ICT-687655

Delivering Single and Multi-Screen Content Services for Immersive, Customised and Shared Experiences in Homes and Social Spaces

2IMMERSE

D3.4 User testing results: Interactions for Football

Due date of deliverable: September 2018

Actual submission date: January 2019

Start date of project: 1 December 2015 Duration: 36 months

Lead contractor for this deliverable: BBC

Version 1 December 2018

Confidentiality status: Public

Abstract

This document describes the results of user experiment tests that led to the development of the Football based experiences and includes the FanZone experience, an at home experience and the development of the production tools that supported the live production of the multi-screen experience of the 2018 FA Cup final from Wembley.

This document also records the results of user experiment led development of the OnBoarding functionality that led to the creation of the Unified Launcher.

Target audience

This document is for public dissemination and experts with good background knowledge of media delivery systems and who are knowledgeable of user requirements in the target scenario areas.

Executive Summary

The 2-IMMERSE project set out to develop an extensible, scalable and robust software platform that would support novel credible multi screen experiences based on dramatic content including Sport and the plays of Shakespeare. The new experiences enabled by the software platform merge content from broadcast and broadband sources and support new visualisations, viewpoints, data and replay facilities in addition to social network functionality such as chatting, commenting, polling etc.

The challenge can be summarised as co-producing the right content for the right screen at the right time whilst allowing a satisfying mix of control between the curation of the producer and the level of control desired by the user.

The reporting framework throughout the 2-IMMERSE project is structured so that we can give methodical, iterative feedback. Therefore, WP3 deliverables outline 'best practice' for ux-design & testing strategy -what we have done, and what we want to do next in terms of design aspirations and capabilities.

D3.1 reported on a group of small studies to inform and ground the overall UX design for the platform. For example, establishing synchronization parameters across devices.

D3.2 reported on UX-design of the Theatre at Home service. For example, audience requirements gathering, and establishing basic screen layout design across devices.

D3.3 described the user interaction design and experimentation work that informed the design of the MotoGP service experience, and specifically the subset of those features tested with connected audiences in private homes. It also reported on the design of the 2-IMMERSE Live Production Tools, used in the live-end-to-end trial, and the design of the SetUp and OnBoarding process.

This document, D3.4, describes the design story behind the features necessary to enable the football based experiences. This includes the development of production tools that supported the live production of the multi-screen experience of the 2018 FA Cup final from Wembley. In addition it described the design story behind the development of the Football FanZone experience and of the accompanying Football at Home experience. Both of which were demonstrated at IBC 2018 where 2-IMMERSE had an extensive presence across three stands including a large stand in the Future Zone as well as on the stands of both Chyron Hego and IRT as well as a talk at the technical conference.

The description includes user interaction designs generic to all trial services, informed by the findings from the Theatre at Home and MotoGP trials; and already reported in D3.1, D3.2 and D3.3.

Some of the design challenges and the resulting experiments in D3.4 will inform the future Theatre in Schools service trial, which will be documented in D3.5.

The methods used in WP3 include conceptual design, trajectory mapping, surveys and lab experiments. This deliverable covers the work and the thinking that led to the development of the service trial. It does not cover the test methodology or the results of the trial, which will be covered in WP4 documentation, or the technical development documentation of the production tools in WP2 and WP5.

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1 Introduction

This deliverable describes some of the user experience 'back-story' that has influenced the 2-IMMERSE platform. The major part of this back-story is an explanation of why certain features have been developed, but another important perspective relates to wider issues relating to evaluation.

In general, platform features are developed in response to a design requirement that comes from a particular service prototype. The general approach of the project is to use service prototypes to elicit and define required functionality on the platform. As expected, we have found that the features and capabilities developed for one service prototype are being used in others.

The WP3 documents are ostensibly structured by service prototype, as this is the way the development within the project was phased. It should not be interpreted that the features and functions described under the heading of a particular service prototype are only used for that service prototype, as this is not the case.

In this document we review the design work that defined the user experience of the Football service trial. It describes the process that led to the development of its features and describes them. We start with early work on Football in social spaces, through to the Football at Home prototype.

Section 2 provides some background to the design task, introduces the original proposal and refers back to the background work completed in conceiving the opportunity originally.

Section 2.2 recaps some of the requirements gathering that has taken place to inform this work. This is largely reported elsewhere. Section 2.3 reports some of the more conceptual ideas, focused on Fan Zone concepts that have framed the direction of some of this work.

Section 3 describes how we set about developing the new football based service prototypes. The project understood the value of illustrating that it was possible to define an end to end workflow for the object based presentation of multi-screen personalized sports event and this underpinned a lot of the development process. The work crystallised into two distinct end user experiences. Section 4 describes the first of these, the Football at Home use case whilst Section 5 describes the Football FanZone use case which explores the presentation of Sport over multiple large screens in a public space.

In section 6 we cover the design of the tools related to the production process that were developed within 2-IMMERSE to support the live end to end production trials. These include a live-edit tool and a trigger-tool.

During this stage of the project a key platform capability that is common to all potential multi screen experiences was developed. This capability, the on boarding and unified launcher capability, is described in section7. This iteration addresses a number of requirement that the fan zone use case created.

Section 8 offers some conclusions from this work and looks ahead to the next phase of work that addresses the Theatre in Schools use case.

The document also reports some related work in the Annex which extends some of the object based ideas to include tangible interfaces. Tangible interfaces were not incorporated into any of the major use case that 2-IMMERSE developed but this use case shows how the object based approach can be extended to support such an approach in the context of a children's game (called 'Runaraound' in the UK when broadcast in the 80s and 90s.)

2 Football: Concept development process

All of the project's service prototypes were initially defined in 2015 for the project proposal. The service prototypes have, of course, developed since that time. This section shows some of that progression starting first with the original geode scenario for the football based service prototype.

2.1 Original proposal – Watching Football in a Pub

The original proposal was described in deliverable D4.1 within which we included a guide scenario and also a sketch (see Figure 1) that helped us to imagine and discuss the service.

This service innovation prototype might be called 'Sports Bar of the future' but since the experience of watching sport is so dependent upon gaining appropriate content rights and because the experience of watching sport will be nuanced by the sport in question, we have chosen to be specific. Thus this multi-screen experience is called "Watching football in pubs".

Figure 1 Guide scenario sketch developed at the beginning of the project

This service innovation relates to an experience designed to suit UK city centre pubs showing sport. It will mix large screen viewing with opportunities to view content and interactive experiences that may be playful and promotional, to personal screens. We anticipate a system capable of supporting a diverse range of experiences centred, ultimately, on a single sport event but that finds a way to encourage and promote business within the pub through promotions and possibly competition.

2.2 Requirements gathering

The project set out to develop and define a platform that would support multi-screen experiences that could immerse viewers more completely than can their single screen alternatives. The 2-IMMERSE Football experience should therefore offer the users an experience that is distinct, and more immersive than, the experience a user can get from existing services (such as watching live sport on TV in a public space today) or that they can generate at home by watching the traditional broadcast alongside an existing app designed for a small screen. To design for this, it was important to understand both what small screen apps exist and what they offer and to understand better the phenomenon of watching football in a public space.

2.2.1 Sport Apps

For the FA Cup content the two most relevant apps are published by the BBC ad BT. They are introduced below.

2.2.1.1 BBC Sports App

The BBC Sports App is one of the leading apps for live text scores and text commentary. It does not provide live video streaming of matches, but does provide free data driven text commentary and stats along with customisable live score notifications and alerts for all English football leagues (and other sports).

Each live match is provisioned with a live match page that combines OPTA driven match commentary with (for key matches) additional BBC production insights and opinions. Basic match summary data (possession, corners etc.) are also included, along with links to national or local BBC radio commentary coverage.

BBC also provides an extensive sports notifications service across a wide range of sports, with football providing notifications of line-ups (pre-match), kick-off and goals scored. Half-time and Full-Time results are confirmed on the completion of each half.

2.2.1.2 BT Sports App & BTTV

Both BT Sport (BT Sport App1) & BTTV (TV Anywhere) offer residential subscriber Apps that can be used in Pubs (WiFi hotspot or 4G coverage required). Both provide live video streaming of matches with the enhanced video player for UEFA Champions League games providing on demand catch-up of the entire match, with additional data overlays and multi-angle highlights for selected key moments. Customers currently utilise the App as either their primary viewing experience (BT Sport digital customers) or as a companion application to the primary TV experience (BTTV or Sky subscribers)

The match broadcast provides a rolling timeline bar populated with key events (goals, key moments, cards and substitutions). This timeline allows the user to navigate backwards in the broadcast to watch the game again from any point.

Browsing the match time line icons provides specific data about that event, such as the exact time, players involved and whether the broadcaster has provided the option of the match from multiple camera viewpoints, in which case the asset is described a san MultiCam asset.

Where a MultiCam asset is made available in the time line, it can be selected to launch a standalone player. The Viewer can the select from 8 different angles of the 20 second event. These can be accessed by a right hand menu labelled with camera positions, or from an overlay graphic that shows the location of the camera within the stadium

In the primary broadcast player, a top menu provides the ability to overlay data features such as text commentary, line-ups, tactics, distances& speed, passes, team stats. Additionally, concurrent match scores can be displayed, with the option to switch to enhanced player for that match.

2.2.2 Watching TV in public space

To better understand the phenomenon of watching football in pubs we conducted literature surveys, worked with brewers, landlords and the BT Sport Commercial team to understand the challenges and opportunities in this space and to learn on the ground 'what works'. Finding from this work is described deliverable 'D4.1 Prototype Services Initial Descriptions – initial versions' and (item 7) in deliverable 'D3.3 – UK-design of generic features'.

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[1] https://www.bt.com/sport/app/

This background research (reported in deliverable D4.1 and D3.3) included:

1. An analysis of the market context
2. An introduction to existing services
3. A review of current auxiliary apps for sports
4. An introduction to the features typical in live streaming services targeting a portable device
5. An introduction to the sociological view of the phenomenon of watching sport in a public places
6. A small scale study of different pubs and the way they support sports viewing
7. A study of user responses to a sports event presented on a single screen and presented over three screens.

Broadly this work suggested that:

1. the presentation of sport with different views on multiple large screens visible in a 'primary viewing area' (defined as being a view a user can see all at once without having to move their head) can be more impactful than showing the same broadcast feed over all three screens.
2. in public spaces the use of auxiliary devices would be limited - it fitted less well with the usually accepted social experience where you stand shoulder to shoulder watching the match rather than looking at an auxiliary screen, though we recognized they might have value in booth set-ups where a group of people known to each other are sharing a table and a screen within a public space. Such situations are structurally very similar to a home scenario
3. for the owner of the public space, simplicity is key. This led us to consider the need for a templated format where the owner of the space could simply select between different options.

Background research analysing the production challenge also alerted us to the fact that

1. The football trial would be the project's best opportunity to explore a live end to end production test
2. There were interesting timing challenges associated with the adoption of the object based delivery approach
3. There were, from the rights distributor with whom we were working (BT Sport), reservations about focusing a use case on pubs and a concern that changes in production should support all our presentation of Sport – both in home and in public spaces as developing a new production chain for one variant only was not economically practical.

We sought to use these insights in the development of a multiple large screen demo suitable for FanZone that was consistent with also delivering a multiple screen experience for a home based user.

2.3 Exploratory work

Lots of exploratory work was under taken by the 2-IMMERSE team to the impact of our design choices around multiple shared screen layouts, and their ability to affect people. An example, that informed the UX of Football in social spaces, considered the physical layout and proximity of the screens, and the type of synchronized content to be displayed on the screens, and is reported in chapter 5 of deliverable D3.3.

Decisions about the screen layouts to use and the selection of content choices to populate each screen were made based on exploratory work carried out by the 2-IMMERSE. The concept of a 'primary viewing zone', an area that can be viewed and assimilated without the viewer moving their head but which may utilize more than one screen, was developed and concepts were developed based on this notion. In these concepts everything must be viable without having to move your head – practically

speaking this demands layout where screens are in close proximity each to the other. One option is shown below in Figure 2 .

The use of the portrait layout is, at first glance unusual, excepting that in many public spaces (and in particular in pubs which was the first focus for the project) screens that are sometimes used for the presentation of sport are the rest of the time used for digital advertising and for this purpose, the portrait mode is quite common. To populate the portrait screen, content that worked better in that mode was chosen such as portrait shots of the managers. These can be cropped from a 'normal' landscape shot.

When portions of matches were presented using this layout it was judged by the designer to offer more insight and to induce more empathy – a perspective assessed in a small scale trial.
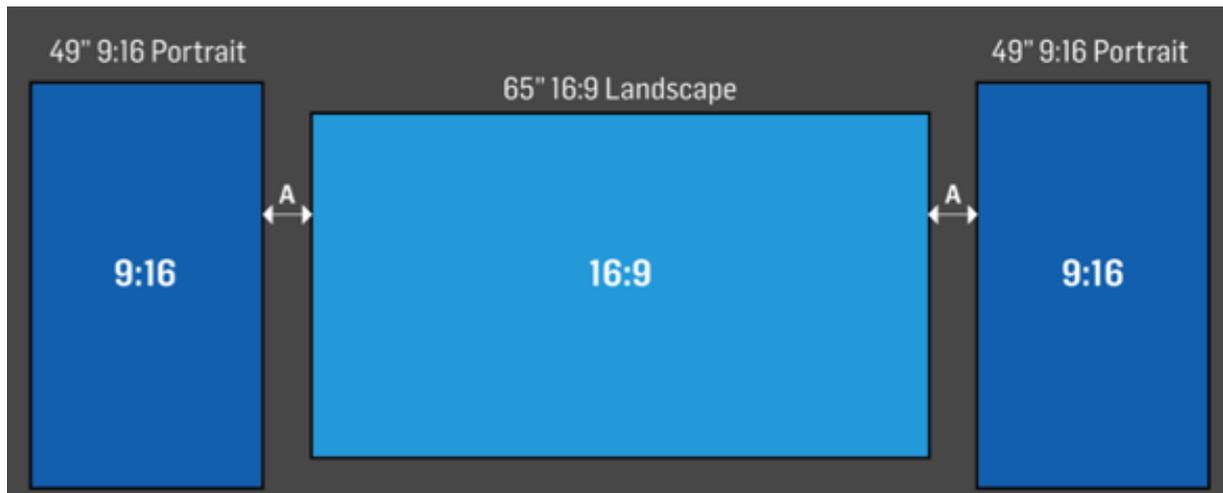
Figure 2 Configuration of screens used in an exploratory exercise on the use of multiple shared screens in a public space.

A video of a football match was used as stimulus material, presented in 4 ways, A to D. The A and B versions of the clip used only a single central screen; clip A used the BT Sport commentary to accompany the video images, clip B used the partisan BBC Radio London Commentary.

Clips C and D were three-screen presentations using the as-broadcast BT Sport presentation in the central screen with side screens, oriented in portrait, showing synchronized streams of the crowd (right screen) and the manager (left screen).

230 students (14years), attending a public event at BT Research headquarters, were asked to compare the 4 different presentations (A_D). Groups of 10-15 students were invited to sit down, to watch and assess clips shown on a 3 screen set-up. The students sat in seats 2-4 metres from the central 65" screen. The side screens measured 49" across their diagonal. Sound (the broadcast commentaries) was played from the speakers of the central TV speaker. We found they preferred a three screen presentation, than a single screen presentation.

2.3.1 Demo space proposal -iCity Showcase

Another take on the use of screens in a public space was a design intended for a public space in iCity (the home of BT Sport) to help showcase some of the sports related concepts in 2-IMMERSE including the 'Watching Football in a Pub' concept. This is shown in Figure 3.

This intention was that this would allow a flexible semi-public viewing area to explore and iterate screen layout solutions to generate user feedback. One constraint, using layouts made up from standard TV screens, was released and this allows concept based on video walls that led to the ability to conceive significantly off format media objects.

Figure 3 A visualization of the iCity Showcase proposal, to allow the semi-public exploration of multi-screen experiences in social spaces.

This direction proved a little too unorthodox and whilst an innovative demo it is difficult to steer a route from this concept to a service that can be monetised.

3 The new football-based service prototypes

The project began with a working assumption that the public space in which sport could be represented well over multiple screens was a pub. This assumption made our service provider partner, BT Sport, uncomfortable as they felt they were not yet in a position to exploit such an approach and were concerned that the presentation of such concepts could lead to confusion with their commercial clients. Without the support of BT sport the project could not expect to retain access to the necessary rights to access and use the content. BT Sport suggested that the project should focus more on an at home scenario.

The review process at the end of Year 2 was keen that the project retained a use case example that was out of the home.

The project spent some time and energy re-scoping the work, a key element of this re-scoping served to underline some of the challenges and opportunities of the object based media approach that underpins 2-IMMERSE. In considering the options it became apparent that it was not that difficult to enable both a multi-screen at home AND a multiple large screen public space representation of sport provided the production method was optimised for object based delivery. This also underlined an incredibly important ambition for the project and that was to deliver a live experience and not just the as-live experience we had so far developed for MotoGP and Theatre at Home.

We re-scoped the work, redefining our pub scenario as a FanZone and sought to satisfy the following project aims:

- To illustrate that with one carefully designed production process, diverse representations of a single event, including both a FanZone and an At Home representation, can be supported.
- To achieve a live end to end production test (in contrast to MotoGP at Home which was as-live/on-demand).
- To illustrate the use of production authoring tools including the use of a live authoring tool – to manipulate and edit the live experience, responding in realtime
- To enable an in-home experience that mixes large screen viewing with opportunities to view content and interactive experiences that may be playful and promotional, to personal screens.

3.1 Revised Guide scenario

The revised guide scenario, as approved in the amendment of the description of work, we used to orient the project development is shown below in the grey box

Arsenal are playing Chelsea and Sue and Dave have agreed to meet their friends to watch the game in town where there are large public displays amongst the bars and cafes. Sue and Dave know they can take their smart tablets along and connect into the synchronised broadcast shown on the big screens. [Public displays working with many personal devices].

Their devices give them a personalised view of the match and enable them to easily relive and replay in slow motion key events in the game and well as participate in a host of synchronised play-along games that prompt them to predict the score, play fantasy football, judge who will cover the most yards and vote for the man of the match [Access to stats data]. Viewers are encouraged to participate, sometimes by the local proprietors offering prizes of meal and drink vouchers. Most people play for the prestige of being the best football pundit amongst their friends. [Synchronised multi-player participation].

The big screens show the main action curated live by the broadcaster's production team. Two of the screens show the home and away supporters from two of the stands in the ground. It adds to the atmosphere when either side score a goal, miss a golden chance or hit the woodwork - it's more like being in the ground and brings a stadium atmosphere to the town centre. [Multi-camera and spatialised audio].

Users if the app can clip and post short sequences of the match to the production team in the studio who can choose to incorporate it into the multiscreen presentation. Dave occasionally uses this to share his favourite clip [Pushing clips to view on the public screen].

Action replays can be collected over the course of the match to be viewed over and over again on individual tablets to settle debates (although they rarely do). Using the 'SloMo' or 'CloserLook' features you can slow down the action or take a look from a different camera angle (was there contact or was that a dive? Was that really over the line Mr Hurst?). [Multi-camera features offered by third-party applets supported by the open framework of platform].

For large events, the system can be configured to allow multiple locations to take part in events, competitions and quizzes. Dave and Sue note a moderated Social Media feed that continuously scrolls though selected comments, synchronised with the broadcast (removing any chance of spoilers) [Space to space and public media sharing].

The new live football scenario has three distinct parts.

- **The live production test** designed to prove the end to end live production capability using production tools developed by the project and advanced object-based sports infographics. Live delivery of object-based sport is a fundamental proof point that the industry needs to see before it will commit to live object-based sport productions.
- **The FanZone demo** that uses the content objects developed in the live production process to explore more advanced and socially oriented features of the multiscreen experience.
- **An At Home Experience** that uses the content object generated through the live production process to showcase a view on how multi screen at hoe experiences could evolve.

3.2 The development schedule

This three part description, 'Live Production test', 'The FanZone demo', and 'The At Home Demo', which puts production before the description of what the user sees, makes sense when viewed from a production perspective. In this document we are describing more of the design process. This reverses the logical order as the capabilities of the production tools are set by the end user experience that we seek. In what follows we thus start with the design of end user experiences and end up with a description of the production tools.

In practice, life and work are a bit more messy and muddled and both parts were designed in parallel, though the causal links are as stated in the design order. Researching with high value content we also found that we had to fit in with the schedule for Football broadcasts, inexplicably we found no desire to amend the football schedule to meet our research timetable.

One over-arching timeline was dictated by the access we could negotiate to sports venues. We required several session to understand develop and prove our system before deploying it in a full end to end live trial, as shown in Figure 4.

Figure 4 Live events used in the development of our Football based experiments.

4   Football at Home

This section outlines new features/components enabled in the Football experiences. Some of which could not be realised in the previous 2-IMMERSE experiences and trials. These features/components are core capabilities of the 2-IMMERSE platform available for all multi-screen experiences.

Although the UX-design for the Football, and early concept for which is shown in Figure 5 experience was heavily influenced by existing broadcast design guidelines, assets and layout (from BT Sport) and the interaction design of the BT Sports & BBC Sport apps, the UX-design strategy for the 2-IMMERSE experience was partially informed by the insights gleaned in previous trials and demos. Thus in common with earlier trials the Football use case included the following features:

- Broadcast graphics –which are replicated & made interactive
- The use of Responsive graphics
- Media objects that can be moved and/or duplicated between TV screen and companion screen

Figure 5 An illustration of some of the functionality the 2-IMMERSE team considered during the evolution of Football at Home. Not all these functions were developed.

4.1   Example requirements

The 'live' football experience was explored as a seamless experience with some core requirement proposals. Below are 5 examples of requirements explored during the early UX design phase; not all these requirements were taken forward.

4.1.1   *Example 1* Live VR

The idea of merging a live VR experience with the broadcast for seamless transition during matches was explored (but did not make it into the final design) see Figure 6.

- Headset Sync: a sync'd VR headset feed enhanced with broadcast graphics elements.
- Magic Window: a sync'd magic window feed is enhanced with match graphics
- 2 Way Screen: a sync'd magic window feed that can be duplicated as a 2 way screen on TV

Figure 6 An illustration of how a live VR experience could appear in a multi-screen layout

The use of VR has been explored by BT Sport and their experiences has established that, to do the VR medium justice requires a parallel production process involving multiple viewpoints and bespoke commentary and ideally much higher capture resolution. The benefit of incorporating VR were deemed slim compared to the technological cost and production complexity.

4.1.2 *Example 2* Live Alternative Views

The idea of offering new video angles of the game that complement the directors' broadcast production was also explored, see Figure 7. A key word here is complement; rights holders, broadcasters and directors area aware that replacing (not complementing) the main broadcast feed with another live feed is highly risky as the main narrative for the match – the one that the commentator and the match director create together – is dependent upon the broadcast match feed. Losing this feed risks disturbing the main narrative thread around which the broadcast presentation is built.

Figure 7 An illustration of how live alternate views that complement the directors broadcast could be shown on the shared TV screen (PiP), on a tablet and on a phone.

Early lab test established that careless mixing of views creates confusion. We observed that in some cases many TV and film conventions, such as crossing the line, are broken because of the significantly different perspectives of some of the camera angles. Nevertheless we identified some ways that some live alternate views could complement and not confuse the main narrative driven by the broadcast feed. These included:

- Manager Cam: Individual live sync'd feeds of auto tracked managers with layout options across multiple screens.
- Player Cams: Individual live sync'd feeds of auto tracked Players with layout options across multiple screens.
- Data driven edit decisions: Switch ISO based in possession or field position.

▪ Graphics Layer : Duplicate key graphics elements of live game for best viewer experience

Thus complementary camera angles were selected with care. They may same modest but in design iterations these are the concepts that seemed to work.

4.1.3 *Example 3:* **In-game Replays.**

In-game replays are lauded by fans of the BT Sport app as a key and valued feature. Thus in this prototype service we wanted to enable a similar feature but to enable it in a sensible way in a multi-screen environment. This led to a replay capability that could be instigated and controlled on the tablet but could appear on either the main TV or the companion screen. In Figure 8, the red and white graphic above the BT Sport logo informs the viewer that the video is a replay.

Figure 8 An illustration of how in-game replays may appear

▪ Multi-screen Replay prompts : Interactive object based graphics prompts when replays are available to display across multi-screen device.
▪ Push to TV [Timeline]: a match timeline with selectable VOD assets to push to TV for display as PiP or 2 Way Screen
▪ Push to TV [Event List]: a match event list with selectable VOD assets to push to TV for display as PiP or 2 Way Screen
▪ Dynamic Graphics Layer: layout key graphics elements of live game for best viewer experience

4.1.4 *Example 4:* **Live Data and data driven graphics objects**

Graphics driven by a synchronized data feed is a feature first seen (in this project) in the Theatre At Home experience (with the scrolling script). The same feature is central to the MotoGP demo too (the leaderboard and lap timings). Here we are using data that will be familiar to viewers of football (see Figure 9 which shows data driven graphics related to the score and above the score clock to details about substitution); in this case however, the moment when the data driven graphics are presented can be controlled by the user.
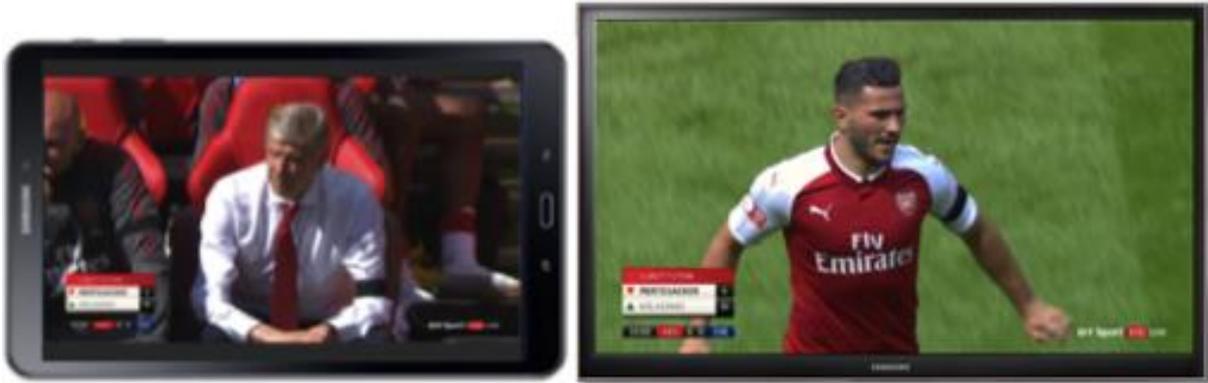
Figure 9 An illustration of live data driven graphics objects that are synchronised to the TV feed may appear.

Data driven graphics include:

- A Stats Flipper: Which adds key match facts to a personalized stats popup.
- Player Tracking: Adding player specific performance data (combined OPTA and TRACAB data) as optional graphics object
- Enhanced Player Supers: Adding detailed performance data to live close ups of Player Cams.
- Graphics layer : Making live graphics objects interactive so viewers can explore further when prompted.

4.1.5 *Example 5.* Social & Participation object.

The goal with social and participation objects is to somehow merge features familiar within and through social media channels (such as sharing, publishing and contributing) with the broadcast experience

Figure 10 An illustration of how social and participatory features could appear.

Examples of social and participation objects include

- Pundits: Curated feed of broadcaster pundits as a multi-screen object.
- Team Specific: Curated feed of specific team as a multi-screen object.
- Custom Group: User defined feed of selected users with non-curated content.
- Calls to Action: Voting for next player cam for each team.

These participation objects illustrated in Figure 10 which include a Vote Now call to action to select a player cam were not developed in detail. The effect of participation can only really be assessed when the features are being used in a live match and when they are being used at scale. Custom graphics

delivering the score from off screen matches (for games where "your team" is playing) were also illustrated.

4.2   UX-design for Football at Home: wireframes graphics and the user interface.

Object-Based broadcasting provides user-level personalization and it thus requires all broadcast graphics (non-video visualizations overlaid on top of the video) to be directly composited on the client device. This is a major shift from traditional broadcasts, where all graphics are overlaid at the outside broadcast truck.

The design of these graphic elements and animations is defined at the pixel level. We tried to adopt a workflow common in traditional TV stations and networks, which meant that a new purpose-built design tool was needed. Since there was no time and resources to create one, the short-term solution was to adapt an existing tool from ChyronHego's product range. The researchers extended the existing broadcast graphics authoring tool *ChyronHego PRIME* with a compatible renderer, making it usable within our object-based broadcast infrastructure. This is a great example of exploitation – the adaptation to PRIME is now available to ChyronHego to develop as a product when the market opportunity is clear.

Football at Home experience was defined to be a multi-screen experience involving a single primary shared screen (Main TV) coupled with a companion device (Tablet).

The design principles applied to the Football at Home experience were:

- For the BT Sport directors broadcast mix of the game (along with commentary) to remain central to the experience.
- To allow the match experience to be enhanced with additional media objects to create different ways to watch the match based on the viewers interest or allegiance.
- For the broadcast (TV) and digital (App) match experiences to feel like a single joined up experience.
- To blur the boundaries of user perception between traditional non-interactive TV graphics on TV and the interactive GUI of digital player (tablet/phone) which are still often disconnected in terms of technology and visual aesthetics.
- To create responsive graphics that adopt the appropriate scale, location and design based on different screen sizes and interactive features (e.g. safe zones for TV or a touch screen companion device).
- To retain a level of control over the quality of the match presentation by applying rules for TV and companion app layout and rendering of Match GRAPHICS based on content type, screen type and context of broadcast.
- Provide a graphical user interface video overlay for the companion App and provides access to and selection of live media objects in the trial. These include match data (team sheets and match stats), video on demand assets (replays) and live video streams (ISO cameras).

Two iterations of the Football at Home experience were applied during the project. The first (version 1) was created and tested during the live end-to-end football trial, from the OB-truck to homes of 2-IMMERSE project team members. The second (version 2) was an iteration of the design, with simplifications and additional features added to the clients for presentation of the experience as an 'as live' demonstrator at IBC in September 2018.

4.2.1   Defining the primary (shared) screen and the companion (individual) screen

We decided that both the primary screen (TV) and the companion screen (Tablet) should provide a 'TV experience', rather than an 'App experience', though not necessarily with the same look and feel across both screens. Below (see Figure 11) is a combination example of a snapshot of the Football at Home experience. The TV (left image) is showing a broadcast stream with object-based graphics, while the tablet (right image) is showing an alternative video feed of the manager, with the same object-based

graphics which are interactive on a touch screen tablet. The interactive graphics on the tablet are used to launch a 'Match menu' and a 'Broadcast menu' shown only on the tablet screen.

Figure 11 Illustrating how object-based graphics (the score clock and the channel bug) can appear over different base video on different screens part of a single multi screen experience and, in the case of the tablet, become interactive.

The primary shared TV screen (left) includes:
▪ Base Video stream
▪ All live camera cuts and replays are defined by director as included in the broadcast feed.
▪ GRAPHICS Layer (outlined in red)
▪ All match Lower Third GRAPHICS and OB are rendered over clean match feed to replicate the current experience.
▪ Interaction
▪ No direct interaction with the primary screen. All control of the layout and content is triggered by interaction with the second screen UI

The companion screen (right image of Figure 11) offers personalization using the touch screen interface, through which users can select dual screen or PiP (picture-in-picture) layouts, or to watch an additional isolated camera feed alongside the broadcast feed on the primary screen.

4.2.2 TV Match Graphics

No unique design process was required to re-create the BT sport Match graphics. The task was to replicate the style, layout and animation of existing on-screen TV graphics via the ChyronHego PRIME authoring tool. Prioritisation decisions were made on which graphics to include/exclude based on their complexity and re-use to ensure maximum return on effort. Style sheets were created (see Figure 12) by the project so that PRIME updates for each of the three trials included the correct team variables.
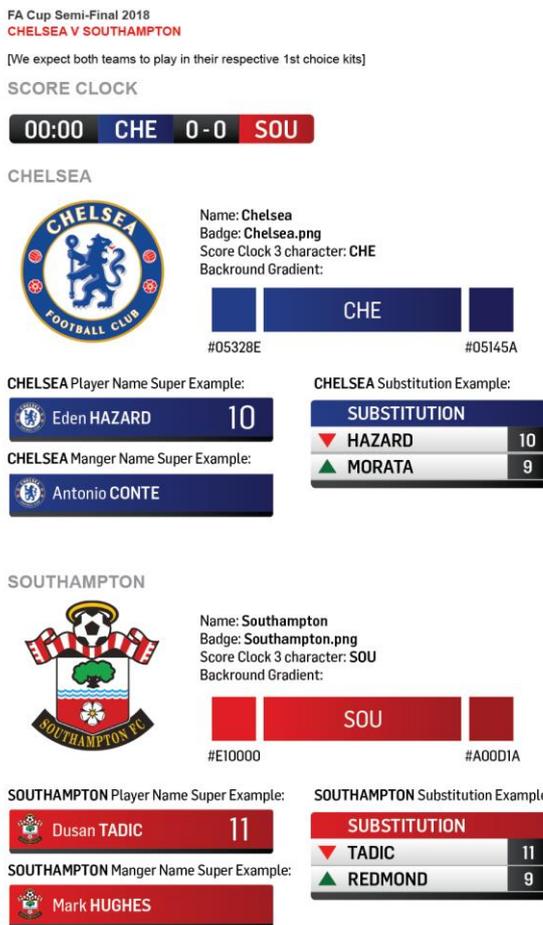
Figure 12 The graphics style sheet created for the FA Cup Semi-Final test

4.2.3   Graphical User Interface (GUI) Video Overlay

To achieve the goal of merging the presentation of the match on the TV with the presentation on the App into a single unified experience - the BT Sport design style was adopted and extended to ensure the companion app appeared as one part of a unified experience.

This also included constraining the graphical user interface to the location of existing on-screen graphics that appeared above the match score clock and channel DOG (display on screen graphic).

To launch the menu the user could tap the existing on-screen Match graphics (the omnipresent score clock) to access more media about the match. A series of examples can be seen in Figure 13, developed using the style guide created for the Score Clock Menu. This guide covered how the 4 tabs: Match Overview, Match Stats, Team Line ups and Replays could be accessed and would appear.

1. Match Overview   2. Statistics

3. Line Ups   4. Replays
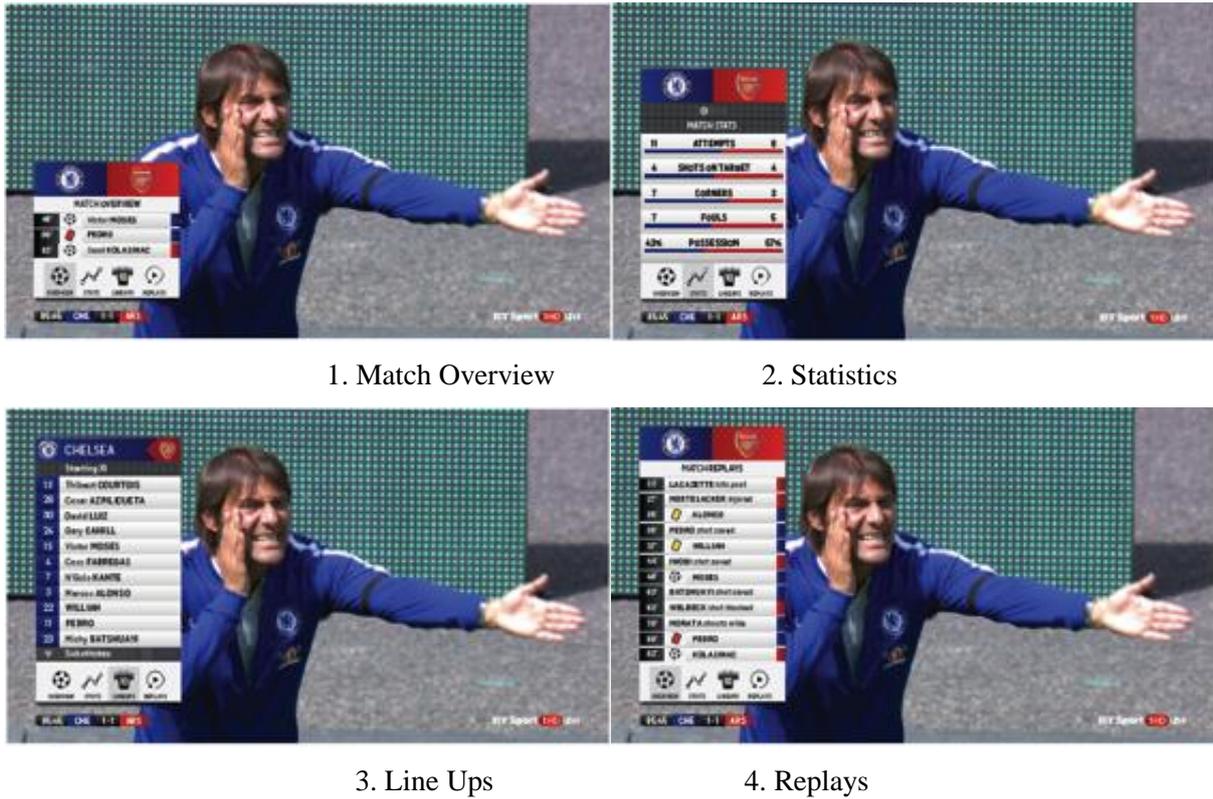
Figure 13 Different tabs within the Score Clock interactive GUI.

4.2.4 Match Overview tab

Taking each tab in turn we will first look at the elements of the Match Overview (see Figure 14), which is the default start tab when the Score Clock Menu is triggered.

Figure 14 Illustration of the Match overview graphic activated from the Score clock

Event bars (Figures below) are generated for both the Match Overview and Replays tabs. The Match Overview lists the key match events, such as Goals and Red Cards.

Figure 15 Illustration of the event bar graphic for 'goal scored' – a detail from the Match overview graphic

For Own Goals (Figure 16), the name of goal scorer + (OG) is displayed, using gradient of scoring team.

Figure 16 Illustration of the event bar graphic for 'own goal' – a detail from the Match overview graphic

For a goal in added time, we use 90+ (added mins), and do not display 93', see Figure 17.

Figure 17 Illustration of the event bar graphic for 'own goal' – a detail from the Match overview graphic

When an individual player scores multiple goals we create an event bar for each goal. This also allows access to individual replays see Figure 18.
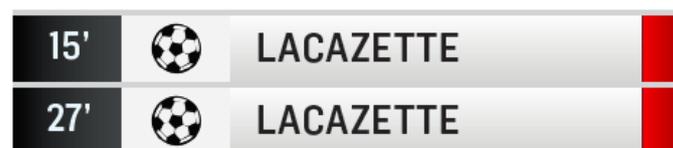
Figure 18 Illustration of the event bar graphic for 'own goal' – a detail from the Match overview graphic

4.2.5   Match Stats Tab

When selected, the Match Stats tab (see Figure 19) provides an overview of the key match statistics per team. Multiple cards listing the top performing players in certain statistics can be accessed by swiping left/right or selecting Team Stats Bar
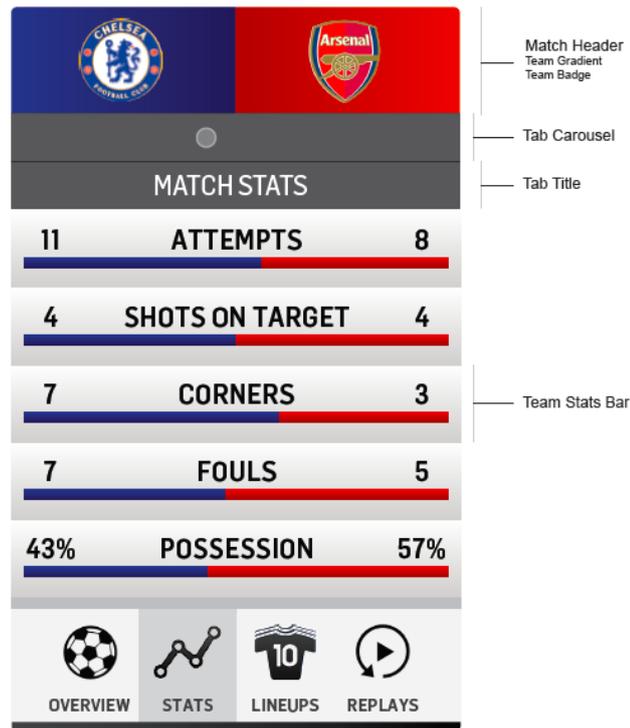
Figure 19 Illustration of the Match Stats card accessed from the score clock menu

There are additional cards available; these are shown in Figure 20 (including Match Stats). These additional cards rank players individually. Note that the original tab height is maintained if there are not enough Player Stat Bars.

Figure 20 An illustration of the Match Stats card showing the Completed passes and Attempts and other stats. All are accessed via the score clock on the tablet.

4.2.6 Line-Ups tab

When selected, the Line-Ups tab (see Figure 21) displays the Starting team or Current team, and the available substitutes. Only one team is displayed at once, with the home team shown as default, with the away team displayed by swiping left.
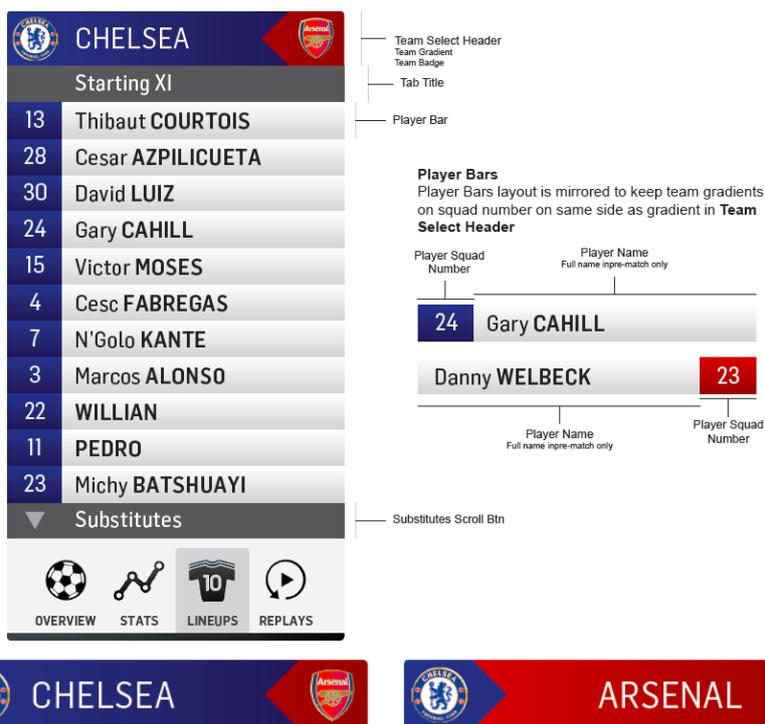
Figure 21 Illustration of the appearance of the line-up card, starting XI card. The Home team is displayed by default with away team accessed by swiping Right

Before the match, the Starting XI (team) and named substitutes are shown for each team. Full player names are used because of available space on player bar. The line-up shown can be switched (to show either team, see Figure 22) by swiping.

Figure 22 Starting XI card - Swipe Left to access Away Team Line-up Swipe Right to access Home Team Line-up
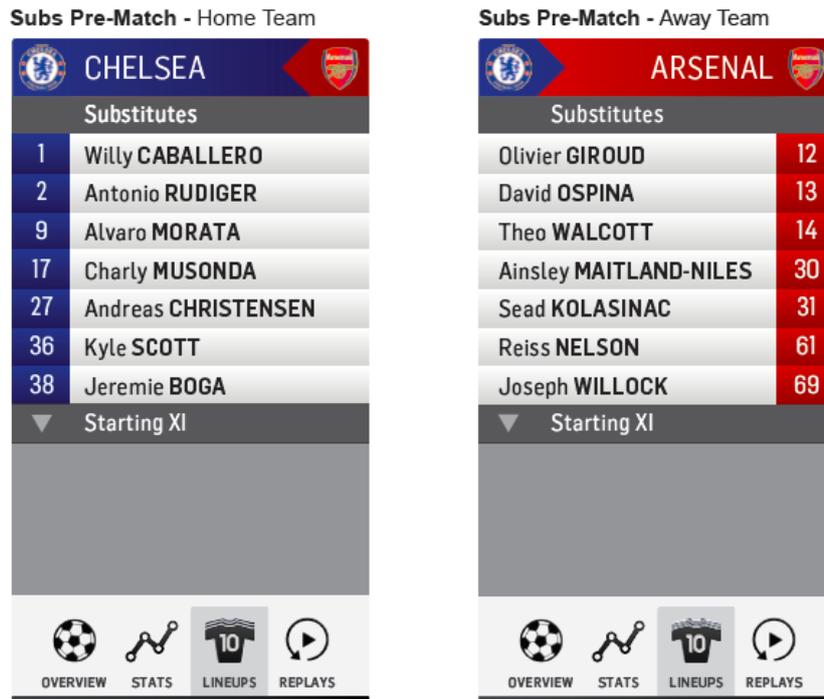
Figure 23 An illustration of the Substitute list accessed from the bottom of the Starting XI card.

Once the match has started, the Player Bar also displays any yellow or red cards awarded and shows the substitution changes for players.

Due to available space, we chose to only show the most recent player event so, for example, if a player from the bench who came on to play (and so was added to current XI) then received a yellow card then only the last event (the yellow card) would be displayed, see Figure 24. With these cards only the player surnames can be shown as this leaves space on each player bar for player events (cards and substitutions).
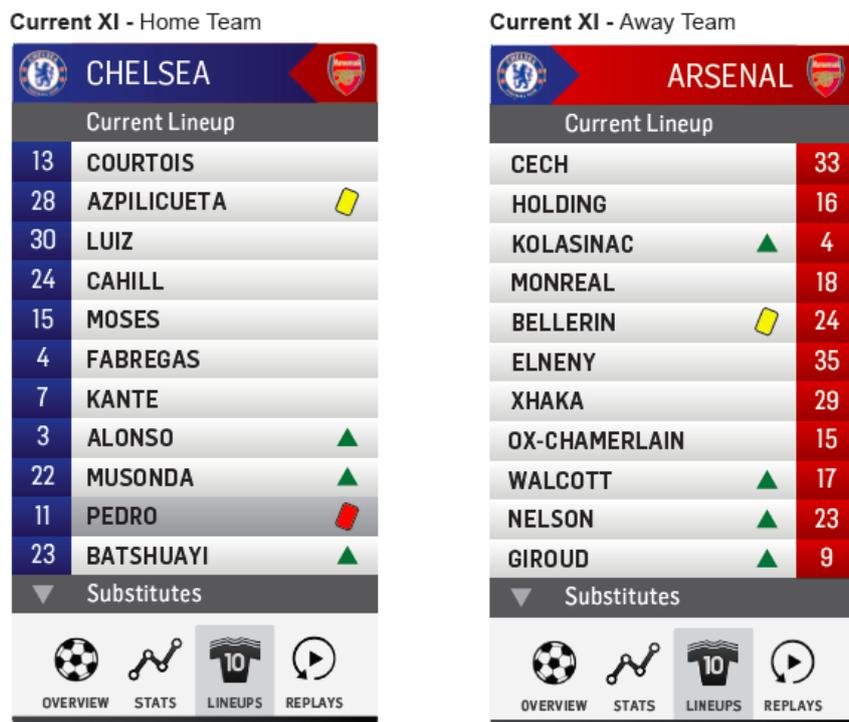
Figure 24 An illustration of Current line-up showing navigation to the substitutes.

The way the substitute lists are handled is shown in Figure 25.
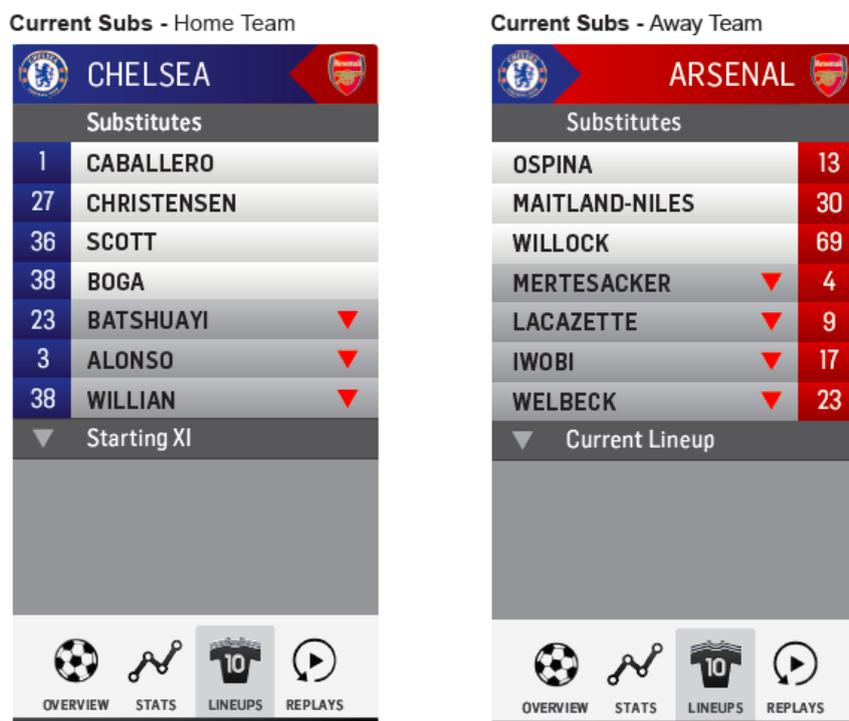
Figure 25 An illustration of substitutes showing navigation to the current line-up.

Figure 26 Shows how various plausible but less commonly used graphics would appear.

Player Yellow Card
Home Team

| 28 | AZPILICUETA | |

Away Team Flip

| | BELLERIN | | 24 |

2 Yellow Cards Sent Off
Keep in Current XI in same position in list.
Change bar background gradient to grey

| 28 | AZPILICUETA | |

Red Card
Keep in Current XI in same position in list.
Change bar background gradient to grey

| | BELLERIN | | 24 |

Substitute added to current XI
Move to current XI list in place of swapped player.
Animate between sub on arrow and time (min) of
substitution

| 22 | MUSONDA | ▲ |
| 22 | MUSONDA | 82' |

Current XI player substituted
Move to Substitutes list (bottom).
Change bar background gradient to grey
Animate between sub off arrow and time (min) of
substitution.

| 38 | WILLIAN | ▼ |
| 38 | WILLIAN | 82' |

Substitute who is substituted
As above and only show last sub action (off)

| 22 | MUSONDA | ▼ |

Substitute who receives Yellow card
As above and only show last action (yellow card)

| 22 | MUSONDA | |

Figure 26 An illustration of various additional, less common, graphics that had to be prepared for the live trial and the subsequent demos

During the live match, halftime and fulltime, the Player Bar can be tapped to access the match performance of individual players (see Figure 27. Although these could be nested under the Match Stats tab, the Lineups tab is an easy way of finding and selecting a particular player. Note (see Figure 28) how the profiles for players from different teams are mirrored in the design.
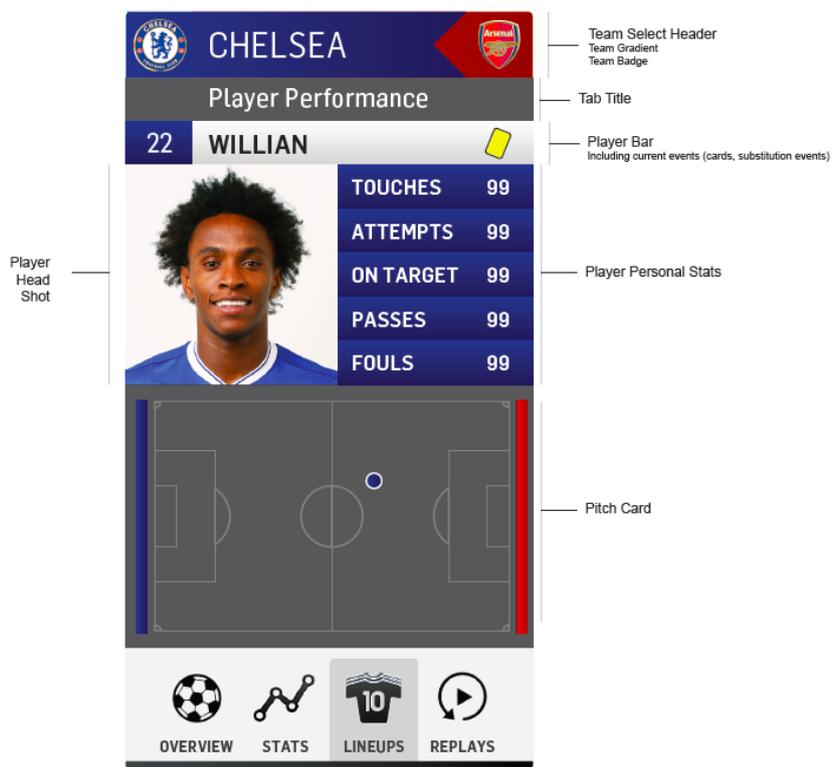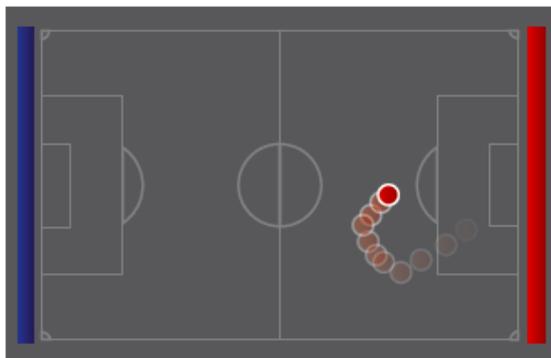
Figure 27 Multiple Pitch Cards -are available by swiping left and right on graphic.
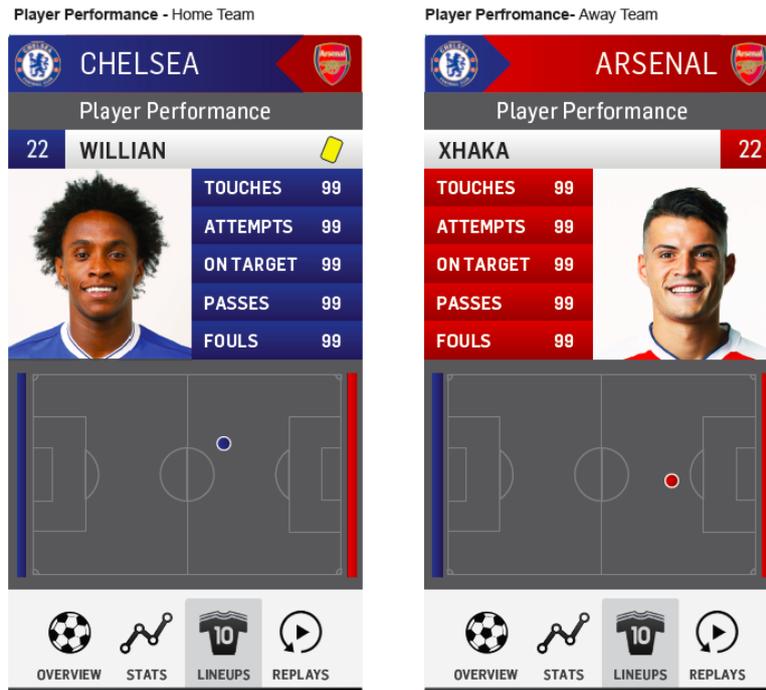
Figure 28 Player performance profiles -Profile layouts are mirrored to reflect the Player Bar, and to match Squad numbers with Club Badge. However, Pitch Cards are fixed to the playing direction of the team.

4.2.7   Replays tab

In the Replays tab, each event bar can be tapped and expanded to show the associated video Replay asset. The video thumbnail menu is a common interaction design used across both live isolated camera streams and on-demand video (match replay clips). Each menu bar for replays or cameras can be expanded to play a thumbnail video of the associated media (see Figure 29 below).

Figure 29 Replays - Previewing videos, and an option to move videos to other screens.
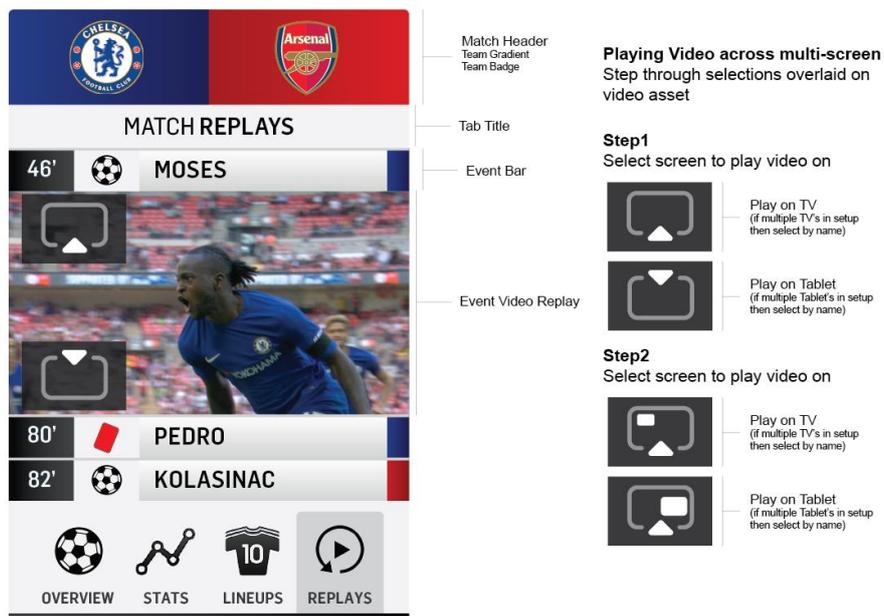
Figure 30 A breakdown of the video thumbnail menu

A part of the ambition to create an experience that spanned the available screens we devised a way (both technologically and in design terms) to allow the user to decide where they would like a particular complementary video stream to appear. In design terms we overlaid a video thumbnail with icons providing options to move this content 'up to the TV' or 'down to your device', see Figure 30. Once this decision was made, based on the layout rules associated with the selected content, the viewer may be presented with further layout options (if available) to play the content as full screen, dual screen (side by side) or PiP (Picture in Picture). The images on the right of Figure 30 shows a breakdown of the video thumbnail menu.

The Replay tab, see Figure 31, is an expanded version of the Overview tab, with identical layout and functionality.)

Figure 31 Replays - comprehensive list of match events (shots on target and yellow cards).

Only one event Replay can be expanded at once. Opening another automatically closes the current replay as illustrated in Figure 32.

Moses Goal   *Pedro Red Card*   *Kolasinac Goal (before upload)*

Figure 32 Opening up several video replays

4.3   Data to populate the Score Clock Menu

For the end-to-end live test at the FA Cup Final, users were provided with a companion device and a NUC (NUC is an abbreviation from Intel for New Unit of Computing, physically NUCs are about 100mmm square and 30-50mm deep) to view the broadcast TV experience. The companion device provided access to Opta-driven statistics, replays and a number of live cameras via two interactive menus.

Opta is a sports analytics company that provides data via a set of APIs' leading up to, during and post live sports events. The data from these APIs' were used to power the score clock menu component on the companion device, allowing users to view team sheets prior and during the match, substitutions, goals, cards and team statistics see Figure 33.

Figure 33 Illustrating the way that data feeds from providers like Opta would be used for populating various data cards

4.4   The Broadcast Menu

Another interactive component available in the Football at Home experience was the broadcast menu, on the bottom right of the tablet screen. In Figure 34 we can see that a picture in picture of Mourinho is shown on the TV screen – this was activated via the broadcast menu accessed via the Channel bug graphic on the tablet.

Figure 34 An illustration of the way the effect of the broadcast menu –

The Broadcast Menu provided access to alternative live cameras, which during the live end-to-end trial offered video streams of the team managers. The Broadcast menu gave the user the ability to push these manager feeds as picture-in-picture components to the TV.
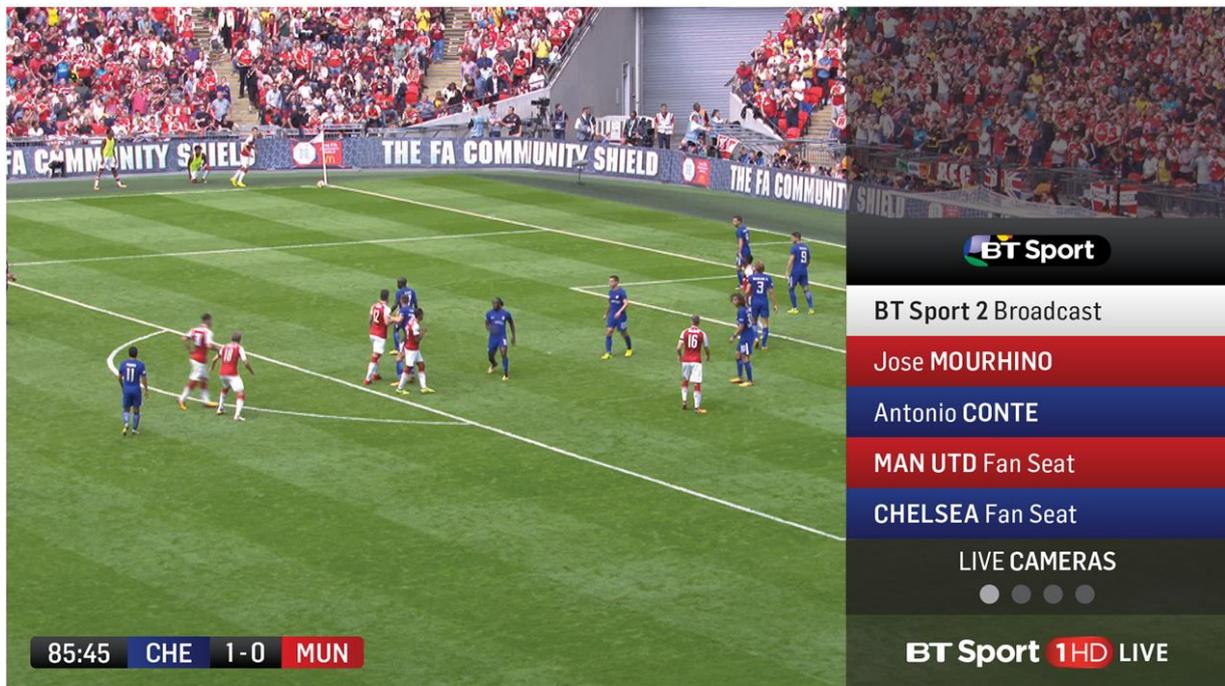
Figure 35 An illustration of the interactive broadcast menu as it appears on the tablet showing the different camera feeds that can be selected

The available cameras, DASH feeds and friendly names were provided to the Broadcast menu component by the timeline service. If a user selected a camera, playback began within the component and provided the option to push to picture-in-picture on the TV.

A number of pre-defined layouts were configured prior to the match, for example a Chelsea fan view that allowed the user to reconfigure the viewing experience at the click of a button. The way these appeared on the tablet screen is shown in Figure 35.

4.5   End-To-End trial & IBC

Although a full design and documentation process was undertaken prior to the May 2018 FA Cup Final, not all features and designs were complete by the time the match was played. The live end-to-end trial was undertaken with the emphasis primarily as a technical test with only a limited number of home viewers. The details of our pioneering live trial of a personalized multi screen broadcast is described in more detail in D4.6. The trial was primarily a technical trial; there were sufficient UX features to allow the technical features to be proven but it did not show a fill feature set.
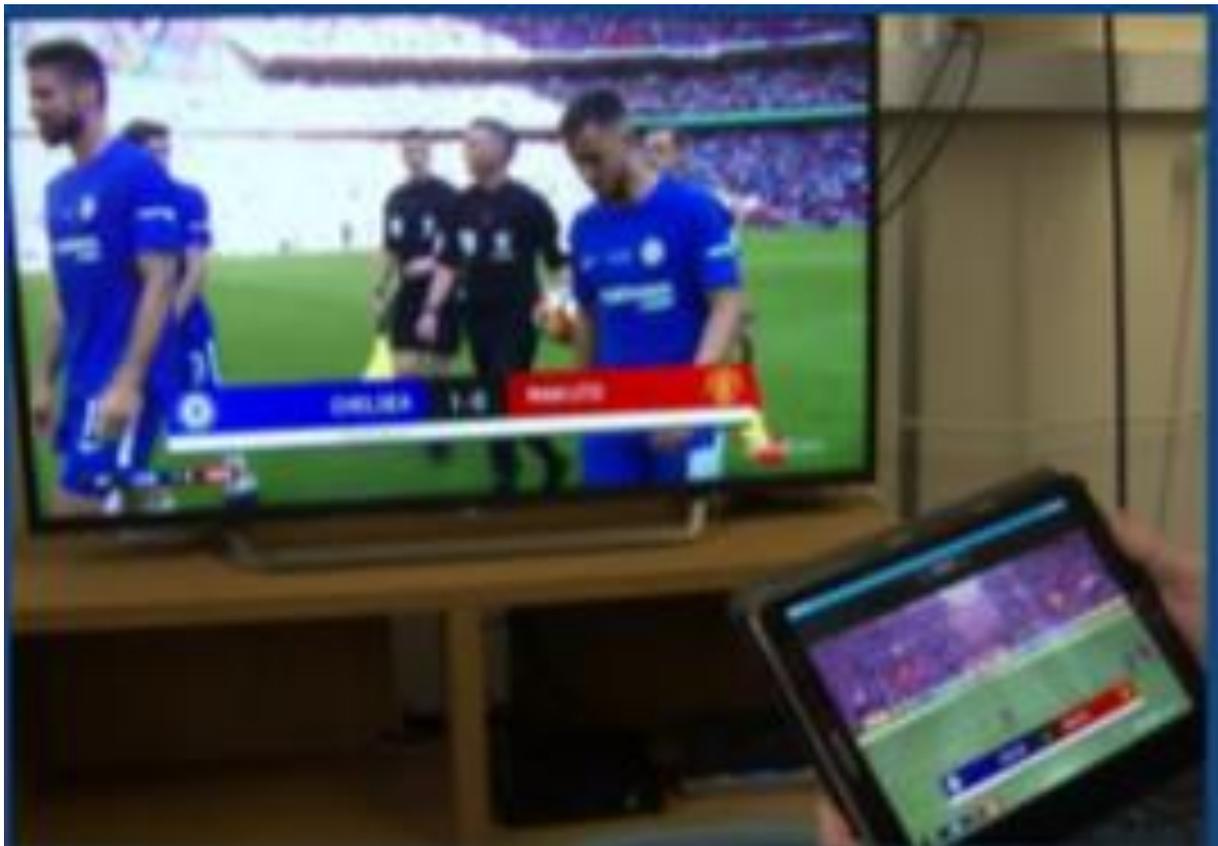
Figure 36 Live end-to-end Football at Home trial from the participant's perspective.

We learned a lot from the version of the experience we used during the live trial for example that we needed to simplify and enlarge the GUI elements while retaining the core design principles. The final client UX for Version 2 can be found in the next section.

4.6   The Client App experience: Version 2

Based on the video assets collected from the live end-to-end trial, we developed a more complete and polished as-live multiscreen FA Cup demonstration. With the live tests complete the UX of the Football at Home (along with the FanZone layout outlined in Section 5) was iterated to Version 2 for presentation at the 2-IMMERSEstand in the IBC Future Zone.

4.6.1 Simplification

Version 2 of the Client App experience was simplified and on screen graphics on the tablet were enlarged to provide a better interactive experience, see Figure 37 . Where possible all non-BT Sport iconography was removed and replaced by clear text labels identifying different tabs and features. Existing BT Sport design guidelines for Match graphics scale and position were relaxed for the companion screen layout to provide a better scale for user interaction. Safe Zones applied for TV were also relaxed for the companion screen to allow menus to launch to the edge of the video canvas on which they were overlaid maximizing available screen real estate. The scale and position of constant screen graphics (Score clock and Channel Bug) used to launch these menus was also adjusted so they appear of complimentary when menus were visible.
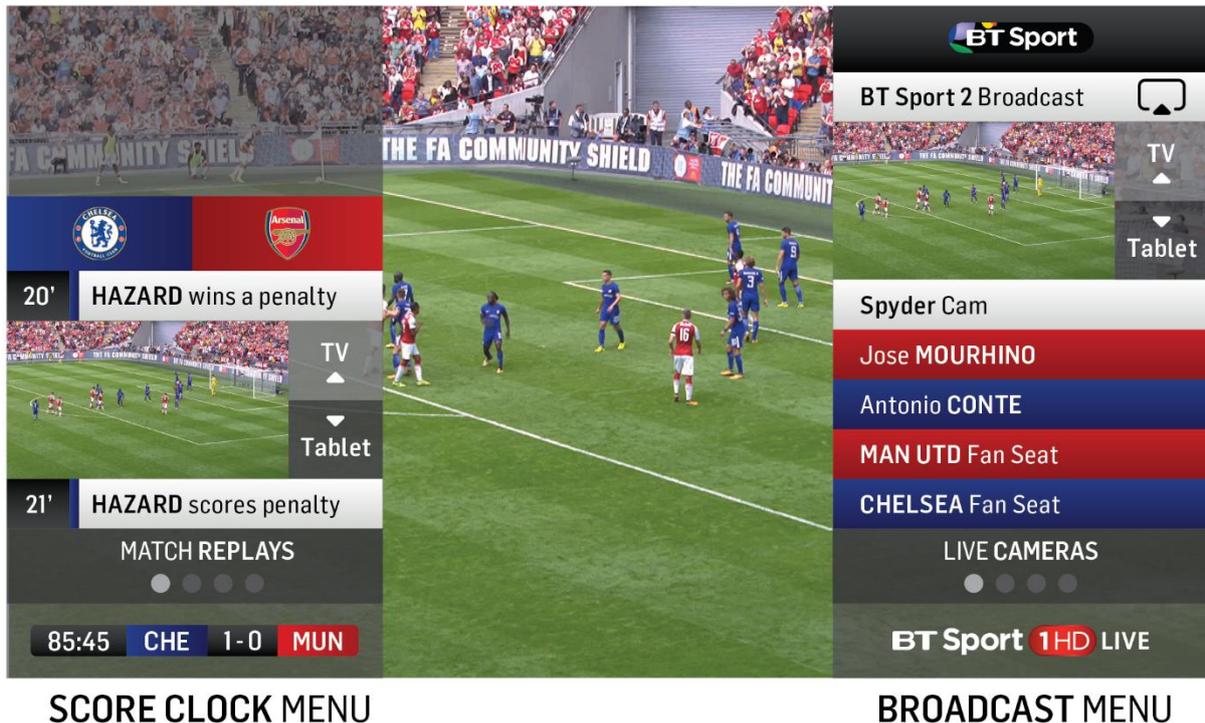
Figure 37 Combined screen showing screen areas used by both Score Clock and Broadcast menus. Although only one menu could be triggered at any once

4.6.2 Score Clock [Match Menu]

There were minor style changes for Version 2 with removal of icons and increased scale. Also, rather than nesting both team sheets under a single tab, the home and away teams were given individual tabs to remove the need for additional sideways swiping within the tab, see Figure 38.

SCORE CLOCK MENU TABS

MATCH **OVERVIEW** MATCH **STATS** HOME TEAM LINEUP AWAY TEAM LINEUP MATCH **REPLAYS**

Figure 38 The Version 2 Score Clock Menu tabs

4.6.3 Broadcast Menu

The broadcast menu was simplified and adjusted to suit the new style guide. Also added, for the IBC demo, were two new feature tabs that were not available for the live trial. Firstly an Audio Options tab, that allowed the user to remove the BT Sport commentary team from the presentation and just experience the stadium atmosphere. Secondly a Custom Graphics menu, was developed that allowed users to toggle On/Off a series of object based match graphics relating to other game scores and TV notifications when replays were made available in the timeline, see Figure 39.

BROADCAST MENU TABS

LIVE **CAMERAS** SCREEN **TEMPLATES** **AUDIO** OPTIONS **CUSTOM** GRAPHICS
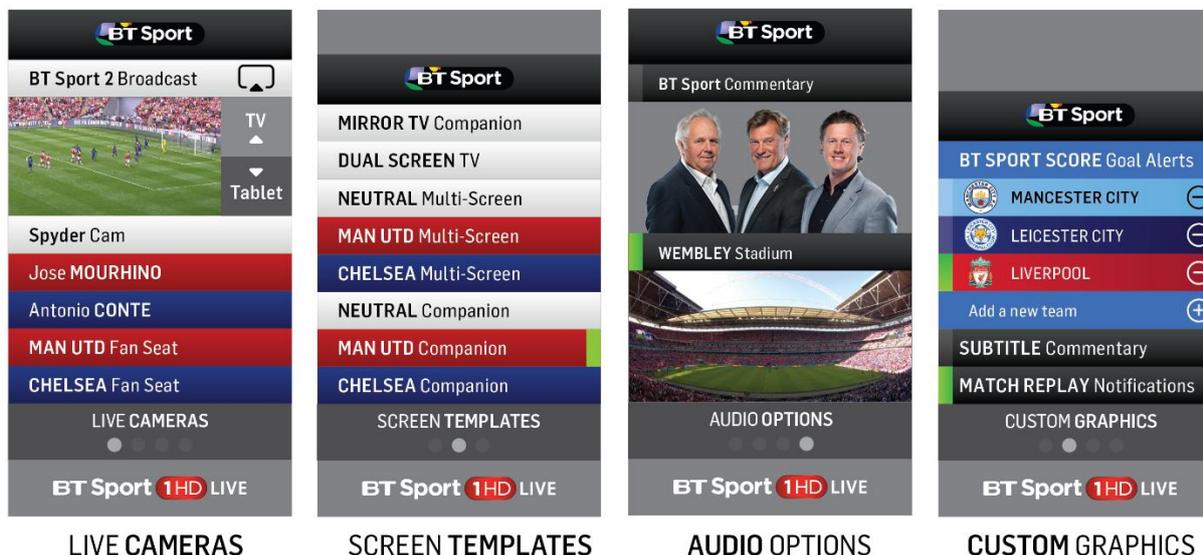
Figure 39 The Version 2 Broadcast Menu tabs

4.6.4 TV Control Bar

The Score Clock and Broadcast Menus were designed purely to launch content across the multi-screen experience, rather than manipulate changes or remove content once it was in place. For the interactive companion app this need was easily addressed by allowing users to tap directly on content (a dual screen video or PiP video) in order to bring up a GUI overlay of options directly over the content.
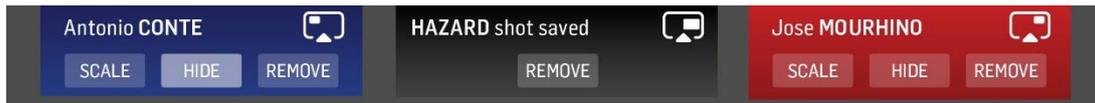
Figure 40 TV Control Bar showing 3 additional video objects added to the current TV screen: 2 Manager PiP's and a dual screen replay.

However for the TV this was not possible as no direct interaction with the screen was made available. Therefore a TV Control bar was introduced to the companion App to represent additional content currently added to the TV, this is shown in Figure 40. This bar was accessed on companion app by pulling down the Tab at the top of the screen see Figure 41.

Video content currently added to the TV experience was represented spatially in the bar. Top left PiP is displayed on the left or the bar and the top right on the right, while any dual screen video content was displayed in the middle of the bar. Design style guides were included to ensure team specific video (Managers or Fan Seats) content was displayed with the relevant team gradient background as well as being identified by name and screen icon. Replays which were non screen specific were given a black background and identified by game minute and title. Content in the TV Control bar included relevant buttons to scale, hide, or remove the content for the TV layout or toggle on/off available OBB match graphics. This feature allowed the companion App to become a full functioning remote to launch, manipulate and remove content from the TV screen without the need for a secondary controller such as a TV remote.
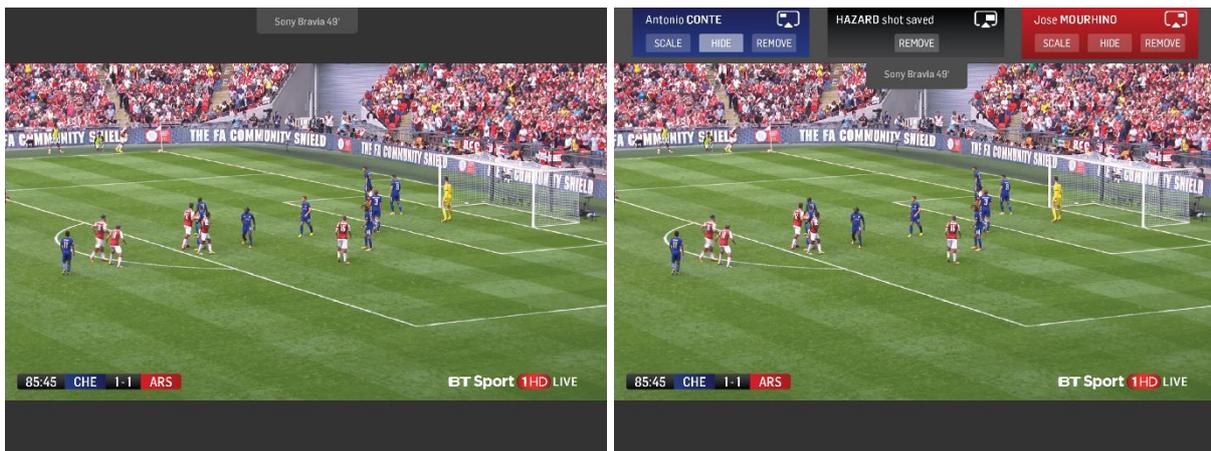
Figure 41 TV Control Bar on Tablet was always visible at top of screen and dragged down by user when adjustments to the content layout on the TV were needed to be made.

The Football at Home (Version 2) was successfully presented at 2-IMMERSE's stand at the Future Zone of IBC (see Figure 42).

Figure 42 Presenting the project at IBC 2018 in Amsterdam

5 Football FanZone

5.1 From Home to Public Space

The final Version 2 FanZone experience showcased at IBC was based upon the Football at Home UX work for the communal shared TV. However, in the case of the FanZone there were multiple shared communal TV's and the role of controller was passed to the venue owner rather than to individual viewers within the space.

However, in a multi-screen FanZone several screens could be available within each customer's field of view. This allows us to relax some of the design principles established for the at home presentation as additional video content can now be allowed to be shown full screen on TV's, if the match directors mix of the match is still available full screen with the same field of view.

5.2 Defining types of screen

Within FanZone environments, with many screens and many different 'fields of view' (unlike a sports cinema with one single screen) choices have to made by the system installer and venue owner about which layout and content choices are to be presented on each screen. As part of the FanZone UX development we classified screens into 5 different categories:

- Primary Screen
- Secondary screen
- Standalone screen
- Flexible screens and
- Fan screens

In the following sections, the way we thought about each of these screens and the layouts were devised for them is described in more detail.

5.3 Primary Screen

In each different FanZone, or FanZone area, you would expect one singular screen to be larger and more prominently positioned to provide the biggest and best view of the match. This screen would be defined as the primary screen and layout restricted to BT Sport director's broadcast to ensure fans are still provided the traditional match experience, see Figure 43.

Figure 43 Primary Screen showing the Broadcast mix full screen

5.4   Secondary Screen

Currently in venues with multiple screens available within a single field of view, normally the same identical content would be duplicated on all screens, (we have also seen instances where a different channel is displayed with the volume turned down). In our design, screens classed as secondary are in the same field of view as a primary screen, but layout rand content are defined to make use of full-screen alternative views of the match (such as the manager cams such as shown in Figure 44 or Fan Seat views). More than one secondary screen may be available either side of a primary screen, and this allows a neutral experience of the match to be developed by using the two screens to present the two managers. Alternatively a biased view can be created, by showing the fans seat view and a manager cam view, concurrently.

Figure 44 Secondary Screen showing the Chelsea Manager Cam

5.5 Standalone Screens

Venues with more complex layouts may have areas were only one screen is in the viewer's field of view because of sight lines or perhaps because other screens are too distant so they naturally use their closest screen as their primary screen. These screens are classified as standalone screens that have to include the BT Sport broadcast as part of layout. Therefore, they behave like a standard at Home presentation when a dual screen layout can be utilised to show the BT Sport broadcast and an alternative match view concurrently, see Figure 45.

Figure 45 Standalone Screen showing the Broadcast Mix with Manager Cam added in Dual Screen layout.

5.6 Flexible Screens

Some FanZone menus may have zones which include so many screens that all content options can be fulfilled. Full screen and duplication may still occurs, such as a row of screens above a bar, but in this scenario extras can be defined as flexible screens which can show the live match, but replace this with additional content when it becomes available (such as a replay of a key moment in the match, in the case shown in Figure 46 this is the penalty) or simply loop through additional content so it is always available as the match progress.
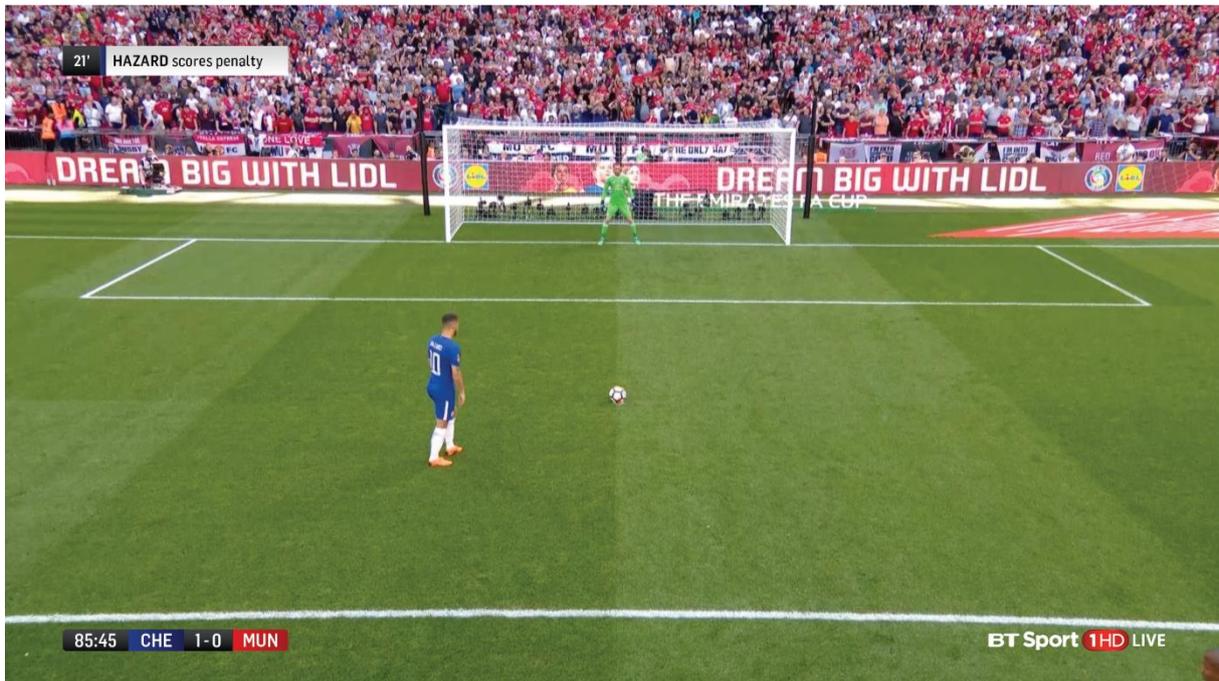
Figure 46 Flexible Screen showing full screen video replay objects during the live match

5.7 Fan Screens

Some FanZones can be subdivided into areas, booths or tables each with a dedicated screen. Although still a communal screen, these screens can be categorised as Fan Screens, see Figure 47, where a small number of viewers can decide together the layout and content choices that they wish to view on their communal device. The effect is that this screen combination offers an in-home experience within a larger public venue. This will allow them features not available via other communal screens, such as customising against the overall content bias of the venue, or launching replays on demand.
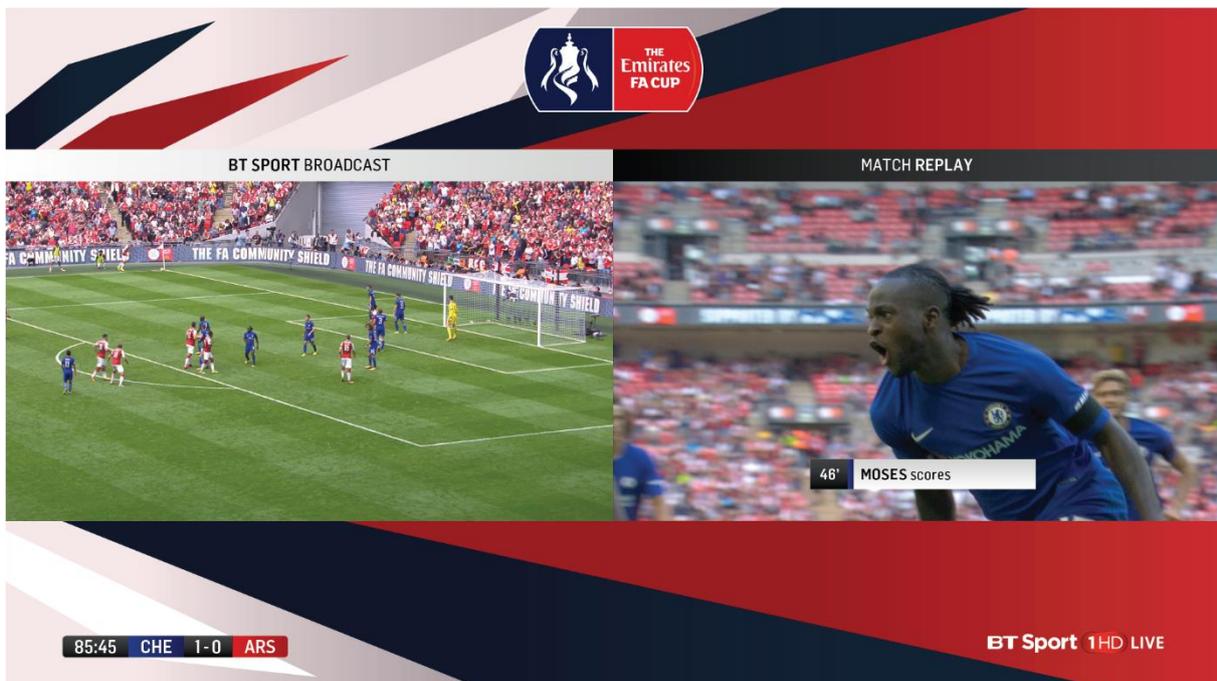
Figure 47 Fan Screen showing a group of viewers launching an on demand replay during the live match.

5.8 FanZone Controller

Our previous research into the use of FanZones indicated that owners would seek to customise screen layouts were possible in ways that are relevant to the game and the allegiance and interest of their customers. These decisions would primarily be made in advance of the event. Therefore, a venue owner would require an easy and simple interface with which to make changes based on pre-defined choices made with the system installer about the categorisation of screens in the venue. Each event producer could then make decisions as to how the content made available would be presented in each venue based on screen categorisation rather than the layout and nuances which would be unknown to them and potentially different for each unique venue.

This then allows the venue owner to be provided with a single screen interface that allows then to adjust the experience in each venue. In the case of a football match this would include a single classic view (or duplicated BT Sport broadcast) as well as 3 multi-screen layouts that have been director defined to provide neutral, home bias or away bias presentations of the match. The FanZone controller interface presenting these simple choices is shown in Figure 48.
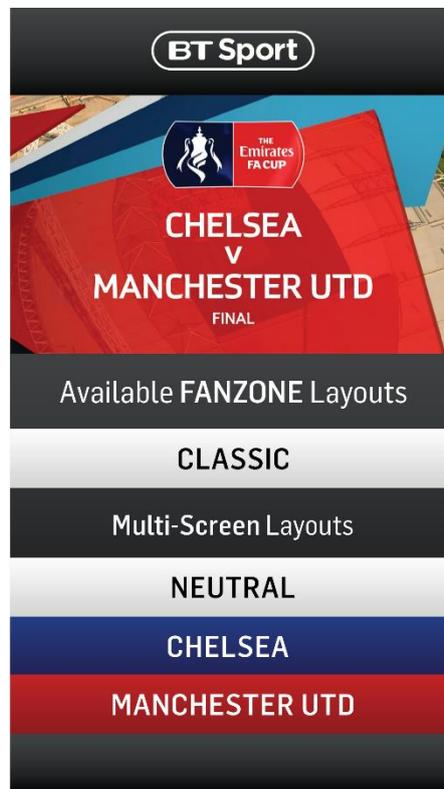
Figure 48 The FanZone controller for venue owners to launch and adjust the multiple-screen FanZone experience.

6   UX of the Preproduction Tool

This section presents the process of developing the 2-IMMERSE object-based multiscreen broadcasting platform, with a focus on the UX design and evaluation of the preproduction tool.

With a growing demand for multiscreen interactive TV productions, media producers do not have the right tools for crafting this new type of programs that can span across several screens. Currently, each broadcast service (media and associated applications) is created in an ad-hoc manner, for specific requirements, and without offering sufficient control to the creative director over the overall multiscreen experience. Our objective, as a contribution to 2-IMMERSE, is to provide an object-based production platform for multi-screen experiences that can be adapted to existing workflows. The 2-IMMERSE production platform consists of three parts: (1) the preproduction tool, (2) the live editing tool and (3) the live triggering tool connected with a stream deck launcher.

- The preproduction tool aims at digitalizing the authoring process, enabling object-based broadcasting. It is a graphical tool to help producers scripting by temporally arranging different media objects (such as video clips, graphics, applications, and subtitles) for TV screens and other devices. (Figure 49)
- The live editing tool enables the production team to react to live events happening during a television program, such as a goal during a football match or an overtake during a MotoGP race. When live events happen, the editorial team can quickly, according to the director's instructions, edit associated media (graphics, name tags, replay clips) based on prepared templates (Figure 50).
- The live triggering tool includes a button-based graphical interface and a keyboard launcher. The edited templates are enqueued as a thumbnail on the interface of the launcher, which can then be easily triggered by the director (Figure 51).
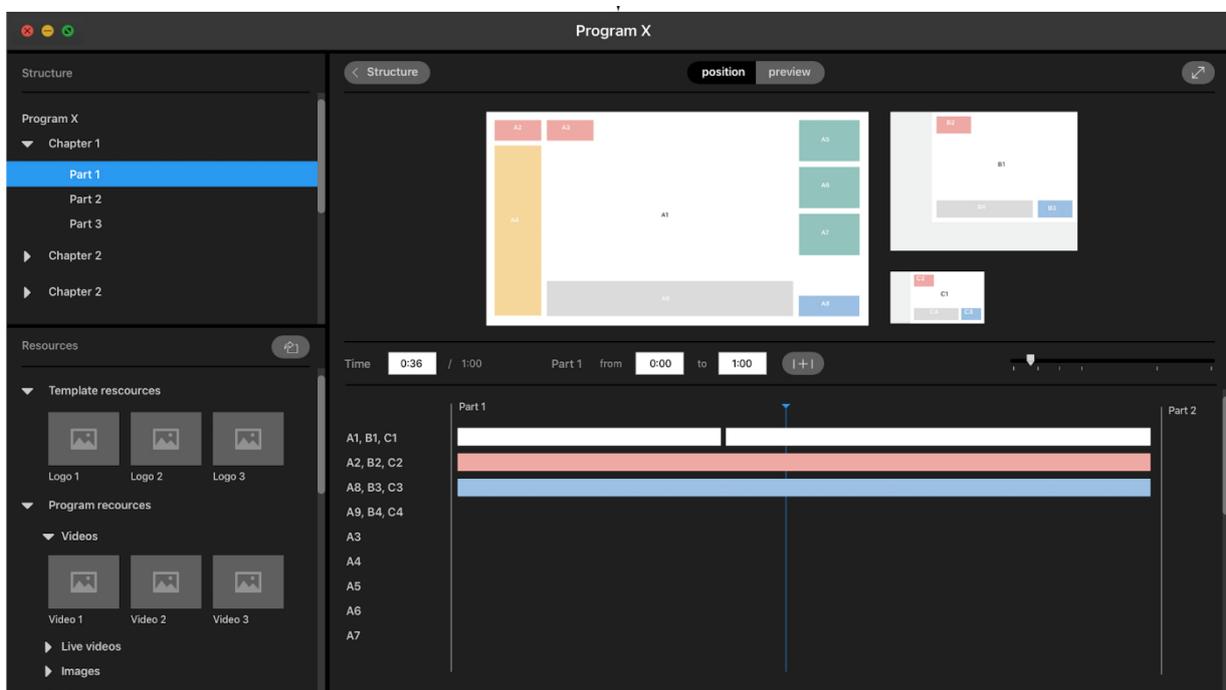
Figure 49 Schematic design of the preproduction tool
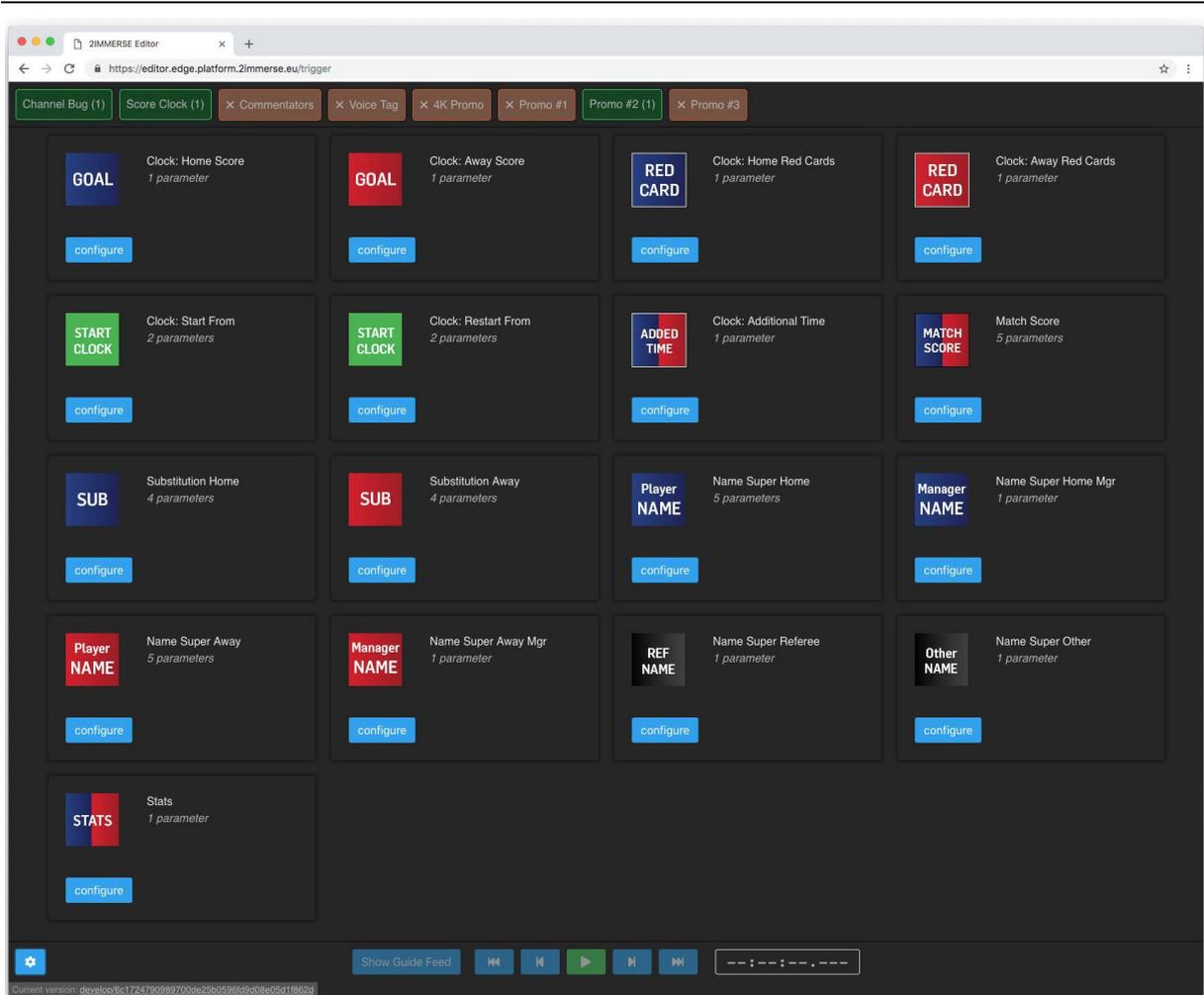
Figure 50 Schematic of the design for the live editing tool
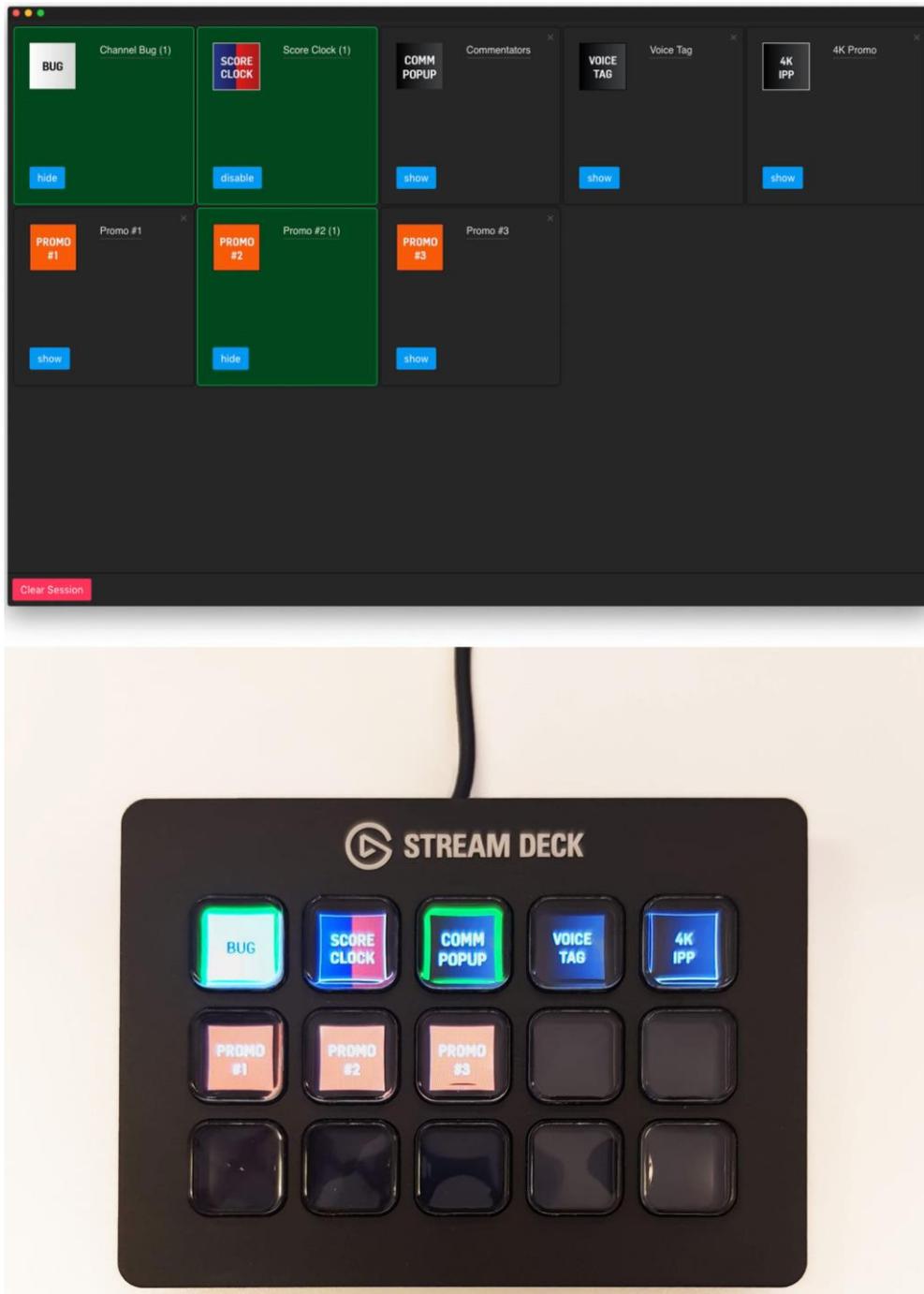
Figure 51 The live triggering tool (top) and hardware device StreamDeck (bottom) triggering launcher.

Figure 52 illustrates the three parts of the platform. We intend to keep the platform "easy-to-use" with graphical interfaces, so that the media producers can quickly learn to use it and adapt it to their current workflows. The expectation is that the preparation of the media assets and the templates (e.g., layout) for multiple-screens are done using existing popular tools such as Adobe Photoshop or Illustrator. Our platform complements such professional tools by adding extra functionality for object-based productions. In this way, the changes on existing workflows are minimal, making adoption easier.

Figure 52 The three parts of the 2-IMMERSE object-based multiscreen broadcasting platform.

The development of the 2-IMMERSE production platform has gone through a series of user-centred studies. The timeline of these user studies is visualized in Figure 53.

Studies

Outputs

December, 2016
User Study 1
Gathering requirements
with producers & directors (10 users)

Requirements for developing a new OBB platform for authoring and broadcasting multiscreen TV program

Four initial wireframe concepts of the production tools

March, 2017
User Study 2
Evaluating the four initial concepts
with producers & directors (10 users)

One concept (the mixed IDE) was selected (see D3.3 for more details)

Improvement suggestions of the mixed IDE concept

Live broadcasting is unpredictable and need more efforts to prepare

August, 2017
Field Study at the MotoGP 2017 Silverstone
Understanding the live broadcasting
with the North One Television live OB truck team

A new OBB platform that can adapt to the existing workflow

The new OBB platform consists of three parts: A pre-production tool, a live triggering tool and a live triggering launcher

January, 2018
User Study 3
Validating the new workflow
with producers & directors (10 users)

Positive feedback about the new workflow

Suitable staff to use the new platform

Improvement suggestions

April-May, 2018
Three field studies at the Wembley Stadium
Testing the live triggering tool and the launcher
with the Live OB truck team
(See D4.6 for more details)

The live triggering tool and triggering launcher were successfully tested at three UK national football matches

Improvement suggestions for the live triggering tool

September, 2018
User Study 4
Redesigning the pre-production tool
with producers & directors (7 users)

Requirements and improvement suggestion collected for redesigning the pre-production tool

December, 2018
User Study 5
Evaluating the implemented pre-production tool
with producers & directors (7 users)

Successfully tested the implemented prototype of the pre-production tool

Positive feedback about the light features of the pre-production tool: Easy to learn, easy to use

Detailed improvement suggestions on usability

Figure 53 The timeline of the user studies for developing the OBB production platform.

As early as December 2016, we started by identifying new requirements for multiscreen production tools and created four initial wireframe concepts based on the requirements collected from media producers and director (User study 1). Thereafter, we conducted a follow-up study (User study 2) to evaluate the four concepts, and selected one concept (the IDE mix) for further development. The feedback from the User study 2 stressed the unpredictability and difficulty of live broadcasting, which may hinder the live broadcasting team from adopting this new platform. To better understand how live broadcasting works, a group of 2-IMMERSE researchers went to the MotoGP 2017 race held in

Silverstone, to observe how current live outside broadcasting works. The knowledge gained in the MotoGP field study has been used to design a new workflow. An object-based broadcasting (OBB) platform should separate tools for the preproduction from the tools for live broadcasting. The proposed 2-IMMERSE OBB workflow is compared with the current workflow in Figure 54. The current workflow involves paper-based program authoring at the preproduction phase, and heavy, intense live editing during live broadcasting. The whole process aims only for TV screens. The extended 2-IMMERSE OBB workflow digitalizes the program authoring at the preproduction phase and reduces the workload at the live broadcasting phase. These two extensions in the workflow enable media producers and directors to author and transmit interactive TV programs to multi-screens.
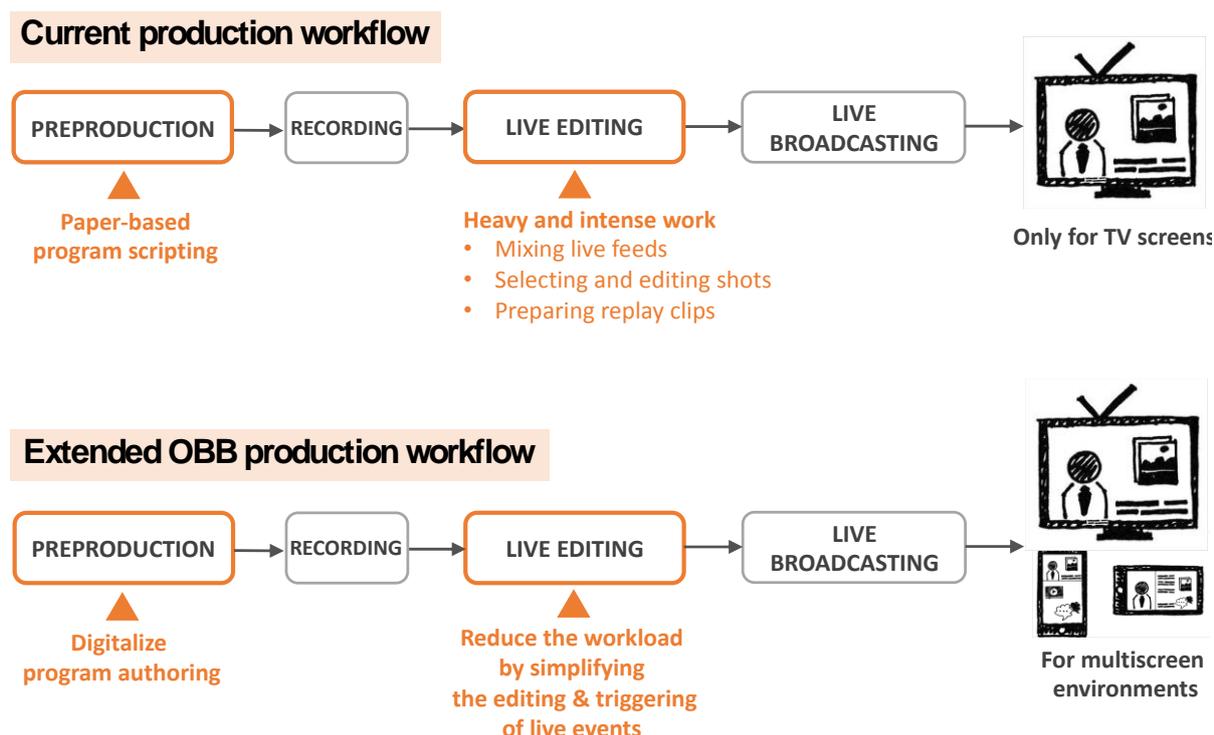
Figure 54 A comparison between current production workflow with the 2-IMMERSE OBB production workflow.

After the proposed new workflow, another user study (User study 3) was conducted in January 2018 to validate the workflow and obtain feedback about who in the production team would be the most suitable users for such a platform. The interviewed producers and directors were all positive about the workflow and suggested to train a separate 2-3 persons team to operate the platform. More details about this study can be found in our published paper (Li et al., 2018). Then, we moved on to test the live editing and triggering tools. Three experiments were conducted during the FA Cup Semi-Final, National League Play-off Final and the FA Cup Final matches between April and May, 2018. The live editing and triggering tools have been successfully evaluated at the football matches and showcased at the International Broadcasting Convention (IBC) 2018 in Amsterdam. More details about the experiments at the Wembley football matches are included in D3.3 and D4.6. In the most recent user study (User study 4) in September 2018, we interviewed a group of producers and directors, to fine-tune the interface and interaction design of the preproduction tool. A design iteration of the preproduction tool was made after this study. The implemented prototype of the preproduction tool was tested in December 2018 (User study 5) with the same group of producers and directors as in the User study 4.

The focus of this deliverable is on the design and evaluation of the preproduction tool. The more technical and deployment results of the production tools can be found in D2.4, D2.5 and D 4.6. The interface design of the two live tools can be found in D3.3 and D 4.6. The following sections will present the processes and results the User study 4 for gathering requirements to redesign the preproduction tool from seven media producers and directors. It also presents the redesigned wireframes and implemented prototype of the preproduction tool. Section 6.2 describes the User study 5 for evaluating the prototype of the preproduction tool. Section 6.3 concludes the studies and exhibits the disseminations of the production tools.

6.1   Fine-tune the preproduction tool

The goal of the study is to finetune the interface design of the preproduction tool, to enable media producers who are not familiar with programming languages to gather and author content in a graphical way.

6.1.1   Methodology

We conducted a one-to-one semi-structured interview with seven professionals (P1-P7; 5 males, 2 females; M=35.0, SD=6.0). The interviews happened from September 3-5, 2018, at the usability lab of BBC R&D, located in the MediaCity, Manchester. Each interview took about one hour. Two researchers from the team guided the interviews. We started with introducing the complete concept of the 2-IMMERSE OBB platform and demonstrated how the live editing and triggering tools work for MotoGP races and football matches. Then, we presented the wireframes of the preproduction tool and asked them to think loud about authoring a sports program using the tool. The backgrounds of the professionals are summarized in Table 1.

Table 1. Seven professionals and their background.

Professionals	Background
P1	Creative director, video producer
P2	Design producer, video content creator
P3	Producer for reality TV, fictional films and music documentaries
P4	Director, filmmaker
P5	Director, filmmaker, lecturer
P6	Cross-platform producer
P7	Researcher on developing object-based video narratives

6.1.2   Results

The professionals suggested to keep the underlying principles (hierarchical structure and the familiar "timeline" look of the preproduction tool). Besides, they advised us to think about the node structure for arranging live video feeds, and leave the layout design feature to other professional tools such as Adobe Photoshop.

Hierarchical structure and timeline. Two important features of the preproduction tool were appreciated by the professionals. They recommended to keep them in the final design. The first one is the hierarchical organization of the program chapters, and the spatial and temporal arrangements of the media objects (DMApp components) on a timeline and on multiple screens (Figure 55). The hierarchical organization offers a clear structure and enables the use of a master layout to reduce repetitive work. For example, the broadcaster logo can be added at the top of the hierarchy tree to be automatically applied to all the sub-chapters. The timeline and preview resemble the interface in the existing production editing software (e.g., Adobe Premiere), which was perceived as "familiar" and "easy-to-use" by all the professionals. The DMApp components are also highly appreciated because they can be configured and reused for authoring interactive experiences on TV programs. For instance, they enable people to select different view angles or to follow their favourite football players.

Node structure. One challenge for the preproduction tool is too place live video placeholders (live video DMApp component) in sequence on the same storyline, because the length of the live video feeds is unknown at the preproduction phase. To solve this problem, the professionals recommended a node structure to link media objects within a chapter, to have an overview of objects that were running in parallel and those running in sequence (Figure 56). In this way, the live video DMApp component can be linked one after another. During live broadcasting the second live feed will automatically start to play when the first one ends.

Layout templates. Regarding the layout of the TV program, the professionals thought it would be redundant to include the layout design feature in the preproduction tool, since the layout of most TV programs have already been defined by the content owner. The most efficient way is to import the existing layout templates to the preproduction tool, not to create layout from the scratch.
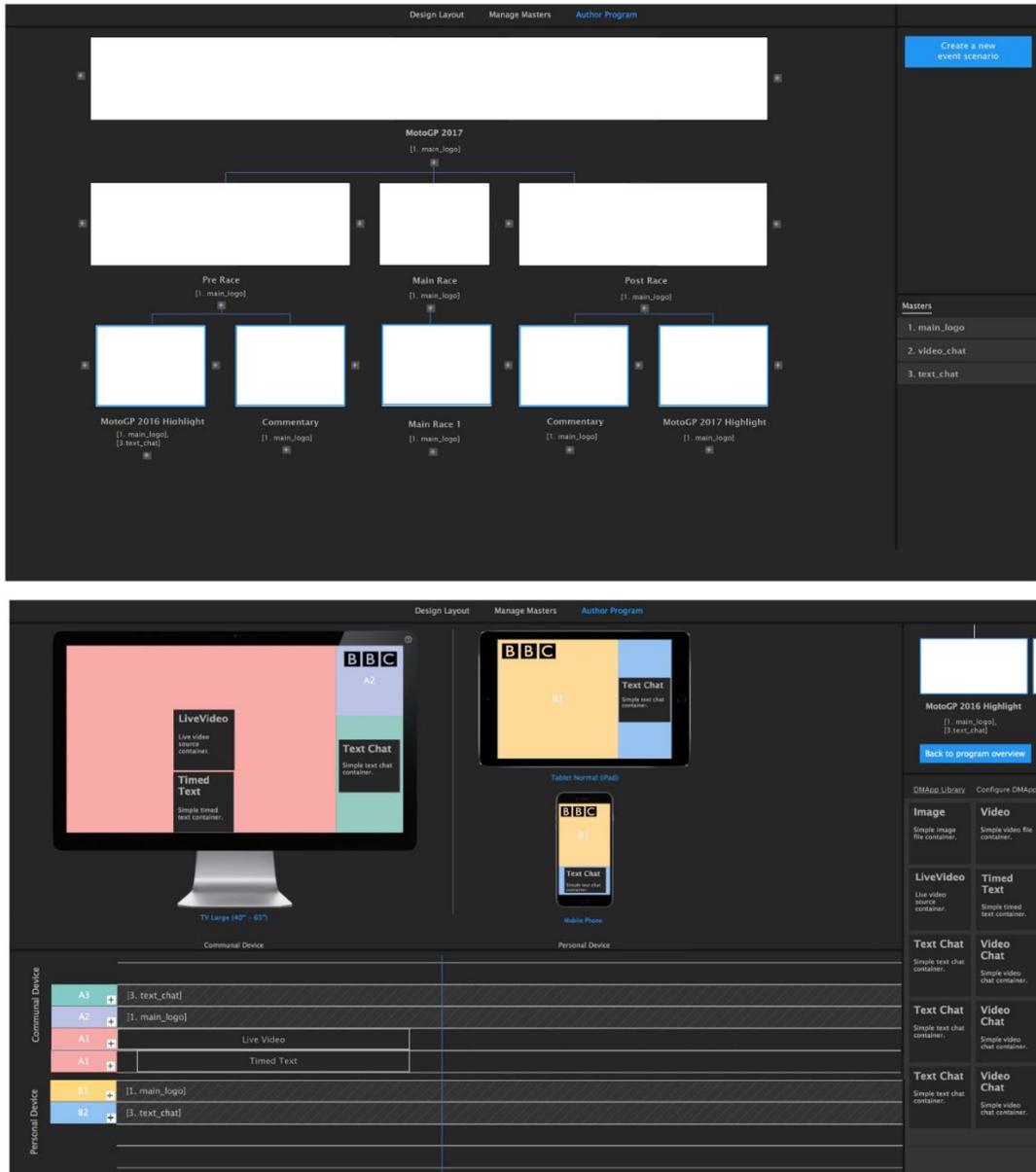
Figure 55 (Top) The hierarchical organization of the program chapters; (Bottom) The spatial and temporal arrangements of the DMApp components.
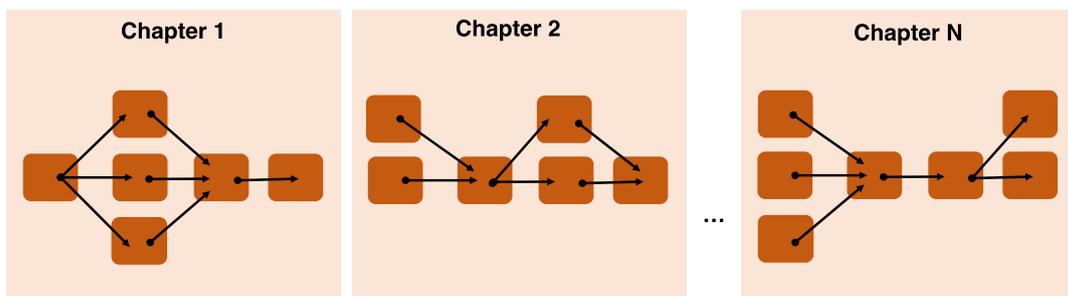
Figure 56 The node structure suggested by the professionals

6.1.3   Redesign the preproduction tool

Based on the feedback, the preproduction tool was redesigned. The new design strengthens the core principle for structuring the program, and keeps the timeline for arranging media objects (DMApp components). The layout design function is removed, because there are professional tools in the market for that.

Since the timeline feature was preferred by most professionals, we did not change it to the suggested node structure. Instead, we tried to integrate the node structure idea within the timeline. Basically, each timeline in the new design is a node. Each chapter of the program only contains one live feed component, but can have several parallel timelines within the same region. Each timeline contains only one component. The parallel timelines allow other components (e.g., graphics, audio) to run with the live feed simultaneously. The length of the chapter is defined by the length of the live video feed in that chapter. The chapter plays one after the other. In this way, we solve the problem of not being able to put two live feed components one next to the other on the same timeline. Figure 57 provides an explanation of this new concept. Figure 58 illustrates the complete wireframes of the redesigned preproduction tool. Figure 59 shows four screenshots of the implemented preproduction prototype that was used in the evaluation.
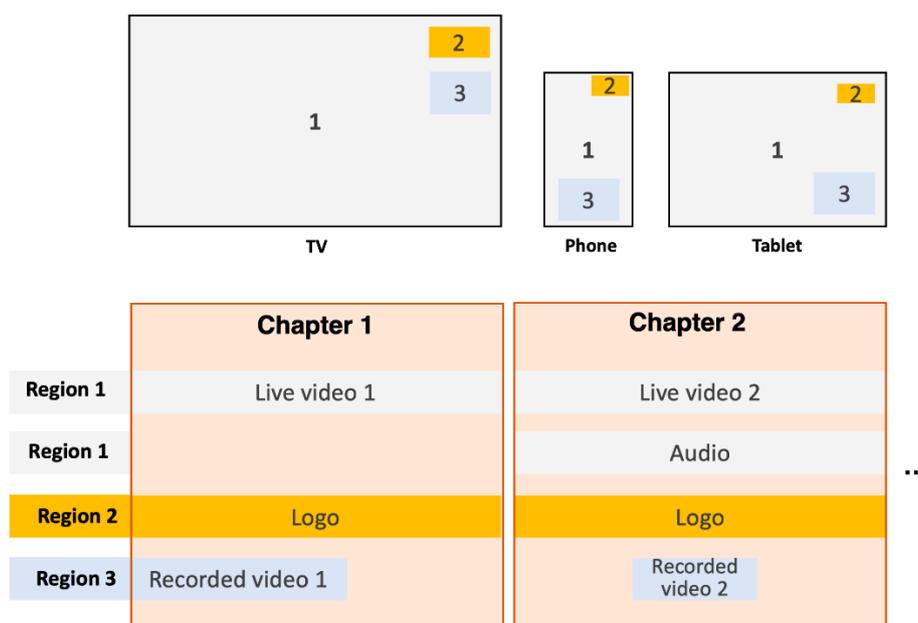
Figure 57 A new timeline concept based on the node structure idea.
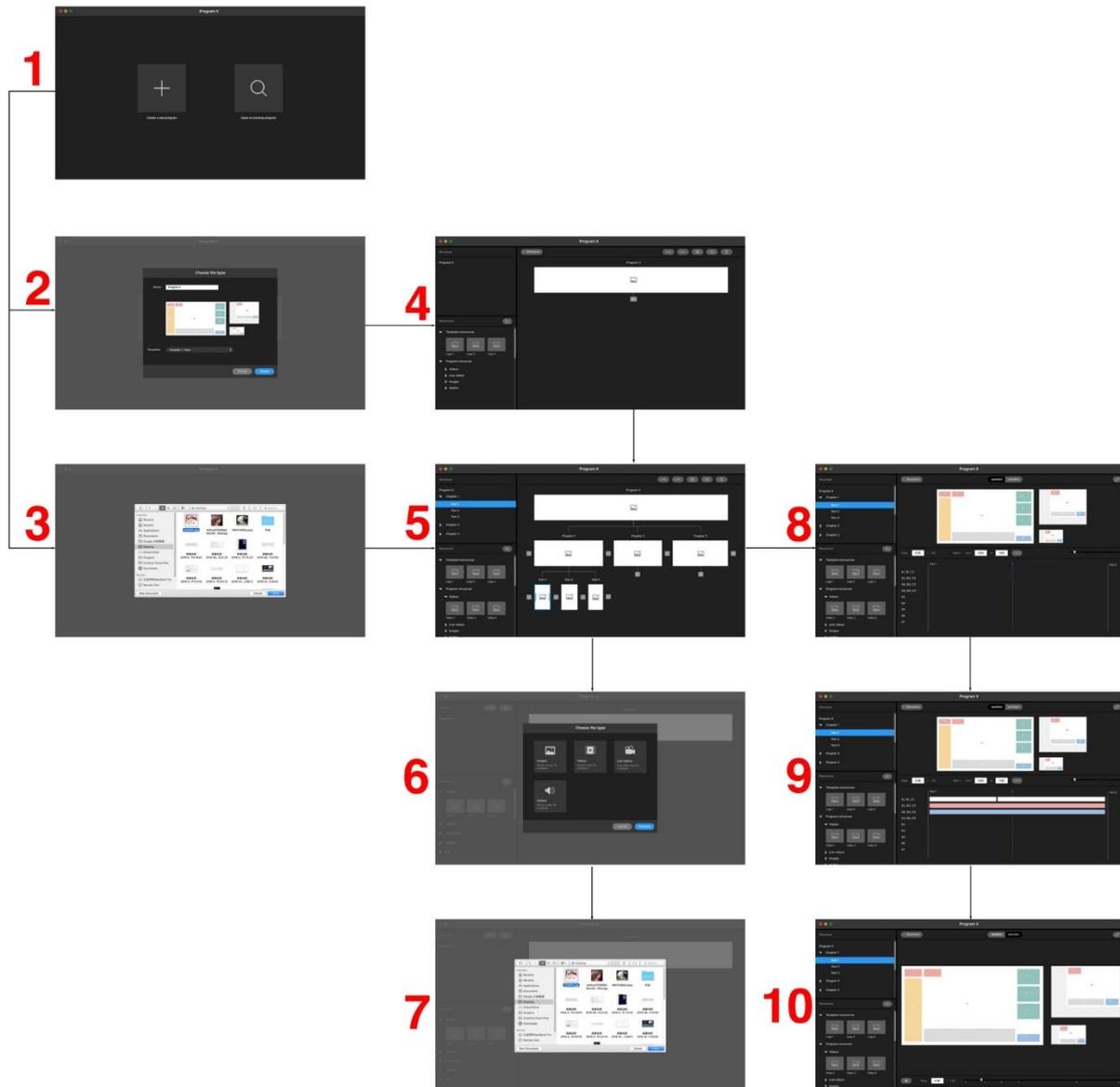
Figure 58 The redesigned wireframes of the preproduction tool: (1) starting interface: create a new program or open an existing program; (2) load the program template; (3) open an existing program from your computer file; (4&5) build the hierarchical structure of the program; (6&7) add media resources (DMApp components); (8, 9 &10) build the program on timelines and multiscreens.
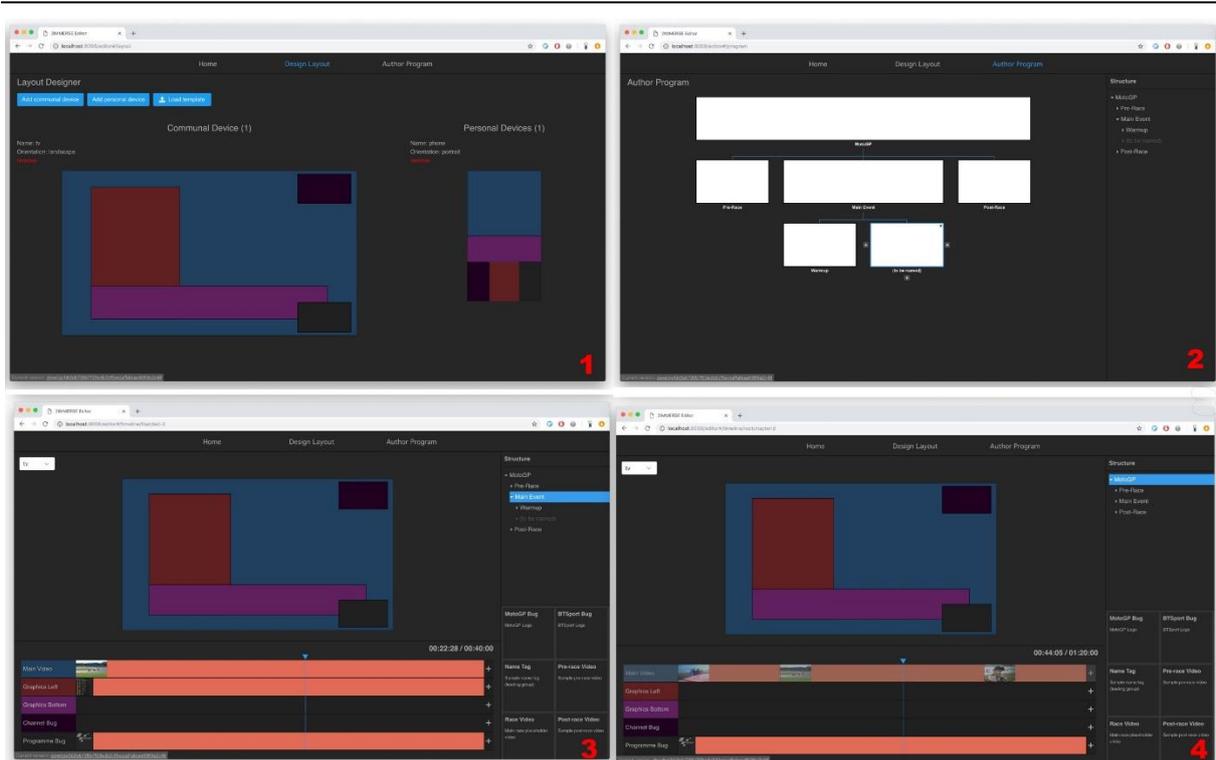
Figure 59 The implemented prototype of the preproduction tool based on the redesigned wireframes: (1) load the program template; (2) build the hierarchical structure of the program; (3&4) build the program on timelines and multiscreens.

6.2   Evaluate the preproduction tool prototype

The goal of this study was to evaluate the final prototype of the preproduction tool by actually letting the professionals use it (as the live tool was tested at the FA Cup matches in Wembley). We provided the professionals with media objects (e.g., pre-recorded videotapes, fixed graphics, audio etc.) and requested them to author a sports TV program for multiscreens.

6.2.1   Methodology

The same seven professionals as in the previous study were invited to participate in the evaluation interviews. The study took place in the same usability lab at BBC R&D. Each interview took about one hour. The procedure was as follows:

1) First, we helped the professional to recall the previous study about the 2-IMMERSE OBB platform and his/her feedback about redesigning the preproduction tool.

2) Then, the professional received a library of DMApp components, including:

   - Live video (placeholders for MotoGP race, live commentary, ceremony)
   - Recorded video (MotoGP opening, rider interview, commercial break)
   - Static image (MotoGP logo, BT Sports logo, name tag templates)
   - Dynamic image (leaderboard, rider info. animation)

3) The professional was requested to make a multiscreen experience using the preproduction tool and the DMApp components library. The following instructions were given:

   - Make the program following the sequence of events

- Opening→rider interview→commercial break→MotoGP race→commercial break→live commentary→ceremony
- Decide how to structure the program based on the sequence of events
- Decide how and where to drop the DMApp components

4) The professional was requested to envision how to perform some tasks which had not been implemented in the current prototype yet, such as

- Split a chapter into two sub-chapters
- Play a live video feed right another live video feed (without knowing the length of the feeds)
- Other tasks suggested by the professionals

6.2.2 Results

The feedback from the professionals are presented as follows:

Easy to use. All the professionals agreed that the redesigned pre-production tool is simple and easy to use. The functions are straightforward and intuitive. It is effortless for them to learn to use it. Some professionals pointed out the flexibility of such a "light" tool. Since the tool is web-based, which requires minimal setup, so they can carry this tool with the laptop or even tablets to the live broadcasting OB truck.

Segmented timeline. The new design chopped the timeline into chapter-based segments. Each segment can only accommodate one timeline for the live video feed, but multiple parallel timelines for other media components such as audio and graphics. In this way, two live feeds placeholders (unknown length) are placed into two adjacent chapters instead of being placed on the same timeline. The professionals found this solution reasonable and easy to understand. They believe the preproduction tool will be an efficient tool that supports the well preparation for live broadcasting.

Split chapters. The professionals mainly suggested two ways to split a chapter into two or more sub-chapters. One way is to do it at the hierarchical structure interface and another way is to split the chapter precisely at the timeline interface. The first method applies when there is not much content on timeline yet. The split is done by add the sub-chapters to the current chapter. When video content is already place on the timeline, then the split requires them to decide the exact timing on the video to split.

Interface and interaction design. The professionals also gave constructive feedback about the interface and interaction design of the tool, according to their experience using other professional software such as *Adobe Premiere*, *Adobe After Effects*, *Blackmagic DaVinci Resolve*. The suggestions include:

(1) defining hot keys on the keyboards and hot buttons on interface
(2) highlighting the interface part when in use
(3) organizing the DMApp components to be easily retrieve
(4) add differentiable preview icons to the DMApp components
(5) rename the tabs (i.e., home, define layout and author program) to minimize the confusion.

6.3 Conclusion

The last two user studies helped us redesign and evaluate an important part of the 2-IMMERSE OBB platform: the preproduction tool. The professionals are positive about the tool and see its potential to be used in current production workflows as a supplement for authoring object-based broadcast. The process of the production platform development was a success. We will consider the recommendations by the professionals. The work in the last years have resulted in a working prototype of a full object-based production platform. The prototype was tested by professionals and is ready to be implemented as a product.

So far, the development processes of the production platform have been published in several prestige academic conferences:

- A case study paper "From the Lab to the OB Truck: Object-Based Broadcasting at the FA Cup in Wembley Stadium" has recently accepted at CHI 2019, as part of the conference proceeding and invited for presentation.
- A long paper "A New Production Platform for Authoring Object-based Multiscreen TV Viewing Experiences" has won the best paper award at ACM TVX 2018.
- A long paper "Workflow Support for Live Object-Based Broadcasting" was published and presented at ACM DocEng 2018.
- A working-in-progress paper "Designing an Object-based Preproduction Tool for Multiscreen TV Viewing" was accepted at ACM CHI 2018 as a poster presentation.
- Another working-in-progress paper "Multi-Screen Director: A New Role in the TV Production Workflow?" was accepted at ACM TVX 2017 as a poster presentation.
- Two demos of the platform were accepted and presented at ACM TVX 2017 and 2018, respectively.

Apart from the publications and a video, the production platform was successfully showcased at IBC 2018 (Figure 60).

Figure 60 A demo of the live editing tool and the live triggering tool at IBC2018

References Li, J., Röggla, T., Glancy, M., Jansen, J., & Cesar, P. (2018, June). A New Production Platform for Authoring Object-based Multiscreen TV Viewing Experiences. In *Proceedings of the 2018 ACM International Conference on Interactive Experiences for TV and Online Video* (pp. 115-126). ACM.

7   On-boarding: Unified Launcher UX

This section reports the design of the Unified Launcher, for the On-boarding process of the service prototypes. This builds on previous work reported in D3.3.

7.1   Introduction

The on-boarding design for the Theatre-At-Home service trial used a bespoke "rendezvous" mechanism to support inter-home synchronisation and required users to enter a pre-agreed lobby code to launch the DMApp. The on-boarding user experience developed for the MotoGP-At-Home service trial used pairing codes to demonstrate cross-network support and was used to illustrate one of many potential device association technologies.

These implementations were not sophisticated enough to support the requirements of live Football-At-Home, Football-FanZone or the Theatre-In-Schools service trials. Concepts such as 'Device Roles' and 'Programmes' were missing from the designs and needed to be modelled in order to satisfy the requirements of these later trials.

It was also becoming apparent that generating new launchers for each experience was not sustainable in the long term and was already causing setup and versioning issues when switching between demos.

In addition, the MotoGP-At-Home on-boarding user experience did not scale well when extra televisions were added because of the overhead of configuring and launching those devices on each iteration using pairing codes. Neither the original on-boarding solution nor the test harness used by the development team were able to launch an experience repeatedly on multiple televisions in a shared space. This was a significant problem for Football-FanZone.

These problems have been addressed by redesigning and generalising the on-boarding process. The following sections discuss the new on-boarding requirements and the final user experience design in detail.

7.2   Revised Requirements

This section summarises the technical and experiential requirements that arose from the service trials and the need to address sustainability.

7.2.1   Device Role Requirements

Devices in the Theatre-In-Schools and Football-FanZone experiences are expected to fulfil quite specific roles, therefore it was important to allow the user to assign a 'Device Role' to each device in the multi-screen experience. This ensures, for example, that administrative controls are only available on the teacher's tablet device, or the second television in the FanZone displays an alternative camera feed.

Device roles needed to be extended beyond the generic 'companion' and 'communal' roles that had been sufficient for MotoGP in order to scope device roles for the Teacher's Tablet, the Student's Tablet, the Fan-zone Manager's Zone Controller, etc. The list of available device roles is specific to the type of experience.

Additionally, the Device Roles could no longer be implicitly selected by the system based on device type (TV or Tablet). The user needed explicit control over the assignment of device roles by being given the ability to select the role in the Unified Launcher's user interface.

7.2.2   Multiple TV Requirements

The principle feature being investigated in the Football-FanZone service trial was the use of multiple television screens to deliver a more immersive match experience. Previously, only a single Television acting as a HbbTV2.0 master device had been used. Configuring and launching an experience on multiple televisions requires the user to perform additional configuration steps and this places greater

emphasis on storing configurations and user preferences for subsequent viewings, emphasising the importance of user sign-in and user profile storage.

Multiple television support, and in particular the ability for a TV to be configured as a HbbTV2.0 slave, introduced significant new technical requirements to the on-boarding implementation which are covered in work package 2 deliverable – D2.5 Distributed Media Application Platform – Description of Final Release.

7.2.3 EPG & Sustainability Requirements

Developing and maintaining separate on-boarding launcher applications for each service trial was not a sustainable approach in the long term and complicated the process of demonstrating the service trials because it required multiple companion applications to be installed and multiple versions of the TV emulator firmware to be managed.

With Football-At-Home, Football-FanZone and the Theatre-In-Schools service trials all being developed and delivered in parallel in the third year of the project, it was prudent to unify the launcher applications into a single general-purpose app. An extensible data-driven Electronic Programme Guide (EPG) was required in the user interface to allow the user to easily select and launch each of the different DMApps. The benefit of this approach is that the user only ever needs to install one Android application on their companion to be able to run any 2-IMMERSEservice trial experience.

7.2.4 Multi-Screen Programme Advertisement Requirements

Allowing the user to run several different multi-screen programmes at the same time on the same network requires unique descriptions of those experiences to be advertised, discovered and displayed in sufficient detail for the user to make an informed selection. We can no longer assume that discovered experiences are all MotoGP-At-Home. This requires a revised discovery user interface in the launcher application.

7.2.5 Native HbbTV2.0 Terminal Support

The previous on-boarding process made use of pairing codes to demonstrate that on-boarding could be achieved when the companion device was on a different network (e.g. 4G) to the TV (e.g. Home Wi-Fi). Whilst this was sufficient for MotoGP-At-Home, a mechanism for discovering and joining experiences cross-network was never implemented. Instead, the "Discovery and Application Launch" (DIAL) mechanism supported by HbbTV2.0 was used. The result was an asymmetric partial implementation that needed improving to support multi-TV launch on native HbbTV2.0 devices.

7.2.6 Terminating Programmes

After having on-boarded multiple TVs into the Football-FanZone experience, the TVs continued to run the experience even if one of them was re-assigned to run a different programme such as MotoGP-At-Home. A mechanism was needed to remotely stop the execution of an experience on one or more TVs otherwise it would be necessary to reboot the equipment each time, which is a laborious process.

7.2.7 Live Programme Discovery

Football-At-Home was a live service trial involving on-the-fly creation of programmes. These live broadcasts needed to be listed in the EPG alongside the on-demand content.

7.2.8 Friendly Device Names

With the introduction of support for multiple TVs, a better way of identifying and differentiating between one TV and another was required. Rather an using auto-generated names, it was important to allow users to assign memorable names to their TVs and to use those friendly names during device

discovery and configuration. This requires that both the TV's Wi-Fi ESSID name and its DIAL Unique Device Name (UDN) are configurable and match one another.

7.3 Wireframes

7.3.1 Original User Journey

The existing on-boarding user journey is illustrated by the companion application wireframes shown in **Error! Reference source not found.**. It shows the pairing mechanism used to grant an access token to a TV bearing the entered display code, which then ultimately triggers the experience to launch.
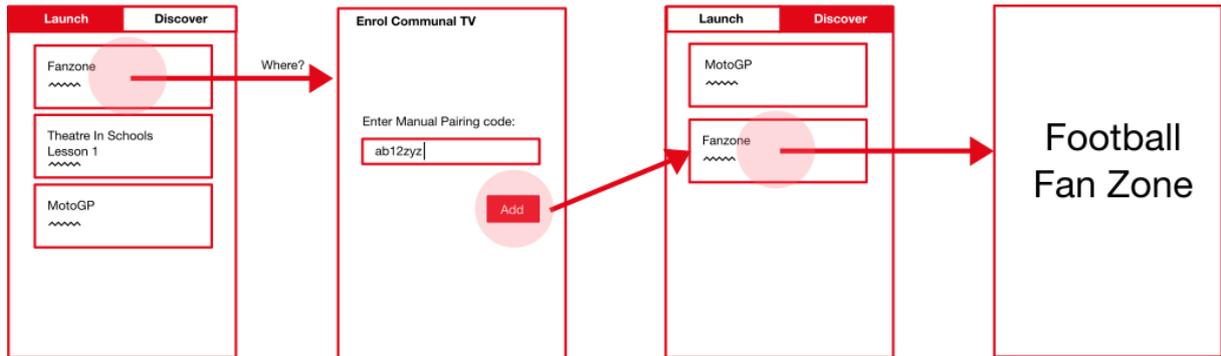

Figure 61 Original Launcher User Journey

7.3.2 Revised User Journey

The user journey for Football-FanZone, Football-At-Home and Theatre-In-Schools depicted in **Error! Reference source not found.** satisfies the requirements outlined in the previous section.
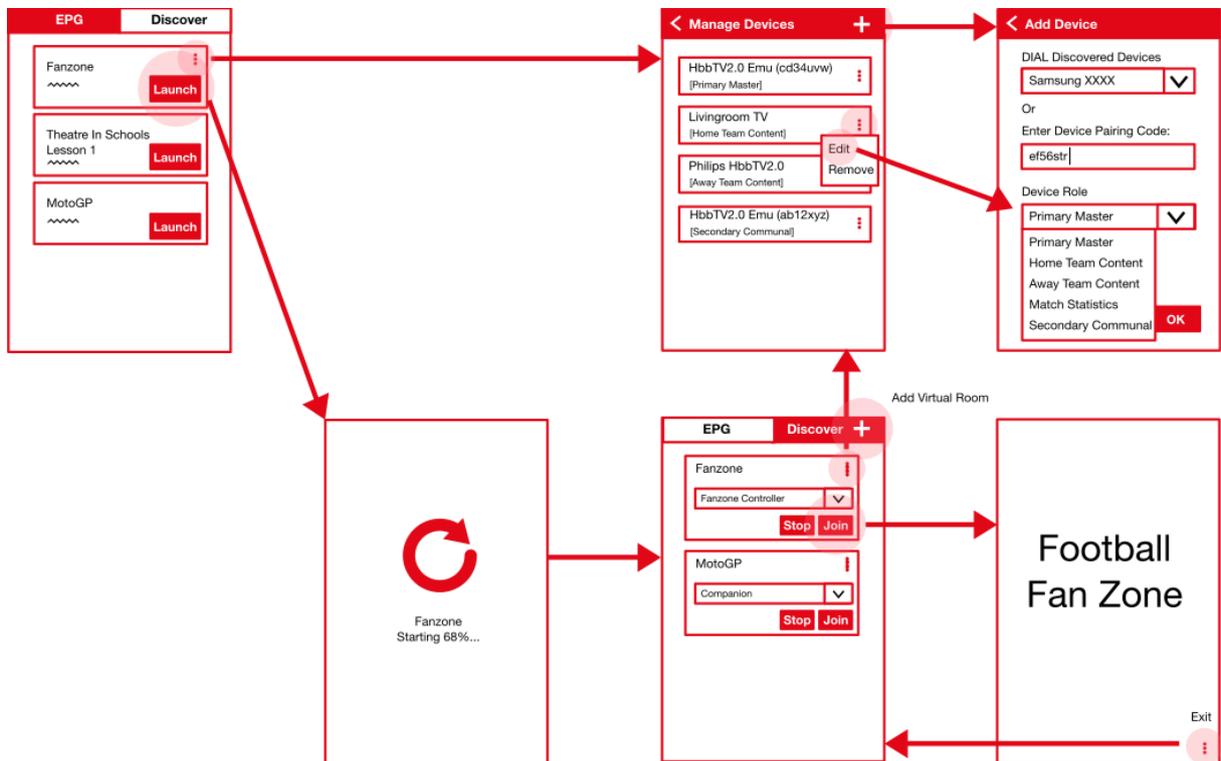

Figure 62 Revised Launcher User Journey

7.3.3 Revised Launch User Experience

The revised design introduces an Electronic Programme Guide (EPG) containing a list of available programmes to launch. The list is data-driven and pulled from a server. It contains information about each programme such as title, description and image thumbnail, but also describes the valid Device Roles for the type of programme and their respective launch instructions. It is used to populate the list of Device Roles in the user interface.

Each programme can be configured to launch on multiple TVs via the 'Manage Devices' tab, where the user can add/remove TV devices discovered via DIAL or manually via the pairing-code mechanism if they are not discoverable on the same network as the companion device.

Device Roles can also be assigned to each TV device. At least one TV must be assigned the role of 'Primary Master' which is verified by the application.

The enrolled TV device configuration for each programme is stored in the user profile of the sign-in user so that it is remembered from one run of the programme to the next. This is a labour-saving mechanism.

After successfully configuring devices and Device Roles, the user can launch the programme across the list of enrolled devices by pressing the launch button. It takes a couple of seconds to launch the experience on multiple TVs, so a progress indicator is included to keep the user informed of progress.

7.3.4 Revised Join User Experience

When the experience is up and running on all TVs, the application displays a list of all the running programmes it can see on the network. In addition to searching the LAN for running programmes, "virtual rooms" can be added to the list of locations that the companion application searches for running programmes, to support cross-network discovery.

The user has the choice of joining any programme with their companion device by pressing the respective Join button. The user can also select a Device Role for the companion, such as "FanZone Controller". Some roles can only be assigned to a single device at a time, which is verified by the application. Other device roles may only be available to users with certain privileges, such as administrators.

TV devices can be added/removed remotely whilst the programme is running by visiting its "Manage Devices" tab. Running programmes can also be stopped at any time and terminated on each on-boarded device by pressing the Stop button.

7.4 Unified Companion Launcher App Implementation

This section shows screen captures of the revised companion app running the on-boarding user experience. Not all the features described in section **Error! Reference source not found.** were implemented, in particular virtual rooms and the ability to add additional TVs after a programme is launched. The features illustrated include User sign in (**Error! Reference source not found.**); the selection screen from which the experiences that are available can then be launched (**Error! Reference source not found.**); a means to define the nature of the screen being paired (using the nomenclature described in section 5.2, see **Error! Reference source not found.**; and a screen dictating the role in which you would like the companion screen
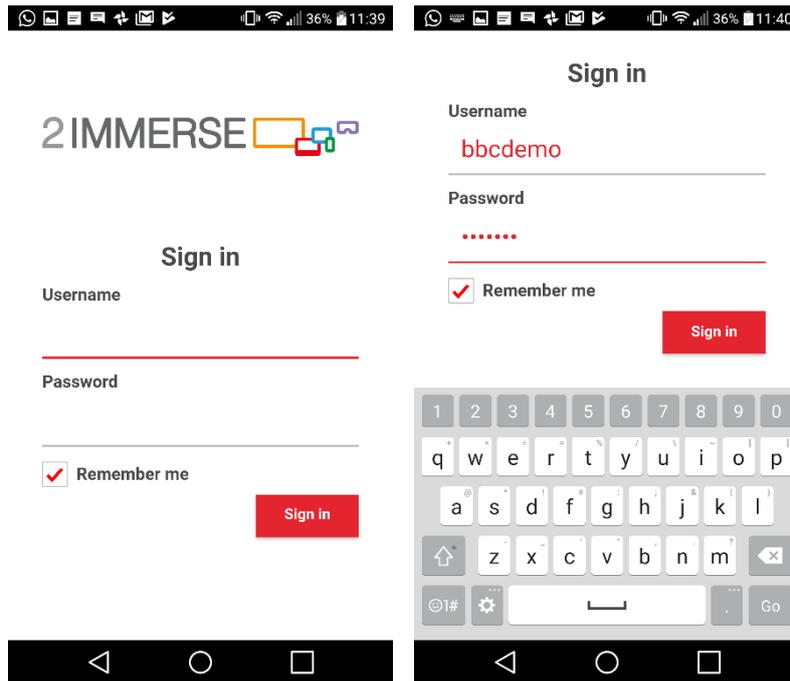
Figure 63 Companion App Revised User Sign-In
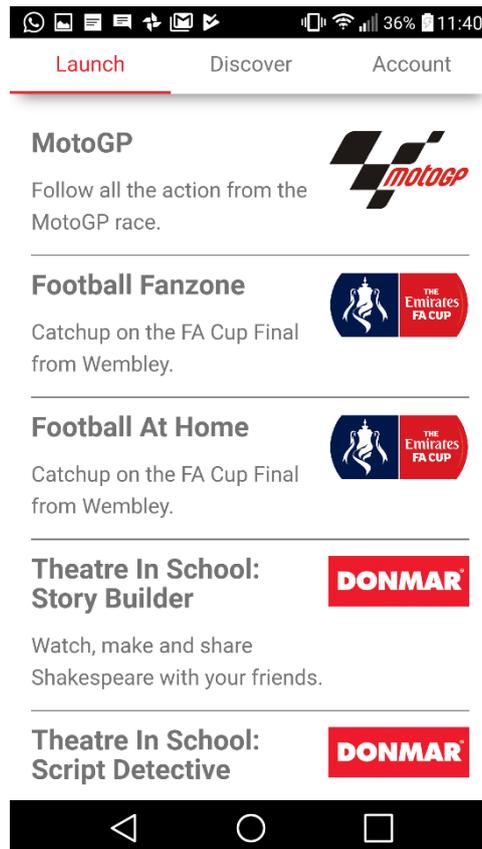
Figure 64 Electronic Programme Guide (EPG)
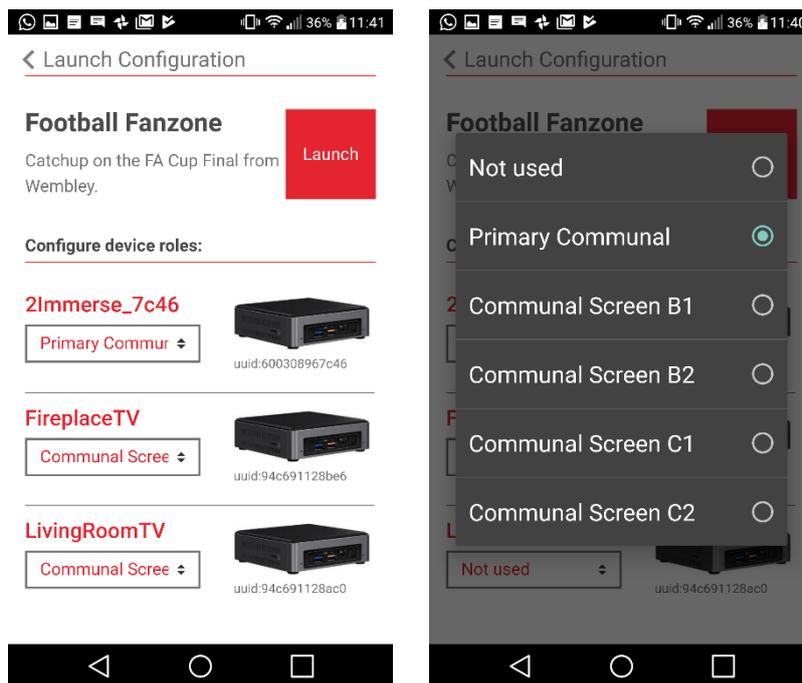
Figure 65 Companion App Multi-TV Launch Configuration
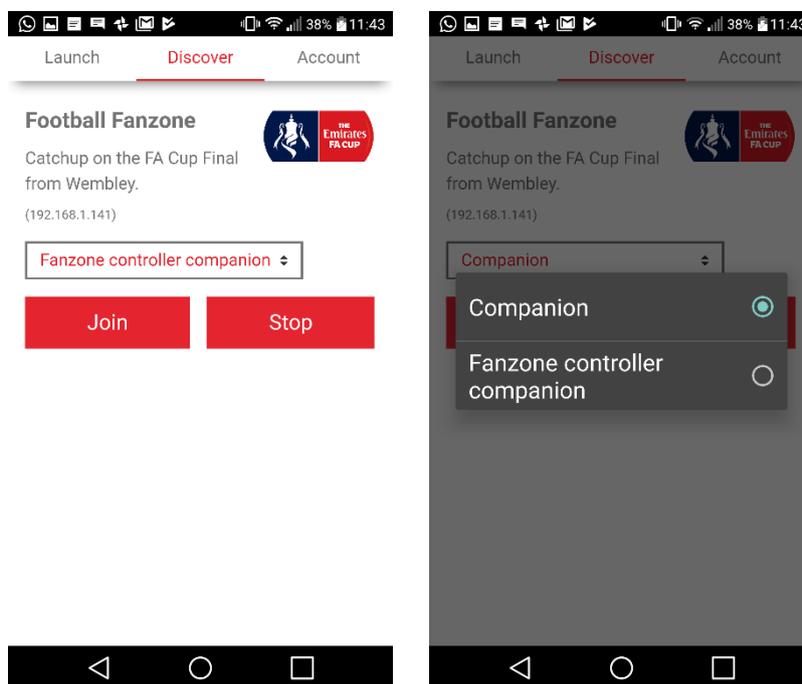
**Figure 66 Companion App Join Configuration for Discovered Experience**

7.4.1 TV Launcher Application

Changes to the TV launcher application were made to advertise programme descriptions correctly via DIAL and to remove the original pairing code mechanism used in the MotoGP-At-Home service trial from the Welcome screen (see **Error! Reference source not found.**). Although not shown in this image,

the TV's ESSID and DIAL server UDN were made consistent and could be configured by a revised admin page hosted by the TV emulator firmware.


Figure 67 DIAL-based TV Launcher App

7.5   Summary

The companion application that implements the revised on-boarding flow became known as the 'Unified Launcher' because it combined several separate launcher applications into one single data-driven application. The user journey was changed to support new device roles and the ability was added to run a programme on multiple televisions. The resulting user journey was simpler compared to the MotoGP-at-Home pairing code solution.

The design of the multi-TV launch mechanism was inspired by ChromeCast, but extended to allow multiple TVs to be selected at once for a single 'cast' operation. This makes the user experience instantly familiar to anyone who has used a ChromeCast.

Cross-network discovery was not implemented. It will be needed eventually to replace the Theatre-At-Home launching mechanism and to allow Theatre-At-Home to be launched directly from the Unified Launcher application across multiple homes. In reality, DIAL-based discovery and a room or "lobby"-based discovery mechanism is required to support application launch and discovery for all networking scenarios. The pairing-code functionality used in MotoGP-At-Home service trial is still implemented but disabled until device discovery using a lobby is implemented.

The Unified Launcher has proven to be invaluable for day-to-day experimentation and demonstration purposes. It makes all the 2-IMMERSE service trials instantly accessible and has helped considerably with sustainability of the 2-IMMERSE platform.

8   Conclusions

This document describes the design process for the development of the Football based use cases. The process is iterative and we describe how the iterative approach has allowed the designers to adapt to respond to some of the principles that control our work. A key component of this design process was the focus on developing practical end-to-end production chain that can support multi-screen personalised presentations of sport.

The work describes how an apparent impasse related to a reluctance to pursue a use cases based in pubs yielded a very useful insight. The insight was that when a production process is used that is inherently object based, it is relatively simple to adapt presentation to suit multiple output formats including those that use multiple big screens (as seen in pubs and FanZones) and those that use both shared TV and companion screens to present the action. This reinforces the value of the approach in developing different presentation for different audiences.

Two related developments essential for these use cases but not limited to them is the development of the production tools required to support live object based productions and a common on-boarding and launcher applications that allows shared and companion screens to discover and join experiences with defined roles.

The resulting experiences are very persuasive and became the cornerstone of the projects major presence at IBC. They have also proved valuable in developing commercial ambition to adopt object based broadcasting as a means to deliver personalized experiences.

The aims and objectives for the remainder of WP3 includes work in the following areas (reported in D3.5) are related to the final use case that of theater in Schools. This work will be delivered in D3.5 and will include a summary of the collated design principles that we have found to be guiding the design work.

Annex A **Supplementary Work**

Complementary studies were carried out in parallel to the main workstream. The aim was to explore usability and design issues from perspectives that were not incorporated or viable within the main workstream use cases, due to technology, time or resource constraints. These studies add to the general knowledge base generated by the 2-IMMERSEproject, and have been documented on the 2-IMMERSEwebsite.

This section covers an exploration of a synchronized tangible companion experiences for children.

8.1   A tangible TV companion (IRT)

2-IMMERSE develops compelling multi-screen applications for MotoGP, football and live theatre productions. The partners invest substantial efforts in designing and implementing intuitive user interfaces, as well as developing a technically reliable platform. The applications are then evaluated in elaborate user trials. When designing the applications for receiving highly relevant user feedback, the project focuses on today's mainstream end-user devices for multi-screen experiences: the TV, tablets and smartphones. However, we are also observing more recent developments in the market and do not want to miss out on potential opportunities. This is why we evaluate emerging technologies that seem exciting to us on the basis of simpler proof-of-concept prototypes, like the one presented in this section.

In cooperation with the German broadcaster ZDF, we developed a TV companion experience for the children's quiz show "1, 2 oder 3", which shows that the companion-screen features of HbbTV 2, which are the basis for all 2-IMMERSEapplications, enable yet unimagined forms of interaction and opportunities for viewer engagement. What is special about our companion experience is, that it does not involve a tablet or smartphone, but a sensor pad, which viewers can potentially easily build themselves at home. The sensor pad connects via a Raspberry PI Micro Computer to an HbbTV 2 application and allows viewers to play along with the TV show.
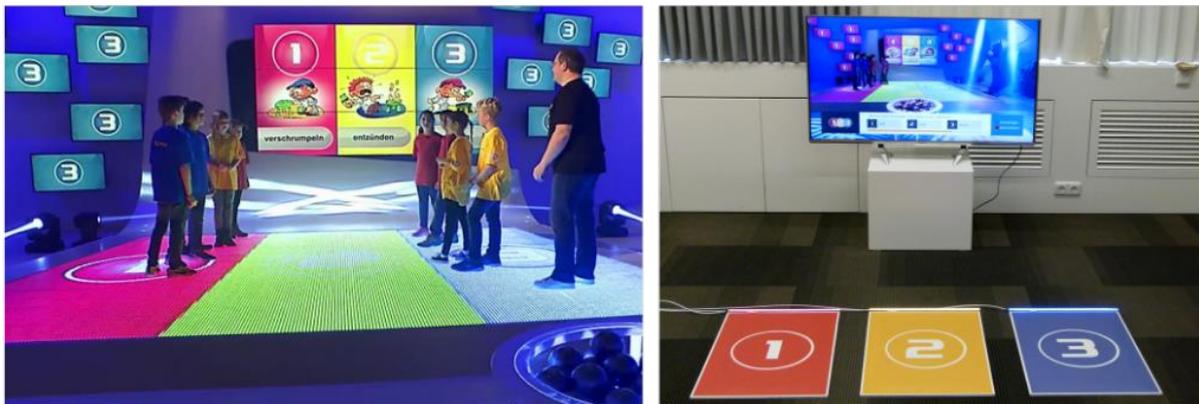
Figure 68 The fields for the answer possibilities in the studio of the programme "1, 2 or 3" (left) and the sensor floor pads we developed for trade fairs (right).

The sensors in our playing field were originally part of cat doorbells. The sensors are covered with printed PVC mats. WS2812 LED strips are mounted on the front of the sensor pad. Light patterns provide feedback on the quiz application's state. Sensor pads and LED stripes are connected to a Raspberry Pi Zero W (RPI) microcomputer. The RPI runs the Node.js-based companion app which makes use of the DIAL protocol to discover HbbTV devices on the local network. Users initiate the discovery by simply stepping on the floor pad.

The HbbTV app is synchronised to the broadcast programme via App-to-AV synchronisation feature of HbbTV 2. Questions and response options are displayed by the HbbTV app at the same time as they are mentioned by the quiz master in the show. When the viewers select an answer by stepping on a field on their connected sensor pads, their choices are displayed on the TV. When the correct answer is presented by the quiz master in the show, it is also relayed to the floor pad via the App-to-App Communication

channel. The segment of the LED strip that corresponds to the correct answer is illuminated. The HbbTV app displays viewers aggregated scores.

In addition to the sensor pad, we have also built a board game version of the companion hardware. The playing field of the board game is made up of three fields of acrylic glass. In addition to LED strips, Reed switches are installed under the three fields. The Reed switches react to the magnetic field release by the permanent magnets in the playing figure. A video demonstrates the boardgame [1].

Figure 69 Figure 29 Board game version of the companion hardware

We believe our demo could prototypically stand for a range of broadcast services fulfilling an educational mission. Information technology (IT) is omnipresent. Educational programmes such as the BBC's micro:bit [2] project intend to enable children to make conscious use of IT instead of just consuming IT products. Our TV app could motivate children to explore IT concepts. A simple version of the sensor playing field could be built by children at home from carton and aluminium foil [3]. Our board game shows that the design possibilities are manifold and that there are no limits to the creativity of the tinkerers.

Figure 70 Prototype of a floor pad sensor build from carton, aluminium foil and adhesive tape

We have shown a demo with huge success at IFA, IBC and "Medientage München" (Munich Media Days). At IFA our demo was shown at two stands: ARD's „Digitale Welt" and at the stand of Deutsche TV-Plattform. The latter was featured on the title page of IFA's daily exhibition newspaper "IFA heute". However, we believe that our demo is more than an attraction at trade fairs.

Figure 71 Piet, the official mascot of the show "*1, 2 oder 3*" presents our demo at the booth of the German TV-Platform at IFA 2018.

Figure 72 Our demo promoted on the cover of the "IFA heute" exhibition magazine

An HbbTV award in the category "Best multiscreen HbbTV service" shows that the experts from HbbTV association are also convinced by the demo. The award ceremony took place on 14th of November 2018 in Berlin.

During the lifetime of the project we were not able to run user tests with this prototype. However, the investigation of the potential of this type of TV companion devices will keep us busy after the end of the project. We applied for a workshop under the topic "Toys and the TV" at CHI '19 to discuss the potential of this type of TV companion devices with researchers from various HCI disciplines. The results of this application will be confirmed in January'19.