations. Qualitative research methods allow thoroughly exploring and identifying the different dimensions of a certain topic. As a methodological approach for this specific task, we designed a structured workshop that is a combination between focus group interviews and co-creation workshops. This approach is inspired by the context mapping as described by Sleeswijk Visser et.al. (2005). A first step in the approach is the sensitization in which respondents could experience different content fragments in VR on head-mounted displays, Google cardboards and smartphones. In a first part of the workshop, a group discussion took place in which the first experiences of the respondents were discussed. In a second phase of the workshop, a structured content ideation exercise was foreseen in which users could develop their own VR program format on paper (see annex 1 for a detailed description of the assignment). The combination of a focus group interview with a generative technique such as a co-creation exercise, allows for a deep understanding of the user context, as is shown in the figure below by Sleeswijk Visser et. al. (2005:124).

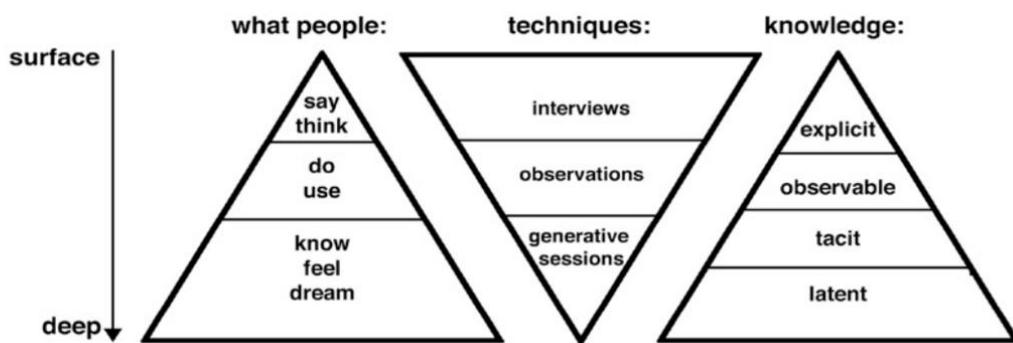


Figure 3: Different levels of knowledge about experience are accessed by different techniques¹

By making users reflect about their own concept for a TV-program they would like to watch, they are also forced to think about other specific contextual factors, such as social context, the specific devices they would use to access the content, etc. The advantage of group discussions is that it is an efficient way to aggregate information of a group of people. The researcher can directly interact with the respondents, go in-depth on certain answers and also notice gestures and facial expressions. The answers on the questions are open and formulated in the respondents' own words. The researcher can find deeper levels of meaning, make important links and identify subtle nuances in expression and meaning. The group aspect of the workshop also allows for rich interactions between the participants, as they can build further on answers of other respondents, and people are encouraged to talk about matters that are evident, and that would otherwise not be mentioned. Contradictory responses can immediately be discussed. On the other hand, some participants in the focus groups might be less eager to talk, when their opinion is conflicting with the general opinion. Another important limitation of group discussions is that there is the risk of overestimating the extent to which the results can be generalised (Stewart & Shamdasani, 1990). Therefore, it is important to organise multiple group sessions, including in other involved countries, also to take into account possible cultural

¹ Sleeswijk Visser, F.,e.a. (2005) Contextmapping: Experiences from practice. CoDesign: International Journal of CoCreation in Design and Arts.

differences. These sessions will be planned for the next iteration of the deliverable. In a later phase of the research, a quantitative survey will also be foreseen as part of our mixed methods research approach, in order to make quantitative generalizations possible.

2.2. Detailed workshop procedure

2.2.1. First iteration

In a first stage of the project, 2 end-user workshops of 2,5 hours took place at VRT premises. The workshops were organised in parallel with the professional requirement workshops that are reported in D2.2. For the introduction and the closing discussion, the end-users and the professional users were brought together for the discussion. The feedback on VR experiences and the ideation exercise took place in separate groups.

The workshops consisted of the following activities (*a detailed overview of the workshop planning can be found in annex I*):

INTRODUCTION

- *Introduction and demo of VR examples (annex I)*: Users could experience some VR examples on different devices (HMD, tablets, Google cardboards).
- *First feedback on VR experiences*: The workshop participants share their first ideas on how they experienced the different demos they've seen as well as their reflections on main opportunities and barriers for omnidirectional video, opportunities for future TV-experiences, optimal content formats and willingness to pay.

IDEA GENERATION AND FORMAT

- *Content ideation exercise – design of the experience*: In teams of 2, end-users are asked to create their own ideal future TV-experience. They receive a blank poster and an inspiration kit including different pictures (people watching TV in different settings), different genres, timeline (how would they map out their program in time, when do they foresee which interaction), etc. They are guided to reflect on the content and the context (where, how, with whom, ...)
- *Presentation of content ideas + discussion*: The teams will present their content formats to each other. This is followed by a discussion about the different formats and the context of these formats.

DISCUSSION WITH END-USERS AND PROFESSIONAL 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 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, we will focus 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.

- *Presentation of end-user formats to professional users:* Also the end-users will briefly present their concepts followed by a discussion.

2.2.2. Second iteration

In the second phase of the project, a new workshop was organised with a specific focus on the live scenario. This workshop consisted of two main parts:

EXPERIENCES AND EXPECTATIONS ON MULTI-DEVICE CONTENT FORMATS

- *Previous experience with VR:* discussion of experiences of participants with VR content and devices (e.g. Google Cardboard, other HMD)
- *Opportunities and barriers of VR in combination with TV broadcast content:* participants discussed their expectations towards multi-device formats in which TV broadcast content is combined with other devices in which omnidirectional video content is displayed. Different opportunities and barriers were addressed.

IDEA GENERATION AND DISCUSSION

In the second part of the workshop, participants created their own format for a live broadcast event. They could select the event themselves; the only requirement was that it was content that was broadcast live. The different developed formats were presented and discussed with the other participants.

2.2.3. Third iteration

Offline content

A new workshop was organised with a specific focus on the exploration mode. The workshop was organized at the imec premises in Brussels. It consisted of the following three main parts (*a detailed overview of the workshop planning can be found in annex II*):

INTRODUCTION

- *Introduction and demo of VR examples:* Users could experience some VR examples on different devices (tablet, HMD). A movie was shown from the ImmersiaTV pilot I demo.
- *First feedback on VR experiences and on the ImmersiaTV concept:* The workshop participants shared their first ideas on how they experienced the different demos they've seen as well as their reflections on main opportunities and barriers for omnidirectional video, opportunities for future TV-experiences and optimal content formats.

IDEATION EXPLORATION MODE TABLET AND HMD

This section of the workshop consisted of two parts.

First, participants were asked to brainstorm on exploration elements. They were shown different examples of static 360° content (e.g. virtual tours of cities and houses) with some basic exploration elements that enable the user to further explore the image. They were asked if they thought this would be interesting for a video as well and what exploration elements provided

an added value, and to brainstorm on what other elements could be added and how they would use these elements to tell a story.

Second, participants were divided into two groups and asked to design a multi-device TV experience for a detective/'whodunit' content scenario. This concept was selected as it will be used in pilot 3 (see D2.3). To keep the discussion as open as possible, they were only provided with the following short synopsis:

Mr. Ample is found dead in his study by his housemaid in the morning. Two police inspectors are called to the scene to this mystery. What happened? Murder or accident? Search for the offender!

The participants were asked to reflect on what content they wanted to see on what device (the television, the tablet and the HMD) and the context (where, how, with whom, ...). After this, the teams presented their content formats to each other. They were encouraged to ask each other questions.

DISCUSSION

In the last part of the workshop, there was an in-depth discussion on the main opportunities and barriers for interactive VR, and the (different) viewing experiences on the television, the tablet and the HMD.

Live content

For the pilot 3 live content scenario, user tests and interviews were organized with end-users. First, each participant was invited to watch a developed demonstrator for pilot 2.

After viewing the documentary, an interview took place with each participant. These user tests and interviews combined two user research activities for the ImmersiaTV project. The interview therefore consisted of two parts:

1. **Part 1: End-user evaluation:** here, the participant was asked to evaluate the developed demonstrator and the viewing experience and portal on the different devices. The results of this first part of the interview will not be discussed in this deliverable, but in the deliverable D4.4 which reports on the user evaluation activities.
2. **Part 2: End-user requirements:** in this part of the interview, input was gathered for the end-user requirements of the live pilot 3. The results of this part of the interview will be discussed in this deliverable. The topic guide can be found in annex III.

INTRODUCTION AND DEMONSTRATOR

To start, each participant was invited to watch a developed demonstrator for pilot 2. The demonstrator showed a live simulation of a soccer game. A web-based set-up was applied, that consisted of a web server deployed in Poznan (Poland) with contents for head mounted displays, tablets and television. On the tablet and the HMD, there was a basic portal to interact with the content (see Figure 4 and Figure 5).



Figure 4: Screenshot portal tablet



Figure 5: Screenshot portal HMD

The test took place in a room that was set up and organized as a living room.

Devices used in the test were:

- HMD: 1 Samsung Gear VR + 1 Samsung Galaxy S7
- Tablet: 1 Samsung Galaxy Tab S2

DISCUSSION AND IDEATION

After discussions about how they experienced the viewing of the demo on different devices, participants reflected on the main opportunities and obstacles for interactive VR in a live broadcast scenario. They were asked to reflect on what content they wanted to see on what device (the television, the tablet and the HMD) and the context (where, how, with whom, ...), and on how the interactive portal should look like on the tablet and the HMD.

2.3. Participants

2.3.1. First iteration

Participants were recruited via posters at VRT premises, social media, a specific call via VRT Proeftuin² and a specific call via the university network.

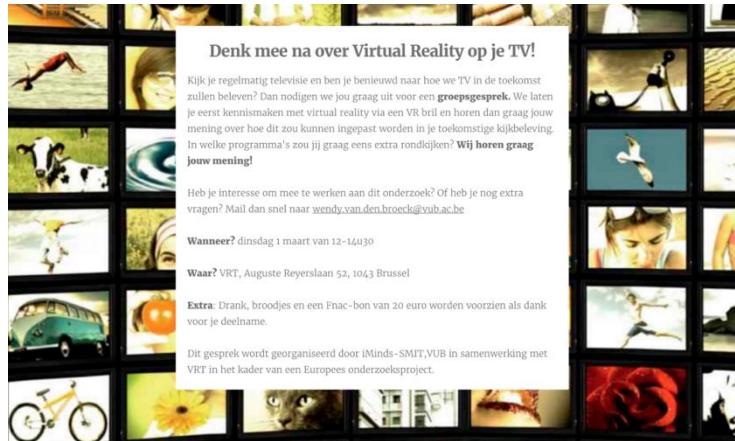


Figure 6: Example of call for participants ‘share your thoughts about VR on TV’

In each workshop, there were 9 participants. There was a good gender balance 10M/8F and a good representation of different age categories. The youngest participant was 20 while the oldest participant was 70. The average age was 37. Some users already had some previous experience with VR demos but most of them did not.

All participants signed an informed consent form prior to their participation in the workshops. For privacy reasons, all names of respondents were replaced by acronyms.

Participants Workshop 1:

Name ³	M/F	Age	Occupation	VR experience
Valerie	F	21	Student Master of Science in Adult Education	/
Lisa	F	21	Student Master of Science in Adult Education	/
Tim	M	39	ICT engineer/management	Demo's oculus rift
Ludo	M	47	Technical engineer	Demo
Rien	F	25	Product designer/ UX designer	Demo + guided VR tour to buy a house

² VRT Proeftuin is VRT’s living lab user panel, consisting of a database of about 1000 users.

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

Eva	F	48	Communication	Oculus rift demo VRT news
Amanda	F	28	Graphical design	Demo Samsung gear
John	M	56	Administrative staff	/
Peter	M	70	Pension	/

Participants Workshop 2:

Name ⁴	M/F	Age	Occupation	VR experience
Mona	F	20	Student	/
Dan	M	61	Director assistant	/
Sarah	F	27	Educational support at NGO	/
Mike	M	56	Project coordinator Telecom operator	/
Tom	M	26	Communication department	News studio demo
Chris	M	27	Looking for a job	/
Rob	M	53	Webmaster	demo
Joe	M	30	Student psychology	/
Els	F	27	Radio advisor	/

2.3.2. Second iteration

In the second iteration, a group interview was organised at the campus of the Vrije Universiteit Brussel. Participants were all students.

Name ⁵	M/F	Age	Occupation	VR experience
Simon	M	28	Student communication studies	Tested VR Google Cardboard

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

⁵ Names have been altered to ensure anonymity of the participants.

John	M	23	Student economics	Brother in law is VR game developer, tested VR games
Sunna	F	22	Clinical psychology	1 demo on Playstation
Jill	F	20	Student communication studies	Google Cardboard short fragments
Sara	F	20	Student communication studies	No experience yet
Ken	M	22	Teaching	Playstation demo
Nadia	F	24	Adult education	Google cardboard short fragments

2.3.3. Third iteration

Offline content

The workshop was organised in the imec offices at the campus of the Vrije Universiteit Brussel in September 2017. Participants were recruited via the university and personal networks of the researchers and an online poster was spread on social media.

7 people participated in the workshop. There was a good gender balance with 3 male and 4 female participants. All participants were in their twenties. Two participants already had some previous experience with VR.

All participants signed an informed consent form prior to their participation in the workshop. They were rewarded with a 20 Euro coupon as incentive for participation.

Name ⁶	M/F	Age	Occupation	VR experience
Ariane	F	25	Student in criminology	/
Andy	M	25	Legal counsel	/
Manon	F	24	Researcher	Demo on event
Jonas	M	27	Computer scientist	Google cardboard short fragments
Jens	M	26	Administrative assistant	/

⁶ Names have been altered to ensure anonymity of the participants.

Astrid	F	24	Just graduated, looking for a job	/
Sophie	F	29	Administrative assistant	/

Live content

The interviews were organised in the imec offices at the campus of Vrije Universiteit Brussel in December 2017. Participants were recruited via the university and personal networks of the researchers.

7 people were interviewed. 3 participants took part in tests individually, and 4 participants took part in tests in 2 teams (2x2 people) and had a duo-interview. These last individuals knew each other already before they participated in the test, as we wanted to observe the social interaction of the participants while viewing the demonstrator.

Interview	Name ⁷	M/F	Age	VR experience
1	Annie	F	26	Google cardboard short fragments, has seen one complete documentary in VR on event
2	Zita	F	23	Demo in electronics store
	John	M	23	/
3	Wendy	F	24	Demo in electronics store
4	Timothy	M	28	/
	Cathy	F	32	Demo at event
5	Walter	M	43	Demo of gaming applications

⁷ Names have been altered to ensure anonymity of the participants.

2.4. Analysis procedure

The workshops were fully recorded on video and audio. A full ad verbatim transcript of each workshop was made. For the analysis, a grounded theory approach was applied, using open, axial and selective coding.

3. END-USER REQUIREMENTS FOR IMMERSIVE TV EXPERIENCES

From the discussions during the end-user workshops in the first iteration, different requirements could be identified. In this section, these requirements are structured and described in more detail. General experiences and requirements are discussed in section 3.1. Next, we address the specific ImmersiaTV challenges with regard to synchronized multi-platform content experiences (3.2) and interactivity in general as well as portal-based interactivity (3.3). In 3.4 specific omnidirectional program formats are discussed, starting with an overview of content types respondents thought were most suited for omnidirectional TV-experiences, followed by an overview of their own developed content formats.

The results of the workshop on live content scenarios (iteration 2) are listed at the end of each section, explaining the similarities and differences with the results from the first research phase. Some additional requirements are also formulated.

A third section (iteration 3) has been added that lists results of the workshop on the pilot 3 offline content scenario, and on the results of the interview on the pilot 3 live content scenario.

The requirements are numbered in a three-layer manner: e.g. R.1.1.1. Where 'R' stands for requirement, the first number refers to Task 2.1 (end-user requirements), the second number refers to pilot 1 (R.1.1.1), pilot 2 (R.1.2.1) or pilot 3 (R.1.3.1) and the third number lists the requirements.

3.1. General VR experiences and requirements

Based on the experience with the different demos and the discussion afterwards, different **findings** related to the user experience and contextual factors influencing this experience were identified. In this section we will discuss these more generic experiences and requirements.

3.1.1. VR is considered an innovative and natural experience

3.1.1.1. First iteration

For those respondents that have no prior experience with VR, the demos are mostly received in a positive way. First impressions mentioned by respondents are **innovative, surprising and interesting**.

I: "What do you mean when you say that it is innovative?"

John, age 56: "That you get immersed in the atmosphere and the reality and that you are so close to it"

Respondents are also surprised about how quickly they get used to the VR experience.

Ludo, age 47: "What I find remarkable is how quick you get used to it. Within a few seconds, you are really into the story. It is really natural. It is amazing how quick you are into the story"

Lisa, age 21: "Yes, you completely forget where you are... I even got scared of movement around me, that I thought, wow, someone came closer and I really thought he's going to bump into me"

3.1.1.2. Second iteration

In the second iteration, almost all respondents already had some previous experience with VR content, mainly via Google cardboard. Based on this previous experience, they see a lot of potential for VR experiences. Mentioned benefits are for example related to **education**, where you could get a 3D omnidirectional view of the study topic (for example in medical training). But also in program formats, some options were seen, for example a **game show**. However, this respondent doesn't expect it to completely take over the traditional broadcast experience, they see it as **complementary to the traditional broadcast experience**:

Simon, age 28: The regular framing of a movie on TV will still exist, but I think it can lead to new formats. For example, game shows in which the viewer can look inside the image and find clues. Or movies in which you are actually in there, just like in games. A bit like we know the 3D glasses now, but then taken to the next level. I think a lot is possible, the question is how the average TV-viewer will adopt this, youngsters maybe quicker than older people".

The offered **perspective** in VR was also something that was considered beneficial. In VR (if shot correctly), viewers have a realistic perspective on people and objects.

John, age 23: "Also the scale is different, it is a completely different experience to see a 2D camera recording of a building or to stand in front of it yourself in VR. The size of things is really difficult to see in 2D, this is much better in VR. I've played for example a Zombie game in VR, you really see people the same size as yourself coming towards you".

3.1.1.3. Third iteration

Offline content

In the third iteration, only two respondents had a limited experience with VR. Among those respondents that had no prior experience with VR, the demos were mostly received in a positive way.

One person said she thought VR could be scary, because you don't know what is coming.

Ariane, 25: "It's nice if you know what's coming, but I'm really afraid of snakes so I would freak out if I watch such kind of movies in VR".

Another respondent thought it would be nicer to be able to walk around with the HMD, to really have the feeling of being 'in' the experience.

Astrid, 24: "I don't think you can really experience it if you sit down. If you could walk, it would be different. You could for example really be in between lions".

Live content

Of all participants that were interviewed, 5 already had a first but limited experience with VR (mostly demo at event or in an electronics store). 2 participants had no experience with VR before the start of their test. One among the latter participants said he liked the HMD experience the most because this was something new and he had already used a tablet.

Timothy, 28: "But I like the VR glasses more because of the novelty factor."

3.1.2. Physical discomfort

3.1.2.1. First iteration

Requirement R.1.1.1 - The end-user shall be informed about possible health risks (e.g., motion sickness, epileptic issues...) by adding a warning to the content

While most users had a positive experience while exploring the demo content (see annex I for an overview of the demo content) in the first phase of the workshop, some respondents experienced some nausea. One respondent had to take a seat, because otherwise she would get nauseated. Valerie was a bit dizzy because she had the feeling she would fall. This is linked to the fact that she could not see her legs when looking down.

Valerie age 21: "My problem was that I could not see myself anymore. That I had something, what am I doing now? You're in two worlds at the same time, you have the real world and the VR world and in the VR world you're gone. I really had the feeling I would fall while I was walking around."

Another linked aspect is the feeling that you are isolated while wearing a HMD with a headphone. Also the use of wearing the HMD is something respondents need to get used to.

3.1.2.2. Second iteration

In the second iteration, only one respondent experienced a physical discomfort in a VR experience prior to the workshop demo. This was in the context of a VR game on the Playstation and the discomfort was related to the **heavy weight of the HMD** that was used, which made it uncomfortable to wear for a longer period of time. The second iteration thus confirmed that physical discomfort should be avoided. Respondents also expressed their **concern about the health aspects** of using VR for a longer period of time. This relates to both physical and mental health. Physically, the influence of the VR experience on the eyes was questioned.

John, age 23 "I do have questions on the fact that, before they always told you not to sit too close to the TV-set because it was bad for your eyes and now they stick the screen on your face. I don't know whether that's really healthy."

Related to the mental aspects, a psychology student in the group questioned the ability of people to distinguish the real and the virtual if different cues would be offered at once.

3.1.2.3. Third iteration

Offline content

Physical discomfort was not part of the topics discussed during the third iteration. However, one person expressed physical discomfort while watching the demo movie, because he was wearing glasses and was astigmatic, which had as a consequence that he couldn't see a sharp image with the HMD.

Jens, 27: "I didn't have a sharp image. It is clear that the technology is not yet suitable for us."

Live content

Physical discomfort was not part of the topics discussed in the interviews.

3.1.3. Evaluation of VR devices

3.1.3.1. First iteration

Requirement R.1.1.2 - The end-user shall be offered a way to control his/her surroundings while watching VR content

All respondents agree that the HMD gives them the feeling that they are truly in another world, however there are some aspects to take into account.

One important element is the **feeling that you are isolated** while wearing a HMD with a headphone. You have to be able to really trust the environment you are in. For example, users would not use a HMD to watch something on the train. But also in other settings you might feel vulnerable while wearing a HMD, as you are audiovisually completely isolated.

Amanda age 28: "There should be something that allows you to have more control over your surroundings. For example, that you would have a button and that you would immediately get a normal view of the room when you push it, in case you hear something, without having to take off the HMD. That would give me more trust to use the HMD".

The **feeling of wearing the glasses** is also something that needs some getting used to. Some respondents didn't like the feeling of having headphones over the HMD, others thought that the HMD were rather heavy. But compared to the Google cardboard, respondents did agree that the HMD gave them the real feeling of being completely in the content.

Although there was almost no prior experience with HMD, how it worked was considered quite **user-friendly**. The only thing you can do is adjust the sharpness and select content by tapping, so there is no long learning curve to be able to work with the devices, it is rather straightforward.

In terms of **pricing**, respondents agree that it would be quite expensive if everyone in the household would need a HMD. If only one of them has one, they question what others in the household would do while one is watching the additional VR content. For example, if they are watching a program together with a VR moment, what should others do then? For some it might be interesting to have a picture in picture on TV that shows what the one with the HMD is seeing. For others, a combination of different devices, others using for example a smartphone or tablet is a realistic option.

Price will be the main drawback for the adoption of a HMD. A Google cardboard offers a cheap and affordable alternative, but it will not offer a similar engaged user experience as the HMD would offer.

Tom, age 26: "To me it is the added value that you put on the glasses (HMD) and that you are in there. While holding a smartphone, it seems like something I already had. We can already click around in smartphones for a long time".

3.1.3.2. Second Iteration

In the second iteration, the requirement on the ability to **control the surrounding** was confirmed. For Julie, the fact that not all types of HMD allow to indicate the walls of the room, led to people bumping into the walls in previous VR experiences.

Jill, age 20: "When I tried it out myself, I was standing on a wooden platform and I saw people falling on the floor, because you don't have any control on the surroundings, you

only see in the glasses... I think there should be someone with you, to avoid you hurting yourself".

Other respondents tested HDM that allow you to **indicate obstacles**, to make the experience safer, as this system will warn you when you are near an obstacle. Of course this is linked to a higher price tag, as only the high-end HMD offer this possibility.

3.1.3.3. Third iteration

Offline content

In the third iteration, preference for a device was linked to its specific affordance. Some respondents preferred the tablet over the HMD because the HMD **isolated** them from their surroundings, while others for exactly this same reason preferred the HMD. They said the HMD gave them the **possibility to be in another world**.

Astrid, 24: "The tablet is less intrusive. With the tablet you are still in this world, you can see the people around you".

Ariane, 25: "The glasses give you the idea that you're not just at home. (...) While with the tablet you can't forget your surroundings".

Live content

No new insights were gathered with regards to this topic in the interviews.

3.1.4. Image quality

3.1.4.1. First iteration

Requirement R.1.1.3 - The end-user shall watch the VR content with an image quality that is equal or better than the image quality on their TV.

Some respondents were surprised and somewhat disappointed about the image quality of some of the demos as they expected a perfect image quality. This is of course related to the content that was used for the demo and also all respondents might not have optimally used the settings for the sharpness in the HMD. Some respondents referred to a grain in the image and the pixels that were too large. It is of course important to keep in mind that users expect at least an HD image quality and in the recordings for the pilots, we should also strive for an image quality in line with the end-user expectations. Users see this as the next step beyond HDTV, so they also have high expectations in terms of quality of experience. They expect at least similar quality to what they are used to from their TV-set at home and from mobile devices they use (smartphone, tablet).

3.1.4.2. Second iteration and third iteration

Image quality was not discussed during the second and third iteration. In these iterations, no specific feedback on the image quality was provided.

3.1.5. Social viewing

3.1.5.1. First iteration

Requirement R.1.1.4 & R.1.1.5 - Social viewing should be facilitated, either physical or virtual:

- *R.1.1.4 - The end-user shall enjoy a physical social viewing experience via picture in picture or via content duplication of the HMD content on other devices.*

The HMD display is automatically linked to individual viewing as people tend to talk to each other when watching content with other people. The use of headphones is not really compliant with this social viewing experience.

Tom: I'm not certain it always has to be with audio. If we are watching together, we talk about the programs and give our opinion. If you would look around and have no interaction with your family members anymore, this would make it very individual. I would prefer to have the audio of the TV if you're with a group of people".

The image of a family all using HMD is not something that is realistic at this moment in time. Respondents feel this is rather awkward and it is also rather expensive to buy multiple HMD.

- *R.1.1.5 - The end-user shall enjoy a virtual social viewing experience via virtual representation of others in the content*

The fact that you see no other VR users in your VR experience is also something that makes it a solitary experience. A social setting in which users could imagine using HMD is a remote use case, in which they would watch a program together with family members or friends at a distant location. Then of course there would have to be a way to interact with other VR viewers. The use of avatars or a real-life representation of the users would then be beneficial.

Also in the content examples that are discussed below, for example in the news enhancement, the representation of and interaction with virtual friends and family in the VR world was mentioned. This should not necessarily be a spoken interaction, also a non-verbal interaction with gestures would be sufficient.

3.1.5.2. Second iteration

In this workshop, requirement 1.1.5 (offering a more social viewing experience by adding avatars or representation of other VR users in the content) was considered one of the main opportunities of VR experiences. In this group, a lot of potential was seen in **created social experiences**, in which people with similar interests could watch content together in VR and interact with others. Examples here were a debate on the US elections that was broadcasted in VR and in which the audience could interact with each other in VR via avatar representations. Other examples were experiencing a movie in VR with friends that lived miles away. Participants agreed that this could be a good **alternative for the loss of real-life social interactions**, which they see as an inevitable effect of the HMD, as this leads to a form of isolation.

However, the use of **avatars** would not only be useful for distant VR experiences. It might also be part of a planned social activity with family members or friends.

Simon, age 28: "It is also an activity that you will probably actively choose to do and then it might be more fun to share this with family or friends. That everyone has a HMD and watches a movie together or plays a game. You can also do this on a tablet, then it's less isolated. I don't think it will completely be asocial, it's a choice you can make for yourself."

The social setting might also have an **influence on the selected device**. One of the respondents expects that the company and the availability of the HMD will influence his choice for a specific device:

Ken, age 22: "I think it will depend on whether you're in a group or not. If you're in a group and not everyone has a HMD, that you would take the tablet because otherwise it's asocial, but if everyone has a HMD, that you would use that".

3.1.5.3. Third iteration

Offline content

Requirement R1.3.1 - The end user shall enjoy a viewing experience with a program flow that enhances social viewing.

The respondents saw both advantages and disadvantages in using a multi-device set-up in a social viewing situation.

It could be interesting because people can view and explore what they themselves find interesting and people can see the same content in different ways. These **different interpretations could lead to interesting discussions**.

Astrid, 24: "It's asocial, but it's cool that different people could experience the same thing in different ways".

Ariane, 25: "If you have an opinion on something and everyone has a different interpretation, then this could be an added value".

At the same time, it is considered very **asocial** to use the tablet and HMD when watching TV in company of others, because **everyone is 'trapped' in his or her own experience**.

Ariane, 25: "The idea of everyone being at home in the couch together, but also locked up in the image, I think that's a bit sad. The cool thing about TV is that you can experience it together, but if everyone is watching something else..."

When using extra devices, a more individual viewing experience is created where not every person sees the same content at the same moment. If someone then reacts upon a certain scene, other viewers will not understand what is happening, or they could accidentally give away the occurrence of an important event (e.g. a sudden death) to the other viewers. This could disturb the viewing experience.

Astrid, 24: "If something major happens, and the person next to you reacts fiercely, then you know something happened. 'Oh no, not him!' and then you know someone died."

Live content

The topic of social viewing was not discussed in-depth in the interviews. However, compared to the opinions on this in the offline content requirements workshop organized for pilot 3, the enthusiasm to use this kind of set-up in a social viewing situation for a live broadcast was not very high, and especially not in the use of an HMD.

Walter, 43: "If there is the option to use the 2nd screen as augmentation, I would use the tablet more. If you have friends, family around you, I would not use the VR headset. That seems a bit rude."

Annie, 26: "I wouldn't even use the tablet if I watch together with someone else. I can't handle too much at the same time."

3.2. Synchronised content across devices

In this section we address the different aspects related to the multi-device scenario in which content is synchronised across different devices.

3.2.1. Switching between devices

3.2.1.1. First iteration

Requirement R.1.1.6 - The end-user shall only have a limited number of VR interactions (3 or 4) in one content format

The idea of having short fragments integrated in the content, would mean that you would have to put the glasses on and off several times during the program. For some this is ok, others would prefer using a Smartphone for that reason. Important is of course the added value of the content. It is not something they would do for every program, there should be a clear added value. It would also be something they would probably not use every day, but for example once or twice per week, for specific selected programs.

Els: "I think with the glasses, if you really have to switch them on and off all the time that it will become something that is only used for 1 program every week. In the beginning you would probably use it more often, but after a month? We are very lazy when it comes to TV- viewing. I think it requires some effort to put the glasses on and off 5 times in a row."

Dan: "Maybe the look of the glasses will also change. It doesn't always have to be this heavy thing. Maybe in a couple of years it looks very different."

3.2.1.2. Second iteration

Requirement R.1.2.1 - The end-user shall be provided with sequences that are long enough to make the switching between the devices worthwhile

In the second workshop, respondents agreed that the number of VR interactions should be limited, but they were also worried about the duration of the interactions. The offered interactions should at least take **more than a couple of minutes**, to make the experience worthwhile. The option to interact should also be indicated on the TV-screen well in time, so people don't miss the interaction. This is particularly relevant in live scenarios, where it is more difficult to pause or rewind the content than in offline content scenarios.

Sara, age 20: "When they say on TV: now there is a VR interaction moment, it can only work if it is for a longer duration. Not for one minute, because then you are probably too late when you are putting on and off your glasses, It should at least be for like 10 minutes or something."

Requirement R.1.2.2 - The end-user shall be offered the option to preview the VR content on a smartphone or tablet

There was an agreement that the HMD offers a better experience compared to the tablet. The fact that you are really in the image when you are wearing the HMD, the 3D effect compared to

the 2D effect on the tablet, the difference in perspective and height and the experience of being more immersed in the content, lead to a clear **preference for the HMD to watch VR content**. Of course the content has to be relevant, which leads to the suggestion of the respondents to use other mobile devices such as the smartphone and the tablet to **preview the VR option**. This way they can decide whether the VR content is sufficiently attractive and relevant to use the HMD. This of course also indicates that while they consider the HMD more enjoyable, they also see it as taking more effort to use it compared to the tablet.

3.2.1.3. Third iteration

Offline content

Requirement R.1.3.2 - The end-user shall only watch a limited amount of (controlled) VR experiences during one broadcast in a whodunit scenario

Because of the effort required to switch between devices and because it always takes some time to get used to the new device (especially when going from the TV to the HMD and vice versa), it would be good to limit the number of HMD experiences during one broadcast. In line with R.1.2.1, these fragments should be long enough to make the switching worthwhile. Particularly in the case of a whodunit scenario in which viewers are looking for clues themselves, it is important that the VR interactions are more controlled and not distract from the storyline. Longer VR episodes initiated by the program director are expected to be more relevant in this scenario. An example here is a VR interaction right after a dead body is found, leaving the viewer the chance to look around in the room and look for clues.

Jens, 27: "We think it's better to limit this. Just once in a while, but then long sequences. (...) So you don't have to change too often. If you need to put the glasses on and off all the time, people would quit".

Astrid, 24: "I'm afraid you will miss certain things. (...) Or that you will not follow the story but be more occupied with what device to use and how to watch it."

Astrid, 24: "If you take off the glasses, you always need a couple of seconds to return to earth".

Live content

All requirements with regards to the switching between devices have been confirmed during the end-user interviews. The end-user shall only have a limited number of VR interactions. For sports content, these moments may suggest themselves quite easily (e.g. during breaks, replay after goal...).

Walter, 42: "It's like ad breaks. Sweet spot where it's least irritating. In a sports type context, these types of moments may suggest themselves quite easily."

3.2.2. Integration with regular viewing experience

3.2.2.1. First iteration

Requirement R.1.1.7 - The end-user shall not be distracted from the storytelling by the implemented VR interactions

Respondents also reflected on **how this would fit in their viewing experience at home**. Walking around could be dangerous, because you could bump into certain objects. If you are seated, you

have to be able to look around 360°, so you almost need a chair on wheels to be able to fully make use of the omnidirectional image. Although it is of course also expected that no one would be constantly turning to look around all the time, this is also not what we do in real life.

Some respondents question their involvement with the content, they feel they might become too **distracted** by the visual content so they might not hear what is said anymore, for example in the news or in a documentary, when you would be able to look around.

'Dan, age 61: "You don't realise what is being said anymore. You are looking to what is happening in 360°. You have to be careful that you don't lose a part of your story".

This is also the reason why respondents expect that it will not be a continuous experience, but that you would have **shorter intermediate fragments** in which people would be able to look around in VR. This would be like fixed break-out sessions within the program in which people could start looking around.

3.2.2.2. Second iteration

In the second iteration, this was foremost linked to requirement 1.19, here it was expected that people might lose track of the storyline if switching between devices takes too much time. This should be avoided.

3.2.2.3. Third iteration

Offline content

Also in the third iteration, the respondents are worried that the extra devices could make them miss (important) parts of the story as broadcasted on TV.

Requirement R.1.3.3 - The end-user shall view VR content not during but right after scenes with a lot of action, to slowly explore the surroundings and details.

The users prefer to watch the main action scenes on the TV, and use the tablet and HMD to further explore the content and surroundings during 'slower' moments in the story.

Andy, 25: "Right after an important moment".

Astrid, 24: "On moments where the story stops a bit. E.g. the scene where they find the body. That's the moment where everyone is thinking what could've happened. But not during action scenes. Then there is too much going on and with the glasses you would focus on something specific."

Jens, 27: "Yes if it goes slow. But if it goes too fast then you might loose track of the story." (...) "I think to explore details. A room, a corner, a bookcase. Things that would be weird to film with a camera".

Requirement R.1.3.4 - The end-user should have the possibility to indicate that the main TV broadcast is automatically paused when the HMD is used.

As discussed in the workshops of the first iteration, it sometimes makes sense to implement or to make use of pauses in the program broadcast on TV to offer viewers the option to look around or to explore. If the broadcast on TV keeps running, the respondents say they would not have sufficient time to explore the context with the VR devices out of fear of missing something.

Andy, 25: "You have to make the choice beforehand. Will it pause or not? If you really don't want to be interactive, then you throw the remote control to the TV. But the other way around, if it keeps running, you will never have the feeling that you have enough time to explore it."

Ariane, 25: "Unless the image would stop. (...) Then you can read the info and continue".

However, **if a broadcast is watched together with others, this might become a challenge**. Not everyone will use the VR devices at the same moment. **Should the TV broadcast be paused in social viewing situations and when?** An idea was raised that in that situation the TV broadcast should keep running, but viewers could then use the tablet to catch up with missed scenes.

Ariane, 25: "If you have chosen to use the VR goggles at that moment, then you pause the video on the tablet. And then you can go back to the tablet to watch the content delayed. People who are not interested in using the tablet or goggles can continue watching TV".

Live content

Requirement R.1.3.3 was confirmed here. Important actions or moments during a live event (e.g. final sprint cycling race, speech during Oscars) are preferred to be seen live on TV (the main device) and only in VR in replay.

Annie, 26: "During emotional moments (e.g. Oscar speech) I want to focus on the TV. Also, when something serious happens. Moments that touch me, I want to be carried away by these and block all other things. (...) Content is more important than interaction."

3.2.3. Length of fragments and integration in the content

3.2.3.1. First iteration

Requirement R.1.1.8 - The end-user shall view short VR content formats (max. 5 minutes) with short VR interactions

Particularly in the first developed examples, it is interesting to see that in most of the formats short fragments are integrated.

Rien: "It is interesting to see that in many of the concepts short fragments are used. This might also be the power of VR".

Dan also questions whether it would be possible to keep a longer program such as a political documentary interesting for 25 minutes when it's fully in VR. He also thinks it will be shorter fragments that are shown in between.

So most participants expect that it will be shorter VR fragments or moments that are integrated in a regular TV-show. In the discussion they also talked about how this integration would work. Some mentioned that there would for example be a regular channel and a **separate VR channel** and that the program was broadcasted on both channels, one for viewers who want to watch the program without any VR and the other one for the VR enhancement.

Another problem would be the **linearity of the program**. If you would for example allow for a VR break in the program, but one person is finished after 1 minute and the other wants to look around longer, how do you cope with that? How would the linear story proceed in that case? Having these VR moments also means that programs will last longer than they do now, which is also something to take into account.

3.2.3.2. Second iteration

This is also closely linked to requirement R.1.2.1. While in the first sessions, respondents agreed that shorter fragments are the way to go, in this group they were foremost worried about the **effort the switching of devices** takes. Therefore, they would go for longer fragments of at least a couple of minutes and the content fragments should also be sufficiently relevant.

In terms of linearity, programs with a different duration might be an option. Of course this is only possible for non-live programs, **for live content** it is important that viewers **keep the regular pace of the broadcast**.

Simon, age 28: "I can imagine that you would have programs in which viewers have to do assignments. It can be programs that follow the pace of the viewer. Some people would do it (the assignment) in 20 minutes, others in 40 minutes for example."

3.2.3.3. Third iteration

Offline content

In the third iteration, the respondents said they wouldn't want to watch a full broadcast for the first time in VR, but only certain fragments. However, it could be interesting to a broadcast for a second time in VR, because this can give new perspective on things.

Jens, 27: "It could be interesting to wear the glasses all the time while watching a broadcast for the second time. Now it also happens often that people watch a second time to look for details they haven't seen before."

Live content

No additional insights with regards to this topic were gathered during the end-user interviews.

3.3. Interactive VR experience

3.3.1. Camera position, viewing perspective and navigation

3.3.1.1. First iteration

Requirement R.1.1.9 - The end-user shall be able to explore the content by zooming in and out

Some respondents mentioned they felt as if being too close to the image while experiencing some of the demo content. This had as an effect that they felt uncomfortable while trying to grasp the scene, they constantly had to turn their head from left to right to get an overview of what was happening. **Being able to zoom in and out** is a necessity in this case. It would also make the experience more interactive.

Dan, age 61: "I constantly had to look from left to right to see what happened. I had the feeling I was too close to the image."

Requirement R.1.1.10 - The end-user shall view VR content that is recorded with the camera standpoint adapted to the viewpoint of the user

In the first workshop, most users experienced the content standing, in the second workshop most users were seated while watching the demos. This led to some differences in how the content was experienced.

In the second workshop where most people experienced the content while being seated, they often complained about the perspective. This is very important as in the ImmersiaTV use cases, we envision an audience that is seated in their living room and thus consumes the content from a different perspective.

Joe, age 30: "I've seen the Music for Life⁸ demo and what I noticed was that the camera was positioned so high. If I looked between the camera and the audience, that zone, there was really a hole, you really looked into the deep. It would have been better if the camera would be positioned on eye-height of the audience."

Els, age 27: "The proportions seem to fit better if you are standing... I think it is easier for your brain if you are standing."

Requirement R.1.1.11 - The end-user shall be able to select his/her preferred viewpoint from a range of different fixed positions

One of the questions was, assume that you would have a format like a football game, how would you want to decide where you would want to look? Here it becomes clear that this is also closely linked to the content. In the example of football, the idea is mimicking being there, on an actual seat in the stadium and being able to look around without any limitations.

Tim, age 39: "I think that this is an example where there can be no direction at all, where you really want to have the experience as, coming as closely as possible to the idea of I bought a seat in the football stadium and I'm just looking around. I think that needs to be the first step".

On the other hand, there is also the need for a "**god-figure approach**"

Amanda, age 28: "But also that you would have a kind of god figure. Because that is VR, you can also play a bit like God, because you can also fly. You're not just in the stadium, you can also fly or stand in the middle of the field"

In this discussion, the idea of multiple viewpoints that can be selected emerged.

Tim, age 39: "What would be great is that you would be able to look through the eyes of the players.

Amanda, age 28: "Or be the ball"

In the examples users give, the being **in someone's shoes perspective** often pops up. For example, being able to view things from the viewpoint of someone else. In that case it is also important to be able to see the feet and hands of the person, to make it a more realistic experience.

⁸Benefit concert of music group Sigma in De Schorre (Boom), for a charity purpose, in December 2015. Link: <https://www.youtube.com/watch?v=opnLc-J3qHs>

Requirement R.1.1.12 – The end-user shall have control over the camera perspective

Related to navigation and switching of perspective, was a comment related to the Music for Life demo⁹. In this demo, there was some changing of the viewer perspective. The image automatically jumped to another viewpoint. This was something that wasn't really appreciated by the users, as it interrupted their viewing experience. Also the stitching was not seamless, which made it even more intrusive. The transition should go more natural and not interrupt the experience

Rob, age 56: "I didn't like the cutting. I expected that I would be able to continuously select my viewpoint myself. But now it was cut and I didn't ask for this, I was watching this so don't interrupt me."

Sarah, age 27: "Yes you should be able to choose from which viewpoint you want to watch, but not the constant switching."

3.3.1.2. Second iteration

In the second iteration, the aforementioned requirements were confirmed. The perspective was seen as one of the main benefits of a VR-experience, so the right **perspective** (eye-height) is crucial. Also the selection of different viewpoints was considered a positive affordance. One of the respondents already experienced a content fragment from the perspective of the main character and found this a very positive experience.

Ken, age 22: "Everything is also maximised when you are in the image. I've seen something about football from the perspective of the ball boy. You really see what he sees when he looks to the left and to the right. If you see it on TV, you see people on the field, but here it was really from his perspective, and it felt much bigger".

3.3.1.3. Third iteration

Offline content

In the third iteration, the aforementioned requirements were confirmed as well. Especially for sports broadcast, the availability of different perspectives is considered a big added value.

Live content

The topic of camera position, viewing perspective and navigation was discussed in-depth in the end-user interviews.

Requirement R.1.3.8 - The end-user shall view VR content from viewpoints that bring the end-user right in the middle of the action and not just on the side line.

In the content that was shown to participants, all cameras were placed on the side line of the soccer field. A common remark during all interviews was that these cameras were placed too far from the action. Participants said that if they would use a tablet or HMD for omnidirectional video, they want to be fully immersed (with the HMD) and view the action from closer and different POVs than those broadcast on TV. Omnidirectional video should give the possibility to stand *on* the field, be *in* the crowd, stand *on* the stage, ... instead of *off* the field or *next to* the audience.

Cathy, 32: "Both the images on the tablet and VR, there were really far away from the actual action. I understand that it was interesting to have a camera next to the

⁹ Benefit concert of music group Sigma in De Schorre (Boom), for a charity purpose, in December 2015. Link: <https://www.youtube.com/watch?v=opnLc-J3qHs>

goalkeepers, but it was still really far. I wouldn't have switched to that if I really wanted to know what was going on. (...) The camera should be more on the field, not off the field. Maybe you could have a camera on the referee."

Wendy, 24: "(During concert) If they play a song everybody knows, it would be great to stand in the audience. Everybody will totally get into the music, and then you can really be immersed into this atmosphere with the glasses."

Requirement R.1.3.9 - The end-user shall view VR content from viewpoints that allow the end-user to have a close-up of the action.

The participants would like to watch extra viewpoints that enable them to have a closer look at things that are happening (close-up, replay from other angle) and see certain actions in detail, so they get to see more than what is broadcast on TV. The tablet and the HMD can and should enable them to be closer to the action.

Wendy, 24: "For gymnastics during the Olympic Games, the exercises sometimes go so fast that you don't see everything. It would be nice to be able to see this from closer. (...) For example, when they have to grab a bar, sometimes they miss it. It would be cool if you're next to the bar and see for yourself whether they will be able to grab it or not."

Requirement R.1.3.10 - The end-user shall view VR content not just from the spectator's POV but also from the POV of players, artists, ...

In line with the first iteration, the respondents like the idea of being in **someone's shoes perspective**. VR can offer the viewers the opportunity to view something from a POV that they would never or rarely be able to see in real life. Therefore, the POV should not just be that of a normal spectator as this is not considered unique or special. The respondents want to be able to stand in the shoes of, for example the athlete, the referee, the lead singer of a band, ... They would like to have the front row experience or have the artist's view from the stage.

Timothy, 28: "Also think that it's a big mistake if in VR that your POV is that of the spectator in the game. This is not a benefit. If a camera can be put at any point, you don't want the spectator experience."

Requirement R.1.3.11 - The end-user should be able to very quickly select and change viewpoints.

In the demonstrator, changing camera viewpoints took some seconds and this was considered too long by the respondents. Selecting camera viewpoints should be quick to access and changing the viewpoint should go very fast, so this doesn't become a burden for the end-user and they don't miss out on important actions.

John, 23: "There was quite some time between clicking and it changing. It needs to go faster."

Walter, 43: "And it should be quick to access, so I don't miss something else."

3.3.2. User wants to be in control

3.3.2.1. First iteration

Requirement R.1.1.13 - The end-user shall be able to select his own viewpoint anywhere in the content and act as a director

Respondents in the focus group really liked the idea of being in control themselves, being able to decide for themselves what and where to watch. They like the idea of viewer as director.

"Lisa, age 21: "Normally if you watch an image, it is always the person behind the camera that decides what you see. And with the VR glasses, you can really decide for yourself, no I don't want to watch there, I prefer to take a look over there. That you have the feeling that you are not pushed in your viewing experience, but that you can take the lead yourself."

Amanda, age 28: "I also like the idea of viewer as director, because even though I have for example nothing with football, I can imagine that for some people that like to watch football, it is interesting to be able to say: I would like to see how that trainer is doing or I want to take a look at the bench. That you can really decide for yourself I now want to see this or that. That really sounds cool for a sports experience."

Of course it is important to keep in mind that even though users clearly say they want to be in control, this is not necessarily always the case in every situation. Sometimes a limited level of control is already sufficient, for example being able to look freely around in an image, but at fixed moments in time that are selected by the storytellers. So there should be a balance in the level of control that is given to the user and that is given to the director or storyteller. Here there will probably also be an important difference in terms of live versus non-live content. This is something to further explore in the next phases of the research.

Level of control: user vs. director

Requirement R.1.1.14 - The end-user shall be able to choose viewer vs. director control

When users would look around in a certain image, it is possible that something interesting happens elsewhere in the image. For example, in a football game, there might be an interesting action that you might not want to miss. For some users it is essential that they would be directed and receive a kind of notification of where to look in case something interesting happens. There should be a way to keep the overview at all time.

John: "You should be able to keep the overview, you need to have a choice, you can now go over there. But you still need to keep the overview. There might be a goal".

For others this is not the case, they see it is a risk, it is also something that happens in real life if you look into the wrong direction and it is part of a natural viewing experience.

Amanda, age 28: "Yes, but that is the risk, it is also possible in real life that you look into the wrong direction. It is about making choices; you cannot watch two things simultaneously"

A suggested solution by the users is that you **build in an option**, where viewers give permission to the directors to turn your viewpoint to where the action is (for example if you are watching the bench and there is a goal). Then they would be certain that they could look around in a relaxed manner, without having to fear they would miss out on something. But this should be optional, to give users the opportunity to fully keep in control if they want to.

Here we noticed in **important difference for live content compared to offline content**. In offline content it would make a lot more sense to implement or to make use of pauses in the program to offer viewers the option to look around or to explore.

3.3.2.2. Second iteration

Particularly for live content, requirement 1.14 was confirmed. The viewers should get the choice to be directed to certain events or to freely look around. For Sara for example, being able to take over control is an essential part of the VR experience:

Sara, age 20: "They (the directors) cannot decide everything, because then it is what it is now on TV and then the concept of VR gets a bit lost".

Requirement 1.2.3. - The end-user shall be offered the option to replay certain parts in VR during and after the live broadcast

For live content, the **fear of missing out** is certainly an issue. The idea of being able to select for yourself what you would like to see, is not always possible in a live setting, because you will miss part of the simultaneous action. One possible option is to have multiple VR streams, each from a different perspective. For example in cycling, viewers could choose to follow the stream that features their favourite cyclist. Another option is to explore events after the live broadcast. For example in live news reporting, viewers might be willing to take a look at the location of the event after the live reporting as well. This idea was also integrated in one of the developed formats (see infra).

3.3.2.3. Third iteration

Offline content

The findings of the first and second iterations were confirmed in the third iteration. Users like the idea of being able to explore the content on their terms, but they are afraid of missing out on important actions at the same time as well. They therefore **prefer to follow the lead of the director that guides you where to look**, especially for fiction.

Jonas, 27: "The director switches to where you have to look. And then you can just have an extra look around if you put on the glasses".

In the whodunit scenario, there is a need for **triggers that guide you where to look** and what device to use for the optimal viewing experience. This to avoid missing certain clues. However, **at the same time, this also actually takes away the idea of user control**.

Sophie, 29: "There needs to be an indication 'now you have to look up', otherwise you might miss things".

Ariane, 25: "But if they indicate that now you have to look up, then the whole concept of being able to choose where to look disappears. Then they could have as well filmed it and you could have seen it on the big screen."

Requirement R.1.1.14 is confirmed. Users want to indicate at the start of the broadcast whether they want to be guided by the director or not.

Manon, 24: "you have to be able to choose. In the beginning of the broadcast, half-way... It should come back a couple of times."

Live content

Requirement R.1.3.12 - The extra camera streams and user viewpoints should give the end-user the possibility to create a more personalized experience, by allowing the end-user to focus on their actors and actions of choice.

All requirements from the previous iterations with regards to user control have been confirmed in the end-user interviews. Being able to be a bit more in control about what and where to watch is considered especially interesting for sports where it is hard to keep a good overview of what is happening (e.g. cycling, Formula 1). For sports where there is a good overview of the field of action (e.g. soccer), TV is considered the best option.

Omnidirectional video and extra camera streams can enable end-users to create a more personalized viewing experience. They can for example choose for themselves to focus on a certain cyclist and follow this cyclist throughout the race.

Zita, 23: "If my father and brother watch a cycling race together and they want to see another peleton, then the glasses are handy."

John, 23: "Yeah it's really valuable for a big fan. If they would place a camera every kilometre, then you can select the camera you want".

Zita, 23: "Or that you can follow the motor (with the camera). And you choose the motor you want to follow."

Annie, 26: "You can make it more personal by filtering out the others. For example, following certain people at the Oscars. Or watch everything from in the corner during a football game."

Requirement R.1.3.13 - The end-user should be guided on certain moments from what viewpoint the content is interesting to see, live and for replays.

Similar to the previous iterations, the respondents have a fear on missing out on important actions when they look around in the image. This is especially the case for live broadcasts. Having multiple screens and multiple video streams on each screen can become too much to follow, making the viewing experience also burdensome.

Annie, 26: "If there are too many options on the tablet, I would never find peace. Aah will watch that, or no maybe this is better... but am I making the right choice? This would make me restless."

There is a need for a little bit of director's control that guides the viewers to where the action is happening. The portal should indicate where the action is happening or from what viewpoint the content is most interesting to see. For example, on the portal a certain viewpoint could start glowing in a certain colour to indicate that this is the best POV to see what is happening.

Cathy, 32: "The problem is, how do you know from before what angle to see? On TV the director chooses for you."

Timothy, 28: "In a way, total freedom is nice, but the added value could also lie in preselection."

Cathy, 32: "A camera that is more important could start glowing red."

Annie, 26: "On the tablet I was often looking in the wrong direction. A green dot around the camera viewpoint could indicate where the action is happening."

Requirement R.1.3.14 - After watching a replay on VR devices, the end-user should be able to click 'resume live broadcast' on the VR device.

Requirement 1.2.3 is confirmed. The end-user should be able to watch replays of certain actions from different viewpoints.

Timothy, 28: "I probably would do it if I was watching TV, and there is a goal and I'm not happy with the images, I would watch the video again."

Cathy, 32: "Can you also have a replay option? That's when I would turn to the... to get more info then you have now."

After watching a replay on the tablet or the HMD, the viewer should be able to very quickly return to live stream by clicking a certain button.

Walter, 43: An action replay that you could watch from different angles. You decide you want to go back 3 seconds and watch this from this angle. 'Rewind camera 1'. And afterwards 'resume game'.

Requirement R.1.3.15 – The end-user should be notified, when watching a replay in VR, of important actions happening live so they don't miss these.

As mentioned before, the respondents have a fear on missing out on important actions when they look around in the image. This is also the case when they watch replays. A notification should alert them to return to the live broadcast if important actions are happening.

3.3.3. Follow the action: make use of triggers

3.3.3.1. First iteration

Requirement R.1.1.15 - The end-user shall be guided on where to look in the VR content by natural triggers that serve as anchor points

Related to the fear of missing out on something is the idea of providing **some anchor points** for the user so he or she always knows where to watch. This can be an automatic tracking of the ball and an indication of where in your view (to the left or to the right) the ball is at any moment in time. This could also be the case in action content, that you would be able to know where the action is. Although here this is also seen as the role of the content creator, to be able to draw viewers to where the action is.

"Tim, age 39: "I was also thinking, if you would have an action movie in 360°, then it would be cool if you could always see where the action is. But that is of course the art, that you are able to pull people towards the action. I think that is the difficulty, if you have the freedom to watch, in the meantime you might have missed out on the action".

Other examples of possible triggers would be if you are watching together with other VR users and you would be able to see them, that they would also be able to point you in a certain direction.

Also **audio cues** might be a good natural way to trigger people to look in a certain direction.

The concept of **portals** was also demonstrated via an example and discussed in the workshops. One of the respondents, Rien already had an experience with a VR tour in a house for sale where

they applied a similar concept to go from one room to another. She thought this was very useful in this context, but she questions whether this will be this easy in every situation.

Portals are also considered a good trigger to point the user in a certain direction, so they know, you can now go there.

Important when using triggers is that they **not interrupt the VR experience** by being too out of line with the content. Therefore, it is essential that the portals are integrated as natural as possible in the content.

Amanda: "*audio is always good as this is a typical natural cue. Also visual things, but they cannot break with the visual experience*"

Ludo: "*I also have the feeling that certain signals will break with the story. I think it will be weird when you're in that world and you suddenly see something flashing. It should be something natural.*"

Amanda: '*For example that a certain type of bird would fly by and that that is your cue to look somewhere. Or a balloon that flies, it should be something natural, not a button that suddenly emerges.*"

Rien: "*Also in the example of the VR news demo, the news anchor pointed to the weather presenter and you were automatically taken to the weather presenter, I thought that was a good transition*".

Ludo: "*You actually need a kind of VR director, someone that based on your interests points out: hey did you notice that?*"

3.3.3.2. Second iteration

The type of clues was not discussed in the second phase.

3.3.3.3. Third iteration

Offline content

The concept of **interactive elements to further explore the content** was discussed in the first and third iteration. Whereas in the first iteration focus was on natural triggers, focus in the third iteration was on portals and interactive visual elements to guide the viewer.

Requirement R.1.3.5 - Onscreen indications shall guide the end-user on what moments it is useful to use the VR devices. These indications shall be subtle and not interfere with the viewing experience.

Portals are a good trigger to point the user in a certain direction, and they can enable interested users to learn more about the content if they wish. **There should be an indication on the TV screen at the moment it is useful to use the HMD or tablet.**

Jens, 27: "*If you don't do that, it becomes chaotic. Then you won't follow the story anymore after a while.*"

Sophie, 29: "*An icon in the image of VR goggles. Or the image that pauses. It should be clear you have to put on the goggles.*"

These indications could be a **dot or a symbol** in the upper right corner of the TV screen. These indications should be subtle so they distract while watching the TV-screen.

Manon, 24: "There should be indication on the screen when you can for example inspect a room. But these indications have to be subtle. We prefer to have not too much happening on the screen. If there is interaction, it should happen on the other devices."

Ariane, 25: "The icons can't be overwhelming. Maybe just an indication with a dot, without it all being pictograms".

If viewers just want to watch the normal TV broadcast and not use any VR device, they should have the **possibility to disable the appearance of interactive icons on the TV screen**.

Astrid, 24: "I would say there is a version with and without. You choose from the start: I don't want dots on my screen and just watch the movie".

Requirement R.1.3.6 - Portals shall guide the end-user to explore additional content when in the HMD experience.

Besides the use of interactive indication on what moments it is useful to use the VR devices, portals can also be used to guide viewers to additional content when they are in the VR mode. Portals inside the HMD experience can show viewers there is another room or space to explore and they could show additional information to explore (e.g. a document, a flashback etc.).

Astrid, 24: "After something crazy has happened, then it would be nice to go back and look around in the room to search for clues that you might not have noticed."

Live content

The concepts of portals to interact with the content was discussed in-depth in the interviews. The evaluation of the portal in the demonstrator was used as a starting point for the discussions. See Figure 4 and Figure 5 for a screenshot of the portals.

Requirement R.1.3.16 - The portal should not be there all the time. The end-user should be able to easily 'request' it, after which the portal should disappear again.

Both on the tablet and on the HMD, it was considered unnecessary that the portal is always there. Especially on the tablet, the portal took up quite some space and the respondents say they don't always want to see it. Most respondents suggested that the portal should only appear when they ask for it and then disappear again, so they're not distracted by the portal while viewing the content. The portal should be small and subtle, so it doesn't catch too much attention.

Zita, 23: "The portal should disappear like the mouse icon disappears when you start watching a movie on your computer."

John, 23: "It should disappear, but you should be able to request it."

Wendy, 24: "I get that it's annoying if something is always in the image. It should appear. Or for example a pop-up with the viewpoints that appears every X seconds and then disappears if you don't look at it. Or that you can set up how many seconds you want it to appear. Or that you can press a button 'I'm sick of this viewpoint, give me other options'."

One respondent would like the portal in the HMD to be on eye height, because now she needed to look down to see the portal, which she considered inconvenient and gave her the feeling she was falling.

Wendy, 24: "I want it to be on eye height, because I don't want to look down because then you feel like you're falling."

One respondent thought it would be nice to have no portal interface in the HMD, but an integrated portal in objects in the content. He thought it would be nice to be able to look at

certain objects in the image (that represent a camera), and that you could then be transported to that object and view from that POV.

Timothy, 28: "It is really stupid that it is with the 3 dots (in the HMD) or with the field drawing (on the tablet). I guess because you're in this environment, because you can look around. Portals can be for instance yellow flags. That at the corner of each field there is a flag, so you say like 'oh there is something happening there, I will look at the left flag' (...) and then you do like a headshake and then you suddenly have that POV. When you change back, you just look to the flag on the field, and not for the portal somewhere else. I used to have this when I had a walk with my mom and dad and I was tired, and I saw like the church or something, that I thought it would be really cool that by just looking at something you suddenly could be there. And like with VR you can actually do that. You don't have to walk. You can say, I want to be where the church is. And you can see from that POV."

Timothy, 28: "Maybe like a real portal. Like a wormhole. That you get teleported. Like a circle that sucks you in. That you have the experience of changing positions."

Requirement R.1.3.17 - In the HMD, the end-user should also be able to use a controller or buttons on the HMD to use the portal.

The respondents say they would like to 'request' the portal by touching the screen (on the tablet) or by using a controller or pressing a button (on the HMD). Selecting things with eyes (in the HMD) still feels quite odd, not familiar.

Annie, 26: "I would rather have a button on the side (of the HMD) that you can press to change camera viewpoint. Maybe we're just not used to select things with our eyes. (...) I would rather not see anything on the screen, and that from the moment you press a button, that you then directly go to the other camera viewpoint. And then there should shortly appear in the image 'You're in corner view'. I don't want to go through a menu."

Wendy, 24: "Maybe you can request the portal with a button on the glasses. Or maybe you should close your eyes for 5 seconds and the machine then notices this."

John, 23: "Or if you touch the screen (on the tablet), that it then automatically goes to another viewpoint."

Requirement R.1.3.18 - The end-user should be informed on where all the extra cameras are placed by means of a map.

In the portal on the tablet, there was a little map drawing of the football field in the left corner that showed where on the field the 3 cameras were placed. Above the map drawing, the three camera streams were displayed. However, it was not indicated which camera stream was connected to which 'dot'. This should be indicated better, for example by giving each viewpoint a number and representing these numbers on the map.

On the portal in the HMD there was no map drawing that indicated where on the football field the cameras were placed. A user of the HMD should also be informed on where the cameras are placed.

Cathy, 32: "Also it should show which of the dots was which camera. If there would be more cameras, it would become confusing. Instead of a dot on the field, it could just show a number. Now the dots didn't show which camera was where."

Walter, 42: "It would be great if you could see on the field which dot represents which camera. I would use this interface in the VR as well."

One respondent thought it would be interesting if it could be indicated on the map drawing where the ball in the football field currently is.

Timothy, 28: "It would be interesting if the portal would indicate if something was happening on this side of the field. Or that the map would indicate in which area was the ball. Now you were just clicking around."

Now, on the tablet, the viewpoints were named 'CAM 01', 'CAM 02' and 'BASE CAM'. One respondent suggested that the names of the cameras should indicate where they are placed (not camera 1 but 'bench camera')

Cathy, 32: "I'm not going to remember them at 'camera 1', 'camera 2', ... I want it to see this team's camera, the bench camera..."

Requirement R.1.3.19 - The end-user should be informed from what viewpoint he/she is currently watching.

During the test, it was considered very unclear from what camera viewpoint the respondents were viewing on the tablet and HMD. It was not indicated which camera viewpoint was 'on', which caused some general confusion. This was especially unclear on the HMD, since there was no map drawing there that indicated where on the football field the cameras were placed. There should be an indication in the image that informs from what viewpoint the viewer is currently watching the content.

Walter, 42: "Also, I can't remember which view is which. There should be some tag that indicates that this is the corner view."

Requirement R.1.3.20 - The end-user should be informed on how to use the portal and the different features.

People should be informed on how to use the portal and the different features. The portal on the tablet was considered very intuitive. This is due to the fact that all respondents had experience with using and navigating with a tablet. However, using an HMD is very new to most people. Navigating within an HMD is therefore less intuitive. Not every respondent could figure out how to use the HMD portal.

Timothy, 28: "After a while I got more of a hang of it. When I tried to select the viewpoints (on the HMD), when I touched the button, something happened that I couldn't figure out. (...) I think there is a learning curve here."

Walter, 42: ". Maybe an on boarding thing should be good. Give people hint that you can zoom in."

3.3.4. Haptic feedback

3.3.4.1. First iteration

Requirement R.1.1.16 - The end-user shall be guided by haptic feedback to make the experience more tangible

Watching VR is also considered a physical experience. People actually believe that objects will bump into them or that they can touch it. At the moment this is not the case, but some haptic feedback would be a useful addition to the experience, making it even more interactive and engaging.

Amanda, age 28: "I think it is a very physical experience. I remember the first time I tried it at home, I never sat still, while when I'm watching TV I'm always sitting still. Now you try to even get closer to the thing, you try to grasp it. It's not that you actually feel something physical, but you can imagine yourself. So it would be even more interesting if there would be some kind of haptic feedback experience with vibrations or something. That would make it even more valuable for me."

Tim, age 39: "What I miss is a kind of deep motion, a kind of Kinect, that you would be able to see your own hands. This would give a completely different feeling, then you would not feel displaced. It would be good if you would also be able to see your hands."

Lisa, age 21: "Certainly to interact. I think there is already this kind of glove with pressure so you have the feeling that you are really touching something."

3.3.4.2. Second iteration

Also in the second phase, haptic feedback was seen as bringing an additional dimension to the experience. Being able to touch and feel things for yourself was considered as the optimal experience. This is also very useful in the interactions with other avatars in a VR environment, because then also gestures could be used to interact.

3.3.4.3. Third iteration

Haptic feedback was not discussed during the third iteration. No specific feedback on haptic feedback was thus provided.

3.3.5. Gaming element as interactive feature

3.3.5.1. First iteration

One of the respondents would like to have a HMD at home, but then he would also expect to have a more interactive approach to the content, he would prefer a kind of gaming element.

Chris, age 27: "I would like to have a HMD, yes. I'm not such a die-hard TV-viewer. It is because I don't like to just sit still and watch. The interactivity appeals to me. And certainly also a gaming aspect."

3.3.5.2. Second iteration

In this workshop, some of the respondents already had experience with VR in gaming, on the Playstation for example. However, they didn't necessarily want to translate the gaming concept to a multi-device TV VR experience. One content example that was provided, was looking for

particular cues in a game show, in which viewers would be able to participate in a game in a virtual environment.

3.3.5.3. Third iteration

Offline content

In the third iteration, gaming elements were only mentioned in the specific context of the detective format. Participants liked the idea of a more interactive mode in which they could become detectives themselves and look for the murderer. In a social setting, it could be nice to play against other detectives and see who can identify the murderer first.

Live content

This topic was not discussed during the interviews.

3.4. Content format requirements

In this section we will discuss the different content formats for which omnidirectional content formats are deemed best suited according to the respondents.

3.4.1. For which types of content or programmes is omnidirectional content best suited?

3.4.1.1. First iteration

Requirement R.1.1.17 – The end-user shall view VR content that is adapted to his/her preferences

The offered content should have a clear added value for the user in terms of personal interest or originality of the content.

Some demos were evaluated more positive than others, so the content itself is really important, even for short experiences in a demo. This is of course linked to personal interest, but also to seeing things you could otherwise not experience.

Rien, age 25: "I think if it is something you normally cannot see. I've seen a Jurassic World movie in which a dino suddenly emerged in front of me. You know that it is not real, normally you never see something like this happening. So things that you would normally not be able to see."

While this is a rather extreme example in terms of things you could otherwise not experience, other examples like watching behind the screens in a concert, seeing a set of a soap opera, take a look in the dressing room at a football game are also examples of being in places you would normally not be able to see. Also distant or remote locations were mentioned as possible interesting content to explore.

In the discussion with the users, the importance of the content was stressed a lot. **Users will only make use of VR when it is content that interests them.** This is often the case when it links close to their **personal interests** (for example sports and travel), or when it allows them to **see something they would otherwise not be able to see for themselves** (for example take a look in a refugee camp).

Below we will discuss the **different content genres** that were mentioned in the first part of the conversation. The different format examples the users created themselves and the feedback on the professional format examples are discussed in the next section.

1) *Sports: it's all about being there (presence)*

Football is an obvious example, but also cycling was often mentioned. In football the main attraction of VR is that you would be able to experience the atmosphere of the stadium. Just as in a real stadium, you would be able to look around to the other supporters, the trainers, the players, etc. You could even go one step further and explore parts of the stadium you would normally not be able to see, for example the players' tunnel and the dressing rooms.

In cycling, TV-viewers now often pause certain scenes to be able to take a look into the environment, or to watch certain phases in more detail. Here being able to watch the cycling game from different viewpoints was mentioned and also further elaborated in one of the user format examples.

2) *Documentaries*

Typical nature documentaries, but also destinations abroad are typically mentioned as interesting VR experiences. Being able to experience certain things as you're there on the first row, nature scenes, cities, but also war zones. This would increase the viewers' empathy, as now a lot of these events are experienced as something that happens far away from here.

3) *Game shows*

Game shows in which viewers can also look for certain hints, etc. would also be an interesting format, because it would allow users to do more than simple viewing, you would be able to become part of the game.

4) *Fiction and human interest*

This is a dubious category, as some say that it would not work in content like this where images are really used to tell the story. In human-interest programs for example, every shot is shown for a reason, the program maker will probably not want to give away the control over the narrative.

Others could imagine the integration of VR in fiction such as soaps for example, where users would be able to experience the content from another perspective or to take a look around in the image. Even though they realise that the typical sets of a fiction series are not made to look around in 360°. For outdoor location it might be an interesting addition. Nevertheless, it would not be something for the daily episodes, but for special events, such as a season finale.

5) *Travel programs*

In travel programs it might be a good opportunity to be able to discover certain regions.

6) *Children programs*

A final category that was mentioned is kids programs, for example practical chemistry experiments or something. It would be a safe way to let them experience this for themselves. Also interactive games would be nice for children.

3.4.1.2. Second iteration

Requirement R1.2.4. - The end-user shall be offered unfiltered reality in live content scenarios so viewers can explore unfiltered content

Since this workshop focused more on live events, the discussed examples were also live broadcasted content. Although also documentaries, movies and game shows were mentioned as possible formats. Below we describe the three live formats that were mentioned in the discussion. Of course it all depends on what is offered in the VR content (type of content and type of interaction) that will determine whether it is considered a worthwhile experience. Specific for live content is that respondents expect to have **the unfiltered reality**. They expect to have full control of what they see. An example they gave was that in football games, now streakers on the field are filtered, but that would not be possible in VR. A main difference with pre-recorded content is that it is less easy to insert certain cues in the content. So they expect less interactive options, such as for example gaming elements.

1) Sports programs

A typical live category are live sports. Here football, cycling and motocross were mentioned as possible formats to watch in VR. The main benefit here would be to experience the game as if you were there (for example as part of the audience) or see it from the perspective of your favourite athlete (for example in cycling). The social aspect of sports experiences was also stressed and should be translated in the VR experiences.

2) News and current affairs

In news and current affairs, the main benefit is being able to access places you would not be able to access otherwise. For example, being on the location of a live event (e.g. US presidential debate) and being able to look around and interact with other people with similar interests was considered a benefit.

3) Unique once in a lifetime events

In this category respondents referred to experiencing certain events such as an astronaut mission to Mars. By enabling a VR experience, complete nations could experience this type of unique events.

3.4.1.3. Third iteration

Offline content

Also in the third iteration, respondents thought live scenarios were best suited for this kind of viewing experience. The participants indicated to especially be interested in the omnidirectional format for sports broadcast and live events (e.g. music concerts) that they can't attend in real life. The affordance of exploring places one could otherwise not visit or experience is attractive.

Jonas, 27: "For sports fans, have different perspectives is a big added value."

Ariane, 25: "It seems cool for a festival as well. (...) You can have the feeling that you were there and didn't miss too much".

Requirement R.1.3.7 – The end-user shall view a format that has been specially designed for a multi-device experience

For fiction, which was the focus of this third iteration, the integration in the storyline is extremely important. This type of format would only work if the scenario is specifically developed for a multi-device experience. If not properly integrated, it can become confusing as it can take the attention away from the main storyline. Also, the director often uses special effects and techniques that would not always work in a 360° context.

Jonas, 27: "for fiction, you have so many series now with special cameras and effects. It will be hard to have a 360 image there."

Sophie, 29: "For science fiction movies you already have the sensation right in front of you. I don't see why I would have to look left or right."

Two respondents said that they're only interested in undergoing an interactive VR experience, if they can have some kind of influence on the ending of the broadcast. They think there is no point in exploring extra content with VR devices, if this would not impact the normal TV broadcast and ending in any way.

Andy, 25: "what's the point of it being interactive, if the choice is not influenced. If you will say 'I will watch this and this' and if this has no impact in the end."

Jens, 27: "I'm not sure if it is a good idea for a detective series. That's something with a fixed storyline from the beginning. From the moment you can impact the storyline, you're not watching TV anymore but playing a game. Then you can as well put it in the category video game."

Live content

Requirement R.1.3.7 was confirmed here. No additional insights with regards to this topic were gathered during the interviews.

3.4.2. Examples: outcome of content ideation exercise

3.4.2.1. First iteration

As part of the content ideation exercise, end-users paired up in teams of 2 or 3 to develop their own concept for a content format in which VR could be implemented. The assignment was to think about a program format that they would enjoy watching themselves. They were asked to reflect both about the content and the context.

The developed concepts are described below. Each of the two end-user workshops led to some specific concepts that are presented below. In parallel of the end-user workshops, also in the two professional user workshops some concepts were defined. These are explained in D2.2.

Workshop 1:

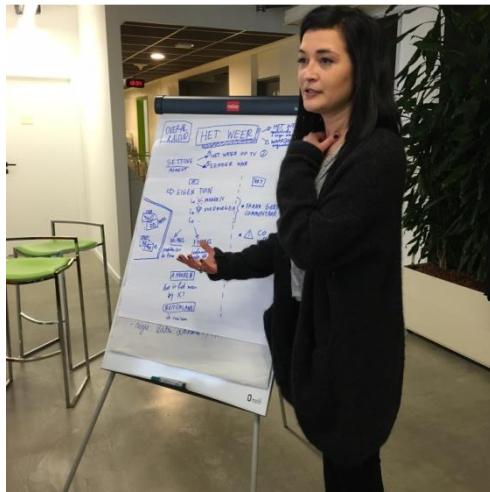


Figure 7: Weather in a new jacket

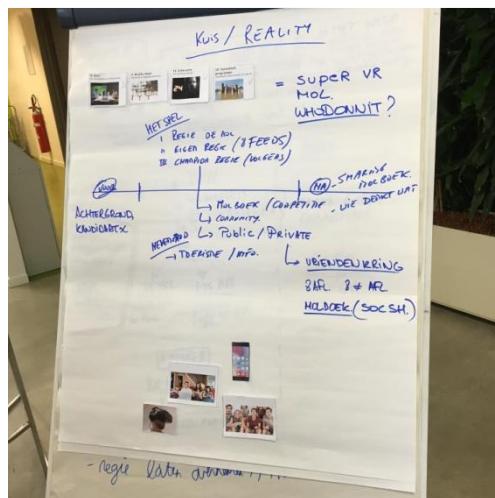


Figure 8: Game show De Mol



Figure 9: Temptation Island



Figure 10: The news

1) Weather in a new jacket

In this idea users would have an app in which they could put on their VR glasses and **experience the weather forecast as if they were standing in their own garden**. For example, if they would ask to see the weather of tomorrow, they would see rain in their garden. It would also work for other locations (for example travel destinations). Other types of information such as on CO₂ and air pollution could also be visually represented in the system. The advantage of the system would be that it is more local and very realistic.

2) Game show – ‘De Mol’

A popular TV format that is aired in Belgium at the moment is “De Mol” (Who is the Mole). It is a program about 10 candidates that have to do assignments to earn money. One of the candidates is the Mole and his or her goal is to make the assignments fail. The other candidates need to unmask the mole. Also the viewers at home don’t know who it is and try to find out his or her identity.

The program is a mix of a quiz, a reality show and an action series. In the second developed idea, this program is placed central. There would be the option to provide viewers with information before the program starts, for example additional information about the candidates. **Then you would be able to choose between different ways to watch the program.** A first option is that every candidate would have a 360° camera on his head and that you would be able to watch through the eyes of the candidate that you are following. You could also have an option that other viewers could **direct their own TV-episode** making use of these different camera streams. This could be part of a kind of **community**, for example a group of friends and everyone is able to direct one of the episodes and share this with the others.

3) Temptation Island

Another reality show that is aired in Belgium is Temptation Island. This is a program in which 5 couples test their relationship. The couples are separated and placed with a bunch of bachelors on an island. The TV-show focuses on how the couples interact with the bachelors.

The idea that was developed during the brainstorm was a novel way to make use of the **commercial breaks** in between the program. The idea is to integrate VR in the commercial break in which viewers could spy on the island. They would for example be able to look around in the rooms of the participants, or even follow an additional couple that is only there in the VR stream.

In this format you would still see the regular TV-show on the TV-screen, but during the break you would put on your HMD to interact with the additional content.

4) The news

The idea in this format is that informative fragments could be **represented as realistically as possible**, to provide the viewers with new experiences. This is possible for news, but also for documentaries for example. Lately there is some criticism on how media frame certain events on TV. This would be a way to let viewers take a look for themselves, without only having to rely on the director.

Linked to the idea is a **personalised news profile** based on your personal interests. The concept could work as follows, you would see regular news items passing by and you would be able to bookmark them via an interactive menu in your glasses. You could then use the portal to go to the additional related content, based on your own interests. You could be on the place of the action, for example in a refugee camp.

There would also be a **social aspect**, if you would be able to look around together with others and also see them in the VR world. This could be with audio communication, but also with non-verbal communication, that you would see for example your friends' avatars and that you could wave to them and interact with them in this way.

In the discussion the users thought that this would indeed generate more impact of news items, as you would be able to really experience the situation by yourself. However, some users thought it was a bit strange that you would be standing there as the western guy or girl with your VR glasses, looking at all the misery around you.

The transition from one item to another would make use of the portal idea, that you could switch to another item or that you would consume related content for an item.

Workshop 2:

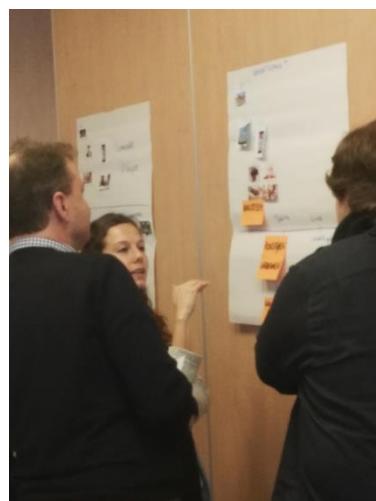


Figure 11: Travel program



Figure 12: Football

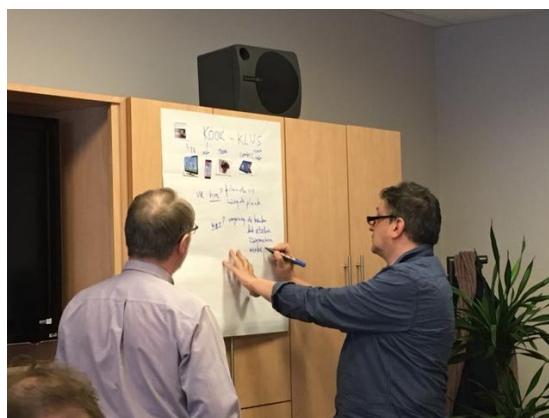


Figure 13: Cooking and hobby program



Figure 14: Cycling

1) Travel program

In this idea, an additional layer is added to a travel program. The starting point would be the program on TV, in which you would have your smartphone at hand to check Twitter or Facebook. And then you would have **moments in the program in which you would be able to look around**. If you would do this alone, you would use your HMD, but with others you would use the cheaper option (Google cardboard), because then it is easier to still talk to your friends and because the

presenters of this concept also consider it less important to have good quality when you're with friends because they believe it is not an ideal viewing experience anyway.

The VR intermezzos would be limited to maximum 2 minutes and a maximum of 3 VR moments within 1 program of half an hour. The presenter would first give some explanations about a certain area and then you would be able to explore this, based on your preferences. As some viewers prefer nature, others city scenes, they would have the choice in what they would want to explore further. The aim is to make people curious about the location and make them travel there in real life. There would also be the option to add an interactive element in the end, for example a quiz question on the content, in which people could win a price.

2) Football

This idea focuses on football. You would have the option **to watch certain phases from different viewpoints and look into certain details.** And also after the game you would be able to see certain phases of the match in replay, that you would be able to select them from a menu. You would also be able to receive additional information, zoom in on certain players, and see more than you would normally be able to see.

3) Cooking and hobby programs

In this concept the idea was that in certain cooking or hobby programs you would be able to **zoom in on certain procedures** and see over the shoulders of the chef or the handyman to experience how it is done.

4) Cycling

In this idea the cycling game would start with a poll. Then people could vote which cyclist would be followed. You would also have the panoramic images in VR, as a lot of people now watch cycling (for example tour de France) for the nice images of the area. You would also be able to provide backstage images or images from inside the VIP-tent. The **viewpoint could also be shifted** from the reported on the motorcycle to the helicopter and back. A question they have themselves with this concept is which kind of comments you would include in this experience. The regular comment or a version that is also adapted to the viewpoint you are selecting, for example if you want to focus more on a certain team.

Lessons learned from the content ideation exercise

The content ideation exercise was a valuable exercise as it forced the participants to think about relevant formats for themselves and integration of these formats in their personal viewing experience.

Common aspects of the examples:

- Most of the examples relate to short fragments in VR. Being able to look around as part of a travel program, have additional VR content during the break of the program, check out a certain procedure in VR... It is clear from these examples that **viewers see the VR experience most suited for short fragments, maximum a couple of minutes.** Only for sports it would also be relevant to watch the full game in 360°.
- In most examples the **HMD** was seen as the preferred device for the experience.

- The **social aspect is very important**. In some concepts the participants reflected on how they would be able to experience this as a group (for example with google cardboards instead of HMD to keep the group contact during the exercise) but also on how the social aspect could be inserted in the virtual experience (for example a virtual representation of family and friends in the VR experience).
- The main device in the examples is still the **TV-screen**. This is the screen on which the main program is displayed. HMD and tablets, smartphones are considered as secondary devices in the experience.
- The content they refer to in the examples is news and documentaries, sports, lifestyle programs (related to travel, cooking programs) and reality shows.
- The specific purpose of the VR experience is to have additional **information**, to watch behind the scenes or to **explore** places or situations in **real-life**, as if you were there.
- In the examples, **control** was balanced between the viewer and the director or storyteller of the program. In the cycling example, people would be able to vote for a certain viewpoint, but the choice of viewpoints would not be unlimited, in the travel example people would be able to look around, but only in those scenes that are chosen by the director.

3.4.2.2. Second iteration

In this workshop, respondents were asked to reflect on the options for specific **live events**. Since at the time of the workshop, the scenario of the live pilot was not yet decided, they were free to choose a format, the only requirement was that it was a live broadcasted program. Three program formats were developed.

1) Mission to Mars

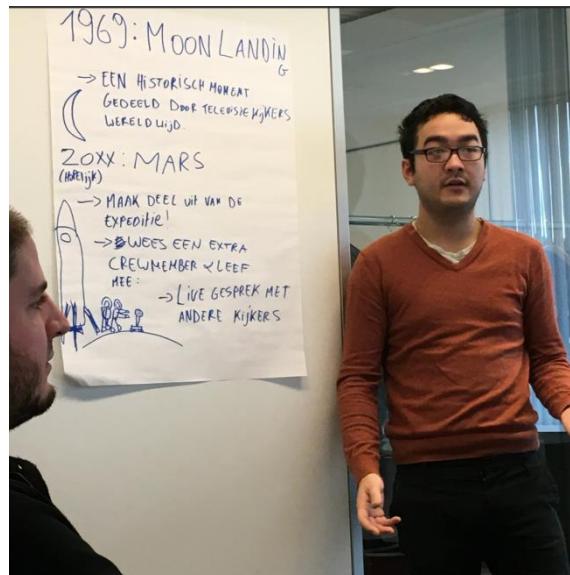


Figure 15: Mission to Mars

In this format, viewers would be able to be part of an expedition to Mars as a crew member. The idea is to be able to step on Mars together with the complete mankind. You would be able to look around during the mission, interact with other viewers and get all types of information on the mission. Real-time interaction with the crew members would not be possible because of the delay, but viewers could send in questions that would then be answered. The astronauts would speak directly to the 360° cameras, giving them a presenter role. On the TV-set, people would see the directed image, by the broadcaster. On the HMD,

people would be able to freely look around in the image and to interact with other viewers. This format would also be usable for other types of events such as expeditions and documentaries. It all evolves around the idea of being somewhere you could never be in real life.

2) Football match

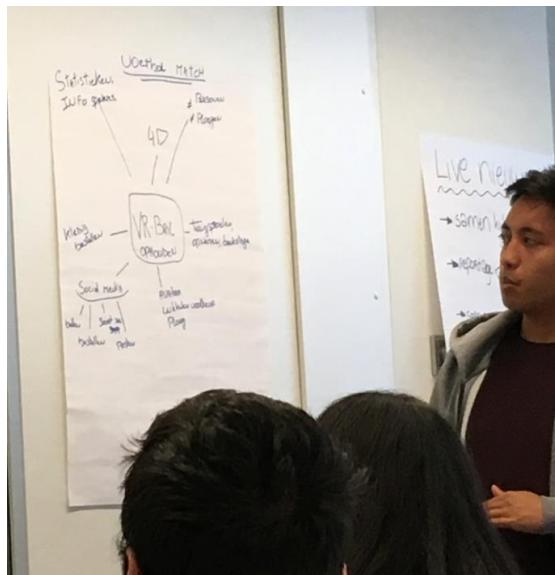


Figure 16: Football game

In this format, the workshop participants developed an interaction uniquely for the HMD. They feared they would miss out on something if they would combine it with the regular TV-experience. They would use the VR to experience the game from different perspectives, but also to look into additional information on the players and the game (e.g. statistics etc.). In this format, viewers would also be represented as avatars, wearing a shirt of their favourite team. They would also have the option to order a shirt of their favourite player for example. An interesting addition in this format is the link with social media. Since every VR experience is unique, they would foresee the option to record a screenshot or video of their VR experience and share this on social media. During the break, they would be able to interact with other VR supporters in the VR bar.

3) Live news



Figure 17: Live news

In this format, a personalised news broadcast was developed in which viewers would have two options. A first option is to watch the news together, but focus on different items depending on your specific interest. A second option was to go back to certain events after the live broadcast. For example, what is happening at this moment at the scene of the bomb attack at Brussels airport, so people would be able to follow the event also after the live reporting. The wish to explore additional content of course depends on the type of item. If it's something political, viewers might be less inclined to watch VR content.

Lessons learned from the content ideation for live content

- The **fear of missing out** in live content was certainly present. In the football example, this even led to the fact that respondents want to keep their HMD on during the game, in order not to miss anything while switching.
- The social aspect was present in all the examples. A virtual representation of the audience is present in all the examples. Also the interaction with other supporters, other people with similar interests, was considered a must.
- The interaction with social networks was quite unique in the examples. All respondents agreed that this was a nice addition to the football format.
- In contrast to the previous examples, here VR experiences were used for longer content fragments.
- The HMD was presented as the preferred device. The tablet would be useful to preview the interaction.
- In the live scenario, respondents expect full control over the content. They want to be able to watch the live content unfiltered. They should be able to choose for themselves whether they want some form of direction or not.
- All examples relate to a form of presence, actually being there, where the action is

3.4.2.3. Third iteration

Offline content

The participants were divided in two groups and were asked to design a multi-device TV experience for a detective/'whodunit' content scenario. The participants were asked to reflect on what content they wanted to see on what device (the television, the tablet and the VR goggles) and the context (where, how, with whom, ...). They were only provided with the following short synopsis:

Mr. Ample is found dead in his study by his housemaid in the morning. Two police inspectors are called to the scene to this mystery. What happened? Murder or accident? Search for the offender!

Group 1:

I want to see this on TV:

- The main storyline
- All the action scenes should stay on the TV

I want to see this on the tablet:

- **Mainly textual information:** Extra information related to the TV broadcast, e.g., files of suspects, background info on the victims and inspectors,

I want to see this on the HMD:

- Crime scene observation: flashback to the moment of the crime, looking for clues, inspection of the surroundings...
- Optional extra images, such as extra rooms. This could be interesting when viewers watch the broadcast a second time.
- →It would be good to **limit the number of HMD experiences** and only have an HMD experience once in a while but then use quite long fragments.

Group 2:

I want to see this on TV:

- Viewers need to be able to choose between three options:
 1. The main broadcast is enriched with interactive indications that show when it is useful for the viewer to watch the tablet or HMD.
 2. The main broadcast stays normal, but the viewer can still interact with the content using the tablet and the HMD. (This could come in handy when watching together with others and some only want to watch the normal broadcast).
 3. The main broadcast stays normal and the tablet and HMD are not used.

I want to see this on the tablet:

- The tablet can be used in two ways:
 1. To read **extra textual information** (e.g. documents)
 2. **As a means to watch the content broadcasted on TV at a later moment.** When you explore the content with the HMD and you're watching together with others who

continued watching the main broadcast on TV, you can use the tablet to quickly catch up with the content.

I want to see this on the HMD:

- Use the HMD to further explore the surroundings and rooms.
- When watching alone, the main broadcast should pause from the moment the viewer uses the HMD.

Lessons learned from the content ideation exercise for a TV experience with exploration mode

- The TV is still the preferred device to view **the most important scenes** contributing to the main storylines. Especially **scenes with a lot of action** in it should be broadcasted on the TV.
- The tablet is the preferred device to consult **extra (textual) information** related to the TV broadcast, such as background info on the main characters.
- With the HMD, viewers want to be able on the one hand to **further explore the scenes and surroundings** as shown on TV. On the other hand, viewers want to use the HMD to **see extra content not shown on TV** such as flashbacks, other rooms ...
- **The number of HMD experiences should be limited.** Viewers only have an HMD experience once in a while but then quite long fragments.
- **Viewers should be able to indicate whether they want to use the tablet and/or HMD** in combination with TV and if not, should be able to watch the normal broadcast on TV without any interactions or indications on the TV-screen.
- If viewers watch a broadcast alone, they want the main broadcast on TV to pause from the moment they put on the HMD. If people watch together with others, the tablet could be used to catch up with content that has been broadcasted on TV while wearing the HMD.

Live content

No specific content ideation exercise was executed in the end-user interviews.

4. OVERVIEW OF USER REQUIREMENTS

In this deliverable, requirements were developed around the following main topics, based on the workshop outcomes:

- General VR requirements
 - o Physical discomfort
 - o Image quality
 - o Social viewing
- Synchronised content across devices
 - o Switching between devices
 - o Integration with regular viewing experience
 - o Length of fragments and integration in the content
- Interactive VR experience
 - o Camera position, viewing perspective and navigation
 - o User control
 - o Triggers
 - o Haptic feedback
- Content format
 - o Content types
 - o Content ideation exercise

Table 1 gives an overview of the identified end-user requirements after the first group of end-user workshops (M3), Table 2 gives an overview of the additional requirements that were identified after the organization of the end-user workshop on content scenarios (M10) and Table 3 of the additional requirements that were identified after the organization of the end-user workshop on the exploration mode (M22).

Table 1: Overview of end-user requirements for pilot 1 - first iteration (M3)

	Requirement	Description
General VR requirements		
R.1.1.1	The end-user shall be informed about possible health risks (e.g., motion sickness, epileptic issues...) by adding a warning to the content	<i>Keep in mind that some users might experience physical discomfort such as nausea or dizziness while watching VR, because they cannot see their own legs in the VR environment and therefore feel detached.</i>
R. 1.1.2.	The end-user shall be offered a way to control his/her surroundings while watching VR content	<i>Users might feel isolated when watching VR content via a HMD. Therefore it is preferable to offer them a way to keep in</i>

		<i>contact with their environment while they are in the experience, for example via an optical see-through display.</i>
R.1.1.3	The end-user shall watch the VR content with an image quality that is equal or better than the image quality on their TV	<i>The image quality of the demo and pilot content should be in line with the quality end-users are accustomed to from their own TV-set and portable devices (smartphone, tablet). They expect that the image quality in the HMD is at least as good as what they are used to.</i>
R.1.1.4	The end-user shall enjoy a physical social viewing experience via picture in picture or via content duplication of the HMD content on other devices	<i>By allowing interaction when 1 user in the household is using a HMD (for example by allowing other viewers to see what he or she is seeing via a picture in picture on the TV screen or to explore the content themselves via other devices).</i>
R.1.1.5	The end-user shall enjoy a virtual social viewing experience via virtual representation of others in the content	<i>By offering a more social VR experience by adding avatars or representations of other VR users in the content.</i>
Synchronised content across devices		
R.1.1.6	The end-user shall only have a limited number of VR interactions (3 or 4) in one content format	<i>The number of VR interaction should be limited in order to limit the burden of switching devices while watching.</i>
R.1.1.7	The end-user shall not be distracted from the storytelling by the implemented VR interactions	<i>The VR interaction should not completely distract viewers from the storytelling.</i>
R.1.1.8	The end-user shall view short VR content formats (max. 5 minutes) with short VR interactions	<i>Viewers seem to prefer short VR fragments (couple of minutes) and a maximum of 3-4 interactions/program.</i>
Interactive VR experiences		
R.1.1.9	The end-user shall be able to explore the content by zooming in and out	<i>The user should be able to zoom in and out.</i>
R.1.1.10	The end-user shall view VR content that is recorded with the camera standpoint adapted to the viewpoint of the user	<i>The camera standpoint should be adapted to the position or the viewpoint of the user. Eye height is recommended in several cases.</i>
R.1.1.11	The end-user shall be able to select his/her preferred viewpoint from a range of different fixed positions	<i>Multi-viewpoint content shall be developed. Different perspectives or</i>

		<i>positions should be possible. Users should be able to select their preferred viewpoint.</i>
R.1.1.12	The end-user shall have control over the camera perspective	<i>Users should be able to choose when to change perspective themselves, or the transition should go more natural and not interrupt the experience.</i>
R.1.1.13	The end-user shall be able to select his own viewpoint anywhere in the content and act as a director	<i>Viewers would like to select their own viewpoint (viewer as director).</i>
R.1.1.14	The end-user shall be able to choose viewer vs. director control	<i>Users should be able to choose whether they want to be directed to certain events, or whether they want to be able to look around freely.</i>
R.1.1.15	The end-user shall be guided on where to look in the VR content by natural triggers that serve as anchor points	<i>Natural triggers should provide anchor points to the user of where to watch or what content to explore.</i>
R.1.1.16	The end-user shall be guided by haptic feedback to make the experience more tangible	<i>Add haptic feedback to the experience, to make it even more tangible for users.</i>
Content format		
R.1.1.17	The end-user shall view VR content that is adapted to his/her preferences	<i>The offered content should have a clear added value for the user in terms of personal interest or originality of the content.</i>

Table 2: Overview of end-user requirements for pilot 2 - second iteration (M10)

Synchronised content across devices		
R.1.2.1	The end-user shall be provided with sequences that are long enough to make the switching between the devices worthwhile	<i>The length of the VR experiences should be sufficient to make the switching of the devices worthwhile.</i>
R.1.2.2	The end-user shall be offered the option to preview the VR content on a smartphone or tablet	<i>The tablet or smartphone could be used for viewers to check whether the VR content is worthwhile, as a kind of preview.</i>

Interactive VR experiences		
R.1.2.3	The end-user shall be offered the option to replay certain parts in VR during and after the live broadcast	<i>In live content, the fear of missing out could be countered by offering the option to replay content fragments during and after the broadcast.</i>
Content format		
R.1.2.4	The end-user shall be offered unfiltered reality in live content scenarios so viewers can explore unfiltered content	<i>In live scenarios, viewers should be able to experience the unfiltered reality, meaning live images without restrictions.</i>

Table 3: Overview of end-user requirements for offline pilot 3 - third iteration (M22)

General VR requirements		
R1.3.1	The end user shall enjoy a viewing experience with a program flow that enhances social viewing.	The content format and storytelling should take into account viewing situations where multiple people watch the same broadcast.
Synchronised content across devices		
R.1.3.2	The end-user shall only watch a limited amount of controlled VR experiences during one broadcast in a whodunit scenario	Because of the effort switching devices takes and because it always takes some time to get used to the new device (especially when going from the TV to the HMD and vice versa), it would be good to limit the number of HMD experiences during one broadcast
R.1.3.3	The end-user shall view VR content not during but right after scenes with a lot of action, to slowly explore the surroundings and details.	End-users prefer to watch the main action scenes on the TV, and use the tablet and HMD to further explore the content and surroundings at more 'slower' moments in the story.
R.1.3.4	The end-user should have the possibility to indicate that the main TV broadcast is automatically paused when the HMD is used.	It sometimes makes sense to implement or to make use of pauses in the program broadcast on TV to offer viewers the option to look around or to explore. If the broadcast on TV keeps running, there is not always sufficient time to explore the context with the VR devices out of fear of missing something.

Interactive VR experiences		
R.1.3.5	Onscreen indications shall guide the end-user on what moments it is useful to use the VR devices. These indications shall be subtle and not interfere with the viewing experience.	There should be an indication on the TV screen at the moment it is useful to use the HMD or tablet.
R.1.3.6	Portals shall guide the end-user to explore additional content when in the HMD experience.	Portals can show viewers there is another room or space to explore and they could show additional information to explore (e.g. a document, a flashback etc.).
R.1.3.7	The end-user shall view a format that has been specially designed for a multi-device experience	For fiction, which was the focus of this third iteration, the integration in the storyline is extremely important. This type of format would only work if the scenario is specifically developed for a multi-device experience. If not properly integrated, it can become confusing as it can take the attention away from the main storyline

Table 4: Overview of end-user requirements for live pilot 3 - third iteration (M24)

Interactive VR experiences		
R.1.3.8	The end-user shall view VR content from viewpoints that bring the end-user right in the middle of the action and not just on the side line.	Omnidirectional video should give the possibility to stand <i>on</i> the field, be <i>in</i> the crowd, stand <i>on</i> the stage ... instead of <i>off</i> the field or <i>next to</i> the audience. End-users want to view the action from closer and different POVs than the ones broadcasted on TV.
R.1.3.9	The end-user shall view VR content from viewpoints that allow the end-user to have a close-up of the action.	The tablet and the HMD should enable the end-user to be closer to the action. End-users should be able to watch extra viewpoints that enable them to have a closer look at things that are happening (close-up, replay from other angle) and see certain actions in detail, so they get to see more than is broadcasted on TV.
R.1.3.10	The end-user shall view VR content not just from the spectator's POV but	VR can offer the viewers the opportunity to view something from a POV that they would never or rarely be able to see in real

	also from the POV of players, artists, ...	life. Therefore, the POV should not just be that of a normal spectator as this is not considered unique or special. The end-user should be able to stand in the shoes of for example the athlete, the referee, the lead singer of a band...
R.1.3.11	The end-user should be able to very quickly select and change viewpoints.	Selecting camera viewpoints should be quick to access and changing the viewpoint should go very fast, so this doesn't become a burden for the end-user and they don't miss out on important actions.
R.1.3.12	The extra camera streams and user viewpoints should give the end-user the possibility to create a more personalized experience, by allowing the end-user to focus on their actors and actions of choice.	Omnidirectional video and extra camera streams can enable end-users to create a more personalized viewing experience. They can for example choose for themselves to focus on a certain cyclist and follow this cyclist throughout the race
R.1.3.13	The end-user should be guided on certain moments from what viewpoint the content is interesting to see, live and for replays.	There is fear on missing out on important actions when looking around in the image with VR devices. The director and portal should indicate where the action is happening or from what viewpoint the content is most interesting to see.
R.1.3.14	After watching a replay on VR devices, the end-user should be able to click 'resume live broadcast' on the VR device.	The end-user should be able to watch replays of certain actions from different viewpoints. After watching a replay on the tablet or the HMD, the viewer should be able to very quickly return to live stream by clicking a certain button.
R.1.3.15	The end-user should be notified, when watching a replay in VR, of important actions happening live so they don't miss these.	End-users have a fear on missing out on important actions when looking around in the image, also during the viewing of replays. A notification should alert end-users to return to the live broadcast if important actions are happening.
R.1.3.16	The portal should not there all the time. The end-user should be able to easily 'request' it, after which the portal should disappear again.	Both on the tablet and on the HMD, it is considered unnecessary and distracting that the portal is always there. The portal

		should only appear when the end-user asks for it and then disappear again.
R.1.3.17	In the HMD, the end-user should also be able to use a controller or buttons on the HMD to use the portal.	Selecting things with eyes (in the HMD) still feels quite odd and unfamiliar for the end-users. The end-user should be able to select and change viewpoints by using a controller or pressing a button on the HMD as well.
R.1.3.18	The end-user should be informed on where all the extra cameras are placed by means of a map.	Both on the portal on the tablet and the HMD, a map should indicate where all the cameras are placed from which the end-user can view the content.
R.1.3.19	The end-user should be informed from what viewpoint he/she is currently watching.	In the portal on the tablet and the HMD, it should be indicated which camera viewpoint is 'on'.
R.1.3.20	The end-user should be informed on how to use the portal and the different features.	Navigating with a tablet and especially an HMD is not intuitive for every end-user. The end-user should be learned about how to use the portal.

5. REFERENCES

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6. ANNEXES

6.1. Annex I – Iteration 1: Detailed workshop outline and planning

Part A. INTRODUCTION

1) Intro & demo – 15 minutes

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. The main aim of this exploration phase is to offer participants a VR experience with varied content and to give them some inspiration material for workshop discussions. They can try out the available examples in an open space in which the material is available. The participants are free to discuss the experiences with each other and pass the HMD devices along. Some participants chose to watch the examples while standing, others were seated. Not every participant tries out every example.

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

A Samsung Galaxy S6 was used as input device, with a 5.1-inch WQHD Super AMOLED display:

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

The following content formats were used as VR examples:

1. Red Bull F1 VR :

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

length: 2min51s

format: youtube streaming

resolution: 3840x2048

frames/s: 30

mimetype: vp9

audio: AAC stereo

example frame:



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

2. 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/>

3. Clouds over Sidra:

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

length: 8min35s

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/>

4. News studio VRT:

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

length: 2min40s

format: youtube streaming

resolution: 3840x2048

frames/s: 30 f/s

mimetype: vp9

audio: AAC, stereo

example frame:



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

2) First feedback on VR experiences (= cR.1.rent situation) (25 min)

- Based on the examples they experienced, respondents 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 fR.1.ther on specific aspects:
 - Main opportunities and barriers they identified
 - Evaluation of HMD? (cardboard?) (+ how does it feel to watch TV with a HMD?)
 - For which type of content they see this best suited (from their own personal preferences and experiences)
 - What makes this experience unique to them?
 - What specific opportunities do they see for futR.1.e TV-experiences?
 - Willingness to pay/ pricing (devices, cR.1.rent available content)

PART B: IDEA GENERATION AND FORMAT

1) *Design of the experience – content ideation exercise* (= futR.1.e situation) (20 minutes)

In teams of 2, end-users will be asked to create their own ideal futR.1.e TV-experience.

They will receive a blank poster and an inspiration kit including different pictR.1.es (people watching TV in different settings), different genres, timeline (how would they map out their program in time, when do they foresee which interaction), stickers they can use,..

They will be guided to reflect on the content and the context (where, how, with whom,...)

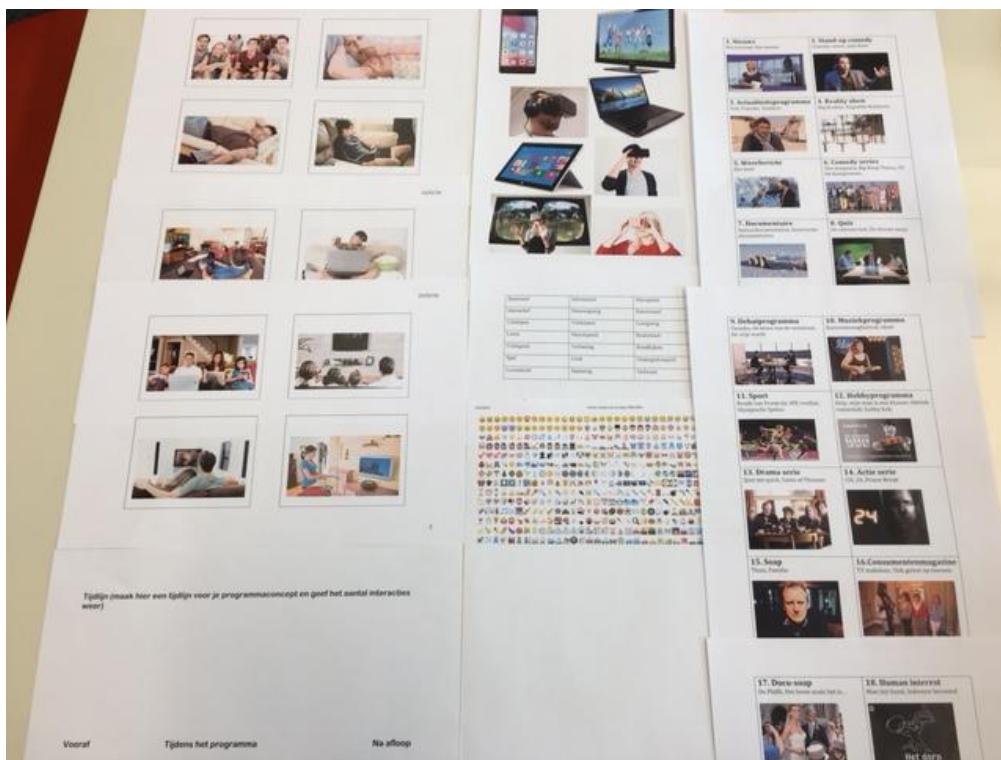


Figure 18: Inspiration kit for the content ideation exercise

2) Presentation of the experience (20 minutes)

- The duos will present their designs to each other, they can also ask each other questions

3) Discussion (40 minutes)

This discussion builds further on the concepts they presented themselves. Important is also to look into whether they selected a specific social setting, a specific genre etc.

Questions that can be included:

- What do viewers see as the main opportunities for VR? (perceived usefulness)
- What do viewers see as the main barriers for VR?
- (- *single viewer <-> multiple viewers? How does this change the viewing experience?*
- *Implications for multitasking?*
- *usability (ease of use, navigation, HMD in combination with glasses, putting on and putting off the HMD,...)*
- How do users see the interplay between TV, VR and mobile devices? (based on specific examples)
 - *How would this create a more engaging experience for them*
 - *How do they evaluate the portal concept? Depending on whether they integrated it in their experiences or not: why did they integrate it, why not? How do they see this fitted in their future TV-experiences?*
 - *How long should the VR interactions last,*
 - *How do they feel about switching between different devices,*

- *What kind of cues do they want to receive (-> also linked to the examples they provided themselves to make it very specific)*
- *How much control do they want and how much should still be in the hands of the director, in terms of storytelling (also linked to their own examples),..*

PART C: DISCUSSION END-USERS AND PROFESSIONAL USERS (30 minutes)

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 barriers 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, we will focus 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.

6.2. Annex II – Iteration 3: Detailed workshop outline and planning

1. Introduction - 10 min

- *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)*

2. Demo immersiaTV - 20 min

- *Show demo's VR*
 - "Lions 360° | National Geographic":
<https://www.youtube.com/watch?v=sPyAQQkIc1s&feature=youtu.be>
 - 360° cockpit view | SWISS Airbus A320 | Geneva – Zurich:
<https://www.youtube.com/watch?v=HEElzZ7UjRg&feature=youtu.be>
 - "Happy Birthday" - A 360° Short Film:
https://www.youtube.com/watch?v=v09F25_MCQ&feature=youtu.be
- *Show immersia tv demo movie :*
<https://www.youtube.com/watch?v=kSQsJKnyZAk&feature=youtu.be>
- *Short discussion*
 - First impressions, good/not good ...
 - how does it feel to watch TV with a HMD?
 - Evaluation of HMD? Tablet?
 - What makes this experience unique to you?

3. In-depth discussion & ideation exploration mode tablet and hmd - 85 min

Part I: Brainstorm on elements exploration - 25 min

- *Show demo immo virtueel:*
 - <http://www.immo-virtueel.be/virtueel.html>
- *show demo brussels from above:*
 - [http://www.brusselsfromabove.be/#s=pano1453?startscene=0&startactions=lookat\(0,0,120,0,0\);](http://www.brusselsfromabove.be/#s=pano1453?startscene=0&startactions=lookat(0,0,120,0,0);)
- *There could be added different other elements in the image that could enable the viewer to explore the image further (video icon, photo icon, info icon, audio icon)*
 - Show slide with examples
- *First impressions, good/not good ...*
- *Do you think this would be interesting for a video as well? For which video types would this be interesting or provide an added value?*
 - Fiction (e.g. the whodunit pilot 3) vs. non-fiction (e.g. sports game).
- *There different elements in the image that enable the viewer to explore the image. What do you think of the different exploration elements? do they provide an added value?*
- *What other elements can be added?*

- How would you use these elements to tell a story? on the different devices?

Part II: Brainstorm on content scenario pilot 3: whodunnit - 30 min

- Explain content idea whodunnit (see pilot 3 - script Lightbox):
 - concept:
 - On TV you see the normal broadcast: the complete story from beginning to end
 - On the HMD and tablet additional content is shown, e.g. flashbacks that show the actions of the main characters, secret conversations between the suspects ...
- Divide end-users in 2 groups (2 x 3 people). Ask them to create their own future TV experience for a whodunnit scenario. Some fragments of the script will be printed as inspiration.

The participants will be asked to brainstorm and think on the following:

- What extra content and experiences would you show on the hmd? And on the tablet?
- Denk na over:
 - At what moments in the story should there be vr interactions? (altijd – soms)
 - What could the role of the hmd and the tablet be here, compared to the tv mode?
 - Moeten er extra clues zitten in de vr wereld?
 - ...

Presentation of the experience: Each duo presents their designs to each other. They can ask each other questions

Part III: Discussion - 30 min

- What do you see as the main opportunities for interactive VR here?
- What do you see as the main barriers for interactive VR?
- Added value tablet experience? Added value hmd experience?
- For which types of videos would this be the most interesting?
- During what moments, scenes... in the broadcast should there be and extra VR interaction on hmd & tablet? How long should these interactions last?
- How do you feel about switching between different devices?
- How do you see the interplay between TV, VR and mobile devices?
- How do you, as a viewer, want to be informed that you should use the hmd and tablet for extra content exploration? Do you want to get informed on this?
- Does this create a more engaging experience for you?
- Would you like this kind of set-up in a social viewing situation (when watching together with others)?
- The use of extra devices could be distracting, or take the attention away from the main storyline on tv. What could be a solution for this you think?
- ...

4. End - 5 min

- Final round-table: Does anybody have any last remarks?
- Give incentives

6.3. Annex III – Iteration 3: Topic guide interview live pilot 3

1. Introduction

- *Informed consent*
- *The project scope and aim user test is briefly explained*
- *Participants present fills in drop-off questionnair (name, age, occupation, possible previous experience with VR)*

2. Show pilot 2 demonstrator football content immersiaTV

→ Observe:

- *Usage of different devices (What devices do they use? When do users switch to another device?)*
- *Feedback (Do they say anything when watching the content?)*
- *Social interaction (Do they talk with others while watching the content? What do they say? What different devices do they use?)*

3. Part I: END-USER EVALUATION (simulated)-live pilot 2

- First impressions?
- How do you evaluate the use of the Head-Mounted Display? And Tablet?
- Tablet:
 - How did you experience the 360° viewing/ the navigation on the tablet?
 - What do you think of the portal on the tablet?
 - Was it clear how you could switch between camera viewpoints?
- HMD:
 - How did you experience the 360° viewing/ the navigation on the HMD?
 - What do you think of the portal on the HMD?
 - Was it clear how you could switch between camera viewpoints?
- How do you feel about switching between the different devices to watch the content?
- Usability:
 - How do you evaluate the user friendliness of the interaction with the content?
 - Is there anything related to the user friendliness of the experience that you would like to see improved?
- Would you like to watch a football match in a multi-device immersive setting in real life?

4. PART II: END-USER REQUIREMENTS live pilot 3: Ideation exploration mode tablet and HMD

- What do you think about the content that was displayed on each device? Was this in line with what you expected?

- **What extra content and experiences would you show on the hmd? And on the tablet?**
- **What could the role of the HMD and the tablet be here, compared to the tv mode?**
- **At what moments in the broadcast should there be vr interactions? How long should these interactions last?**
- **What should the portal look like on the HMD and tablet? (similar to the one in the demo?)**
- What do you see as the main opportunities for interactive VR here?
- What do you see as the main barriers for interactive VR?
- How do you, as a viewer, want to be informed that you should use the hmd and tablet for extra content exploration?
- The use of extra devices could be distracting, or take the attention away from the main storyline on tv. What could be a solution for this you think?