

ICT-687655

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



2IMMERSE

D3.3 User Interaction Design: the development of generic components & features to inform MotoGP Service Trials, Production Tools, and OnBoarding.

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Abstract

This document describes the User Interaction Design for the various scenarios based on user testing results. The document will be continuously updated throughout the project. The current version describes MotoGP user interactions which builds on the previous design responses for Theatre at Home. It describes the development of generic components & features to inform MotoGP Service Trials, Production Tools, and OnBoarding.

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.

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Executive Summary

The 2-IMMERSE project proposes to create and pilot new media services built on research and development related to the *production* of, *access* to and *engagement* with rich content across the screens of multiple devices (multi-screen experiences). New multi-screen services will 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.

This document , D3.3, describes the user interaction design and experimentation work that has informed the potential design of MotoGP service experience and specifically the subset of those features to be tested with connected audiences in private homes, prompted by and developed since the *Theatre in the Home* experience trial (D3.2).

This document describes the user interaction design that has informed the Set-Up and OnBoarding experience, generic to all trial services, and informed by the findings from the *Theatre at Home* trial (which stated that onboarding and set-up are essential components of a service trial experience).

This document also describes the user interaction design that has informed the design and development of the Production Tools.

Some of the design challenges and the resulting experiments will inform future service trials in this project.

The methods used in WP3 include conceptual design, trajectory mapping, surveys and lab experiments. This deliverable covers the work and the thinking that lead 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, or the Technical development of the Production Tools covered in WP5.

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1 Introduction

This deliverable describes some of the user experience ‘back-story’ that has influenced 2-IMMERSE platform.

The narrative of this work has three parts:

- 1.The addition of onboarding and set-up functionality to the 2-IMMERSE platform (& service trials)
- 2.The audience experience of the MotoGP service
- 3.The addition of production tools

The first two are builds on the previous trials and extend the challenges for the 2-IMMERSE platform. The second adding new multi-screen challenges and data stream integration.

The production tools are front and centre for a live, data-rich, unpredictable event.

The major part of the ‘back-story’ is an explanation of why certain components (Distributed Media Application components or ‘features’) have been developed, but another important perspective relates to wider issues relating to evaluation.

Distributed Media Application Component (DMAApp) Development

In general, platform components are developed in response to a design requirement that comes from a particular service prototype. The general approach of the project is to build four service prototypes and, as expected, we have found that the components/features and capabilities developed for one service prototype are being used in others.

This document is structured by service prototype, as this is the way the development within the project is being phased. It should not be interpreted that the components (functions) described under the heading of a particular service prototype are only used for that service prototype as this is not the case.

Each component has its own section and we describe:

- The process that led to the development of the component/feature ideas
- The nature of the components/features and our assessment of their importance and value
- The design process that informed the assessment of importance and value.

1.1 Context & Recap – an overview of new capabilities and components

Since the publication of D3.2 a number of new components have been developed and incorporated into the 2-IMMERSE service prototypes:

- Set-Up
- OnBoarding

3 Key Capabilities within services:

1. **Multi-screen Presentation** - content can be seamlessly presented and synchronised across multiple devices.
2. **Object Based Media** - content as discrete media 'objects' which can be flexibly presented across available display devices.
3. **Flexible Media Composition** - control how content is presented and consumed.

These capabilities include individual features such as:

- Display and layout –views panel offering picture in picture capability, and mosaic views;
- Multiple camera streams –offering alternatives camera angles and 360 video options
- Multiple audio streams
- Responsive layered graphic presentation, and overlays
- Events panel and timeline navigation
- Broadcaster and viewer initiated event replays
- User profiles and experience levels
- Orchestrating broadcast graphics with object-based overlays

Production tooling:

- The design and development of a pre-production tool that will create future multi-screen services
- The design and development of a LIVE production tool –for live edits of a multi-screen experience
- The design and development of a trigger/event tool

1.2 A note on the evaluation of service prototypes

With regard to the issue relating to evaluation we have two major threads.

The first is how to assess the impact of certain design on the overall experience when so many other factors are at play. For example, it would surprise no one to find that poor coverage of an important and 'good' race involving a MotoGP rider you care about will probably create more engagement than good coverage of a dull irrelevant race involving riders that are not important to you. So how can we make assessments about whether a different presentation contributes to a better experience?

The second evaluation issue relates to the sets of stakeholders: audiences, producers and developers. How should we assess the success of the work across the people in the value chain? What kind of test evaluations and proof-points should we seek as we try to validate that the approach we are taking is relevant for and useful to the industry?

2 Set-Up & OnBoarding

2.1 Rationale and position

“Onboarding” describes the stage in a user experience of introducing a user to a system, what the features are and how to use them. As part of the project’s aim to create a reusable platform for multi-device experiences, we have identified the need to develop the user experience that surrounds the different specific content experiences to provide a higher quality end-to-end experience for both trial participants and future audiences. Previously, we have discussed the process of designing the user experience for individual content experiences, such as Theatre At Home and MotoGP, but have not explored the user journey that proceeds and follows each content “programme” or “episode”. We have created a user experience design for this phase in the 2-IMMERSE platform, taking inspiration from commercially available multiscreen systems.

The work on “Onboarding” was started in response to some of the user feedback and technical problems from the Theatre At Home trial, to improve the user experience of the platform ready for the MotoGP trial.

This piece of work scoped the following:

- Making the 2-IMMERSE hardware easy to setup so a trial participant could install a 2-IMMERSE experience in their home without a member of the technical team. In the short term, this facilitates larger scale simultaneous trials, such as MotoGP, where up to 10 households will be participating at the same time. In the long term, this sets hardware and user requirements for broadcasters wanting to use the 2-IMMERSE platform for delivering multiscreen experiences to audiences.
- Simplify the experience of connecting the TV Emulator device to a network connection (in a home or public space), when the TV emulator device lacks a keyboard and mouse. Ensuring network connection is robust and when there are issues, clearly communicate them to the user and not let them impact connected houses or other devices participating in the experience.
- Creating a platform level, content agnostic way of logging in to the platform and selecting an experience or joining one that had been previously started.
- Providing a consistent way of extending the experience across a collection of devices.
- Reducing information overload experienced by users by proceeding the experience with a series of slides explaining the phases of the programme and their expected durations. This also allows us to set user expectations about the nature of experience.
- Introducing various components that will be presented to the user, so that they are fully aware of their features and the different ways of interacting with them.

2.2 Background Research and Competitor Analysis -state of the art review

Our UX design process started by examining examples of “Onboarding” in commercially available web and mobile applications, through both direct interaction and examining “teardowns” of various interfaces available online (such as those available on useronboard.com). An example of an application that includes “onboarding” is the BBC Sport mobile application, which contains screens that help the user setup notifications for particular sports they wish to subscribe to. The common

features of these interfaces is that they are highly instructional, making use of simple language, images and animation to break complex tasks or features into simple, easy to understand steps.

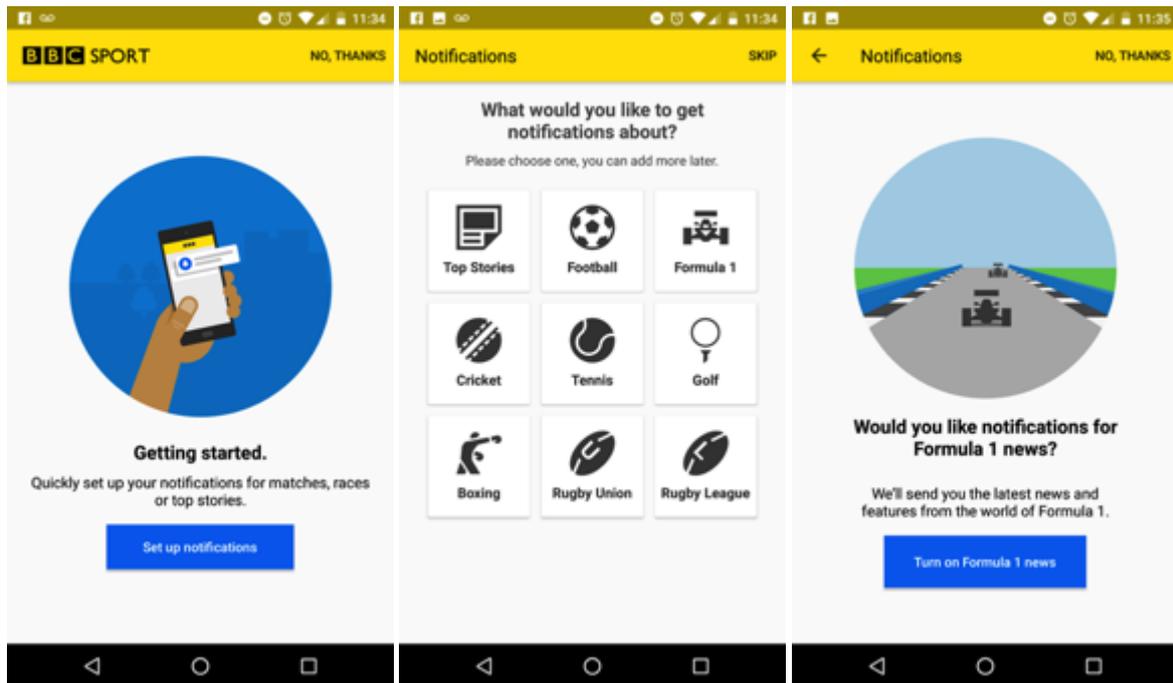


Fig 1. BBC Sports App

Designing the “onboarding” process for 2-IMMERSE introduces some different UX challenges as the user is interacting across multiple screens, with attention moving between personal and communal devices. In addition to this, multiple users in a space can join a single experience, so we guided our research to draw from examples of commercially available multi-screen platforms. Firstly, we looked at the implementation of the BBC’s sign system for cross platform authentication (<http://www.bbc.co.uk/rd/blog/2014-09-cross-platform-authentication>), which allows the user to use a device with a keyboard or touch screen, such as a smartphone or laptop to login to a device which has limited interaction capability, such as an Internet radio. The BBC has recently begun to explore using this technology to sign in to the iPlayer application on Smart TVs. When the user selects the sign in option, they are given an instructional video on screen to take them through the process of logging in.

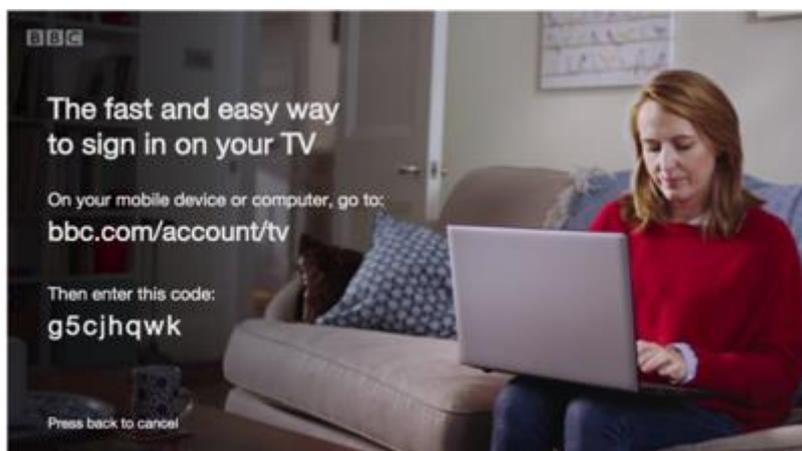


Fig 2. BBC iPlayer Personalisation Screen

The user visits a URL on the BBC website on their mobile device or computer and is prompted to log in, if they are not already signed in to BBC ID. Once signed in, they input the unique code displayed by their TV, which grants the Smart TV access to their account. However, this user experience assumes the Smart TV has already been connected to a network and that the user has some means of selecting the action to sign-in, which the 2-IMMERSE TV emulator does not have.

There are a number of commercially available platforms which require connecting a device with limited user input to a wireless network, including internet of things devices such as Amazon's Echo smart speaker and digital streaming devices such as Google's Chromecast. In designing the 2-IMMERSE onboarding process, we did a detailed analysis of the Chromecast user experience, as this had several similarities with the user and hardware requirements for the onboarding project (see Appendix A). The Chromecast is a small device which plugs into the HDMI socket on a large screen and displays audiovisual content that is "cast" to it by a linked mobile application. The onboarding process for the device presents the user with a series of animated instructions across the large screen and the mobile device, taking them through connecting the device to the network and how to "cast" content from a mobile device onto the main screen. The Chromecast also features a "Guest Mode", which was devised to allow users without local network access to cast content to a TV. In guest mode, the Chromecast exchanges a pin code with the casting device (using ultrasound or manually) to establish proximity and then uses a cloud relay to signal the Chromecast. We have taken inspiration from the Chromecast user experience to craft the wireframes for the 2-IMMERSE onboarding experience.

After devices have a network connection, users need a mechanism for adding them to the currently running experience. The MediaScape¹ project [MediaScape EU FP7 (610404) Dynamic Media Service Creation <http://mediascapeproject.eu/about.html>] identified that there are multiple technological solutions to achieve this, including QR/Visual Codes, Ultrasonic signals, network discovery or simply typing in a code. In order to support different strategies, the Association API abstraction layer was created to provide a technology-agnostic way for devices to join a multiscreen session and share state. We have followed this strategy in designing the user experience for onboarding, concentrating on the user interaction required to facilitate a device to be added to an experience, but not the specific technology to be used, at this stage.

2.3 End to End User Journey

Onboarding for 2-IMMERSE captures the end to end user journey for the 2-IMMERSE platform, in the short term for the participants in our prototype experiences and in the long term, for future audiences. In designing this experience we have considered the following different users making use of the 2-IMMERSE platform:

- An audience member with access to the content starting to watch an experience in their home who wants to run an experience using their TV and personal mobile device
- A second audience member in the same home or space who wants to join the same experience as the above user and have related but differing content on their personal device. The device could be on the same or different local network than the device that initiated the experience.

¹ MediaScape EU FP7 (610404) Dynamic Media Service Creation <http://mediascapeproject.eu/about.html> BBC, IRT, W3C, Norut, Vicomtech.

- An audience member who wants to join their friend's experience which is running in a different household (on a different local network)
- A person who wants to run an experience in a public/shared space across multiple screens and allow participation via mobile devices (i.e. Football in the Pub/Theatre in Schools).
- A person developing or demonstrating experiences for the 2-IMMERSE platform

The different types of user, how they collaborate with each other and how they interact with various devices and different content experiences present a complex set of user requirements. From these we have been able to identify the following common phases in the on-boarding process of 2-IMMERSE:

1. Connecting the TV emulator to the Internet
2. Signing into the 2-IMMERSE service on each device
3. Choosing and launching the experience
4. Extending the experience to other devices
5. Joining an inter-home synchronised experience (a lobby/room)
6. Joining a experience in your immediate environment/proximity
7. Introducing the experience and component features

For evaluating the 2-IMMERSE project through our various prototype experiences, we must also consider the end to end experience for participants in our various trials, from signing up to the end interview. This process is detailed in the flow diagram below (fig.3).

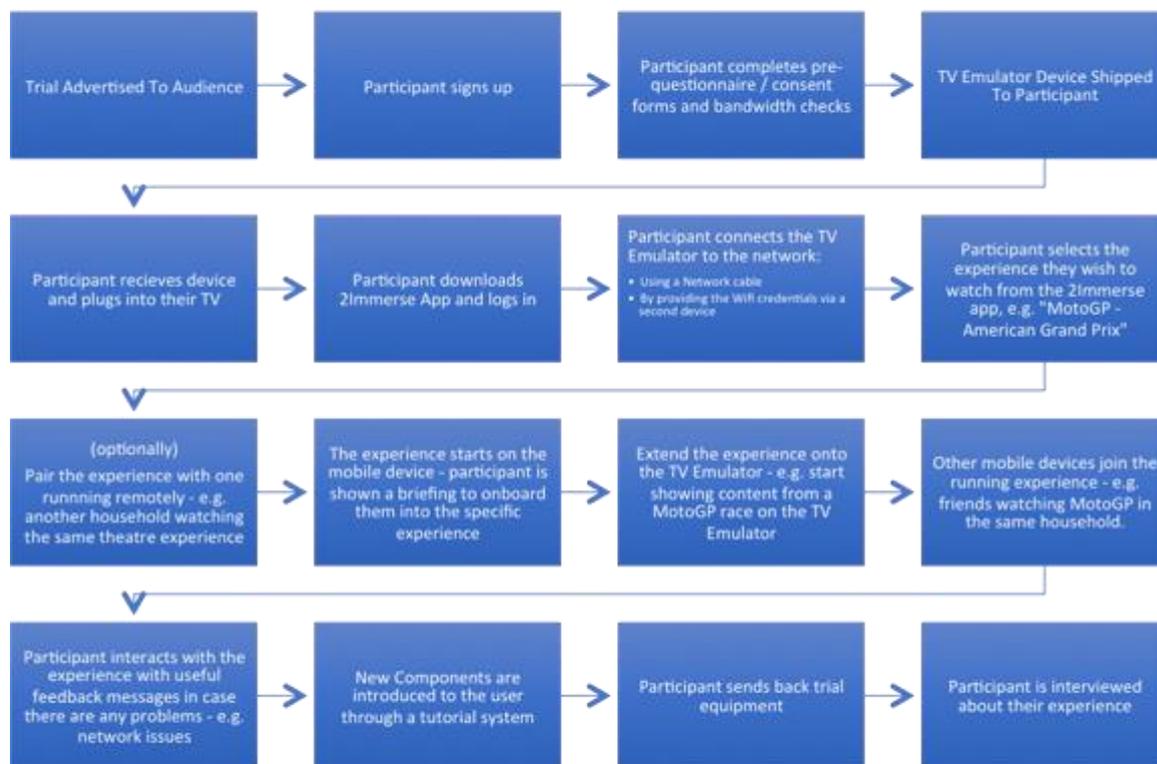


Fig.3. Steps in the end-to-end user journey

We have designed a series of wireframes to capture this user journey (see Annex B).

2.2.1 Connecting input-restricted devices to the Internet

Large screen devices, such as the TV Emulator in 2-IMMERSE, typically require a remote means of user input, which typically takes the form of a TV remote control. One of the difficulties in this user experience with current Smart TVs is that Wi-Fi passwords are cumbersome to enter using the remote and in addition there are privacy issues with displaying the onscreen keyboard input to everyone in the room. As the 2-IMMERSE platform already makes use of personal devices such as smartphones and tablet computers for extending the visual experience beyond the main screen, we recommend using the input capabilities of this device for entering the Wi-Fi password as these devices are better optimised for text entry than a remote with 5 point navigation.

In order for the user to input the Wi-Fi password into their personal device and send it to the TV emulator, the two devices must establish a secure point-to-point connection with each other. In the 2-IMMERSE platform, the TV emulator serves a local Wi-Fi network to allow mobile devices in the room to connect to it and setup its internet connection. The TV emulator firmware uses a captive portal architecture, which intercepts HTTP requests made by the mobile device and redirects it to a locally hosted gateway page. Captive portals are typically used by public Wi-Fi hotspots, such as those in hotels and public transit, to provide user authentication, payment or acceptance of terms of service agreements. When a user connects to a captive portal from a mobile device or laptop, the operating system generally automatically opens the served gateway page automatically using the default browser. In the 2-IMMERSE TV emulator firmware, when a companion screen device connects to the hosted Wi-Fi network, the browser on the mobile device displays a list of nearby

wireless networks the TV can connect to. Through touch screen interaction, the user can select a wireless network for the emulator to connect to and provide an access key, if required. When the TV Emulator successfully connects to the internet connected Wi-Fi network, the access point and captive portal are turned off. If an error occurs connecting the device to the internet or the connection drops, both the TV and mobile devices should display error messages and provide troubleshooting steps to assist the user in reconnecting the device.

2.2.2 Signing into the 2-IMMERSE service on each device

The MotoGP trial has identified the requirement for authentication in the platform, both to support enhancement of the experience through personalisation and to allow digital rights management to protect the intellectual property of content from our suppliers. As the 2-IMMERSE platform will be publically accessible over the internet, authentication is also a requirement for securing our back-end services from unauthorised use. In future, authentication could be used by broadcasters to protect access to pay per view or subscription content. In the 2-IMMERSE architecture, access to the platform micro services is protected by the API gateway, which requires devices provide a valid OAuth2 access token. In order to generate a valid access token for a device to authenticate, a user must provide a username and password, which means there must be a means for the user to provide these on both the TV emulator and companion device, which in the absence of a keyboard and mouse on the TV, presents an interaction challenge. Therefore, the user interaction with the 2-IMMERSE platform, must be initiated on the mobile, companion device, via the 2-IMMERSE application. Once the TV emulator is connected to the internet, the interface should display instructions to the user on how to download the application, which for the MotoGP trials will be distributed as a downloadable Android Application Package (APK) file on a shortened URL. In future, the application would be distributed via approved channels, such as the Google Play Store (for Android devices) or the Apple App Store (for iOS devices). The Android (and iOS) application wraps the device's native web browser, which will show a log in screen and prompt the user to enter their username and password. For trial participants, accounts will be generated by the technical team on their behalf until a full user experience for user registration is completed.

2.2.3 Choosing and launching the experience

Upon entering valid user credentials into the mobile 2-IMMERSE application, the platform generates a valid access token for the device, associated with a particular user. This will enable the application to list the different experiences that the user has access to, such as a particular MotoGP race, football match or theatre production, limiting access for trial participants to the particular prototype they are signed up to. As the TV emulator device has no form of user input, the selection of an experience can only happen on the signed in mobile device. The mobile device initiates a content experience in a particular space.

2.3.4 Connecting other devices to an experience

The user must have the capability to extend a content experience so it can run across multiple screens and we plan to support this functionality before or after the experience has been initiated by the user. Once the device has been connected to the internet it should contact the 2-IMMERSE platform and request a unique, human-readable identifier to display to the initiating user on screen. The generated codes should be easy to type on a mobile device keyboard, being as short as possible and only using alphanumeric characters in the same case. The 2-IMMERSE mobile application will

allow the user to type in this unique code, which will extend the selected content experience on to the device. As previously stated, there are a number of available technologies which could be used to discover and add nearby device identifiers, but in our wireframe design we have visualised the process of manual code entry. The user should also have the capability of removing a device from an experience, for example, in the use case that a TV device needs to be used for another purpose.

2.3.5 Joining an inter-home synchronised experience

The 2-IMMERSE platform provides the facility for multiple households or spaces to watch a synchronised experience, developed as part of the Theatre At Home content experience. For future experiences that want to support these scenarios, the on-boarding experience must support a way of joining a remote experience. In the current user experience, this is achieved by sharing a pairing code between households. In future, the authentication system could be leveraged to provide an invitation and messaging system between users wanting to take part in multi household synchronised experiences.

2.3.6 Joining a Proximate Experience

A Proximate experience refers to a 2-IMMERSE content experience that is running in the space around a user, which may have been initiated by someone else. In respect to our trial prototypes this refers the following:

- Theatre At Home – a person known to the trial participant who has initiated the experience who is within the same room, with visibility of the TV emulator, typically a friend or family.
- MotoGP At Home – same as in the Theatre At Home scenario
- Football in the Pub – a member of the public who has walked into the pub and wishes to join the experience using their mobile device.
- Theatre In Schools – a pupil who wants to view content on their tablet device that synchronises to the experience currently running in the classroom.

There are several possible ways to discover experiences running in proximity to a device and this largely depends on what its networking capabilities are and how much access to a specific network is provided to a given user. If users are permitted to connect their devices to the LAN (probably via Wi-Fi), then a network discovery protocol such as DIAL can be used. This is currently the case for the 2-IMMERSE Theatre At Home experience, where the companion device “discovers” the experience that has been initiated by the TV emulator.

There are a number of common scenarios that would prevent LAN-based discovery:

- There is no Wi-Fi network available
- Users are denied access to the Wi-Fi
- Users are segregated onto a guest Wi-Fi SSID
- Users are granted Wi-Fi access but the access point is locked down to prevent devices from discovering each other, such as in a coffee shop or office environment.

In order to achieve network-agnostic setup, we will focus on the concept of connecting a device to an “experience identifier”, carefully noting that this is different from a “device identifier”. An “experience identifier” is generated when the content experience is initiated by a user and is used by a second user to connect their device to the running experience. The user experience for this consists of signing into the mobile 2-IMMERSE application and selecting an option from the main menu to “join” a specific content experience. If the user is on a network or in a space where the content experience is discoverable, it will be enumerated in the menu and be selectable. If experience discovery is not supported, the user will type in the experience identifier instead. To support this the TV emulator should support displaying the experience identifier on screen in the space.

2.3.7 Introducing the experience and component features

From the initial Theatre At Home prototype user trial, our findings suggested that users felt confused by the experience that was presented to them and unfamiliarity with the interface meant their user interaction with the wide variety of content that was available was limited. Firstly, an improvement is required in introducing the users to a specific content experience, rather than landing the user directly into the experience, as was the case with Theatre At Home. A set of screens could be presented to the user at the start of the experience, taking them through the various phases of a content experience and how long they are likely to take. In prototype experiences for trial participants, this can also be used to set user expectations that they are taking part in an experimental service and that things might break. As with the preceding on-boarding user experience, instructional content should be mirrored across devices, with the companion screen providing the primary user interaction for stepping through the different screens. When the experience begins, the user should be introduced to individual components, what features they offer and how to use them. We suggest using a pattern used by many applications and highlighting the components by greying out the area around them and providing an instructional caption beside them, which may step through common actions and highlight particular buttons and controls within that element and explain what they do. As components can cross different screens, some which lack user input, there must be controls for the tutorial system available on a touch-enabled device, such as companion screen to facilitate interaction with the tutorial system.

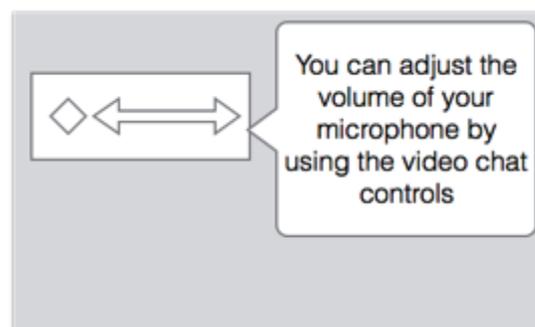


Fig.4.Example of touch-enabled control

Leveraging the authentication system, a user’s interaction with the various tutorial components can be recorded, so they do not have to repeat these interactions next time they start a content experience or view a certain component.

2.4 Hardware specification

The Football and MotoGP service trials have more demanding video processing and presentation requirements necessitating a powerful TV emulator device, than has been used previously on the project. The work to improve the “on-boarding” user experience also infers new hardware requirements, a device that facilitates automatic configuration without requiring keyboard or mouse inputs. Finally, the TV emulator needs to have more powerful Wi-Fi networking to improve effectiveness in a range of challenging domestic Wi-Fi environments. These goals are summarised below:

- Scale up to larger trials
- Improve multi-device on-boarding for trial participants
- Support the more demanding features of MotoGP and football
- Improve robustness and increase trial success rate

The following requirements should help us to address the goals highlighted, whilst tackling some of the lessons learned from the Theatre At Home service trial.

2.4.1 General Requirements

- The TV device must be capable of running each of the 2-IMMERSE service trials.
- Small enough / light enough, yet robust enough to be posted to trial participants and returned.
- As cheap as possible, but avoiding performance issues, OS/driver stability problems and extra development effort that are characteristic of cheaper devices.
- Sufficiently over specified to avoid investing time in optimisation that could be spent on feature development.
- More than capable of delivering full trial specifications without feature compromise.
- Quick and easy to apply a system image and update it at a later date.
- An OS that the majority of the 2-IMMERSE technical team feel comfortable developing for.
- High quality Wi-Fi networking (preferably 802.11ac to deliver speed at range and enable use of the 5GHz band to reduce the chance of interference. Multiple antennae would be an advantage to support beam forming).
- Sufficient performance (CPU and network) to act as an access point and perform high-bandwidth routing to/from multiple companion devices.
- Ethernet
- HDMI (+ audio over HDMI)

2.4.2 Software Requirements

- Keyboard-less / mouse-less configuration (CEC/remote not required)
- Run background HbbTV2.0/2-IMMERSE emulator services
- Run Google Chrome or Chromium supporting MSE and CENC
- Captive portal / access point control and configuration
- Background network QoS monitoring and reporting
- Able to decode and render at least (1 x 1080p30) + (3 x 540p30) DASH video feeds simultaneously (based on MotoGP requirements)
- Hardware accelerated WebGL support for 360 video rendering
- Able to render composited animations/infographics (e.g leader boards) @ 30Hz

- Robust kernel/OS (preferably mainline).
Ability to boot OS straight into Chrome/Chromium full-screen kiosk mode as a user with restricted permissions

These requirements inform the choice of TV emulator device, operating system and software/firmware.

2.4.3 Firmware

The choice of TV emulator is heavily influenced by the experience we want to give the users in terms of on-boarding. The 2-IMMERSE TV emulator could be packaged in a few different ways:

1. As an AndroidTV/Tizen/WebOS/FirefoxTV app
2. As a dedicated kiosk OS

Both options are viable, but the latter option delivers a more streamlined, locked-down experience. That's why digital signage solutions adopt this approach. A dedicated kiosk OS puts us in complete control of device setup, security and the overall user experience. It results in fast boot times and small maintainable system images. This minimises the chance of things going wrong during the service trials.

It is conceivable to package the 2-IMMERSE HbbTV2.0 emulator as an app for AndroidTV, thereby adding some HbbTV2.0 support to AndroidTV. In future, it might be possible for both technology stacks to be supported on a single device.

2.4.4 Operating System

There are a number of turnkey digital signage and kiosk operating systems to choose from and although many are 'nix'-based, few are mainstream or provide the degree of control required by 2-IMMERSE. The recommendation is to build the TV Emulator around a Linux distribution (as a reference implementation) for the following reasons:

- Linux broadens the choice of devices
- A solution developed for Linux is more transferable, because other operating systems such as Android, ChromeOS and MacOS are *-nix derivatives.
- Linux is an open source (non-vendor) platform that doesn't lock you into a any particular supplier's ecosystem or platform rules.
- It has great support for streamlined images with minimal dependencies (LinuxKit, Docker)
- Linux is the OS that the consortium has the most experience with

2.4.5 Hardware

A number of devices have been considered for the hardware specification, including ARM and Intel CPU based systems. Price and size were only two of many factors to weigh up and they weren't necessarily the most important.

2.4.5.1 Assessment of ARM-based devices

There are many attractive ARM devices out there, which meet many of the 2-IMMERSE requirements, but kernel and driver support falls short when it comes to robustness.

The Linux kernel running on ODroid C2 (an original candidate device for the Theatre At Home service trial) has been heavily customised by HardKernel to support the Amlogic S905 SoC, but these changes are not in mainline branches of the Linux kernel. Most of the products based on these SoCs are running a modified version of an old Android kernel.

Lack of mainline Linux kernel support means that Amlogic SoC devices don't directly benefit from the wider community of Linux kernel developers. Feature support tends to be proprietary and unstable, whilst lagging behind the mainline. This is typical of many of the ARM-based devices that were under consideration. There are plans by Amlogic for mainlining support for their devices in future, providing improved drivers for video acceleration, input devices and networking. Work is currently in progress to support the Mali-450 GPU. These devices are likely to meet the requirements of the project in future, but this will probably be beyond the timescale of the 2-IMMERSE project.

2.4.5.2 Assessment of Intel-based device & Intel NUC

The recommendation is to adopt an Intel x86_amd64 architecture for the 2-IMMERSE TV emulator. Intel's own NUC devices are the most promising in terms meeting the 2-IMMERSE requirements:

- Intel x86/amd64 is ubiquitous and mature
- Intel design NUCs using their own components as opposed to licensing other vendor's designs for improved compatibility and operation.
- Intel NUCs are slim-line and come with a mounting bracket so they can be hidden behind the device and be less intrusive
- Intel NUCs are used extensively in digital signage applications, which have a lot in common with 2-IMMERSE multi-screen experiences.
- Intel NUCs are general purpose and are not tied to an OS or software ecosystem. This means that devices don't have to be rooted or hacked (Hackintosh, chrooted Android or jail-broken ChromeOS etc.) which is complicated and gets in the way of provisioning devices, e.g. requiring EFI bootloaders etc.
- Intel NUC drivers are optimised for Windows and Linux

2.4.5.3 Video Decoding support

The video decoding demands of the MotoGP and football service trials are high, so it is important to investigate video decoding capabilities and performance of the devices under consideration.

Hardware accelerated video decoding is only needed when there is limited CPU resource available. The 6th generation Intel Core i3 found in a low-spec Intel NUC device is capable of simultaneously decoding a UHD DASH video (3840p30, 12Mbps) and an HD DASH video (1920p30, 8Mbps) in software without stalls, utilising 3.5 CPU threads. That's more than double the amount of video decoding required to satisfy the requirements of MotoGP. Experiments have shown that enabling hardware accelerated video decoding reduces the CPU load down to 12% (from 350%) on this device given the same video decoding jobs.

Hardware accelerated video decoding is more valuable on low performance devices where CPU resource is limited, for example STBs (Set Top Boxes) and SBCs (Single Board Computers) such as the RaspberryPi & ODroid C2. Paradoxically, the cheaper price point of these devices means that less effort has been invested in software/driver/kernel support for hardware accelerated video decoding.

Cost savings made by choosing an SBC can be swallowed up by the extra development effort needed to optimise for them.

The 2-IMMERSE prototype implementation is written and optimised as a web application for Chrome/Chromium, as it is one of the most capable and wide spread web browsers in use today. It is important that Chrome/Chromium can exploit hardware video decoding capabilities of the chosen TV emulator device. Chrome provides out of the box support for hardware accelerated video on ChromeOS, Android, Windows and MacOS (10.9+) but there is a lack of support for Linux due to concerns from the developers around the stability of drivers. Chromium on Linux can either be patched to enable the VA-API (Linux Video Acceleration API) code paths, which are there to support the ChromeOS x86 build, or you can change the build arguments to "cross-compile" ChromiumOS which runs in a window on Linux. Either option will suffice for a 2-IMMERSE full-screen web kiosk (for more information, see: https://github.com/saiarcot895/chromium-ubuntu-build/blob/master/debian/patches/enable_vaapi_on_linux.diff). The VA-API has good driver support from Intel for the graphics processors commonly found within the NUC.

2.5 How will we evaluate this?

2.5.1 Recommendation Intel NUC

After analysing the requirements and having weighed up processor architecture, operating system and support for hardware accelerated video decoding, we are proposing use of the Intel NUC for future trials to ensure the optimal user experience and support the requirements for Onboarding. Specifically, the Intel NUC7i3BNK provides the best form factor, hardware specification and price.

2.5.2 Evaluation plan for Set-up & OnBoarding

The Set-Up and OnBoarding process will be included as part of the MotoGP service evaluation.

The aim is for participants in the evaluation to set-up the service on their own, in their own homes, without the support of the 2-IMMERSE team.

Instructions for the Set-Up and OnBoarding will be provided with each trial kit, and a support line will be available for trouble shooting.

Participants will be questioned about their Set-Up and OnBoarding experience in the post-trial questionnaires and interviews.

3 Features and Components developed for MotoGP User Experience Design & Trial Plan

This section outlines new features and components enabled in the MotoGP experience.

It must be emphasised that these features and components have been developed as core capabilities of the 2-IMMERSE platform, which will be available for the creation of future sports and non-sports related multi-screen entertainment experiences.

Context of MotoGP

Although the user experience design for the MotoGP experience was heavily influenced by existing broadcast design guidelines, assets and layout (from BT Sport & Dorna) and the interaction design of the MotoGP app, the user experience design strategy for the 2-Immerse experience was also informed by the insights gleaned in the *Theatre in the Home* prototype and trial.

3.1 MotoGP at Home Trial aims

The aim of the *MotoGP at Home* trial is to broadly gain an understanding of how audience engagement is impacted by the provision of live multiscreen sporting events within a home environment.

We are also looking to gain insights on the requirements of the production tools and production workflow associated with creating a multi-screen presentation of a live broadcast. These insights will be gained during the pre-trial development work and post-trial review with stakeholders.

Original proposal for *MotoGP at Home*

The MotoGP at home service innovation prototype will provide a user with a personalised multi-screen experiences that can be customised to suit a viewer's interests and level of experience with the sport. It will further support video, timing data and other race information to be responsively presented across a large shared TV display and on smaller personal screens.



Fig 5. MotoGP Service Illustration

MotoGP at Home was selected as the primary motorsport use-case as it offers access to synchronised video, audio and data feeds.

3.1.1 Hypotheses & research questions

Our starting hypotheses is that content creators, content service providers and audiences will find much value in adopting a new approach to programme creation and delivery which offers to provide flexible, synchronised, interactive and customisable entertainment experiences for multi-screen audience environments.

We further believe that the following 3 key capabilities are necessary to enable is vision of future entertainment production, delivery, presentation and consumption.

4. **Multi-screen Presentation** - Content can be seamlessly presented and synchronised across multiple devices including TVs, Tablets and Smartphones.
5. **Object Based Media** - Content remains as discrete media 'objects' which can be flexibly presented across available display devices.
6. **Flexible Media Composition** - Producers, Broadcasters and the Audience can control how the content is presented and consumed.

The *MotoGP at Home* trial has been designed to provide the project with an understanding of how audience engagement is impacted by the provision of live multiscreen sporting events within a home environment. More specifically we are looking for the trials to provide answers to the following research questions;

- Have we provided a more compelling experience for viewers than currently offered?
- Has our attempt to provide a multi-screen responsive personalised experience increased viewer engagement?
- What facilities worked well (enhanced the viewing experience) and what needs to be improved?
- How much do viewers value the enhanced experience? How much would they be willing to pay for such services?
- How multiple viewers within a household engage in this type of shared experience using personal devices together with a shared TV screen?

The trial will also gain insights on the requirements of the production tools and production workflow associated with creating live multi-screen sports broadcast. These insights will be gained during the pre-trial development work and post-trial review with stakeholders. More specifically, we are looking to further understand the following;

- What are the challenges associated with producing object-based multi-screen responsive personalised entertainment?
- Did our platform resolve these challenges? What enhanced or new facilities may be required for use within industry?
- What is the impact on current workflows and what needs to change in production and delivery?
- What's the overall financial impact in delivering these forms of enhanced multi-screen entertainment?
- Does the producer (Dorna) see value in providing broadcasters with content as objects which can be flexibly presented?
- Do broadcasters (BT Sport, BBC) see value in the provision of personalised experiences through adoption of OBB?
- Do third-parties see value in providing their services via our platform?

3.2 Background Research & UX design development

3.2.1 Prior Work

BT, BBC, Cisco and other project partners have previously investigated and developed prototype multiscreen applications that have been tested and trialled with users. Those involved in supporting the development of the user experience shared insights gained from prior work at a number of specific User Experience development workshops that were held in April and May in London.

3.2.2 Background Research

Our starting point in the development of the MotoGP user experience was to review the key service offerings provided by a number of current motorsport TV content providers. We specifically focused on the features and facilities of the companion screen applications that was provided alongside the TV broadcast. Whilst the Dorna and BT Sport apps are, for obvious reasons, the most relevant apps with respect to the development of this MotoGP use case, inspiration and ideas may also be drawn from the providers such as SkyItalia (for MotoGP again and again based on Dorna feeds), Formula 1 and Nascar.

The key App capabilities offered included;

- **Multi-camera** - Multi-cameras feeds which are synchronised and can be viewed simultaneously in a number of preconfigured mosaic layouts.
- **Highlights** - Highlight clips made available where viewers can jump back to any moment to replay and then return to live viewing.
- **Data** – Track timing, vehicle telemetry and other statistical analysis.
- **Tracking** – Live race track maps that show the position of bikes through-out the race.
- **Commentary** - Live text commentary which can accompany the viewing of a race or session by providing extra details such as statistical information, race tactics or rider wellbeing after a crash.
- **Audio Control** - Audio setting options allow the viewer to control whether to listen to live commentary, ambient sound or an On-Board factory engine
- **Results** - competition results for drivers/riders and teams
- **News** – Latest news from o
- **Profiles** - driver/rider profiles and stats
- **VoD catalogue** - Prior races, technical insights, rider interviews
- **Mirror to TV** – Screen mirroring or casting capability which enables some content to be displayed on the TV in either full-screen or as a picture in picture (PiP).

All the Apps investigated were designed to provide a standalone experience and do not provide a synchronised experience which spans across TV and companion-screen device. Differences in how video is delivered to the TV (Multicast) and App (Unicast HLS) typically results and an App trailing approximately 40 seconds behind video played on the TV.

3.2.3 Stakeholder Consultation

Throughout the development of the MotoGP user experience, we have regularly consulted with Dorna and BT Sport production. During these consultations the project team asked for feedback and steer on the key capabilities being considered. These were presented in the form of capability feature lists, wireframe designs, exemplar screen designs and visual prototype demonstrators. We also consulted and took steer on the format of trial that could be supported.

Key feedback included:

- Responsive TV Presentation – Dorna saw great value in the adaptability Object Based Broadcasting provided in the layout, scale and design of presentation of TV graphics. There was also interest in how the design of the graphics themselves could be responsive, noting the responsive leaderboard design being used in the project.
- Personalised TV PiP presentation – Dorna again were very interested in viewers being able to personalise the presentation on the TV. However, they saw some challenges in understanding how they could ensure camera framing integrity was maintained i.e. ensuring shots were framed in relation to what on-screen graphics were being shown.
- Multi-screen synchronised video/data presentation – Both Dorna and BT Sport saw synchronised multi-screen presentation as a key capability that would deliver the greatest impact to viewer experience. However, concern was raised about the delay of TV video feeds that would be required to deliver a synchronised experience across additional companion-screen devices.
- Viewer Experience Levels – Again both saw benefit in facilities that supported delivery of more personalise experiences aligned to the experience level of the viewer.
- OBB TV graphics – Dorna made specific note on the impact OBB graphics could have on regionalised branding and customisation. BT Sport noted the outstanding crispness of the TV graphics, when compared to traditional broadcasts.
- 360 Degree Video – Both BT Sport and Dorna were intrigued with the provision of 360 degree video content on the TV and companion screen app, which is synchronised in terms of both timecodes and viewpoint.

3.2.4 Early Consumer Feedback

During 2017 we've had a number of opportunities to showcase our early visual prototypes to others outside of the project team. This has enabled us to gain some useful feedback and debate around key facilities supported within the 2-IMMERSE platform.

In June 2017 we demonstrated over five days at BT's Innovation 2017 event at BT R&D Labs in Suffolk, UK. Feedback gained from a largely technical enterprise audience was very positive on the key facilities we showcased.



Fig 6: 2-IMMERSE MotoGP visual demonstrator shown at BT Innovation 2017, June 2017.

In September 2017 we demonstrated over four days at New Scientist Live event at Excel in London, UK. Feedback from the public audience was overwhelmingly positive on the key facilities we showcased, with many also asking when it would be launched as a service.



Fig 7: 2-IMMERSE MotoGP prototype demonstrated at New Scientists Live event, September 2017.

3.2.5 Rituals of watching MotoGP

Our understanding of how viewers currently watch MotoGP and related motorsports has been primarily developed through prior MotoGP user trials, desk based research and discussions with sports broadcasters. A snapshot of comments from viewers is provided below:

MotoGP viewer interests and experience

- “I tune in because I am first a motorcycle fanatic. I like bikes. I liked bikes before I even knew there was such a thing as MotoGP. I love to see these men manage these machines I love so much and do amazing things with them. That is first and foremost why I tune in.” [1]
- “I watch because I love motorcycles and motorcycle racing. I have been watching grand prix racing for almost 20 years. It's my absolute favourite sport and nothing comes even remotely close. It got me into riding bikes and I have been doing so for the last 15 years.” [1]
- “I watch racing because I love to see people overcome a tough challenge and triumph in the end. Nothing is more exciting than watching 2,3,4,etc racers battle it out lap after lap and have a race come down to the final corners. Conversely nothing is more boring than watching someone get way out in the front, and win without an unchallenged fight” [1]
- “Pure and simply it's the best sport on the planet. Skilful, adrenaline pumping, hair raising competition that is extremely closely fought... Often with three or four manufacturers duking it out at the front with a fantastic tyre war being fought at the same time. All this at 300kph+ mind you. What more could you want?” [1]
- “The ability to actually see the riders working is a big thing, and also after the race the riders are able to engage with the fans. In F1, the winner might wave and maybe jump off their car, but then it's straight to the scales and then the podium. They don't even celebrate with their team much.” [2]
- “MotoGP races are sprints. No pit stops. Fuel and tires for the full distance. Just ride your ass off and try to save your tires and hope you can hold off the rider behind you.” [2]
- “F1 is a primarily vehicle manufacturers' competition and MotoGP is a riders' competition. The rider is a much greater component of the performance, and the appeal, and to a younger, perhaps more emotional audience, and a larger one, though not a more affluent one. And you can see the rider in his vulnerable entirety, moving around a lot more to influence the trajectory of his little vehicle.” [2]

How Motorsports is watched [3]

- What is the main reason you watch Formula 1?
 - Rivalry and competitiveness between drivers and teams = 42.6%
 - The speed and risks involved = 14.8%
 - To follow one driver or team = 6.3%
 - Technical innovations = 14%
 - Glamour of F1 = 2.7%
 - History and prestige = 14.2%
 - Other = 5.4%
- Which of the following would give you more insight into F1?
 - More interviews with drivers or team personnel over a GP weekend = 14.6%
 - More information about teams' headquarters = 6.7%
 - More social media access = 8.7%
 - Opportunities for fans to access the F1 paddock = 24.5%
 - Better on-screen info graphics = 29.8%
 - Better camera angles (in and out of car) = 15.7%
- When watching a grand prix do you use a second screen to access live timing through the F1 app or formula1.com website?
 - Yes = 21.3%
 - No = 49.8%
 - Sometimes = 28.9%
- How often do you record coverage of sessions and then watch 'as live' at another time of day?
 - Always = 17.1%
 - Sometimes = 52.9%
 - Never = 30%
- If you have access to live TV coverage, how much do you usually watch at home during a GP weekend?
 - Practice, qualifying and the race = 19.4%
 - All sessions plus pre- and post-race discussion = 36.0%
 - Qualifying and the race = 36.7%
 - Just the race = 3.8%
 - Only highlights = 1%
 - No access to live coverage = 3%
- Quantity of GP Broadcast Viewed? [5]
 - Race, Preview and Post = 60%
 - Race: Lights to flag = 31%
 - Race: Start and race end only = 5%
 - Race: Just the start = 2%
 - Race: Until boring = 8%
 - Highlights only = 1%
- Fans Future Viewing Preferences [5]
 - Live Streamed on TV = 77%
 - Live streamed Laptop = 11%
 - Live streamed Mobile/Tablet = 7%
 - Recorded on TV = 2%
 - On Demand on TV = 5%
 - Highlights TV = 1%

MotoGP for new viewers

- “My husband has been a fan forever...but as much as I hate to admit it, it was Rossi's antics and over the top personality that caught my attention. From there, I became more and more interested in the racing and all of the riders.” [1]
- “I started watching MotoGP last summer with my brother and kind of learned and picked everything up in the sport and now watch it every weekend, and it is definitely filling the gap from what I used to enjoy from F1.” [2]
- “Qatar was the first MotoGP race I’ve ever watched, and it was great. I recently started riding a motorcycle, and have never really been into motorsport before. So, I figured, why not check out MotoGP? I’m still learning the terminology, and had to read up a bit on factory and satellite bikes, so I could understand. Also, don’t really understand what the differences between tyres are, but I will learn. At the moment, I am just watching the main race on TV. I will consider getting a package online. As I would like to check out Moto2 and Moto3, along with qualifying... I’m not sure who to barrack for yet, but there seems to be some big personalities which is great.” [4]
- “I just started last year. It’s not hard to pick up but there is a nuance to it you will appreciate as you go on. Moto3 is awesome. They all finish in a line less than a second apart. Moto2 is cool. Watch the practices and the qualifying. Qualifying is often the fastest you will see them go. One perfect lap for pole position. Every track has its own lore and presents a unique problem. Some tracks are known for eating tires, others have tons of rights or left.” [4]

These research findings provided us with the following key insights that helped to direct the design of the MotoGP experience.

- The 2-Immerse MotoGP experience should support watching live MotoGP races in full on the TV, as 90% of viewers already do so for similar motorsports. Further, as 60% currently watch the full race including the preview and post-race analysis, the 2-Immerse MotoGP experience should also support the pre and post-race presentations.
- Many motorsport viewers (50% in one survey) use a second-screen to see live timing information when watching a live race. This highlights a specific need and opportunity for the 2-Immerse prototype to support the provision of synchronised timing information within the MotoGP user experience.
- MotoGP fans typically have a favourite rider which drives their interest and attention in the sport. The 2-Immerse MotoGP experience should provide facilities to recognise a viewer’s favourite rider and provide a customised experience promoting achievements by that rider.
- Customised MotoGP presentations should be provided which align to individual viewer’s experience levels of MotoGP racing. Development of a MotoGP user experience specifically for newcomers would help to demystify terminology (such as differences in tyres), develop knowledge and sustain interest in MotoGP. Further, to accommodate the interests of more experienced fans a specific presentation should be developed. The provision of enhanced race track information would be useful for some viewers.
- The 2-Immerse MotoGP user experience should offer flexibility for viewers to customise the presentation of information on both TV and companion screen devices. This should specifically support customisation of on-screen TV graphics and alternative camera angles.
- Many viewers watch MotoGP together with friends and family. The 2-Immerse MotoGP user experience should therefore look to support multiple viewers watching together and provide a personalised experience multiscreen that accommodates different levels of experience with MotoGP.
- Some viewers have motorcycle themselves and have a strong empathy with the riders.

3.2.6 MotoGP at Home Experience Timeline

In order to provide an optimal MotoGP user experience we needed to understand the current timeline of events that take place during a typical MotoGP. It was important to adopt the current MotoGP broadcast TV narrative provide by the partnership between Dorna and BT Sport. This partnership enables a regionalised broadcast, where Dorna provides coverage via the International Programme Feed (IPF) which is then enhanced by regional broadcasters, such as BT Sport in the UK, who produce further presentation content that encapsulates the main race coverage.

MotoGP events, covered with the Dorna IPF over the UK Silverstone race weekend were;

Friday 25 August	09:00 - 09:40	Racing Moto3 Free Practice 1
	09:55 - 10:40	Racing MotoGP Free Practice 1
	10:55 - 11:40	Racing Moto2 Free Practice 1
	13:10 - 13:50	Racing Moto3 Free Practice 2
	14:05 - 14:50	Racing MotoGP Free Practice 2
	15:05 - 15:50	Racing Moto2 Free Practice 2
Saturday 26 August	09:00 - 09:40	Racing Moto3 Free Practice 3
	09:55 - 10:40	Racing MotoGP Free Practice 3
	10:55 - 11:40	Racing Moto2 Free Practice 3
	12:35 - 13:15	Racing Moto3 Qualifying
	13:30 - 14:00	Racing MotoGP Free Practice 4
	14:10 - 14:25	Racing MotoGP Qualifying 1
	15:05 - 15:50	Racing Moto2 Qualifying
Sunday 27 August	09:40 - 10:00	Racing Moto3 Warm Up
	10:10 - 10:30	Racing Moto2 Warm Up
	10:40 - 11:00	Racing MotoGP Warm Up
	12:15 – tbc	Racing Moto3 Race (17 laps)
	13:40 – tbc	Racing Moto2 Race (18 laps)
	15:30 – tbc	Racing MotoGP Race (20 Laps)

BT Sport Broadcast Schedule covered the following;

Friday 25 August	9am-4pm,	BT Sport 2: FP1 & FP2 – Live
Saturday 26 August	9am-4.15pm,	BT Sport 2: FP3, FP4 and Qualifying – Live
Sunday 27 August	9.45am-11.30am,	BT Sport 2: Warm-ups – Live
	11.50pm-13:30pm,	BT Sport 2: Moto3 Race – Live
	13:30pm-3.00pm,	BT Sport 2: Moto2 Race – Live
	3.00pm-4.30pm,	BT Sport 2: MotoGP Race – Live (Trial Content)
	4.30pm-5.30pm,	BT Sport 2: MotoGP Chequered Flag – Live

For the MotoGP trial we decided to focus on the most popular MotoGP race. This would include the MotoGP race coverage produced by Dorna and the pre and post-race presentations produced by BT

Sport. The trial would fundamentally replicate the 15:00 to 16:40 coverage broadcast on BT Sport 2 on Sunday 27th August.

From the Silverstone MotoGP video material provided to us from both Dorna and BT Sport (North One Productions) we created a hybrid video (mixture of ‘dirty’ and ‘clean’ feeds) of approximately 1 hour 20 minutes in length which will be used in the MotoGP trial. We then mapped key user experience activities against these segments to help us define when to switch chapters used within the multiscreen trial.

Users are prompted to change chapter approximately 60 seconds and 30 seconds before the start of the next chapter. Changing chapter within the companion screen applications could be automated, but we wanted the user to change chapter manually (at least in the initial stages of the trial), so the user was more in control and was therefore better engaged in the multi-screen interactive experience.

Inside MotoGP Chapter provides access to a tutorial video and additional supporting videos that introduce the Silverstone race circuit, show interviews with key riders and showcase some of the technical aspects of the bikes.

Watch Live Chapter supports the primary capabilities of scalable and personalised graphics on the TV with the companion application providing a ‘Leaderboard Panel’ with interactive rider cards a ‘View Panel’ which controls the presentation of alternative cameras and timing data in a mosaic layout, and an ‘Event Panel’ which presents a timeline of key events that can be replayed.

Race Review Chapter provides access to multiscreen replay facility that enables users to review the race events and watch selected replays presented across both the TV and companion screen.

We also developed wireframes for a Set Up chapter which outlines a process for new users to set-up a user profile. Since developing the wireframes, we decided not to implement the Set Up Chapter in preference of provided viewer prompts during the broadcast to change predefined default settings. Wireframes for that and other Chapters can be found in Annex E.

Timecode	Duration	Programme Content	User Activities	Chapters
			On-boarding to set-up devices / network and launch MotoGP	
00:00:00 00:01:19	01:19	MotoGP Introduction	Watch TV	Inside MotoGP
00:01:19 00:04:39	03:30	Presenter discussion on riders and forthcoming MotoGP race	Watch tutorial video on CS	Inside MotoGP
00:04:39 00:16:24	11:45	Grid walk and rider interviews	Watch other videos of interest on CS	Inside MotoGP
00:16:24 00:17:50	01:26	BT Sport race commentary starts	Prompt to select a Favourite Rider	Watch Live
00:17:50 00:20:40	02:50	Warm-up lap	Prompt to select an Experience Level	Watch Live
00:20:40 01:01:26	40:46	Race start to finish line (clean video with on-screen graphics and replays removed)	Prompt to select the preferred TV Gfx scale General interaction	Watch Live

Timecode	Duration	Programme Content	User Activities	Chapters
01:01:26 01:05:10	03:44	Winner Lap and highlights	Watch TV	Race Review
01:05:10 01:17:34	12:24	Parc Ferme and rider / team interviews	Watch replays on TV and CS	Race Review
01:17:34 01:21:24	03:50	Podium	Watch replays on TV and CS	Race Review
01:21:24 01:21:47	00:23	Closing presentation	Watch TV	Race Review

3.2.7 User Experience Key Capabilities

Through a combination of analysis of similar motorsport broadcast and application features, discussions with Dorna, BT Sport and North One Productions, and early design ideas followed by UX design workshops we created a list of key features and capabilities that were considered useful for the MotoGP use to support. These 'key capabilities' were socialised amongst the wider project team and presented to stakeholders for review and comment.

Following this process we then prioritised the key platform capabilities we intended to develop and test in the MotoGP trial. We categorised these capabilities as Essential, Important and Ancillary in order that we focus our attention on the highest priority capabilities first.

Essential

- Multiple video streams are synchronised across a TV screen and multiple companion screen devices within the same local.
- Multiple video streams can be viewed on TV screen as PiPs and on companion screens as a mosaic view.
- User can change video streams shown on TV and CS including PiPs via CS interface.
- TV graphics are rendered over clean video feed supporting personalised presentation.
- Seamless switching between 'clean' video and 'dirty' video with composited graphics.
- TV graphics are data driven from Dorna timing and event data.
- Layout - 'Responsive' layout of components and on-screen graphics presentation on TV and CS (layout A, B, C roughly equivalent to 32", 50" and 65" TV)
- Personalisation - Experience Levels (Spectacle Mode for Novice and Analysis Mode for Experts) with different layouts and TV graphics content such as leader board presentation.
- On-boarding (device set-up, user sign-in, etc.) and tutorials are supported within the trial experience.

Important

- Interactive timeline navigation and event markers with sync across all linked screens.
- 360 video control - PiP on TV with Field of View (FoV) mirrored from CS control.
- Continuous 'Live' feature – Replays and slow-motion cutaways from live in broadcast feed automatically spawn a PiP which shows continuous live race action.
- Leader board that shows distance between riders
- Supporting media available to explore – rider and team profiles, track information, prior race information. etc.

- Chapters that define the programme narrative and change what interactions can be performed by the user.

Ancillary

- User event bookmarking facility for interactive timeline
- Interactive ‘touch’ TV graphics when presented on the CC
- Number of (%) viewers watching OB feeds indicating popularity
- Participation – Play-along games, voting, etc.
- Social integration – Synchronised twitter feed.

In parallel to the technical development of these capabilities, the UX team developed wireframe designs that described how these capabilities would be presented to the user. The following section outlines the most recently developed user experience.

3.3 Screen Layouts

Early concepts through to later wireframe designs have all been developed with a multiscreen experience in mind. The effectiveness of the multiscreen layout will be assessed through analysis of the use logs and through the trial questionnaire.

The following section outlines what has been developed for the MotoGP trial. Earlier user experience concept ideas have been provided in Annex D. These include ideas explored in some of the earlier UX design workshops held in London with BBC, BT and Cisco.

3.3.1 TV Screen Layout

Our starting point was to analyse how Dorna and BT Sport currently present MotoGP in the UK. We studied a number of races to understand how different graphics are used and regions they occupy on the TV screen. We further looked into the pre and post-race presentation created by North One Productions for BT Sport.

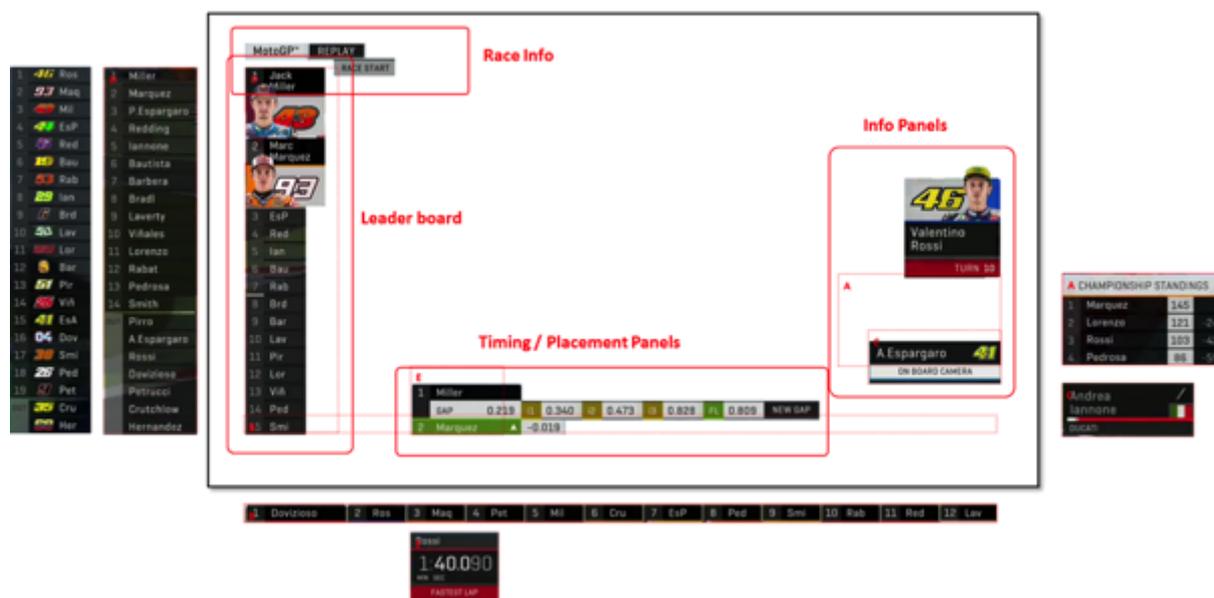


Fig 8: MotoGP TV Graphic Regions

We undertook a series of early technical tests exploring if we could replicate the look and feel of the MotoGP graphics using Adobe Animate which exported HTML / JavaScript files. We developed a 'visual demonstrator' which enabled us to get feedback on our early work from Dorna and BT Sport. These tests confirmed that we could create graphics that were a good facsimile of those current used by Dorna and that we could control them via a web based production tool.



Fig 9: MotoGP Visual Demonstrator

We further developed the visual demonstrator adding features such as data input driven leaderboard, scaling layout and graphics, data input to graphics and multiple PiP overlays. We also tested 360 degree video playback and control successfully. The visual demonstrator was shown at a number of quarterly project 'all-hand' meetings to gain input and feedback from the wider project team.

Dorna provided video, image, audio and data assets from the British Silverstone MotoGP race which they agreed the project could use for research and trial purposes.

We analysed which graphics were used within the Silverstone race, then developed replica Adobe Animate graphics which could be used in the MotoGP prototype trial experience. These assets were exported as HTML, JavaScript and PNG assets. Simple code within the Adobe Animate file enabled external control of animations, vector based graphics colours, replacement of text and images.



Fig 10: TV Graphics recreated in Adobe Animate and exported as HTML, JavaScript and .PNG assets

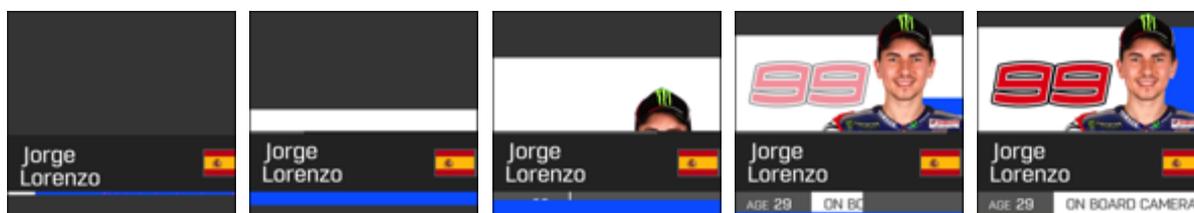


Fig 11: Animation timeline for Lorenzo On-board Camera graphic from hidden to fully open.

The prototype broadly replicates the existing layout and graphics created by Dorna. The following list outlines the key changes that were adopted so we could exploit new capabilities of the platform.

- Leaderboard was changed to support responsive scaling with the ability to represent time/distance between riders.
- PiPs were developed to explore the impact of multiple video streams and responsive layouts.
- New layouts were adopted for 32", 50" and 65" sized TVs.
- Some leaderboard graphics were not developed as the information was available on the companion screen app. These included rider pictures and on-board camera streams.
- Full-screen replay transition graphic was developed to hide changes in video and graphics and provide consistency between broadcaster actioned and viewer action replays.

3.3.2 Companion Screen Layout for Smartphones and Tablets

The MotoGP experience needed to accommodate both tablets and smartphones as potential companion devices. Furthermore, the trail has been designed around two or more people in a household experiencing the prototype MotoGP service using both a tablet and smartphone device.

A simplified 'Main Menu' is provided on tablets and phones which enable the user to access chapters and configure key settings. The following controls are provided.

- Change Chapter – Inside MotoGP, Watch Live and Race Review
- TV Graphics scale – Large, Medium and Small
- TV Presentation – Novice, Fan, Standard
- TV Audio Balance – Ambient and Commentary volume
- Tablet Presentation - More Video, Mixed Video and Analysis, More Analysis
- Favourite Rider – Select from a list of riders

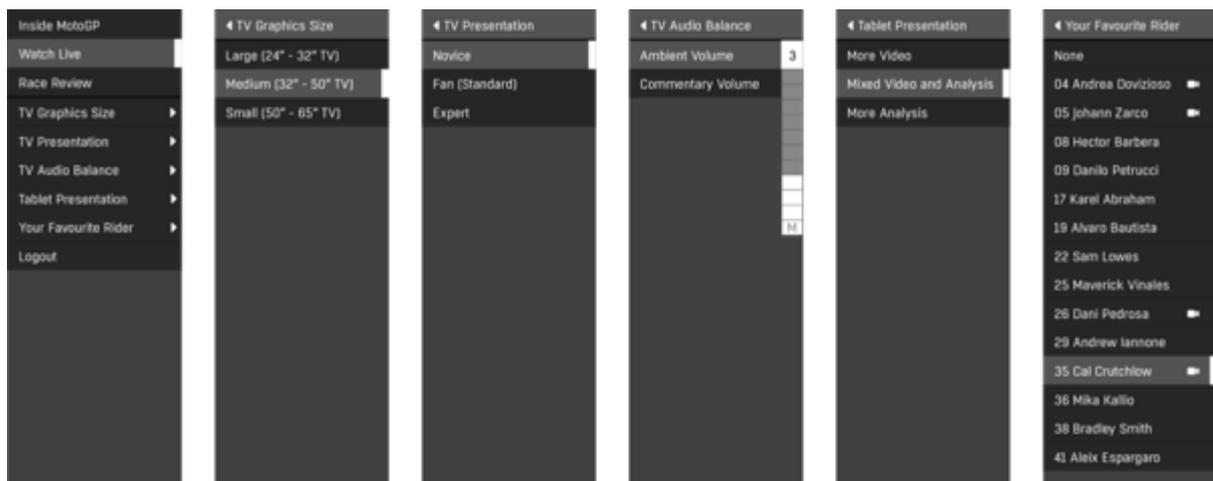


Fig 12: Main Menu

The MotoGP experience has been divided into 3 key Chapters which align to pre-race (Inside MotoGP), race (Watch Live) and post-race (Race Review) activities. Each Chapter has its own layout and specific modes of interaction.

Set Up Chapter

We developed wireframes for a Set Up chapter which outlines a process for new users to set-up a user profile. However, we decided not to implement this facility for the trial in favour of a 'prompt facility' which can be used by the broadcaster or content creator to direct the viewer towards an interaction, such as setting the Experience Level or Screen Graphic scale. Prompts and associated alerts can be presented on both the TV and companion screen device to encourage and help facilitate interaction.

Inside MotoGP Chapter

Inside MotoGP provides access to a variety of short-form VoD materials which includes GUIDE videos, CATCHUP videos that introduce the Silverstone race circuit and interviews with key riders and TECHNICAL videos that outline the technical aspects of the bikes.

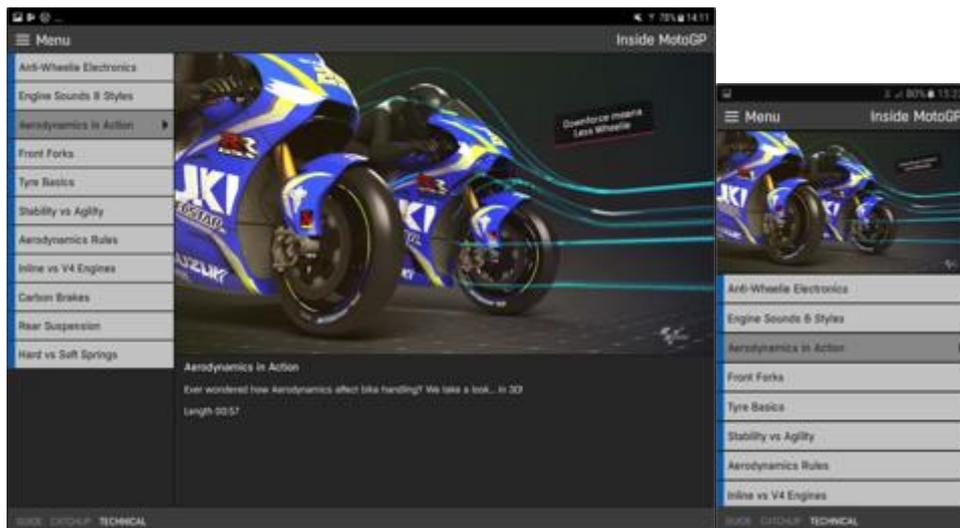


Fig 13: Tablet and Phone User Interface for Inside MotoGP

Watch Live Chapter

Watch Live provides a ‘Leaderboard Panel’ with interactive rider cards, an ‘Event Panel’ which presents a timeline of key events that can be replayed and a ‘View Panel’ which controls the presentation of alternative cameras and timing data in a mosaic layout.

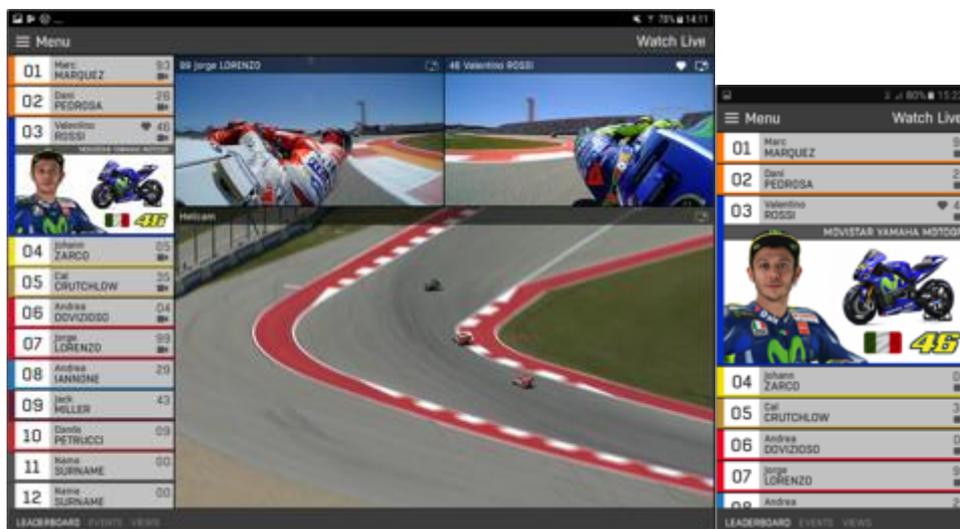


Fig 14: Tablet and Phone User Interface for Watch Live

Race Review Chapter

Race Review provides access to multiscreen replay facility that enables users to review the race events and watch selected replays presented on the companion screen device. We explored providing facilities that enable related replay event clips to also play on the TV, but as this functionality was already provided in Watch Live, we felt it beneficial to trial different functionality in

Race Review. Playback on the companion device also better suited the TV programme narrative, which focused on post-race replays and analysis.

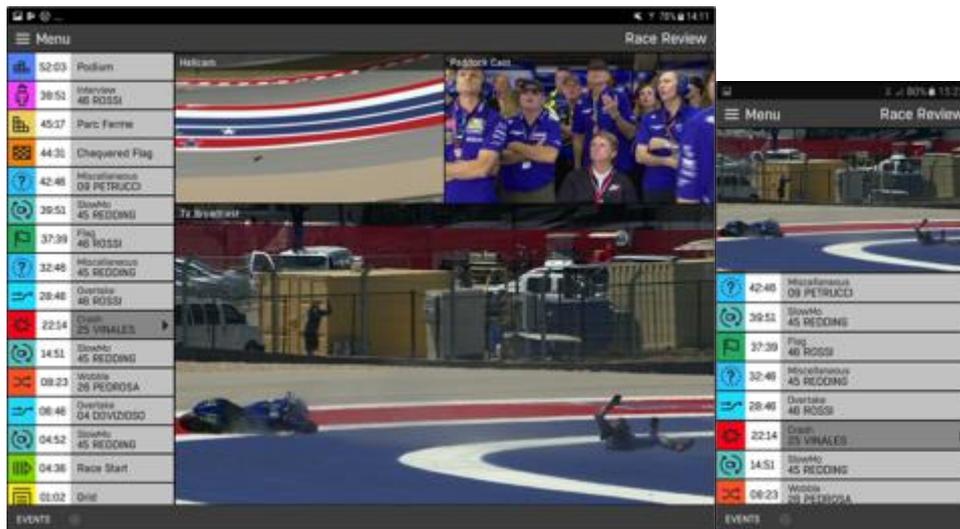


Fig 15: Tablet and Phone User Interface for Race Review

A complete wireframes for MotoGP Set Up, Inside MotoGP, Watch Live and the Race Review chapters described above can be found in Annex E.

3.4 Key Capabilities, Components and Features

This section outlines key platform capabilities, components and features included in the MotoGP experience.

3.4.1 Layered Graphic Presentation

Key to leveraging the flexibility offer by object based broadcasting is the creation of separate HTML5 graphic components which can be dynamically layered over a 'clean' primary video feed on the client device. Layered graphic presentations can closely replicate the look and feel of today's composited sports presentations which typically burn-in the graphics to the video before they leave the outside broadcast truck.

Layered presentation (1 is the top most layer).

1. MotoGP Brand graphics (BT Sport and MotoGP logs)
2. Replay transition animated graphic
3. PiP Videos
4. TV Graphics (Leaderboard, Information, Timing, etc.)
5. Clean Video

A layered approach enables the presentation to be personalised to suit each viewer, such as showing a favourite rider as a PiP or scaling the graphics to match the size of TV. Furthermore, the visual quality of final layered presentation tends to be crisper than the more traditional composited approach.

3.4.2 Multiple Camera Streams

A key capability required for the MotoGP use case is the synchronised presentation of video across multiple display screens. Dorna use over 160 cameras during a live broadcast of MotoGP and typically offer 12 video feeds to broadcasters for use within their own TV programmes and Apps. All motorcycles within MotoGP have 4 cameras which can be remotely activated by the production crew. However, Dorna are currently restricted to streaming eight concurrent video from the bikes.

These feeds comprise of:

- 1 x International Programme Feed (IPF)
- 8 x on-board camera feeds (the maximum number Dorna can currently stream live from bikes)
- 1 x Helicam Feed
- 1 x Tracking Feed
- 1 x Timing Feed
- 1 x 360 degree feed from 1 motorcycle

Within the MotoGP use case we want to offer the viewer full access to watch any of the available feeds. We're also keen to support the presentation of multiple concurrent videos on the companion screen in a mosaic format and on the TV as picture in pictures.

However, it's currently unclear if a user could really follow the race narrative across such a large number of videos playing on two or more devices. Also, depending on the size and resolution of screens it's also unclear if the video windows could show the video large enough.

There are further challenges to overcome in providing sufficiently good quality video streams. Bandwidth requirements for streaming such a large number of concurrent videos in HD would likely require specific content delivery optimisation schemas that manage the availability of streams to a viewer with respect to their available bandwidth.

Current MotoGP wireframe designs enable a viewer to select which content streams they want to watch. This information is then passed onto the layout engine to best decide on which device to show which video.



Fig 16: Early MotoGP concept for synchronised multiscreen video and data presentation.

3.4.3 360 Degree Video

Since late 2016 Dorna have been experimenting with the capture and delivery of 360 degree video as part of their future MotoGP offering. In 2017 they provided viewers access to a live 360 degree camera feed (MotoGP 05 Zarco) via their website.

We wanted to integrate 360 video into the MotoGP use case as it enabled us to showcase a useful multiscreen facility, where 360 video could be watched on the TV with the viewpoint being controlled from the companion screen app. We had seen evidence of others exploring this concept at IBC 2106 where both Opera TV (now Vewd) and Push-Pull TV showcased a similar capability.



Fig 17: Early MotoGP concept for controlling 360 video viewpoint using companion screen.

The effectiveness of the 360 degree video capability will be assessed through both analysis of the interaction logs and through the trial questionnaire.

3.4.3.1 VIEWS Panel

The VIEWS panel enables the user to select which supplementary media feeds they want to see while watching the race. Media feeds include the on-board video feeds, helicam video feed, timing data and tracking map.

Our early concepts for controlling the layout of supplementary media feeds closely echoed the approach adopted by Dorna's VideoPass application which asked viewers to first choose a predefined matrix layout, which was then manually populated using 'drag n drop' from a palette of available media feeds. This approach was further enhanced by enabling the viewer to choose which media thow within two PiPs on the TV, as can be seen in the concept UI below.



Fig 18: Early MotoGP concept for configuring companion video mosaics and TV PiP video placement.

Although the above approach was robust, it made selection and placement of feeds on TV and companion screen potentially long winded and onerous for the user. We also felt that it could cause confusion for the user if certain media feeds had to be dropped due to the user changing the TV Graphics Scale or User Experience Level, which fundamentally alters the space available for graphics on the TV screen.

We explored further approaches which enabled the user to direct where they wanted specific media feeds to appear, but these again appeared overly complex.

We then considered if the Layout Engine could be used to help remove this perceived complexity from the user. We developed a UI concept where the user simply states which media they wanted to watch and the layout engine decided how to show it and where best to place it. This approach also enabled the content producers to better define the optimal viewing experience for the user.

The VIEWS panel shows all the available media streams. On-board cameras are identified with the rider's name, number and team colour bar. Visible streams are marked as darker grey. The user's selected favourite rider is marked with a heart icon.

All streams are video except Timing Data, which is a live data stream updated throughout the race.



Fig 19: VIEW Panel shown within the MotoGP tablet app with six view mosaic.

The current MotoGP prototype that will be trialled uses the following layout rules to control multi-camera video, in order to keep the experience as simple as possible and prevent potential conflicts between devices.

- PiPs on the TV during the ‘as live’ race by default will show the favourite riders selected on each device (as indicated by a heart symbol).
- Each companion tablet device will show by default the following video streams:
 - The on-board camera feed of the favourite rider selected on that device.
 - The Helicam video feed.
 - The timing data feed.
- Companion phone device does not have a facility to shown video streams on the VIEW panel. These facilities are available in the LEADERBOARD panel.
- Users can change which video is shown on the TV by tapping on the video and selecting to ‘cast TV PiP’ or to ‘stop TV PiP cast’. A simplified user flow for ‘TV PiP casting’ from companion screen to TV is shown below.

Top row shows - video not TV PiP cast > user selects to cast > video cast as TV PiP.
 Bottom row shows – video cast as TV PiP > user selects to not cast > video not cast as TV PiP.

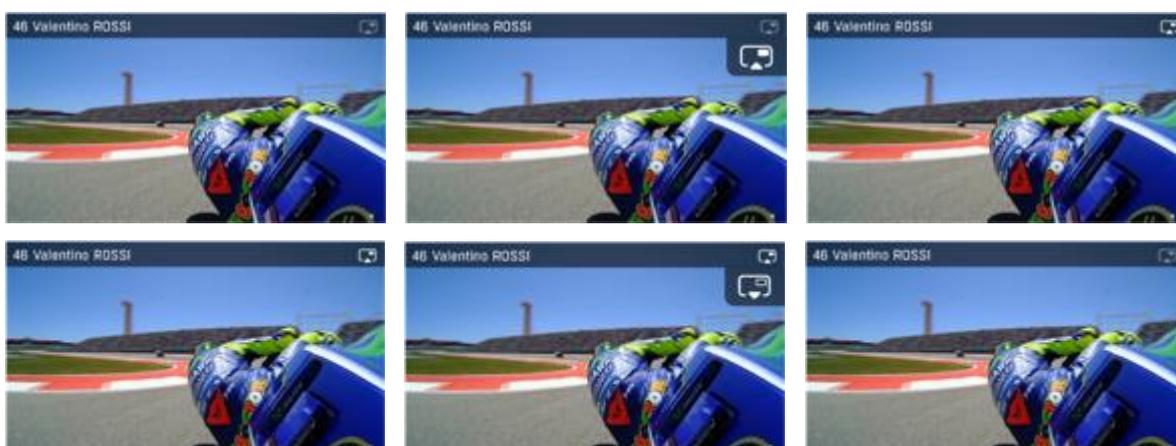


Fig 20: PiP Cast icons on companion screen interface.

The effectiveness of controlling media layout across multiple screen will be assessed through both analysis of the use logs and through the trial questionnaire.

The provision and use of multiple synchronised media streams is so key to the MotoGP experience that it warrants special investigation within the trial. The questionnaire and platform instrumentation will be used to support our investigation into the following questions.

- Are multiple cameras useful and do they enhance the overall MotoGP experience?
- Which media streams are most popular?
- Does the user gain anything from still seeing the race live when the broadcaster cuts away to show replays?
- Does the use of the layout engine help users, or would they prefer more control to define where media streams are placed?
- Communal voting on camera choices or using automated data from tracking or virtual crowds could highlight popular camera choices.
- What third-party alternative media streams could be supported beyond that provide by the producer and broadcaster? Such media could include alternative commentaries from YouTubers or regional pundits.

3.4.4 Multi-channel audio selection

Within the MotoGP prototype we have provide a facility for users to alter the presentation of audio on the TV. We have two independent audio streams; Ambient which contains general background noise from the venue and Commentary which is provided by BT Sport commentators Keith Heuwen and Julien Ryder. This will give viewers the option to change the volume of each stream independently, enabling them to mute the commentary or reduce the ambient background sound as they see fit.

This facility is provided in the main Menu under 'TV Audio Balance'.

The effectiveness of audio balance control will be assessed through both analysis of the use logs and through the trial questionnaire.

3.4.5 Responsive TV layout

Object based broadcasting requires key content elements to be provided as discrete media objects. This offers TV producers and broadcaster an unprecedented level of flexibility in dynamically reconfiguring how content is presented based on the screen size, resolution and orientation of the display device.

There are significant benefits to be had in adopting a responsive approach to the presentation of on-screen TV graphics. For larger screen TVs graphics can be reduced in size and repositioned to either make space for new on-screen features or to simply give more space to showcase the race action.

In the MotoGP use case, we're using responsive presentation with a number of key components including; leaderboard, Picture in Picture (PiP) videos, information and timing on-screen graphic. As the size of TV increases we similarly reduce the size of graphics by the same amount, resulting in them physically (as they appear on-screen) remaining the same size.



Fig 21: Early concept of responsive TV layouts optimised for 32”and 65” TVs

We adopted 3 ranges of TV size for simplicity and designed new on-screen graphics layouts for 24”- 32” TVs, 32”- 50” TVs and 50”- 65” TVs. However, although we looked to optimise the layout and scale of graphics relative to the size of TV, we believe viewers will adopt a scale which is suited to their personal preference i.e. if they suffer from poor eyesight a larger scale may be preferable. It’s for this reason the feature is described as ‘TV Graphics Size’ with the options of Large, Medium and Small, with only a side reference to the optimal TV screen size.

We redesigned the leaderboard graphic so that it could visually represent the distance/time between individual riders as dynamically variable gaps driven by live timing data from Dorna. The PiP videos, information and split timing graphics are scaled and repositioned.

The facility to change the size of TV rendered graphics is provided in the main Menu under ‘TV Graphics Size’.



Fig 22: Responsive TV Expert Mode layout optimised for 32” , 50” and 65” TVs

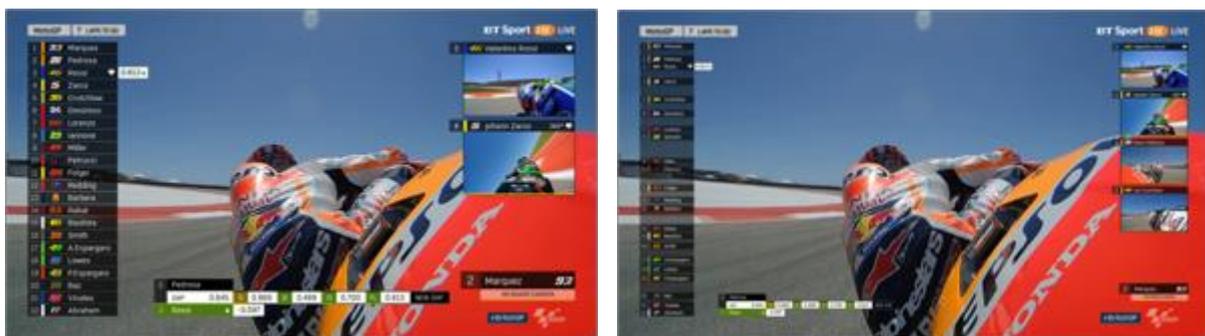


Fig 23: Responsive TV Novice Mode layout optimised for 32”and 65” TVs

The effectiveness of providing a responsive TV presentation will be assessed through both analysis of the use logs and through the trial questionnaire. We will also look to gain further feedback from Dorna and BT Sport as their view of the value it brings to sports broadcasting.

3.4.6 Leaderboard Panel

Leaderboards are an essential part of any motorsport. Within MotoGP the leaderboard provides real-time information on a rider's position within a race in addition to timing information such as fastest lap and time gap between two riders, it can also show a rider picture of the rider (including bike number, tyre configuration and nationality) and on-bike camera video feed.

The TV leaderboard has a number of presentation styles which the director regularly swaps between during a race, in order to meet the needs of the broadest range viewers from newcomers through to seasoned veterans.

We have redesigned the TV leaderboard to enhance its core feature (rider position indicator) and simplify its use by providing a supplementary leaderboard on companion displays which can be interacted with by the user. Touching on a rider expands

The Leaderboard Panel used on both the phone and tablet companion apps provided the user with real-time information on the position of riders during the race. It also provides access to further rider specific information covering rider profile, on-board camera, timing and tyres. Touching the tab causes it to expand and reveal the cards on a carousel which can be seen by swiping left or right.

The heart icon indicates the user's choice of favourite rider. The camera icon indicates which riders currently have on-board cameras that are active.

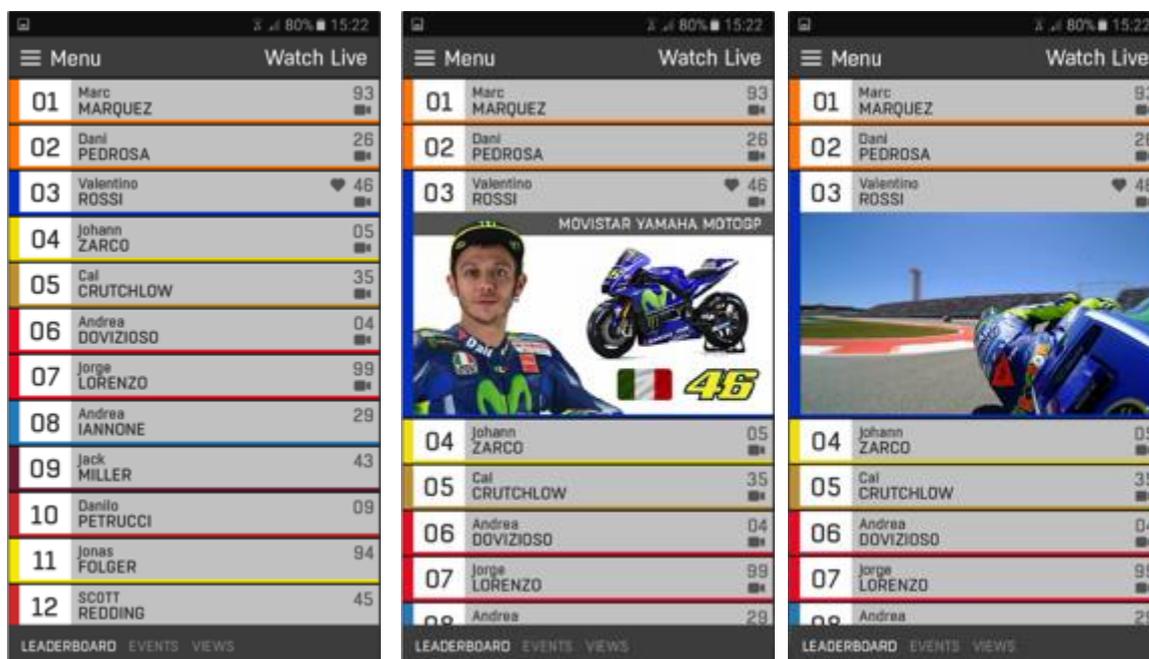


Fig 24: Leaderboard on a Smartphone

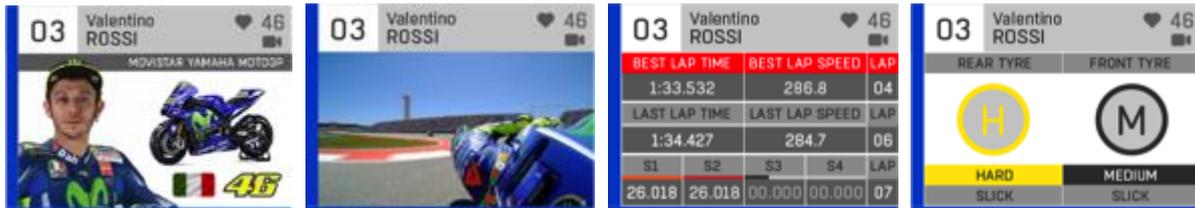


Fig 25: Leaderboard Cards for 46 ROSSI

Rider Profile Card shows a picture of the rider and their bike, the rider graphic number, nationality and team name. It was designed to provide novice users with an easy way to develop their ground knowledge of riders and their bikes.

On-board Camera Card provides access to the on-board cameras from typically 8 riders during the race. A small camera icon is shown for riders that have active cameras. This was included to offer smartphone users a simple way of watching additional cameras. For novice users it also closely linked together the rider's identify (via Rider Profile Card) with the camera feed.

Timing Card shows timing information for that specific rider which includes; fastest lap time, fastest speed, last lap time, last lap speed and the sector timings for the current lap. This was primarily provide for expert viewers, who may be more interested in timing statistics. The format and colours used have been adopted from Dorna's current online style guide to preserve consistency with the TV graphics.

Tyres Card provides information of the rider's current tyre configuration. This is driven from Dorna metadata contained in their timing streams.

Additional Cards could be provided from third parties. Such cards could provide access to merchandising, links to additional rider information, social media, fan clubs, gaming, etc.

The effectiveness of this capability will be assessed through both analysis of the interaction logs and through the trial questionnaire.

3.4.7 Events Panel and Timeline Navigation

Dorna provide facilities for viewers (MotoGP VideoPass subscribers) to navigate the race timeline via their App and website using an interactive scrub-bar and drop-down highlights menu. We wanted to replicate and enhance the highlights facility within our prototype.

We proposed that an events panel should be provided which enables users to easily navigate race highlights through the selection of key events that were identified by the programme producers during the broadcast. This takes the form of a social media feed which is temporally updated. Each event is identified by an event type (such as Crash, Flag, Overtake, etc.), race timecode and name (such as Rider name, Race Start, Parc Ferme, etc.). We also proposed a facility for viewers to bookmark their own events for later reference and replay.

Although the events panel is accessible both during (Watch Live chapter) and after the race (Race Review chapter) we wanted to change how videos are replayed depending on the current chapter. During the live race (Watch Live), replays will be shown on the user's companion screen device. After the race (Race Review), replays can be replayed across multiple screens; where the main programme feed is shown on the TV and additional synchronised camera view that help to show the event are played on the companion screen.



Fig 26: Early MotoGP concept for interactive scrub bar on TV and companion screen device.

Early design concepts explored the possibility of a timeline control capability which would enable viewers to scrub back through video and replay previously bookmarked events. This included events which were colour coded to indicate crash, overtake, etc. We also suggested that the tracking bar could be displayed on both the TV and CS to support better shared multi-viewer control.

However, after developing our design thinking further we decided to abandon this approach in preference of a vertical ‘twitter’ chronological event list which would be simpler to navigate to access available event replays. Background research on the use of timelines, using use cases such as BBC LIVE, can be found in Annex D.

We did explore providing a facility for user generated event bookmarks, which would enable viewers to replay their own favourite events within the programme. But we decided not to implement that feature for the MotoGP trial. We imagined the facility would create an event using a single ‘bookmark timecode’ which was then extended before and after to encapsulate the actual event. Categorising the event would define how much time before and after the bookmark was provided in the clip.

Events are categorised and have a timecode to indicate when they occurred in the race. The following defines an extended set of event categories based on the categories Dorna currently use.

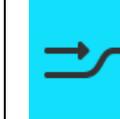
					
Interview	Crash	Flag	Wobble	Curious	Overtake
					
Parc Ferme	Race Start	Chequered Flag	Grid	Podium	Slow Motion

Fig 27: EVENT categories used in companion screen events panel.



TIME	EVENT	RIDER	LAP	TIME	SPEED
52:03	Podium	93 MARQUEZ	04	1:00.000	000.0
39:51	Interview 46 ROSSI	46 ROSSI	06	1:00.000	000.0
45:17	Parc Ferme	93 MARQUEZ	04	1:00.000	000.0
44:31	Chequered Flag	46 ROSSI	07	1:00.000	000.0
42:46	Miscellaneous 09 PETRUCCI	09 PETRUCCI	07	1:00.000	000.0
39:51	SlowMo 45 REDDING	45 REDDING	07	1:00.000	000.0
37:39	Flag 46 ROSSI	46 ROSSI	07	1:00.000	000.0
32:46	Miscellaneous 45 REDDING	45 REDDING	07	1:00.000	000.0
28:46	Overtake 46 ROSSI	46 ROSSI	07	1:00.000	000.0
22:14	Crash 25 VINALES	25 VINALES	07	1:00.000	000.0
14:51	SlowMo 45 REDDING	45 REDDING	07	1:00.000	000.0
08:23	Wobble 26 PEDROSA	26 PEDROSA	07	1:00.000	000.0
06:46	Overtake 04 DOVIZIOSO	04 DOVIZIOSO	07	1:00.000	000.0
04:52	SlowMo 45 REDDING	45 REDDING	07	1:00.000	000.0
04:36	Race Start	25 VINALES	07	1:00.000	000.0
01:02	Grid	37 ABRAHAM	07	1:00.000	000.0

Fig 28: EVENT Panel shown within the MotoGP tablet app with single screen view of timing data.

The effectiveness of this capability will be assessed through both analysis of the interaction logs and through the trial questionnaire.

3.4.8 Event Replays

We wanted to offer viewers the ability to watch replay events as soon as they became available during the live race. We also saw great value in providing this facility after the race had finished.

There are three distinct types of replay used within the MotoGP experience;

- Broadcaster initiated replay during Watch Live (during the race)
- Viewer initiated replay during Watch Live (during the race)
- Viewer initiated replay during Race Review (after the race)

Viewer initiated replays are automatically cast to the TV. To help viewers distinguish replays from live race action, a two second transition animation is used preceding and tailing the replay clip. On-screen graphics also indicate that the viewer is now watching a replay.



Broadcaster initiated replay during Watch Live

We've replicated Dorna's standard replay functionality so we can ensure visual consistency across broadcaster and viewer actioned replays. Within the trial all broadcaster initiated replays will be orchestrated using a pre-scripted timeline document served from the Timeline Service which controls

when replays should start and what content should be shown. When replays are shown on the TV, the companion screen continues to show the live race action.

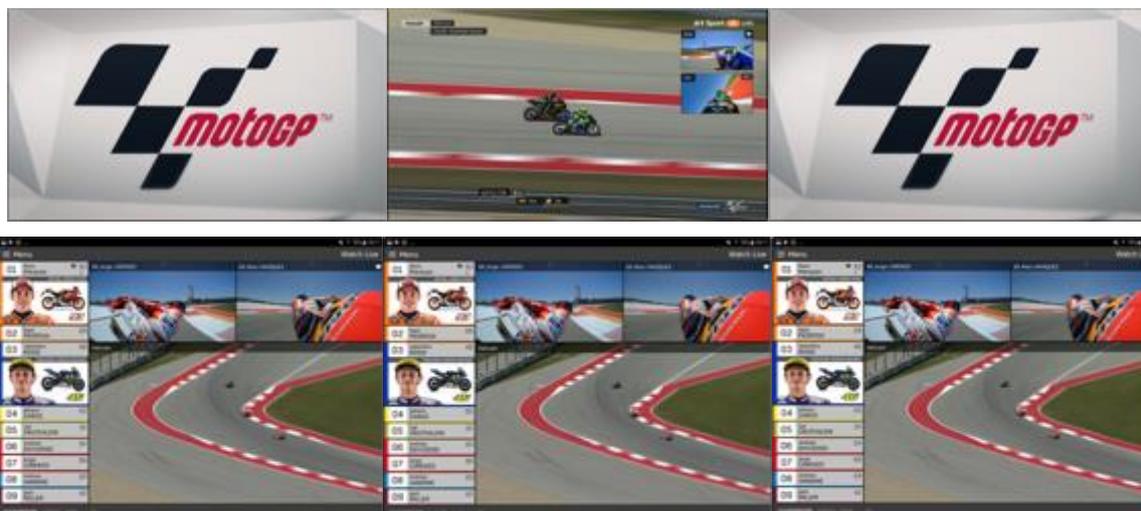


Fig 29: Broadcaster initiated replay storyboard during Watch Live from left to right. TV (top) Tablet (bottom).

Viewer initiated replay during Watch Live

A key feature of this facility was to provide a continuous view of the live ongoing race during the replay. When a replay is initiated by a viewer via their companion screen app, a Picture in Picture is automatically added into the replay so that a continuous view of the race is shown, meaning that none of live action is missed. When replays are shown on the TV, the companion screen will show alternative camera angles if available that complement the primary replay clip.

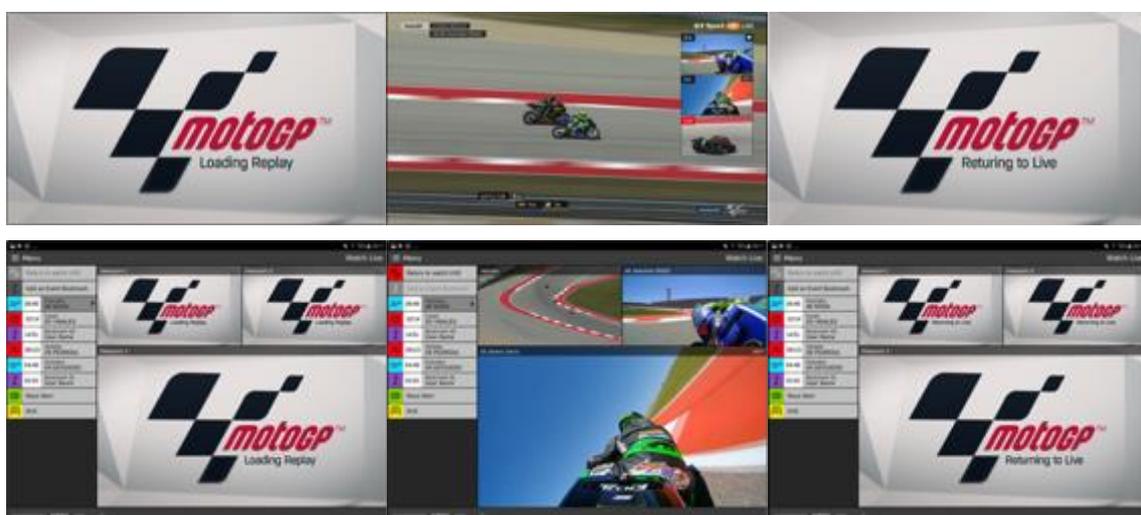


Fig 30: Viewer initiated replay during Watch Live storyboard from left to right. TV (top) Tablet (bottom).

Viewer initiated replay during Race Review

Within the Race Review chapter the companion screen App shows the EVENTS panel. When a replay is initiated by a viewer, the replay is presented on their companion screen app and the TV continues to show an uninterrupted live broadcast. The companion screen will show alternative camera angles if available that complement the primary replay clip.

The effectiveness of the event replay facility will be assessed through both analysis of the interaction logs and through the trial questionnaire.

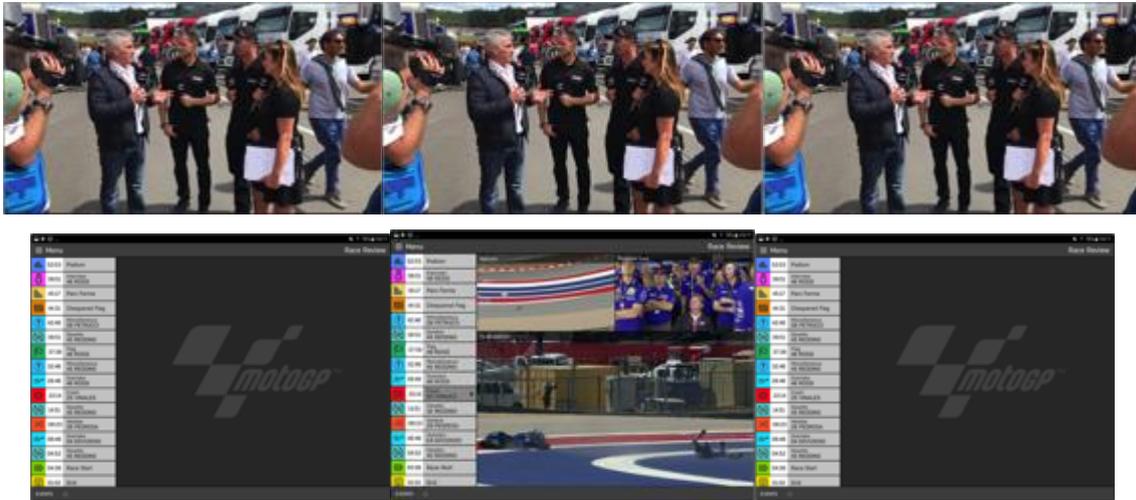


Fig 31: Viewer initiated replay during Race Review storyboard from left to right. TV (top) Tablet (bottom).

3.4.9 User Profiles and User Experience Level

In our earliest concepts we wanted to use the flexibility offered by adopting an Object Based Broadcasting approach to personalise the presentation of MotoGP with respect to the level of experience a viewer had with the sport.

Dorna attempts to cater for their viewer's different level of experience, by changing the presentation of graphics during a race. This is most evident in the ever changing presentation of the leaderboard which adopts 3 styles; a) position number and three letter rider short name, b) position number, graphic rider number and three letter rider short name, and c) position number, graphic rider number and rider long name.

We have designed the MotoGP experience around three distinct viewer experience levels which map to differing styles of race presentation across TV and companion screen application.

Novice - Viewers that are unfamiliar with MotoGP are provided with a presentation that focuses on the spectacle of the event. TV graphics are descriptive and offer full rider names on the Leaderboard and PiPs in addition to rider graphic numbers and team colours. The default companion screen presentation focuses on providing additional video feeds and introductory information on the riders including photo of the rider, nationality, bike, number and manufactures team.

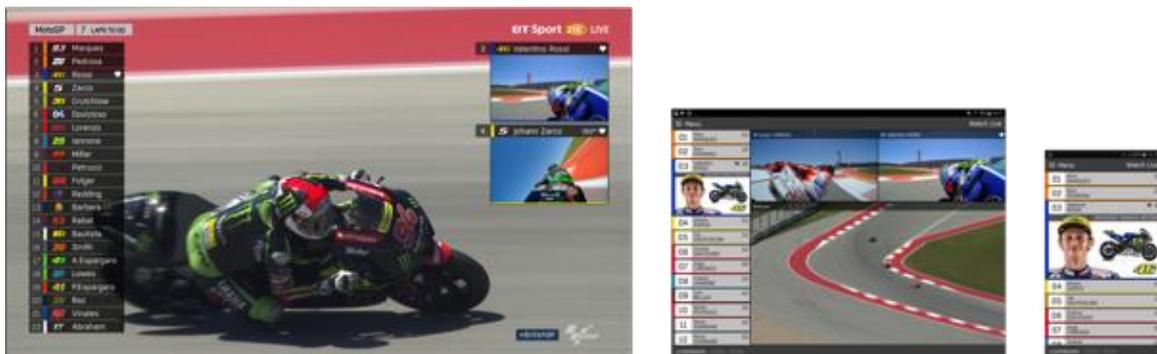


Fig 32: Default Novice Layout Presentation across TV, Tablet and Smartphone.

Fan – Semi-regular MotoGP viewers who are familiar with MotoGP are provided with a presentation that is balanced between spectacle and analysis. The companion screen app shows by default additional camera feeds and timing data. The leaderboard shown on the TV closely echoes the standard format used throughout normal MotoGP coverage i.e. position number, graphical rider number, and abbreviated rider name.

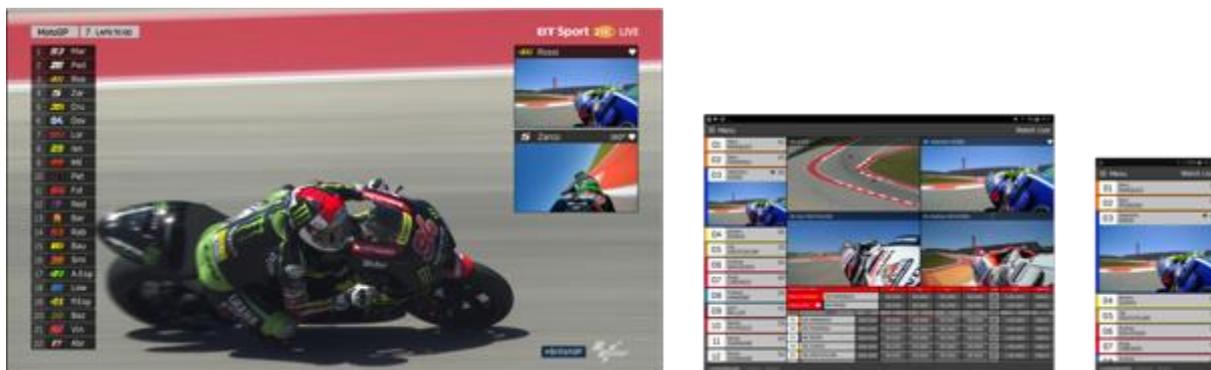


Fig 33: Default Fan Layout Presentation across TV, Tablet and Smartphone.

Expert – Regular MotoGP viewers who are interested in the stats and statistics of the sport are provided with a timing and data centric presentation on the companion screen device which compliments the TV presentation. TV graphics are kept to a minimum with the leaderboard showing just the position number and the abbreviated three letter rider name. The size of PiPs are also minimised so more PiPs could be shown on the TV if desired.

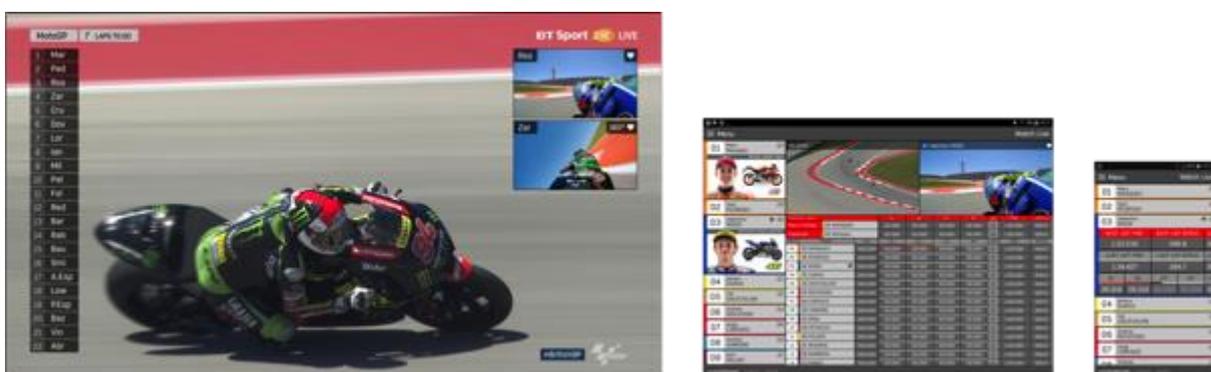


Fig 34: Default Expert Layout Presentation across TV, Tablet and Smartphone.

Key facilities include;

- Leaderboard changes appearance aligned to Novice, Fan and Expert experience levels.
- PiPs change appearance aligned to Novice, Fan and Expert experience levels.
- Leaderboard panel shown on the companion screen app can display 4 different cards aligned to the interests of Novice, Fan and Expert viewers. The experience level of the users changes the default starting position on the card carousel, so a Novice would start on Rider Profile Card and an Expert viewer would start with the Stats Card.
- Favourite rider selection is used to define the default PiP videos shown on TV.

- Companion screen videos can be personalised via View Panel on tablet or Leaderboard panel on phone
- The TV presentation is responsive and the on-screen graphics scale can be set by personal preference. This is not automatically scaled based on physical TV size and resolution (EDID).

A default User Profile will be created for each user. The experience level will be set at Novice and a Favourite rider will be automatically selected from the list of top riders whose on-board cameras are available.

We have through the course of our design and development work explored the pros and cons of user controlled placement of the alternative camera view on specific screens. Through the wireframes we proposed a system where the user selects which views they want to see and the platform decides where to place them based on layout engine intelligence (size of TV screen, graphics scale, companion screen device, etc.) and bandwidth availability. We believe this makes the overall user experience simpler and more intuitive.

A users Experience Level should ideally be established during the initial user profile generation process, with a facility to change this via the companion screen application.

Experience Levels affect the presentation of content on a user's personal companion screen device and the shared TV screen in different ways. Personal companion screen applications always reflect the set Experience Level. The shared TV screen however needs to accommodate multiple viewers who may have the same or different experience levels.

If multiple local viewers have the same experience level then the TV can echo that experience level. If however multiple local user have different experience levels, then the TV should adopt the (standard) fan experience level. This approach does however make the control of TV graphics obscure and potentially baffling to users. We therefore decided to set the scale of TV graphics as a shared state which is reflected across all local users' companion screen apps.

This capability will be assessed through both analysis of the interaction logs to verify if User Experience Level was changed and through the trial questionnaire to assess the effectiveness of this feature.

3.4.10 Notifications

A 'notification facility' has been provided which can be used by the broadcaster or content creator to notify the user or direct them towards an interaction such as changing the Chapter or setting the Screen Graphic scale. Prompts and associated alerts can be presented on both the TV and companion screen device to encourage and help facilitate a viewer action.

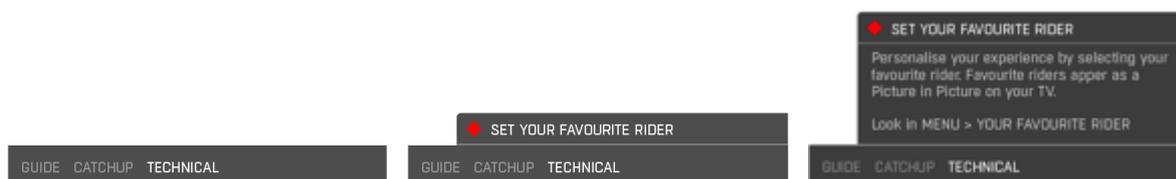


Fig 35: Notification message shown on a smartphone companion screen device.

Notifications appear at the bottom of a companion screen application. They are shown as a single 'headline', which the user cannot dismiss until they read the full message. The full message can be seen by swiping upwards or tapping on the headline text.

3.4.11 Interactive 'touch' on-screen graphics

In our early UX design concepts we considered how Object Based Broadcasting could enable TV graphics to become interactive when displayed on a companion screen device. We imagined an interactive leaderboard could be used to show additional information such as the rider profile picture, tyres, on-board camera feed, etc.



Fig 36: Early MotoGP concept for interactive 'touch' graphics when viewed on companion screen device.

Similarly, the race grid graphics could be used to support viewer participation in polls and competitions where viewers are asked to select 1st, 2nd and 3rd podium positions.



Fig 37: Early MotoGP concept for interactive 'touch' graphics when viewed on companion screen device.

Although we saw great value in developing this facility within the MotoGP use case we did foresee some potential issues with graphics becoming too small to interact with when video was displayed on small screen smartphones and on tablets where a number of videos were displayed in a mosaic format. Although, these issues could potentially be overcome through intelligence in the layout engine, we made the decision to develop this facility further in the Football at Home use case.

3.5 MotoGP: Trial Plans

In the MotoGP use case, as in The Theatre At Home use case, we will seek to evaluate users' assessments of the overall experience and of certain features.

The Theatre at Home use case had limited functionality. The MotoGP use case has built on the foundations established by the Theatre At Home use case, adding a number of significant features and capabilities that need to be evaluated. Specifically:

- In Theatre at Home the mechanism for joining users to the experience was of necessity 'hard wired', in this MotoGP case the joining mechanisms requires user intervention but has been designed to be robust and tolerant of different network configurations (e.g. the "set top box" can be either Ethernet connected and acting as a local hotspot for the mobile devices or the "set top box" and the mobile devices can both connect to a separate WiFi network.)
- In Theatre at Home the only ancillary devices was a tablet. In the MotoGP use case second screen layouts have been designed to adapt for both tablet and mobile screens, both of which can be supported simultaneously.
- In Theatre at Home the layout changes on the tablet were triggered by events on the timeline – users could choose different elements to be displayed within a region of the layout but could not add elements to the layout – neither could they affect layout choices on the TV screen. In MotoGP the control elements have been developed that allow actions on the tablet to effect layout changes on the main TV screen and to effect changes within the second screen too.
- In Theatre at Home only one second screen device could be active and only one set of choices could be made at each end. In the MotoGP use case, with the experience supporting multiple additional screens, a means of orchestrating the way a number of different devices may seek to affect the experience on the main screen has had to be designed.
- In Theatre at Home we did not enable responsive design capability. Responsive design is where the size and layout of graphic elements presented dynamically adapt to the physical size of the display screen. In the MotoGP use case, responsive design features have been enabled for a number of key components including; leaderboard, Picture in Picture videos, information and timing graphics.

In Theatre at Home use case responses to the absence of some of these features were implicitly probed through questioning. For example:

- In the Theatre at Home use case we asked users whether they would have liked more control over the layout - they said they would.
- In The Theatre At Home use case we asked whether they would have liked additional camera angles – they said they would.

However, it was not possible, given the design of Theatre At Home to assess, even implicitly, an absence of responsive design or an absence of a small screen version of the same experience. These will be assessed in the MotoGP use case. The differences in the approach to the evaluation are shown in table below. The Moto GP use case will build on the methods developed from Theatre at Home trial but will benefit from;

- a higher number of evaluations
- better logging analytics
- assessment via direct observation
- recruitment from a user pool more independent of the 2-Immerse team

	Theatre At Home	MotoGP
Venue	Home only	Home and within Lab conditions
Numbers	12 instances/paired homes (24 responses/individual homes)	We will seek up to 100 responses from 50 instances
Recruitment	Led by the partners within the consortium attracting those with an interest in the subject matter from colleagues, friends and family	Led by an external recruiting agency attracting those with an interest in the subject matter (MotoGP) from the managed list of professional trial recruiters.
Evaluation methods	Closed questionnaires Interviews Logs from the micro service platform	Closed questionnaires Interviews Logs from the micro service platform Logs from Google analytics Observations from lab based evaluations

The MotoGP use case will be evaluated, like the Theatre at Home use case within people's homes. It will also be evaluated within a Lab environment.

The MotoGP evaluations are scheduled to start in November 2017. More details of the design of the evaluation including the questionnaires used, will be published in deliverable Production Trial - Observation & Data Collection at Silverstone.

Each MotoGP trial household will be provided with client devices including TV set top box (NUC PC), a tablet (Samsung Tab S2, Google Pixel 2 or iPad) and a smartphone (Samsung S6/S7 or iPhone). It's expected that each household will use their own TV and an internet connected broadband Wi-Fi hub. It's desirable that across the trial a range of TV sizes are used (from 32" to 65" TVs) in order to trial the responsive presentation of TV graphics.

3.5.1 General Research Questions

The MotoGP trial will adopt the generic user experience research questions that have been used on prior 2-Immerse trials. These include;

1. Ease of use and general usability.

- Comparison of what we wanted the audience to do and what they actually did in the trial.
- Have we provided a more compelling experience for viewers than currently offered?
- Has our attempt to provide a multi-screen responsive personalised experience increased viewer engagement?
- What facilities worked well (enhanced the viewing experience) and what needs to be improved?
- How much do viewers value the enhanced experience? How much would they be willing to pay for such services?
- Did the nature of the trial being 'as-live' impact user engagement and interaction?

2. Synchronisation

- How important is the synchronisation of content across multiple devices?
- Does the type of content being watched alter the need or perception of synchronisation, if so what guidelines can we offer for future trials and service development opportunities?
- Level of accuracy needed by viewers?

3. Screen UI design

- Are the aesthetics and general look and feel (font, colours, etc.) sympathetic to the brand, and does this benefit the overall user experience?
- How was the provision of multi-camera video and data in a mosaic layout perceived by users? Was there a preference single, dual, tri, quad, etc. view on companion screen?
- Did users perceive benefits from the flexible layout of information across screens?
 - How information was shown across the large TV screen and companions screens.
 - The ability to 'cast' content from the companion screen to the TV screen
 - The use of common interaction design metaphors such as the expanding rider cards showing profile, on-board camera feed, timing and tyre configuration on the Leaderboard Panel
 - The position of alternative cameras angles and related video feeds. Can users map between placements of videos and the feeds they are showing?

4. Navigation and use of components

- Did we get the interaction design right?

5. User Experience (control & consuming content)

Companion screens can support both control and viewing an experience. Components can be aimed at control use (selecting which video cameras feeds to watch) and viewing use (watching video, reading supporting information, etc.).

- Did we get the orchestration of experience right?
- Did we get the right balance between manual and automated configuration?
- How did users negotiate permissions to place content on shared screens? Did they just discuss and agree with others?
- Use of the shared screen - Individuals can choose to view videos and replays on the shared TV display, but in so doing they interrupt others viewers. What were the social rules?

6. Phases of the experience & component usage

- What do people do during the different phases of the experience?
- User rating and usage of individual features provided.
- What features were used and when?
 - Multi-camera mosaic and picture in picture on the TV
 - Event replays and timeline navigation
 - Personalisation features – Experience Levels, Favourite Rider, etc.)
 - Responsive TV and TV graphics scaling.
 - Synchronised data features? Timing and tracking data.

7. Commentary and editorial

- Control of audio levels for ambient and commentary
- Use of event replay during race
- Impact of commentary on interaction – Was interaction driven by commentary or editorial prompts.

8. Content playback

- Was the swap between 'dirty' and OBB enhanced 'clean' video noticed during the presentation?
- Did users perceive any difference between traditional 'burnt-in' and OBB 'client-side layered' TV graphics?

9. Supporting Information

Did people use the supporting information?

- Tutorials, Introduction, News and Technical Videos available in 'Inside MotoGP' chapter.
- Rider cards (rider profile, on-board camera feed, timing, tyres) in the leaderboard panel.
- Was there a preference for more video or timing data on the companion screen?

10. Third-party applications

- Would users see value in the integration of twitter or similar social media facilities within the MotoGP experience?
- Would user see value in other 3rd party facilities being supported such as gaming, betting, merchandising, etc.?

4 New Production Tools

Recent technical advances make authoring and broadcasting of interactive multi-platform experiences possible. Most of the efforts to date, however, have been dedicated to the delivery and transmission technology (such as HbbTV2.0), and not to the production process. Media producers face the following problem: there is a lack of tools for crafting interactive productions that can span across several screens. Currently, each broadcast service (media + application) is created in an ad-hoc manner, for specific requirements, and without offering sufficient control over the overall experience to the creative director. Our intention as a contribution to 2-IMMERSE is to provide appropriate and adequate authoring tools for multi-screen experiences that can reshape the existing workflow to accommodate to the new watching reality.

We are working to identify new requirements for multi-platform production tools. The requirements for traditional broadcast productions are clear and well-established, and are fulfilled by conventional broadcast mixing galleries. But it is far from clear how multi-platform experiences will be produced and authored, as so far there are only a few experiences available. Each of these current experiences has been treated as independent projects and as a consequence has been implemented on demand for some specific settings. The next generation of production tools must be particularly designed for interactive multi-platform experiences. These new tools are intended for broadcasters and cover both pre-recorded and live selection of content.

In the 2-IMMERSE project, the design and development of the new production tool consist of five phases (Fig 38).

- (1) Collecting requirements for the new production tool and identifying potential users of the new tool;
- (2) Designing a few representative initial concepts based on the collected requirements;
- (3) Evaluating the initial concepts with professionals, and improving the selected concept;
- (4) Evaluating the selected and improved concept with professionals and improving it for the implementation;
- (5) After the design, the tools are implemented in an iterative manner. Pilot studies are planned to test these tools.

Phase 0 has been reported in D2.3.

Schedule for Design & Development				
PHASES	TASKS	START DATE	DUE DATE	% COMPLETE
0	Data collection, wireframes of experiences, manual authoring, and auxiliary tools (reported in D2.3)	March, 2016	November, 2016	100%
1	Collecting requirements	November, 2016	February, 2017	100%
2	Initial wireframe concepts	February, 2017	March, 2017	100%
3	Evaluating initial concepts	March, 2017	March, 2017	100%
	Re-design based on evaluation	April, 2017	June, 2017	100%
4	Validation and detail design suggestions	June, 2017	June, 2017	100%
5	Development and pilots	January, 2017	December, 2018	50%

Fig 38. Schedule for design and development

A number of research questions are investigated:

Phase 1: What are the requirements for the new workflow for producing multi-screen experiences? Who will be the potential users (operators) of the new production tools? How do the new tools and new operators fit into the current production workflow?

Phase 2: What are the main characteristics of each design concept? How do these main characteristics link back to the requirements?

Phase 3: What are the strengths and weaknesses of each design concept? What concept is recommended by professionals?

Phase 4: How is the experience professionals using of the design concept?

Phase 5: How is the user experience with the implemented production tools?

The following sections will detail the work and results of each phase.

4.1 Phase 1: Collecting Requirements

This phase contains three main tasks. First, we ran interviews to gather requirements for developing the object-based authoring tools. Second, we reviewed existing production tools to learn about how current TV programs are authored and how the tools could adapt to object-based media tools. Third, we investigate current production workflows and roles involved, to see who will use the new 2-IMMERSE authoring tools and how the 2-IMMERSE tools fit into them. The answers to the research questions of Phase 1 are highlighted as follows:

(1) What are the requirements for the new workflow for producing multi-screen experiences?

The most relevant requirements for the new workflow include testability, (quick) reaction to live events, components on demands, editable templates, live events template, and priority of components (see Table 1).

(2) Who will be the potential users (operators) of the new production tools?

A new role was identified to be the potential user of the new production tools: the multi-screen director.

(3) How do the new tools and new operators fit into the current production workflow?

The new production tools are extensions of existing tools. The multi-screen director is in charge of the new tools. She/he is coordinating all contents that are shown aside from the main TV broadcast. This may be information that is displayed in an app or additional streams that are displayed in multi-screen environments. Besides content selection, she/he also has to decide on the placement of the content. Thereby, she/he has to collaborate with the director and team of the main TV broadcast.

4.1.1 Interviews for collecting requirements

The interviews were conducted with seven technical and five non-technical participants, trying to identify state-of-the-art knowledge and current challenges when creating interactive multi-platform experiences (Fig 39). A set of questions were asked to find out who will use the 2-IMMERSE tools in the future and for which purpose. Some examples of questions are presented as follows:

- Who will be users of the system?
- What level of education or training do users have?
- What technical platforms do they use today? What tools do they use to produce (immersive) experiences?
- What other IT systems does the organization use today that the new system will need to link to?
- What training needs and documentation do you expect for the future system?

Functional and non-functional requirements were then gathered. Exemplary questions for functional requirements were:

- What does the production process for live experiences look like?
- Is spatial and temporal authoring desired?
- Is the spatial design based on templates or can elements be arranged freely? How should layout support be realised, if at all?
- Should the application be able to preview the presentation. If so, then to which degree of detail?
- Which data formats do you use for video/audio/images that have to be processed by the authoring environment?

Exemplary questions for non-functional requirements were:

- What are your expectations for system performance?
- Are there any legal requirements or other regulatory requirements that need to be met?

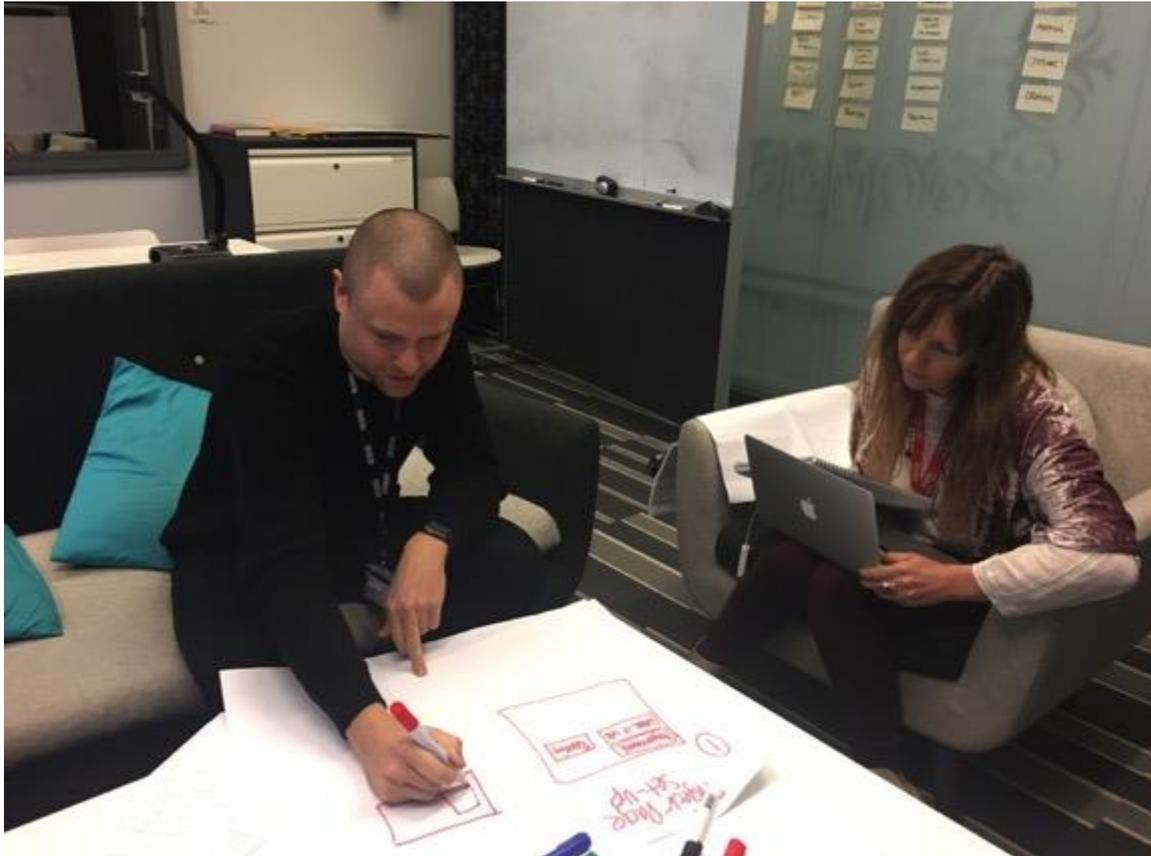


Fig 39. Interviews for collecting requirements

After conducting the interviews, the transcripts were analysed, and user characteristics, general and environmental constraints, assumptions and dependencies related to live broadcasts, and open questions (green post-its) and issues (pink post-its) were identified and noted. We also differentiated between functional requirements (yellow post-its), and non-functional, i.e. technical and user requirements (orange post-its). Figure 40 shows a subset of the initial collection of requirements, open questions, and issues. These were then rearranged according to phases of the production process, for which see Figure 41.



Fig 40. A subset of the initial collection of requirements, open questions and issues.



Fig 41. Rearranged requirements, open questions and issues.

Based on the interviews and data analysis, we identified user characteristics, general and environmental constraints, assumptions and dependencies related to live broadcasting, and open questions and issues. Technical and user requirements were also gathered and differentiated. The most relevant requirements for designing object-based authoring tools that support immersive TV viewing experiences are presented in Table 1.

Most relevant requirements	Descriptions of the requirements
Testability	The layout should be testable without a real/live video stream. (LIVE)
Reaction to live events	Reaction to live events should be possible. Timing should be decided by sequential events instead of timelines. (LIVE)
Components on demands	Statistics and graphics should be generated on demand. Easy interactions (e.g., clicking on buttons) can create components from predefined settings that can be shown on screen or in companion apps.
Editable templates	Predefined templates and styles for spatial layouts can be changed (e.g., font sizes, space constrictions). It should be possible to define safe zones where no content can be. A pool of templates derived from the initial ones are being built over time.
Live events template	It should be possible to create templates for live events (e.g., A goal is scored, then show slow-motion replays of the left and the right camera, and show the player profile picture). Timing is set per program. Sequences are created for content-types.
Priority of components	Set which components (e.g., chat, social sites) are available to the viewer, and at which priority (e.g., lower priority components may not be visible on small screens, and might be overlaid by the higher priority components). Define the priority of components.

Table 1. The most relevant requirements for object- based authoring tools

4.1.2 Reviewing existing tools

Commercially available production tools were reviewed alongside BBC internal production tools for both pre-production & live programming.

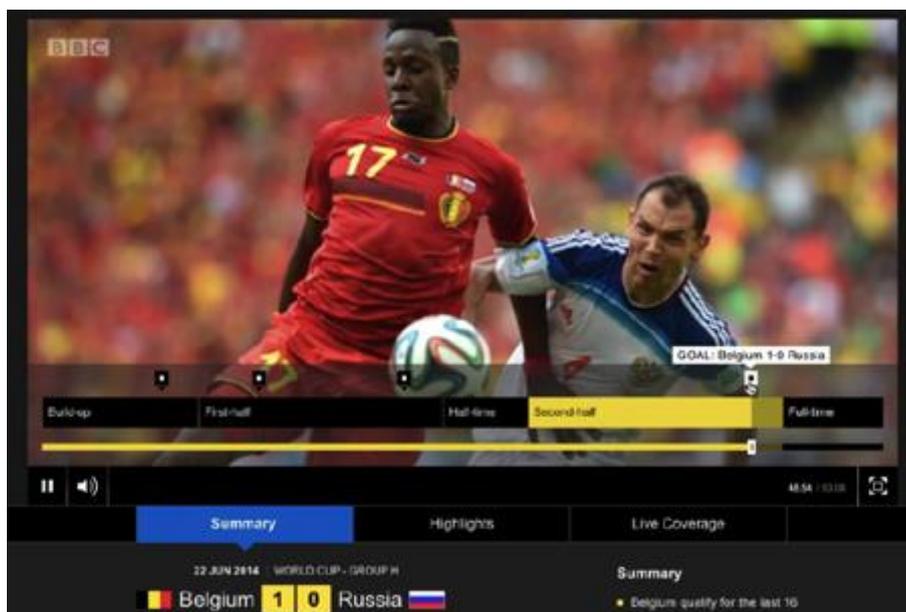


Fig 42. BBC internal production tool with Timeline



Fig 43. BBC 'LIVE' tools

Below are rough sketches illustration ideas about how current tools could be adapted to object-based media tools. Common features such as 'preview areas', 'templates' and 'timeline/event lines' can be transferred, while features depicting the qualities of an individual object need to be expanded to encompass all possible adaptations a media object affords (Fig 44). For example, previously a name on a leader board would consist of a text box, but the adaptive object-based media leader boards you could also incorporate a photo of the rider, the tyres they are using, long and short versions of their name.

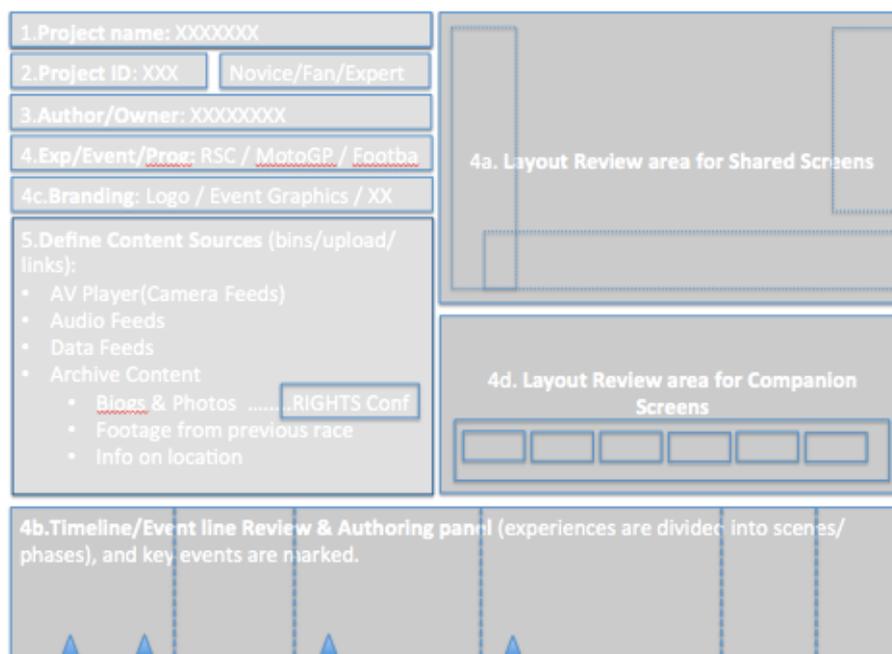


Fig 44. Rough sketches about how current tools could be adapted to object-based media tools.

Templates (layout & timeline & rule-set) and branding are part of a pre-existing experience formats, which can then be adapted by the production team (or the user as part of the companion experience). New experiences can use existing templates, with new branding. This page is used to assign a project ID, and identify content sources. Content items (objects) are selected, and assigned characteristics and rules (to control relationships and behaviours) from the timeline/event line. The same content items (object) can be assigned with different rule set. The ‘review’ layout areas reflect objects added to the timeline/event-line (Fig 45). The production team can drag the playhead along the timeline/event-line to see a synchronised review in the layout areas. The review layout areas change the ‘view’ depending on the type of experience, for example, a 360 video experience will appear as a sphere, a single screen experience will have one panel, a multi-screen experience will have two review panels (for shared devices and companion devices).

Assign and define objects, select object characteristics, and associate rules and behaviours to objects. In other words, objects can be assigned templated characteristic, rules and behaviours. For example, those associated with branding or those from the layout manager. The production team need the ability to ‘publish’ and ‘remove’ objects in real time, overriding previous scripts, and updating any changes to the object.

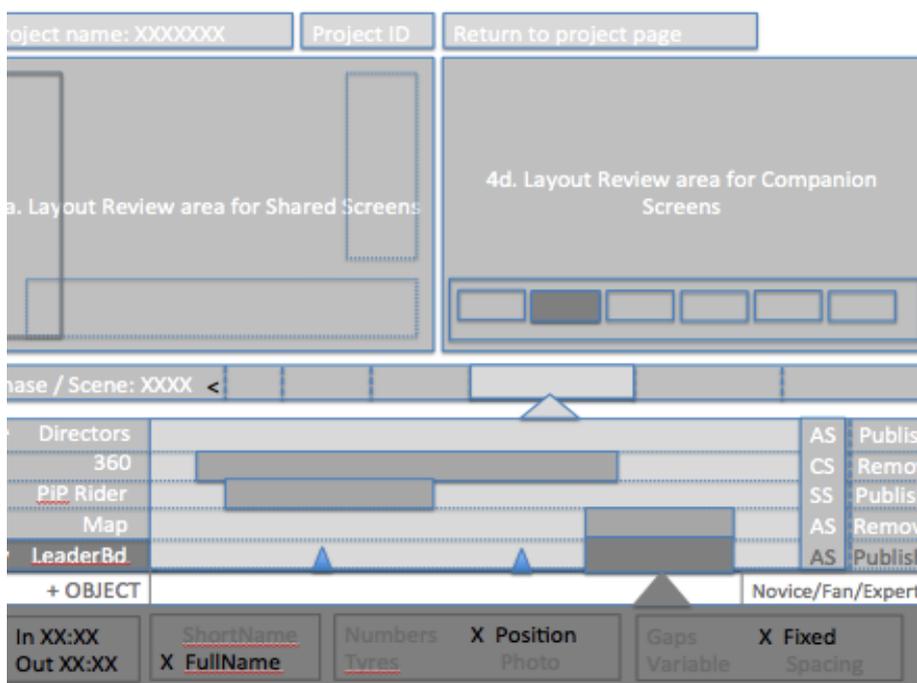


Fig 45. Rough sketches timelines and previews of multiple screens.

4.1.3 Mapping a new multi-screen work process

A detailed mapping of current production workflows was created from interviews with practitioners. Initial workflow sketches (Fig 46) were collated into a single illustration, depicting processes, activities within processes and roles. The illustration also captured knowledge on where multi-screen production input would need to be implemented (Fig 47).

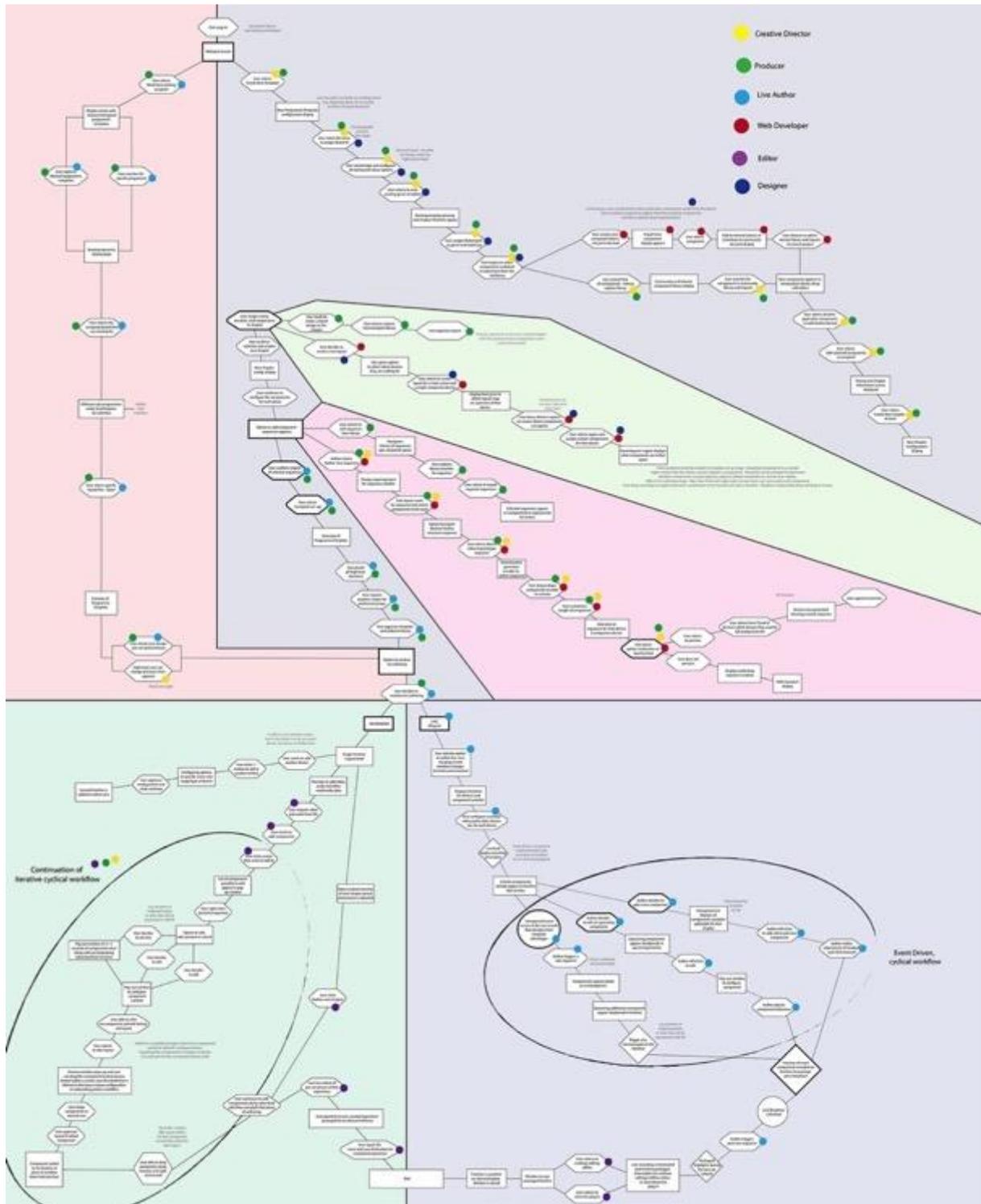


Fig 47. Initial workflow sketches were collated into this illustration, depicting processes, activities within processes and roles.

The high-resolution digital version of this figure can be retrieved on <https://bscw.2-IMMERSE.eu/sec/bscw.cgi/36927>, file name: Authoring Process Tree-01.png



Fig 48. Exemplary studio setup with workspaces for the team involved in the production of a broadcast.

An analysis of the existing workflow and production setup (Fig 48) showed that the person in charge of social media (secondary screen content) is far away from the core team of the production. She/he is currently isolated and remote. One of the goals of the project is to define a new role with a spot in the front row. This will be an extension in the production workflow that will require new tools and skills. For each production, live or pre-recorded, several settings have to be made. A configurable and stylable spatial template has to be chosen which defines where additional contents will be displayed to the viewer. This may be on additional TV screens, smartphones, tablets, or other devices which all require a distribution of the screen in case more than one content is shown. After defining the spatial settings, contents can be added and previewed, either by working on a timeline or by triggering events for live playback.

In a second step, we analysed this coarse grained workflow and tried to find a more fine grained description of the individual sub-tasks and steps and who is in charge for executing them. The roles from the standard broadcast process, namely technical manager, producer, director, vision mixer, light and vision, audio, autocue controller, deputy producer, and social media journalist, were analysed and assigned to the different tasks. This analysis showed that the task-sets of traditional roles have to be extended.

A new role was identified: the multi-screen director. She/he is in charge of coordinating all contents that are shown aside from the main TV broadcast. This may be information that is displayed in an app or additional streams that are displayed in multi-screen environments. Besides content selection, she/he also has to decide on the placement of the content. Thereby, she/he has to collaborate with the director and team of the main TV broadcast.

The high level production workflow for interactive multi-platform experiences is shown in Fig 49.

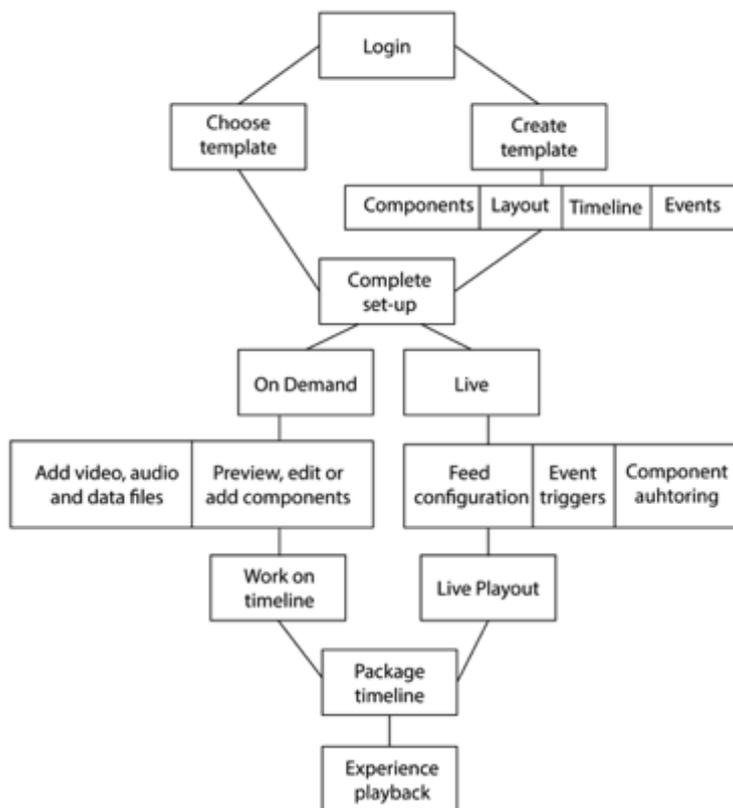


Fig 49. A high level production workflow for interactive multi-platform experiences

4.2 Phase 2: Initial wireframe concepts based on the requirements

The set of relevant requirements are used as the basis to design the four concepts of the new 2-IMMERSE production tool, namely the chapter-based IDE (Integrated Design Environment), mixed IDE, workflow wizard and Premiere plugin. The answers to the research questions of Phase 2 are presented as follows:

(1) What are the main characteristics of each design concept?

The main characteristic of the first concept (chapter-based IDE) is the division of a program into chapters. Each chapter has a group of relevant components. The second concept (IDE mixed) emphasizes on the use of Distributed Media Application (DMAApp) components and optimizes the layout design across multiple screens. The third concept (workflow wizard) illustrates the production workflow within the tool and encourages collaborations between production team members. Team members must strictly follow the workflows. The layout of the workflow wizard is defined by templates of different brands. The last concept (Premier plugin) shares many characteristics with the second concept, but has a Premier-like interface.

(2) How do these main characteristics link back to the requirements?

Even though the four concepts have different characteristics, they are designed to cover as many as possible the relevant requirements presented in Table 1. The chapter-based IDE concept meets all the requirements, but the freedom to edit the templates are limited, because the brands have defined the look of their programs. The mixed IDE concept meets all the requirements, with more flexibility to do the layout design. The workflow wizard meets all the requirements, with limited

ability to edit templates and limited flexibility in “reversing” the workflows. Collaborators must follow the workflow step by step. The Premier plugin concept is similar to the IDE mixed concept. It meets all the requirements.

The descriptions and screen shots of the four concepts are presented in the following four subsections.

4.2.1 Chapter-based IDE concept

The chapter-based IDE concept (Fig 50) divides a program into several chapters (e.g., for a sports event such as MotoGP, including pre-race, main race and post-race). Each chapter contains (dozens of) components such as leader board, course map, live video. The authoring process starts with newly-created or predefined templates. All the components are assigned to specific regions on screens. The timing for each component to start and end is authored on a timeline. The priority of each component can be ordered by moving the timeline (where the component is placed) up and down. For instance, if you want the program logo overlay the main video, you need to drag the timeline where the “logo” component is placed above the timeline where the main video component is placed. Live event templates are also included in this concept, leaving the live video stream and other live components as “placeholders”, the program author could edit the live templates in advance.



Fig 50. Chapter-based IDE concept

4.2.2 Mixed IDE concept

The mixed IDE concept (Fig 51) does not specify different phases/chapters of a program. A collection of re-usable DMap components, includes components that play audio and video, present text and image content, and provide real-time video communication and text chat. The limited collections of DMap components reduce the diversity/complexity of the components. Dragging and dropping the DMap components into the defined regions on screens allows program producers to author the multi-screen experience into a coherent look and feel. The sequence of the applied DMap components are editable on a timeline. The priority editing of the components is the same as the chapter-based IDE concept. Dragging and dropping the DMap components into the defined regions

on screens allows program producers to author the multi-screen experience into a coherent look and feel. The sequence of the applied DMAApp components are editable on a timeline.

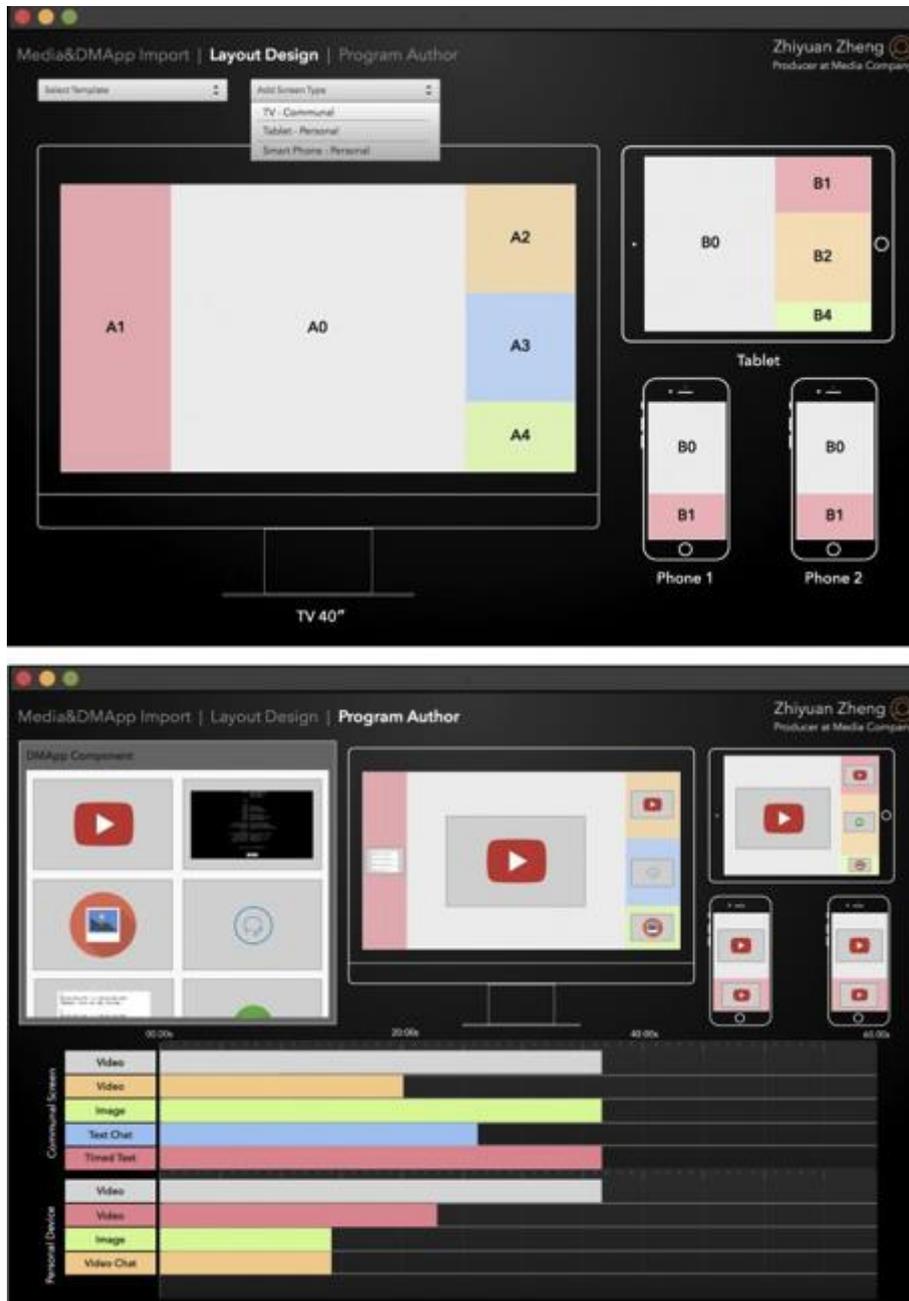


Fig 51. Mixed IDE concept

4.2.3 Workflow wizard concept

The Workflow Wizard (Fig 52) concept gives program authors a shared overview of the authoring process and guides the authoring step-by-step. It allows the assignment of work to different collaborators and facilitates a check on everyone’s progress.

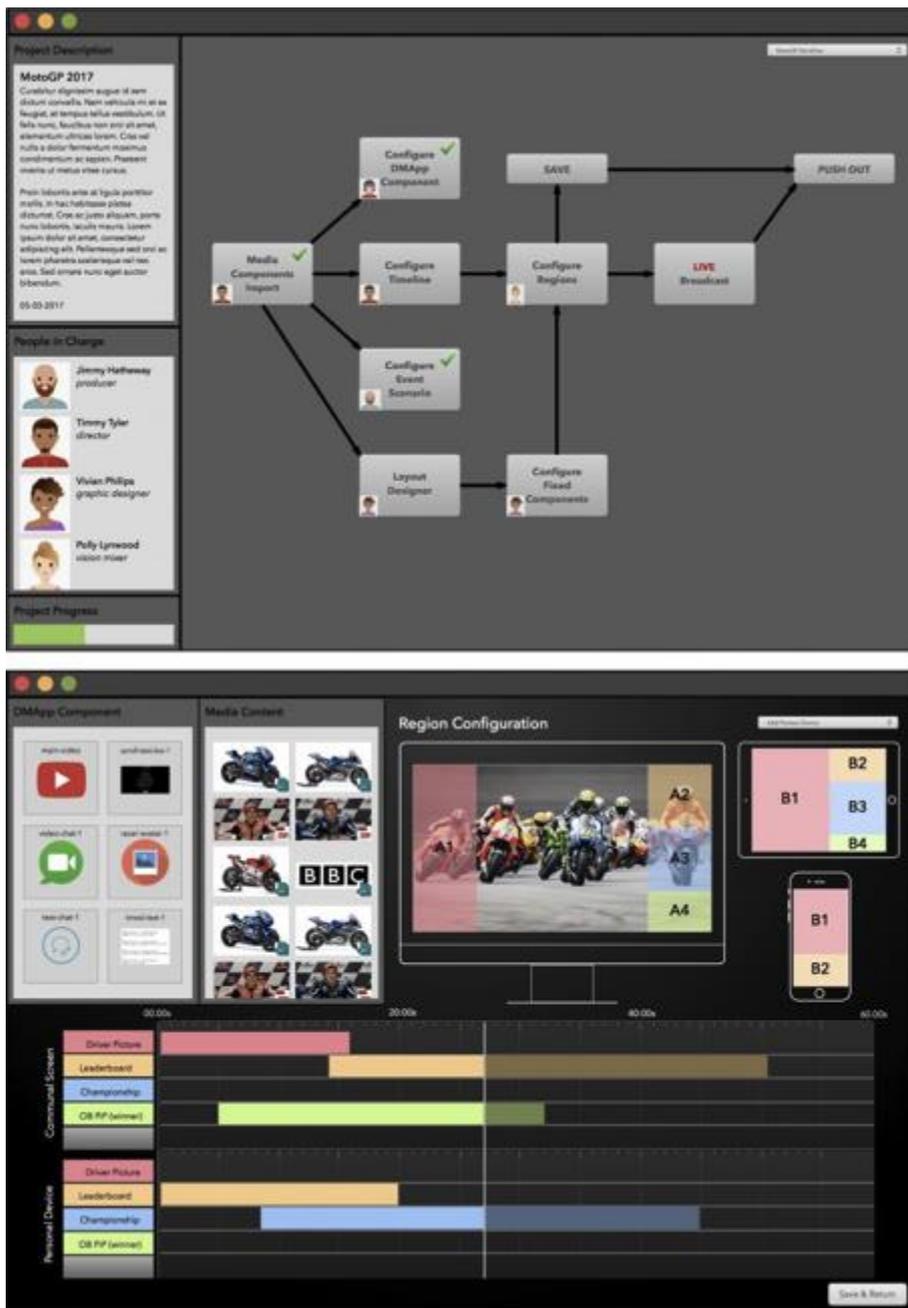


Fig 52. Workflow wizard concept

4.2.4 Premier plugin concept

A Premier Plugin (Fig 53) is similar to the mixed IDE concept, but is based on the interfaces of Adobe Premiere. Since it is assumed that program authors are expert users of Adobe Premiere, the idea behind this concept is to increase their feeling of familiarity and ease of use.

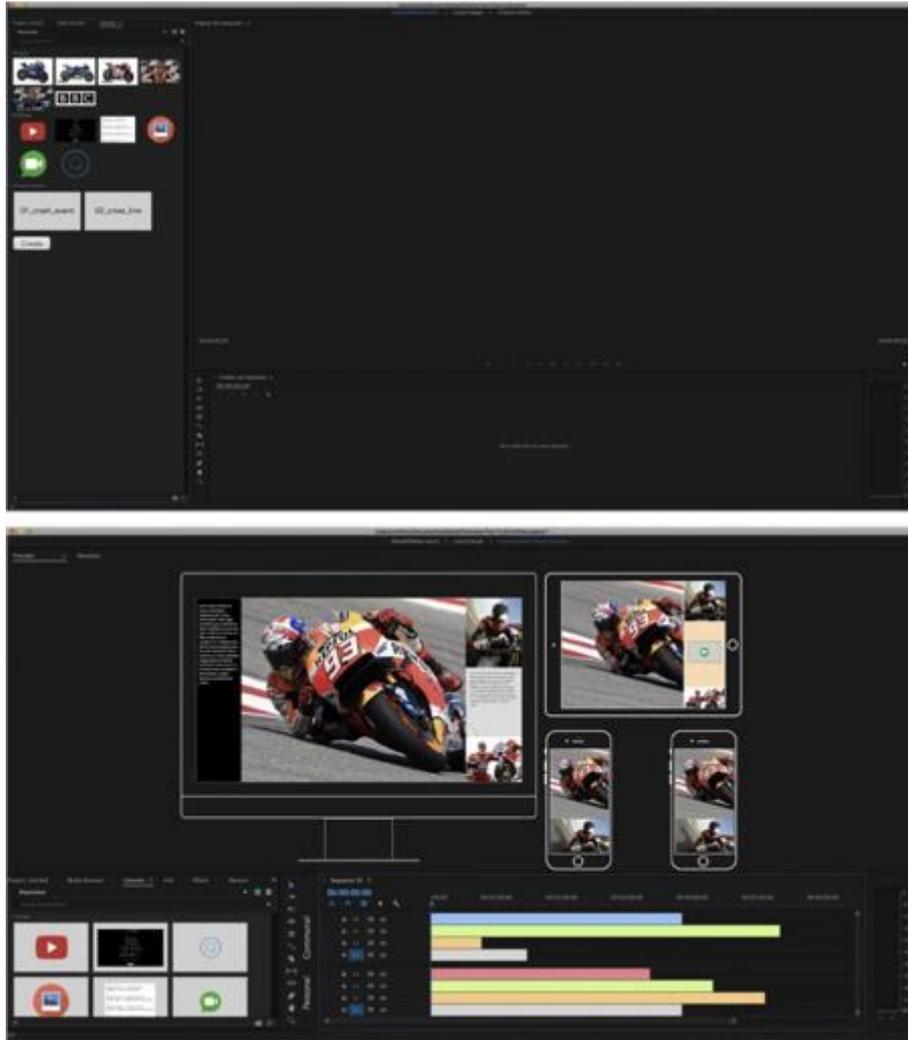


Fig 53. Premier plugin concept

4.3 Phase 3: Evaluation of the four concepts

The goal of the evaluation is to assess the strengths and weaknesses of the four concepts presented in Section 4.2, which leads to a final design requirement guideline and concept that is ready for implementation. Except for the four concepts, two separate ideas were also evaluated. The first idea is to see whether the professionals find region-based templates helpful in creating the layout, or whether they prefer flexible region-less templates. The second idea is to see whether professionals prefer the live production with a timeline, or whether they prefer it as a series of triggering buttons.

The research questions of this phase are answered as follows:

(1) What are the strengths and weaknesses of each design concept?

The strengths and weaknesses of each design concept are presented in Table 3.

(2) What concept is recommended by professionals?

The mixed IDE concept is recommended by professionals.

4.3.1 Participants

Ten broadcasting professionals (Table 2) were invited to evaluate the four concepts and the two ideas. Eight of them are working at BBC (British Broadcasting Council). Their job functions cover a wide range of specialties, including (creative) director, R&D engineer for new audience experiences/authoring tools/new workflows, film maker, technology manager etc. The other two professionals are working at British Telecom (BT) and Illuminations Media (IM), respectively. One is leading the interactive TV research group at BT, the other is the director of screen productions at IM.

Professionals (Interviewees)	Specialties
P1	Head of interactive TV research at British Telecom, focusing on next generation multi-screen and immersive TV application.
P2	Director/producer of screen productions at Illuminations Media, experienced in broadcasting and film.
P3	Film maker and content producer at BBC, experienced in the provision of intergenerational content, the use of haptic feedback devices for accessibility and editorial purposes and development of ambient media prototypes.
P4	Senior development producer for 360 video, virtual reality, immersive experiences at BBC.
P5	Senior technology transfer manager at BBC, focusing on The New Broadcasting System based on IP production as well as general production workflows.
P6	Lead research and development engineer at BBC, leading the Future Experience Technology group's Object-based media (OBM) work stream, building tools that can be used to create OBM experiences, and researching whether OBM can bring efficiencies to traditional programme making.
P7	Executive director, new workflow research director at BBC, experienced in developing innovative tools for critical creative tasks, including the production of subtitles and shot planning for multi-camera TV direction.
P8	New workflow researcher at BBC, focusing on investigating, informing and evaluating media experiences of the now and longer term future.
P9	Creative director for production systems at BBC, experienced in user experience design and design of editorial systems.
P10	Research and development engineer at BBC, focusing on new types of synchronised companion SCREEN experiences for connected homes.

Table 2. Ten professionals for evaluating the four concepts and their specialties.

4.3.2 Preparation and facilities

The wireframes of the four concepts were printed on A2 papers for the evaluation interviews. Each A2 paper consists of four screen shots of the wireframes. A brief introduction about the 2-IMMERSE project was prepared, using the images from the 2-IMMERSE official website to assist the interviewees in understanding the four concepts. Besides, a voice recording device and four video cameras were used during the interview to record the conversations as well as the interviewees' "interactions" with the wireframes from different angles (Fig 54).



Fig 54. Video camera recorded the evaluations from four different angles.

4.3.3 Procedure

The interviewer facilitated the evaluation interviews in a meeting room, on a one-to-one basis, guiding the interviewees through the four concepts. The order of the four concepts were randomized for each interviewee. Each interview consisted of five steps and took about one hour.

Step 1: Introduction (5 minutes): The facilitator briefly introduced the 2-IMMERSE project and what interactive immersive multi-screen experiences mean for production authors and TV viewers. Then, he gave a general explanation about the goals of the four concepts.

Step 2: Evaluation paradigm (thinking-aloud, 35 minutes): The interviewees were asked to say whatever came into their mind as they were “interacting” with the wireframes. The video camera recorded the “interactions”. The order of the four concept was randomized for each interviewee.

Step 3: Follow-up interview questions (10 minutes): After evaluating all the four concepts, interviewees were asked follow-up questions to clarify their preferences and recommendations. Three examples of the follow-up questions are listed as follows.

- (1) Which features or elements do you prefer among the four concepts?
- (2) Could you rank the four concepts according to your preference?
- (3) What can be the improvements for your favorite concept?

Step 4: Evaluation of the live production tool (5 minutes): The interviewees were asked to compare two different live editing possibilities (namely a timeline-based live production tool or a live tool with a series of triggering buttons), and reflect which fits the best in the live production workflow.

Step 5: Evaluation of the layout design (5 minutes): The interviewees were asked to compare two different layout design mechanisms (namely region-based layout or region-less layout), and reflect which fits the best with their workflow.

4.3.4 Data collection

The recordings of the interviews were replayed and relevant information from the conversations were noted and sorted into four main categories, namely evaluations of the concept (i.e., pros and cons of each concept), order of preferences of the four concepts, preferences of the design elements (i.e., live interface with buttons versus timelines, and preferences of the layout design (i.e., specifying regions or allowing it to be flexible and region-less). The four categories of information indicate a direction for further improvement of the production tool.

4.3.5 Results

Before indicating their preferences, the professionals have extensively discussed the strengths and weaknesses of each concept. Their main comments are summarized in Table 3.

The Four Concepts				
	Chapter-based IDE	Mixed IDE	Workflow Wizard	Premier Plugin
Strengths	<ul style="list-style-type: none"> The complexity of the authoring process might be reduced, because one person takes charge (P4). Chapters are similar to the “parts” of a program. (P3, P7) 	<ul style="list-style-type: none"> It is good that this concept includes media content, DMAP components, event scenarios together on one interface, because program authors always consider them together (P4). Dragging and dropping DMAP components to the regions are convenient (P4, P9, P10) The colors of the region correspond with the colors of the timeline (P4). The complexity of the authoring process might be reduced, because one person takes charge (P4). DMAP components can work as placeholders (P5). 	<ul style="list-style-type: none"> This concept can be adapted to the current OB truck studios, where a team of professionals work together (P3). Allow program authors to share an overview of the progress. It helps them understand the flow (P4, P9). 	<ul style="list-style-type: none"> This concept has a similar interface as Premier. It can be quickly picked up by some professionals (P3). Premier is ideal at editing pre-recorded videos (P4).
Weaknesses	<ul style="list-style-type: none"> Chapters are too simplified (P6). 	<ul style="list-style-type: none"> Audio part of the authoring seems being overlooked (P5, P9). 	<ul style="list-style-type: none"> This concept is not flexible. The further steps cannot be done without finalizing the previous steps. Reversing the process is impossible once the step is finalized with a “√” (P4, P9). Multiple collaborators who are editing parallel add complexity (P4, P6, P7). It focuses on pre-production, ignoring the live event scenarios (P5). 	<ul style="list-style-type: none"> This interface might be familiar to one person (e.g., a film maker), but not another (P3, P4, P6, P7). Premier is not designed to manage productions (P4).

Table 3. Strengths and weaknesses of the four concepts

4.3.6 Preferences of the four concepts

The Mixed IDE concept is preferred by the most professionals (Table 4). Apart from the preferences, professionals pointed out that the live part of the new production tool should be simplified into “button” based rather than timeline based. They also would like to have a set of templates to help program authors to specify regions across multiple screens. The re-design is based the Mixed IDE concept.

Professionals	Preferences of the four concepts (A-first preference; B-second preference)			
	Chapter-based IDE	Mixed IDE	Workflow wizard	Premier plugin
P1				
P2		B		A
P3	B			A
P4	B	A		
P5				
P6	B	A		
P7	A		B	
P8		A		B
P9	B	A		
P10				
In total	A+4B	4A+B	B	2A+B

Table 4. The preferences of the four concepts by the ten professionals

4.3.7 Re-design based on the mixed IDE concept

Fig 55-59 shows five screen shots of the re-designed wireframes of the production tool (the pre-live part), representing the five main functions of the pre-live part of the production tool:

- (1) Add multiple preview screens (i.e., TV, tablet and phone),
- (2) Define the layouts on multiple screens,
- (3) Add DAMpp components, leaving them as placeholders or configuring them as graphics (e.g., BBC logo),
- (4) Build hierarchy between “parts” of a program, applying masters at higher level will reduce the workload and
- (5) Build hierarchy between “parts” of a program. Applying masters at higher level (e.g., BBC logo), and the lower level will inherit the contents in masters.

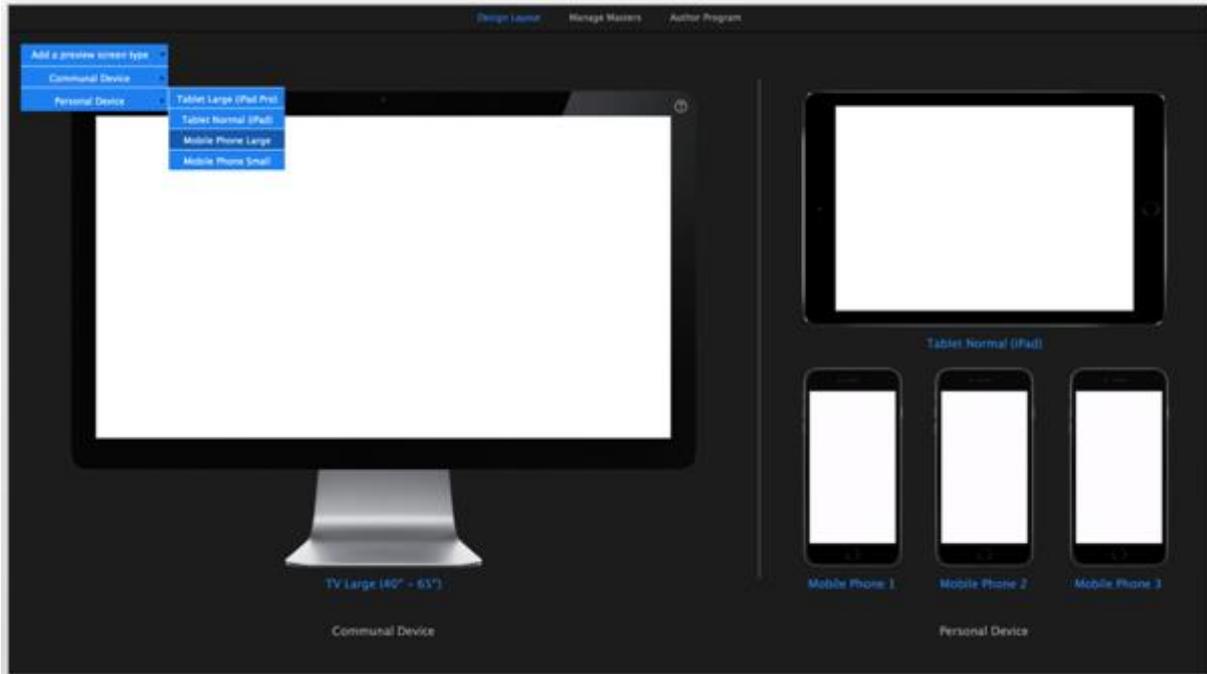


Fig 55. Add multiple preview screens.

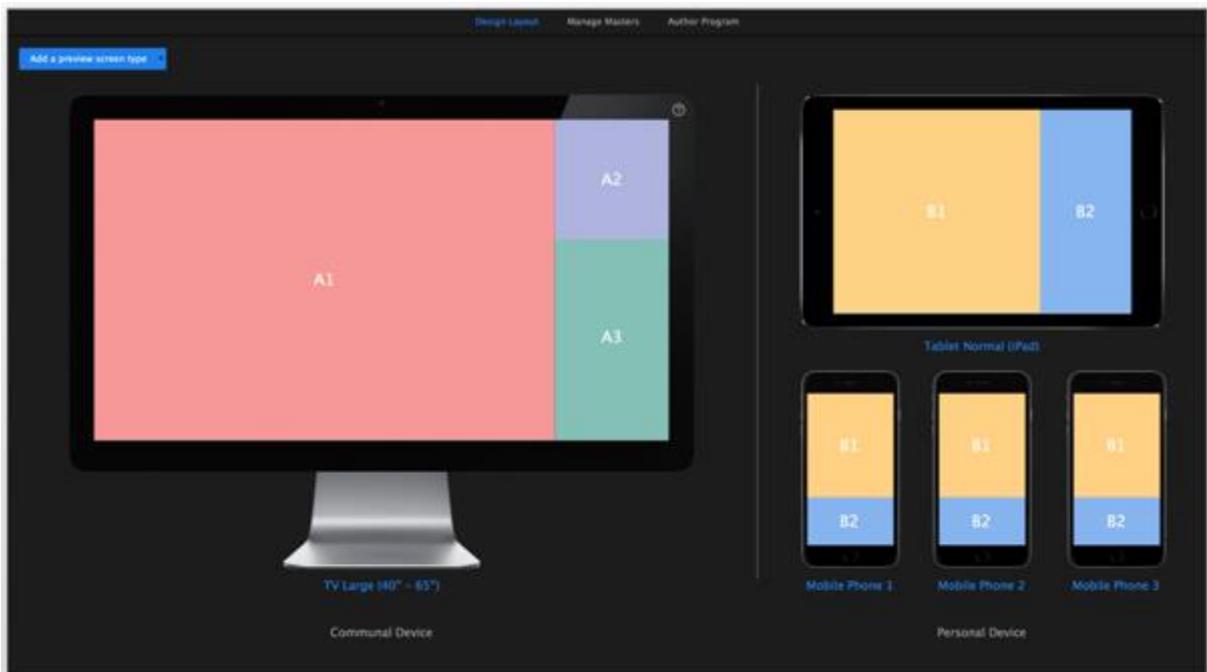


Fig 56. Define the layouts on multiple screens.

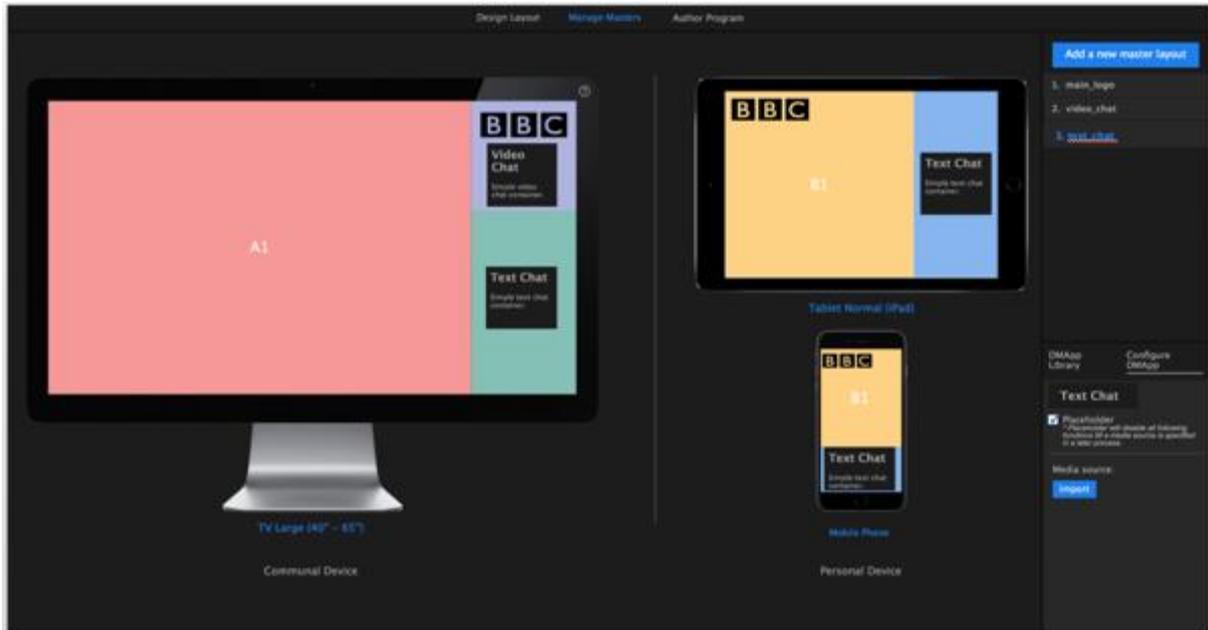


Fig 57. Add DMApp components, leaving them as placeholders or configuring them as graphics (e.g., BBC logo)

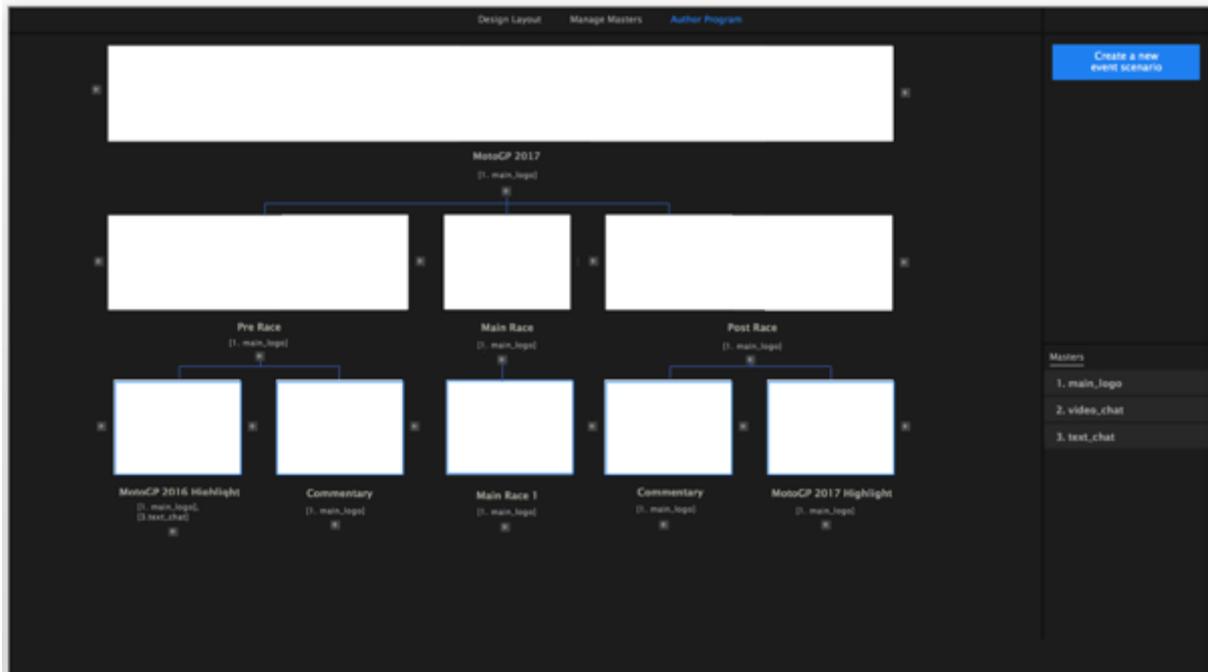


Fig 58. Build hierarchy between “parts” of a program, applying masters at higher level (e.g., BBC logo), the lower level will inherit the contents in masters.

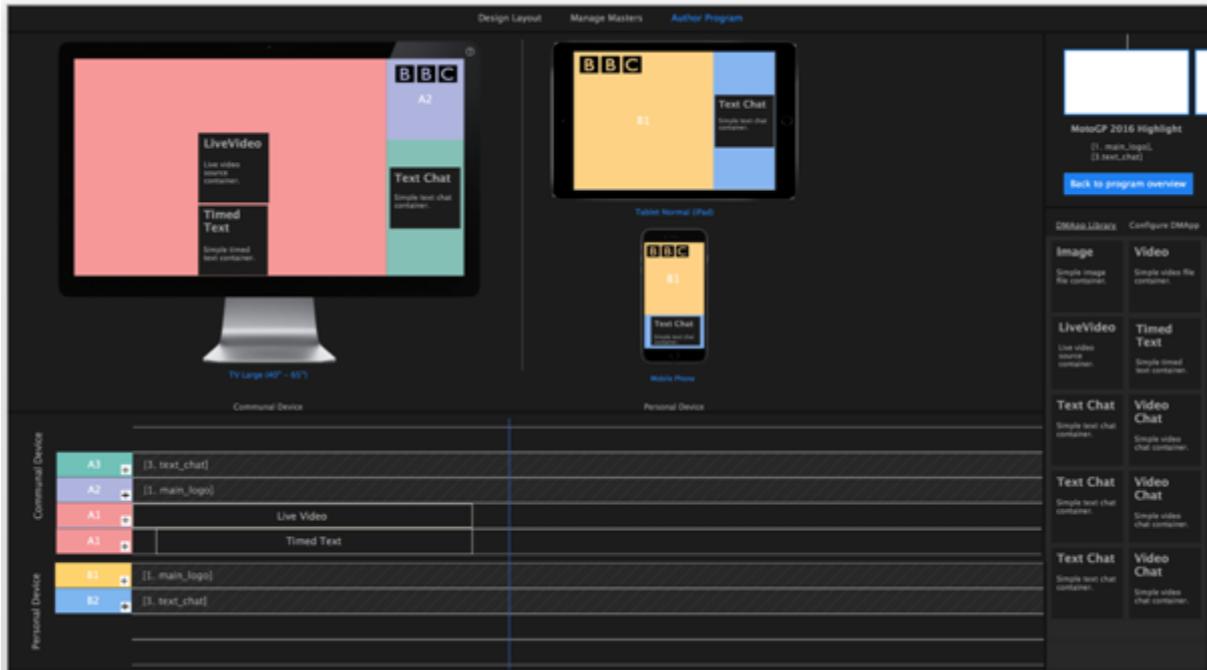


Fig 59. Configure each part of a program.

4.4 Phase 4: Validation and detail design suggestions

Three project members, who are also professionals related to the production field, evaluated the re-designed concept. Two of them (PM1 and PM2) participated in the evaluation interviews presented in Section 6.3. Apart from PM1 and PM2, a third project member PM3, who is experienced in TV production across multiple screens, was invited to validate the re-designs.

Project members for validating re-designs	Specialty
PM1	Head of interactive TV research at British Telecom, focusing on next generation multi-screen and immersive TV application.
PM2	Director/producer of screen productions at Illuminations Media, experienced in broadcasting and film.
PM3	Principle user experience designer at British Telecom, focusing on TV production across multiple screens

Table 5. Three project members for validating re designs.

The wireframes presented in Section 6.3 were made into interactive slides, simulating the possible interactions on the interface. The three professionals were given ten tasks, and asked to complete the tasks on the interactive wireframes of the re-designed concept.

The research question of Phase 4 is “What are the experiences of the professionals using the design concept?” In general, the professionals are very positive about the re-designed concept, meanwhile they point out important details to be improved.

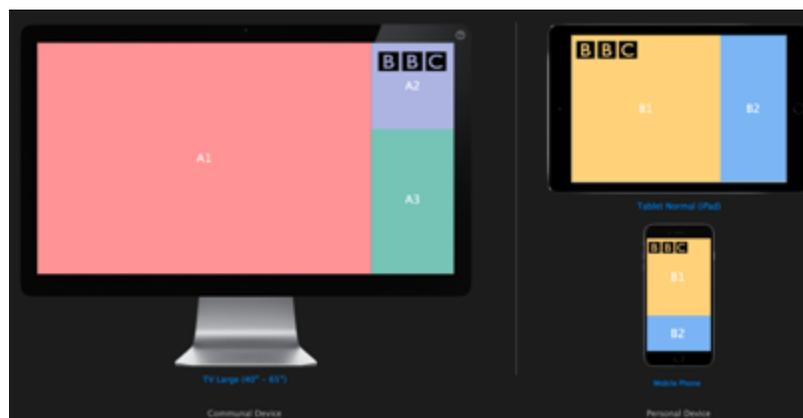
The ten tasks of the evaluation are described as follows:

1. Add preview screens of a communal device (TV large 40”-65”) and two personal devices (iPad Normal and Mobile Phone).
2. Create layouts for the three preview screens as shown in *Questionnaire Image 1*.



Questionnaire Image 1

3. Add a new master layout, name it as “1. main_logo”, and place the BBC logo on the preview screens as shown in Questionnaire Image 2.



Questionnaire Image 2

4. Add a new master layout, name it as “2. video chat”, and place a “VideoChat” placeholder into Region A2 on the TV preview screen.
5. Add a new master layout, name it as “3. text_chat”, and place the “TextChat” placeholder into Region A3 on the TV preview screen and Region A2 of the two personal devices.

6. Go to program overview. Name a new program as “MotoGP 2017”, and add three child chapters of the new program: Pre Race, Main Race and Post Race.

7. Under the three child chapters, add two sub-chapters (MotoGP 2016 Highlight and Commentary) to Pre Race, add one sub-chapter (Main Race 1) to Main Race, and add two sub-chapters (Commentary and MotoGP 2017 Hightlihgt) to Post Race.

8. Apply “1. main_logo” master layout to all the (sub-)chapters. Apply “3. text_chat” layout to sub-chapter “MotoGP 2016 Highlight”.

9. Go to the editing mode of sub-chapter “MotoGP 2016 Highlight”. Add LiveVideo and TimedText as two placeholders in Region A1 on the TV screen.

10. Expand the sequential “timeline” of Region A1 into two. Place LiveVideo and TimedText onto the two split “timelines” of A1.

The evaluation received positive responses from the three professionals, but they also pointed out some details. For instance, how to define the exact position of certain graphics, to prevent that they get overlapped on the screens once they are on air at the same time. The following Table 6 presents their validations of the concept and suggestions about details by the three professionals.

Three professionals within the 2-IMMERSE project		
PM 1	PM 2	PM 3
<ul style="list-style-type: none"> •Designing layouts, adding preview screens, selecting three different screens, make sense •Program overview, find it under author program •Add 1. main_logo to all the subchapters, didn't how to do, when explained, found it understandable, when apply master layout to lower level, it doesn't influence the upper level. •“Save” reminder popping up is good •Hierarchical level is understandable, from top to bottom, left to right. •Expandable the timeline is good, which allow multiple timelines for the same region. Each timeline is specific for a DMAP component. Order of the timeline is defined by the priority of the components. •Be able to delete master layout applied at all levels, if delete at the lower level, it doesn't influence upper level. •No editing in this software, agreed, only import image, video... •For the event scenario authoring, similar to the program authoring, basically all placeholders, understandable. 	<ul style="list-style-type: none"> • Add preview screens. It is not completely intuitive, but once explained, make sense. It fit well with other work packages of the 2-IMMERSE project. <p>Dragging, placing and re-sizing images are good and important.</p> <ul style="list-style-type: none"> • Popping-up “Save” reminder is good. • Very positive about the new version. 	<ul style="list-style-type: none"> •Have no problems with adding preview screens •Have no problems with finding “add a new master layout”, drag and drop components and configure the components •Find “program overview” under “author program”, no problems •Hierarchical programs is good, snap between sub-chapters. •Drag and drop masters to the higher level, it applies to all sub-chapters. Make sense. •Be able to edit each lowest level at the hierarchical program. If you do not want to apply a master layout to a sub-chapter (at the lowest level). Directly delete the master layout from that sub-chapter. It does not influence other applied master layouts. This is good.
<p>I.1</p> <ul style="list-style-type: none"> •The point shows x, y position. The line to separate screens can be moved across screen, drag-able. •Overlap in the same region, e.g., A1, leader board and other information may collide. Specify the position of components, e.g., bottom 1/3, right side. •Layouts can be dynamically swapped between different size of screens, or three different layouts/sizes for a single TV, let users to decide which size/resolution they prefer. •To know exactly pixel sizes and distance to the border of the region/screen, when move the components. •Master layout, a bit confusing, which is 	<ul style="list-style-type: none"> •Want to drag and move the line to define regions. Important! •Make the fonts on the interface more visible. • Placeholder is a bit vague about the precise size of the component within it. •For theatres use case, need exact timing while authoring on the timeline. 	<ul style="list-style-type: none"> •Drag-able lines are necessary to add flexibility (layout design) •High levels in the hierarchical tree look like folders. Do they show contents as a preview? Should make the higher levels flatter, to make it clear that they are not editable. •Main race should occupy most of the timeline, probably show it as larger “folder” at the program overview. •Show exact timing on the timeline when needed. •Further define the layering and exact position of the objects in the same region, to avoid conflict. During live, need to trigger certain information, for example, when a

Three professionals within the 2-IMMERSE project	
<p>actually a layout with fixed components/objects</p> <ul style="list-style-type: none"> •It is not necessary to know exact timing. However, when editing, show the timing, e.g., video and timed text has a 5-second difference •Live interface is not timeline-based. Information and graphics appearing on the screens are triggered as events following a sequence, not really timeline-based. •For the companion screens, design the layout like a website, with menus. • End user options should be allowed to select single video, side-by-side two videos or event four videos at the same time, with different videos/contents. 	<p>player scored a goal, graphics about the player and time of the goal need to be triggered manually (This cannot be determined at pre-live phase). Make sure these graphics are not overlapped with others. Reserve an area on screens for this kind of information.</p> <ul style="list-style-type: none"> •Some information must be shown all through the race (fixed components, logo, sponsors), they might overlap at the same area, you must give them hierarchy/reserve position when authoring. Make sure this kind of information should be always on screens. •For different end users, showing different version of the information, e.g., for neutral audiences, showing both teams side by side. •For pre-race and main race, the priority of the DApp components is different. Give some hierarchy to the DApp components.

Table 6. Validations and suggestions about details.

4.5 Phase 5: Development and pilots

Phase 5 focuses on implementing the design concept with the details suggested by the professionals, and planning for pilot tests of the implemented prototypes. As advised by the professionals, an anthropological study was conducted at MotoGP Silverstone for understanding the live production process. The implementation is in progress. The research question “How is the user experience with the implemented production tools?” has not been answered yet.

4.5.1 Silverstone: Observing the MotoGP Production Process

The MotoGP production process was observed in the OB trucks at Silverstone in August 2017, to provide a wider view on workflows and tooling, within a different context. (i.e., moving from studio based production facilities to an outside broadcast Live scenario). Two sets of observations were made:

- (1) Dorna production facilities Tour;
- (2) BT Sport (NorthOne) Gallery during MotoGP Grand Prix.

The aims of the MotoGP study are presented as follows.

- (1) To understand more about DORNAs production tools and work processes. What tools are used? What are the roles and responsibilities of people in the OB truck? To support this we’d really like to observe DORNA and North One operations in an OB truck during a live race.
- (2) To understand more about the editorial decisions you make during a live race. What rules govern your decision making, what’s automated and what is dynamically editorial driven?
- (3) To clarify some technical details on content formats for data, audio and video. How do you synchronize different content streams? What bitrates do you encode at for delivery to TV, App and Websites, etc.? How would media and data feeds be provided for a future OBB production?
- (4) Confirm additional material that will be useful for our trials. Specifically, this includes higher resolution .png of rider numbers, side profile of bikes, rider pictures, sting and cut video sequences.

The study at MotoGP Silverstone provided insights about the live production processes. Live production is intense and stressful. Once the live button is on, everyone in the broadcasting team is

utterly focusing on their own tasks. Fig 60 illustrates a simplified map of the seats and roles at the NorthOne OB truck. The main tasks of each member of the live broadcasting team are presented as follows.

- 1-Production assistant.** Keep up with the schedule, counting down with a stopwatch.
- 2-Producer.** Decide together with Director, and inform the whole team about a sequence of content that will be presented next, typically during a break. Work together with BT coordinator about what replay clips should be made.
- 3-Director.** Coordinating the whole team. Decide the look and feel of the program. Communicate with the presenters and the camera men.
- 4-Graphic operator.** Make graphics (results, name labels etc.) in real-time. Usually use a template and just type in statistics.
- 5-Graphic editorial.** Check the graphics before sending it on air. Edit higher-level graphics, commercial clips in Premier.
- 6-Audio mixer.** When program is on air, making sure it has the correct audio signal.
- 7-Researcher.** Have good knowledge of MotoGP, help BT coordinator to decide the replay clips
- 8 & 10-K2 operators.** K2 is a replay controller (Figure 2). Two operators are constantly making, coding and sorting replay clips during the live production.
- 9-BT coordinator** is directing the K2 operators to make replay clips (e.g., deciding when does the clip start and how long it should be).

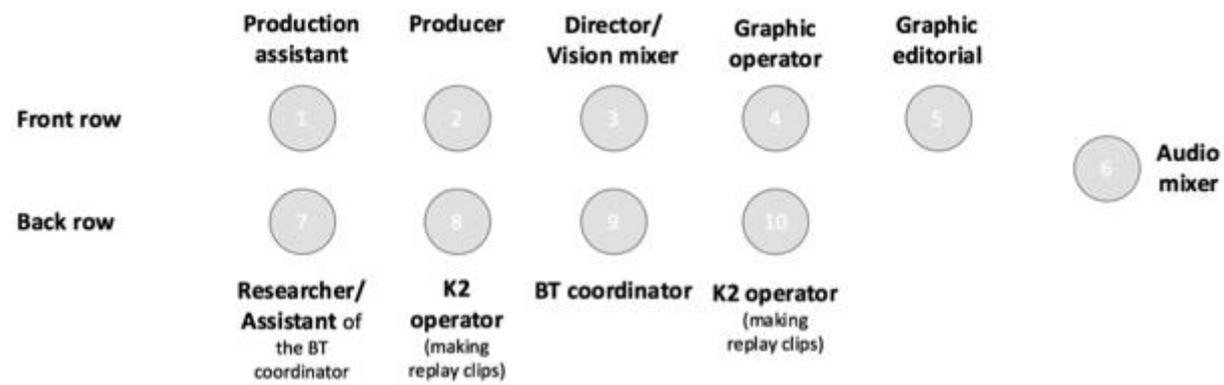


Fig 60. A map of seats and roles at NorthOne OB truck

The live production is a mature process. The team works as a symphony orchestra. However, it is still a stressful process. Currently, the team only focus on TV screens. It is difficult to follow current process to provide content for multiple screens. In the next section, we propose to develop an extensive pre-production tool, a live event template tool and a simplified live triggering tool.

4.5.2 Current status: Three production tools and pilots

According to the anthropological study at MotoGP, we decided to include both pre-live and live function into our tools. Therefore, we plan to develop a set of three tools, namely multiscreen scripting editor, near-live event editor and live triggering tool. The suggestions of detail designs will be taken into consideration while implementing the tools.

The multiscreen scripting editor is for planning and authoring programs for multiple screen experiences. It provides a hierarchical overview of the “parts” of a program, and layout templates for different screens. DMAP components can be applied across screens, to be left as placeholders or to be configured into pre-recorded videos, graphics and other contents that can be prepared during pre-live process. The near-live event editor aims at reducing the workload during live broadcasting by providing templates for certain events (e.g., crashes, overtakes in MotoGP). The template resembles a “data package”, including graphics, placeholders for camera feeds, and scripts describing sequence of contents within this event. For instance, when a crash happens at MotoGP, there will be profiles of the drivers on air, a replay of the crash, a picture-in-picture showing the team reactions of the drivers etc. With the help of the near-live event editor, some anticipated events can be prepared in advance for multiple screen. Thus, the workload of the live broadcasting can be reduced. The interface of the live triggering tool contains only “buttons”. The director can trigger the events at the correct timing. The unique selling points of the three tools are presented in Figure 61.

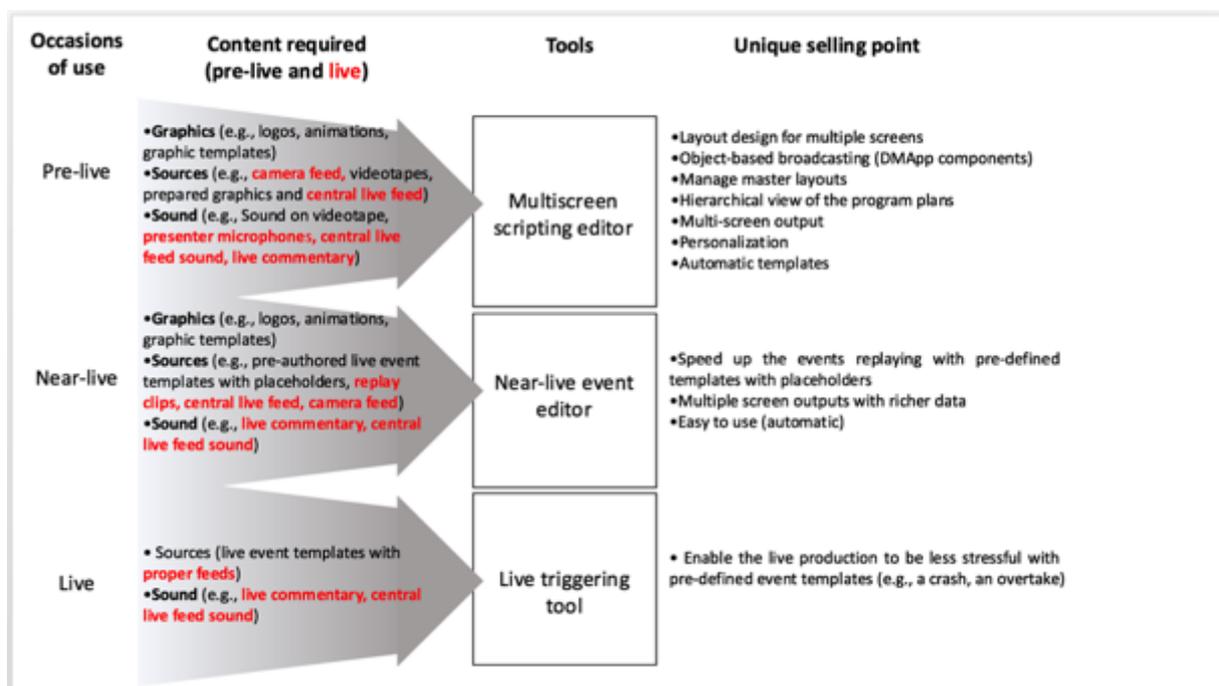


Fig 61. Three tools to be implemented for the pre-live authoring and live broadcasting for the multiple screen experiences.

Multiscreen scripting editor

The implementation of the multiscreen scripting editor is based on the re-designed IDE mixed concept (Fig 62). Recommendations from the evaluations are considered. The development of the scripting editor considers the requirements discussed in Section 6.3.2, including testable layout designs, editable templates, DMAP components that allow statistics, graphics to be generated on demand, and organizing the components and parts of a program.

Next step, the multiscreen scripting editor will be tested with “theatre in school” scenario. The first step is to test the prototype with production professionals and refine the prototype. The second step is to test it with school teachers, who work as “program authors” of the course content. The teachers are expected to build “theatre-in-school” viewing experience for their students on multiple screens.

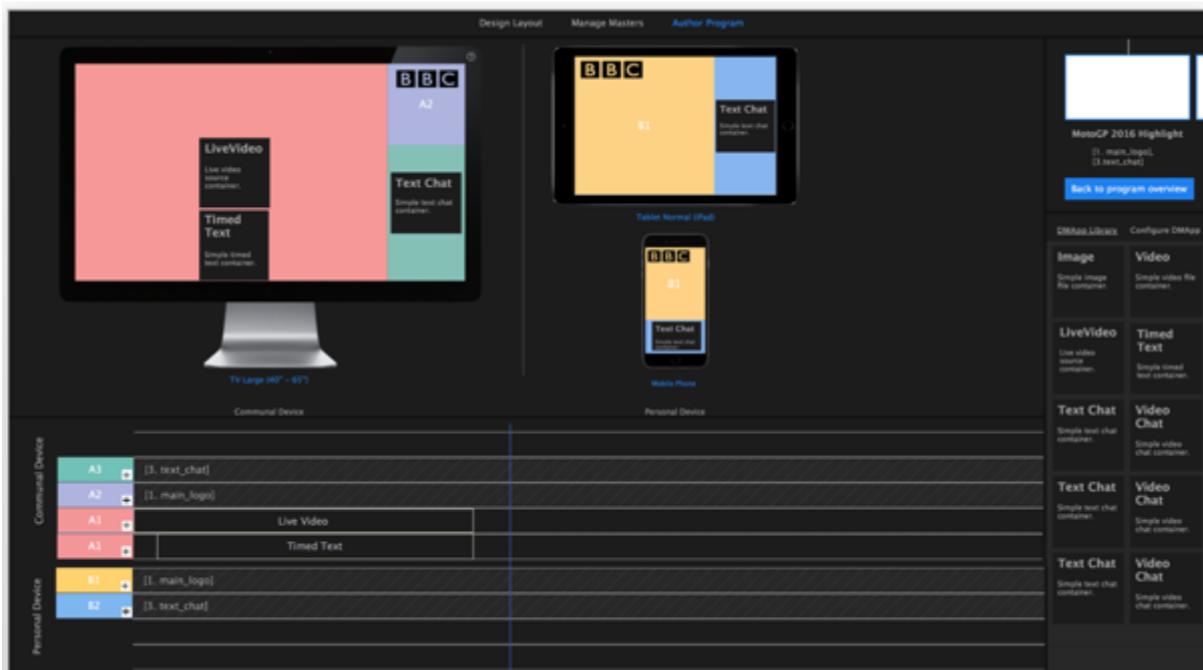


Fig 62. Multiscreen scripting editor

Near-live event editor

The near-live event editor is an extension of the multiscreen scripting editor, and a supplement for the live triggering tool. It aims at providing templates for live events and enabling quick reactions to those events (see requirements in Table 1). Since live broadcasting is an intense and stressful process, it is impossible to require current live broadcasting teams to provide contents for multiple screens. The near-live event editor is developed to make it possible by reducing the workload during live period, allowing the team to prepare most contents pre-live.

Next step, the near-live event editor will be tested in lab, with “as live” simulations of MotoGP race.

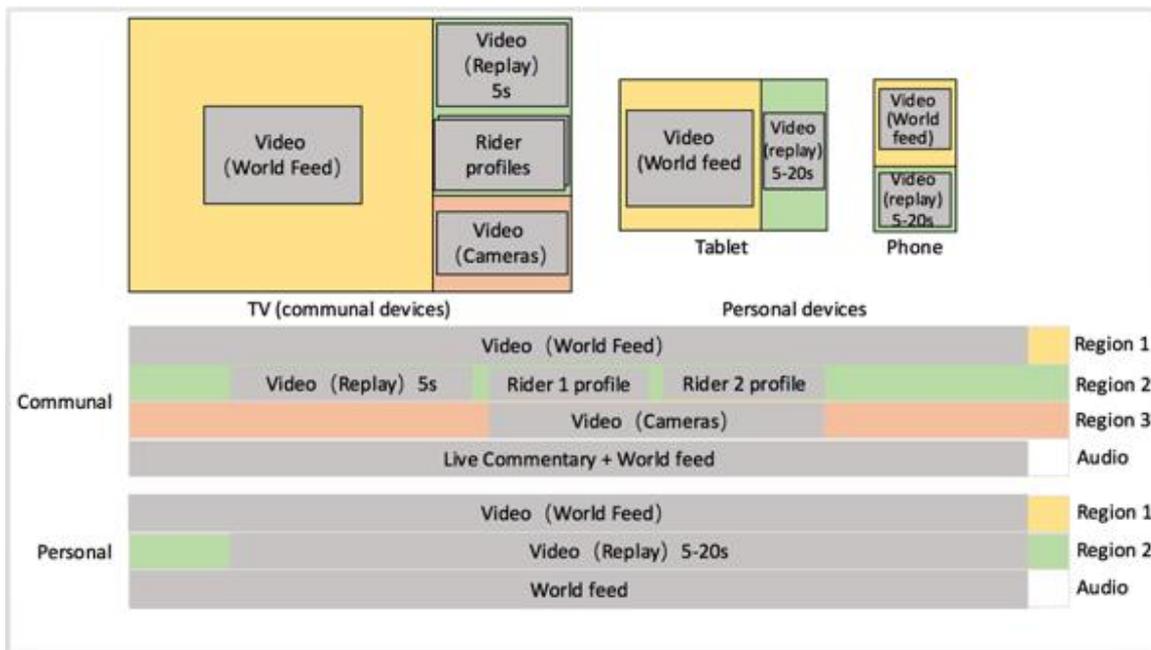


Fig 63. Near-live event editor: A pre-defined “template” include what need to be shown when an event happened (e.g., two riders crashed).

Live triggering tool

The live triggering tool is simplified to have only two types of “buttons”. One is to trigger a prepared event, another is to modify the event (e.g., remove the event, reduce the length of the event, editing the event in the live event template tool). A separate screen will show the preview of the triggered events by clicking on “launch preview” (Fig 64-66).

Next step, the live triggering tool is planned to be tested in live OB truck for football matches.

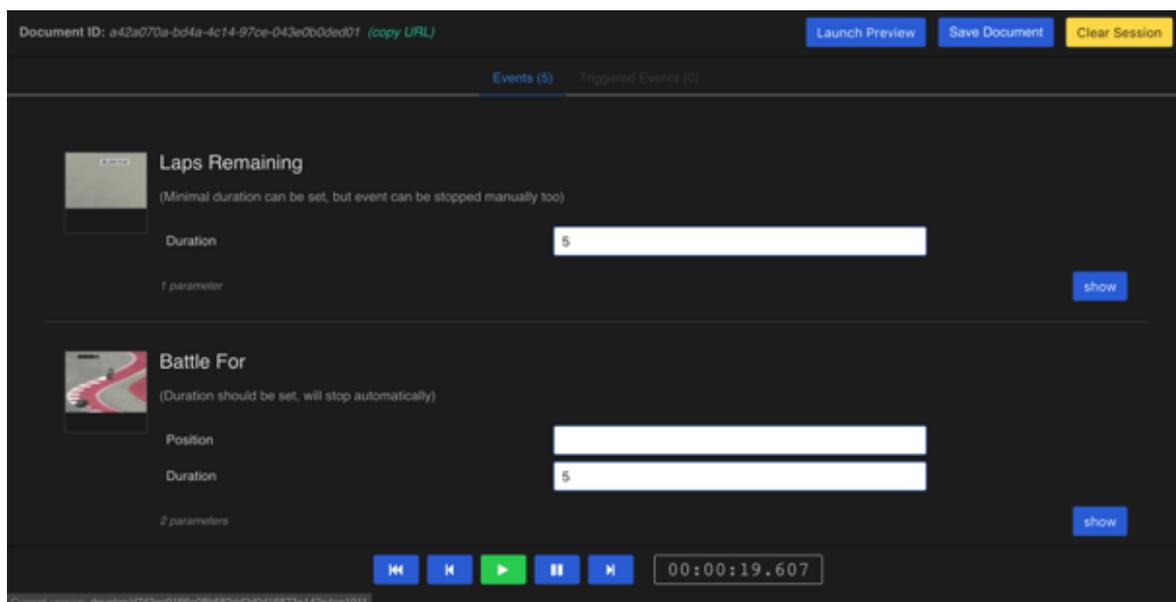


Fig 64. Live triggering tool: Prepared and un-triggered events. Click “show” to trigger.

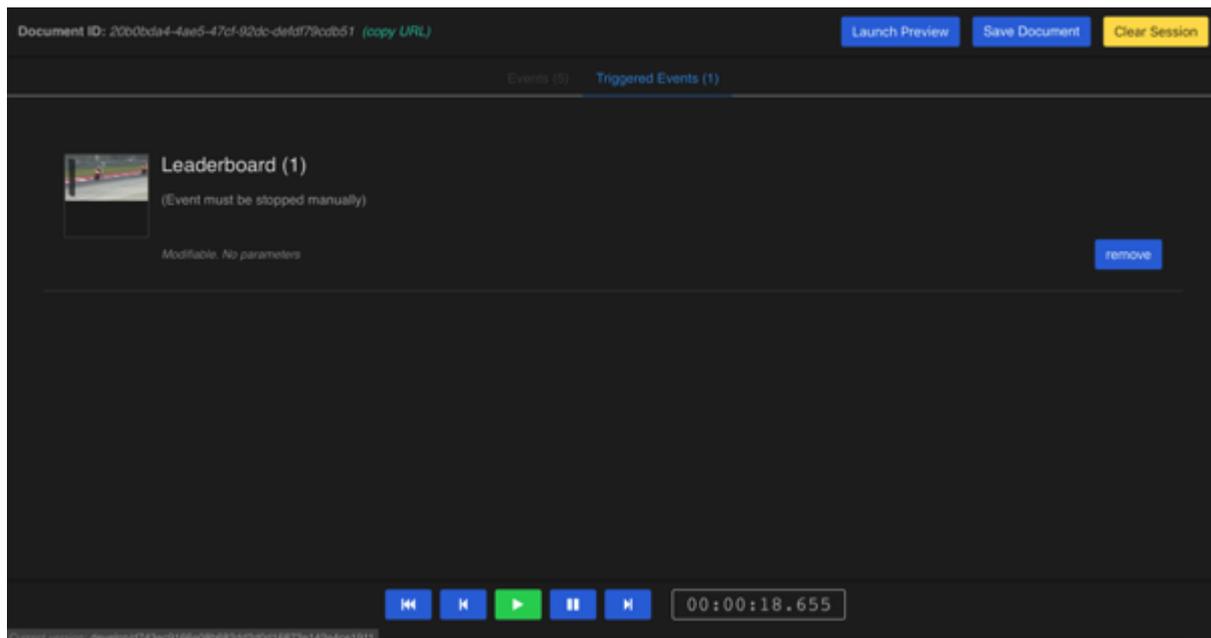


Fig 65. Live triggering tool: Triggered events. Click “remove” to stop.



Fig 66. Live triggering tool: Launch preview to see “triggered” leaderboard.

5 Supplementary trials

The work described in this section looks at usability and design issues from a perspective that may be considered to be broader than are considered in the previous section. We have two questions that we have been addressing. The first relates to the assessment of the impact of certain design choices on an overall experience when so many other factors are at play. The second evaluation issue relates to a different set of users, as it relates not to viewers but to developers. How can we assess that the work we are conducting is good for the people in the industry that may make use of it? What kind of test evaluations and proof-points should we seek as we try to validate that the approach we are taking is relevant for and useful to the industry?

With regard to the general ambition of the project and the multi-screen experiences we want to present, be they football, theatre or Moto GP to viewers, we want the design choices we make to have two distinct impacts, which we hope are convergent. We want the design choices we make to be attractive to people and we want the design choices we make to cause increased positive affect on the audience.

Assessing the relative affect of design-choices relating to the presentation of Football in Pubs

One of the enduring concerns we have is that to assess the impact of our design choices and their ability to affect people, we really need our users to engage with content under the terms that they would normally engage with it, if it were a live service. So ideally it would exist as a live service before it is being assessed.

The complexity, technical risk and cost of enabling parallel system at scale currently precludes the ideal testing system – i.e A-B testing where live customers are randomly presented with alternative presentations of the “same” experience and feedback on their experience is sought objectively, so alternatives have to be sought.

Part of our problem is the perishable nature of potency of the stimulation that can affect our viewers. Watching my team score a late winner will be a highly affecting experience when viewed live. When viewed again a week later it may stimulate a fond remembered response but the intensity is completely different. Likewise the potency of the dénouement in good drama will almost certainly be felt more keenly the first time it is experienced, almost regardless of the quality of that production.

Similarly it would surprise no one to find that poor coverage of an important and ‘good’ game involving a team I care about will have greater affect than good coverage of a dull, irrelevant game involving teams that are not important to me. So how can we make assessments about whether a different presentation contributes to a better experience?

This work has, as its focus watching sport in pubs. This use case is not in focus any more within the project but at the time this work was explored it was still very relevant. Watching sport in pubs has been examined by academics as a sociological phenomenon [7-13], by both regulators and the judiciary as a cultural phenomenon [14,15] and by analysts as an economic phenomenon [16]. It is clear that watching sport in pubs has importance sociologically, culturally and economically. And we want to understand whether the design choices we make can be correlated with the experience being more affecting.

This experiment is designed using recorded content of a football match. The content has, therefore, lost the potency to affect because of its ‘liveness’. Given that loss of potency, we sought an

experimental design that would not presume the long-term engagement and attention of the viewers and sought to make assessments based on short segments of the experience. An advantage of this ambition is that overall assessment time could be reduced and the number of viewer assessments in a given time could be increased so we could gain the responses of more viewers.

We refined the test further with a particular event in mind, knowing that we would have access to our judges for only about 15 minutes.

The test sought to assess, and ultimately to compare, the enjoyment levels reported for four different presentations of football. We had licensed access to recorded content from the 2016 FA Cup final contested between Crystal Palace and Manchester United. The match was quite dull, only coming to life in the second half when Crystal Palace scored. Manchester United soon equalized and eventually won during extra time. The content we had recorded included 12 isolated camera feeds in HD from the entire broadcast. These included captures from: the helicopter camera hovering above Wembley stadium; the in-stadium spider camera, providing a birds-eye view of the match; a camera focused on the Crystal Palace supporters; the Manchester United in-goal camera; and a camera focused on the Crystal Palace Manager. We also had access to camera streams recorded from trials of a number of robotic cameras that provided coverage of the entire match. One showed the whole pitch; one framed an image based on the location of the Manchester United Captain (Wayne Rooney) and one framed a shot based on the position of the ball. In addition to these video assets, we also had access to a number of recorded commentaries from the BT Sport team and from BBC Radio London. The latter were enthusiastically pro Crystal Palace in their approach.

An important test design was to assess the enjoyment of one of four presentations of a test clip as compared to the recorded enjoyment of a common baseline clip. The baseline clip was of the kick-off. It was a single screen presentation. This clip, which was uneventful, lasted 75 seconds and was seen by all groups. It was followed, for each group by one of four presentations (A to D) of the test clip which lasted a little over 3 minutes. The test clip was eventful as it showed a goal scored by Crystal Palace. The A and B versions of this clip used only a single screen showing the as-broadcast BT Sport presentation shown on the central screen; clip A used the BT Sport commentary, 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 Crystal Palace crowd (right screen) and the Crystal Palace manager (left screen). Figure 1 shows the screen layout used for the 3 screen presentations. This 3 screen layout was judged by the designer to offer more insight and to induce more empathy.

The screen layouts and content choices used were made based on professional judgement from designers based on extensive experimentation. The designer developed the concept of a primary viewing zone which is defined as an area that can be viewed and assimilated without the viewer moving their head but which may utilize more than one screen. The layout of the primary viewing zone for multi-screen presentations is.

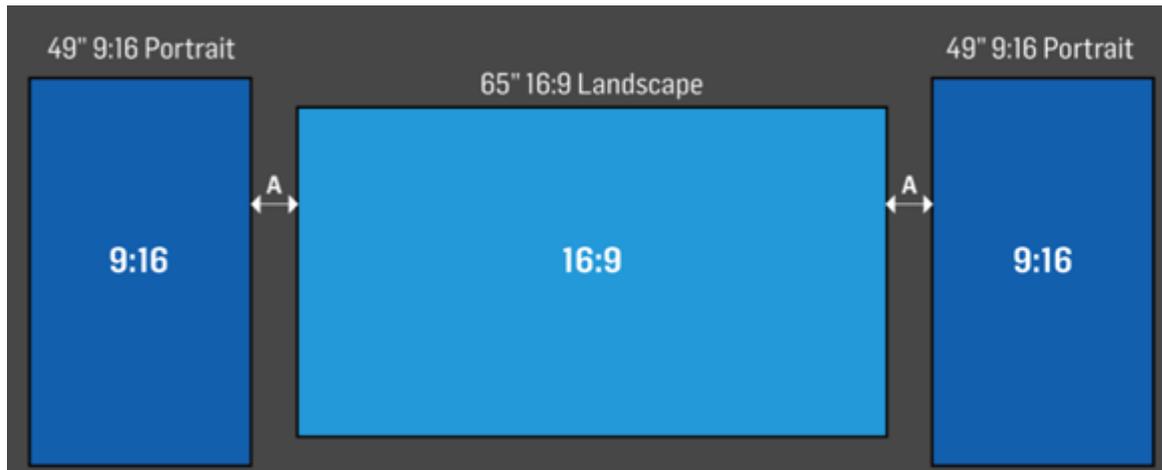


Fig. 67. Configuration of screens developed for the three screen presentations.

Each group was made up from 15 or so children (judges), from a single school accompanied by an adult, usually their class teacher. Each group was invited to sit down and to watch and assess two clips. The judges sat in numbered seats between 2 and 4 metres from the central 65” screen. The side screens measured 49” across their diagonal. The lighting was subdued. Sound (the broadcast commentaries) was played from the speakers of the central TV speaker and the volume was set at maximum, it was not distorted. A number of segmentation questions were asked (Age, Gender, How much do you like football? etc.) in order to help us understand the make-up of our judging panel.

	<i>Commentary</i>	<i>Screen Left</i>	<i>Screen Middle</i>	<i>Screen Right</i>
A	BT Sport		Broadcast feed	
B	Radio London		Broadcast feed	
C	BT Sport	Crowd	Broadcast feed	Manager
D	Radio London	Crowd	Broadcast feed	Manager

Table 7. Summary of the conditions for the four presentations being assessed

After each clip the judges were asked to indicate “How much did you enjoy this clip” by placing across on a line labelled at the left hand end, “I didn’t like it at all” and on the right hand end “I loved it”. Each group had received training in the question format using the questions “How much do you like chocolate?” and “How much do you like school?”.

RESULTS

Two hundred and thirty judges made assessments; 118 were female, 112 were male.

Assessment of the responses received involved measuring the distance in millimeters between the left hand end of the line and the cross placed by each judge. Three scores were recorded for each judge: one for the calibrating kick-off clip, one for the test sample (A, B, C or D). The third score, the

calibrated score, was derived by subtracting the score given for calibration sample from the test sample this became a measure of how much more they preferred the second clip to the first clip.

Age	9	10	11	12	13	14	Adults
Count	4	75	90	8	29	10	16
%	2%	33%	39%	3%	13%	4%	6%

Table 8. Age Demographic of participants

ANALYSIS

Eleven of the response sheets were clearly not used correctly. Judges were placing ticks above the descriptive term at the end of the line “I didn’t like it at all” and “I loved it” rather than placing a cross upon the line. This was addressed through illustrating how to answer the test questions on a white board at the beginning of each 10 minutes session.

	A	B	C	D
Count	58	49	67	56
Mean	76	66	61	62
Variance	2447	1607	1568	2001
SD	49	40	40	45
SD as % of mean	65%	60%	65%	72%

Table 9. - The raw scores of the enjoyment levels as indicated by the judges

The raw data, see TABLE 9. are noisy, with standard deviation measured as a percentage of the mean showing the scores had wide variance. However, in our test design it is the calibrated score, i.e. the measure of by how much more our judges preferred the second clip (one of the clips A to D) to the first clip, is our metric.

The mean value of the calibrate scores see TABLE 10. suggests the three screen presentations (clips C and D) offered more enjoyment than the single screen presentations with the calibrated mean scores for C and D being 26 and 33, while A and B were 19 and 18.

	A	B	C	D	AorB	CorD-
	-k.o.	-k.o.	-k.o.	-k.o.	-k.o	k.o.
Count	58	49	67	56	107	123
Mean	19	18	26	33	19	29
Variance	1441	1769	1470	1266	1576	1376
SD	38	42	38	36	40	37
SD as % of mean	196%	228%	145%	108%	210%	126%

Table 10. The calibrated scores of the enjoyment levels as indicated by the judges

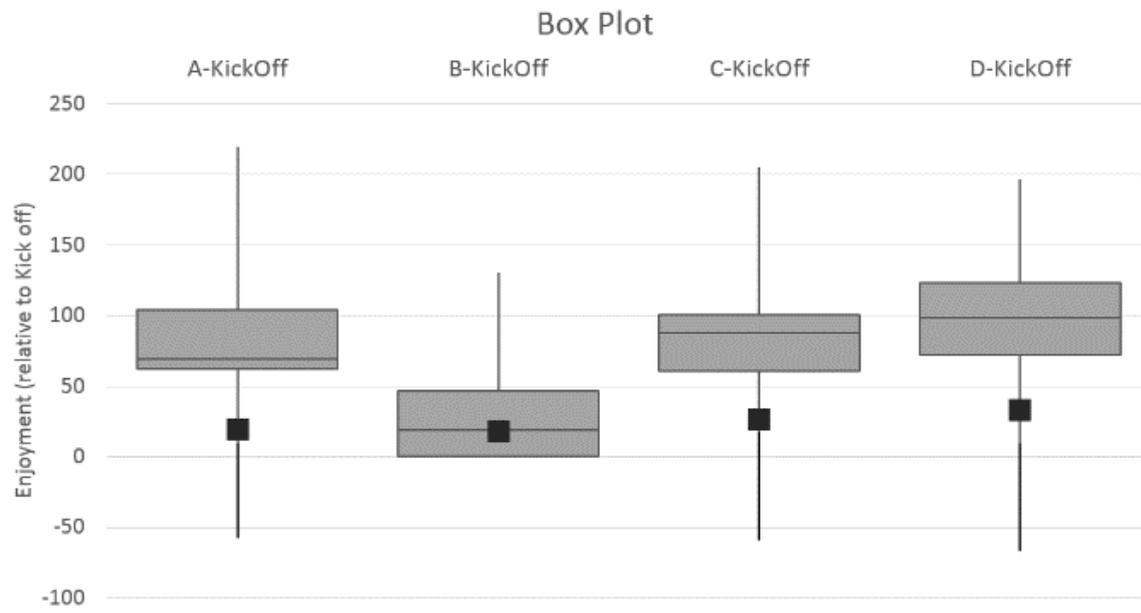


Fig. 68. Box plot of the calibrated scores for the indicated enjoyment of the different presentations.

In order to explore how likely it was that any reported differences occurred by chance Student’s t-tests (two tailed and for different numbered samples with normal distribution not assumed) were carried out for the seven paired cases shown in Table 11.

	A-B	A-C	A-D	B-C	B-D	C-D	AorB/– CorD
T-test (cal)	92%	30%	5%	30%	6%	34%	4%

Table 11. T-test values, indicating the likelihood that the difference in mean scores between various sample pairings was down to chance alone

Table V results show weak evidence that our null hypothesis is invalid. Only the comparison pair AorB to CorD resulted in a Student’s t-test score suggesting that the difference is less than 5% likely to be by chance.

CONCLUSION

An analysis of the assessments made by a population of 230 people, 83% of whom were aged 14 or under, of the enjoyment derived from 4 different TV based presentations of football has been completed. Student’s t-tests were carried out for pairings of all data sets and they suggest that the only pairing for which there was less than a five percent likelihood of the reported difference occurring by chance, is that judges gained more enjoyment from a three screen presentations (designed as a partisan representation to favor Crystal Palace) than they did from the single screen presentations. No significant differences in enjoyment were reported from the use of different commentaries.

Whilst the results of this experiment do not strongly contradict the null hypothesis that no differences in enjoyment would be observed, we are encouraged by the opportunity offered by the test design. Organizing subjective tests is complex and time consuming but this method, whilst intensive, allowed us to collate the opinions of 230 subjects whilst only using about 15 minutes of the time of any one contributor. We believe the method is valid and could be used again in exhibition like situations enabling opinions on different screen presentations to be assessed.

6 Summary & Looking Ahead to D3.4

This document has described the three contributions to the preparation for the MotoGP service development and trial. It has described the results of prototyping and testing interaction mechanics, making reference to additions or changes made to the core set of 2-IMMERSE platform features (previously described in D3.2) in the following areas:

1. OnBoarding and Set-up: we have designed & built a Set-Up and OnBoarding process which includes notifications, troubleshooting, some tutorial assets.

2. New capabilities of the 2-IMMERSE platform (utilized in the MotoGP service): for example we have created DMAPp functions for multiple camera streams including 360 video, responsive and adaptive screen layout and overlays, and timeline based events and replays.

We proposed a user experience interaction design for the new set of DMAPp features –illustrated in detailed wireframes from which we generated technical requirements. We created MotoGP user interface assets & macros.

We identified research questions & data analytics required for the service trial, adapting and refining the trial method from the *Theatre at Home* service trials. We have observed the MotoGP production process.

3. 2-IMMERSE Production tooling: We gathered requirements gathering for design and development of **Production Tools** through observations, interviews, and workflow mapping exercises. Design processes such as wireframing fed into the development of 4 production tool concepts, and the creation of 3 production tool prototypes to be evaluated.

Next steps for WP3

The aims and objectives for the remainder of WP3 includes work in the following areas (to be reported in D3.4, and D3.5):

1. OnBoarding & Personalisation

- Development of Tutorials
- Dealing with Experience levels (Personalisation)

2. Theatre in Schools

- Reflection on the lessons learnt from *Theatre At Home* trial
- Identifying drivers and initial assumptions behind the *Theatre in Schools* service
 - Defining context—through observations in schools & interviews with education practitioners
 - Defining concepts & requirements –through presentations & workshops
- Designing the User Experience
 - Workshoping concepts with donmar
 - Prioritisation of UX concepts –tech-reviews, and ux-design proposal reviews (with the Donmar theatre company & other education practitioners)
 - UX design & layout, Interaction design activities –wireframing the user journey, creating user interface assets

- Background research and exploratory studies on the 2-IMMERSE production tool – from building an experience, through to orchestration & curation of the experience (e.g., designing user journeys for producers, educators, teachers & students)

3. Football In the Home

- Background research: exploring viewing positions in public spaces; user requirements gathering; Screen layout & composition demos.
- Defining the **aims of the Football trials** and the scenarios of use to be included –e.g., Live or as-Live, Private or Public space, Multiple scenarios/different devices/set-ups-and their configuration/orchestration, multiple TVs 3G/4G/Wifi networks, additional stakeholders in the value chain (landlord)
- Defining **new DMAP features** to be included in the 2-IMMERSE platform:
 - **Immersive VR** -Headset Sync; Magic Window, a sync'd magic window controlling TV
 - **Live Alt views:** Manager Cam, Player Cams, Data driven edit decisions, duplicate GFX Layer (no PiP)
 - **In game replays:** Multi-screen Replay prompts, Push to TV [Timeline, selectable VOD assets to push to TV), Push to TV [Event List, selectable VOD assets to push to TV), Dynamic live GFX Layer.
 - **Data driven GFX objects:** Stats Flipper, Player Tracking, Enhanced Player Supers, GFX Layer.
 - **Social & Participation Objects:** Pundits:, Team Specific, Custom Group, Calls to Action.

4. Production/Authoring Tool (*this is captured in WP5 but UX preparation work is captured in WP3*)

- Evaluate the 3x concept designs –with multiscreen editors and producers-use case for *MotoGP* (Dec'17), and *Dorna*; and *Theatre in Schools* (April/May & Sept'18) with producers, and teachers.
- WP3 activities for building the *Football* service will offer an opportunity for the evaluation of 'capture' (e.g., IOS capture –alternative methods to capture are required as a 'bolt on' to existing production; also compact, automated systems); and the evaluation of the 2-IMMERSE production tools, for example, live end-to-end production; (March'18), and longitudinal trials.

5.2-IMMERSE Platform trials

A series of trials to access the 2-IMMERSE platform will be carried out. That will stress-test the platform, refine its usability and sustainability, and consolidate and iron-out outstanding issues. This will include external and internal assessment of the platform, this could be the ground work to build-up to a full scale trial.

For example, a series of small studies with developers could explore the use of the 2-IMMERSE platform, such as evaluating the process of developing and adding a DMAP component; we could plot out the graceful degradation of the experience in response to variable bandwidth and encode it into the system (i.e., how might we scale it depending upon the bandwidth available and the requirements of the producer); we could explore *Configuration & Personalisation* of the 2-IMMERSE system, such as comparing the automated pre-loading of components vs. manual component

selection; we could explore levels and types of curation & mediation with a variety of ‘contexts of use’ –such as the user at home experience (host & guest perspectives), or the directors experience of creating a new service for a variety of users, or the teachers experience vs the student.

We plan to cover:

Orchestration (when and where things happen)

- Orchestration of:
 - Timeline (events)
 - Layout (screen real-estate)
 - Bandwidth (content delivery)
 - Timing (synchronisation)
 - Data (shared state)
 - Device roles (user interaction, device capabilities, battery life)
- Also driven by experience design constraints and personalisation

Platforms Lab Tests

- Current Trials
 - **Fixed hardware, invariant setups for comparability / consistency**
- Platform Trials / Lab Tests
 - **Better for accommodating variability**
 - Testing features of the platform required by service trials
 - Evaluating the platform (community of practice)
 - Sustainability, usability, maintainability
- Technical debt & technical discussions
- Reference architecture, documentation & dissemination

Platform Tests/Lab Trials

1. Evaluate platform behaviours not tested by service trials
 - Multiple networks, scalability/availability, multiple TVs, layout configuration, roles & permissions, graceful degradation over TV device capabilities, HbbTV2 device support etc.
2. Test service trial features
 - Beta testing “live” end-to-end
 - Network bandwidth and QoS tests
 - “OB truck” content ingest test
3. Platform evaluation (qualitative and quantitative)
 - Tutorial and Criteria-based evaluation
 - Authoring 3rd Party components, services and DMApps

- 3rd party peer review
- Plug-fest, hackathon

6. Summary & Dissemination of UX work

It is important to summarize and disseminate the insights from our UX design work in digestible forms, such as **guidelines, visualizations, responses to components/features**, as guidance for developing a multiscreen experience for the user, for the producer, and the developer.

We will use a number of methods for dissemination, including dissemination to users via:

- Web
- Showcase events
- User trials

We will disseminate to producers via:

- (Observation or inclusion in) User trials
- Guidelines and recommendations

We will disseminate to developers via:

- API guidelines
- Workflow examples.

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Annex A Google Chromecast User Experience Analysis

Google Chromecast



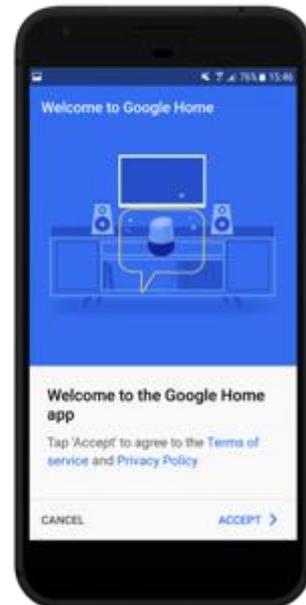
Chromecast device on the TV requires mobile or tablet device to set up wi-fi connection.



Google Chromecast



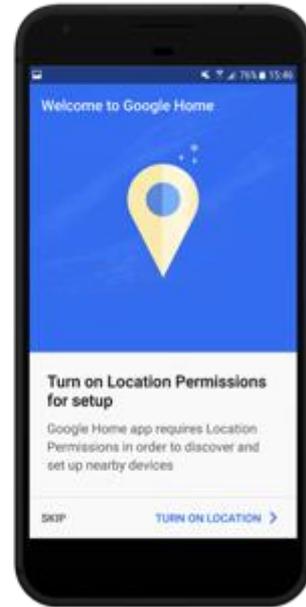
Mobile app is installed. Majority of on-boarding is done on the mobile device.



Google Chromecast



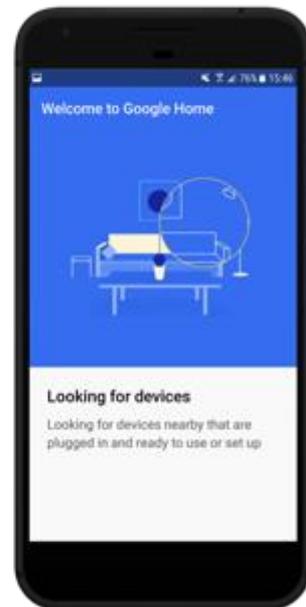
Simple illustrations accompany each step.



Google Chromecast



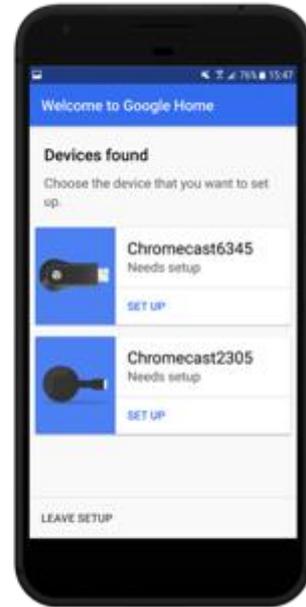
Google Home app will search for compatible devices that need to be set up.



Google Chromecast



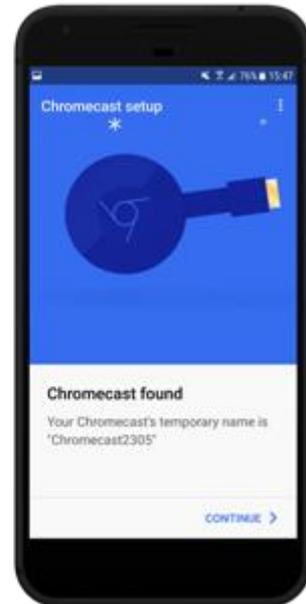
You can select the device that matches the Chromecast name displayed on the TV.



Google Chromecast



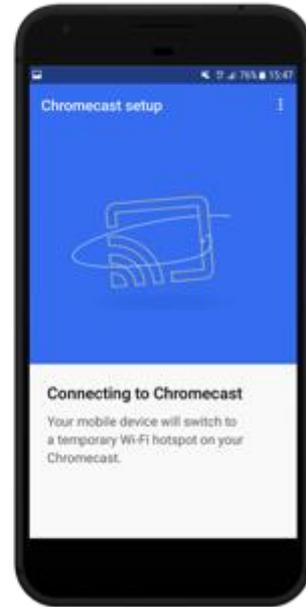
You can select the device that matches the Chromecast name displayed on the TV.



Google Chromecast



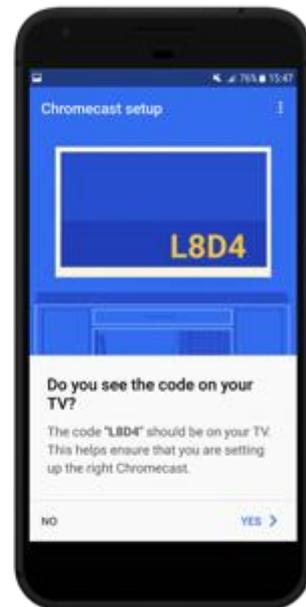
Setup will try to automatically connect to the Wi-Fi hotspot produced by the Chromecast.



Google Chromecast



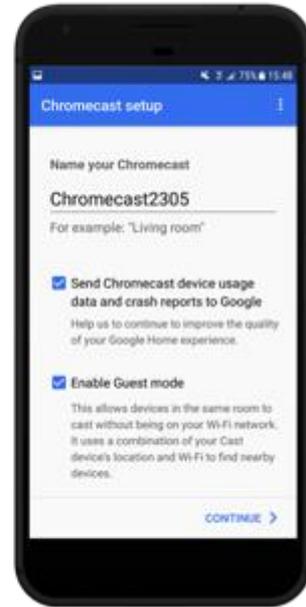
Pairing code is presented once the Chromecast has been detected.



Google Chromecast



Ability to change the device name to make it more personalised/recognisable to the user.



Google Chromecast



Wi-fi setup is done through the mobile device.



Google Chromecast



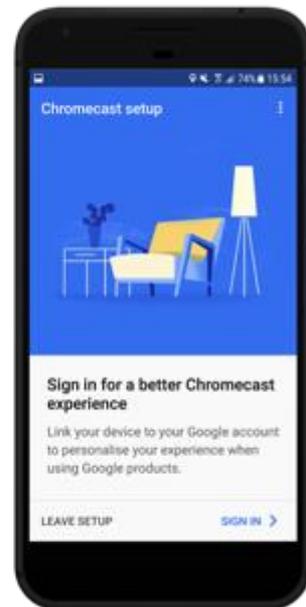
Wi-fi setup is done through the mobile device.



Google Chromecast



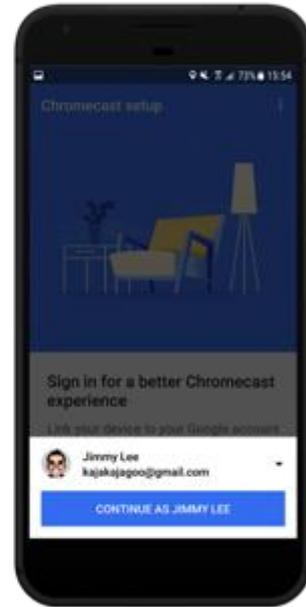
Prompts to sign-in with a Google account, for a better experience.



Google Chromecast



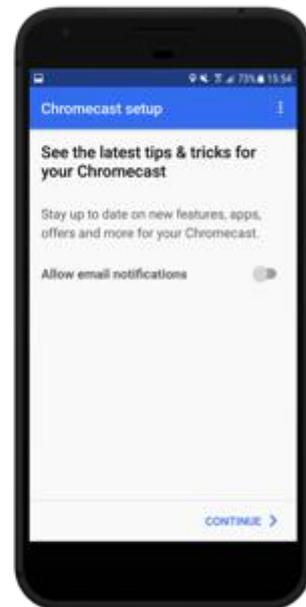
Prompts to sign-in with a Google account, for a better experience.



Google Chromecast



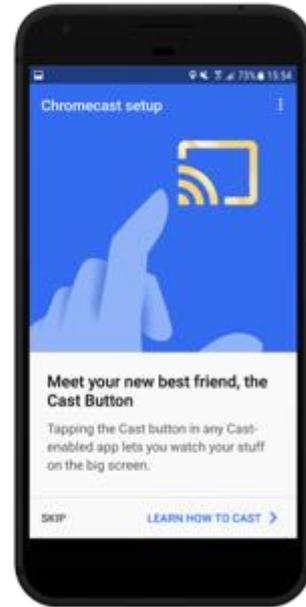
Toggle notification settings.



Google Chromecast



Onboarding for Chromecast features start here.



Google Chromecast



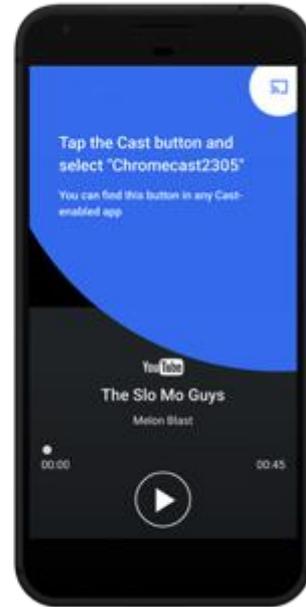
By getting the user to go through the motions of casting, they can learn the feature contextually.



Google Chromecast



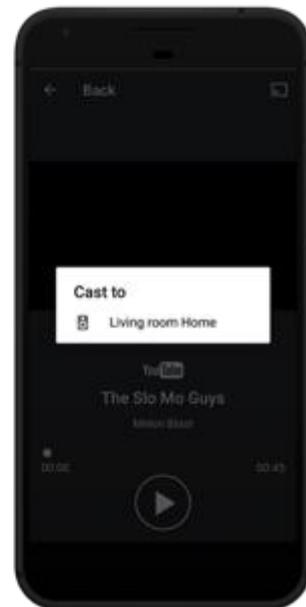
Use of animation draws attention to the CTA button.



Google Chromecast



Cast demo content to a device that the user has just set up.



Google Chromecast



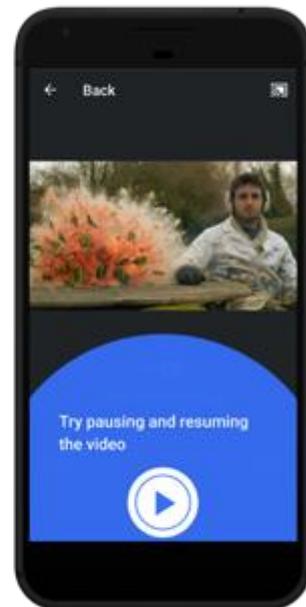
Visible result from action of trying out the cast button, appears on the main TV screen.



Google Chromecast



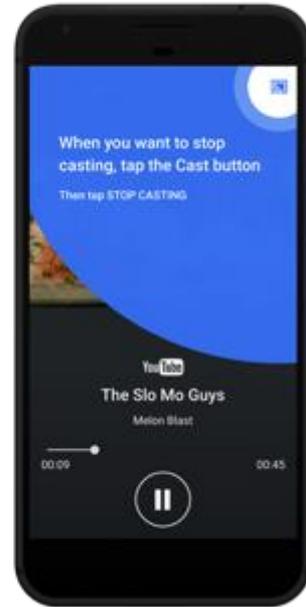
Animation draws attention to other features available on the mobile app.



Google Chromecast



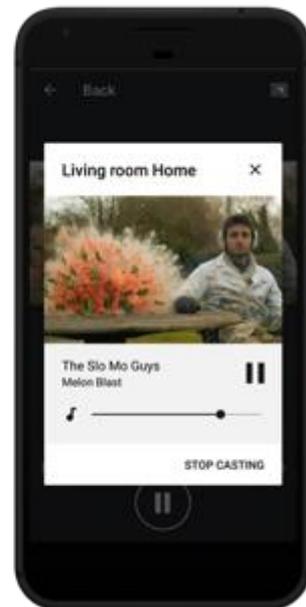
Repetition of on boarding approach for toggling on-off the cast function.



Google Chromecast



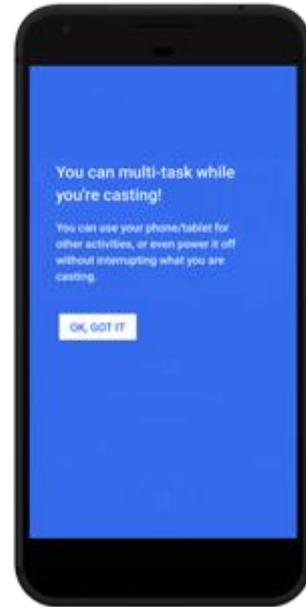
Confirmation window to stop casting



Google Chromecast



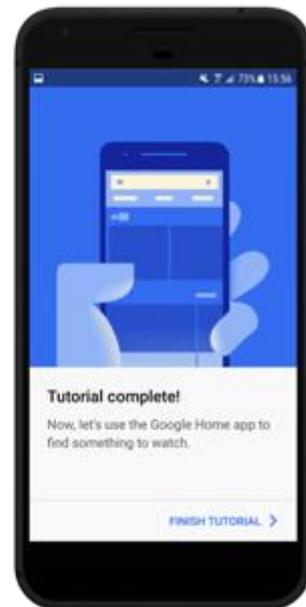
Penultimate on boarding screen to make sure user understands features.



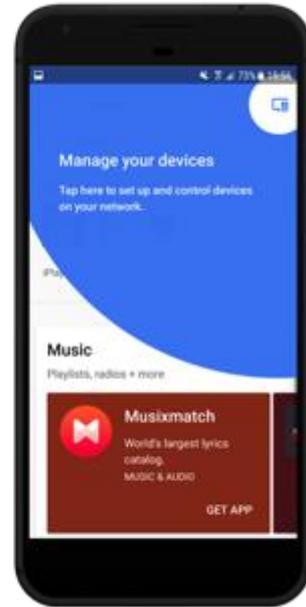
Google Chromecast



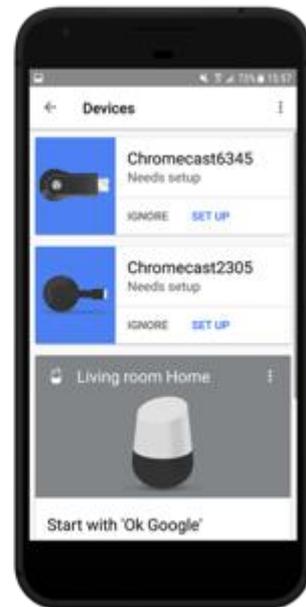
On-boarding tutorial complete.



Google Chromecast



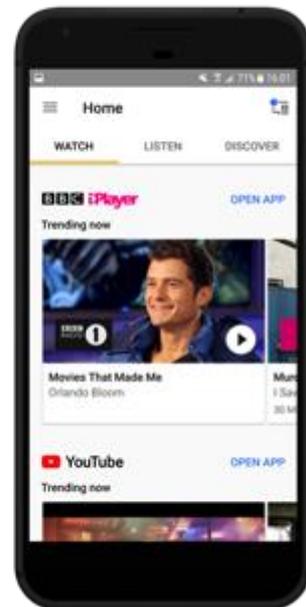
Google Chromecast



Google Chromecast

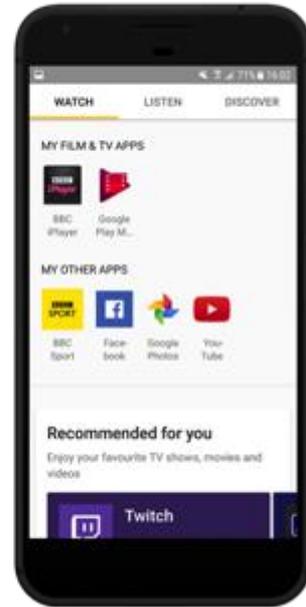


Google Chromecast

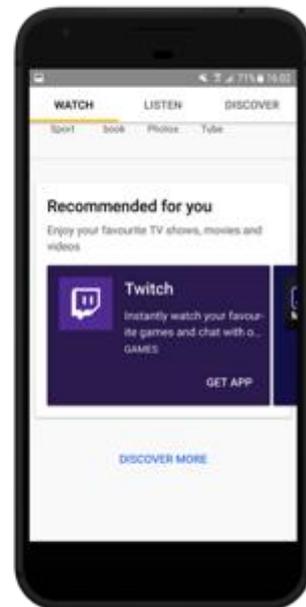


More content to get user stuck straight into the act of casting content.

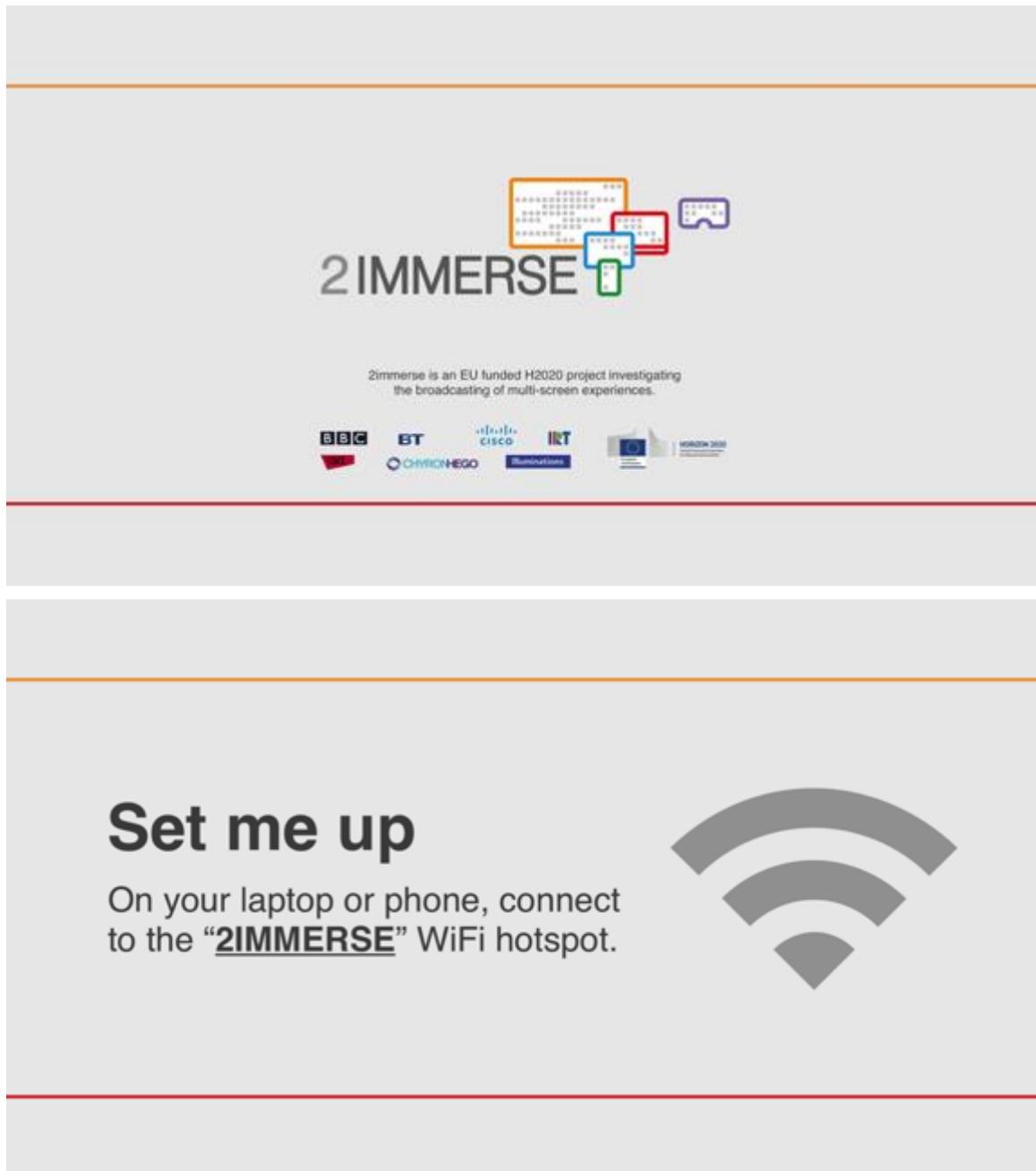
Google Chromecast



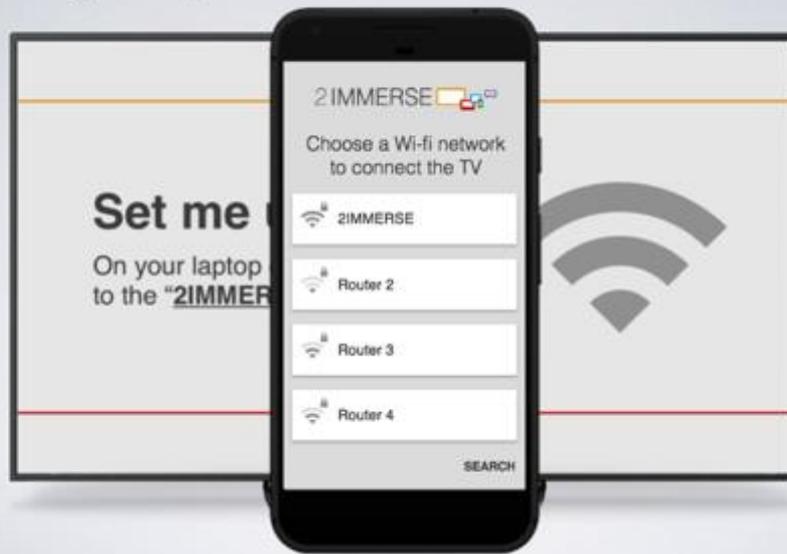
Google Chromecast



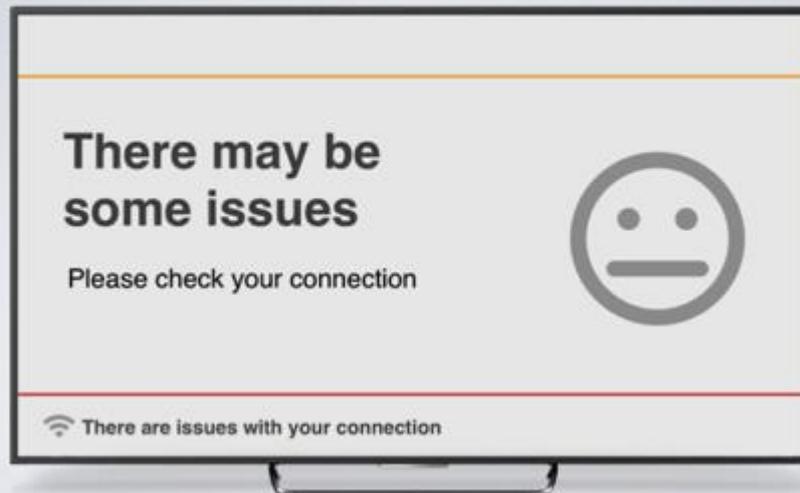
Annex B Wireframes for 2-IMMERSE Onboarding

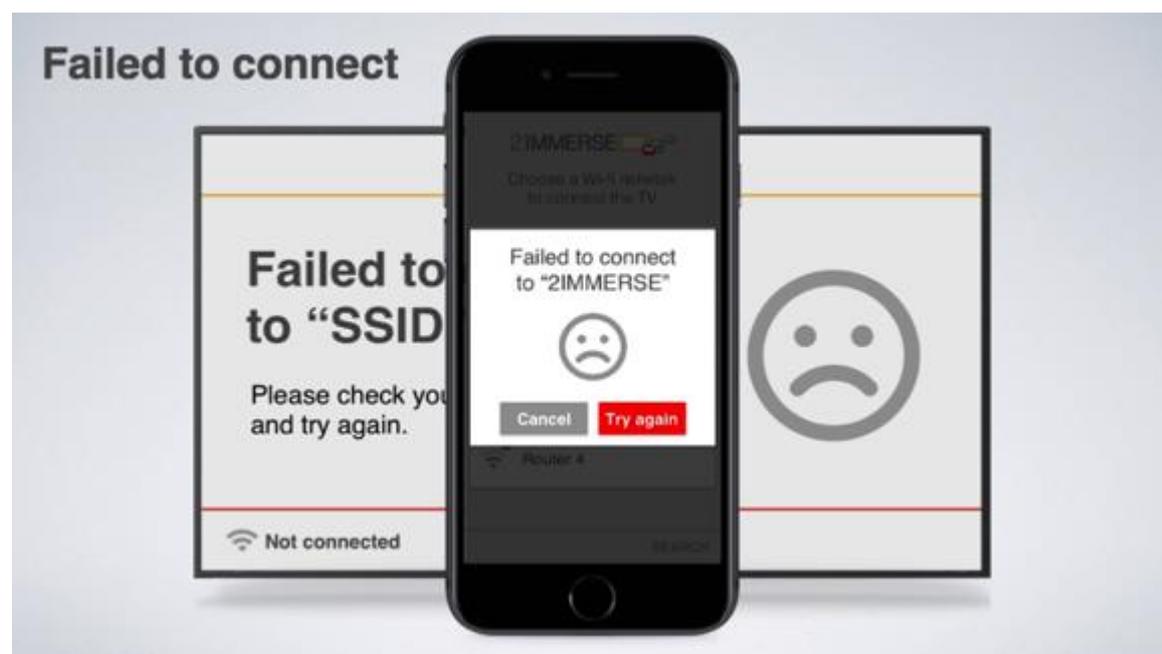
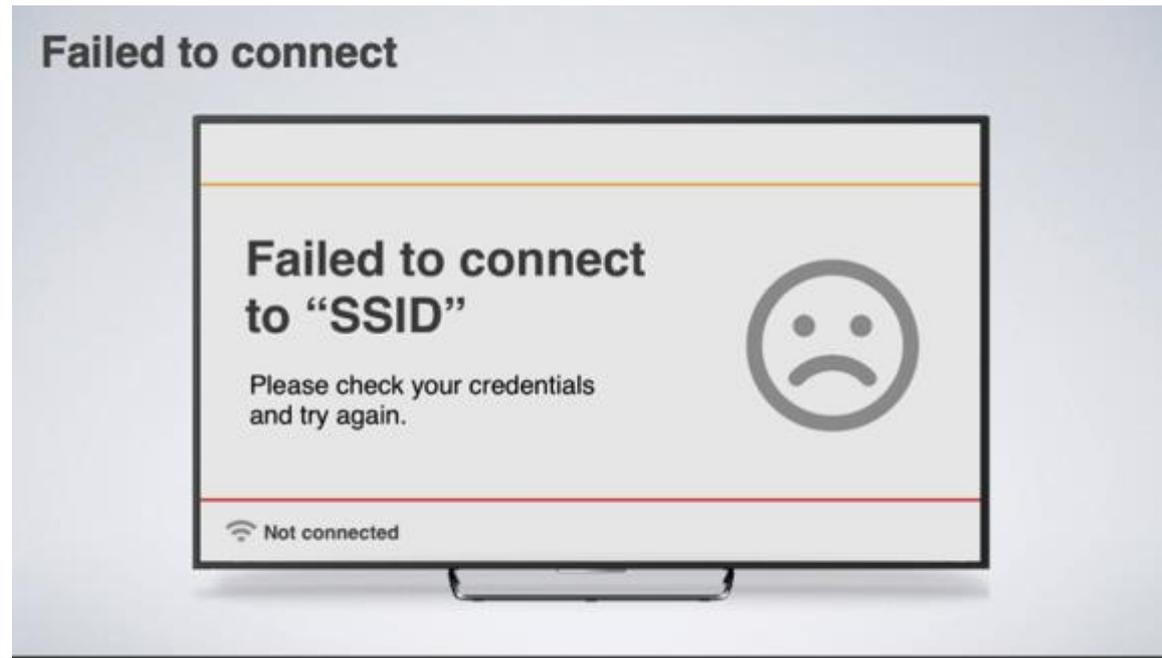


Connecting a keyboardless TV to the internet



Connection issues





Launching an experience



Launching an experience

App splash screen



Signing in on the app

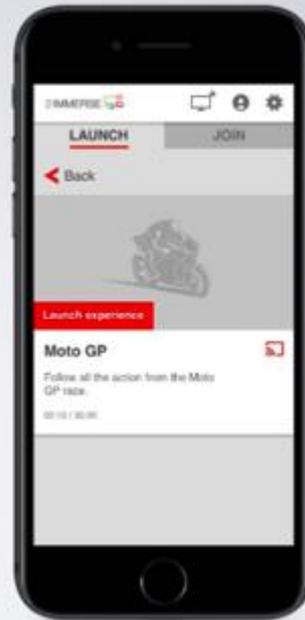
This part of the process is only required for the first time a user opens the app.



Launching an experience



Launching an experience

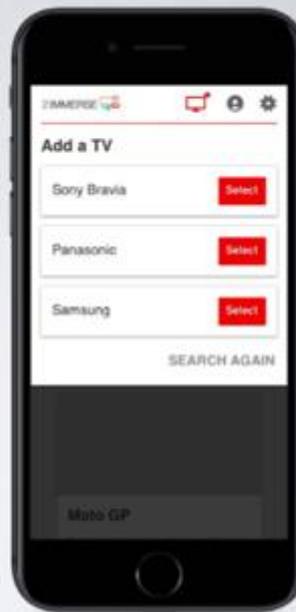


Launching an experience

Tooltips to guide users to features within the app.



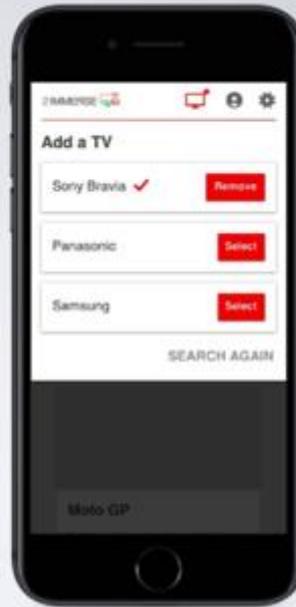
Adding a screen



Adding a screen



Adding a screen



Other menu items

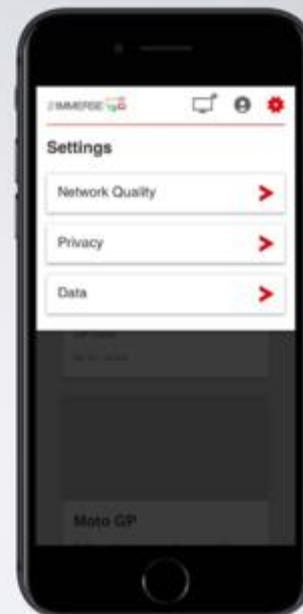


Signing in on the app

This part of the process is only required for the first time a user opens the app.



Other menu items



Annex C Background Research on Timelines

Timelines UX Research; timelines, scrub timelines, replays/highlights, and how they work alongside a live stream.

Context of MotoGP and a PiP scenario (live stream in one window and another window showing highlights from the same event)

Key Questions:

- Will the user get confused?
- Should we do this?
- How do we signal to the user what is going on?
- How good are individuals at self-organisation
- Timeline Behaviour - what exists; what is expected; what would be beneficial?

Users not knowing whether they were watching live or a replay - issue if the replay mode offers additional functionality (fast-forward or slow-mo possibly).

PiP of showing either live or replays on different screen configurations and interactions

Literature Research:

Many-Screen Viewing: Evaluating an Olympics Companion Application - Anstead, Benford & Houghton, 2014

Controlling playback

Both the remote control and each tablet offered a mechanism for controlling the television channel and the playhead in the video stream. During interview S72 referred to this as "a bombardment of controlling the same thing in many different ways

'Liveness'

- Half (5) of our groups having issues with comprehension both when they were watching live and when they were watching 'replayed'
- Lack of visible representation of where they were in each video, as the application didn't offer visibility of the video playhead
- Confusion as to whether the fast forward functionality was available. We observed 7 groups try to fast-forward beyond the live playhead in an attempt to skip past programming that they were not interested in, unaware that they were already watching live.
- Confusion around liveness and a lack of its visibility were especially apparent when a viewer switched the television to a channel that another was already watching on the tablet, where either of these devices was not watching at the live playhead
- "they are happening at the same time but different times"

Queuing other feeds - (watching critical/popular OBPIP outside of live viewing?)

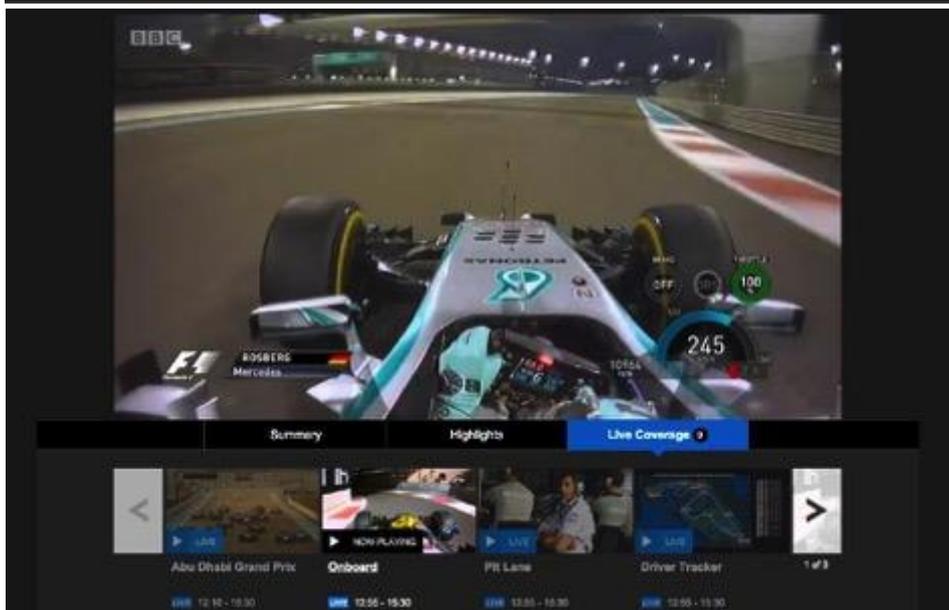
- Unlike other studies into EPGs, which provide mechanisms by which users could see what events and programming were about to start [10], the Olympics application did not offer this feature.
- Complex viewing behaviours, most notably that of queuing, were enabled by the applications 'resume' feature
- Particularly important in allowing users the freedom to schedule their viewing across the feeds, ensuring they saw as many key events as possible
- However, users suggested the option to play content on the TV or the tablet from the start of an event, offering a potentially more elegant solution
- Offer option of virtual crowd for each OB PiP to allow users to see what may be more popular stream and what to watch outside of traditional viewing if the race is getting boring
- Recommend in building-in a resume playback function between devices, or a mechanism by which viewers could skip to key moments of the action. This feature offers the desirable opportunity to allow users to perform ad-hoc scheduling of content as the situation unfolds
- Struggling to establish a sense of whether they were watching live or whether they were watching from an earlier location in the video programme
- Interactive mechanisms would allow users to collaboratively generate playlists of events and content they wish to see. (add to watch later - function to package highlights and OB graphics that they may wish to introduce to second screen in dull periods of the race) - visible on the timeline - critical points would be able to be clicked and press play now, or select add to watch later playlist in order to watch it once their main action has died down. May be watching an intense battle but crash might have gone on elsewhere. Able to continue their experience following the battle, but highlight crash main event on timeline and add to watch later

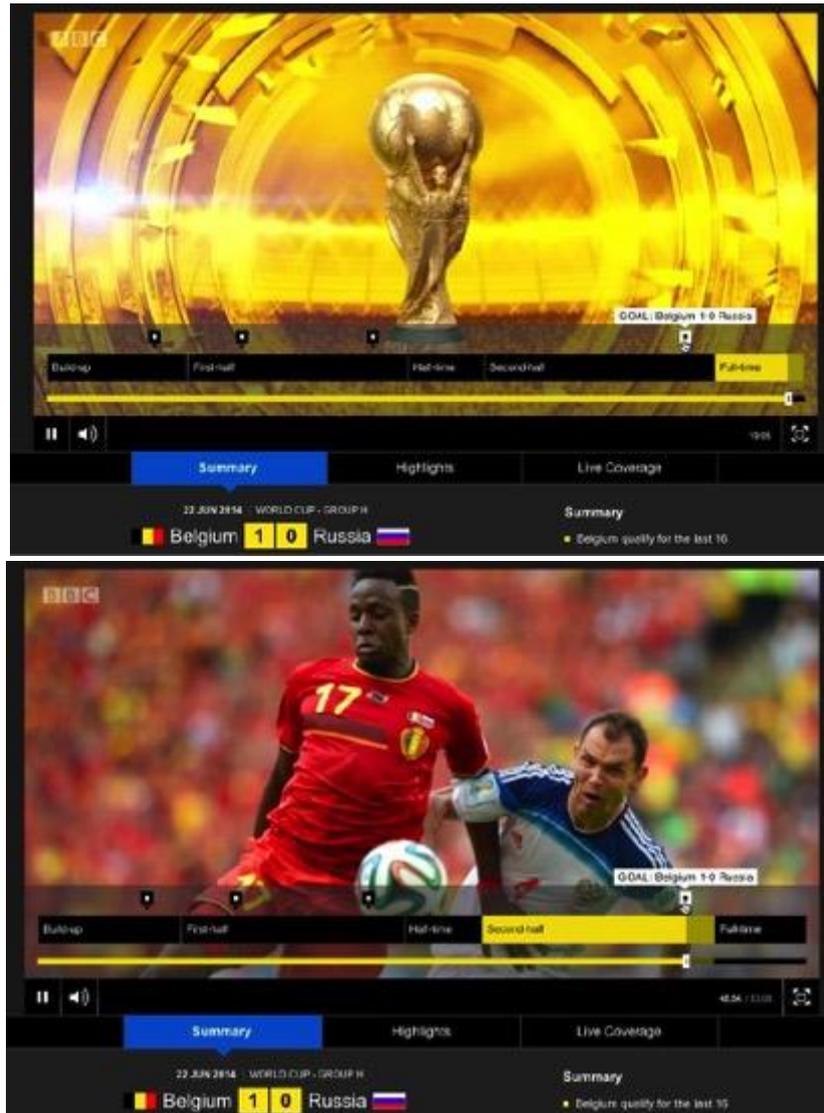
Conclusions

- Improved feedback to the user, informing them whether they are watching live and any impact this has on fast-forward functionality
- Issues of liveness led to instances where viewers were potentially seeing spoilers on the television of events they had yet to see on the tablet
- Blocking future content on the television until all users have caught up, or by providing adequate warning to viewers of potential spoilers.

BBC Live 2014

- Multiple live session streams: Commonwealth Games, Glastonbury
- 'Alternative View' Live Streams: able to offer simultaneous alternative live feeds for the actions, leaving it to the user to decide what perspective they preferred (e.g. Formula 1)
- Video Cue Points of Chapters & Key Moments - live rewind and editorially defined cue points enabling people to easily relive crucial moments
- Live Text Commentary - Reflects voice of editorial staff as well as encouraging contributions from our users, including a real-time voting module that can enhance broadcast TV coverage
 - particularly popular on mobile device





Sliders Versus Storyboards – Investigating Interaction Design for Mobile Video Browsing - Hürst & Hoet, 2015

- Suggestions of interface integrating both Storyboard and Timeline designs for navigating video content
- Storyboard - Representing a video's content in a grid-like arrangement of static images extracted from the file
- Slider - Enabling users to interactively skim a video's content at random speed and direction along the timeline

Increasing availability of videos on mobile devices also results in a growing need for better search and browsing functionality.

Users want to interactively skim video content to find parts of particular relevance or skip ones of minor interest (O'Hara, Mitchell & Vorbau, 2007)

Browsing videos is traditionally a difficult problem due to the transient nature of the continuous signal. Applying such timeline browsing mechanisms to mobile devices, such as smartphones and

tablets, introduces a whole set of additional problems (due to their form factor and resulting limited screen estate)

Observe a trend of integrating storyboard-like visualizations into the browsing process, for example, by visualizing related thumbnails on top of the slider's thumb while dragging – as done in the popular YouTube online video platform

Granularity problem: small screen sizes on mobile devices, moving the slider even just one pixel can result in a relatively large jump in the file, thus not enabling users to explore content in detail

ZoomSlider [Hürst, Götz & Welte, 2007] where skimming a video is done by left/right gestures on the screen - but then content is often covered by user's fingers

Hürst & Merkle, 2008 - Accidental content hiding is reduced to a minimum by placing the thumbnails to the left of the screen and browsing them via gestures made on the right side. Yet, the solution does not account for the aforementioned granularity problem

Hudelist, Schoeffmann & Boeszormentyi, 2013 - Overcomes both problems - Right side features a thumbnail-enhanced slider for video browsing, while the left side of the screen enables users to activate different functions, including an option to modify the right thumbnail-slider's scale

Current Study: *initial player interface*: slider at the bottom, representing video length, allowing quick access across all positions of timeline. The interface is hidden during normal playback but becomes visible as soon as user touches the screen. A thumbnail image representing the corresponding content provides real time feedback during browsing, displayed on top of the user's thumb.

Advantages: flexibility, familiarity, provides location feedback for full video file.

Disadvantages: suffers granularity problem

Storyboard design - 5x5 interface extended to top and bottom beyond the screen - scrolling is done via up or down gestures

Potential advantages: provides detailed content information, easy to skim (static character), intuitive layout, easy to understand following user-familiar interaction designs

Potential disadvantages: additional display of content enforces additional interaction (up/down scrolling), need to switch between two separate screen layouts for playback and browsing.

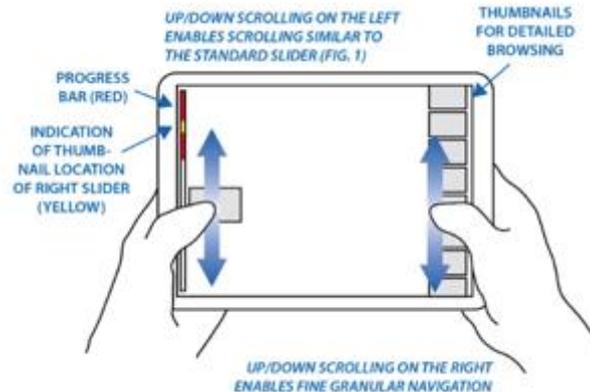
Slider interfaces: usually placed horizontally to minimize risk of covering relevant content during browsing. Yet, when comfortably holding the device with two hands, it still requires people to release one hand from the device during operation

Placing a slider vertically counters the problem of reach, yet enhances the granularity problem (due to screens aspect ratio) - introduce second slider bar on right hand side representing only a fraction of the video displaying additional content information in the form of a vertical filmstrip. Like other designs - playback feature is hidden until user touches the screen

Potential advantages: better visualization of more content during browsing, support of higher and lower granularity levels (left side can be used to get a quick overview of the file or find a larger region/scene of interest, whereas the right side can be used for more detailed skimming to find a

specific event in that scene), interface can be operated easily while naturally holding the device in two hands.

Potential disadvantages: less familiar design, both in terms of vertical orientation, but difficulty in recognising an established direction for the playhead to travel (top-to-bottom or bottom-to-top)



Controlled study to compare designs:

Holding phone: hypothesized that most would hold in two hands with thumbs as operating instruments. Heat mapping and neutral observer noted only one held the device like this. Most used non-dominant hand to support device and interact with the other hand - only 9/24 operated right hand storyboard

- Vertical sliders were easy to reach and good positioned
- People appreciate more advanced browsing options if exact functions aren't possible with traditional sliders but using right slider increased search time 54.87s compared to 22.73s

User Preferences - unable to determine whether user had specific preference for either design

- Avg. 6.63/10 for storyboard, 6.38 for slider interface
- Easy of use - preference toward a slider design (7.43 for slider, 6.38 for storyboards)
 - Necessary switch between two layouts is a major negative issue for storyboards
 - Slight delay of thumbnail generation - hinted negatively by some users - but not for fast scrolling - less noticeable - only when trying to find specific point
- Slider = fast, easy to use and intuitive; user praised storyboards clarity and clearness
- Perceived search time was fastest in slider - even if objective performance didn't concur - illusions of extra effort and load going into the storyboard - participants feel more laborious in searching
- Mixed opinions - personal taste and habits may be influential - what people are habituated to

Few participants used the device in the relaxed way intended - may be external influence of the lab environment inhibiting comfort and ability to emulate behaviour they would display at home or whether the research team overestimated the wish of users to hold the device in such a way while browsing

- Comparative study yielded no clear advantage of either layout, nor identify any situations where one may be preferred

- People still rely on simple sliding mechanisms and should only be supplemented with more complex designs like the storyboard if it complements the basic habituated design and interaction mechanics
- Some users suggested integrating both designs into one - providing an interface where users could start using simple browsing actions (standard timeline sliders) first, then switch to more advanced ones depending on context, situation, and personal preference (again following commonly accepted design guidelines from other domains)
- Usage data does not verify that vertical timelines would be more intuitive based on how users hold the device - (especially if the device was a tablet?) - need more more long term naturalistic study of how user interact with phones orientation, heatmaps, interaction

Video Interaction Tools: A Survey of Recent Work - Schoeffmann, Hudelist & Huber, 2016

Pongnumkul et al., 2010 - Dynamic timeline approach for seeker-bar navigation in video

- Building on the idea of the elastic timeslider proposed by Hürst et al. (2004), which adjusts playback speed through a nonlinear function of the mouse distance for smoother interaction.
- The dynamic timeline approach uses an intelligible presentation of video content at high-speed scrubbing. More precisely, at high-speed navigation it shows only a portion of key-clips from the video, each with a duration of one second, but at a more convenient speed (e.g., 2x), instead of all frames/shots at an unrecognizable speed. Key-clips are selected from shots of the video based on a hierarchical clustering approach.

Girgensohn et al., 2011 - Hierarchical video navigation method

- Tree of keyframes that are sampled by two different approaches:
 - (i) by color dissimilarity
 - (ii) by a split-based clustering algorithm that produces a well-balanced tree.
- User is presented a simple timeline with associated and clickable keyframes allowing quick horizontal navigation as well as hierarchical refinement by simple mouse-wheel interaction. Video browser implemented as an online tool with HTML5
- Received positive user feedback (though based on two users)

Al-Hajri, et al., 2013 - Viewing history and crowd-sourced navigation footprint features.

- Tool offering multiple ways to explore video content (Typical video timeline, filmstrip, history timeline, video mash-up, preview area and two footprint indicators.)
- The filmstrip shows a fixed number of video segments represented by thumbnails, to which users can directly navigate. Furthermore, the history timeline records all watched segments (start and stop of playback). The video mash-up and preview area can be used to easily create small video compositions like summaries or previews. The tool also visualizes the popularity of segments in the video via colored two bars. One bar uses blue marks to visualize frequently visited segments and the second bar crowd-sourced popularity via red indicators.

Hudelist et al., 2013 - Ergonomic video browsing on mobile devices

- Video browsing while sustaining comfortable hand postures. Landscape orientation hiding interaction items during normal playback reducing screen clutter.
- Left side = radial menu provides navigation controls like play, pause, fast forward, fast reverse, bookmark creation swiping from left edge.
- Right side = vertical timeline seeker control with a resizable preview window to skim through the video and jump to specific positions.
- Possible to stretch the timeline in order to have better control with longer videos (tackle granularity problem).

Zhang et al., 2013 - Collaborative annotation of videos + video navigation with sketch gestures

- Sketches, entered through the touchscreen, are immediately visible to the other user if they are in the same part of the video.
- Users can also share their current position and annotations, indicated with a small image presented at the bottom right of the screen.
- Users can communicate with each other via a built-in chat function and navigate in the video by applying predefined touch gestures.
 - For example, dragging both fingers from the sides to the center of the screen opens the playlist, drawing a line from right to left starts fast reverse, and a single tap on the screen starts playback or pauses the video.

Haesen, et al., 2013 - The Video Archive Explorer

- Physically and collaboratively explore videos on a multi-touch table through interactive content visualizations.
- Enter textual query -> explore and re-arrange the results presented in three different visualizations:
 - Animated keyframe slideshow
 - Video clock visualization (other video keyframes arranged in a circle according to temporal manner)
 - Video timeline visualization (similar to clock, but arranging keyframes on timeline from left to right)
- The tool was evaluated in a qualitative user study (10 experts and 4 search tasks).
 - Very convenient inclination to use on desktop as well.

Cunha et al. 2012 - Adding textual annotations during video playback.

- Annotations used as video navigation aid
- Can be shared among users for the scenario of collaborative authoring.
- Additional view: shows a list of all annotations with thumbnails of the corresponding keyframes, the user can jump to all marked positions in the video.
- Qualitative evaluation (N=6) - easy to use the mobile authoring and navigation features.

GOAL! Event detection in sports video - Tsagkatakis, Jaber & Tsakalides, 2017

Dynamics, complexity and variation of video sequences makes detecting and understanding events in live sports events very difficult.

Current paper: Exploit capabilities of the framework of deep learning - Independently encoding spatial and temporal information via convolutional neural networks and fusion of features via regularized Autoencoders. Compiled dataset composed of goal and no-goal sequences.

Experimental results demonstrate that extremely high classification accuracy can be achieved, from a dramatically limited number of examples, by leveraging pre-trained models with fine-tuned fusion of spatio-temporal features.

Content-Aware Dynamic Timeline for Video Browsing - Pongumkul, Wang, Ramos, Cohen, 2010

Traditional timeline slider effectiveness and precision degrade as video's length grows (more frames than pixels in slider) - UX problem as frames flash too fast, frames become inaccessible and scrolling actions cause jumps in media

Proposal of content-aware dynamic timeline designed to overcome granularity problem by decoupling video speed and playback speed in addition to leveraging video content analysis to allow salient shots to be presented at an intelligible speed

Makes use of previous research on elastic sliders, allowing creation of an accurate navigation control
Borrow from PVslider - uses vertical distance between the cursor and control to adjust control-display ratio

This context-aware timeline employs a skimming method to present the user with meaningful abstraction of the video when the user rapidly scrubs the video - providing discernable frames as user skim through playthroughs

Aside from watching a video, users also engaged with (1) fast-speed skimming through a long video and (2) low-speed interaction in a small section of the video

Fast skimming occurred in situations where the user was unfamiliar with the video, and wanted to get a quick overview of its content and identify some interesting parts. Low-speed navigation occurred when users wanted to accurately locate a specific frame or time code in the video, e.g., the beginning of a scene, or a representative frame of a shot

Playback speeds of x8, then temporal coherence is lost and video appears as random frames

Elastic Timeline: User clicks on the slider, the video jumps to the corresponding frame. However when the user drags the handle and moves along the timeline, the handle does not stay directly attached to the mouse pointer.

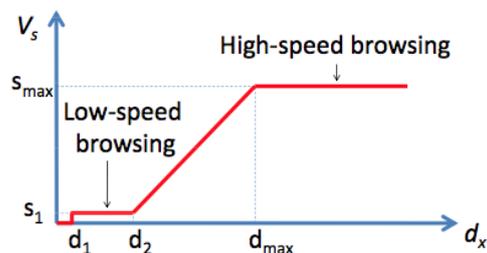


Figure 1: The function of normalized video speed V_s vs. the normalized horizontal distance between the mouse pointer and the handle d_x .

Dynamic Video Skims: skimming too fast will result in a fast playback speed. Unrelated frames displayed together resembles similarities to flashing images that degrade the experience a video has the ability to provide, which is the smooth continuity of frames

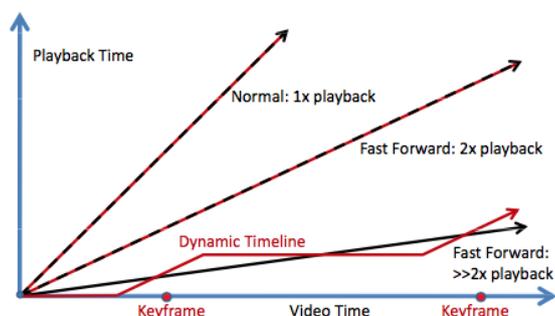


Figure 2: The illustration of dynamic timeline. At 1x, the playback time matches the video time, as illustrated with the top slope. At 2x, the playback time is half of the video time. As the video speed exceeds 8x, instead of naive uniform sampling, the dynamic timeline displays clips to play at 2x. This is followed by a jump to the next clip, to maintain the desired video speed.

Conclusions: Main contribution is the decoupling of video speed and playback speed, which allows a meaningful visual abstraction of the video content to be dynamically created, as users skim through a video. Acknowledge there may be similar problem in the playback and abstraction of a soundtrack or audio accompaniment when browsing across a timeline

Improving Video Browsing with an Eye-Tracking Evaluation of Feature-Based Color Bars - Moraveji, 2004

Interactive timelines are standard on most media players. Query-based video retrieval interfaces can show users where matches occur in the video document (vertical strips on the timeline) but context is lost.

With few matches, scrolling timeline for event becomes trial and error

Feature-based colour bars: visually distinct events codifying event categories. Cursor over colour bar reveals information about that segment of the video (descriptive tag?) description allows users more freedom in not having to learn what each colour means. Clicking on coloured segment moves the video to that chapter of the video.

User study: N=12 subjects given 4 random-order tasks. Listened to audio tutorial of interface controls and had eye-trackers calibrated.

- Each task displayed the user one of 4 timeline conditions:
 - Timeline with colour bars and query matched lines (Both)
 - Timeline with only colour bars (Colour)
 - Timeline with only query matched lines (Lines)
 - Timeline with no extraneous information (Neither)
- Tasks created in accordance with video browsing assessment metrics proposed by Wildemuth, et al.
- Tasks also had a mixture of unique and multiple answers

- “Find a person ABNews interviewed in Iraq.”
 - (A - Action recognition – textual, multiple possible answers)
- “Find a scene depicting text written on trophy basketballs.”
 - (B - Object recognition – textual, one answer)
- “Find the scene where the head of Microsoft sings a song.”
 - (C - Action recognition – textual, one answer)
- “Find an image of this clean-burning car.”
 - (D - Object recognition – graphical, one answer)

Results of user study: Colour bars improved efficiency on all tasks. UNIqueness of feature had large impact on how useful colour bars were

Timeline use without colour bars was 32%; timeline use with colour bars rose to 69%

Eye Tracking: increased portion of the user's' attention paid to the timeline while decreasing overall fixations (extended looking - inferred to be a negative indicator of task efficiency)

Conclusions: Making events distinguishable by colour in timelines is shown to be an efficient interaction technique enabling more informed browsing of a video segment.

Interfaces for Timeline-based Mobile Video Browsing - Hürst & Meier, 2008

Preferences for both interface designs for scrolling content on a timeline were highly liked, and equally efficient and useful as a result. Yet, individual preferences exist and are not necessarily related to the actual performance of a system. User perception, experience, and fun all affect ratings that people give, so a high rating to a timeline interface does not necessarily suggest it is the most effective interface design, individual preferences may bias results.

Interesting to do a long term study where participants interact with different timeline mechanisms under real world conditions in their everyday life, rather than one off preference assessments in a lab.

Difference in timeline scrolling interface preference may be a reflection of the task itself as different tasks require different interaction (slow vs. fast scrolling) with the device. Storyboards may be effective for large jumps in content, but not in fine details when frames may look identical etc. Similarly, visualisation of metadata may be helpful but at the same time increase complexity, reduce clarity and complicate ease of use.

Multi-touch interaction may be a topic worth further investigation rather than classifying individual buttons

A Video Timeline with Bookmarks and Prefetch State for Faster Video Browsing - Carlier, Charvillat & Tsang Ooi, 2016

Reducing seek latency by predicting what users will access is important for UX during video browsing as users frequently seek to skim through a video.

Existing research: strive to predict user access pattern more accurately to improve the prefetching hit rate

Approach in this paper: Prefetch hit rate is improved by biasing the users to seek to prefetched content with higher probability through changing the video player UI

Results of user test: lead to up to 4x more seeks to bookmarked segments and reduce seek latency by 40% compared to traditional video player interface. User understanding of the video content when browsing is not compromised by the changes in seek behaviour.

Chen et al - viewer behaviour from 540 sessions. Users seek in 62.5% of sessions. Average 9.36 seeks for movies, 4.75 for music videos

Linear watching = sequential - can buffer future frames so there is no delay

Seeking = non-linear, no time to pre-buffer content and playback is jerky and jarring

Prefetch segments that may be regularly called upon to try and eliminate seek latency with pre-buffered content, even at different to the playhead

This paper has a different path to reduce the seek latency: instead of prefetching the segments that we predict the users would seek to, we bias the users to seek to the segments that we have prefetched - actually showing the prefetched segments on the timeline. Instead of prefetching where we think the user would seek to, only show what is already fetched to influence user behaviour.

Results: User's behaviour is more predictable, lowering search latency

DRAGON: A Direct Manipulation Interface for Frame-Accurate In-Scene Video Navigation - Karrer, Weiss, Lee & Brochers, 2008

This technique benefits tasks such as professional and amateur video editing, review of sports footage, and forensic analysis of video scenes.

Dragging objects in a scene along their movement trajectory enables users quick and precise navigation to a specific point in the video timeline where an object of interest is in a desired location (e.g. where a sprinter crosses the finish line, or where a nuke passes a time checkpoint)

User study: significantly reduces task completion time for in-scene navigation tasks by an average of 19–42% compared to a standard timeline slider.

Qualitative feedback: felt more natural than the traditional slider for in-scene navigation.

Facebook Live timeline - overlays a reaction timeline on top of the video progress bar. Similar to soundcloud, see users comments and jump to that point. Does not guarantee it is a 'good' bit, but it is an indicator of popularity and most likely an interesting event that you may wish to jump to. While it may increase popularity of streams as people can ensure that they are getting 'better' content, or the availability of popular events is more visible, it may seriously impact the flow narrative of the video - May 2016

Annex D Early Design Concepts for 2-IMMERSE MotoGP

Early Concepts 1/5



Notes:

- Object Based Graphics enabled personalised presentations.
- Customised Picture in Pictures are supported.
- Multiple 'virtual desktops' support easy swapping between personalised layouts.
- Interactive map provides enhanced view of race action and shows location of the riders.
- Shared 'TV' screen on tablet means the user doesn't miss any of the action.

Early Concept 2/5

**Notes:**

- Multiple video streams in Mosaic on both tablet and phone companion devices.
- Drag and drop on board feeds into predefined layouts.
- Interactive Leaderboard links to expand menus on main TV screen.
- Instant replay function on companion, supporting rewind and fast forward 10 seconds.
- Interactive Scrub-bar enables the user to move freely around the broadcast.
- 360 video on companion screen can control viewpoint of PiP on TV.

Early Concept 3/5

**Notes:**

- Interactive Map enables viewers to better understand the track
- Camera positions are highlighted corresponding to the broadcast feed.
- Replay clips are accessed from the location they were recorded from around the track.

Early Concept 4/5

**Notes:**

- 'Virtual desktops' enable set-up and customisation of magazine style layouts for news, etc.
- Merchandising integrated into the experience.
- Live detailed telemetry from favourite riders provided on companion screen devices.
- Favourite rider positions are displayed on map shown on the TV screen.

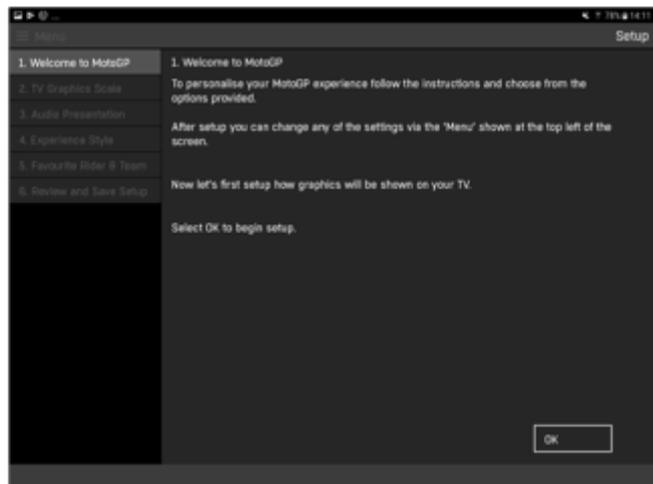
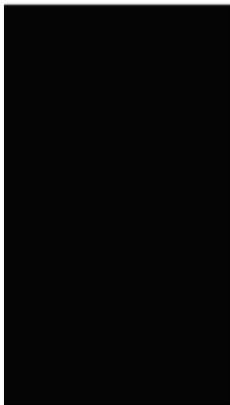
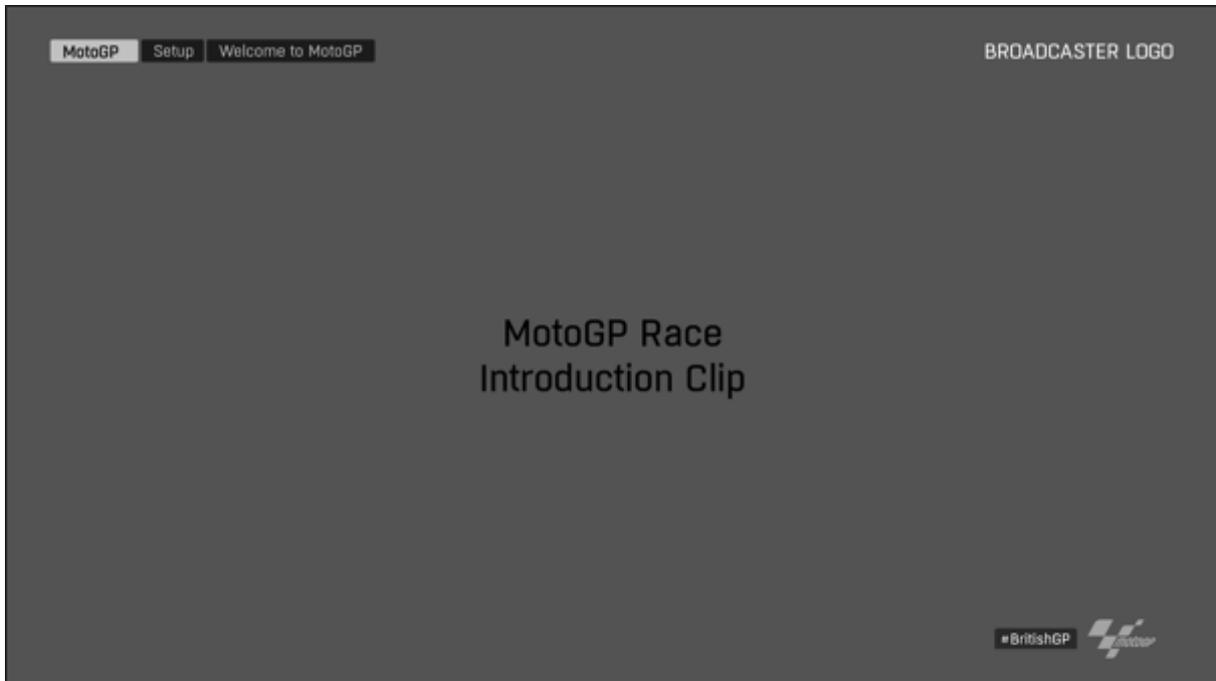
Early Concept 5/5

**Notes:**

- Interactive timeline with race events marked supports fast access to replay clips.
- Replays are mirrored on TV PiPs to support local shared experience
- Interactive leaderboard offers a wide variety of information

Annex E Wireframes for 2-IMMERSE MotoGP UX

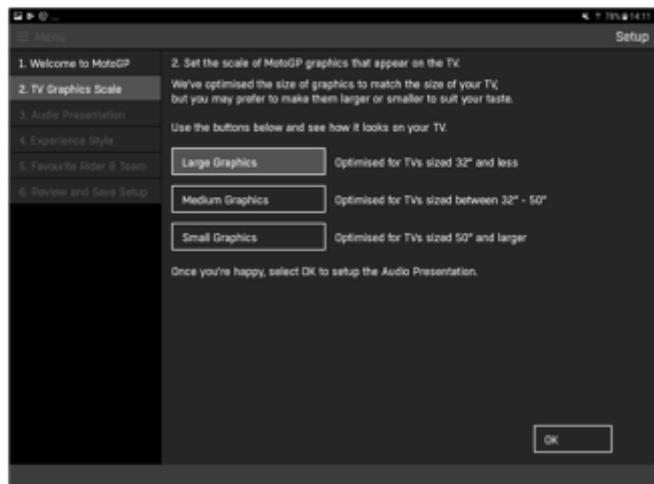
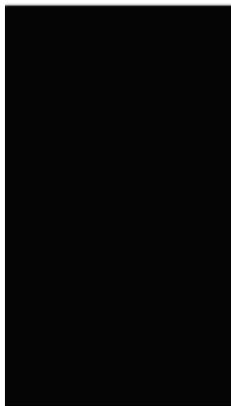
Set Up User Flow 1/6



Notes:

- Welcome to Set-up
- It was presumed that during the 'on boarding' process a User Account has been set-up. The settings for MotoGP would be associated with that users account.

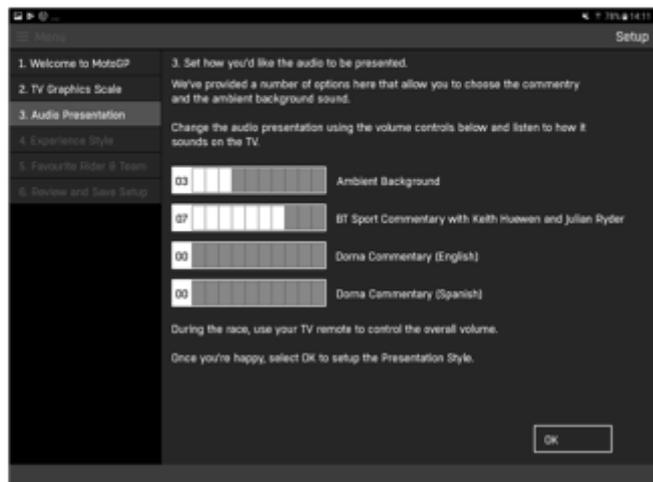
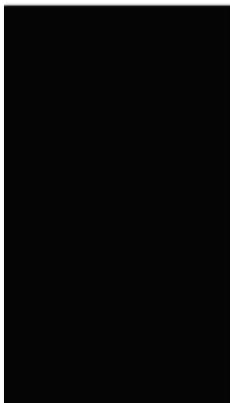
Set Up User Flow 2/6



Notes:

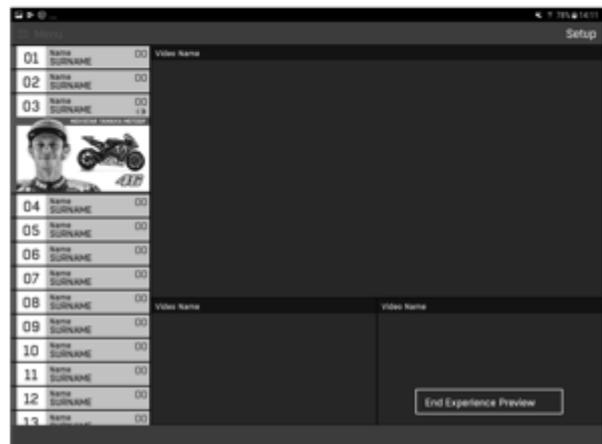
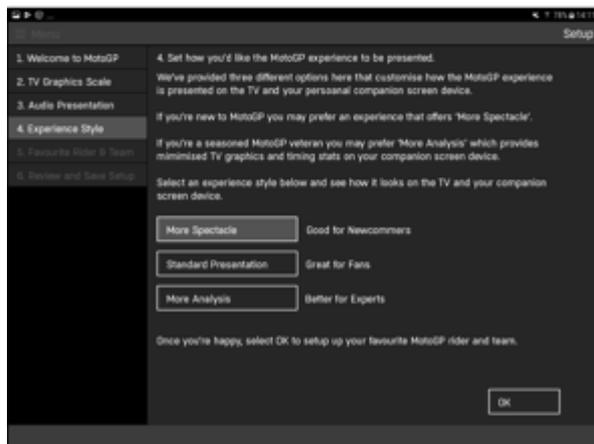
- Setting TV Graphics Scale
- Three different scales were provided.
- On selection of a setting the TV would preview what that would look like during the race.

Set Up User Flow 3/6

**Notes:**

- Setting Audio Levels
- Four settings were provided aligned to available audio tracks.
- Suitable audio would be played during the set-up process so the user could choose their preferred setting.

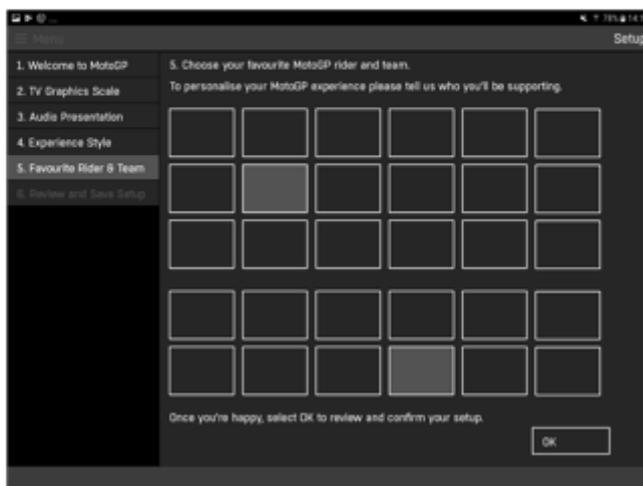
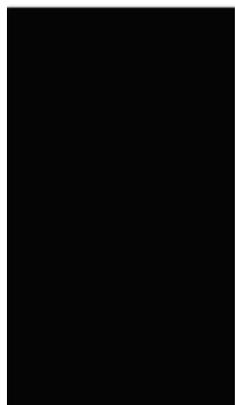
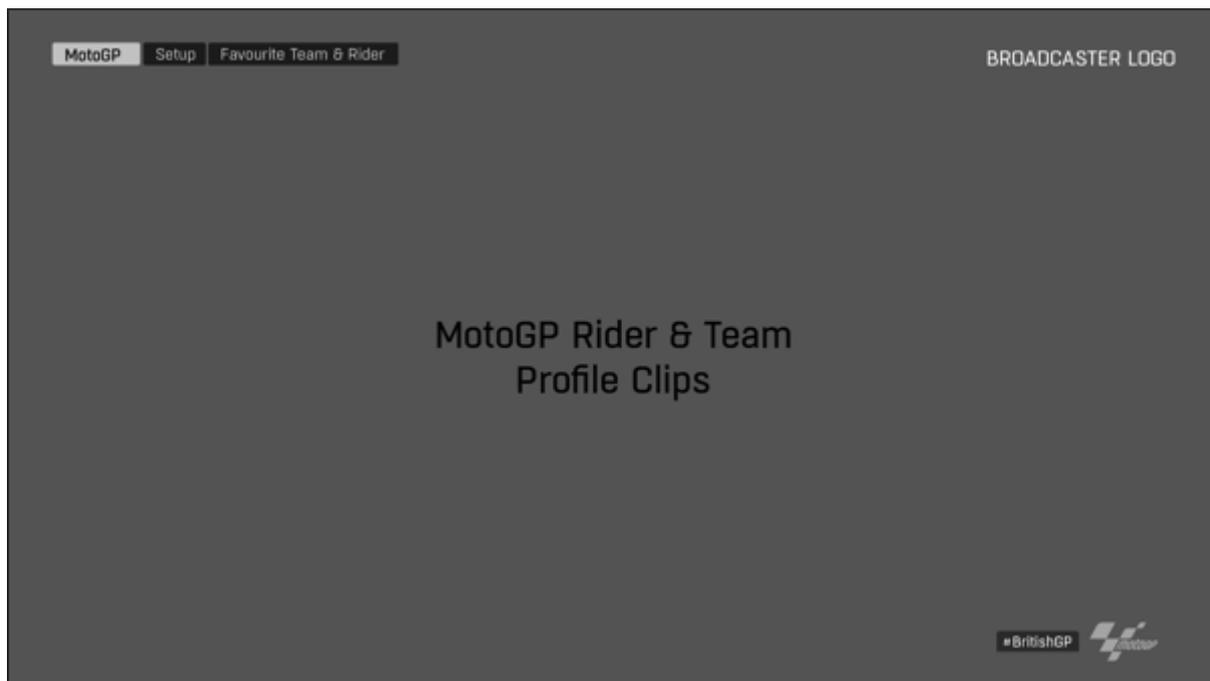
Set Up User Flow 4/6



Notes:

- Setting the viewer Experience Level
- On selection of an Experience Level, both the TV and Companion screen preview the UI.

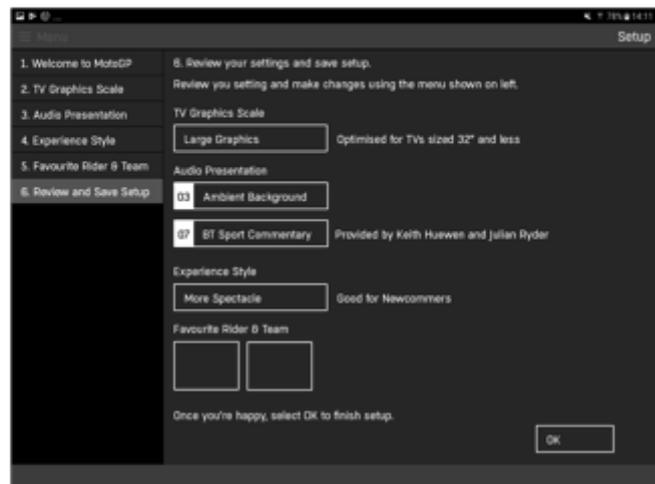
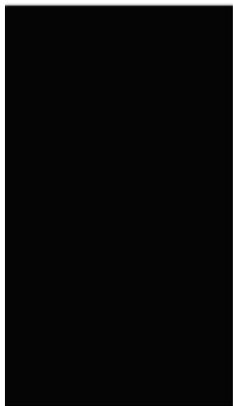
Set Up User Flow 5/6



Notes:

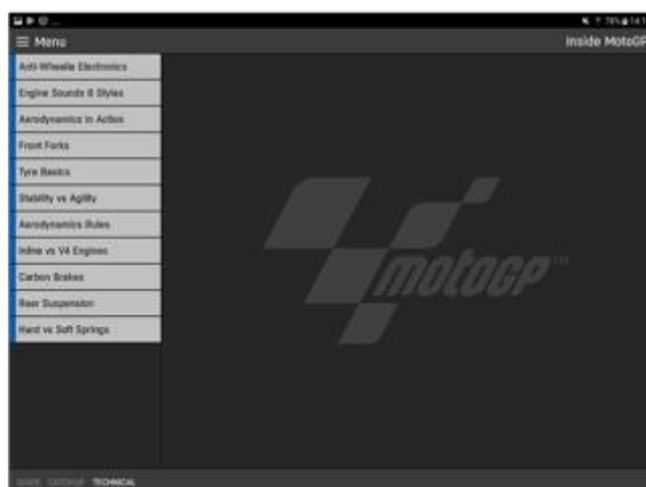
- Selection of the user's Favourite Rider and Team

Set Up User Flow 6/6

**Notes:**

- Review of settings prior to OK and progression to 'Inside MotoGP'

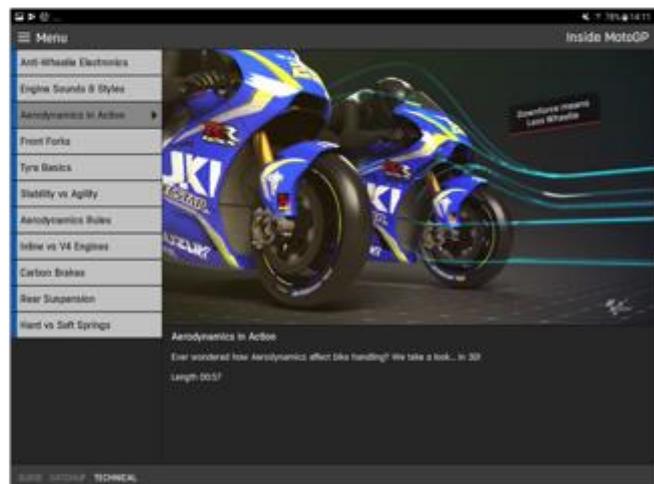
Inside MotoGP Overview 1/2



Notes:

- TV shows pre-race presentation
- Companion in 'Inside MotoGP' chapter mode
- Companion provides access to 3 areas offering short videos on Guide, Catch-up and Technical
- Guide videos provide tutorials on key facilities with MotoGP app (2-Immerse platform)

Inside MotoGP Overview 2/2



inline with notification of a Chapter change, the Chapter title on the TV goes amber (30 seconds) then red (30 seconds) before the Chapter changes.



Text Colour #000000 Text Colour #FFFF Text Colour #FFFF
 Box Background Colour #333333 Box Background Colour #cc6600 Box Background Colour #cc0000
 Box Border Colour #000000 Box Border Colour #000000 Box Border Colour #000000

Notes:

- User selects video to play
- Video playback on companion devices
- TV continues to show broadcast video
- TV shows Chapter approaching end via coloured bars and companion devices show notification asking user to progress to next chapter 'Watch Live'.

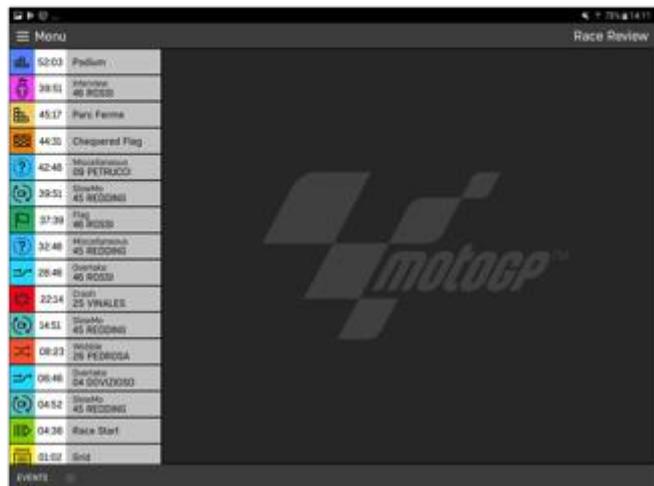
Watch Live Overview 1/1



Notes:

- TV shows race with client-side composited layered graphics and PiP videos.
- Tablet companion device shows interactive leaderboard. Tablet also shows multiple video streams which are configured via the views tab.
- Phone companion shows interactive leaderboard.

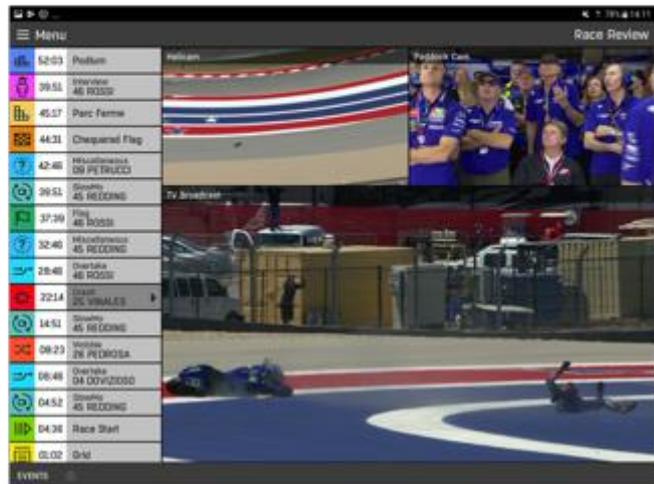
Race Review Overview 1/2



Notes:

- Starting UX in the Race Review chapter
- TV Shows main broadcast
- Companion Events available are shown in EVENTS panel
- Companion Video windows are blank

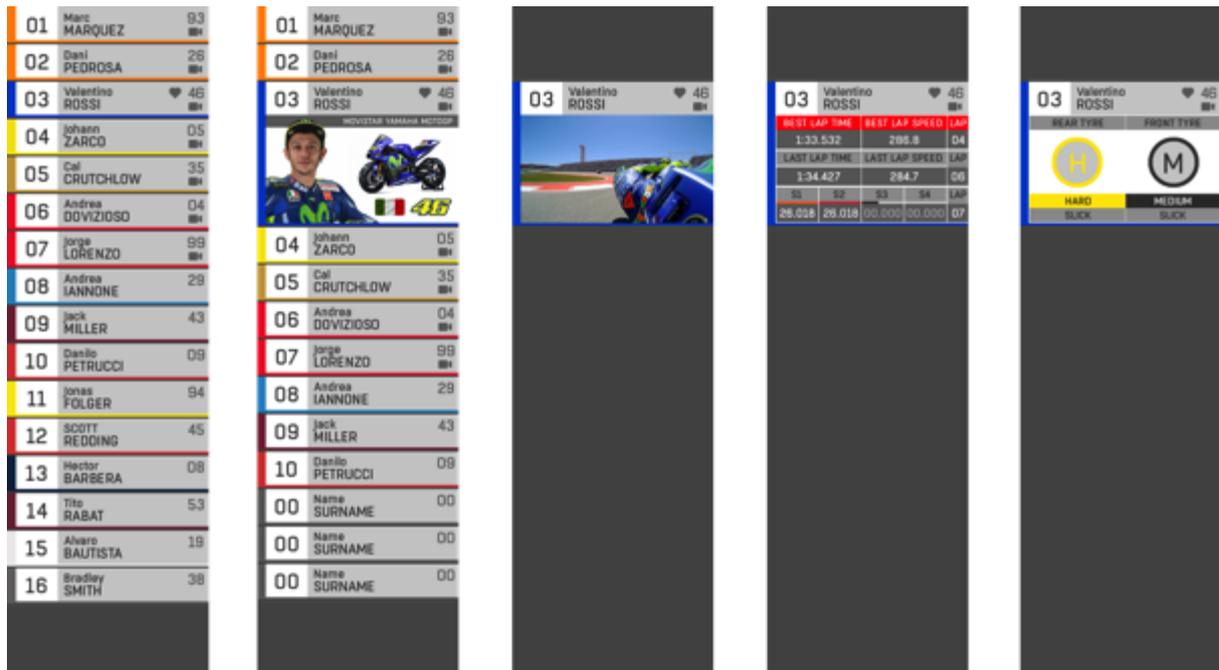
Race Review Overview 2/2



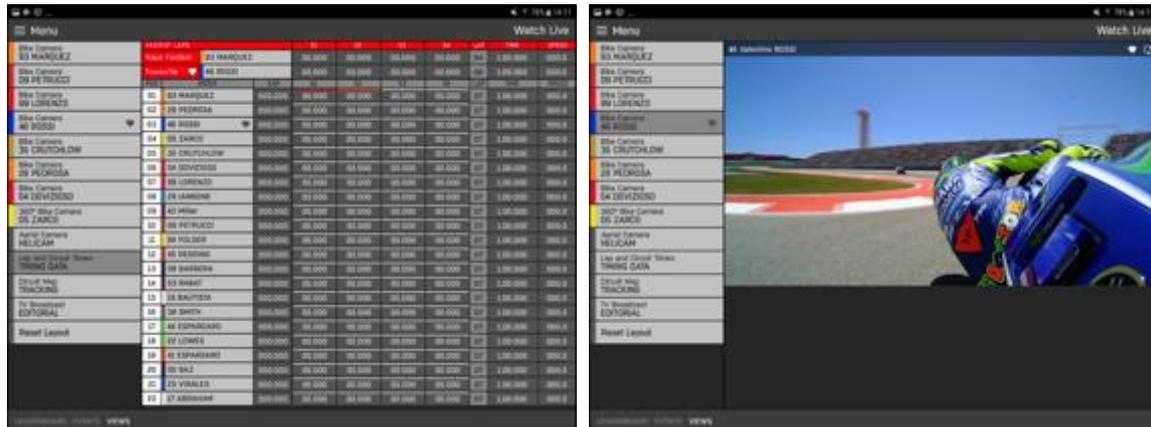
Notes:

- User selects to view Viñale's Crash
- Video starts to play
- TV Shows main broadcast
- Companion Phone shows main replay video
- Companion Tablet show main and two additional synchronised video replay videos
- After video has finished the companion screen UI returns to default screen.

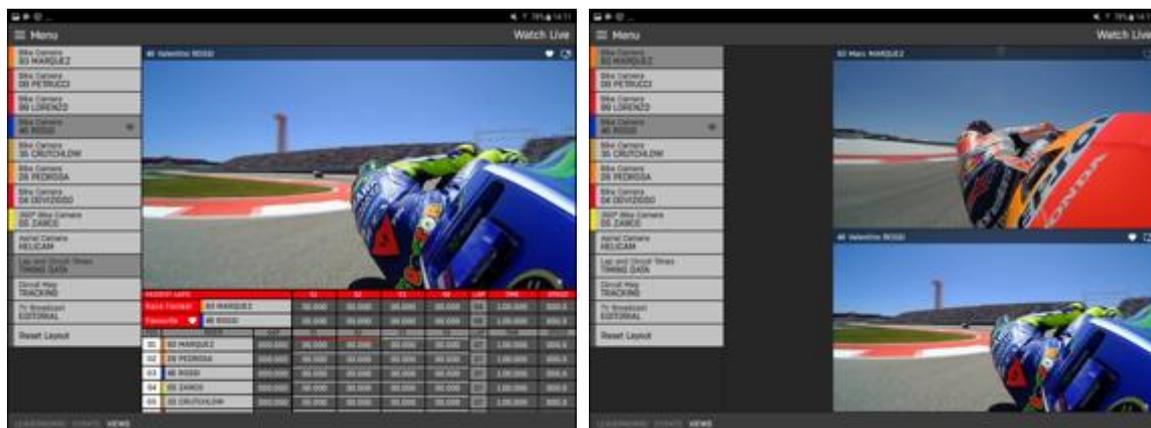
Leaderboard Panel and Rider Cards



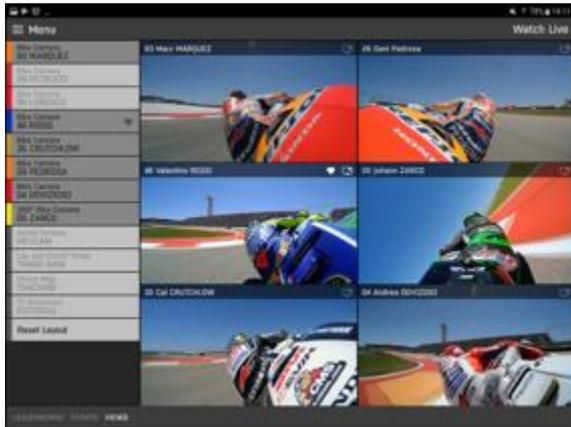
Tablet Video Layouts – 1 x Panel



Tablet Video Layouts – 2 x Panels



Tablet Video Layouts – 6 x Panels



Companion Video Stream Cast to TV PiP - User Flow



1. Video bar shows that PiP is available, but not selected.

PiP icon is 50% transparency.



2. User 'taps' on the screen to show options. Option to push to TV PiP is shown at the top of the screen.

If the user taps on the TV PiP button, the action to cast video to the TV PiP is performed.

If the user does nothing, the icon remains on screen for 3 seconds before fading out. If the user taps on the screen the icon fades out.



3. PiP on the TV is created and video is shown on TV PiP. If the maximum number of PiPs have been reached, this PiP replaces the 'oldest' PiP displayed on the TV.

TV PiP icon on the CS video window is shown at 100% transparency (i.e. no transparency).

TV PiP button fades out once pressed.



4. CS video window returns to normal.

Stop Casting Companion Video Stream to TV PiP - User Flow



1. Video bar shows that PiP is being cast to TV

PiP icon is 100% transparency.



2. User 'taps' on the screen to show options.



3. If the user taps on the TV PiP button, the action to stop casting video to the TV PiP is performed.

TV PiP button fades out once pressed.



4. CS video window returns to normal.

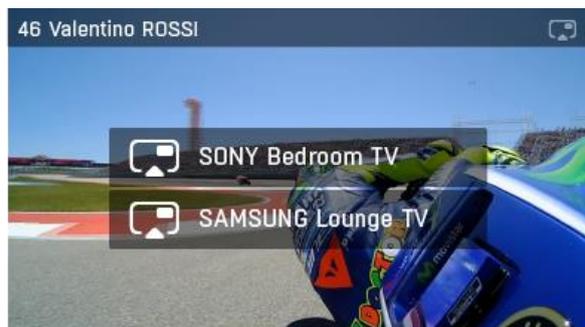
Cast TV PiP - Additional



Default state for Favoutite Rider with PiP on on the TV.

It is possible to stop casting Favourite to TV.

Video bar shows 'white' PiP icon to indicate that this video is currently beign shown as a PiP on the TV.



Alternative for multiple 'shared' screen environments, when the user needs to select on which screen to cast their PiP